Attachment 70

Comments of Environmental and Public Health Organizations on:

EPA, California State Motor Vehicle Pollution Control Standards; Advanced Clean Cars II Regulations; Request for Waiver of Preemption; Opportunity for Public Hearing and Public Comment, 88 Fed. Reg. 88908 (December 26, 2023); Docket ID No. EPA–HQ–OAR–2023–0292

Submitted February 27, 2024

THE EV TRANSITION: KEY MARKET AND SUPPLY CHAIN ENABLERS

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November 2022

ATLAS PUBLIC POLICY
WASHINGTON, DC USA

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Acknowledgments

This report was supported by the Alliance for Automotive Innovation. Thanks to Emily Burlinghaus from the Atlantic Council, Danielle Woodring from SAFE, Peter Slowik from ICCT, and Jordan Brinn from NRDC for their careful edits and inputs. The findings and views in this publication are the sole responsibility of the authors.

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Introduction

The United States (U.S.) continues its march toward transportation electrification. Bloomberg analysts predicted that the U.S. had passed a pivotal tipping point in EV adoption, as more than five percent of new light-duty vehicle sales were electric in Q1 2022 and nearly seven percent in Q2 [1]. The analysis found that the U.S. was on track to follow the 18 other countries that have also crossed the five percent threshold, from early adopters into mainstream adoption. The analysts anticipated that a quarter of all light-duty vehicles sold by the end of 2025 could be electric.

Other signs also point to a transition that is growing momentum. Many manufacturing sites are being announced domestically, creating jobs and opportunities across the country. Utilities continue to invest in critical infrastructure to support EV charging, and government support is bolstering electrification efforts. The Infrastructure Investment and Jobs Act (IIJA), signed into law by President Biden in November 2021, set aside $7.5 billion for EV charging, including $5 billion for an EV charging formula grant program and a further $2.5 billion for fueling stations (including EV charging, hydrogen, and other alternative fuels). Then, in August 2022, Congress passed the Inflation Reduction Act (IRA), which included the largest climate spending ever appropriated by the Federal Government. These two packages will deliver considerable funding to support decarbonization efforts and grow economic development and jobs. States likewise are investing billions in vehicle incentives and charging to support light-duty, medium and heavy-duty vehicle electrification.

In addition, new regulatory frameworks, like California’s Advanced Clean Cars II (ACC II) regulations, will speed up the transition to EVs. The ACC II rule, adopted on August 25, 2022, will require that 35 percent of vehicle sales be EVs in 2025, ramping up to 68 percent in 2030 and 100 percent in 2035 (see Box 4). These requirements are expected to be adopted by other states and will put significant pressure on automakers, the adopting states, and the U.S. to progress innovative and effective policies to make the transition.

To decarbonize the transportation sector, uptake must continue to grow rapidly. As uptake grows, there will be new challenges and tailored solutions required to ensure the benefits of electrification accrue to all. Challenges include charging quality and availability, the affordability of EVs, equitable charging access, and supply chain issues. Supply chain constraints leave the U.S. dependent on high levels of imports for key critical minerals since domestic extraction of critical minerals is minimal and faces significant challenges. Likewise, domestic processing capabilities for those critical minerals are limited. These supply chain pressures may drive up prices and limit growth.

This report will focus on key market and policy developments and key supply chain enablers for light-duty electric vehicles. Although production depends on strong global cooperation, the focus of this report is on the U.S.

Data

Data used in this report is primarily derived from the Atlas EV Hub. The data source is noted when data are not derived from EV Hub.

EV Sales are sourced from light-duty passenger EV sales provided by IHS Markit (2019-present) and the former Alliance for Automobile Manufacturers (2011-2018). Aggregated EV sales data for all states are provided by vehicle make and model since 2019, including light-duty battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV). Sales data includes new vehicle sales only. Data included in this report are current as of the end of June 2022.

EV Charging tracks all deployed publicly available EV charging infrastructure and is sourced from U.S. Department of Energy's Alternative Fueling Station Locator. Atlas only counts individual ports that can be used simultaneously. These numbers are current as of the end of June 2022.

Electric Utility Investment tracks EV-related investments and is sourced from investor-owned electric utility dockets filed to state utility regulators. The investment data includes both EV programs proposed by utilities that await commission approval as well as investments approved or denied by commission orders. Data included in this report are current as of the end of June 2022.

Public Funding for EVs tracks federal and state government funding programs dedicated to transportation electrification, including funding allocated through the Volkswagen Settlement. Data included in this report are current as of the end of June 2022.

EV and EV Charging Manufacturing Employment and Investment measures the number of direct manufacturing jobs and investment supported by light, medium and heavy-duty EV, and EV battery production as well as EV charging. This figure is tied to specific facilities and is typically reported directly in press releases. Data included in this report are current as of the end of June 2022.

Critical Mineral, Battery Recycling and Processing Facilities tracks critical mineral extraction and processing sites, as well as battery recycling facilities. The data is sourced from the USGS Mineral Commodity Summaries 2022, National Renewable Energy Laboratory's Lithium-Ion Battery Supply Chain Database and User Guide report, reporting and press releases. The summaries only include those facilities (either announced or operational) based in the United States, with a proposed location and company lead announced. The data is limited, and for many of the projects, key details are not readily available. Another challenge in the data is connecting the materials to the production of electric vehicles. We have endeavored to only include facilities where there is the potential for those materials to be used in EVs, though due to limited information that remains a challenge. Data are through the end of August 2022, however Processing Facilities data was updated in November 2022 after a significant announcement of funding allocated by the Department of Energy.

Market Summary

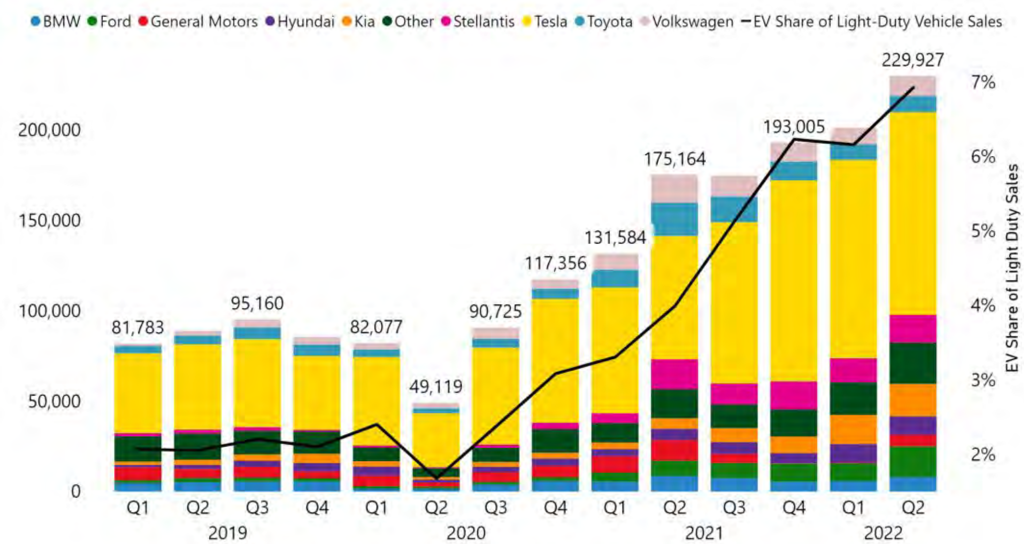
Electric Vehicle Sales

EV Sales

The EV market continues to grow in the U.S. As of June 30, 2022, there have been more than 2.9 million cumulative EV sales in the United States (including Battery Electric Vehicles (BEVs), Plug-in Hybrid Electric Vehicles (PHEVs) and fuel cell electric vehicles (FCEVs). The second quarter of 2022 saw a record 230,000 EVs sold, 14 percent more than the record. In Q2 (Figure 1), EVs made up seven percent of the light-duty market. This is a more than 70 percent growth in market share year over year from Q2 2021 (four percent).

The market and competition have shifted considerably over the past few years. There was a critical inflection point in 2018 with the release of the Tesla Model 3. Through the end of June 2022, PHEVs make up a third of all EV sales though, in the first half of 2022, PHEVs made up just 22 percent of EV sales. If the trend in Figure 2 continues, that proportion will continue to shrink. In Q2 2022, of the top 10 EV models by sales, only one was a PHEV.

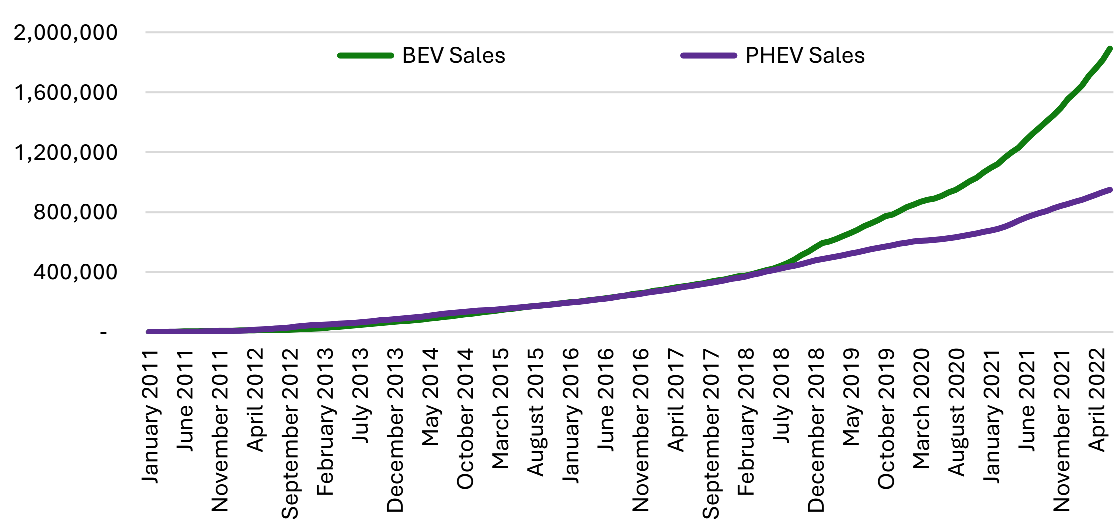
Figure 1: U.S. EV Sales and Market Share from Q1 2019 through Q2 2022



This data captures sales of plug-in hybrid electric vehicles (PHEVs), battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs) by parent company[1]. Hyundai and Kia were split into two companies for the purpose of this report.

Source: Atlas EV Hub.

Figure 2: Cumulative New EV Sales by Technology from 2011 through June 2022



Cumulative new light-duty vehicle sales by technology.

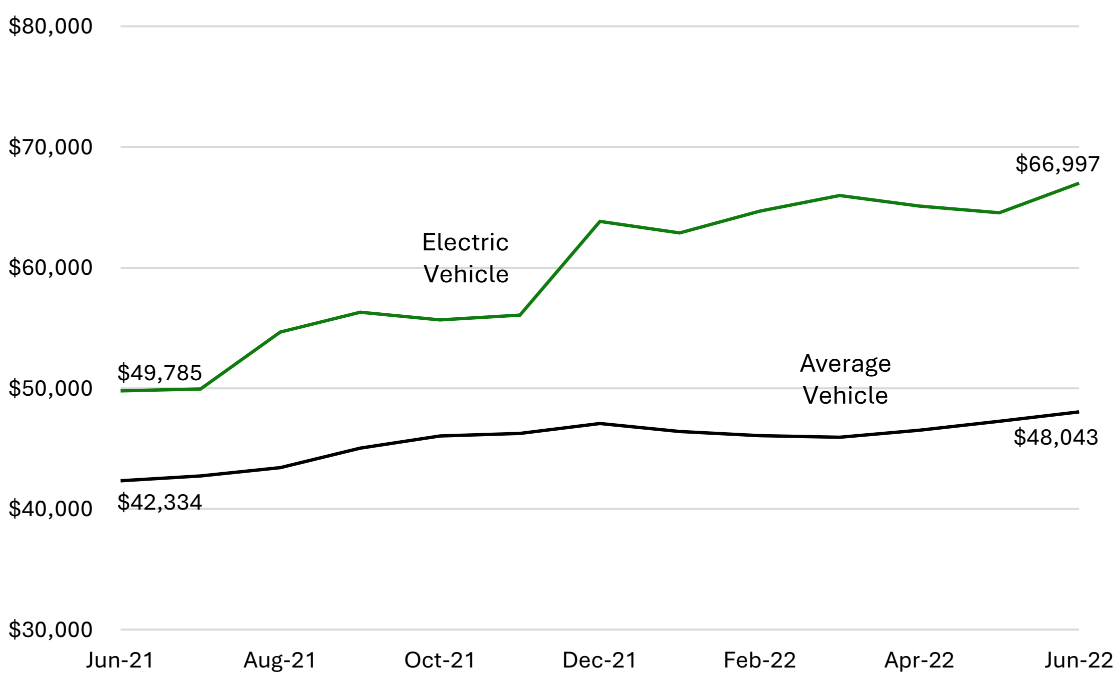
Source: Atlas EV Hub.

[1] Note that this captures national sales data and there is considerable interregional variation in EV uptake across the United States.

Electric Vehicle Costs

Electric Vehicles cost more than internal combustion engine vehicles to buy. Using Kelley Blue Book data in Figure 3, the price gap has opened further over the past 12 months, even as both EVs and internal combustion engine vehicles have experienced increased purchase costs. These average transaction prices do not necessarily account for possible federal or state rebates. Moreover, fuel costs for EVs are typically much lower than gasoline vehicles (particularly for EV drivers with access to home charging). Likewise, maintenance costs for EVs are expected to be lower than gasoline vehicles. These cost savings substantially lower the total cost of ownership over the life of an EV [2].

Figure 3: Electric Vehicle Average Price and the Market Average for New Vehicles



The average vehicle price takes the average for the market from June 2021 through June 2022.

Source: [3]

Hydrogen Vehicles

Hydrogen fuel cell electric vehicles (FCEV) draw on an alternative zero-emission drive technology to battery electric vehicles. Like plug-in EVs, they use an electric motor for propulsion. FCEVs generate electricity using a fuel cell stack that combines hydrogen from onboard containers with oxygen from the air for energy [4]. The only byproduct of this reaction is pure water. FCEVs require only about five minutes to refuel, and the range exceeds 325 miles for the three light-duty hydrogen vehicles available for lease or purchase in the United States: the Honda Clarity, the Toyota Mirai, and the Hyundai Nexo. From Q1 2019 through Q2 2022, 7,124 FCEVs were sold in the United States. As of August 2022, there were just 54 public hydrogen fueling stations around the country (53 of which were in California) [5] [6].

Box 1. California's Clean Car Programs: Clean Vehicle Assistance Program and Clean Cars 4 All

First launched in June 2018, the Clean Vehicle Assistance Program (CVAP) offers grants for income-qualified Californians to help purchase or lease a new or used hybrid or battery EV. CVAP addresses the barriers to clean vehicle ownership, such as the high upfront costs, limited access to charging infrastructure, and predatory auto loans, by providing approved applicants with a clean vehicle grant, a charging station grant, and a fair loan option that is capped at an eight percent interest rate. The issued grants do not need to be repaid. CVAP's grants support the purchase or lease of both new and used battery electric vehicles (BEV) and plug-in hybrid vehicles (PHEV). For BEVs and PHEVs, a purchase grant of up to $5,000 and a charging grant up of to $2,000 are available depending on the applicant's income [7]. For an individual applicant, the maximum qualifying income is $51,520 [8]. As of May 2022, the program has disbursed approximately $22 million in grant funding to support 4,330 vehicles including 860 grants to residents of disadvantaged communities.

The Clean Cars 4 All (CC4A) Program enables low-income drivers to upgrade to cleaner vehicles [9]. Vehicle owners living in designated zip codes with high levels of pollution who meet income and vehicle requirements are eligible. The vehicles are then traded in for more efficient, lower polluting alternatives. CC4A has awarded $127 million including 11,338 grants as of November 30, 2021. Of funds implemented, 97 percent has benefited "priority populations" per the California Climate Investments 2022 Annual Report released [10]. CC4A participants can receive up to $9,500 in grant funding toward the purchase of a new or used EV. Alternatively, participants can choose up to $7,500 in incentives to access other mobility options, such as public transit passes or electric bicycles.

EV Models

The number and variety of EV models have increased dramatically this decade as major automakers have committed to the electrification of bestselling models. Through the end of June 2022, automakers have brought 83 models to market, a 41 percent increase in EV model availability from January 2020. From sedans to SUVs and even pickup trucks, the options for light-duty vehicles are proliferating as automakers vie for EV market share in new consumer segments. Tesla remains the dominant player with 53 percent of the total EV market in the 12 months from July 2021 through June 2022.

In 2022, alongside Tesla's continued dominance, there have been other key market developments. For instance, Kia is the only other company with more than one model in the top 10 for Q2 2022. Likewise, General Motors reemerged in the top 10 for EV models in Q2 2022 after a recall of the Chevrolet Bolt. In April, Ford's F-150 Lightning went into full production after receiving 200,000 preorders [11]. The first vehicles were delivered in May 2022 [12]. Emergent automakers Rivian and Lucid continue their introduction.

Box 2. Charge Ahead (Oregon)

Oregon's Charge Ahead program provides income-qualified buyers rebates of up to $5,000 towards purchasing a used or new EV (increased from $2,500 in January 2022). The rebate stacks with Oregon's standard EV rebate when applied to new EVs, for a combined maximum of $7,500, one of the largest state incentives in the country [13]. From the program's inception in 2018 to June 10, 2022, 2,439 participants have claimed $9.9 million in Charge Ahead and Standard funding [14]. Thirty-six percent of those participants bought used vehicles – one of a select few such programs around the country in which used vehicles are eligible [13]. On average, applicants received $4,934 for the combined rebates and $2,552 for the Charge Ahead only rebates. Charge Ahead requires that recipients buy a vehicle through a dealer, register that vehicle in Oregon, and own the vehicle for at least 24 months. The standard rebate program offers $2,500 to anyone who purchases a new battery EV or plug-in hybrid for under $50,000. Income qualifications for the Charge Ahead rebate changed from 120 percent of area median income to 400 percent of the federal poverty guideline in January 2022. The Charge Ahead rebate can only be claimed after purchase. As a result, participation is potentially more challenging for low-income participants that must produce more money upfront or secure additional financing to purchase a vehicle.

EV Charging

EV Charging Needs

To accommodate the fast-growing EV market, the United States needs to continue to build out public EV charging. The Biden Administration has often referenced a target of 500,000 EV chargers. Analysis by Lucy McKenzie and Nick Nigro from Atlas Public Policy likewise found that 495,000 charging ports for light-duty vehicles[2] are needed by 2030, assuming a trajectory towards 100 percent EV sales from 2035 onward. This analysis assumed 21 percent of vehicles on the road in 2030 will be EVs and 81 percent of all new light-duty vehicle sales will be electric in 2030 [15].

McKenzie and Nigro found that $87 billion in charging infrastructure investments is needed over the next decade to achieve 100 percent passenger EV sales and carve out the path for full-scale electrification. Of that funding, $39 billion is needed for publicly accessible charging. Public charging infrastructure investments are often less attractive, mostly because the direct revenue from these services may not cover installation and operation costs. The analysis anticipated a further $22 billion in single-family home charging and $17 billion in multi-unit home charging is needed. As it stands, the current pace of investments for EV charging falls short of the $87 billion needed over the next decade to achieve complete EV sales by 2035 (further investment will be needed after that time to support EVs). Additionally, McKenzie and Nigro found that larger investments upfront can result in significant savings. Installing six to 10 fast charging ports at each site ($38.8 billion) instead of just two ($47.4 billion) will save $8.6 billion in installation costs. The authors also found savings by installing 350kW DCFC ports ($38.8 billion) rather than 150kW ports ($51.8 billion) [15].

A McKinsey and Company analysis from April 2022 found if half of all new vehicle sales in 2030 were electric, there would be a need for 1.2 million public chargers at a cost of $35 billion (this estimate does not include grid and site electrical upgrades) [16]. The estimate is in addition to workplace, depot, and home charging (the latter of which makes up most of the charging). A more conservative estimate from 2017 by the National Renewable Energy Laboratory (NREL) assumed EV uptake would be 20 percent of light-duty vehicle sales by 2030. As a result, NREL assumed there would be a need for 600,000 Level 2 chargers and 25,000 DCFCs by 2030 [17]. Across each of these three studies, from the more conservative uptake estimates to more optimistic estimates, there is a significant need for rapid growth in EV charging installation.

[2] Note that the analysis does not consider fuel cell electric vehicles and the DCFCs in the modeling are 350kW.

Charging Deployed

There are 137,907 EV charging ports installed throughout the country, including 111,940 Level 2 chargers and 25,967 DCFC chargers as of June 30, 2022 (of those, there were nearly 26,000 Tesla proprietary chargers). This is a growth in chargers of 27 percent over the past 12 months. The total includes both public chargers and semi-private chargers that are publicly available – for instance, at a hotel. It is important to note that tracking charging installations is imprecise and that it does not include residential chargers (except some at Multi-Unit Dwellings).

Through funds allocated in the Infrastructure Investment and Jobs Act, the public EV charging network will receive a significant boost primarily from the National Electric Vehicle Infrastructure (NEVI) funding program. NEVI allocated $5 billion to states to build out a national EV charging network. The network must be built on Alternative Fuel Corridors (AFC). For NEVI, the federal government's $5 billion will cover 80 percent of the cost, requiring states or others working with states to contribute at least 20 percent of the cost. There is also a $2.5 billion discretionary grant program for EV and other alternative fueling. This funding, split between the Corridor Charging Grant Program and the Community Charging Grant Program, requires consideration of locations for underserved or low-income communities, and is available for all alternative fuels, not just electric charging infrastructure.

Table 1: Summary of EV Charging Available

Total Charge Ports	Level 2 Chargers	DCFC Chargers	Change Since July 1, 2021
137,907	111,940	25,967	27%

Total charging ports by type as of June 30, 2022.

Source: Atlas EV Hub.

In addition to boosting the supply of public charging, the NEVI Program has the potential to establish strong national standards. In June 2022, the Federal Highway Administration released proposed minimum standards including that each NEVI funded station must:

- Use Combined Charging System (CCS) plugs
- Provide a minimum of four DCFC ports per station, every 50 miles
- All ports must be able to deliver at least 150 kW simultaneously (minimum of 600 kW per station)

- Ensure annual uptime (the amount of time that the charger is working) requirements of 97 percent
- Ensure that it is easy to use credit and debit cards (as opposed to stations where membership payment is easy but payment with a credit card is cumbersome)

This reflects a broader standardization of charging ports and a move towards CCS ports and away from CHAdeMO. The only BEV that uses the CHAdeMO is the Nissan LEAF, and Nissan's upcoming Ariya model will have CCS [18]. Electrify America has indicated it will phase out CHAdeMO from 2022 onwards. Meanwhile, Tesla has indicated that it will open its Supercharger network of chargers to non-Tesla owners in 2022 [19]. Non-Tesla vehicles will still need an adapter to access the nearly 26,000 Tesla chargers across the nation.

Charger reliability is critical to support mass adoption of EVs. Drivers must have confidence that chargers will be available and operable when they arrive to charge. Reliability has long been a pain point for the charging industry. In a March 2022 study, *Reliability of Open Public Electric Vehicle Direct Current Fast Chargers*, Rempel et al. found that only 72.5 percent of the 657 DCFC CCS chargers tested in San Francisco were functional [20]. In 4.9 percent of cases, the cable was not long enough, and in the remaining 22.7 percent of cases, the charger did not work due to "unresponsive or unavailable screens, payment system failures, charge initiation failures, network failures, or broken connectors" [20]. If drivers are experiencing charging issues with more than a quarter of public chargers, there may be impacts on rates of adoption for EVs. Nevertheless, it is encouraging that the NEVI program is centering reliability as a core performance indicator for building out the next phase of chargers.

Finally, to ensure equity, it is crucial that public chargers are both affordable and available for low to moderate income Americans who are more likely to rent or live in a multifamily building where home charging access may be limited or nonexistent. Public charger dependence can increase fueling costs as costs-per-kWh are higher at those chargers than residential electricity rates. These chargers may also be inconvenient if the individual must wait with the vehicle as it charges. Moreover, public charging station investment has historically lagged in low to moderate income communities, creating *charging deserts* where residents must travel long distances to access public charging stations. This challenge may be even more pronounced in rural communities where drivers commute significant distances, providing a higher level of reliance on both home charging access (if installed) as well as access to public charging stations. Some of this need may be served by the $2.5 billion discretionary grant program for EV and other alternative fueling in the IIJA. This funding, split between the Corridor Charging Grant Program and the Community Charging Grant Program, requires consideration of locations for underserved or low-income communities.

Box 3. New Federal Funding for EVs

The Infrastructure Investment and Jobs Act provides funding for light-duty EVs including:

- **EV Charging**: Funding to states to "strategically" deploy EV charging, maintenance for the infrastructure and "establish an interconnected network to facilitate data collection, access and reliability". Includes $5 billion in formula funding and a further $2.5 billion in discretionary grants.
- **Battery processing and manufacturing:** Funding of $6.1 billion to support battery material processing grants and battery manufacturing and recycling grants.
- **Critical Minerals Mining and Recycling Research:** Grants worth $400 million to support supply chain resiliency that support basic research that will accelerate innovation to advance critical minerals mining, recycling, and reclamation strategies and technologies.

The Inflation Reduction Act also provides significant support for light-duty EVs including:

- **EV Tax Credit:** While it removes the 200,000-vehicle manufacturer cap, the amended $7,500 tax credit introduces new battery and critical mineral sourcing requirements and immediate application of requirements for North American assembly. In the short term, it is likely that only a number of vehicles will be eligible for the tax credit due to sourcing requirements. There are also eligibility requirements including income limits and a Manufacturer Suggested Retail Price (MSRP) cap. Finally, the credit will be available at point of purchase from 2024.
- **Used vehicle tax credit:** Starting in 2023, households earning below $150,000 ($75,000 for individuals) will now be eligible for a $4,000 or 30 percent point-of-sale credit, whichever is less. To qualify, the vehicle must be purchased from a dealer and cost less than $25,000.
- **Tax Credit for Commercial EVs:** New credit for clean commercial vehicles capped at $7,500 and $40,000, respectively.

- **Alternative Vehicle Refueling Property Credit:** Reinstates the expired credit. The funding provides up to a 30 percent tax credit for qualified stations up to $100,000.
- **Production tax credit:** This advanced manufacturing production credit provides differing amounts of support based on the component but includes qualifying battery components and any applicable critical mineral.
- **Investment Tax Credit:** Supports a "qualifying advanced energy project" which may include manufacturing that help reduce GHG emissions and projects that support electric and hybrid vehicles.
- **United States Postal Service Clean Fleets:** Provides $1.29 billion for the Postal Service to purchase electric delivery vehicles, and $1.71 billion to purchase and install charging infrastructure.

Utility Investment

Investor-Owned Utilities (IOUs) have been an important source of investment in transportation electrification. Through the end of June 2022, utility regulators have approved $3.6 billion in rate payer funded IOU transportation electrification investments. These funds could support more than 7,800 DC fast charging (DCFC) stations and more than 304,000 Level 2 charging stations. Note that this is the count of chargers approved, not a count of chargers that have been built. In addition, a number of utilities offer a wide range of consumer incentives for EVs, including purchase incentives and charging incentives.

The scale of investment by utilities is considerable. For comparison, Electrify America is the largest DCFC charging network provider in the country (aside from Tesla's proprietary network) and has installed more than 3,400 DCFC stations since 2017, less than half the number that could be supported by approved investor-owned utility programs. California leads all states with approved investment of $1.55 billion. California IOUs have proposed a further $1.8 billion in spending that has not yet been approved by regulators. New York State has approved $712 million in funding for transportation electrification. Utilities in Florida ($278 million) and New Jersey ($266 million) have also committed significant funding to support transportation electrification. These four states make up nearly 80 percent of all approved IOU EV funding around the country.

Table 2: Investor-Owned Utility EV Investments from 2012 through June 2022

Status	States	Filings	Utilities	Investment	DCFC Stations	Level 2 Stations
Approved	34	138	55	$3,552,187,517	7,839	304,428
Pending	25	61	36	$2,040,621,863	3,716	158,428
Denied/ Withdrawn	22	47	28	$718,953,126	854	90,543

Summary of Investor-Owned Utility Investment in EVs by funding status (approved, pending, or denied).

Source: Atlas EV Hub.

Utilities are uniquely positioned to assist in the development of charging infrastructure for underserved communities. Of approved funding, $994 million has been committed to underserved communities (28 percent of total funding).[3] A recent report from Atlas Public Policy notes that in the second half of 2021, all approved utility filings included an equity provision for underserved communities [21]. Utility equity investments have included provisions such as budget carve outs, offering higher rebates (predominantly for EV charging) for income-qualified customers, creating targeted education and outreach programs, or including equity considerations in selection criteria for choosing charging sites.

There was a further $2 billion in pending investments awaiting decisions from public utility commissions as of June 30, 2022. A large portion of these filings will likely be approved given that the approval rate for utility proposals is over 80 percent.[4] Finally, nearly $719 million has either been denied by commissions or withdrawn by the utility.

Municipal utilities and federally owned utilities have also made efforts to invest in transportation electrification not captured here. Data on investment totals from those utilities is more difficult to access but these utilities continue to make commitments to transportation electrification. For instance, the Tennessee Valley Authority (TVA) is the largest federally owned power company in the country and covers Tennessee, and parts of Alabama, Mississippi, Kentucky, Virginia, North Carolina, and Georgia [22]. TVA announced in August 2021 plans to electrify the entirety of its passenger vehicle fleet and half of its pickup and light cargo truck fleet by 2030, a total of 1,200 vehicles [23]. The TVA also joined

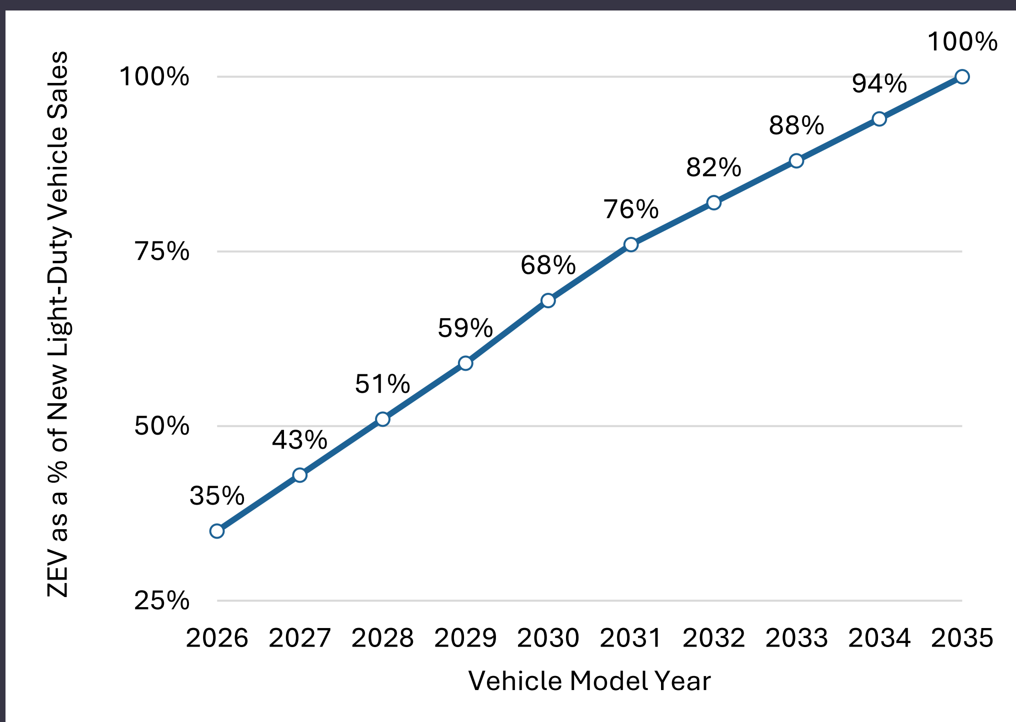
[3] Equity is defined by the utility and approved by the utility commissions. Utilities and/ or commissions define and measure equity differently.

[4] The approval rate [1] to the number of elements considered rather than the amount.

a collaboration of utilities called the National Electric Highway Coalition (NEHC), announced in December 2021. The NEHC includes more than 60 electric companies and cooperatives serving more than 120 million customers across the country. The NEHC is committed to ensuring that customers can drive “with confidence” along major corridors by 2023, knowing that there will be fast charging ports to access.

Box 4. Advanced Clean Cars II

Figure 4: New Vehicle Sales Requirements in Advanced Clean Cars II 2026-2035



Advanced Clean Cars II proposed rules through Model Year 2035.

Source: [24]

Advanced Clean Cars II (ACC II) was approved in August 2022. The Program will require all new vehicles sold in California after 2035 to be ZEVs, including PHEVs, BEVs, and FCEVs. ACC II specifies that up to 20 percent of ZEV credits can be generated by selling long-range plug-in hybrid EVs (minimum of 50 miles range by 2030), with the other 80 percent of credits generated by BEV and FCEV purchases [24].

The ACC II Standardized Regulatory Impact Assessment (SRIA) notes a suite of benefits for environmental justice communities including credits for “community car share programs, producing affordable ZEVs, and keeping used vehicles in California to support CARB’s complementary equity incentive programs” [24]. It also notes that the program will deliver more than $81 billion in net cost savings from 2026 to 2040 due to lower total costs of ownership and considerable health benefits from improved air quality. There will also be significant greenhouse gas emissions reductions as captured in analysis from the Environmental Defense Fund [25]. However, CARB staff estimates that these benefits will come at a cost of $30.2 billion to businesses and will result in a net job loss of 39,800 jobs by 2040 [24]. Section 177 of the Clean Air Act allows other states to adopt California’s standards in lieu of federal standards. To date, 15 other states have adopted the ZEV Program under ACC I, the first iteration of the ACC rules, for model years up to 2025 [26]. While it is unclear at this time how many of those states would adopt California’s new rules, the states of New York, Washington, Oregon, Massachusetts, and Vermont have indicated they will adopt ACC II.

State Policies

States are continuing initiatives to drive EV adoption including EV purchase incentives and zero-emission vehicle (ZEV) regulations per Advanced Clean Cars (ACC) rule. Across the country, 14 states had an EV rebate in place to incentivize is the purchase of EVs at the end of June 2022. These rebates range from the CHEAPR program in Connecticut (a buyer may access up to $2,250 in rebates for the purchase of an EV with an MSRP of less than $50,000 or up to $4,250 for low-income residents) to the newly implemented Electric Vehicle Rebate Program in Illinois. From July 1, 2022, Illinois residents are eligible for a $4,000 rebate for a battery EV with a priority for low-income applicants.

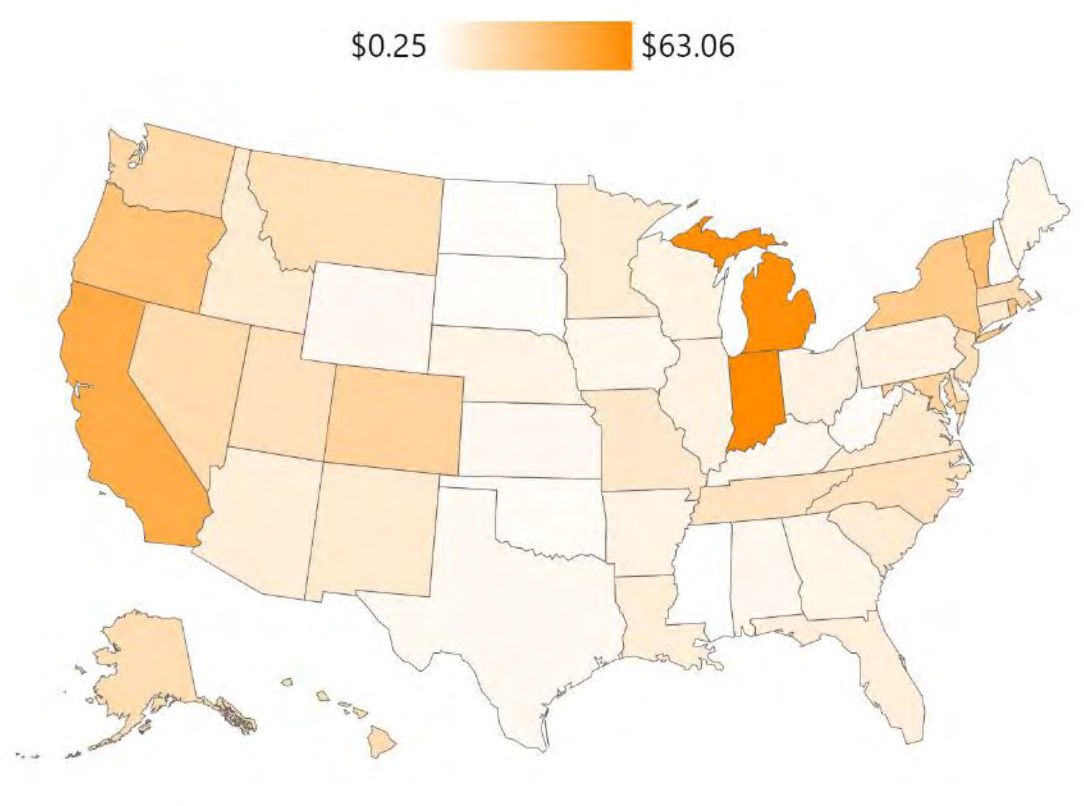
The most prominent state-led policy to date is the ZEV regulation (part of California’s ACC regulations). The ZEV regulation requires automakers to sell an increasing percentage of zero emission vehicles within markets that have adopted the regulation. The current regulation targets seven to 10 percent of new vehicle sales by 2025. California just approved the ZEV program for model years 2026 through 2035 through the ACC II standards (featured above). As of July 2022, ZEV states include California, Colorado, Connecticut, Massachusetts, Maryland, Maine, Minnesota, Nevada, New Jersey, New Mexico, New York, Oregon, Rhode Island, Virginia, Vermont, and Washington state.

Together these states constitute 35.9 percent of all light-duty vehicle sales in the country [26].

As well as supportive policies, states have also implemented policies that may hinder EV adoption. Around the country, 31 states have some form of annual fee for EVs over and above registration fees, applied as an alternative to gas taxes for internal combustion engines that help fund roadways. The highest in the country is Washington with a fee of $225, then Georgia which has a $213.70 annual fee for EVs. The annual fee is at least $200 in five other states: Ohio, West Virginia, Wyoming, Arkansas, and Alabama. In most states, there is a lower fee for plug-in hybrid vehicles.

Public Funding

Figure 5: Public Funding for Light-Duty EVs and Charging per Person by State



On a per person basis, Indiana, Michigan, and Washington DC lead all states in public funding for light duty EVs followed by California, Vermont, and Oregon. This funding may come from either federal or state government and does not include loans or the recent NEVI formula funding.

Source: Atlas EV Hub.

Public funding for EVs continues to grow. Through the end of June 2022, public funding for light-duty transportation electrification and charging equipment from both state and federal programs (including VW Settlement funding) was $1.4 billion. On a per capita basis, Indiana, Michigan, and Washington DC led all states in public funding for transportation electrification. Key sources of public funding to date include the American Recovery and Reinvestment Act of 2009, and the Federal Transit Administration's Low- or No- Emission (Low-No) and Buses and Bus Facilities grant programs and the Volkswagen (VW) Settlement.

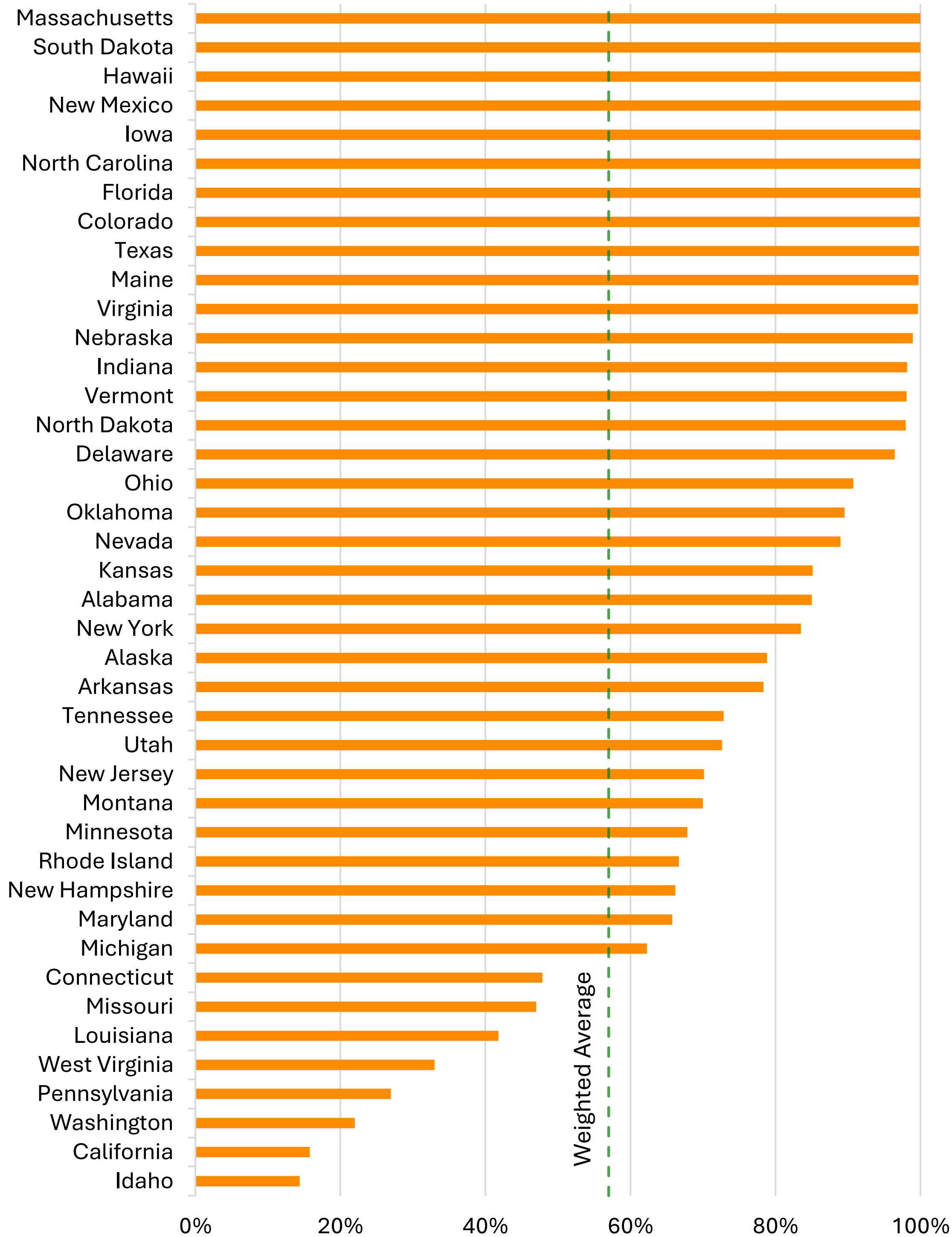
The NEVI Program will bolster funding for states. The $5 billion in formula funding will support key charging infrastructure. States may compete for the $2.5 billion available in discretionary funding for hydrogen fueling, or community and corridor charging. There is also other funding in the Infrastructure Investment and Jobs Act that will go to EV charging and transportation electrification including the $6.4 billion in formula funding for states and localities through the Carbon Reduction Program (CRP).

VW Settlement Funding for EV Charging

The 2017 Volkswagen Settlement allocated $2.8 billion to states to make grants to reduce diesel emissions. The Settlement allows states to use up to 15 percent of their allocation for light-duty EV charging. Based on plans submitted to the trust, states intend to allocate $318 million to charging, representing 75 percent of the $423 million allowable.

As of the end of June 2022, states have awarded or made available $239 million for EV charging, representing 75 percent of the planned amount. Eleven states have already awarded their full 15 percent while eight states (Arizona, Illinois, Kentucky, Georgia, Wisconsin, South Carolina, Oregon, and Wyoming) and Washington DC have not yet made any awards for EV charging.

Figure 6: Percent of Allowable EV Charging Spent per the VW Settlement by State



Arizona, Illinois, DC, Kentucky, Georgia, Wisconsin, South Carolina, Oregon, and Wyoming have not awarded any VW Settlement funds to light-duty EV charging deployment as of June 30, 2022.

Source: Atlas EV Hub.

Supply Chain

EV Manufacturing

Table 3: The Top 15 Largest Announced EV Manufacturing Facilities (by Investment)

Parent Company	State	Vehicles Produced	EV Investment	EV Employees
Hyundai	GA	Multiple Classes, Batteries	$5,540,000,000[5]	8,100
Ford	KY	Batteries	$5,800,000,000	5,000
Ford	TN	Light-Duty (Class 1-2)	$5,600,000,000	6,000
Rivian	GA	Light-Duty (Class 1-2)	$5,000,000,000	7,500
Tesla	NV	Light-Duty (Class 1-2)	$4,500,000,000	7,000
Tesla	CA	Light-Duty (Class 1-2)	$4,100,000,000	10,000
General Motors	MI	Light-Duty (Class 1-2)	$4,000,000,000	2,350
Statevolt	CA	Batteries	$4,000,000,000	2,500
SK Innovation	GA	Batteries	$2,610,000,000	2,600
General Motors	MI	Batteries	$2,600,000,000	1,700
Stellantis	IN	Batteries	$2,500,000,000	1,400
General Motors	OH	Multiple Classes	$2,300,000,000	1,100
General Motors	TN	Batteries	$2,300,000,000	1,300
General Motors	MI	Light-Duty (Class 1-2)	$2,200,000,000	2,200
VinFast	NC	Multiple Classes	$2,000,000,000	7,000

Summary of the top 15 announced EV manufacturing facilities. All facilities were announced on or before June 30, 2022. The jobs are announced jobs.

Source: Atlas EV Hub.

[5] An additional $1 billion was invested by Hyundai suppliers, which is counted separately.

The Department of Energy estimates the U.S. was home to eight percent of global EV lithium-ion cell manufacturing in 2020 with 59 GWh [27]. Since then, automakers have increased their commitments to support domestic EV manufacturing. In the first six months of 2022, 35 percent of all battery manufacturing jobs to date in the United States were announced and four of the top five largest facilities in the U.S. were announced in the past 12 months. Through the end of June 2022, automakers announced more than 115,000 jobs and $82.1 billion in investment for EV manufacturing in the United States.

In September 2021, Ford and battery manufacturer SK Innovation together announced plans to invest $11 billion to build batteries and assemble EVs in Kentucky and Tennessee. According to Ford, this project will create 11,000 jobs between the two states and would be the largest private investment in Kentucky's history [28]. The investment will fund the production of the F-150 Lightning, the electric version of the top-selling vehicle in the country. As part of the announcement, Ford also announced a plan to collaborate with Redwood Materials on a closed-loop battery recycling system.

In December 2021, Toyota invested $1.2 billion in a new North Carolina battery production facility that will come online in 2025. The facility will create as many as 1,750 jobs and will be able to deliver enough lithium-ion batteries for up to 1.2 million EVs per year. In addition, in December 2021, Rivian announced a $5 billion investment in the company's second vehicle assembly plant outside of Atlanta, Georgia, that it says will eventually create 7,500 jobs. The Governor of Georgia lauded the initiative as the largest economic development project in the state's history. A few months later, Hyundai set a new record with the announcement of a facility to support 8,100 jobs in the state to build batteries and assemble EVs. Other key components of the supply chain for EVs – including Electric Motors (AC) and inverters – must be scaled up to meet surging demand for EVs.

Charging Manufacturing

The Biden Administration has a target of 500,000 charging stations in the U.S. by 2030 [29]. It is not clear how many of those charging stations will be produced domestically. Table 4 summarizes the manufacturing facilities that produce either DCFC and/or Level 2 charging stations. These manufacturers produce charging stations both for public and private use and ensure the U.S. has domestic manufacturing capabilities for EV charging equipment.

Table 4: Charging Manufacturing Facilities in the U.S. (Announced or Operational)

Site Name	State	Company	Year Operational	Charging Unit Production (Annual)	Type of charger
Innovation Park Facility	IL	EVBox	Operational	10,400	DCFC
Wendell Facility	NC	Siemens	Operational	NA	DCFC
Auburn Facility	CA	ClipperCreek	Operational	10,000	Level 2
Gigafactory 2	NY	Tesla	Operational	NA	DCFC
SemaConnect Manufacturing Facility	MD	SemaConnect	Operational	50,000	DCFC, Level 2
Auburn Hills Plant	MI	FLO	2022	50,000	DCFC, Level 2
Tarrant Facility	TX	Wallbox	2022	500,000	DCFC, Level 2
Lebanon Facility	TN	Tritium Charging	2022	30,000	DCFC
FreeWire Manufacturing Facility	CA	FreeWire Technologies	2022	NA	DCFC
Milpitas Facility	CA	ChargePoint	2026	20,000	DCFC, Level 2
Pomona eMobility Hub	CA	Siemens	NA	NA	Level 2
Grand Prairie eMobility Hub	TX	Siemens	NA	NA	Level 2

This data includes all EV charging supply equipment production factories that we were able to identify and verify through some means. NA means that the data is not available. Data source: Blue Green Alliance Foundation and press releases.

Source: [30]

Box 5. BlueLA (California)

In 2015, Los Angeles was awarded a grant from the California Air Resources Board to pilot an electric car sharing service in low-income communities. Blink Mobility now operates the service, BlueLA, in partnership with the City of Los Angeles and the Los Angeles Department of Transportation [31]. Through BlueLA, shared vehicles can be picked up and dropped off at 40 designated stations around Los Angeles, each with five charging ports. BlueLA features low monthly membership costs in addition to a lower per minute charge for rentals (25 percent off the general rental fee). Through July 2020, users had traveled more than 63,000 trips and more than 1.3 million miles. Blink estimates that the average trip length is six miles [32]. Of those trips, fifty-five percent were rides made by low-income users. Due to high utilization rates, the Los Angeles City Council voted to approve an expansion of the service. Blink Mobility plans to increase the fleet from 300 to 500 vehicles and add 300 more charging stations [32].

Batteries

Background

Nearly all EVs use lithium-ion batteries [27]. These batteries include an anode (mostly graphite) and a cathode (multiple materials, dependent on the battery chemistry). Lithium ions travel between the anode and cathode through an electrolyte [33]. The three primary battery types are nickel manganese cobalt (NMC), nickel cobalt aluminum (NCA), and lithium ferro phosphate (LFP) (also known as Lithium Iron Phosphate or LiFePo). These battery types are all named for the main components of their cathodes.

Battery capacity needed to meet new vehicle sales

The range of EVs has improved significantly in the past decade as battery prices have plummeted and energy density has improved. Only 12 years ago, the first mass-market EV hit the roads: the Nissan LEAF. The LEAF was a definitive city-commuter with a 73-mile Environmental Protection Agency (EPA) rated range [34]. Most EVs in 2022 have triple the range of a 2011 Nissan LEAF. For instance, the Ford Mustang Mach-E, one of the best-selling EVs in 2021, can travel 270 miles on a single charge [35]. Some EVs can go even further. The Dream Edition of the Lucid Air – among the most expensive EVs on the market – received a remarkable EPA rating of 520 miles [36]. To allow for this significant improvement in range, the average capacity of battery packs has increased dramatically. A

2011 LEAF sported a 22-kWh battery pack [37]. A 2021 Lucid Air Dream Edition can store 118 kWh – over five times that much energy [38].

As EVs increase in both average range and popularity, battery demand is set to skyrocket. The Argonne National Laboratory outlined the potential scenarios in a March 2021 report. The authors, aggregating existing projections, anticipate global battery demand could reach anywhere from 600 GWh to nearly 2,500 GWh in 2030 (including light-duty and medium and heavy-duty vehicles) depending on assumptions about policy and other parameters [39]. At the upper range, analysts from Argonne National Laboratory and Leiden University assumed that EVs (BEVs and PHEVs) would constitute 30 percent of all light-duty sales by 2030.

More recently, the IEA Global EV Outlook 2021 projected that global battery demand will exceed 1,600 GWh a year in 2030 under a scenario in which no new beneficial policies are introduced [40]. However if more sustainability-oriented policies are implemented, demand may reach 3,200 GWh, demonstrating the significant potential range in future demand based on markets and policy settings. For context, global production was only 160 GWh in 2020 [40]. In the United States, President Biden set a target in December 2021, that half of all new light-duty vehicle sales will be electric by 2030 [41]. Meeting that goal is made more challenging with geopolitical turmoil and will require significant growth in the extraction of critical minerals, significant battery production and that those new facilities quickly bring batteries to market at an affordable price.

Battery cost per kWh estimates

The cost of lithium-ion batteries has plummeted over the past decade. Between 2010 and 2020, the price per kWh fell from $1,100 to $137 [42]. Considering most new EVs now house batteries 60 kWh or larger, every percentage drop is critical to achieving sticker-price parity with internal combustion engine (ICE) vehicles.

Estimates for the future price of batteries, even from the most credible sources, have been imperfect. Many experts historically underestimated the impact that economies of scale and efficiency gains would have on cell costs. Looking ahead, it is important to treat price projections with caution as many variables determine future costs and supply chain challenges have the potential to slow or reverse price drops. However, estimates still provide insight into price direction and economic patterns for the battery market.

As further explained in the Battery Composition section, the cost per kWh of lithium-ion batteries varies across different chemistries. According to Bloomberg New Energy Finance (BNEF), lithium ferro phosphate (LFP) battery prices were nearly 30 percent cheaper than nickel cobalt manganese (NCM) variants in 2021 [42].

Supply chain slowdowns and rising input costs are affecting all battery chemistries. As a result, the average cost per kWh may not fall below $100 until 2024 [2]. In 2021, battery packs experienced a modest 6 percent drop from the year prior – far from the 35 percent plummet between 2014 and 2015. Looking forward, in March 2021, the National Academies of Sciences (NAS) estimated that costs would drop further to $65-$80 kWh in 2030 [24]. In addition to the rising cost of raw materials, demand from adjacent industries including stationary batteries could put pressure on battery prices. BNEF estimates that worldwide battery energy storage system deployment will demand as much as 1,028 GWh by 2030 (up from 17 to 34 GWh in 2020) [43].

Battery Composition

Several different varieties of lithium-ion batteries power modern EVs, each with its own composition. While all modern EV batteries contain lithium, the quantity of lithium and other critical minerals varies by battery chemistry [33]. In 2020, NMC batteries represented the lion's share of the market – present in 72 percent of all EVs produced that year (globally excluding China) [44]. The most common variations of NMC batteries are NMC811, NMC523, and NMC622 [44]. The numeric suffixes of these batteries represent the percentage of each mineral within the cathode [45]. For example, NMC811 is roughly 80 percent nickel, 10 percent manganese, and 10 percent cobalt.

Each battery chemistry has its advantages and disadvantages. The primary benefit of LFP batteries compared to nickel based NCAs and NMCs is that they require no cobalt [45]. LFPs are also cheaper to produce and can deliver more watt power (i.e., better acceleration) per kilogram. However, they are less energy dense – less energy (i.e., shorter range) is stored in the battery per kilogram. Thus, LFPs are better suited for EVs where the range requirement is lower (200-250 miles) or in heavy-duty vehicles where power density is particularly important. Tesla has already switched its Standard Range Model 3s to LFP chemistry, and other automakers are beginning to follow suit for non-luxury models [46].

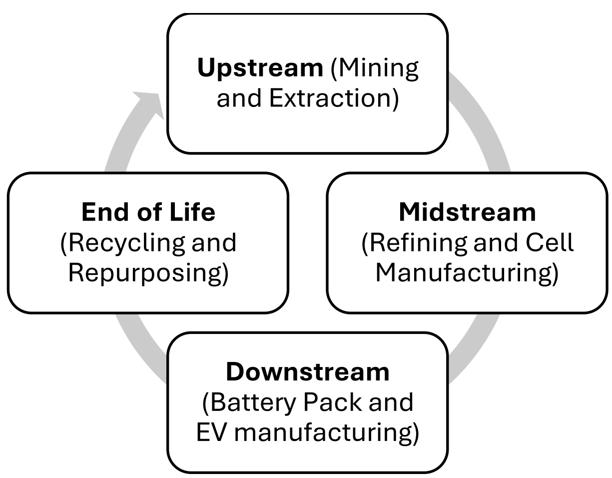
Cobalt-based chemistries are still widely employed because they can support longer ranges [47]. Achieving over 300 miles on a single charge is essential for vehicles at the higher end of the cost curve. But given concerns about cost and the ethics of cobalt production, automakers are incentivized to phase it out where possible. Even when switching to LFP batteries is not feasible, reducing mineral intensity is a secondary option. One example of this is Ford's partnership with SK Innovation to produce NMC batteries that only require five percent cobalt and five percent nickel, halving the amount needed per vehicle [33].

While current battery competition revolves around these three main types: NMCs, NCAs and LFPs, two potential disruptors could be significant to battery innovations. The first is solid-state batteries [48]. Solid-state batteries use a solid electrolyte rather than a liquid one, and therefore require no separator between the negative cathode and the positive anode. Removing the separator decreases the space the battery takes up and allows for greater energy density, and thus a greater number of kWh. Another benefit associated with a solid electrolyte is the potential for enhanced safety through the reduction of the risk of explosion or fire. Solid-state batteries are also less reliant on nickel and cobalt. Solid-state battery companies like QuantumScape and Solid Power hope to begin selling solid-state batteries over the next few years, albeit nowhere near mass-production [49]. Delivering on those ambitions and scaling up to meet market demand will be a significant challenge.

Likewise, sodium-ion batteries may prove to be an essential battery solution – either through applications in EVs or in other battery-powered objects, reducing overall demand for lithium-ion batteries. These batteries are cheaper to produce and less dependent on critical minerals. The challenge is that sodium-ion batteries can only charge so many times before they need to be replaced. CATL, the world's largest EV battery maker, has signaled it will produce sodium-ion batteries [50]. However, the technology is still years away from making any dent in the market.

Critical Minerals Overview

Figure 7: Lithium-ion Battery Supply Chain



Source: [51]

Background

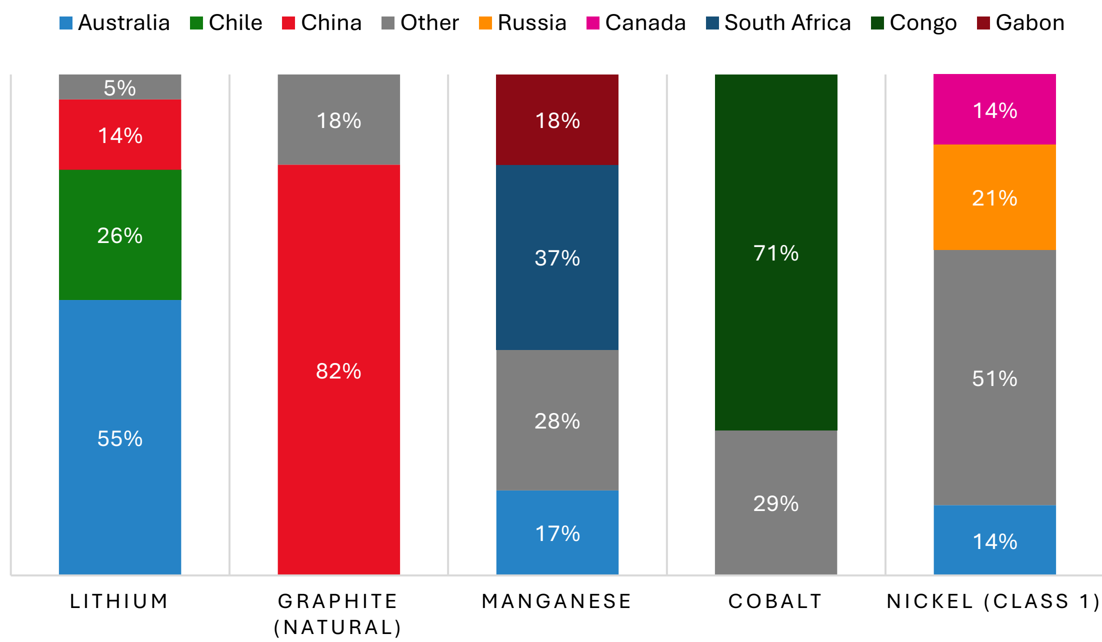
To ensure that 50 percent of all new light-duty vehicle sales are EVs by 2030, the United States will need to increase domestic production and international partnerships to secure supply of at least five critical minerals used in lithium-ion batteries: cobalt, lithium, manganese, graphite, and nickel [52]. While ICE vehicles also require manganese (for steel production), battery electric vehicles require more than twice the amount of manganese compared with ICE vehicles. More broadly, EVs require six times more critical minerals than ICE vehicles [53]. As a result, legacy automakers are rushing to secure access to these new vital battery components.

Time is of the essence. According to a press release from the White House in February 2022, global demand for critical minerals is projected to multiply four to six times over the next several decades, and even more for lithium and graphite in particular [54]. To mitigate a future supply chain crunch and potential price spikes, President Biden invoked the Defense Production Act (DPA) in March 2022 [55]. The DPA allows the President to exert greater control over funding allocation to speed up battery production at all levels of the supply chain and allocated $750 million to study ways to attain higher grade products, progress mine waste reclamation and other initiatives [56]. Further, the Infrastructure Investment and Jobs Act appropriated funding to support the U.S. Geological Survey (USGS) to map critical minerals. Key to these efforts is $64 million to support geoscience data collection of critical mineral resources across 30 states, announced in June 2022 [57].

Challenges

The United States has become dependent on foreign markets for critical minerals in this new-age gold rush. This was not always the case. For several decades following the Second World War, most of the world's supply of lithium came from North Carolina [58]. Back then, however, demand for the metal was comparatively small. By the 1990s, lithium mining output in the United States had mostly dried up as investments were deprioritized. Similarly, graphite has not been mined domestically since the 1950s [59]. In the intervening years, the United States has become a net-importer of critical minerals. In 2021, the United States imported more than 25 percent of its lithium, 48 percent of nickel, 76 percent of its cobalt, and all its graphite and manganese [60].

Figure 8: Critical Mineral Extraction is Highly Concentrated in a few countries



Critical mineral extraction by country for 2021 (data is from 2019 for Nickel). "Other" captures countries ranked fourth in production of the critical mineral or if the value for a country is less than ten percent. Data source: USGS and McKinsey.

Source: [61] [62]

Continued reliance on foreign sources for EV-related minerals has important supply chain and domestic security consequences. In 2021, China made nearly half of all new lithium acquisitions in its attempts to capture the burgeoning critical minerals market [63]. A Chinese stranglehold over the battery mineral market could have significant outcomes (in terms of meeting climate targets and economic disruption for instance) for the U.S. automotive industry in the coming decades, given the implications of the recent U.S.-China Trade War [64]. For instance, artificial graphite imported from China into the U.S. has been subject to a 25 percent tariff because of the trade dispute [65].

A second and equally important consequence surrounds environmental sustainability and human rights. Take cobalt for instance. The silver-gray metal is still a core component of long-range EV batteries. Two-thirds of cobalt supply is currently mined in the Democratic Republic of the Congo (DRC) and is tied to a well-documented history of human rights violations and environmental degradation [66]. From miners digging by hand to radioactive waste leaking into drinking water, the use of Congolese cobalt undermines EV-related sustainability goals. As a result, the industry is seeking ways to move away from the controversial metal. Tesla, for instance, produced nearly half of its vehicles in Q1 2022 without cobalt or nickel, relying instead on iron based LFP batteries [67].

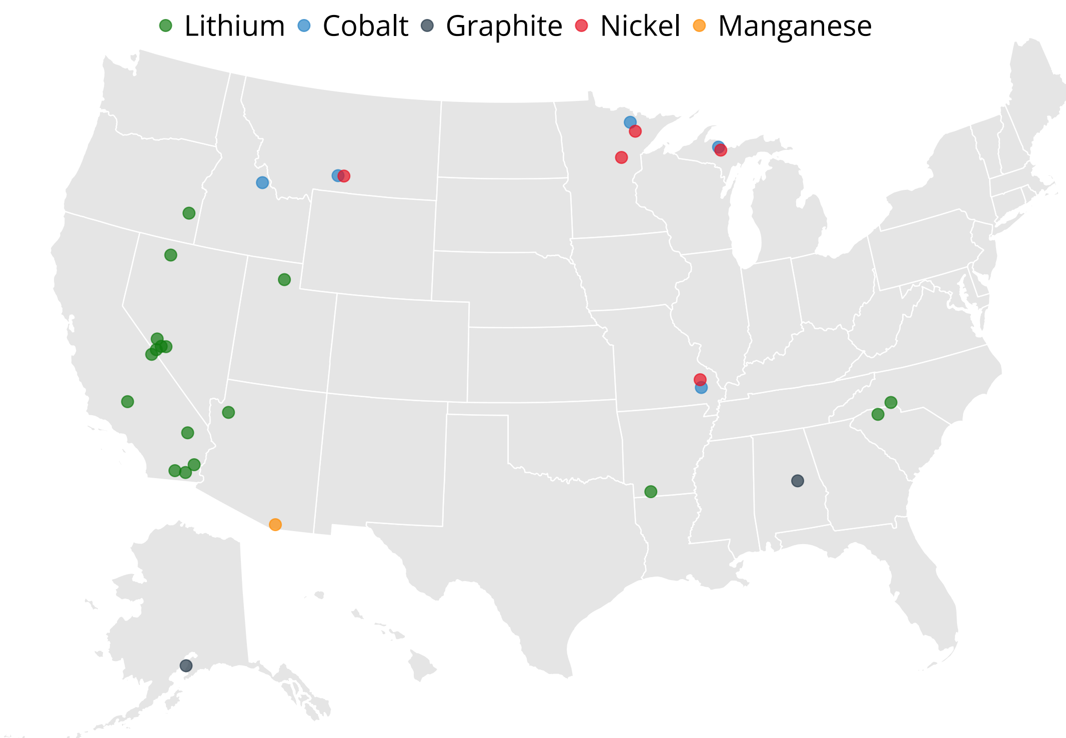
Across all five critical minerals, there are environmental justice concerns. For instance, research from MSCI found, “97% of nickel, 89% of copper, 79% of lithium and 68% of cobalt reserves and resources in the U.S. are located within 35 miles of Native American reservations” [68]. Given the long and harmful history of exploitation of Native land for mineral extraction and resistance to that extraction, it is important that the extraction of critical minerals not repeat those harms [69] [70]. Decision making must weigh the societal benefits (e.g., enabling decarbonization and reliable domestic supply of minerals) and risks to communities (e.g., risks to water sources, air quality, land fertility, and health, disruption of way of life, and desecration of sacred sites) in the extraction of critical minerals. In March 2022, the Biden-Harris Administration initiated an “Interagency Working Group on Mining Regulations, Laws, and Permitting.” The Group is expected to report back in November 2022 [71].

There have been shifts in the cost curves in 2022. Analysis from the IEA notes that the cost of critical minerals has increased significantly – lithium and cobalt prices doubled in 2021 [72]. Rising demand and supply chain challenges continue to push up costs.

Extraction of Critical Minerals

EV batteries require many critical minerals. This summary of five critical minerals reflects a review of sources, including the USGS critical minerals list for 2022, the International Energy Agency (IEA) summary of needs over the coming decades, and the report *How Technology, Recycling, and Policy Can Mitigate Supply Risks to the Long-Term Transition to Zero-Emission Vehicles* by the ICCT in December 2020 [73] [74] [75]. In May 2022, the Biden-Harris Administration directed the Department of Defense to stockpile the five minerals summarized here [52]. Many of these facilities are years off. According to analysis from Benchmark Mineral Intelligence, it takes a minimum of five years and often much longer, to build a lithium mine in the United States [76].

Figure 9: Critical Mineral Mines (current and proposed) in the United States



Where one mine is the source of more than one critical mineral, that mine is represented by one dot per critical mineral. Data source: Press releases, NREL's Lithium-Ion Battery Supply Chain Database and User Guide report, and USGS Mineral Summary for 2022.

Source: [77] [61]

Lithium

Table 5: Domestic Lithium Extraction Sites (Announced and Operational)

Site Name	State	Year Operational	Parent Company
Silver Peak Mine	Nevada	Operational	Albemarle
Hell's Kitchen	California	2024	Controlled Thermal Resources
Project ATLiS	California	2024	EnergySource Minerals
Rhyolite Ridge	Nevada	2025	Ioneer
Big Sandy Lithium Project	Arizona	2025	Hawkstone
Compass Minerals Lithium Project	Utah	2025	Compass Minerals
Berkshire Hathaway Project	California	NA	Berkshire Hathaway
Thacker Pass Lithium Mine	Nevada	NA	Lithium Americas
McDermitt project	Oregon	NA	Jindalee Resources Limited
Carolina Lithium Project	North Carolina	NA	Piedmont Lithium
NeoLith Energy pilot plant	Nevada	NA	Schlumberger
Arkansas Smackover Lithium Project	Arkansas	NA	Standard Lithium
Bristol Lake	California	NA	Standard Lithium
Kings Mountain Mine	North Carolina	NA	Albemarle
Boron Plant	California	NA	Rio Tinto
Clayton Valley Lithium Project	Nevada	NA	Cypress Development
Zeus Lithium Project	Nevada	NA	Noram Lithium

NA means that the data is not available. Data source: Press releases, NREL's Lithium-Ion Battery Supply Chain Database and User Guide report, and USGS Mineral Summary for 2022.

Source: [77] [61]

There is currently only one lithium mine in operation in the United States: The Silver Peak Mine in Nevada. According to the Idaho National Laboratory, this facility produces 4,500 metric tons a year – roughly two percent of global lithium supply [78]. Table 5 summarizes the other mines under some stage of development domestically. U.S. imports of lithium from 2017 to 2020 were predominantly from Argentina (54 percent), Chile (37 percent) and China (5 percent) [61].

Two types of lithium may be used in EVs: lithium carbonate and lithium hydroxide. Lithium hydroxide is produced from lithium carbonate that is put through a chemical process. Demand for lithium will skyrocket over the next decade, which could necessitate an increase in imports. According to a report by McKinsey & Company in April 2022, worldwide lithium demand will surge from 500,000 metric tons to between 3.3 and 3.8 million metric tons annually in 2030 [79]. The authors note they only have visibility on 2.7 million metric tons of lithium supply in 2030.

According to USGS data, the cost of lithium is also skyrocketing. Lithium carbonate prices were $75,000 per metric ton in March 2022, compared with $17,000 in 2021 [80]. The price rises may threaten the downward trajectory of battery prices seen over the past few years [42]. Production and consumption of lithium also went up, but not nearly as steeply. According to the USGS 2022 Summary for Lithium, global lithium production (excluding the United States) increased by 21 percent to 100,000 tons in 2021 while consumption was estimated at 93,000 tons, 33 percent higher than 2020 [61].

The Department of Energy (DOE) identifies the three key forms of lithium extraction:

1. Open-pit mining (predominantly Australia)
2. Brines (predominantly South America, North America, and Europe)
3. Geothermal extraction (Salton Sea, California and Rhine Valley, Germany) [81]

Lithium must then be processed. Much of this processing takes place in, and much of the mining is controlled by, China. China has stakes in lithium mines in some of the largest lithium-producing countries in the world, including 67 percent of output in Chile. In Australia, Chinese firms have secured deals for 9 of the 11 most significant projects to come and of those deals, two thirds are exclusive deals [82].

There are serious concerns about environmental justice linked to lithium mines, including the proposed Thacker Pass mine in Nevada. Local protests have centered on mining on Native land, the potential destruction of sacred sites as well as water contamination [83]. Other sites have met similar resistance. In North Carolina, there is local opposition to the re-opening of a dormant lithium hard rock mine [84]. Piedmont Lithium leads the project and has faced resistance from residents who recall earlier mining and have concerns about the impact on local water tables, pollution, and their way of life. State regulators have also expressed concern about the impact of the mine on water table levels and sewage systems [85].

There has been more muted opposition to proposed lithium extraction sites at the Salton Sea in California. The opposition often revolves around many of the unknowns in direct lithium extraction [86]. According to estimates used by the California Energy Commission, the Salton Sea could produce up to 600,000 tons of lithium per year [87]. While this form of extraction is greener as it uses renewable geothermal energy and is significantly less water intensive, it is also more expensive at this stage and has not yet been produced at a commercial scale [88] [89]. Controlled Thermal Resources, one of the companies involved at the Salton Sea, has pledged to support 220 jobs initially and 1,400 jobs in the longer term [90]. The company has also pledged that 95 percent of those jobs would be sourced locally [90]. California's Lithium Valley Commission, a state government initiative tasked with providing guidance on the region's significant lithium resources, has floated the idea of a levy on the mineral to support the local community in building infrastructure. In June 2022, the state's legislature passed a lithium tax ranging from $400 (for the first 20,000 tons they produce) to $800 per ton (for anything above 30,000 tons) [91]. The Commission released a draft report in October 2022 [86].

Automakers are also building partnerships with lithium mines, going further upstream in the supply chain including Tesla in Nevada, GM in California, and BMW in Argentina [92]. In June 2022, Ford announced a deal to source lithium from a mine in Western Australia through a partnership with Liontown. The deal would mean Ford could source more than 165,000 tons of lithium spodumene concentrate a year for five years [93].

Cobalt

Table 6: Domestic Cobalt Extraction Sites (Announced and Operational)

Site Name	State	Year Operational	Parent Company
Madison Mine	Missouri	Operational	United States Strategic Metals
Eagle Mine	Michigan	Operational	Lundin Mining Corporation
Idaho Cobalt Operations	Idaho	Operational	Jervois Global
Stillwater West Project	Montana	NA	Stillwater Critical Minerals
North-Met	Minnesota	NA	Glencore

The Idaho mine opened in October 2022. NA means that the data is not available. Data source: Press releases, NREL's Lithium-Ion Battery Supply Chain Database and User Guide report, and USGS Mineral Summary for 2022.

Source: [77] [61]

The United States imported 76 percent of all cobalt consumed domestically in 2021 according to the USGS Mineral Commodity Summaries 2022 [61]. This summary includes cobalt required for purposes other than producing EV battery cells.

The only domestic sources of cobalt in the United States are The Eagle Mine in Michigan (trace amounts only and set to close in 2026) and the Madison Mine in Missouri (from historic mine tailings). In October 2022, the Idaho Cobalt Operations site opened. According to the USGS, Minnesota has the greatest reserves of cobalt of any state in the U.S. Aside from Idaho and Missouri, any future cobalt production would be a byproduct for other minerals. As with lithium, automakers are securing deals with mines. GM has initiated a multiyear partnership with Glencore to source cobalt from Australian mines [94].

The dependence on cobalt in lithium-ion batteries is costly – estimates are that cobalt alone makes up a quarter of the cost of the battery's cathode [95]. Further, supply chains are reliant on problematic sources, principally from the DRC [96]. More than 70 percent of all cobalt globally is sourced from the DRC, and according to reporting from the *New York Times*, 15 of 19 cobalt-producing mines in DRC were owned or financed by Chinese companies [97].

The DRC has seen egregious human rights abuses linked to cobalt mining. There are two main kinds of cobalt mines in the country. First, there are artisanal mines: mostly small-scale mines where people work independently and usually by hand. Reporting has shown that these mines are dangerous and dependent on child labor [66]. The other type of mine is industrial mines, where 80 percent of cobalt is sourced in the DRC. Industrial mines are larger-scale mines where companies employ workers. A report from Rights and Accountability in Development and the Centre d'Aide Juridico Judiciaire in November 2021 highlighted abuses at industrial mines [98]. Automakers have partnerships with a number of these mining companies. The challenges are greater when companies subcontract services, which is increasingly common. The report details employees' experiences at industrial mines where they do not earn a living wage, are subject to unsafe or hostile work conditions, and either have poor health insurance or none at all [98]. The report notes that one gap in oversight is that international mining standards are voluntary and not binding.

Thanks to developments with solid-state and LFP batteries, the battery supply chain may be less reliant on cobalt over time. The Department of Energy aims to remove cobalt from EV batteries by 2030 [27], and research indicates that high levels of recycling will reduce raw cobalt demand by 26-44 percent by 2050 [27] [99].

Nickel

Table 7: Domestic Nickel Extraction Sites (Announced and Operational)

Site Name	State	Year Operational	Parent Company
Eagle Mine	Michigan	Operational	Lundin Mining
Madison Mine	Missouri	Operational	United States Strategic Metals
Tamarack Nickel Project	Minnesota	2025	Talon Metals Corp
Stillwater West Project	Montana	NA	Stillwater Critical Minerals
North-Met	Minnesota	NA	Glencore

NA means that the data is not available. Data source: Press releases, NREL's Lithium-Ion Battery Supply Chain Database and User Guide report, and USGS Mineral Summary for 2022.

Source: [77] [61]

The United States imported 48 percent of all nickel consumed domestically in 2021, according to the USGS Mineral Commodity Summaries 2022 [61]. This summary includes nickel required for purposes other than the production of EVs. There are two classifications of nickel purity: class 1 and class 2. Only class 1 nickel is suitable for EV batteries [100]. Around 17 percent of the global supply of Class 1 nickel comes from Russia [72].

There are two nickel mines in operation in the United States: The Eagle Mine in Michigan and the Madison Mine in Missouri. It is difficult to determine if those nickel mines produce or will produce class 1 nickel. There are several mines under development, including the North Met project in Minnesota. The project has received permits, although it currently faces multiple legal challenges [101]. One legal challenge to a permit revolves around the Environmental Protection Agency's assessment that dredging for the project "may affect" the waters of the Fond du Lac Reservation [102] [103].

As with other critical minerals, automakers are building partnerships with mining companies to secure supply. Tesla has secured deals with BHP and Vale, the Tamarack Mine in Minnesota and other companies [104]. Meanwhile, the Department of Energy aims to remove nickel from EV batteries by 2030 to "reduce U.S. lithium-battery manufacturing dependence on scarce materials" [27]. Tesla produced nearly half of its vehicles in Q1 2022 without cobalt or nickel [67]. According to some experts, nickel is one of the highest CO_2-emitting elements of the battery [105].

Manganese

Table 8: Domestic Manganese Extraction Sites (Announced and Operational)

Site Name	State	Year Operational	Parent Company
Hermosa Project	Arizona	2027	South32

NA means that the data is not available. Data source: Press releases, NREL's Lithium-Ion Battery Supply Chain Database and User Guide report, and USGS Mineral Summary for 2022.

Source: [77] [61]

The United States imported 100 percent of all manganese consumed domestically in 2021, according to the USGS Mineral Commodity Summaries 2022 [61]. This summary includes manganese required for purposes other than the production of EV battery cells.

There are no manganese mines currently in operation in the U.S. However, there is presently one mine in the exploration phase in Arizona. The manganese in the United States is generally low grade, has high extraction costs, and has high waste outputs and energy inputs [61]. No manganese has been produced domestically since 1970 [61].

Manganese was predominantly sourced from South Africa, Gabon, and Australia in 2021 [61]. The 100-Day Reviews under Executive Order 14017 released in June 2021 by the White House of supply chain materials noted that while there is no domestic production of manganese, the wide distribution of the mineral and the good relationships that the United States has with those countries make it "less of a concern" than other critical minerals on this list [106].

The same review anticipated that manganese may grow in prominence in EV batteries due to the relatively low cost, safety, and abundance of the mineral. The Department of Energy aims to remove cobalt and nickel from EV batteries by 2030, in which case there will be greater demand for manganese [27]. Manganese helps batteries to perform more safely at higher temperatures and is present in many cathodes [107].

Graphite

Table 9: Domestic Graphite Extraction Sites (Announced and Operational)

Site Name	State	Year Operational	Parent Company
Coosa Graphite Project	Alabama	2028	Westwater Resources
Graphite Creek	Alaska	NA	Graphite One Inc.

NA means that the data is not available. Data source: Press releases, NREL's Lithium-Ion Battery Supply Chain Database and User Guide report, and USGS Mineral Summary for 2022.

Source: [77] [61]

The United States imported 100 percent of all-natural graphite consumed domestically in 2021, according to the USGS Mineral Commodity Summaries 2022 [61]. This summary includes graphite required for purposes other than the production of electric vehicle battery cells. Graphite was sourced mainly from China, Mexico, and Canada in 2021 [61].

There are no graphite mines currently in operation in the United States however, there are presently two mines in the exploration phase. The largest deposit in the country is the Graphite Creek deposit in Alaska, according to the USGS Survey [60]. The United States has not produced graphite domestically since the 1950s [108]. Both natural graphite and synthetic graphite are used in batteries and though synthetic graphite is more expensive, costs are coming down.

The 100-Day Reviews under Executive Order 14017 released in June 2021 by the White House noted that graphite is not as significant a concern for supply chains as lithium, nickel (Class 1) and cobalt given "the growing synthetic graphite production and price reduction domestically, as well as advancements in fundamental understanding of the applicability of substitutes" [106]. Graphite is the go-to for lithium-ion battery anodes as it is cheap, abundant, and can hold a charge for a long time. While the battery cathodes can be made up of a variety of mineral compositions, anodes are almost always comprised of graphite. Developments with silicon batteries however may reduce reliance on graphite in the future [109].

Processing

In the midstream of the EV supply chain is the processing and refining of critical minerals into battery-ready materials. Processing plants generally produce either anode or cathode materials. The materials are then developed into battery cells. EV batteries require high levels of mineral purity to ensure the batteries are effective.

Table 10: Critical Mineral Processing Facilities in the U.S.

Facility Name	State	Product Type	Company	Year Operational
Amsted Graphite Materials	West Virginia	Anode Materials	Anovion	Operational
Elyria Lithium-ion Battery Material Manufacturing Plant	Ohio	Cathode Materials	BASF Toda America LLC	Operational
Battle Creek Lithium-ion Battery Material Manufacturing Plant	Michigan	Cathode Materials	BASF Toda America LLC	Operational
Synthetic Graphite Anode Production Facility	New York	Anode Materials	Anovion	Operational
Syrah Vidalia Facility	Louisiana	Anode Materials	Syrah Technologies	Operational
Spokane Facility	Washington	Anode Materials	Anovion	Operational
Humboldt Mill	Michigan	Cathode Materials	Lundin Mining	Operational
Bessemer City	North Carolina	Cathode Materials	Livent Corporation	2022
Novi Plant	Michigan	Cathode Materials	Battery Resourcers	2022
Alabama Graphite Products	Alabama	Anode Materials	Alabama Graphite Products LLC	2023
Graphex Michigan I	Michigan	Anode Materials	Graphex Technologies	2023

Chattanooga Facility	Tennessee	Anode Materials	Novonix	2023
Anode Pilot Plant	New York	Anode Materials	Li-Metal Corporation	2025
NA	Alabama	Anode Materials	Anovion	2025
Tennessee Lithium	Tennessee	Cathode Materials	Piedmont Lithium	2025
Moses Lake Facility	Washington	Anode Materials	Sila	2026
Advanced Graphite Anode Facility	Washington	Anode Materials	Graphite One Inc.	NA
Tahoe-Reno Industrial Park facility	Nevada	Cathode Materials	Redwood Materials	NA
Kings Mountain Lithium Materials Processing Plant	North Carolina	Cathode Materials	Albemarle	NA
NA	Nevada	Cathode Materials	American Battery Technology Company	NA
Carondelet Plant	Missouri	Cathode Materials	ICL-IP America	NA
NA	Nevada	Cathode Materials	Lilac Solutions	NA
St Gabriel Facility	Louisiana	Cathode Materials	Koura	NA
Battery Minerals Processing Facility	North Dakota	Cathode Materials	Talon Nickel	NA

Facilities that are announced, under development, or in operation. NA means that the data is not available. The product types "cathode materials" and "anode materials" includes materials that will require further refining / processing to become a cathode or anode. Note that facilities provide minimal data publicly about their operations or facility capacity and so this list includes only those facilities – proposed or operational – where there is some evidence that they may process EV materials. Data source: NREL's Lithium-Ion Battery Supply Chain Database and User Guide report, as well as press releases.

Source: [77]

China is the leader in processing critical minerals. According to the 100-Day Review under Executive Order 14017 released in June 2021 by the White House, China is the "world's major processor of lithium carbonate into lithium hydroxide, cobalt into cobalt sulfate, manganese refining, and uncoated spherical graphite refining" [106]. Regarding lithium, there are five companies that dominate global lithium processing: Albemarle, Gangfeng Lithium, Tanqi, Livent, and SQM [110]. Albemarle and Livent have a presence in the United States. Albemarle currently operates a lithium mine in Nevada, is scoping out re-opening a lithium mine in North Carolina and the company has announced a new lithium processing facility in North Carolina. Per Table 10 there is some processing capabilities domestically though there is limited public data available on the capacity of these facilities.

In October 2022, the Department of Energy announced recipients of the Battery Materials Processing and Battery Manufacturing Grants Program funded by IIJA (updated November 1, 2022) [111]. Given the size of this support, those projects that have an announced location and processing anode or cathode materials are included in Table 10. Some of these facilities are expansions of existing facilities and others are new facilities.

There are environmental hazard risks with processing materials. For example, in 2014, a nickel processing facility in New Caledonia spilled 100,000 liters of acid-tainted effluent, contaminating local waterways, and enraging the local community [112]. In Russia, Norilsk Nickel (the largest producer of class 1 nickel in the world) has caused the "worst sulfur dioxide pollution in the world" according to reporting [113]. However, measures can align mineral processing with the greater sustainability goals of the EV transition [114]. Renewable energy (including geothermal) can be utilized to power facilities and mitigate emissions. Materials can be transported using electric medium- and heavy-duty vehicles. Tailings (the toxic slurry waste from processing) can be better stored to reduce the risk of harm. Though there is a long history of degradation due to mining and processing, EV production does not have to repeat historical injustices. Strong domestic laws and binding international standards are crucial to delivering more sustainable outcomes.

Battery Recycling

Battery recycling can reduce dependence on raw materials. EV batteries are also promising in their potential to produce good batteries. Research from October 2021 found that batteries made from recycled materials not only perform well, but some recycling techniques mean the batteries will perform even better than batteries manufactured from primary materials due to the "unique microstructure of recycled materials" [115]. See Table 11 for facilities that have either been announced or are in operation to recycle EV batteries in the U.S.

Table 11: EV Battery Recycling Facilities in the U.S.

Site Name	State	Target Capacity (tons/year)	Facility Product	Year Operational	Company
St Louis Facility	IL	24,000	Battery Grade Materials	Operational	Interco
Spoke Facility	NY	5,000	Black Mass	Operational	Li-Cycle
Worcester, Pilot Plant	MA	15	Cathode materials	Operational	Ascend Elements
Fairfield County Facility	OH	NA	NA	Operational	Cirba Solutions
Wistron Greentech facility	TX	500	Direct Recycling	Operational	Princeton NuEnergy
Spoke Facility	AL	10,000	Black Mass	Operational	Li-Cycle
Spoke Facility	AZ	10,000	Black Mass	Operational	Li-Cycle
Recycling Facility	GA	30,000	Cathode materials	2022	Ascend Elements
Spoke Facility	OH	15,000	Black Mass	2023	Li-Cycle
Hub Facility	NY	35,000	Battery Grade Materials	2023	Li-Cycle
Apex 1	KY	NA	Battery Grade Materials	2023	Ascend Elements
SungEel Recycling Park	GA	50,000	NA	2024	SungEel Materials
Carson City facility	NV	20,000	Battery Grade Materials	NA	Redwood Materials
Lithium-Ion Battery Recycling Pilot Plant	NV	20,000	Battery Grade Materials	NA	American Battery

					Technology Company
Lithium-Ion Battery Recycling Plant	WA	NA	NA	NA	Lab 4 Inc

NA means that the data is not available. Note the Winstron Greentech facility in Texas and the Li-Cycle facility in Alabama both opened in October 2022. This table lists all EV battery recycling facilities that are announced, under development or in operation and includes both hub and spoke facilities. Many facilities provide little data about their operations. This list includes only those facilities for which there was enough information to determine with some confidence that they recycle EV batteries (as opposed to lithium-ion batteries broadly). Source: *NREL's Lithium-Ion Battery Supply Chain Database and User Guide report*, the California EPA, and press releases.

Source: [116] [77] [77]

Currently, five percent of lithium-ion batteries are recycled in the United States per DOE figures (2019) [117]. However, this number includes all lithium-ion batteries, not just EV batteries. There is a precedent of recycling lead-acid batteries for internal combustion engine vehicles. Given the high rate of recycling of lead-acid batteries (around 99 percent), a business case based on recycling other types of batteries at scale may be possible with the right policy settings and economic incentives [118].

Many recycling facilities are partnering with automakers and locating facilities close to large battery manufacturing centers. For example, the Li-Cycle facility in Warren, Ohio is co-located with Ultium Cells' battery cell manufacturing mega-factory (currently under-construction). The CEO of Li-Cycle said that the co-location will "substantially optimize costs and logistics." [119] Mercedes has indicated its intention to partner with battery recyclers in the US. Likewise, new players in recycling batteries continue to arise, including an announcement in May 2022 that a recycling company, Blue Whale Materials, aims to build five recycling facilities across the U.S. and Europe [120] [121]. Northvolt, a battery maker in Sweden, already has batteries using 100 percent recycled nickel, manganese, and cobalt [122].

In June 2022, Toyota announced it would partner with battery recycling company Redwood Materials. Redwood Materials also has partnerships with Proterra, Ford, Volvo, and Panasonic (Panasonic supplies batteries to Tesla) [123]. Redwood claims it can recover 95 to 98 percent of critical minerals from recycled batteries (this claim refers to all lithium-ion batteries and not just EV batteries). Redwood is looking to expand into the battery materials business more broadly by also producing batteries from raw materials in the United States.

Recycling Challenges

There are some key challenges to expanding battery recycling as described in Table 12.

Table 12: Challenges in Recycling EV Batteries

Barrier	Description
Labelling	Batteries are not well labeled and so it is challenging for recyclers to know how to recycle a battery without knowing the components.
Accessing	At present, it is difficult and time-consuming to dismantle the battery to recover the materials.
Transporting	Transporting combustible EV batteries to recycling or production facilities is expensive and presents safety challenges.
Lack of Regulations	A lack of regulations including producer responsibility and recycled content requirements slows progress.
Low value minerals/ lack of market	Some minerals may not be worth recycling at this stage. That said, with economies of scale and as raw material prices increase, the economic case for recycling improves.

This table summarizes key barriers to greater levels of EV battery recycling to meet the expected increase in EV adoption in the coming years. The barriers mentioned here were principally sourced from research including reporting in *Science* magazine by Ian Morse.

Source: [124] [125]

Analysis by McKinsey indicates that excitement about the potential for EV battery recycling should be tempered. The company notes in a 2022 report, “By 2030, such secondary supply is expected to account for slightly more than 6 percent of total lithium production” [79]. An analysis by Wood McKenzie agreed with the McKinsey assessment that recycling will not be a significant factor in battery materials until at least 2030, in part because the market is still small and EVs have an increasingly long-life span, meaning there are limited materials available to recycle [126]. Other estimates point to more recycling in the near term.

A report by researchers Dominish, Florin and Wakefield-Rann at the University of Technology Sydney (UTS) in April 2021 found high potential rates of recycling of critical minerals. The researchers found it is technologically possible to recover at least 90 percent of cobalt, nickel, copper, and lithium through recycling [127]. Due to the issues associated with cobalt, many battery manufacturers are working to phase the metal out of newer battery designs. However, because cobalt is one of the more valuable minerals in EV batteries, the recycling business case becomes less lucrative without it [128]. A similar issue exists with nickel.

Recycling Initiatives

Several federal government initiatives have supported battery recycling. The Infrastructure Investment and Jobs Act includes funding for EV battery recycling. For instance, the Battery Manufacturing and Recycling Grants Program includes $3 billion in appropriated funding to support "Demonstration projects, construction of commercial-scale facilities, and retrofit or retooling of existing facilities for battery component manufacturing, advanced battery manufacturing, and recycling" [129]. There was also $125 million in the Act to support the Battery and Critical Mineral Recycling Program.

In the Inflation Reduction Act, signed into law in August 2022, one of the requirements for the revised Clean Vehicle Tax Credit is that an EV battery must be recycled in North America and/or source critical minerals domestically or from a free trade partner. This incentive may boost domestic recycling efforts [130]. Elsewhere, the Federal Government has supported the ReCell Center for battery recycling, which opened in 2019 with a $15 million grant and funds the Battery Recycling Prize and the Defense Production Act will avail funds for battery recycling [131].

The *National Blueprint for Lithium Batteries 2021–2030,* released by the Department of Energy, identifies recycling batteries as a key priority [27]. The Blueprint lays out short and long-term objectives. These short-term objectives (by 2025), include designing battery packs to enable easier recycling, increasing recovery rates of critical minerals, and federal recycling policies. Longer-term objectives (by 2030) include creating incentives to achieve a 90 percent recycling rate of EV batteries and requiring materials to be recycled in cell manufacturing materials streams.

At the state level, an Advisory Group to the California Environmental Protection Agency released a report in March 2022, *Lithium-ion Car Battery Recycling Advisory Group Final Report* [116]. The Advisory Group recommended two key policies. The first policy was a core exchange with a vehicle backstop. A vehicle backstop policy means that the entity that is the last to handle the battery has a responsibility to properly reuse, repurpose or recycle the battery. The second policy the Group recommended was producer take-back. A producer take-back policy ensures that it is the producer's responsibility to take back the battery at the end of life at no cost to the consumer. The Report will go to the state legislature, where some recommendations may become law. Several other states have begun efforts to look at battery recycling, and thus far, the auto industry continues to support the core exchange program under consideration in California.

Repurposing

EV batteries are expected to last between 10 and 15 years. Given concerns about acceleration and range, batteries may reach the end of their useful life for vehicles but still be able to perform other energy storage functions, such as backup power for buildings or assets for the electrical grid [132]. Repurposed batteries[6] have around 70 to 80 percent of their original capacity [99]. The challenge is to ensure these batteries can feasibly, safely, and affordably be repurposed for other functions.

The startup B2U based in California reuses Nissan Leaf batteries to store solar energy [133]. The company purchased batteries that reached the end of their useful life in Nissan EVs far below the market rate for new batteries. The startup remains small, but the company is quadrupling its storage capacity on-site. Researchers note that repurposing battery materials delays them from re-entering the recycling loop, decreasing the supply of recycled materials [99]. However, their use in other settings reduces demand for new batteries, and once they are no longer useful as repurposed batteries, they may be recycled.

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Attachment 71

Comments of Environmental and Public Health Organizations on:

EPA, California State Motor Vehicle Pollution Control Standards; Advanced Clean Cars II Regulations; Request for Waiver of Preemption; Opportunity for Public Hearing and Public Comment, 88 Fed. Reg. 88908 (December 26, 2023); Docket ID No. EPA–HQ–OAR–2023–0292

Submitted February 27, 2024

AXIOS Log In

Updated Feb 1, 2023 - Economy & Business

Scoop: Biden's EV surprise

Joann Muller, author of Axios What's Next

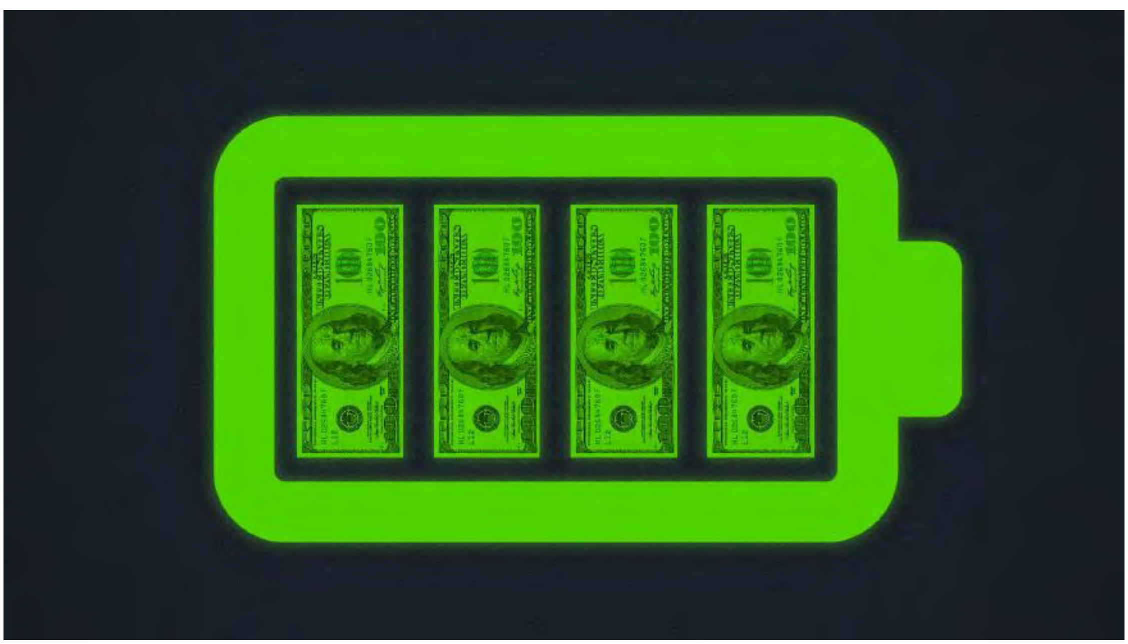


Illustration: Aïda Amer/Axios

The Biden administration's plan to jump-start a domestic supply chain for electric vehicles (EVs) is on track to shatter expectations.

AXIOS

- Some experts say the value of those tax credits may be four times higher than Congress' budget experts anticipated.

Why it matters: This is what President Biden and congressional Democrats wanted — to seed a domestic EV supply chain and reduce America's dependence on China, while accelerating the transition to cleaner transportation.

- Companies announced more than $73 billion in planned U.S. battery plants in 2022 alone, according to Atlas Public Policy.

Details: The Inflation Reduction Act, passed last year, is loaded with goodies for consumers and carmakers to spur EV sales.

- The most lucrative incentive offers battery manufacturers a tax credit of $35 per kilowatt-hour for each U.S.-made cell, which slices their production costs by a third.

Example: If a manufacturer produces 70-kWh batteries for 1 million vehicles, its total credits would be worth $2.45 billion a year.

By the numbers: When the bill was being debated last summer, the Congressional Budget Office projected the tax credits would add up to about $30.6 billion over 10 years (including credits for solar and wind manufacturing).

- The actual total will almost surely be much higher, thanks to a surge of new battery plants across the country.

- One estimate, prepared by Benchmark Mineral Intelligence for Axios, pegs the cost of the battery rebates at $136 billion over 10 years — and Tesla has already announced new plans that will drive the number even higher.

- Tesla alone expects to earn up to $1 billion in battery tax credits this year.

- In a recent earnings call, CEO Elon Musk said the value of such credits could become "very significant" and potentially "gigantic" in future years.

- Tesla's Nevada plant, for example, will soon be able to produce 100 gigawatt-hours of battery cells, and that could grow to 500 gigawatt-hours in the future. At an annual production rate of 500 gigawatt-hours, the credits would be worth a staggering $17.5 billion per year.

The big picture: Other companies also stand to reap huge credits as they ramp up domestic battery production, including General Motors and Ford Motor and their Korean joint venture partners, such as LG Energy and SK On.

- Ford expects more than $7 billion in tax breaks from 2023 to 2026, with CEO Jim Farley predicting a "large step-up in annual credits" starting in 2027 during a recent earnings call.

- GM chief financial officer Paul Jacobson told reporters that the automaker will earn about $300 million this year, with the credits eventually being worth $3,500 to $5,500 per vehicle.

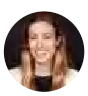
What they're saying: "We have already seen hundreds of billions of dollars in new private sector investments across clean energy industries, including batteries, electric vehicles and solar panels," said White House assistant press secretary Michael Kikukawa in a statement to Axios.

how American workers are the finest in the world."

The bottom line: The battery production tax credits are just one of many U.S. policy initiatives intended to accelerate the transition to electric vehicles — but they're clearly among the sweetest.

Editor's note: This story has been corrected with the current corporate name of SK On, which was spun off from parent company SK Innovation in 2021.

Go deeper



Erin Doherty
49 mins ago - Politics & Policy

Supreme Court strikes down affirmative action at colleges

Attachment 72

Comments of Environmental and Public Health Organizations on:

EPA, California State Motor Vehicle Pollution Control Standards; Advanced Clean Cars II Regulations; Request for Waiver of Preemption; Opportunity for Public Hearing and Public Comment, 88 Fed. Reg. 88908 (December 26, 2023); Docket ID No. EPA–HQ–OAR–2023–0292

Submitted February 27, 2024

California Surpasses 1.5 Million ZEVs Goal Two Years Ahead of Schedule

Published: Apr 21, 2023

B-ROLL: *Governor Newsom and First Partner Jennifer Siebel Newsom tour ZEVs at the California Natural Resources Agency in Sacramento (download)*

WHAT YOU NEED TO KNOW: California achieved its goal of 1.5 million zero emission vehicles (ZEVs) sold in the state two years ahead of schedule, with $2 billion in ZEV incentives having been distributed to Californians to make the transition more affordable – a major victory in the state's ambitious climate action plan.

SACRAMENTO – Today, Governor Gavin Newsom announced California has exceeded 1.5 million ZEV sales two years ahead of schedule. To date, nearly $2 billion in ZEV incentives, as part of a broader $9 billion ZEV budget, have been provided to help Californians – especially those who are low-income – afford making the transition. In 2012, then-Governor Jerry Brown set a goal to hit that sales level by 2025. This year, 21% of all new cars sold in California this year have been ZEVs, and 40% of ZEVs sold in the U.S. are sold in California.

"No other state in the nation is doing as much as we are to accelerate our electric and zero emissions future," **said Governor Newsom.** "California is setting the bar for climate action – and we're achieving our goals years ahead of schedule thanks to unprecedented investments secured in partnership with the Legislature. We're making real progress on the world's most ambitious plan to end the tailpipe so our kids and grandkids are left with a cleaner, healthier planet."

California's ZEV leadership continues to inspire other states to follow California's example.

And earlier this month, the Governor applauded the Biden-Harris Administration for proposing new federal emissions standards that effectively require half of all cars sold in the U.S. to be zero emissions vehicles (ZEV) by 2030, calling it a "great day for America."

Also today, in an effort to supercharge the state's EV charging infrastructure, California announced a new Joint Statement of Intent between several state departments and agencies to help guide planning for energy supply, facilities, grid development, as well as EV chargers and hydrogen stations.

CALIFORNIA'S ZEV RECORD:

- **21.1% of all new cars sold this year in California were ZEVs**, according to the California Energy Commission
  - 124,053 ZEV sales in California in Q1 2023
  - 1,523,966 total ZEV sales in California to date

- **40% of ZEVs sold in the U.S. are sold in California**, according to the Veloz EV Market Report

- Context: California has more ZEVs than New Hampshire has cars, twice as many ZEVs as Wyoming has cars and more than twice as many ZEVs as Norway

- **Up to $24,500 in grants & rebates available** for low-income Californians (learn more here)
  - California has provided consumers with nearly $2 billion in incentives and rebates through programs like the Clean Vehicle Rebate Project and Clean Cars 4 All

- **California approved one of the world's first regulations** last year requiring 100% of new car sales to be ZEVs by 2035, following Governor Newsom's 2020 executive order to develop new rules for in-state sales.
- **U.S. EPA last month approved California's plan** to require nearly half of all new heavy-duty trucks be zero emissions by 2035
- **ZEVs are a top state export** thanks to California's success, spurring major advances in manufacturing and job creation
- **California is home to 55 ZEV and ZEV-related manufacturers** and leads the nation in ZEV manufacturing jobs
- **Billions of dollars are going out the door** to build ZEV charging infrastructure across the state, with a record amount dedicated to disadvantaged communities:
  - $2.9 billion investment plan approved by the California Energy Commission in December accelerates California's 2025 electric vehicle charging and hydrogen refueling goals
  - $2.6 billion investment plan approved in November by

- $2.6 billion investment plan approved in November by the California Air Resources Board supports a wide range of ZEV projects, with 70% of the funds directed to disadvantaged and low-income communities – the state's largest-ever investment in the equitable expansion of clean transportation

Attachment 73

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Submitted February 27, 2024

Announced EV Infrastructure Funding

As of March 31, 2023, Atlas Public Policy (Atlas) estimates $67 billion dollars in battery electric vehicle charging infrastructure investments that have been announced by the public, private, utility sectors but not yet installed as charging ports in the ground. Table 1 provides a summary of tallied investment amounts, which include:

- $33 billion in announced, unspent investments for light-duty vehicle (LDV) charging
- $30 billion in announced, unspent investments for medium- and heavy-duty (MDHD) vehicle charging, and
- $4 billion in announced, unspent investments for use across any vehicle class.

Table 1. Estimated U.S. Charging Infrastructure Investments Announced but Not Yet In the Ground, as of March 31 2023

	Investments Announced ($millions)			
Funding Sector	**Funding available only for light-duty vehicle charging**	**Funding available for light-duty, medium-duty or heavy-duty vehicle charging**	**Funding available only for medium- and heavy-duty vehicle charging**	**Total**
Public	$22,263	$4,360	$20,562	$47,186
Private (Non-Utility) [incomplete tally]	$6,254		$4,292	$10,546
Low Carbon Fuel Standard [2023 – 2032]	$2,941		$3,278	$6,219
Utility	$1,886		$1,402	$3,288
Grand Total	**$33,344**	**$4,360**	**$29,534**	**$67,239**

Note: LCFS and Public Sector value assume EV adoption consistent with a) 50% of light-duty vehicle sales being battery electric by 2030 (in line with President Biden's goal), and b) medium- and heavy-duty battery electric vehicle adoption consistent with the EPA's proposed LMDV and HDV regulation. Note that these figures do not include any funding amounts for hydrogen fuel cell vehicles.

Public funding programs included are those that cover only EV charging infrastructure, or for which EV charging infrastructure is expected to comprise the vast majority of funding. This includes federal National Electric Vehicle Infrastructure (NEVI) formula and Charging and Fueling Infrastructure (CFI) Discretionary Grant funding, state funding commitments, and modeled estimates of 26 U.S. Code § 30C tax credit payments[1] consistent with an EV adoption trajectory that meets President Biden's goal of 50% ZEV sales share by 2030 (for LDVs) and an electric vehicles sales trajectory matching EPA's proposed emissions regulations for medium- and heavy-duty vehicles.

Atlas' s tally of Private Sector commitments is likely incomplete. Private sector actors often do not announce their investment plans, and are especially unlikely to do so if they are investing in home, depot, or workplace charging. Investments here include announced commitments to public charging network developments made after January 1, 2022 by companies including Tesla, Electrify America, BP, General Motors, Daimler, and Mercedes. For MDHD vehicles, private sector commitments are taken largely from Environmental Defense Fund's Electric Fleet Deployment & Commitment List.[2] Tallied private sector commitments *exclude* an estimated $3.0 billion in capital raised by charging companies (including ChargePoint, EVgo, Blink, Volta), some percentage of which is expected still to be invested in charging hardware and installation.

The estimated Low Carbon Fuel Standard value is based on modeling from Dean Taylor Consulting for California, Oregon, and Washington and does not include capacity credits. It uses a 2023 – 2032 EV adoption trajectory for those three states that meets President Biden' s LDV goal of 50% ZEV sales share by 2030 (which is lower than the trajectory modeled in the EPA' s proposed vehicle emission standards), an MDHD EV adoption curves modeled on the EPA' s proposed

[1] Atlas assumes that 1) all qualifying projects receive the tax credit, 2) on average, qualifying projects will receive tax credits worth 18% of covered costs, and 3) that the U.S. Department of the Treasury will classify a census tract as not urban if more than 10% of the blocks within the census tract are designated as rural census blocks (as recommended by Natural Resources Defense Council (NRDC), Alliance for Automotive Innovation, American Council on Renewable Energy (ACORE), Ample, CALSTART, ChargePoint, Clean Energy Works, Earthjustice, Elders Climate Action, Electrification Coalition, Environmental Defense Fund (EDF), EV Charging for All, EVBox, Forth Mobility, Green Latinos, International Brotherhood of Electrical Workers (IBEW), International Parking & Mobility Institute, Itselectric, League of Conservation Voters, National Association of Convenience Stores (NACS), National Consumer Law Center, NATSO, Navistar, Plug in America, Representing America s Travel Plazas and Truck Stops, Rivian, Sierra Club, SIGMA: America s Leading Fuel Marketers, TeraWatt, Transportation for America, Union of Concerned Scientists (UCS), Volvo Group North America).

[2] See https://docs.google.com/spreadsheets/d/1l0m2Do1mjSemrb_DT40YNGou4o2m2Ee-KLSvHC-5vAc/edit#gid=2049738669. MDHD fleet vehicle counts are multiplied by charging ports per vehicle and costs per port modeled in Atlas's Investment Needs of State Infrastructure for Transportation Electrification (INSITE) tool.

emissions regulations for MD and HD vehicles, and modeling from Atlas’ s INSITE tool of MWh demanded by MDHD vehicles.

Utility program investments include approved investor-owned utility programs with an EV charging element. Amounts are unspent program dollars as of the most recent program report available as of March 31, 2023. If no program report was available, Atlas used the percentage of time remaining in the approved program schedule to estimate the unspent proportion of program funding.

Appendix

Attachment 74

Comments of Environmental and Public Health Organizations on:

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Submitted February 27, 2024

World Energy Investment 2023

INTERNATIONAL ENERGY AGENCY

The IEA examines the full spectrum of energy issues including oil, gas and coal supply and demand, renewable energy technologies, electricity markets, energy efficiency, access to energy, demand side management and much more. Through its work, the IEA advocates policies that will enhance the reliability, affordability and sustainability of energy in its 31 member countries, 11 association countries and beyond.

This publication and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Revised version, May 2023
Information notice found:
www.iea.org/corrections

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International Energy Agency
Website: www.iea.org

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Ukraine

Abstract

This year's edition of the *World Energy Investment* provides a full update on the investment picture in 2022 and an initial reading of the emerging picture for 2023.

The report provides a global benchmark for tracking capital flows in the energy sector and examines how investors are assessing risks and opportunities across all areas of fuel and electricity supply, critical minerals, efficiency, research and development and energy finance.

It focuses on some important features of the new investment landscape that are already visible, including the policies now in place that reinforce incentives for clean energy spending, the energy security lens through which many investments are now viewed, widespread cost and inflationary pressures, the major boost in revenues that high fuel prices are bringing to traditional suppliers, and burgeoning expectations in many countries that investments will be aligned with solutions to the climate crisis.

Table of contents

Introduction

A turning point for energy investment?

This new *World Energy Investment 2023* (*WEI 2023*) report is the eighth in our annual series where we provide the global benchmark for tracking capital flows in the energy sector. The last few years have been a period of extreme disruption for the energy sector. The new *WEI 2023* offers an opportunity to take stock of what this has meant for investment, and what those investments might mean in turn for the future security and sustainability of the energy sector.

The shock to the system from the global energy crisis has come at a time of increasingly visible impacts of a changing climate and has taken many forms. Price spikes created strong economic incentives to increase supply and to find alternative or more efficient ways to meet demand. Energy security shocks created powerful incentives for policy makers to reduce vulnerabilities and dependencies, while also – for many developing economies in particular – draining the financial resources available to address them.

In the new *WEI 2023* we provide a full update on the investment picture in 2022 and an initial reading of the emerging picture for 2023. Huge uncertainties remain over how events will play out. But some important features of the new investment landscape are already visible, including the policies now in place that reinforce incentives for clean energy spending, the energy security lens through which many investments are now viewed, widespread cost and inflationary pressures, the major boost in revenues that high fuel prices are bringing to traditional suppliers, and burgeoning expectations in many countries that investments will be aligned with solutions to the climate crisis. The structure of this year's WEI 2023 is as follows:

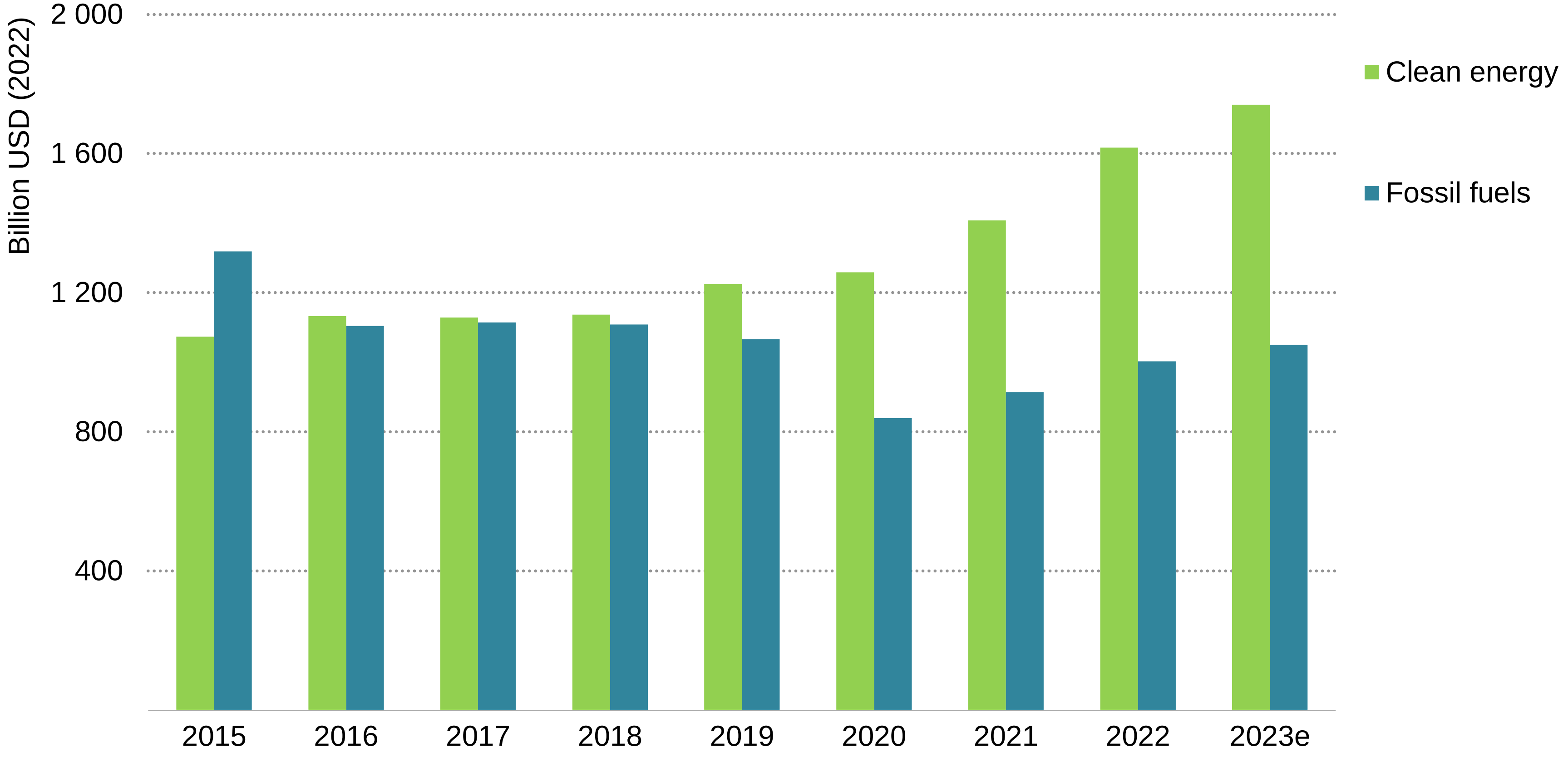
In Chapter 1 we present the overview and **key findings**. Chapter 2 covers the **power sector**, while Chapter 3 reviews the latest developments and trends in **fuel supply** investment. Chapter 4 deals with investment in **energy efficiency and the end-use sectors**, and Chapter 5 brings insights on energy **research and development and innovation**. The concluding Chapter 6 considers trends in **energy finance**.

While the focus of *WEI 2023* is to track investment and financing trends in 2022 and provide an early indication for 2023, the report also benchmarks today's trends against future scenarios from the IEA World Energy Outlook. The **Stated Policies Scenario (STEPS)** is based on today's policy settings and considers aspirational targets only insofar as they are backed by detailed policies. The **Announced Pledges Scenario (APS)** assumes that all climate commitments and net zero targets made by governments around the world will be met in full and on time. The **Net Zero Emissions by 2050 Scenario (NZE Scenario)** sets out a narrow but achievable pathway for the global energy sector to achieve net zero CO_2 emissions by 2050.

Overview and key findings

The recovery from the Covid-19 pandemic and the response to the global energy crisis have provided a major boost to global clean energy investment

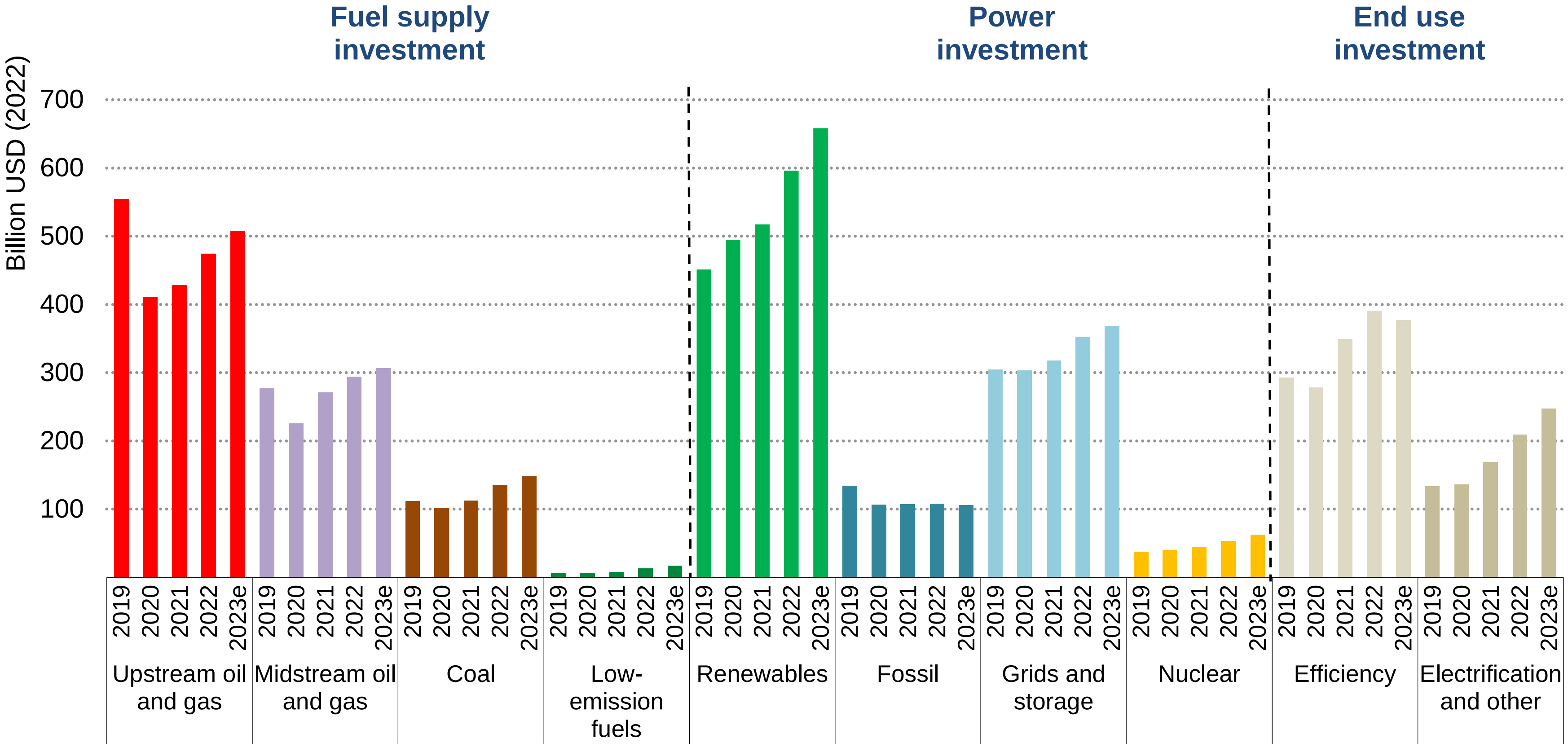
Global energy investment in clean energy and in fossil fuels, 2015-2023e



Note: 2023e = estimated values for 2023.

Increases across almost all categories push anticipated spending in 2023 up to a record USD 2.8 trillion

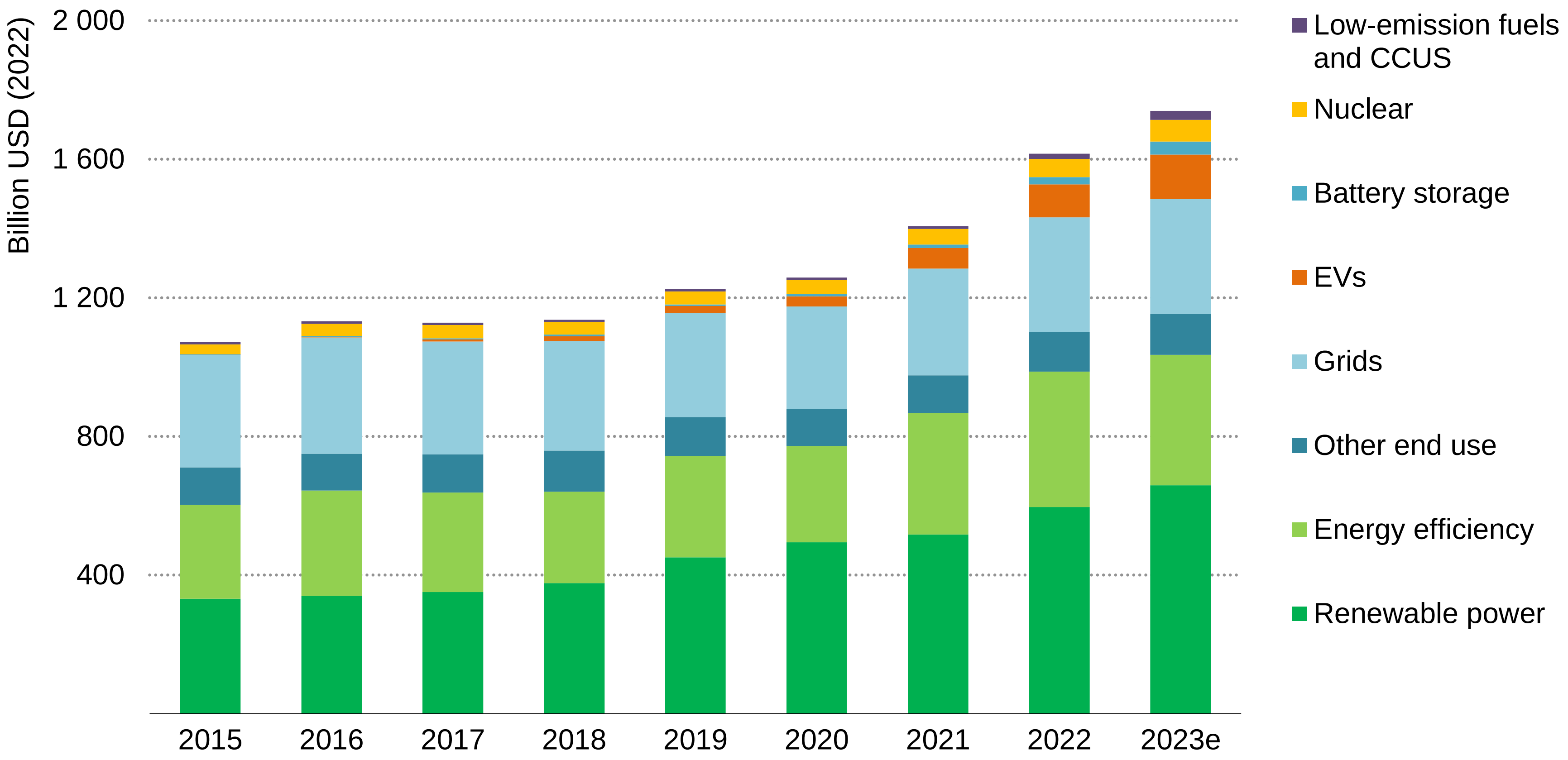
Energy-sector investment, 2019-2023e



Notes: "Low-emission fuels" include modern liquid and gaseous bioenergy, low-emission hydrogen and low-emission hydrogen-based fuels; "Other end use" refers to renewables for end use and electrification in the buildings, transport and industrial sectors. The terms grids and networks are used interchangeably in this report and do not distinguish between transmission and distribution; 2023e = estimated values for 2023..

Renewables, led by solar, and EVs are leading the expected increase in clean energy investment in 2023

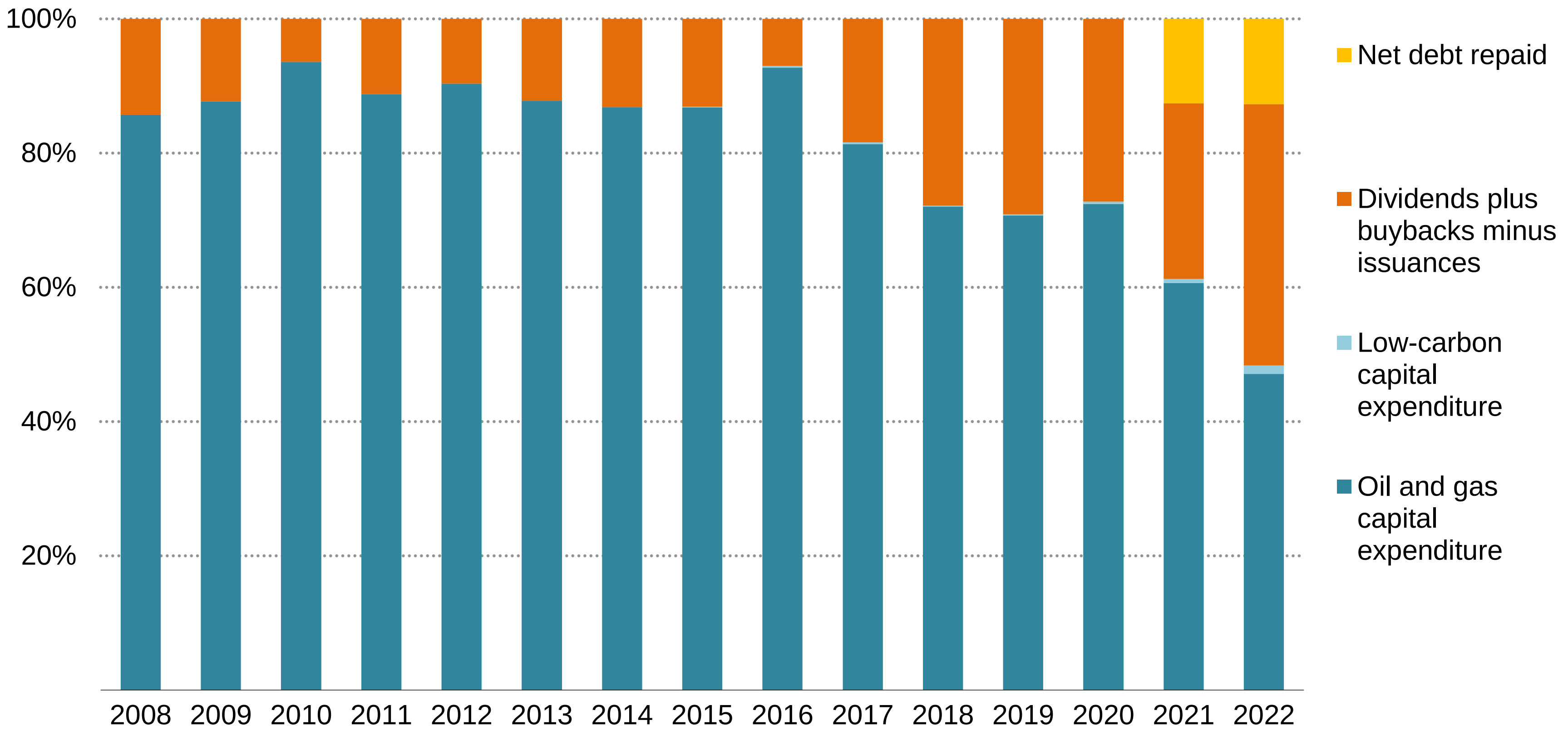
Annual clean energy investment, 2015-2023e



Notes: "Low-emission fuels" include modern liquid and gaseous bioenergy, low-emission hydrogen and hydrogen-based fuels that do not emit any CO_2 from fossil fuels directly when used and emit very little when being produced; "Other end use" refers to renewables for end use and electrification in the buildings, transport and industrial sectors. 2023e = estimated values for 2023; CCUS = carbon capture, utilisation and storage; EV = electric vehicle.

Less than half of the oil and gas industry's unprecedented cash flow from the energy crisis is going back into traditional supply and only a small fraction to clean technologies

Distribution of cash spending by the oil and gas industry, 2008-2022



Source: IEA analysis based on data from S&P Capital IQ.

The momentum behind clean energy investment stems from a powerful alignment of costs, climate and energy security goals, and industrial strategies

The recovery from the slump caused by the Covid-19 pandemic and the response to the global energy crisis have provided a significant boost to clean energy investment. Comparing our estimates for 2023 with the data for 2021, annual clean energy investment has risen much faster than investment in fossil fuels over this period (24% vs 15%). Our new analysis highlights how the period of intense volatility in fossil fuel markets caused by the Russian Federation's (hereafter "Russia") invasion of Ukraine has accelerated momentum behind the deployment of a range of clean energy technologies, even as it also prompted a short-term scramble for oil and gas supply.

We estimate that around USD 2.8 trillion will be invested in energy in 2023. More than USD 1.7 trillion is going to clean energy, including renewable power, nuclear, grids, storage, low-emission fuels, efficiency improvements and end-use renewables and electrification. The remainder, slightly over USD 1 trillion, is going to unabated fossil fuel supply and power, of which around 15% is to coal and the rest to oil and gas. For every USD 1 spent on fossil fuels, USD 1.7 is now spent on clean energy. Five years ago this ratio was 1:1.

Clean energy investments have been boosted by a variety of factors. These include improved economics at a time of high and volatile fossil fuel prices; enhanced policy support through instruments like the US Inflation Reduction Act and new initiatives in Europe, Japan, the People's Republic of China (hereafter "China") and elsewhere; a strong alignment of climate and energy security goals, especially in import-dependent economies; and a focus on industrial strategy as countries seek to strengthen their footholds in the emerging clean energy economy.

This momentum has been led by renewable power and EVs, with important contributions also from other areas such as batteries, heat pumps and nuclear power. In 2023 low-emissions power is expected to account for almost 90% of total investment in electricity generation. Solar is the star performer and more than USD 1 billion per day is expected to go into solar investments in 2023 (USD 380 billion for the year as a whole), edging this spending above that in upstream oil for the first time.

Consumers are investing in more electrified end uses. Demand for electric cars is booming, with sales expected to leap by more than one-third this year after a record-breaking 2022. As a result, investment in EVs (defined as the incremental spending on EVs vs the average price of vehicles sold in a given country) has more than doubled since 2021, reaching USD 130 billion in 2023. Global sales of heat pumps have seen double-digit growth since 2021.

The increase in fossil fuel investment expected in 2023 is unevenly spread around the world; less than half the cash flow available to the oil and gas industry is going back into new supply

2022 was an extraordinarily profitable year for many fossil fuel companies, as they saw revenues soar on higher fuel prices. Net income from fossil fuel sales more than doubled compared with the average in recent years, with global oil and gas producers receiving around USD 4 trillion.

Our overall expectation, based on analysis of the announced spending plans of all the large and medium-sized oil, gas and coal companies, is that investment in unabated fossil fuel supply is set to rise by more than 6% in 2023, reaching USD 950 billion.

The largest share of this total is going to upstream oil and gas, where investment is expected to rise by 7% in 2023 to more than USD 500 billion, bringing this indicator in aggregate back to the levels of 2019. Around half this increase is likely to be absorbed by cost inflation.

Many large oil and gas companies have announced higher spending plans on the back of record revenues. But uncertainties over longer-term demand, worries about costs, and pressure from many investors and owners to focus on returns rather than production growth mean only large Middle Eastern national oil companies are spending much more in 2023 than they did in 2022, and they are the only subset of the industry spending more than pre-pandemic levels.

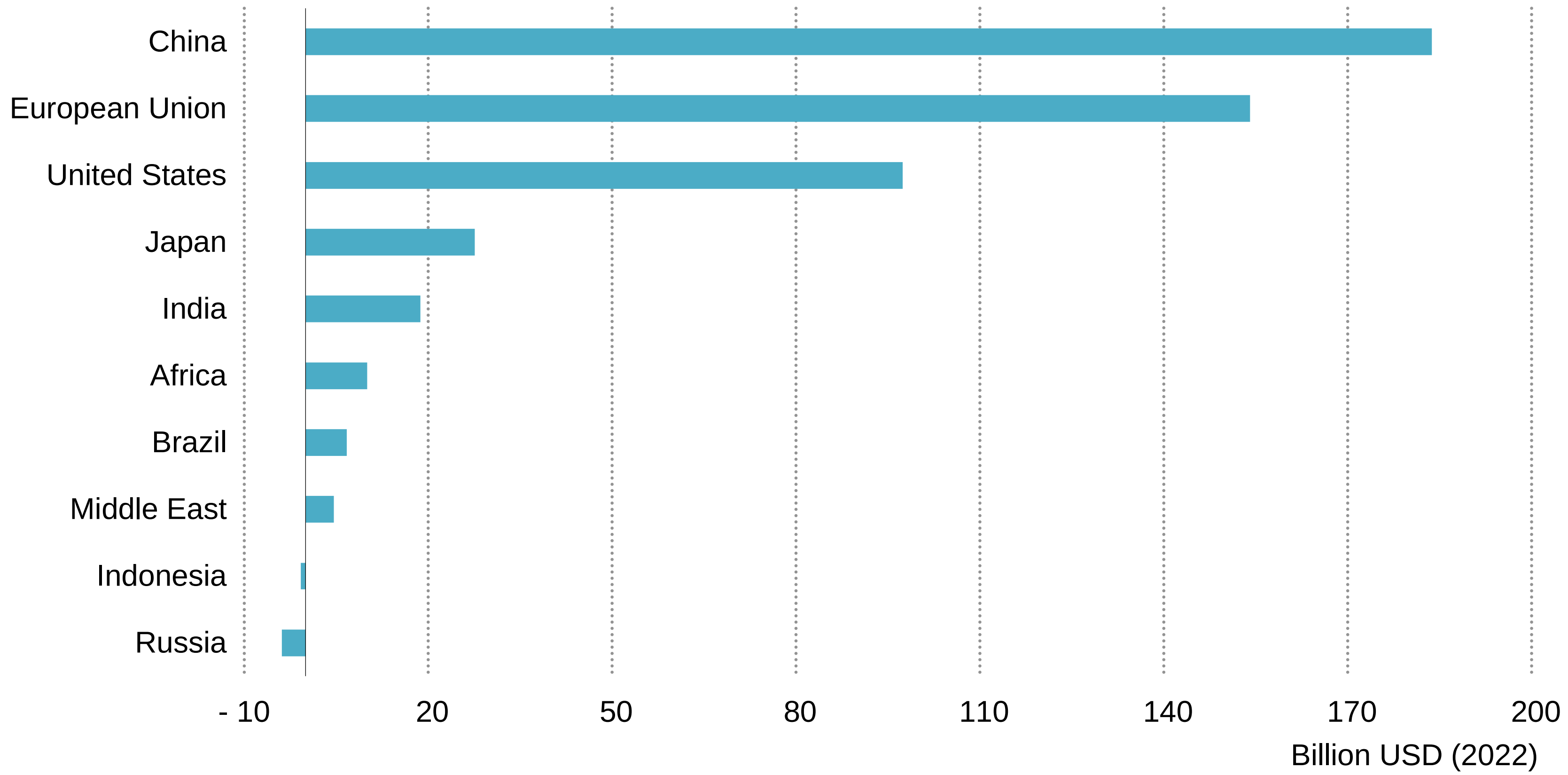
The headline rise in spending on new oil and gas supply represents less than half of the cash flow that was available to the oil and gas industry. Between 2010 and 2019, three-quarters of cash outflows were typically invested into new supply. This is now less than half, with the majority going to dividends, share buybacks and debt repayment.

Investment by the oil and gas industry in low-emissions sources of energy is less than 5% of its upstream investment. This indicator differs widely by company, with double-digit shares common among the large European companies. Investment by the industry in clean fuels, such as bioenergy, hydrogen and CCUS, is picking up in response to more supportive policies but remains well short of where it needs to be in climate-driven scenarios.

Investment in coal supply is expected to rise by 10% in 2023, and is already well above pre-pandemic levels. Investment in new coal-fired power plants remains on a declining trend, but a warning sign came in 2022 with 40 GW of new coal plants being approved – the highest figure since 2016. Almost all of these were in China, reflecting the high political priority attached to energy security after severe electricity market strains in 2021 and 2022, even as China deploys a range of low-emission technologies at scale.

The increase in clean energy spending in recent years is impressive but heavily concentrated in a handful of countries

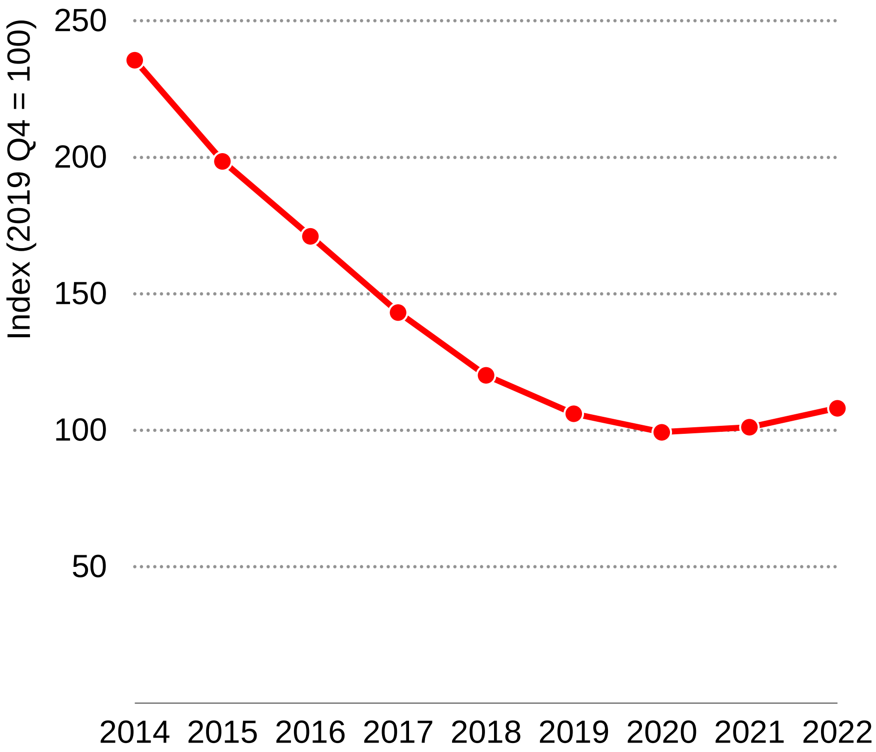
Increase in annual clean energy investment in selected countries and regions, 2019-2023e



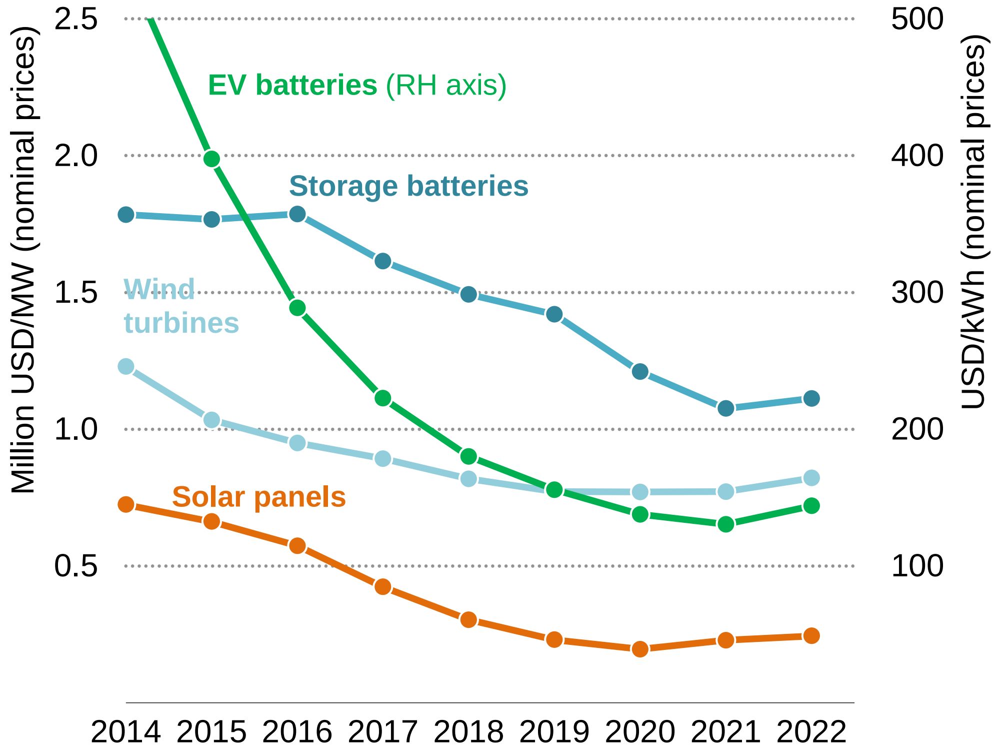
Note: 2023e = estimated values for 2023.

Clean energy costs edged higher in 2022, but pressures are easing in 2023 and mature clean technologies remain very cost-competitive in today's fuel-price environment

IEA clean energy equipment price index



Average prices for selected technologies



Notes: The IEA clean energy equipment price index tracks price movements of a fixed basket of equipment products that are central to the clean energy transition, weighted according to their share of global average annual investment in 2020-2022: solar PV modules (48%), wind turbines (36%), EV batteries (13%) and utility-scale batteries (3%). Prices are tracked on a quarterly basis with Q4 2019 defined as 100.

Notes of caution amid rising momentum behind clean energy transitions

The positive momentum behind clean energy investment is not distributed evenly across countries or sectors, highlighting issues that policy makers will need to address to ensure a broad-based and secure transition. The macroeconomic environment presents additional obstacles, with higher short-term returns for fossil fuel assets and rising borrowing costs and debt burdens. Clean energy investments often require high upfront spending, making the cost of financing a crucial variable for investors, even if this is offset over time by lower operating costs.

More than 90% of the increase in clean energy investment since 2021 has taken place in advanced economies and China. There are bright spots elsewhere: for example, solar investment remains dynamic in India; deployment in Brazil is on a steady upward curve ; and investor activity is picking up in parts of the Middle East, notably in Saudi Arabia, the United Arab Emirates and Oman. However, higher interest rates, unclear policy frameworks and market designs, financially-strained utilities and a high cost of capital are holding back investment in many other countries. Remarkably, the increases in clean energy investment in advanced economies and China since 2021 exceed total clean energy investment in the rest of the world.

After an unbroken run of cost declines, prices for some key clean energy technologies rose in 2021 and 2022 thanks largely to higher input prices for critical minerals, semiconductors and bulk materials like steel and cement. Solar PV modules were around 20% more expensive in early 2022 than one year earlier, although these price pressures have eased since. Wind turbine costs, especially for European manufacturers, remained high in early 2023, at 35% above the low levels of early 2020. Permitting has been a key concern for investors and financiers, especially for wind and grid infrastructure.

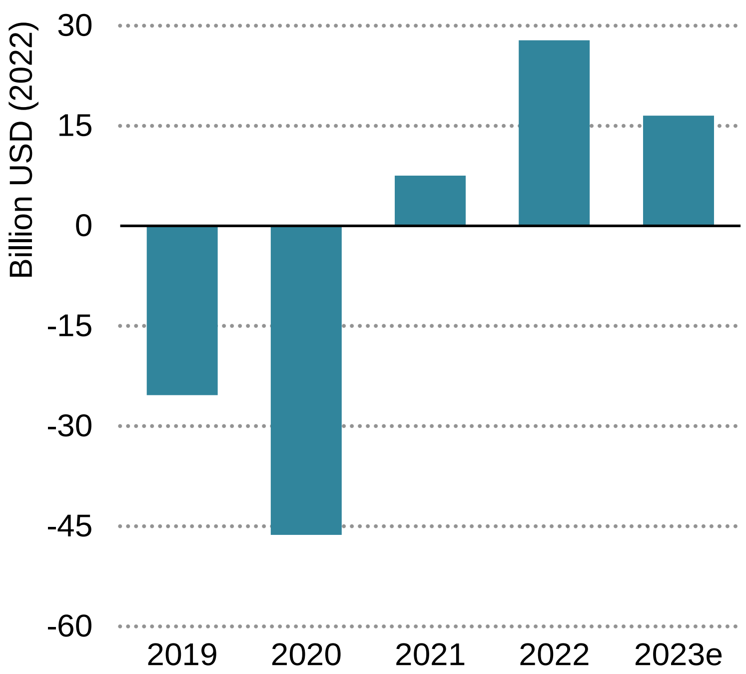
While solar deployment has been increasing year-on-year, the project pipeline for some other technologies has been less reliable. Investment in wind power has varied year-on-year in key markets in response to changing policy circumstances. Nuclear investment is rising but hydropower, a key low-emission source of power market flexibility, has been on a downward trend.

Weak grid infrastructure is a limiting factor for renewable investment in many developing economies, and here too current investment flows are highly concentrated. Advanced economies and China account for 80% of global spending and for almost all of the growth in recent years.

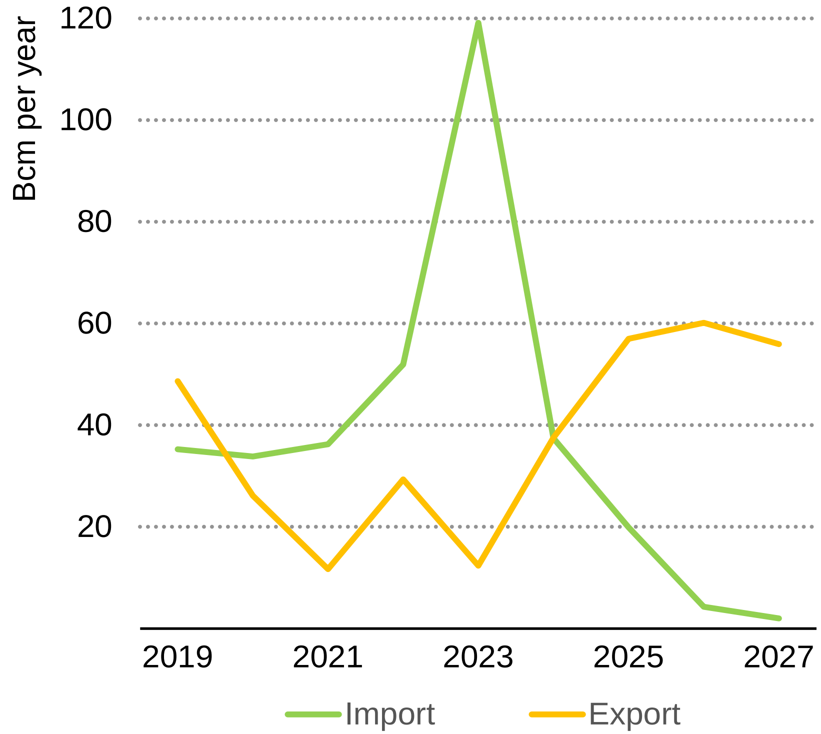
Our analysis presents a mixed picture on the prospects for energy efficiency and end use investments. They rose in 2022 thanks to the stimulus provided by new policies in Europe and North America, alongside exceptionally high energy prices. However, we expect spending to flatten in 2023 amid a slowdown in construction activity, higher borrowing costs and strains on household budgets.

Cuts in Russian gas deliveries to Europe have prompted higher investment in alternative sources of supply and in LNG infrastructure

Change in global investment in natural gas supply



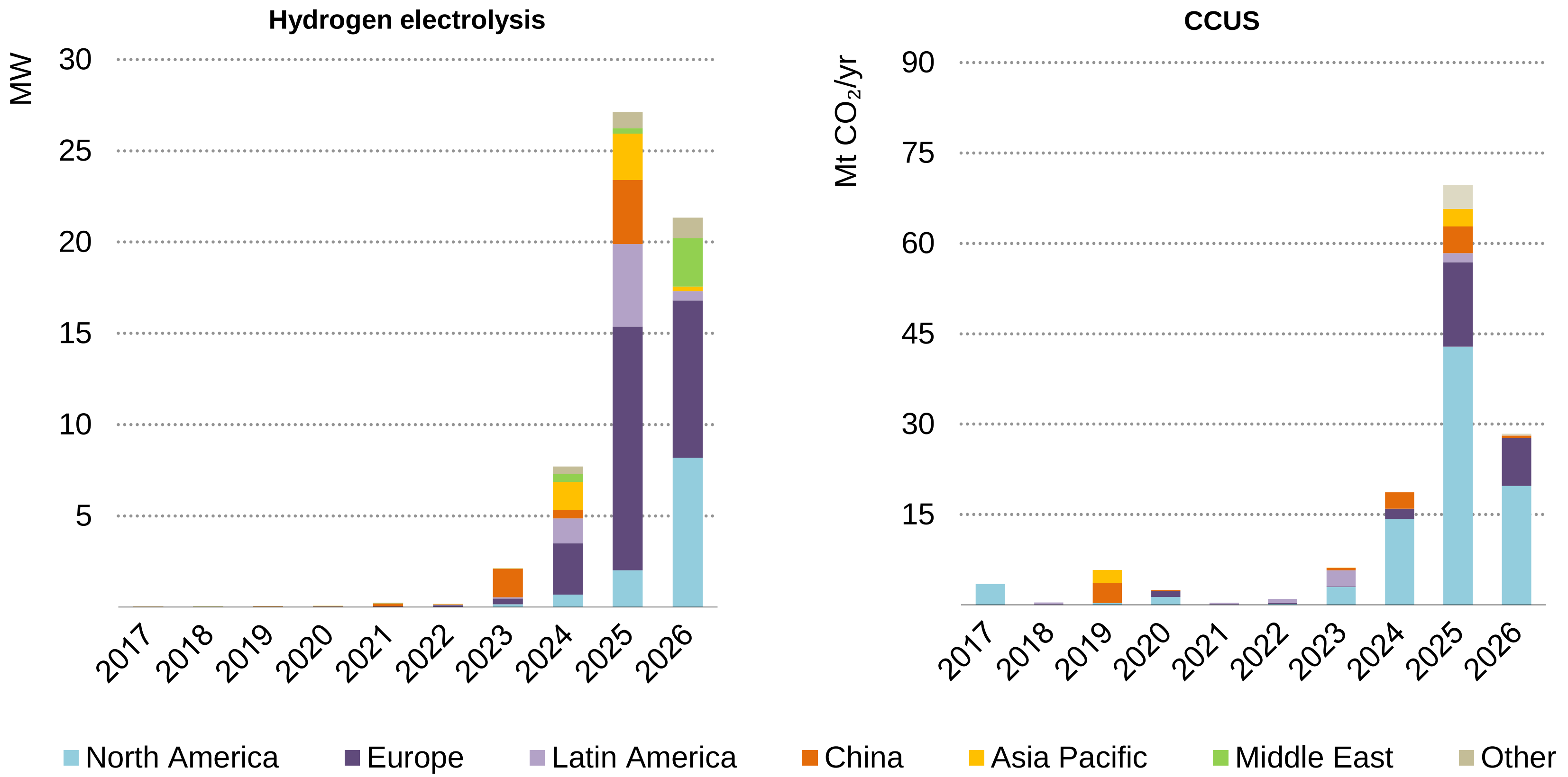
Annual LNG import and export capacity additions



Notes: "Gas supply investment" includes upstream and transport (LNG liquefaction, shipping and regasification and pipeline transmission and distribution).
2023e = estimated values for 2023.

Strong policy signals and new support schemes have triggered a rapid expansion in the project pipelines for low-emissions hydrogen and CCUS

Capacity additions for hydrogen electrolysis and CO_2 capture projects by announced start date, 2017-2026



Notes: GW = GW of electricity input; for years before 2023, actual start dates are shown; for 2023 onwards, scheduled start dates as announced by developers are shown; CCUS covers all sources of CO_2, including low-emission hydrogen projects using CCUS; data include projects at the “feasibility” stage and beyond.

Sources: IEA analysis based on IEA hydrogen project database, CCUS projects database and recent announcements.

Gas investments are caught between immediate shortfalls and longer-term uncertainty, although low-emission opportunities are growing

Russia cut pipeline deliveries of natural gas to the European Union by around 80% in 2022, seeking leverage by exposing consumers to higher energy bills and supply shortages following its invasion of Ukraine. This led to strong price and policy incentives for investors to step up non-Russian gas supply, build up alternative delivery infrastructure, and scale up alternatives to natural gas. All of these effects are visible in our analysis.

The amount of new oil and gas resources approved for development in 2022 and 2023 has been below the average level seen over the past decade. However, 2023 is seeing a 25% increase in new approvals relative to 2022 and most of these are for natural gas, reflecting the push to substitute for the shortfall in Russian supply.

A wave of new regasification capacity is also underway as countries look to secure liquefied natural gas (LNG) imports. Europe's annual regasification capacity is set to increase by 50 bcm from 2022-2025, expanding the continent's overall LNG import capacity by one-fifth. Import projects are growing even more quickly in Asia, which is set to add over 100 bcm of LNG import capacity by 2025 (more than half in China).

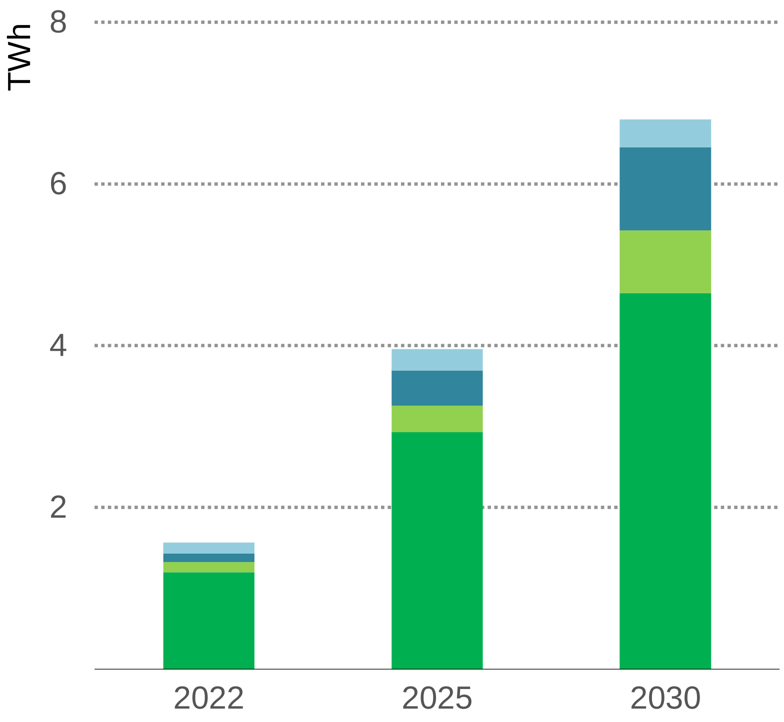
The crisis has also prompted additional investment in liquefaction capacity, the most expensive part of the gas value chain. Around 60 bcm of capacity has been given the green light since Russia's invasion of Ukraine, nearly double the rate of new approvals compared with the past decade. Along with projects already under construction, this leads to an unprecedented 170 bcm of export capacity that could come into operation between 2025 and 2027.

A key dilemma for investors undertaking large, capital-intensive gas supply projects is how to reconcile strong near-term demand growth with uncertain and possibly declining longer-term demand. This is a particular issue for Europe, given the continent's strong climate goals. Many importers have been reluctant to commit to long-term contracts for gas supply. A preference for floating regasification terminals has been a way to avoid locking in future emissions.

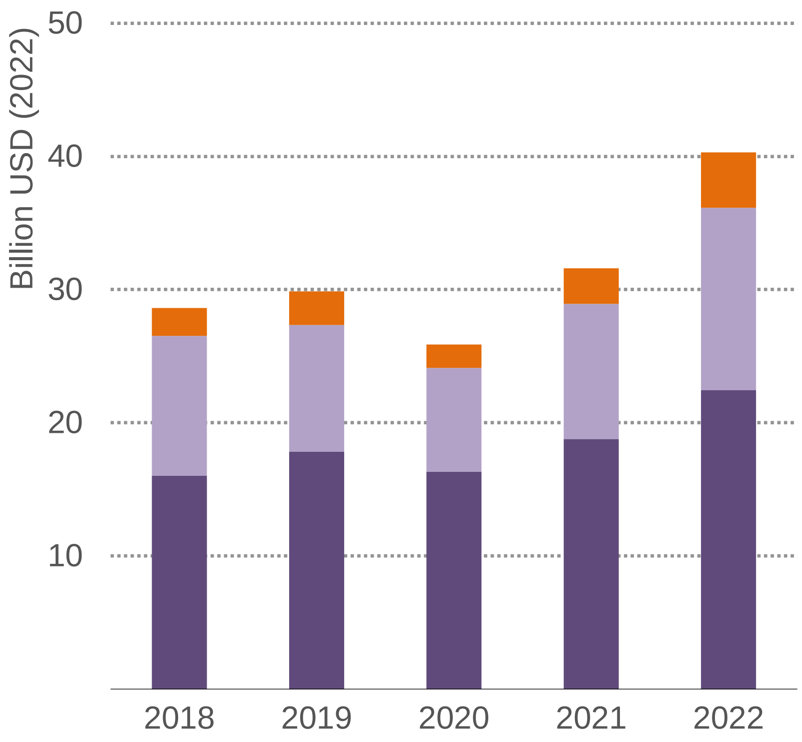
Another avenue is to expand investment in low-emission fuels and in CCUS. New policies are swelling the project pipeline in these areas, driven by energy security and climate imperatives. Europe has a burgeoning number of electrolytic hydrogen projects, and reinforced US incentives in the Inflation Reduction Act have prompted a wave of investor interest in hydrogen and CCUS. After a number of false dawns, the number of large-scale projects and well-capitalised sponsors, along with a string of acquisitions by oil and gas majors (notably in transport biofuels and biogases), suggests that investment in low-emission fuels could grow strongly in the coming years.

Investment is flowing to clean energy manufacturing and critical minerals, but ensuring well-sequenced growth of new supply chains will be a major task

Lithium-ion battery manufacturing capacity



Capital expenditure by major mining companies in the non-ferrous metals



China · Europe · United States · Rest of world · Diversified major · Cu,Ni,Co specialist · Lithium specialist

Notes: Cu = copper; Ni = nickel; Co = cobalt; the illustrative expansion of manufacturing capacity assumes that all announced projects proceed as planned.

Competition for clean energy manufacturing and for supplies of critical minerals and metals is a major issue for the resilience of transitions

A secure transition to clean energy hinges on resilient and diversified clean energy technology supply chains. According to the IEA Energy Technology Perspectives, some USD 1.2 trillion of cumulative investment to 2030 is needed in clean energy manufacturing and in critical minerals supply to get on track for a 1.5°C scenario, in addition to the energy sector investments covered in this report.

Record sales of EVs, strong investment in battery storage for power (which are expected to approach USD 40 billion in 2023, almost double the 2022 level) and a push from policy makers to scale up domestic supply chains have sparked a wave of new lithium-ion battery manufacturing projects around the world. If all capacity announcements were to materialise, then 5.2 TWh of new capacity could be available by 2030.

For the moment, China is the main player at every stage of global battery manufacturing, with the exception of the mining of critical minerals. The announced manufacturing plans would somewhat erode this position. In 2022, over 75% of existing battery manufacturing capacity was located in China. However, despite accounting for two-thirds of yearly global capacity additions to 2030, China's share of global capacity could fall by nearly 10 percentage points by the end of the decade.

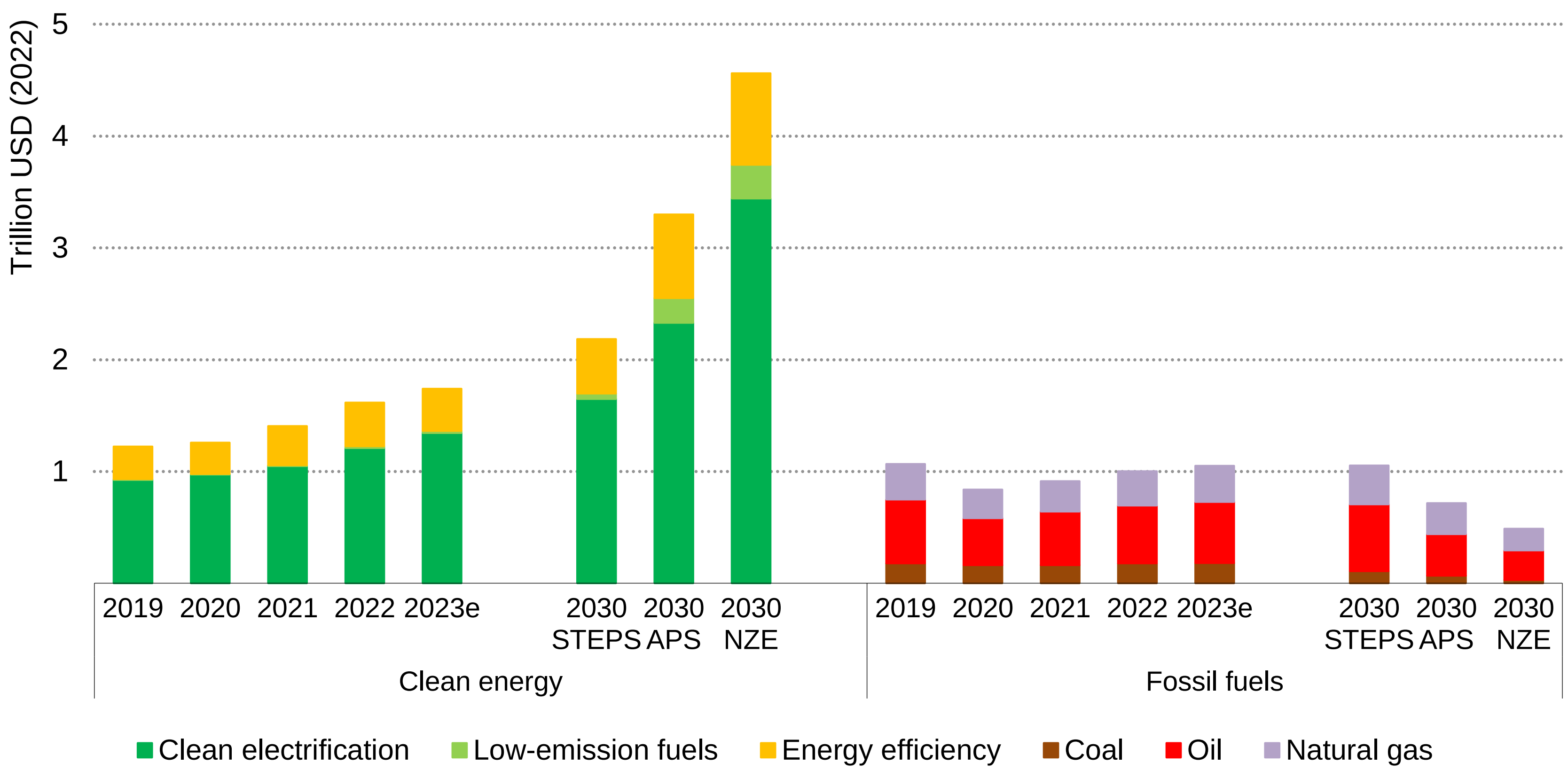
A key question for battery manufacturers is whether supplies of critical minerals will keep up with demand. Thanks to high prices and growing policy support, investment in critical mineral mining rose by 30% in 2022. Exploration spending also grew, notably for lithium, copper and nickel, led by Canada and Australia and with activities growing in Brazil and resource-rich countries in Africa. But moving from exploration to new production can take more than 10 years, and there remain widespread concerns that critical mineral investment will become a constraining factor for clean technology manufacturing and deployment.

Critical minerals and batteries are among the areas where clean technology innovation remains essential. Public spending on research and development has been on a steady upward trend, as has corporate spending. But venture capital funding for clean energy, after reaching a high in 2022, faces headwinds in a more difficult macroeconomic environment.

For a decade, cheap capital has lowered barriers to investment in riskier bets and thereby concealed potential weaknesses in innovation systems. With the cost of money set to rise, the health of these systems and the level of public support will be a critical determinant of how quickly new technology ideas continue to flow.

Scaling up clean investment is the key task for the sustainable and secure transformation of the energy sector

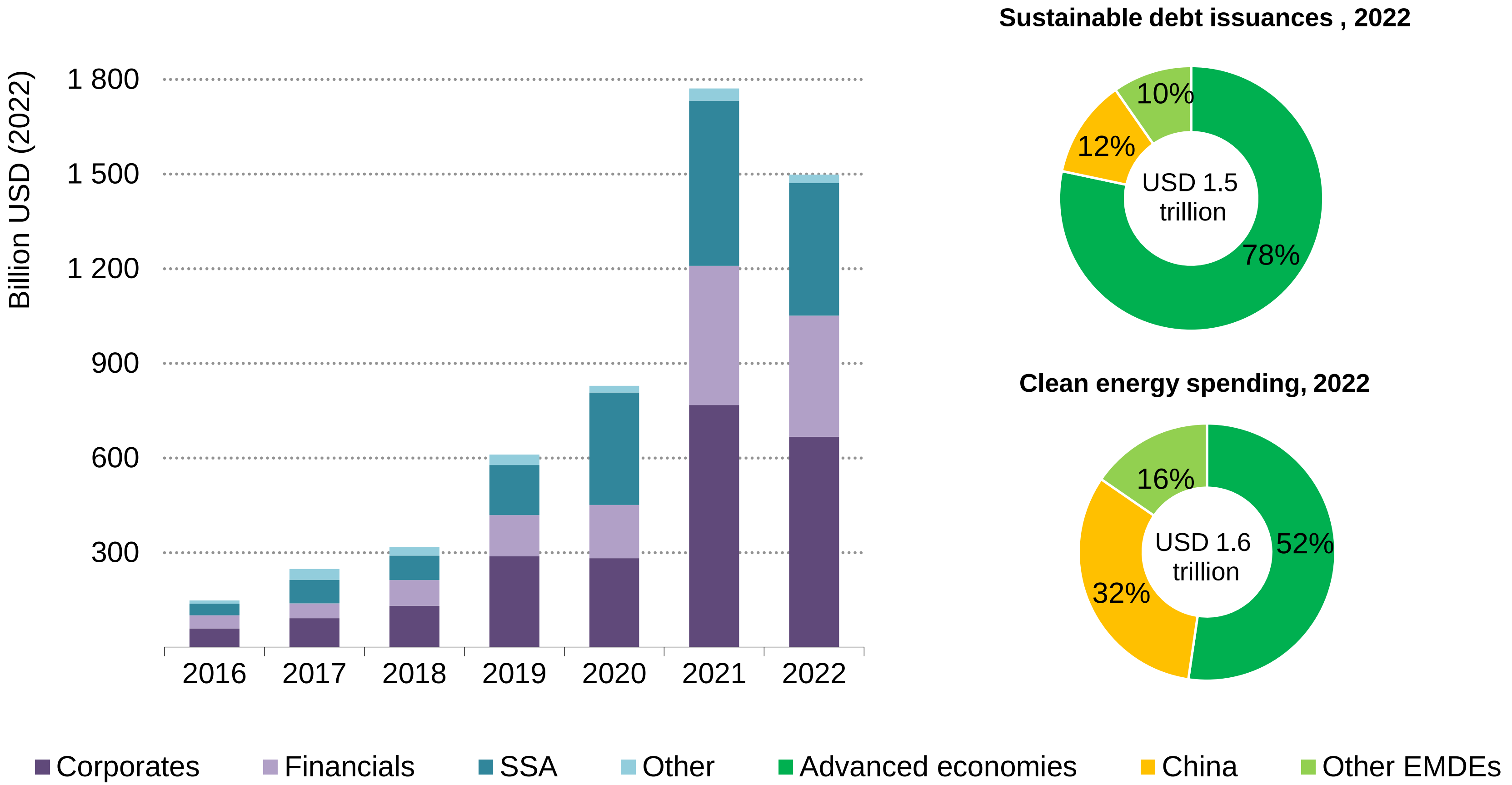
Historical investment in energy benchmarked against needs in IEA scenarios in 2030



Notes: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario; NZE = Net Zero Emissions by 2050 Scenario. 2023e = estimated values for 2023.

Expanding access to finance will be vital: sustainable finance has weathered the storm of the energy crisis, but remains heavily concentrated in advanced economies

Sustainable debt issuances by issuer type, and region, 2016-2022



Notes: SSA = sovereigns, supranationals and agencies; this category also includes municipals; Other = asset-based securities and project bonds.
Sources: Bloomberg; Refinitiv.

Clean energy investment is starting to flow, but imbalances point to continued risks ahead

In the IEA World Energy Outlook 2021, we wrote that "the world is not investing enough to meet its future energy needs … IEA analysis has repeatedly highlighted that a surge in spending to boost deployment of clean energy technologies and infrastructure provides the way out of this impasse, but this needs to happen quickly or global energy markets will face a turbulent and volatile period ahead".

This picture is starting to change: global energy investment is picking up, and the rise in clean energy investment since 2021 is leading the way, outpacing the increase in fossil fuel investment by almost three-to-one. Clean electrification is leading the charge. If it continues to grow at the rate seen since 2021, then aggregate spending in 2030 on low-emission power, grids and storage, and end-use electrification would exceed the levels required to meet the world's announced climate pledges (the APS). For some technologies, notably solar, it would match the investment required to get on track for a 1.5°C stabilisation in global average temperatures (the NZE Scenario).

However, progress has been uneven. Investment in expanding and modernising grids is lagging behind in many countries. A rising share of solar and wind needs to be accompanied by spending on technologies that provide greater flexibility to power systems. Supply chain and skills bottlenecks could constrain growth. And, above all, the geographical imbalances in investment need addressing, with clean energy investment in many emerging and developing economies growing only slowly and the number of people without access to modern energy services remaining stubbornly high.

Other pillars of clean energy transitions do not yet show the same positive dynamics as clean electrification. Investment in energy efficiency has been increasing, but is well off track to meet more ambitious climate scenarios. Investment in low-emission fuels is being spurred by new policy measures, but from a very low base.

Spending on fossil fuels is most closely aligned with the 2030 needs of a scenario reflecting today's policy settings (STEPS), but producers need to watch closely how clean energy spending evolves, particularly the ways in which clean electrification affects demand for fuels in power generation, and for mobility and heat. The risks of locking in fossil fuel use are clear: fossil fuel investment in 2023 is now more than double the levels required to meet much lower demand in the NZE Scenario.

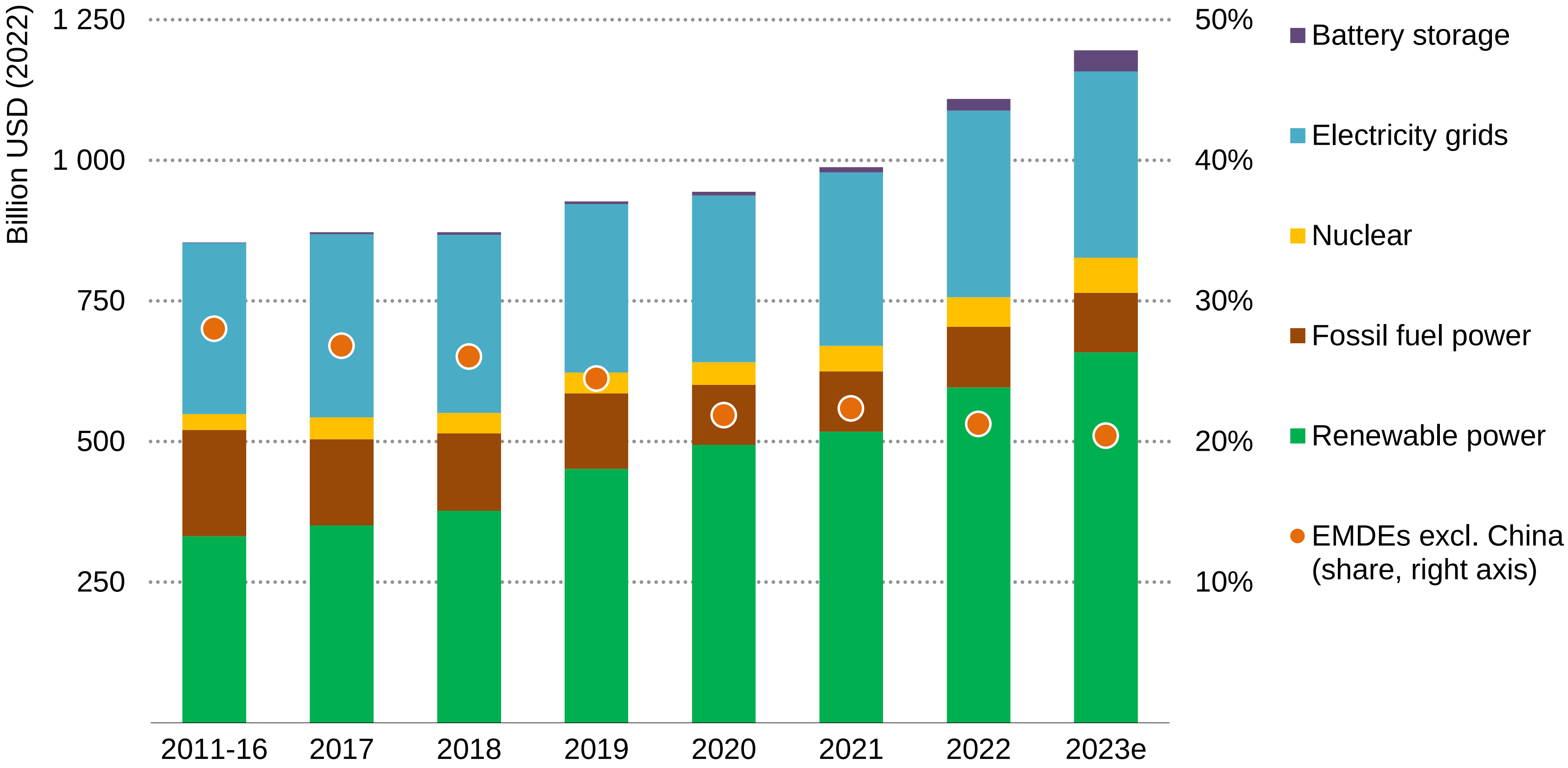
The crucial open question is how quickly clean energy investment scales up in emerging and developing economies, where supportive strategies and policies will need to be accompanied by improved access to finance. For the moment, sustainable finance instruments remain concentrated in advanced economies, accounting for nearly 80% of sustainable debt issuance in 2022. Issuances elsewhere (outside China) are growing from a low base, with India's successful first green bond a landmark in this sector. Scaling up these instruments and mobilising much greater support from development finance institutions will be critical to the continued broadening and acceleration of clean energy transitions.

Power sector

Overview of power investment

Power sector investment increased by around 12% in 2022 to USD 1.1 trillion with 2023 expected to see further growth to almost USD 1.2 trillion

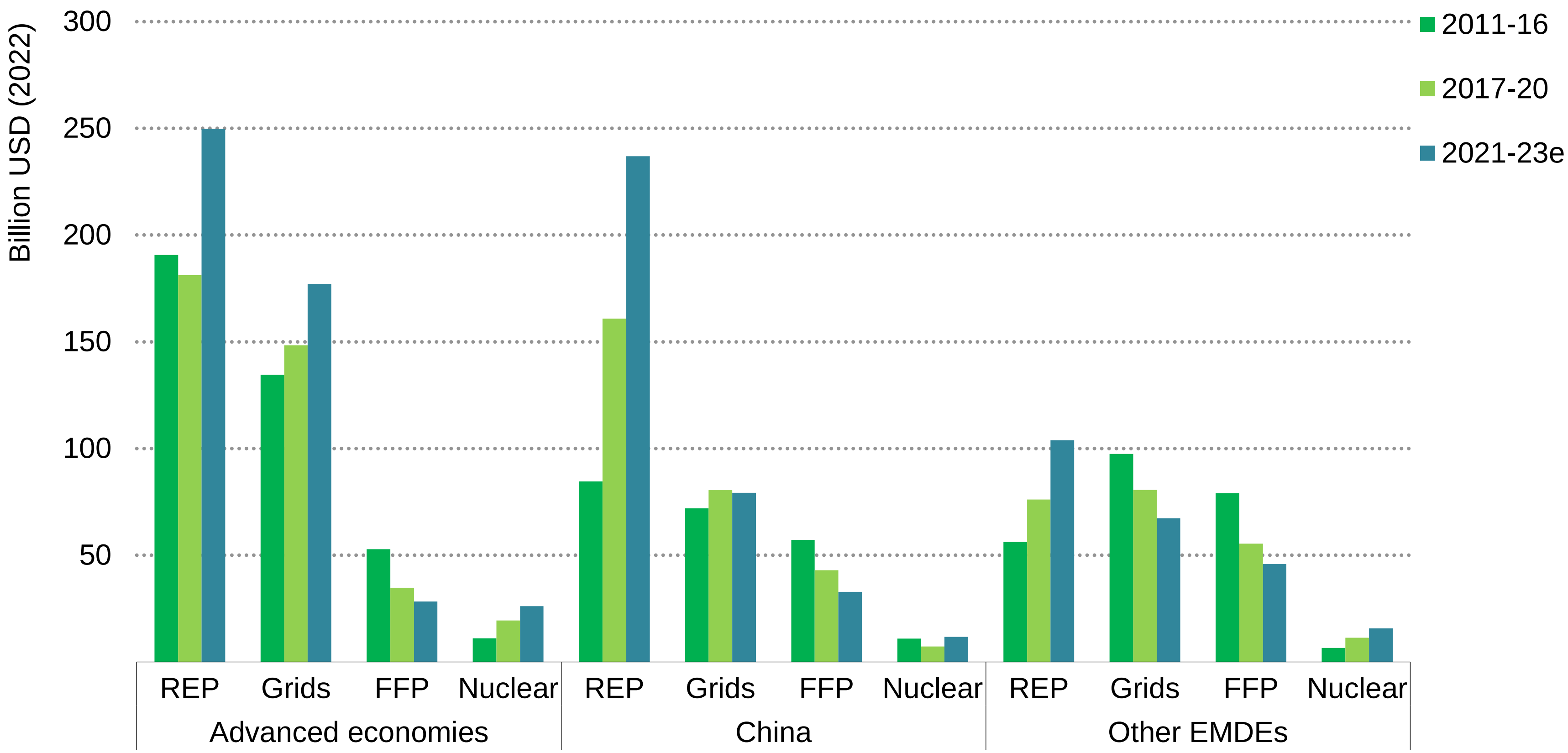
Global average annual investment in the power sector by category, 2011-2023e



Notes: Investment is measured as ongoing capital spending on new power capacity; all numbers throughout are in 2022 USD; Fossil fuel power includes unabated and abated power; EMDEs = emerging market and developing economies; 2023e = estimated values for 2023.

Advanced economies and China lead investment in renewable power generation and grids, while many other EMDEs struggle to mobilise sufficient capital for a clean and secure energy transition

Average annual investment in the power sector by geography and category, 2011-2023e



Notes: REP = renewable power; FFP = fossil fuel power; batteries are excluded here; 2023e = estimated values for 2023.

Investment in renewables, grids and batteries has accelerated during the global energy crisis, with capital spending on unabated fossil fuel power generation edging downwards

Power sector investment grew by 12% in 2022, topping USD 1 trillion for the first time, with 2023 expected to see further growth to almost USD 1.2 trillion. Our tracking of capital flows and investments suggests that a major effect of the global energy crisis has been to accelerate the deployment of clean energy technologies. The strong underlying economics of renewables have been reinforced by policy packages such as the US Inflation Reduction Act, the EU REPowerEU plan and Fit-for-55 package, and India's renewables targets. Renewables and grids are the leading components of power investment and are expected to account for more than USD 1 trillion of investment on their own in 2023.

Global spending on renewables hit a new record in 2022 at almost USD 600 billion, driven by solar PV and wind (especially in China) despite cost and supply chain pressures. Given the reinforced push for renewables in a range of large markets (e.g. USA, China, Europe, India) and the gradual unwinding of supply chain problems, we are now expecting higher capacity additions for wind and especially solar PV than last year, with 2023 expected to see another 10% increase in renewables investment to more than USD 650 billion.

Capital expenditure on fossil fuel power increased marginally in 2022 to almost USD 110 billion but this was still significantly lower than the annual average of USD 135 billion in the period 2016-2021. While coal-fired power investment decreased, investment in gas-fired power picked up. Spending on fossil fuel power with CCUS rose but remains marginal at USD 1 billion. Spending on dispatchable clean generation, on the other hand, continues its downward investment trend, with increased spending on nuclear not able to compensate for a drop in hydropower investment.

Spending on electricity grids built on its 2021 rebound with a further 8% increase in 2022, but initial signs suggest a flattening in spending in 2023. Most of the infrastructure investment is in advanced economies and China, underpinned by the need to enable greater electrification and meet grid balancing demands in power systems that are increasingly renewables rich. Spending on grids in most emerging market and developing economies (EMDEs) is falling behind, a worrying signal given the prospect of rapid increases in electricity demand. Battery storage investment in 2022 grew in line with our strong expectations and is set for further growth in 2023, encouraged by the US Inflation Reduction Act and other incentives in Europe, Australia, China, Japan and Korea.

Despite upbeat expectations for clean power, final investment decisions (FIDs) in 2022 had a mixed picture. Solar project approvals remain strong, while offshore wind lags behind. FIDs for coal- and gas-fired plants reached their highest level since 2016, driven almost entirely by China, reflecting security of supply concerns.

Outside China, power sector spending in many EMDEs remains low; it needs to pick up quickly to meet access, security and sustainability goals

Power sector investment in EMDEs outside China has been averaging around USD 230 billion per year in recent years, only around 20% of the global total. This figure increased by 7% in 2022, but investment spending in advanced economies and in China rose more rapidly by 14%, reaching more than USD 850 billion.

A number of EMDEs are stepping up their efforts to deploy clean power. India remains a dynamic market, in particular for solar PV, with policy makers also focused on building out the grid, promoting new sources of flexibility in power markets, and encouraging the domestic supply chain. India's Production-Linked Incentive (PLI) scheme is providing incentives for domestic manufacturing of high-efficiency solar PV modules as well as for batteries.

Renewable power investment is also starting to pick up in the Middle East, notably for solar in Saudi Arabia, the United Arab Emirates and Oman. Deployment is on a steady upward curve in Brazil. South Africa concluded the sixth round of its Renewable Energy Independent Power Producer Procurement Program. New power projects are urgently needed to relieve chronic power shortages: the South African authorities even declared a "state of disaster" in the energy sector from February-April 2023. Investments in renewables should also benefit from the Just Energy Transition Partnerships (JETPs) that South Africa, Indonesia and Viet Nam have signed with international partners and financial institutions. JETPs aim to boost clean power and reduce reliance on coal assets, while addressing the social implications of change. Kenya also lifted a ban on new power purchase agreements (mainly affecting renewable projects).

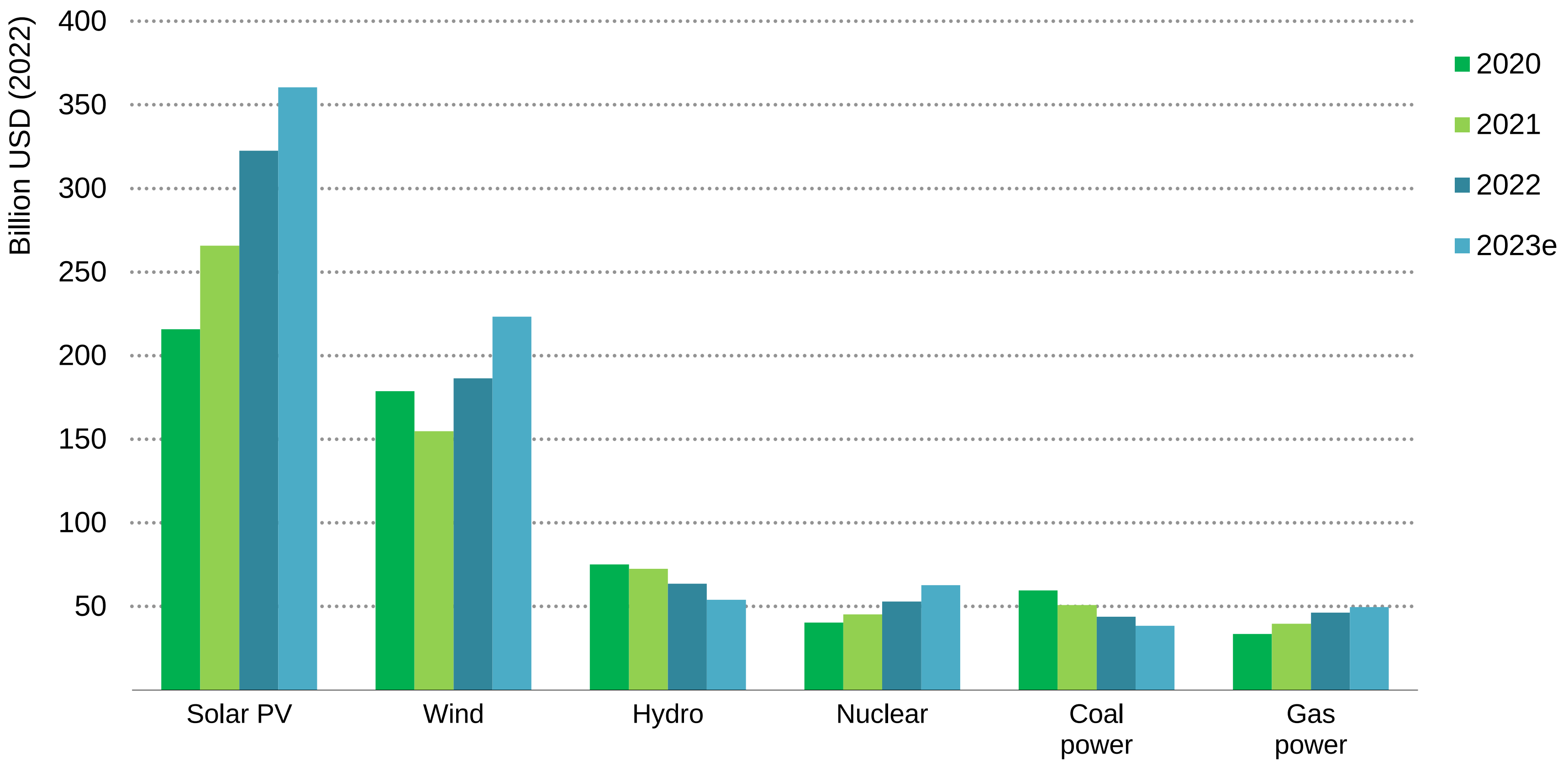
However, the landscape for renewable power investment in many EMDEs remains difficult, and much more needs to be done to improve perceived and real investment risks and to reduce costs. Greater investment in clean power in EMDEs is hindered by a range of barriers such as higher financing costs, high debt burdens of electric utilities and the absence of clear clean energy strategies, as well as challenges related to land acquisition, enabling infrastructure and skilled labour. Low levels of spending on grids (even compared with past spending averages in EMDEs) exacerbate challenges with security of supply and electricity access, as well as leaving EMDEs ill-prepared for increased investment in variable renewables.

A step up in concessional funding and other dedicated multilateral support is critically important to increase clean power investment. The upcoming Summit for a New Global Financial Pact, which aims to define a new financial pact with EMDEs, will be an important stepping stone towards realising this goal. A forthcoming joint IEA-IFC report will provide analysis and recommendations.

Generation

Variable renewables are by far the most dynamic sectors for investment in power generation…

Global annual investment in the power generation by selected technology, 2020-2023e

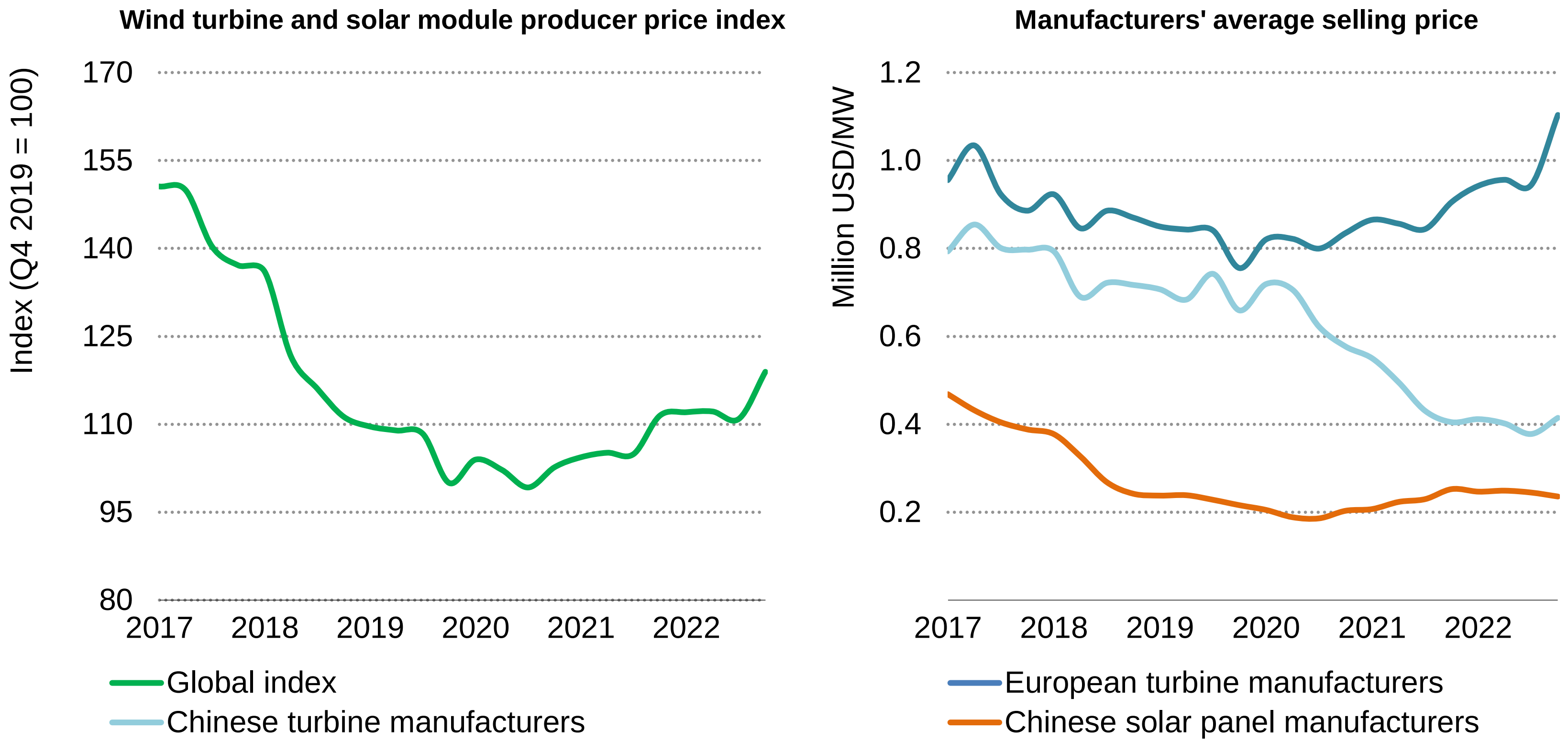


Notes: Gas-fired generation investment includes both large-scale plants and small-scale generating sets and engines; hydropower includes pumped-hydro storage; 2023e = estimated values for 2023.

Sources: IEA analysis based on calculations from IRENA (2023) and S&P Global (2023).

…despite tight supply chains and higher input costs pushing up renewable project costs in many markets

IEA global wind turbine and solar PV module producer price index and average manufacturing prices among key regions

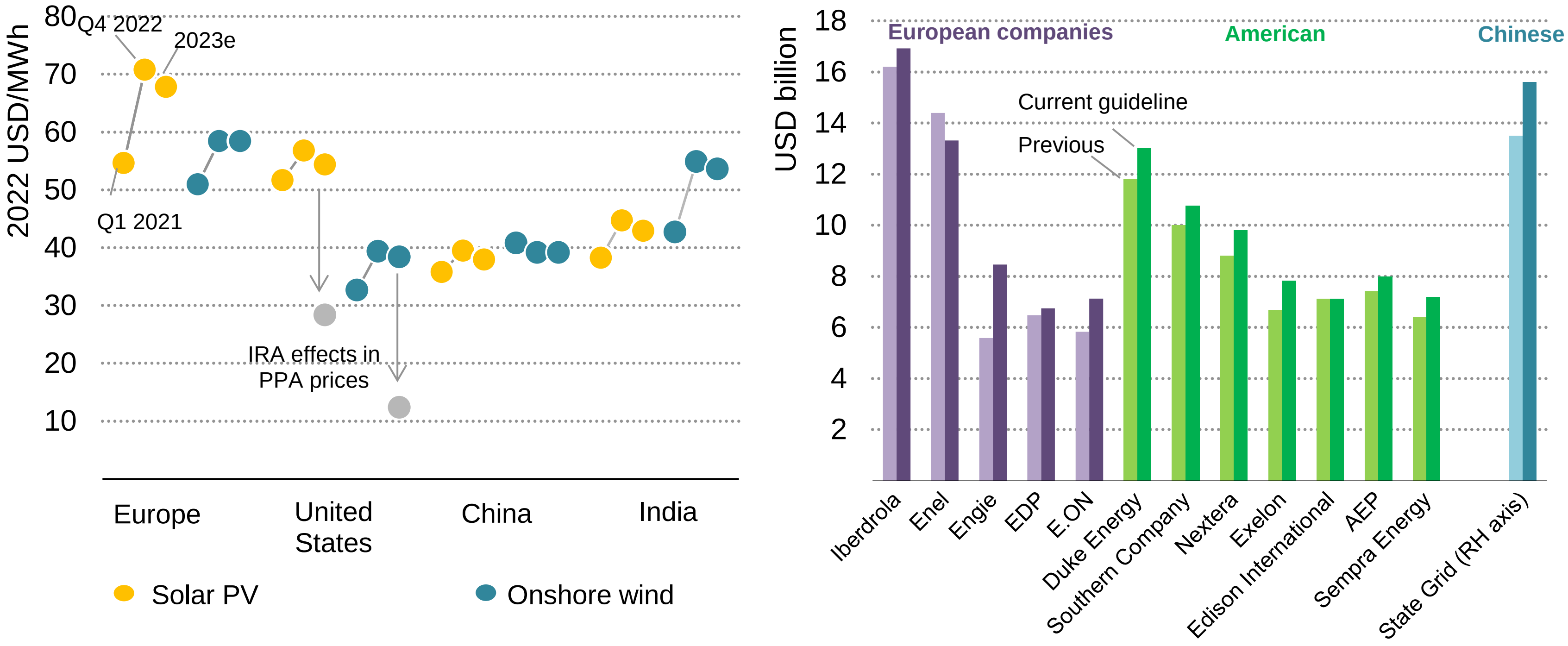


Notes: The index, developed by the IEA, tracks price movements of a fixed basket of solar PV panels and wind turbines against a base period (Q4 2019); prices are weighted according to the shares of global average annual investment in 2020-2022: solar modules (58%) and wind turbines (42%); wind turbine prices reflect a weighted average of both onshore and offshore turbine manufacturers' prices, noting that this is more sensitive to changes in onshore turbine prices given that they account for a larger share of production; given that the supply of solar PV modules is highly geographically concentrated (with the majority of production based in China), and data availability constraints, where only the price trends of Chinese manufacturers are included.

Sources: IEA calculations based on companies' financial reports, Bloomberg data and BNEF.

Power company investment plans remain robust, even as levelised costs for renewables moved higher

LCOE estimates of utility-scale solar PV and wind; and average annual short-term investment guidelines of selected power companies

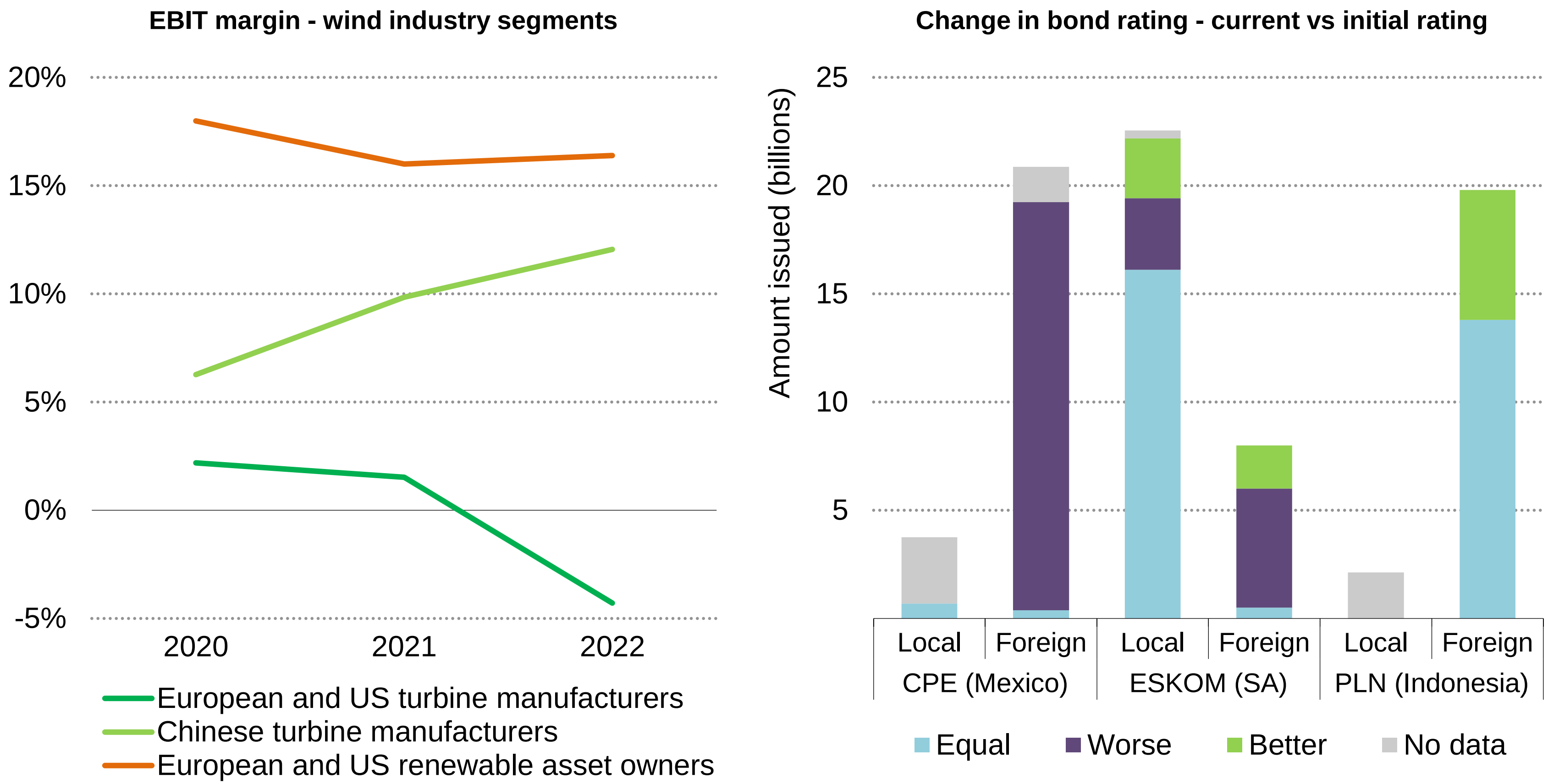


Notes: LCOEs calculations assume increases in the cost of capital in Europe, United States and India between Q1 2021 and Q4 2022 for both solar PV and wind, while remaining constant in 2023e. Capital costs are assumed to increase in Q4 2022 across the four regions (except wind in China) and reduce or remain flat in 2023, though not totally compensating for the 2022 increase. Capacity factors are consistent with WEO 2022. IRA effects assume a 26 USD/MWh of production tax credit. Annual company investment reflects nominal capital spending guidelines (for all group-level related activities) published in annual reports or strategic plans; for example, if a company announced an investment of USD 15 billion over 2020-2023 and USD 18 billion over 2023-2025 (most recent announcement) this is reflected as USD 5 billion (previous) and USD 6 billion (current); figures for Indian companies were not included as data were unavailable; the drop in Enel's figures is due to Enel streamlining its business (e.g. exiting Argentina, Peru and Romania), but its investment in other geographies remains as planned. 2023e = estimated values for 2023; IRA = US Inflation Reduction Act; LCOE = levelised cost of electricity

Sources: Companies' annual reports.

Some key parts of the power investment chain are showing greater signs of stress

Profitability of major wind turbine manufacturers and asset owners; and change in bond rating of SOEs in selected EMDEs



Notes: EBIT = earnings before interest and taxes, annual basis; European and US manufacturers represent a weighted average (by market share) of Vestas, Siemens Gamesa, Nordex and GE; Chinese manufacturers represent a weighted average (by market share) of Goldwind, Windey and Mingyang; European and US asset managers represent a simple average of Nextera, Ørsted, Iberdrola, RWE and Enel; SOE = state-owned enterprise; "Worse" means that the bond's rating has been downgraded; "Better" means that the bond's rating has been upgraded; "No data" means no data on rating available; "Foreign" refers to bonds issued in USD or EUR.

Sources: Companies' annual reports, Wood MacKenzie and Bloomberg.

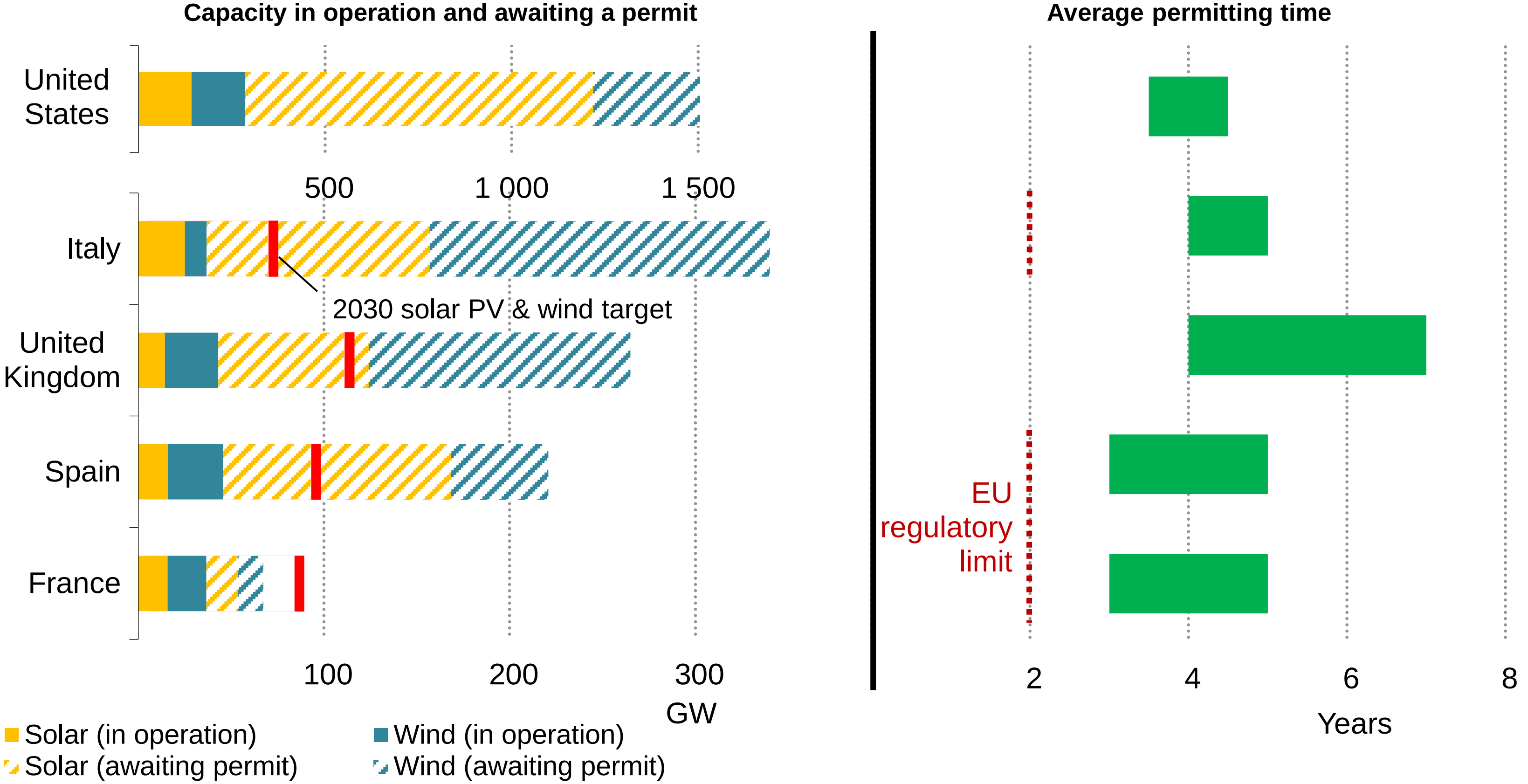
New policies are providing an important boost to the prospects for low-emission power

Key low-emission power policies introduced and proposals announced in 2022-2023 in selected countries and regions

Region	Policies
United States	• Approval of the Inflation Reduction Act o Tax credit extensions for solar PV and wind: production credit (per unit of energy) and investment credit (capital costs) o Investment tax credit also available for battery storage and zero-emission nuclear o Financial support for grids and manufacturing clean power equipment
China	• 14th Five-Year Plan raises renewable target to 33% of power consumption by 2025 (and 18% for non-hydro renewables)
Europe	• Announcements by the European Commission: REPowerEU Plan, Net-Zero Industry Act proposal and other potential reforms o Increase EU 2030 renewables target to 45% by 2030 (whole energy matrix not just power) o Fast-tracking permitting process plus ~EUR 225 billion in loans for grids o Proposed reform of market design and technology-specific targets for EU manufacturing capacity • Nine European countries committed to boost offshore wind capacity to over 120 GW by 2030 and over 300 GW by 2050
Indonesia and Southeast Asia	• Indonesia introduced its JETP o Renewable energy target up to at least 34% of power generation by 2030, accelerate coal power plant retirement and achieve net zero emissions in the power sector by 2050 o USD 20 billion of initial funding • Thailand introduced new regulation for renewable power procurement, establishing the feed-in tariffs payable by distribution companies and capacity targets (additional 5 GW of biogas, solar, solar with storage, and wind) • Philippines set out a 35% renewable electricity generation target by 2030 (from about 20% in 2021) and 50% by 2040
India	• Continues to expand the Production-Linked Incentive (PLI) scheme o 50 GWh of battery manufacturing capacity o 40 GW of solar PV manufacturing capacity to be added in next three years
Japan	• Government is studying extension to lifetime of nuclear power plants (beyond 60 years)
Korea	• Plan to increase nuclear power to 35% of total generation and renewables to 31% from 10% in 2021 by 2036 • Coal-fired power to reduce to 15%
South Africa	• Government concluded sixth renewable auction
Brazil	• Planning two major transmission auctions in 2023, including the largest ever held in Brazil (in investment terms)

But getting projects up and running has often been slow, putting the focus on permitting and other practical obstacles facing investors

Capacity awaiting permits and under construction and average permitting times in the United States and major European renewable markets



Notes: United States, United Kingdom and France show capacity in December 2023; Italy shows capacity in January 2023 and Spain in March 2023; wind includes onshore and offshore.

Sources: Red Eléctrica, Terna, Ministère de la Transition Energétique, National Grid and Lawrence Berkeley National Laboratory; BNEF (average waiting times).

Solar PV made most of the headlines for power generation investment in 2022, although increased financing and capital costs were also part of the story

Capital spending on new generation has been setting new records each year, driven by strong performances from solar, and we expect the same to be true in 2023. China alone added over 100 GW of solar PV capacity in 2022, almost 70% higher than in 2021, and annual installations increased by 40% or more in Europe, India and Brazil, despite inflation and supply chain issues. Investment in wind power increased, albeit less than solar (as mainly large projects continue to face delays) while spending on hydropower continued to fall.

Nuclear power investment also rose, mainly in advanced economies and China. More than a decade after the accident at Fukushima Daiichi, an increasing number of countries are taking a fresh look at how nuclear technologies might provide low-emissions and dispatchable power. Investment in fossil-fuel based electricity was flat, reflecting lower spending on unabated coal power alongside higher investment in gas-fired plants.

Despite the growth in many sectors, power generation investment in 2022 faced some headwinds. On the financing side, the cost of borrowing increased as base rates rose to fight inflation. Equity risk premiums – the premium above risk-free rates that equity investors expect for an average unit – have gone up across the world. This is problematic as highly leveraged companies, like many power utilities, may have to tap into the equity market for financing as higher leverage (more debt) could affect their credit ratings.

A global producer price index of solar PV modules and wind turbines developed by the IEA shows that prices fell to a low point in Q3 2020 but then were pushed up by tight markets for materials and labour, ending 20% higher in Q4 2022. Module prices were around 20% higher in early 2022 y-o-y, but started to come down in early 2023 as input costs declined (solar grade silicon and wafers) and manufacturing capacity expanded (largely in Asia). Wind turbine costs, especially from European manufacturers, remained high in early 2023, at 35% above the low levels of early 2020.

China has followed a different path. Debt financing remained favourable as the People’s Bank of China has kept reference lending rates low to boost the economy and renewable projects can access preferential rates. Capital costs for solar PV increased slightly in 2022 before falling back, while wind capital costs were less affected than elsewhere. The price of local wind turbines continued to decrease given Chinese manufacturers’ ability to manage supply chain pressures and a growing number of orders.

Solar and wind retain a strong competitive advantage, although pressures are higher in the wind sector and the conditions for mobilising capital in EMDEs remain challenging

The rise in project costs has translated into a higher levelised cost of electricity (LCOE) across technologies. LCOEs for solar PV and wind, having fallen for years, increased in 2022, but remained a more attractive proposition than fossil fuel power for new generation in most markets around the world.

In Europe the average LCOE for solar PV increased by 30% and by 15% for onshore wind between early 2021 and late 2022, despite continued gains from technology learning. However, absolute values remain low and capital cost pressures are expected to ease in 2023. Investment plans by major European utilities also remain strong. Wholesale power prices have fallen compared to a year ago, but are still high in historical terms, an additional signal for investors, although it remains to be seen how the proposed changes to the EU power market design may affect investors' views.

Recent years have been challenging for the wind equipment manufacturing industry outside China. The average ratio of earnings before interest and taxes (EBIT) to revenues among the largest European and US turbine producers has been meagre if not negative. This measure of a company's profitability saw a big drop in 2022 as revenues were hit hard by supply chain delays, inflationary pressures and in some cases impairments due to Russia's invasion of Ukraine. Higher prices are also contributing to lower order intakes, even as the help near-term results, which are also being assisted by improvements in the service business.

Most EMDEs outside China are experiencing higher costs, especially where investments are denominated in US dollars. State-owned utilities – often the main investor and counterparty with the private sector in EMDEs – remain financially fragile, and rising interest rates and falling domestic currencies make it harder to pay their existing debt, let alone invest. More attractive conditions for renewables investments in advanced economies may also discourage capital from flowing into countries with higher real or perceived risks. India's size and well-developed policy frameworks, especially for solar, underpin continued strong interest from investors and project developers, although offtaker and transmission risks remain.

LCOEs for solar PV and onshore wind rose in the United States in 2022, but PPAs are set for important reductions given the tax extensions in the Inflation Reduction Act. In China LCOEs for solar PV were also up in 2022, while wind LCOEs fell. After subsidies for onshore wind were removed in 2020, investment appetite reduced, forcing domestic turbine makers to slash prices. Increased orders helped offset lower prices for manufacturers, but competition remains strong. Manufacturers have also focused on building bigger turbines, and on innovation and cost control.

Ambitious new policies to accelerate clean power investments are in place, but there are uncertainties over how quickly these will translate into flows of new projects

The passage of the Inflation Reduction Act in the United States was a major legislative milestone that included significant financial support for low-emission technologies. It includes new or extensions to tax credits for wind, solar PV and storage based on project investment costs (USD) and generation (USD/MWh), tax credits for local manufacturing and grid upgrades, and various other forms of assistance.

The European Union is looking to increase deployment of renewables across power generation and the end-use sectors as part of its goal to reduce greenhouse gas emissions by at least 55% by 2030 and to address the energy market disruption caused by Russia's invasion of Ukraine. A provisional agreement was reached in March 2023 to raise the EU's renewable target for 2030 to a minimum of 42.5% of final energy consumption, up from the current 32% target. The European Commission also proposed a Net Zero Industry Act, which targets domestic manufacture of up to 40% of Europe's clean energy technology deployment needs by 2030. The act would cover eight technologies and simplify regulation, supported by existing funding channels (e.g. InvestEU; the Recovery and Resilience Facility).

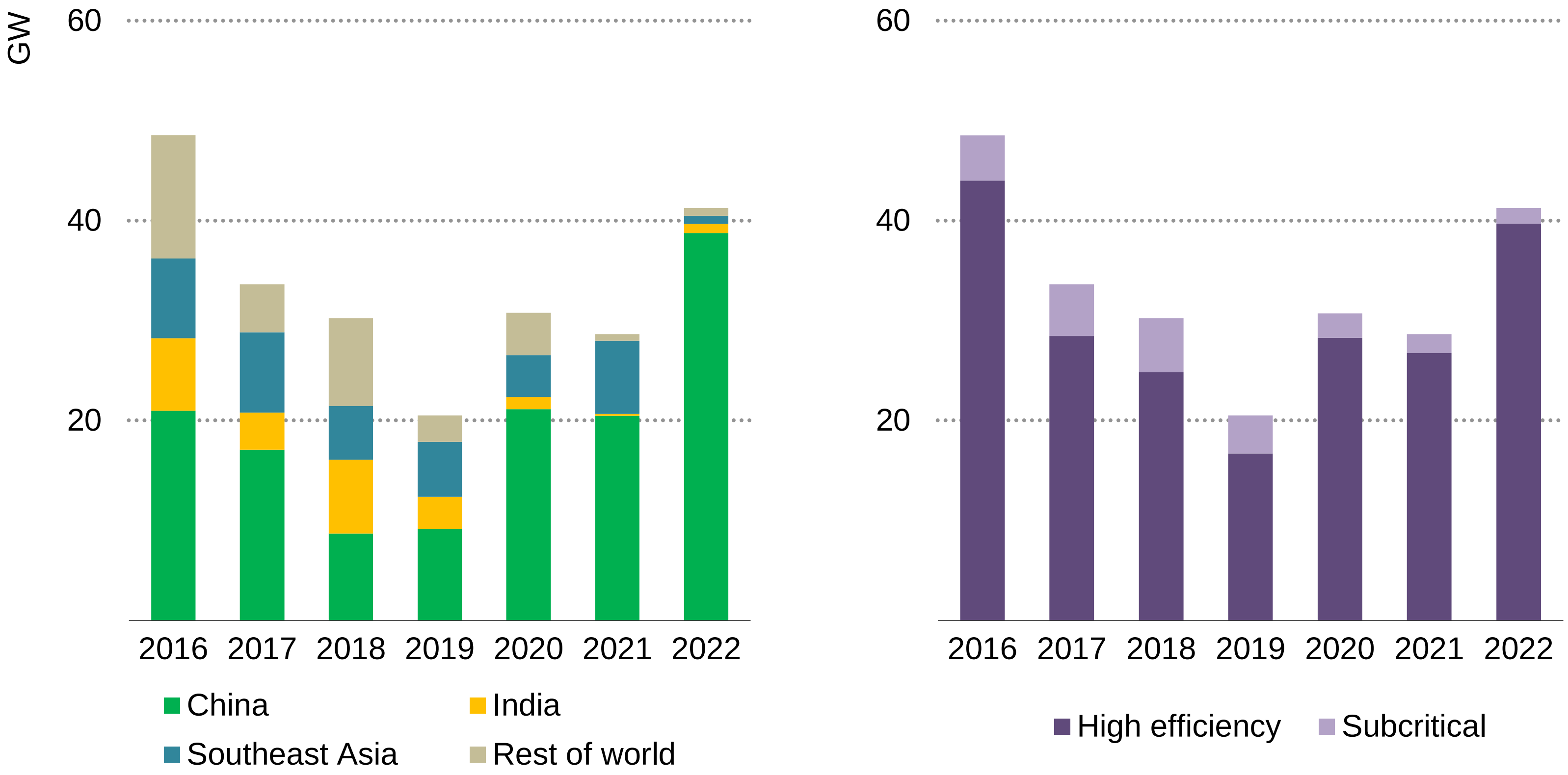
In many parts of Asia, policies supporting both renewables and nuclear power are on the rise. Japan is discussing legislation to extend nuclear power plant lifetimes beyond 60 years and South Korea's 10th Electricity Plan incorporates a slightly higher share of nuclear power in the generation mix (35% by 2036) as well as a sharp increase in the share of renewables to 31% by 2036 (up from 7.5% in 2021) Among EMDEs, Indonesia and Viet Nam concluded JETPs to accelerate the energy transition away from fossil fuels and towards renewables. Indonesia's JETP, for instance, expects to receive USD 20 billion of initial funding over the next three to five years, with capital coming from both commercial and concessional sources, and private as well as public money.

Getting projects up and running at the scale and speed needed to reach targets is proving hard, with challenges beyond prices. Permitting has been a key concern for investors and financiers recently, especially for wind and grid infrastructure. Europe has been at the centre of this debate, with substantial renewable capacity in the pipeline waiting for permits, and queues well beyond set limits. Governments are now enacting policies to address this issue. Other risks include transmission bottlenecks (either missing or poor-quality grid infrastructure to connect new renewable projects) and shortages of skilled labour.

Final investment decisions (FIDs)

More than 40 GW of coal-fired plants were approved in 2022; almost all of this was in China, reflecting a strong electricity security priority even as low-emissions power scales up fast

Coal-fired power generation capacity subject to a FID by geography (left) and segment (right), 2016-2022

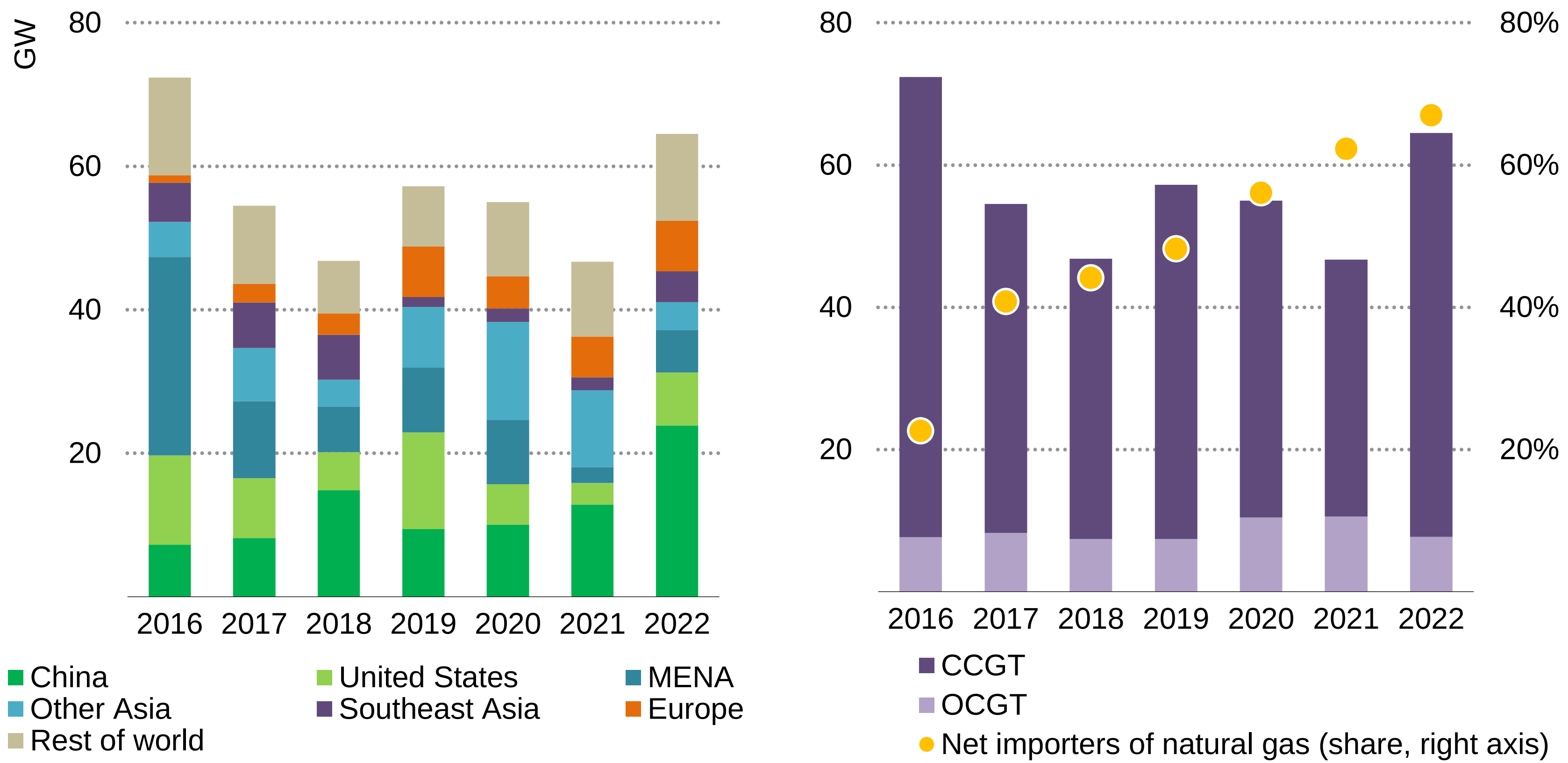


Notes: FID = final investment decision; FIDs are an indication of the scale of future capacity to come online in the coming few years; the IEA tracks projects that reach financial close or begin construction to provide a forward-looking indicator of future capacity additions and spending activity.

Source: IEA calculations based on McCoy Power Reports (2023).

Despite high natural gas prices, FIDs for unabated gas-fired power generation rose in 2022

Gas-fired power generation capacity subject to a FID by geography (left) and segment (right), 2016-2022



Notes: MENA = Middle East and North Africa; CCGT = combined-cycle gas turbine; OCGT = open-cycle gas turbine; FIDs are an indication of the scale of future capacity to come online in the coming years; the IEA tracks projects that reach financial close or begin construction to provide a forward-looking indicator of future capacity additions and spending activity.

Source: IEA calculations based on McCoy Power Reports (2023).

In 2022 FIDs for unabated fossil fuel generation reached levels last seen in 2016 on the back of security of supply concerns and diversification

Globally, FIDs for unabated fossil fuel power generation increased by 40% year-on-year to more than 100 GW in 2022, the highest level since 2016, driven by newly approved coal and natural gas capacity. China accounts for the vast majority of these FIDs (95% in coal-fired power) and if China is excluded the global growth rate falls to just 3%.

A severe electricity supply crisis in late 2021 and continued market strains amid a heatwave in 2022 provide the backdrop to China's proposed expansion in capacity. The strains were caused by drought conditions that lowered hydropower output, inflexible interprovincial electricity export contracts, and a combination of rising coal prices and low wholesale tariffs that led some generators to stop operations. This triggered various regulatory changes, as well as central government support for more coal- and gas-fired power investment.

The investment case for this new capacity is hardly clear-cut given the rapid pace of renewable deployment. For the moment, it remains unclear whether this new capacity – if and when it comes online in a few years – will be used primarily for flexibility purposes or for baseload generation; the implications for emissions will depend on the answer to this question.

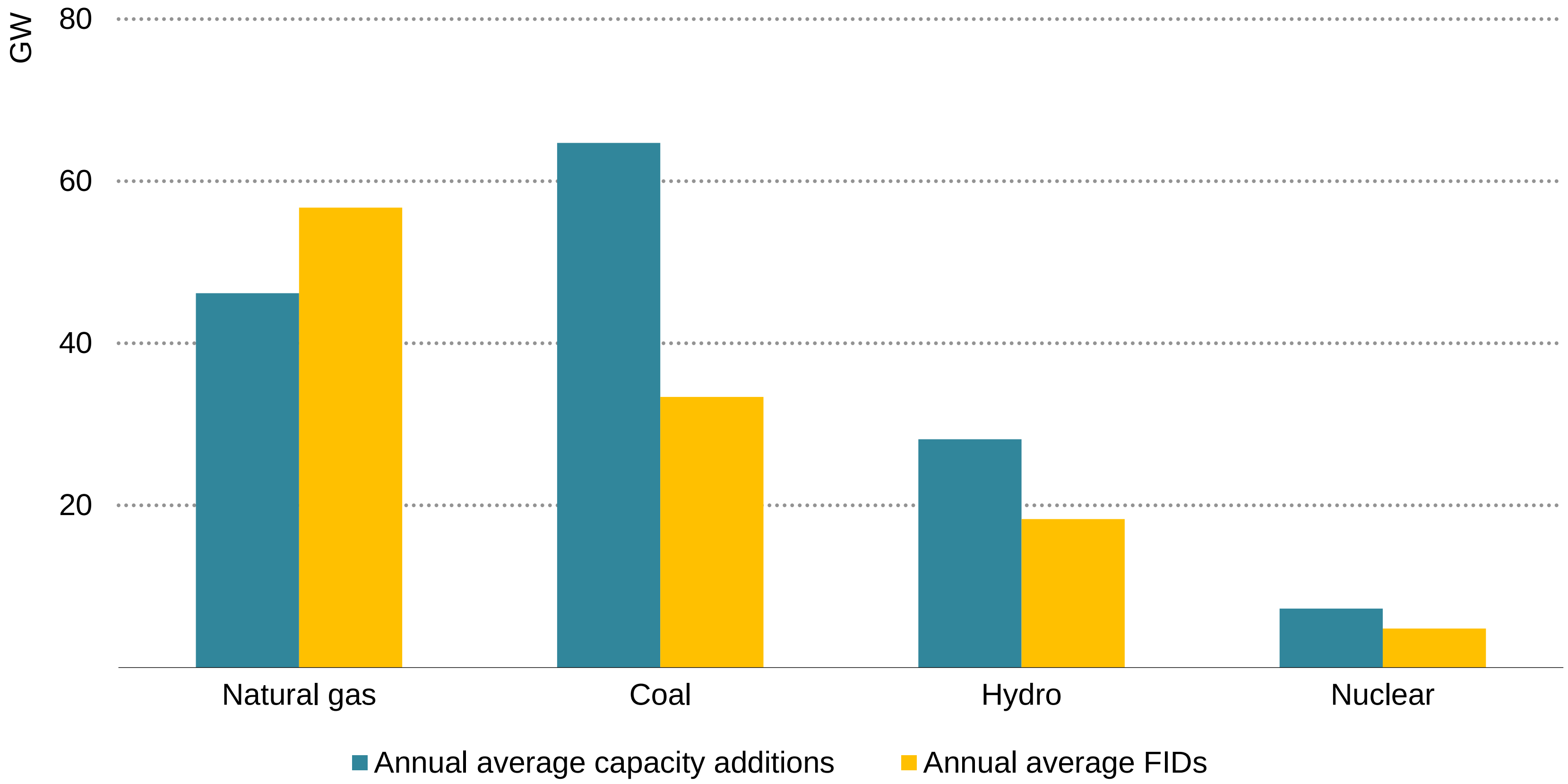
In Indonesia, in contrast to 2021, there were no new coal FIDs, an encouraging signal given the country's net zero pledge and JETP. In other Southeast Asian countries and the rest of the world (e.g. Lao PDR and Russia), only a very limited number of new coal-fired plants were approved for development, reflecting pledges from a range of countries and financial institutions to stop backing their construction (notably the Chinese commitment to stop building or financing coal plants abroad). Those approved continue to be of relatively high efficiency, with subcritical facilities dropping to below 5% of new FIDs.

Similar to coal, FIDs for gas-fired power generation amounted to 65 GW in 2022 – a jump of almost 40% despite very high prices for natural gas in the wake of Russia's invasion of Ukraine. Some of these new FIDs were from gas-importing countries that were exposed to price pressures from natural gas markets. China is a notable example, approving almost twice as much gas-fired capacity as in 2021. This was largely in the heavily populated southeastern coastal regions, within reach of LNG import facilities; worries about hydro availability also supported decisions to go ahead with gas.

Other regions seeing new gas FIDs were largely those with large resources, such as the United States and the MENA region. While FIDs in Southeast Asia (especially in Thailand and Viet Nam) rose year-on-year, decisions to go ahead with gas-fired power in other parts of Asia, outside China, fell by more than 60%.

Irrespective of the recent increase in new coal FIDs, the pipeline of new coal, hydropower and nuclear projects is slowing, while gas-fired projects are accelerating

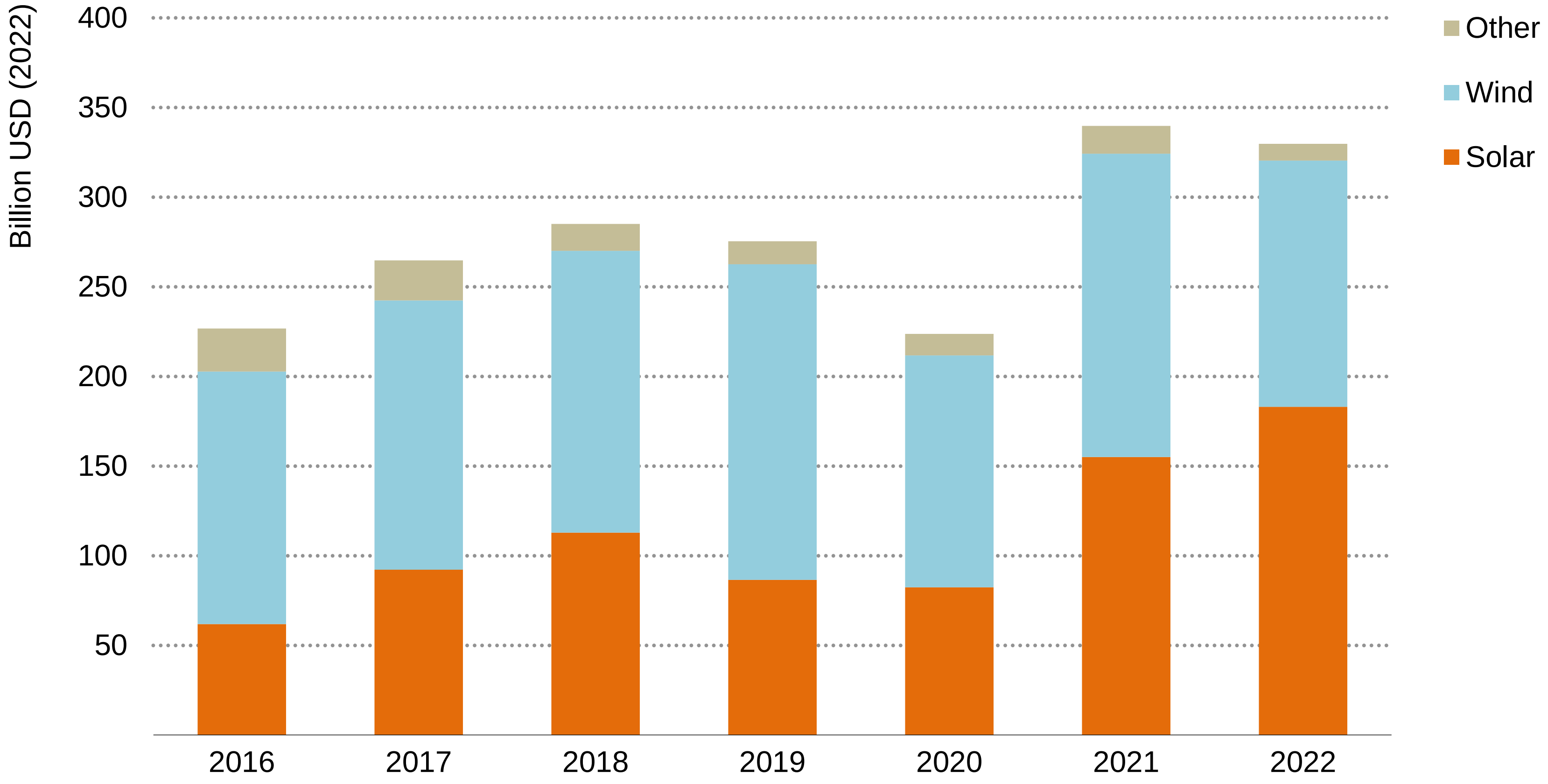
Annual average capacity additions and FIDs by capacity, 2019-2022



Notes: Annual average FIDs are an indication of the scale of future capacity to come online in the next few years; the time it takes for a new plant to go online can differ; for example, a new natural gas plant can take three years, while a new nuclear plant can take seven years.
Sources: IEA calculations based on McCoy Power Reports (2023), S&P Global (2023) and IAEA (2023).

FIDs for utility-scale renewables remained around 2021 levels in 2022, with higher solar but a decline in approvals for wind

FIDs for utility-scale renewable plants, 2016-2022



Notes: Excludes large hydropower; Other includes biomass, waste-to-energy, geothermal, small hydro and marine.
Source: IEA calculations based on Clean Energy Pipeline (2023).

Buoyant FIDs for solar kept utility-scale renewables around record levels in 2022

FIDs for utility-scale renewable plants remained high in 2022, following a record year in 2021. FIDs for solar projects increased significantly, reaching more than USD 180 billion – 20% more than in 2021 – while wind power experienced a drop, in particular for offshore wind projects, which fell more than 50%. The total number of utility-scale FIDs increased, with deals above USD 1 billion playing a larger role.

In monetary terms, utility-scale renewable approvals in China decreased by around 5% overall, though increasing by the last quarter of 2022 (48% higher than in the third quarter). In India, by contrast, decisions for renewables projects tripled, pushed by its 2022 target for 100 GW of installed solar capacity and the continuing push for innovative "round-the-clock tenders" (combining renewables with storage). A similar jump was observed in South Africa, as the country aims to tackle a severe electricity crisis and diversify its electricity mix, supported by the investment plan of its own JETP and a group of leading countries. FIDs in the European Union remained flat, while in the United States they increased by around 5%, with US approvals in particular accelerating in the second half of 2022 after the passage of its Inflation Reduction Act.

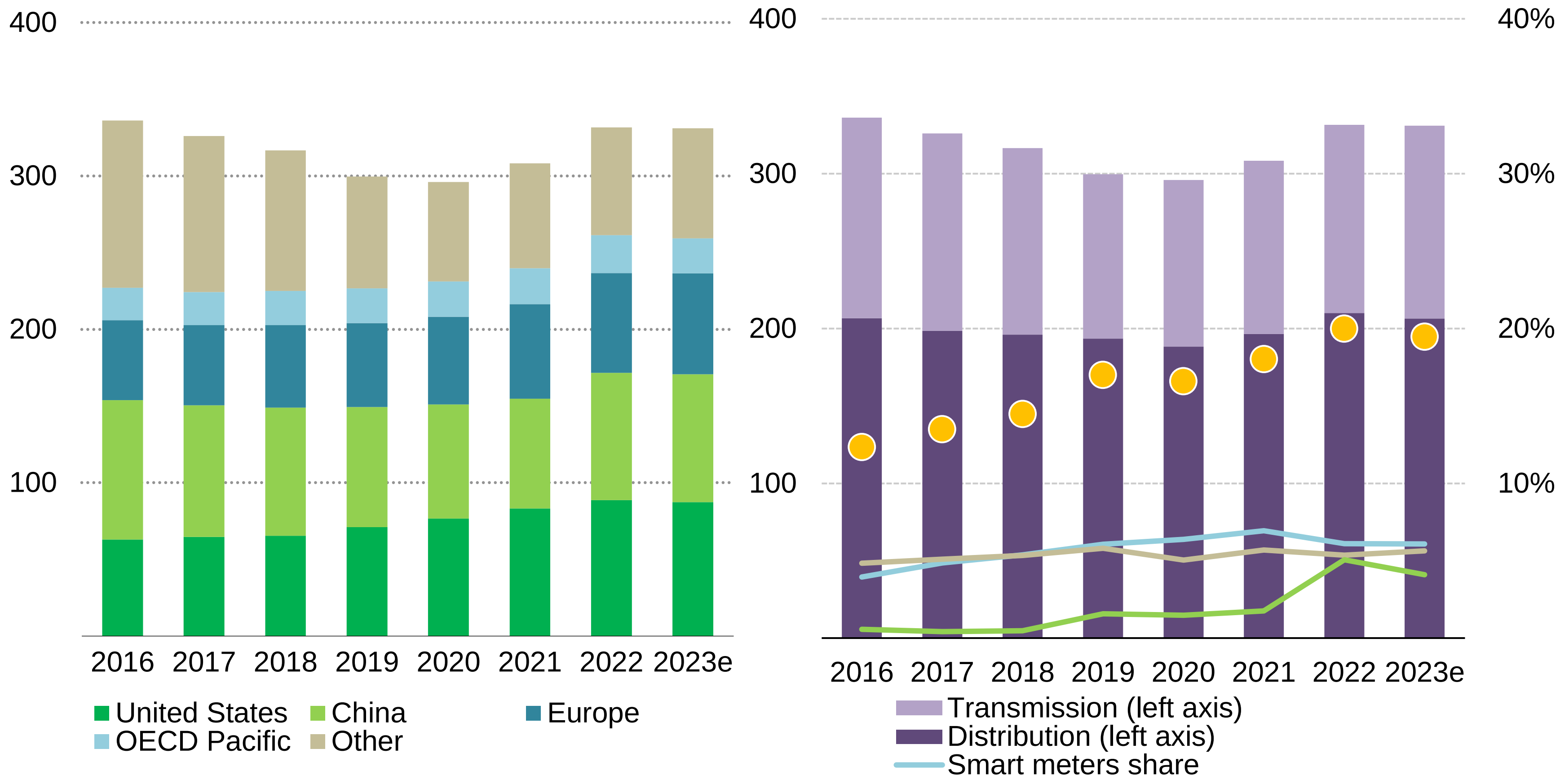
FIDs for large hydropower and nuclear power plants decreased significantly to 14 GW and 4 GW respectively (from 20 GW and 6 GW in 2021, respectively). In 2022 China was the only region to start the construction of a new nuclear power plant, while investment in large hydropower was dominated by China and India. Pumped hydro, which can serve as an energy storage facility, constituted 90% of the hydropower FIDs. After an uptick in 2021, the declining pipeline for these projects is a reason for concern given their potential to support power sector decarbonisation and supply security. However, additional capital is being spent on modernising and extending the lifetimes of existing plants, which is not captured by FIDs; and policy is becoming more supportive to new project approvals in future.

Renewable projects have shown uneven growth, with solar gaining relevance in the mix and wind facing major challenges particularly for offshore wind energy, which has experienced setbacks due to construction delays and supply chain constraints. Furthermore, fossil fuel power FIDs have risen as many countries have prioritised energy security projects. However, as Covid-19 regulations are now largely lifted, supply chain pressures easing and prices for key components such as critical minerals are moderating, there is growing support for renewable energy aided by supportive policies in key regions. Recent examples are the US Inflation Reduction Act and Germany's USD 31 billion push to expand wind and solar. This is expected to lead to an increase in FIDs for utility-scale renewables in 2023.

Electricity grids and battery storage

Investment in power grids continues to rise in advanced economies and China, with a rising share of spending on digitalisation…

Investment in power grid infrastructure by geography (left) and segment (right), 2016-2023e



Notes: Automation and communication include both distribution and transmission; 2023e = estimated values for 2023.
Sources: IEA analysis based on transmission and distribution companies' financial statements, and Guidehouse (2022).

…but many EMDEs outside China still face challenges in mobilising capital for infrastructure development

Advanced economies and China continue to lead investment in grids, together accounting for 80% of the global spending. Investment in electricity grids is growing at a stable pace in advanced economies, with capital expenditure rising 6% in 2022, and China seeing a steeper 16% rate of growth in investment, despite investment in 2021-2023 overall being lower than in the previous three-year period.

US capital spending on grids remains largely concentrated on enhancing reliability and upgrading outdated infrastructure. The amount invested in this area in 2022 was almost USD 90 billion, around 7% more than in 2021. Europe's spending rose at a similar rate, reaching USD 65 billion.

China's investment continues to grow, especially in ultra-high voltage transmission projects, with over USD 22 billion worth of projects in the second half of 2022 and the start of 2023.

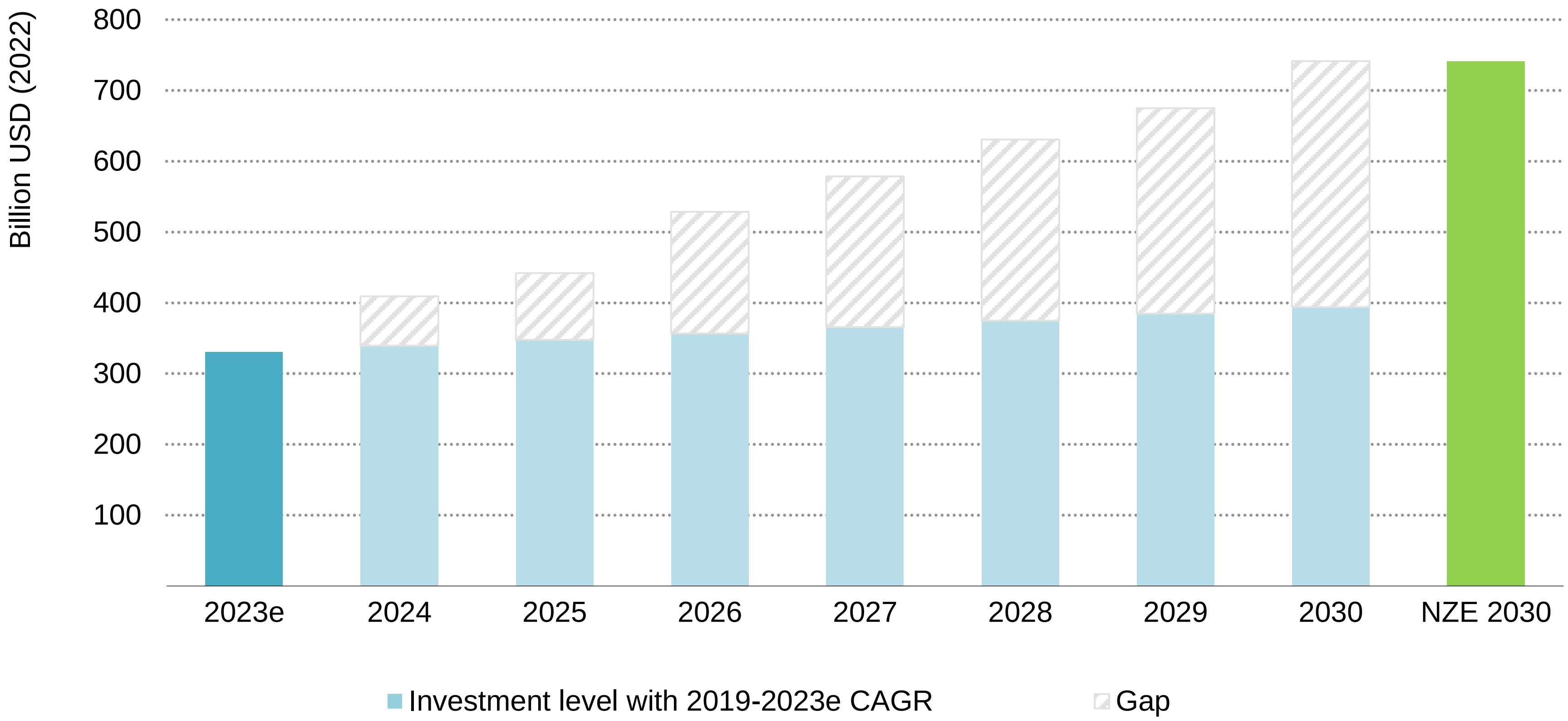
Overall, grid investment in EMDEs (excluding China) has been low in recent years, with 2019-2022 average annual spending around a third lower than in the 2015-2018 period. The Covid-19 pandemic, a focus on affordability for consumers and constrained balance sheets have left grid investment feeble. Privately financed transmission and distribution investment is also low, outside specific regions such as Latin America, where private finance is gaining more relevance. In some regions it is not even allowed. Africa still shows low levels of investment in absolute terms, despite its enormous access needs. In 2022, however, investment in grids increased significantly across the continent. In South Africa, investment rose by a third to USD 290 million, albeit still short of the investment required by its 2023-2027 JETP. The domestic regulator recently approved an 18% tariff increase that should strengthen Eskom's balance sheet and provide financial relief to the power system.

India's investment picked up in 2022, focused on both expanding its network as well as improving efficiency and better supporting the integration of renewables into the grid. The Green Energy Corridor Phase II was approved in 2022, which entails a budget of over USD 1.4 billion being spent over the next four years on capacity additions (lines and substations), interregional transmission and neighbouring links for trade. India's 2022 spending still remains about a third below its 2015-2018 annual investment average.

Digital spending plays a critical role in enhancing the reliability, flexibility and efficiency of power grids. There is an increasing focus on the distribution segment, which now represents over 75% of the total digital spend. Moreover, there has been a substantial upswing in investment in EV charging infrastructure, which has doubled in 2022 compared to the previous year.

If policymakers and regulators do not provide the necessary incentives for investment in grid spending, it could pose a significant obstacle to the clean energy transitions

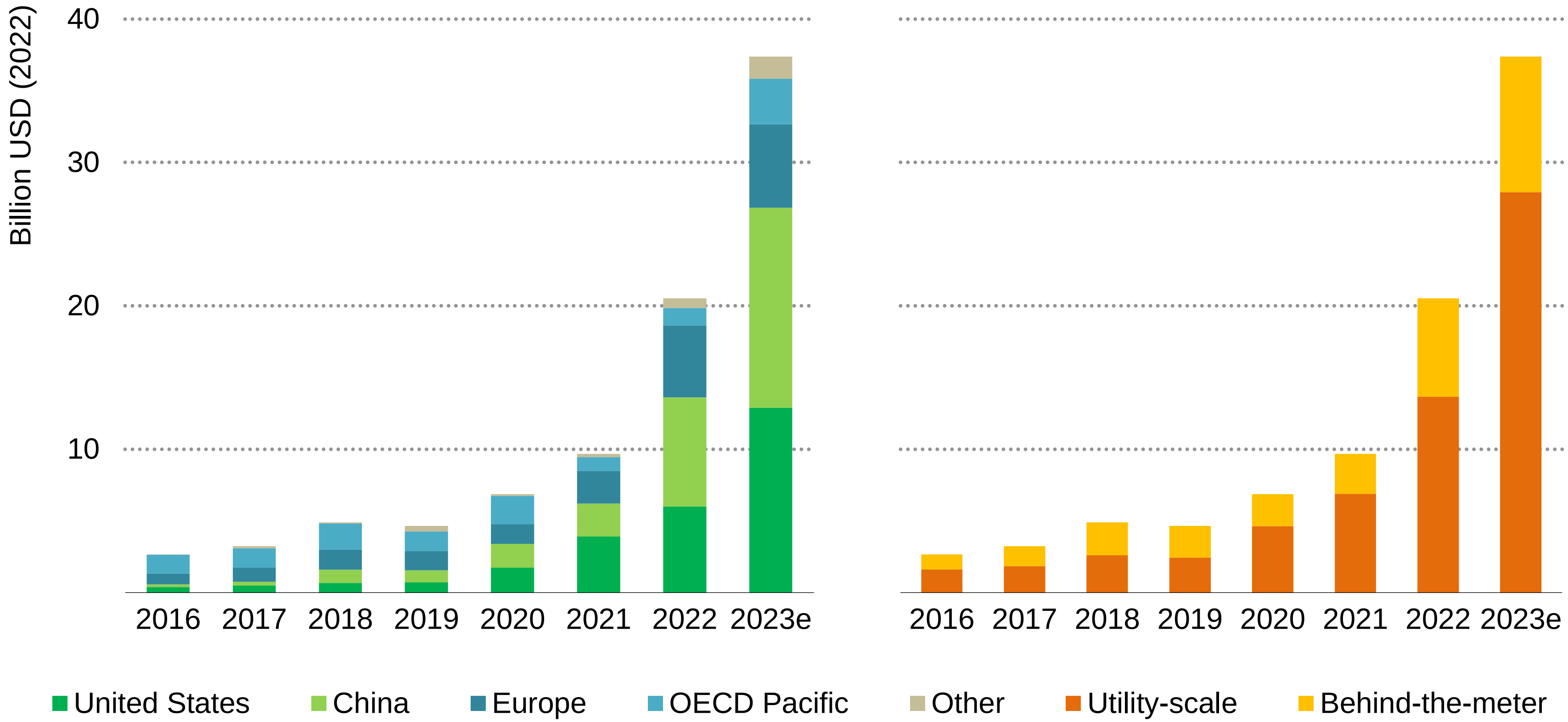
Grid investment level with current growth trend and gap to reach NZE Scenario trajectory



Notes: IEA estimation applying the compound annual growth rate (CAGR) of 2019 to 2023e to grid investment between 2024 and 2030; NZE = IEA Net Zero Emissions by 2050 Scenario; 2023e = estimated values for 2023.

Investment in battery storage is set for continued rapid growth in 2023, notably in utility-scale battery systems

Battery storage investment by geography (left) and segment (right), 2016-2023e



Note: 2023e = estimated values for 2023.
Sources: IEA calculations based on Clean Horizon (2023), BNEF (2023), China Energy Storage Alliance (2023).

Investment in battery storage more than doubled in 2022, driven by institutional investment and solar developers

The energy system is undergoing a major transformation towards a more flexible grid that can respond to demand and price volatility. In 2022 expenditure on battery storage exceeded USD 20 billion, with the United States, China, and Europe accounting for 90% of spending. This concentration can be attributed to the technological complexities of the value chain and the need for supportive policies and market designs.

China has demonstrated its commitment to battery storage through significant investments, such as the construction of the world's largest battery storage peak-shaving power station. China has also recently established its first peak-shaving capacity market, which regulates pricing limits for transactions and compensation for demand response. In total, spending on battery storage in China tripled in 2022 to almost USD 8 billion. 2023 is expected to see this increase to USD 14 billion on the back of favourable economics for utility-scale battery storage and strong policy support.

In Europe, although hydro storage remains predominant, investment in battery projects is rapidly gaining ground, reaching USD 5 billion in 2022. A joint venture partnership between Next Energy (70%) and Eelpower (30%), for example, could create up to USD 370 million in investment opportunities.

Spending in the United States totalled USD 6 billion in 2022, 50% more than the previous year. The expectation of increased benefits under the Inflation Reduction Act (see next page) may affect the timing of certain projects, but the environment is increasingly supportive. Consequently, we expect battery storage investments to more than double in the US to USD 13 billion in 2023.

Asia Pacific (excluding China) invested 27% more than last year, reaching more than USD 1 billion in 2022, with 2023 investments expected to triple. India's government, for example, has ambitious targets for battery storage. The government is also supporting the creation of a domestic value chain for the battery industry with financial allocations of over USD 2 billion under the National Programme on Advanced Chemistry Cell (ACC) Battery Storage. Other developing countries have also shown growth, although the absolute level of investment remains relatively low.

Capital costs for batteries increased in 2022 for the first time in a decade due to various factors including tight supply chains for battery metals and a sharp increase in demand. Despite the increase in battery capital costs, a clear regional differentiation still exists: China continues to see the lowest costs for utility-scale batteries, followed by Europe and the United States.

Impact of the US Inflation Reduction Act on battery storage

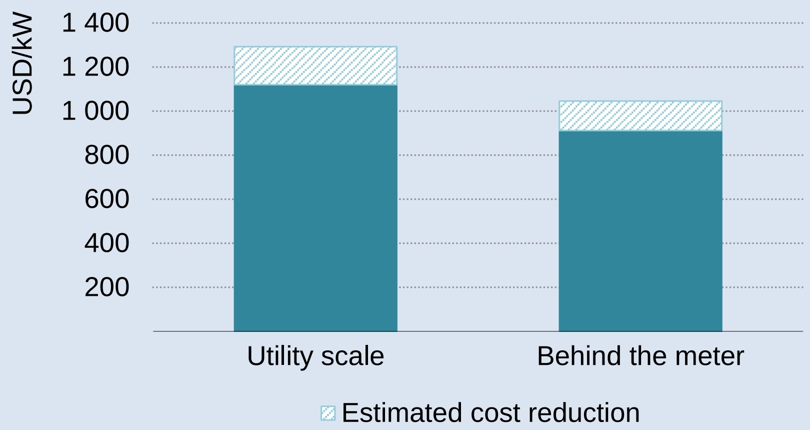
Collectively, the Inflation Reduction Act and the Bipartisan Infrastructure Law offer an estimated USD 24 billion in federal investment in EVs, batteries and infrastructure, on top of tax credits. The long-term regulatory certainty also provides critical stability for private investors in the sector. We estimate that the new federal support could reduce capital costs for battery storage by almost 15%, providing a significant boost to US battery storage investment, which is now expected to double in 2023.

The act also includes provisions that could complicate the timing of investment, such as domestic sourcing requirements for critical materials like lithium that could prevent some battery projects from benefiting. Several Chinese companies are responding to this situation: CATL, for example, recently announced a partnership with Ford to establish a USD 3.5 billion plant in Michigan.

In Europe the act sparked fears that its local content requirements would lead to private investment shifting away from the continent. Major European players such as Volkswagen, BMW and battery maker Northvolt announced new battery manufacturing investments after the US act was adopted. However, most of these announcements concern investment plans predating the act, which have now been accelerated, rather than displacing new European projects.

Moreover, the European Union is now aiming to expand available funding for net zero industries via its Green Deal Industrial Plan. The United States and European Union are also planning to deepen their economic relationship while addressing shared economic and national security challenges in the clean energy transition.

Estimated impact of the US Inflation Reduction Act on average US capital costs for battery storage (in 2022 costs)

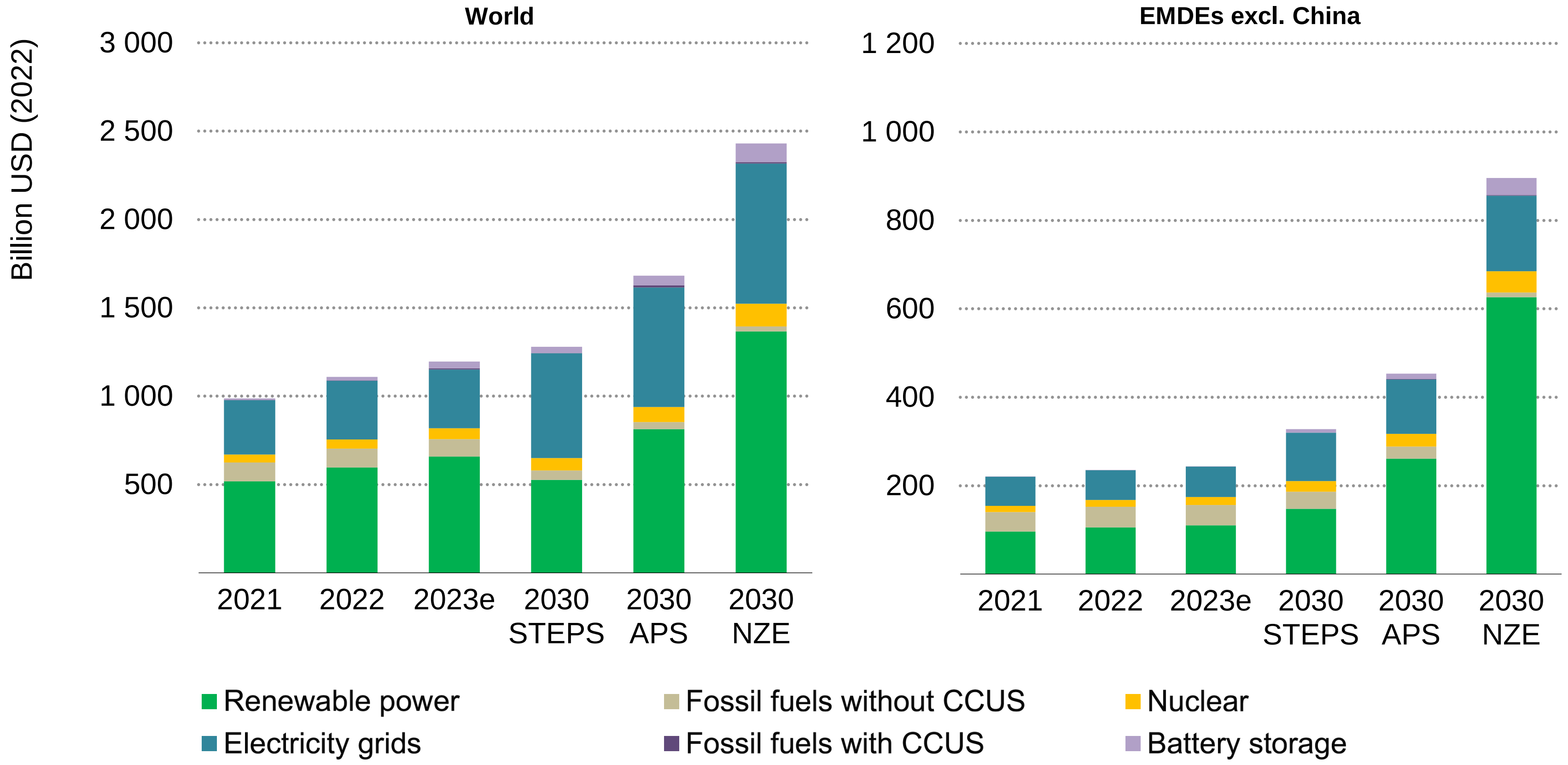


Sources: IEA calculations based on BNEF (2023), Wood Mackenzie (2023) and Lazard (2023).

Implications

Global power sector investment is growing quickly but unevenly; secure and sustainable development of the power sector will require much higher investment in EMDEs outside China

Investment in the power sector in 2021-2023e compared with investment for IEA scenarios in 2030



Notes: STEPS = IEA Stated Policies Scenario; APS = IEA Announced Pledges Scenario; NZE = IEA Net Zero Emissions by 2050 Scenario; CCUS = carbon capture and storage; 2023e = estimated values for 2023.

Despite positive signs, there's much more to be done to get the power sector on track for a 1.5-degree scenario

Recent years have seen considerable growth in clean power investment, and overall spending in generation, grids and storage would need to rise by another 30% by 2030 to be consistent with announced climate pledges (IEA Announced Pledges Scenario [APS]). Aggregate investment trends offer reasons for optimism. The rate of growth seen in power sector capital expenditure over the last five years, if maintained, would be enough to surpass the 2030 figure for the APS.

However, the aggregate numbers mask imbalances across technologies and regions that would need to be addressed to ensure secure and sustainable development of the power sector. And today's global investment would need to more than double by 2030 to get on track for a 1.5-degree stabilisation in global average temperatures, as in the NZE Scenario.

In particular, despite some bright spots such as renewables in India, power sector investment trends in most EMDEs (excluding China) are well off track for scenarios that meet national or global sustainable development goals. Our new analysis suggests that power sector investment in EMDEs outside China could rise by 4% in 2023. It would need to increase by around 20% each year to reach the level projected in the NZE Scenario in 2030, with capital spending on renewables growing at an exceptionally steep rate of 30% every year (compared to 10% in advanced economies). The deficit in spending on grids in many EMDEs is also striking, and difficult to resolve given the financial condition of many utilities.

Elsewhere, the growth trends for power sector investment are more encouraging. If China were to maintain its overall growth trend since 2019, this would be consistent with the investment level required in 2030 for the NZE Scenario, with advanced economies coming close. Total power sector investment in China and advanced economies would need to grow by 5% and 10% every year between 2024 and 2030, respectively. Maintaining such high growth rates throughout the decade cannot of course be taken for granted, not least because supply chains need to be expanded, permits secured, flexibility requirements need to be managed and financing needs to be mobilised.

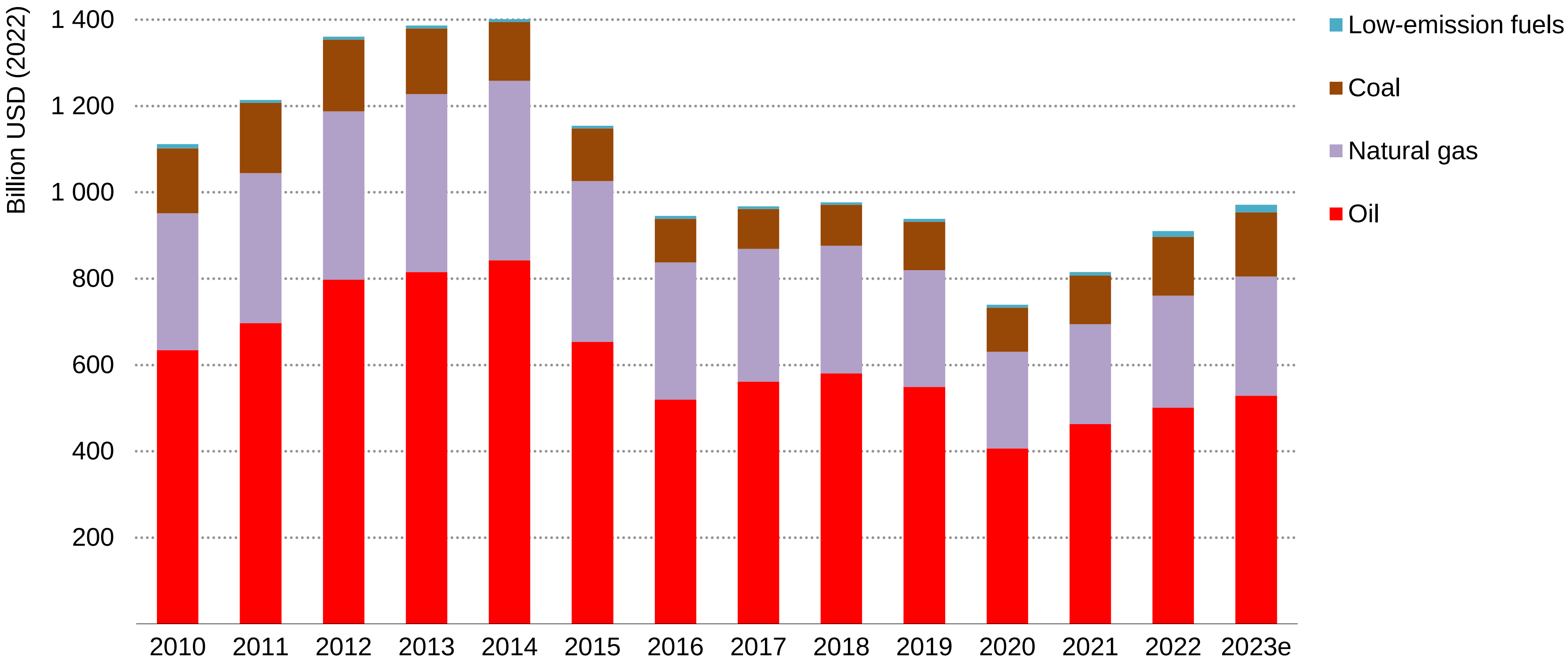
Among the different technologies, the growth in global capital expenditure in the last five years, if maintained, is on track for an NZE Scenario only for a handful of technologies, led by solar PV and battery storage. Investment growth in wind and hydropower would need to increase considerably, and similarly in electricity grids (especially given their enabling role for renewables penetration).

Fuel supply

Overview

Global investment in fuels rose in 2022 and is expected to return to pre-pandemic levels in 2023

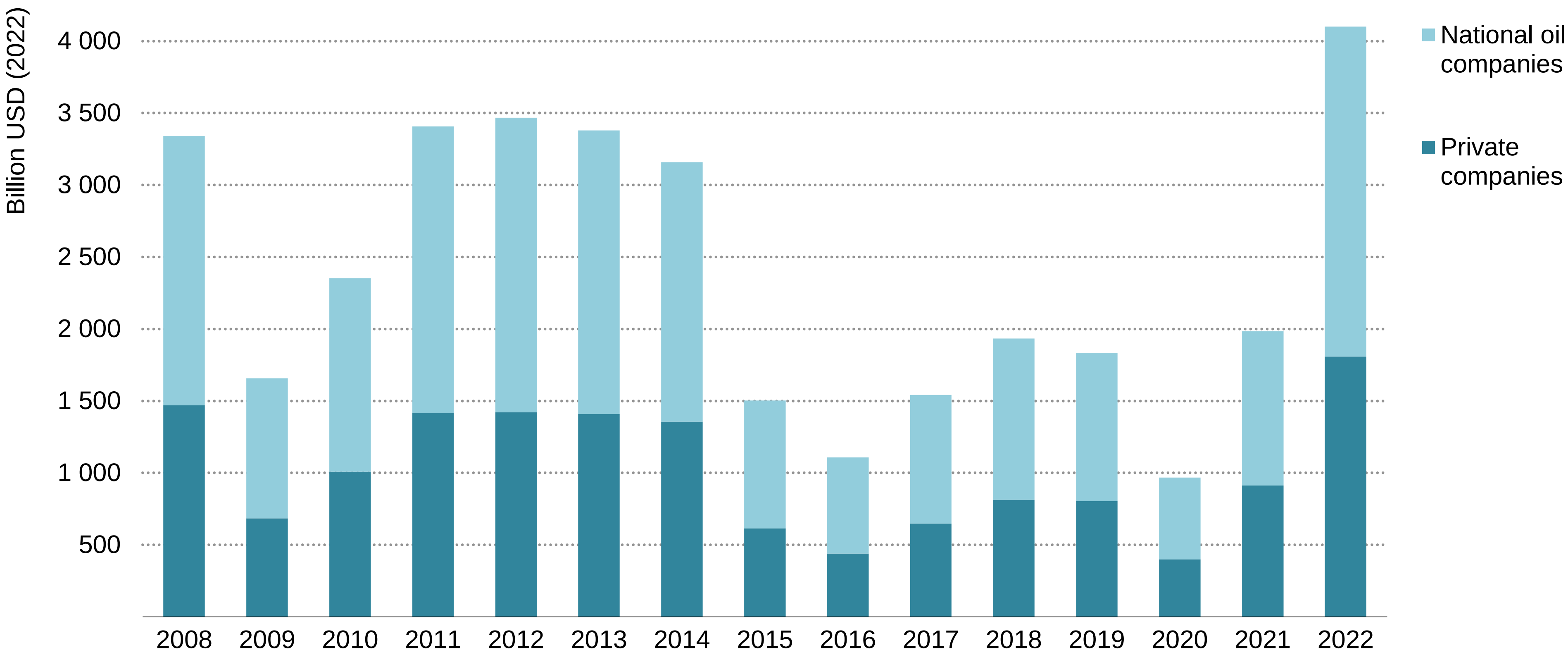
Global investment in fuel supply, 2010-2023e



Notes: Oil, natural gas and coal include upstream and midstream investments. Low-emission fuels = modern bioenergy, low-emission hydrogen and hydrogen-based fuels. 2023e = estimated values for 2023.

Net income of the global oil and gas industry reached a record high of USD 4 trillion in 2022

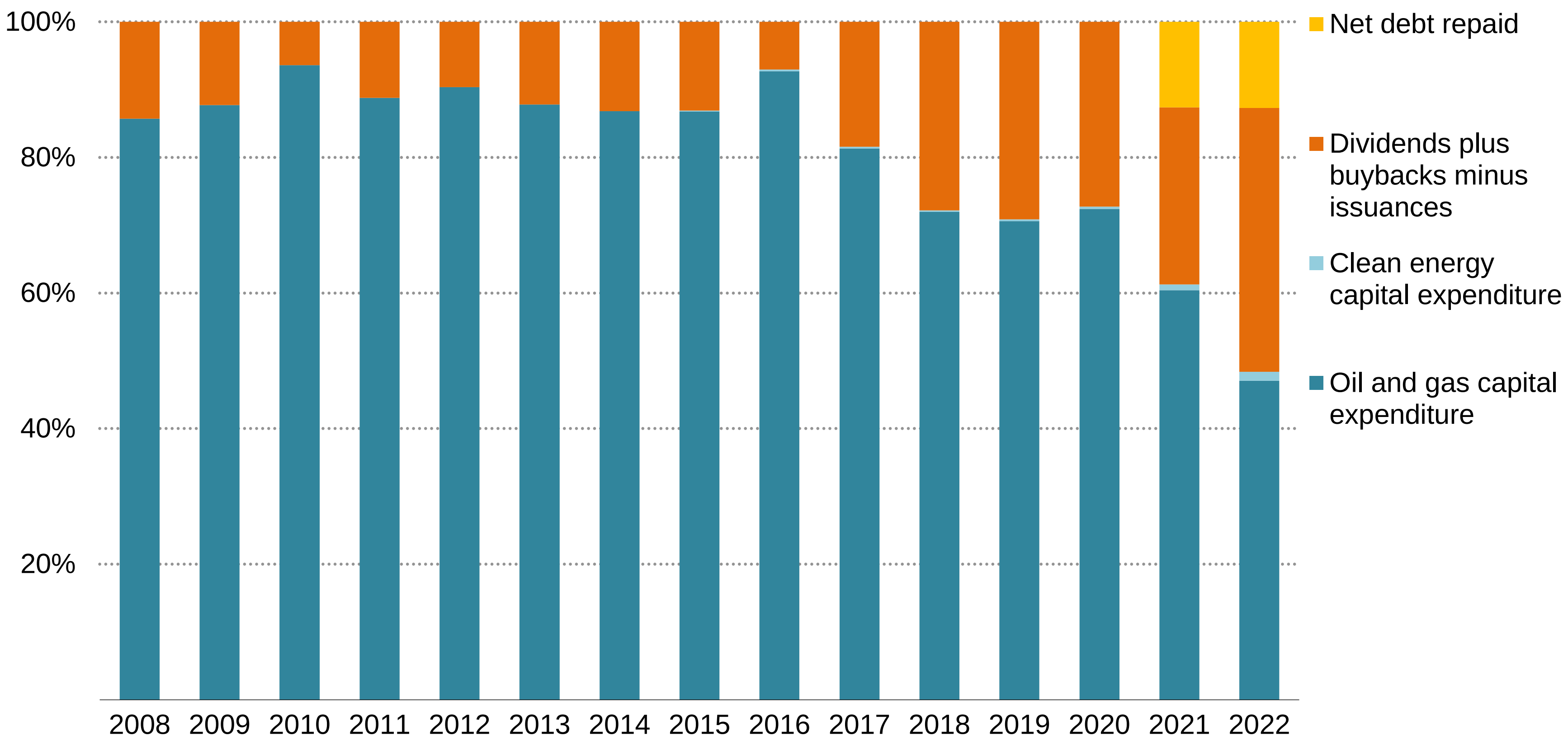
Net income of the oil and gas industry, 2008-2022



Notes: Net income is calculated from oil and gas production at prevailing oil and gas prices (including subsidies) after operating costs but before taxes; "private companies" here includes listed and non-listed companies.

Record income in the oil and gas sector was used to increase shareholder returns and pay down debt, with only a fraction of free cash flow directed towards clean energy investments

Distribution of cash spending by the oil and gas industry, 2008-2022



Source: IEA analysis based on S&P Capital IQ.

Ample revenues and high prices are pushing fossil fuel investment higher, but spending is constrained by worries about costs and long-term demand

The year 2022 was an extraordinary year for fuel suppliers and traders. Russia's invasion of Ukraine drove natural gas prices to record levels in many parts of the world and oil prices back up to levels not seen since the mid-2010s. Net income from fossil fuel sales also rose to levels never seen before, with the global oil and gas industry earning around USD 4 trillion.

High prices have spurred an increase in fossil fuel investment: our expectation, based on analysis of the announced spending plans of all the large and medium-sized oil, gas and coal companies, is that investment in new fossil fuel supply will rise by 6% in 2023 to USD 950 billion.

Some of the windfall gains in 2022 are going back into traditional areas of supply, with companies seeking out "advantaged" resources that can be brought to market relatively quickly, at low cost and with low emission intensities.

But many upstream projects are also facing cost pressures, as tight markets for services and labour and increased raw material costs erode the impact of increases in investment on real activity. Around half of the increase in upstream oil and gas investment in 2023 is likely to be a consequence of cost inflation.

There are significant variations by region and type of company. Only Middle Eastern national oil companies (NOCs) are set to spend meaningfully more in 2023 than they did in 2022, and they are the only subset of the industry spending more than pre-pandemic levels. Real spending on oil and gas supply by most European and North American companies remains below where it was in 2019.

The headline increase in oil and gas spending represents less than half of the cash flow that was available to the oil and gas industry. Between 2010 and 2019, three-quarters of cash outflows (account for capex, dividend and buybacks as well as net debt repaid) were invested into supply. In 2022, this dropped to less than half, with the other half used primarily for dividends, share buybacks and debt repayment.

Hesitation about traditional oil and gas supply investments comes from a variety of factors, including worries about costs, uncertainties over longer-term demand, calls for the industry to step up its role in tackling climate change, and pressures from many investors and owners to focus on returns rather than production growth.

The latter consideration is particularly visible for tight oil and shale gas operators. After a decade in which the shale industry failed to generate any positive free cash flows, companies are now being rewarded for increasing value rather than volumes.

Conventional oil and gas resources approved for development in 2023 are likely to be around 25% more than in 2022 but still well below the average level seen over the past decade. The increase in 2023 comes mainly from natural gas, reflecting market pressures as well as the push to substitute the shortfall in Russian deliveries.

In the midstream sector, Russia's cuts in pipeline gas deliveries to Europe have prompted higher spending on LNG infrastructure. New regasification capacity is coming into operation in the near term, but new export facilities take longer to develop. Export projects already under development have been supplemented by a steady stream of new approvals during the energy crisis, promising a major 170 bcm wave of new LNG liquefaction capacity in 2025-2027. A key dilemma for investors in large, capital-intensive gas supply projects is how to reconcile strong near-term demand growth with uncertain but possibly declining longer-term demand.

Robust coal demand and high prices during the global energy crisis are also feeding through into higher global investment. Coal investment increased to USD 135 billion globally in 2022 and is expected to rise to nearly USD 150 billion in 2023. Nearly 90% of this investment takes place in the Asia Pacific region, notably in China and India where both countries have looked to expand production and develop new coal mines.

Elsewhere, nearly all coal investment is focused on maintaining or boosting production from existing mines as concerns over climate change, increased emphasis on environmental, social and corporate governance, slow permitting and public opposition limit the availability of finance for new coal mine development.

In aggregate, fossil fuel investments are now broadly aligned with the Stated Policies Scenario (STEPS) in 2030, a scenario based on today's policy settings. However, if the current momentum behind clean energy investment is maintained and clean energy deployment scales up quickly, demand for oil, natural gas and coal would come under much greater pressure. Benchmarking today's investment levels against scenarios that hit global climate goals illustrates a large potential mismatch. Today's fossil fuel investment spending is now more than double the levels needed in the Net Zero Emissions by 2050 Scenario (NZE Scenario). The misalignment for coal is particularly striking: today's investments are nearly six times the 2030 requirements of the NZE Scenario.

The surge in revenue in 2022 offers a major opportunity to scale up investment in low-emission fuels; momentum is increasing, but remains well short of where it needs to be

The surge in oil and gas company revenue in 2022 opens up the possibility for accelerated spending by fuel suppliers on energy transitions. This relates not only to increasing investment in low-emission fuels and technologies but also accelerating investment that reduces the emissions intensity of existing fuel production.

Oil and gas industry spending in these areas is rising, and significant new commitments are being made across the whole spectrum of clean fuels. Oil and gas companies boosted their spending on bioenergy to a record USD 11 billion in 2022 with a series of large acquisitions of transport biofuel and biogas producers.

The sector's commitments to carbon capture, utilisation and storage (CCUS) and hydrogen are also growing; many of the largest projects announced in 2022 were underpinned by the participation of oil and gas majors and NOCs, several of which have ambitious capacity targets for 2030. To date, only a handful of these projects have been subject to a FID, meaning that annualised spending on hydrogen and CCUS projects was around USD 1 billion in 2022.

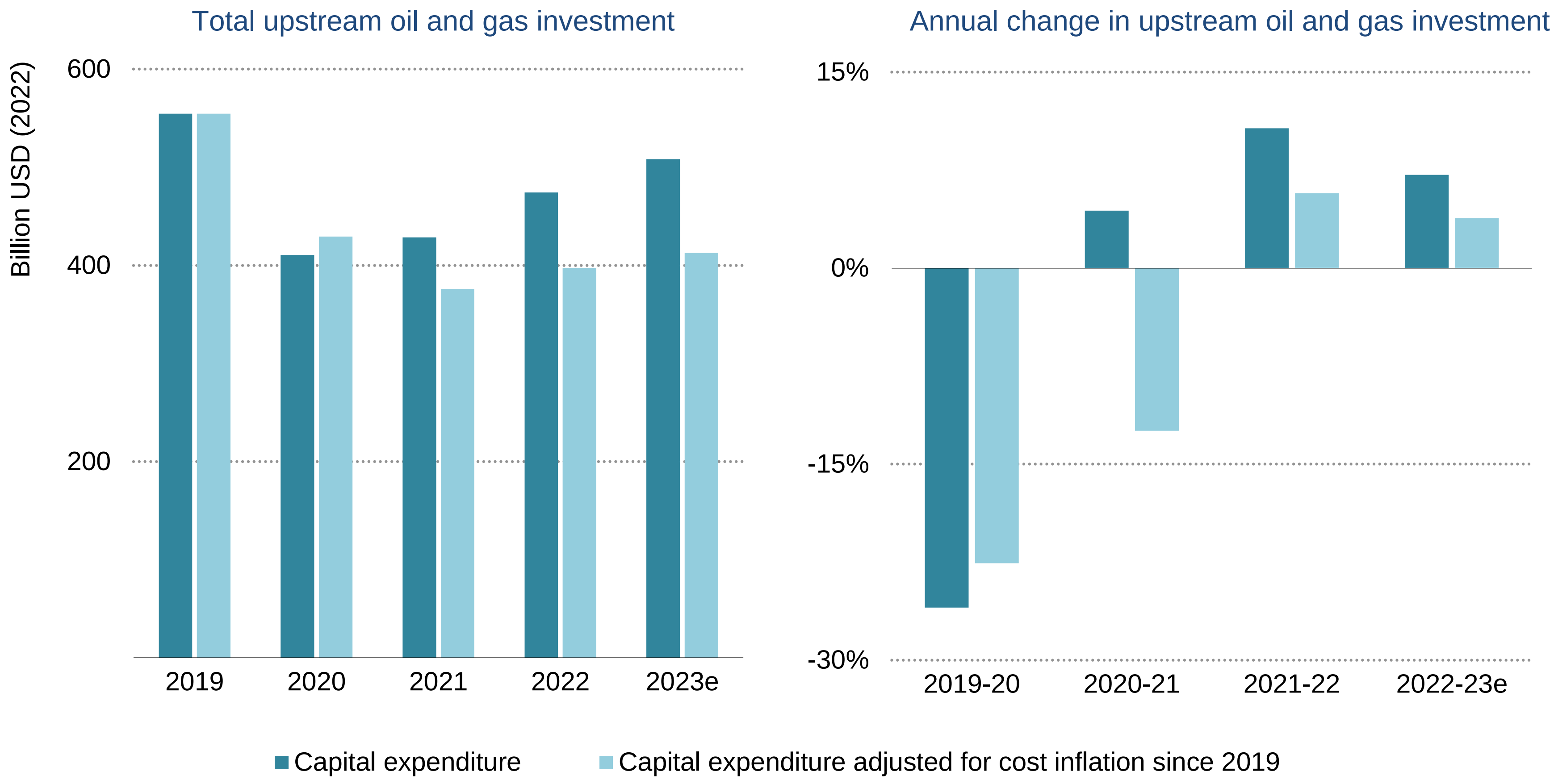
Some NOCs have announced commitments to reduce supply chain emissions, such as Sonatrach's efforts to bring down flaring at Hassi Messaoud and at its LNG export infrastructure.

Policies are increasingly supportive of these kinds of investment, notably via the Inflation Reduction Act in the United States, and the number of announced projects is rising, especially for clean hydrogen and CCUS. But as total investment in low-emission sources of energy (including clean electricity, clean fuels and CCUS) was less than 5% of upstream investment by the oil and gas industry in 2022, much larger shifts in capital allocation are needed to clean up existing production and to position the oil and gas industry as part of the solution to climate change. For example, to maintain its 30% share of total capital spending on CCUS as seen in 2022, the oil and gas industry under the NZE Scenario would have to spend around USD 25 billion annually by 2030. Similarly, its spending levels on hydrogen supply would need to reach USD 19 billion by 2030, based on the current 12% share of investment in electrolyser projects.

This is a crucial topic for COP28 in Dubai. COP President Sultan Al-Jaber has called on the oil and gas industry to "up its game, do more and do it faster". With this in mind, the IEA will be producing new analysis on the role of the oil and gas industry in net zero transitions in advance of COP28.

Upstream oil and gas

Upstream oil and gas investment rose by 11% in 2022 and is expected to rise by 7% to USD 500 billion in 2023, but half of these increases are absorbed by rising costs

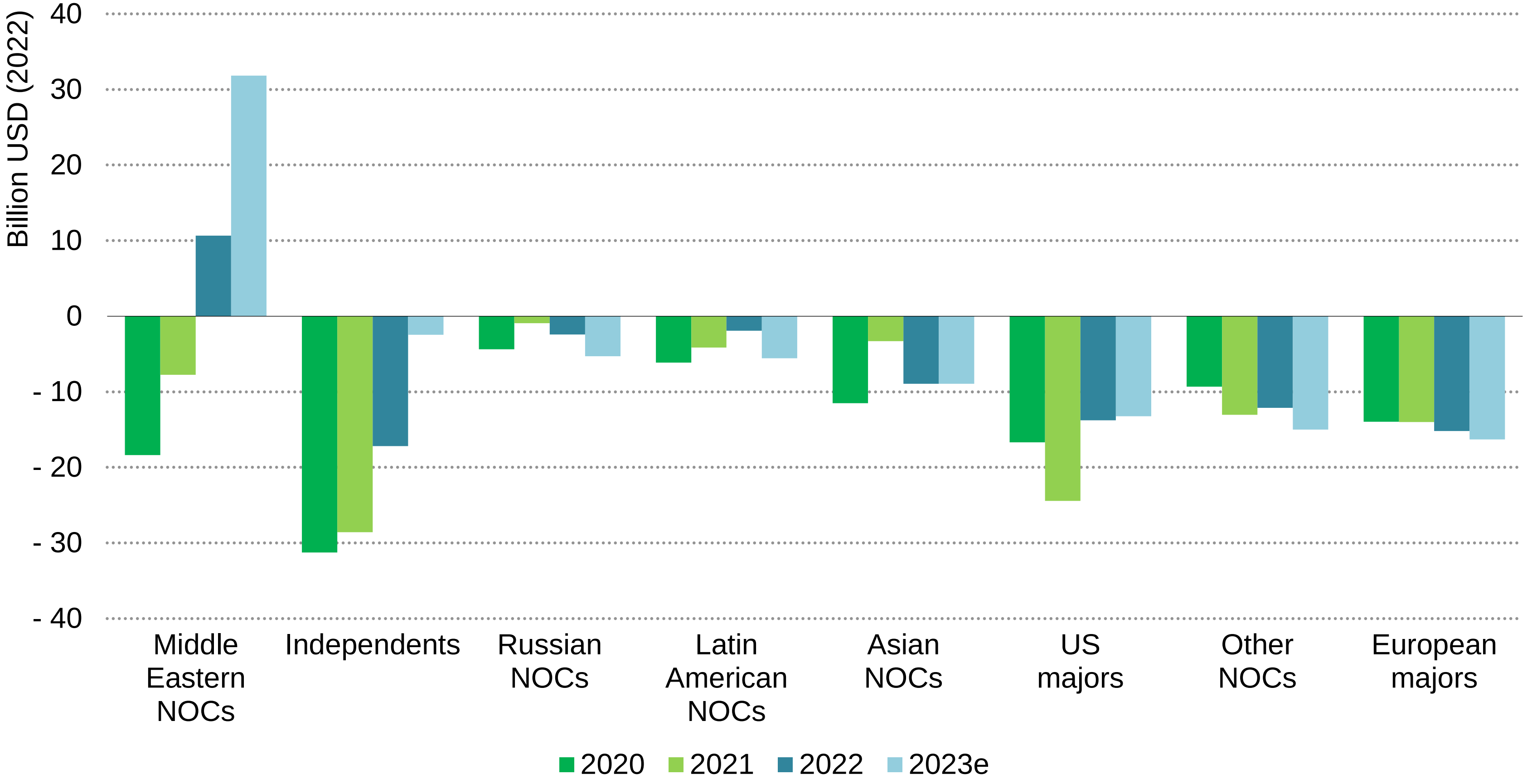


Notes: "Capital expenditure adjusted for cost inflation since 2019" adjusts capital expenditure for changes in finding and development costs using the IEA's upstream investment cost index that reflects the price of a basket of goods and services required to develop oil and gas fields. 2023e = estimated values for 2023.

Sources: financial report disclosure of a sample of 90 companies; cost index based on data from Bloomberg, FRED and IMF data.

Middle Eastern NOCs are the only segment of the industry spending more than before Covid-19

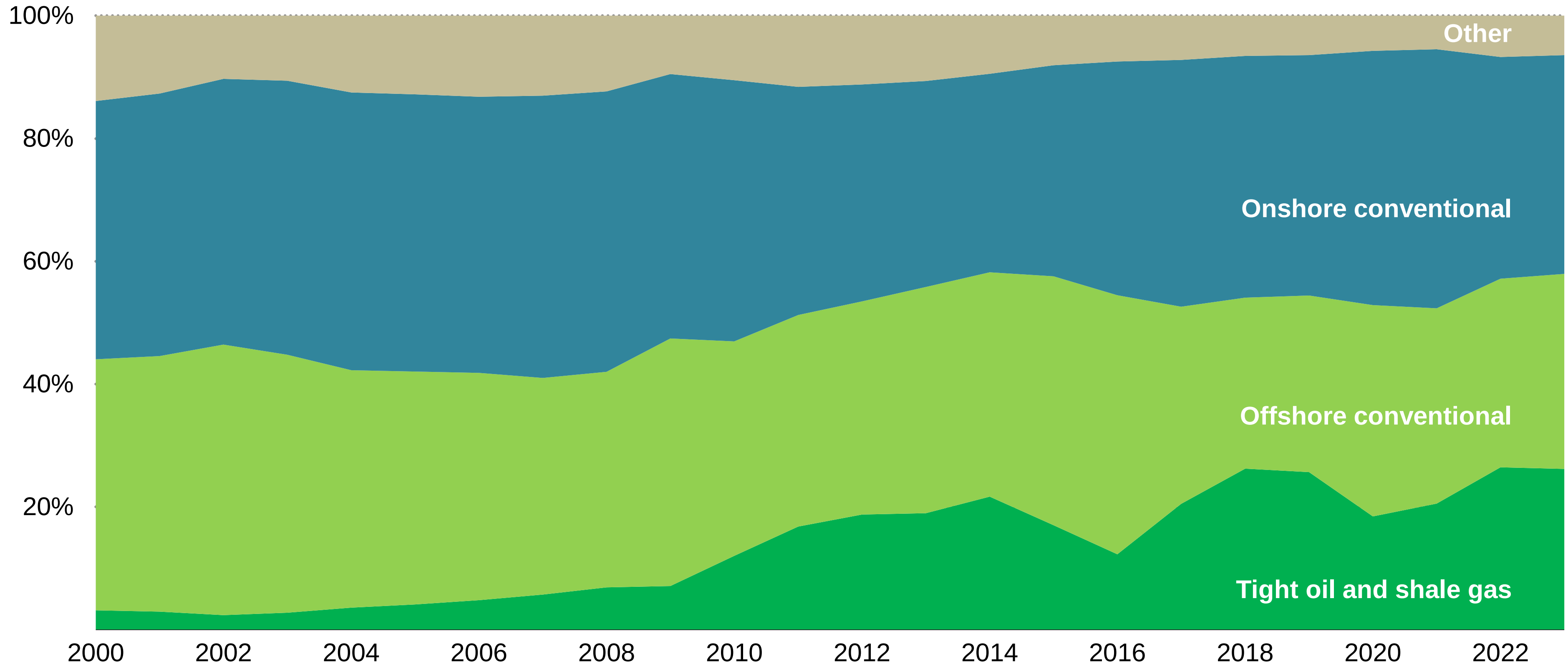
Change in upstream oil and gas capital investment relative to 2019 by company type, 2020-2023e



Note: 2023e = estimated values for 2023.
Sources: IEA analysis from annual reports and Rystad based on a sample of companies accounting for more than 70% of global production.

The shale sector represents around a quarter of total upstream oil and gas investment even as operators prioritise returns over production growth

Share of oil and gas investment by asset type, 2000-2023e



Note: "Other" includes coalbed methane, tight gas, coal-to-gas, extra-heavy oil and bitumen, gas-to-liquids, coal-to-liquids and kerogen oil. 2023 values are estimates.
Sources: IEA analysis from annual reports and Rystad.

Upstream companies are searching for "advantaged resources" amid rising pressures on costs and renewed energy security considerations

Upstream oil and gas capital expenditure rose by 11% in 2022 and our initial estimate is for a 7% increase in upstream spending in 2023, to reach just over USD 500 billion.

Companies are filtering investment opportunities through an increasingly demanding set of criteria. Advantaged investments need to be competitive on cost, but also have low emission intensities. Deepwater projects tend to score highly on these metrics and areas like Guyana, the US Gulf Coast, Brazil and emerging producers like Namibia (which has seen major discoveries in recent years) are attracting a lot of investor interest.

Another priority is short development cycles. It takes around three to five years on average globally from when a conventional project receives its FID to production starting. The use of standardised designs and existing infrastructure could shorten this time as well as reduce development costs, but despite increasing efforts by the industry to do so, there is little evidence to date of a structural reduction in these development timelines.

Another increasingly important consideration, in the light of the energy crisis, is geopolitical risk. Among other characteristics, companies and potential importers are also looking for "trustworthy barrels", especially where they can be delivered relatively quickly. Even countries that are actively pursuing rapid energy transitions have proved ready to view some upstream investments through this energy security lens.

Part of the recent increase in spending reflects higher upstream costs: adjusting for rising costs, the increase in activity is only around half the headline increase in upstream investment. This increase in upstream costs in 2022 is due to service companies' higher margins, the higher cost of drill pipes, casings, tubing and proppants, and, to a lesser extent, higher labour, cement and electricity costs. The US shale industry is experiencing a persistent labour shortage in the Permian Basin, the main producing area, where it is has been challenging to fill mechanical and electrical positions with local residents.

Tight or underdeveloped markets for services and equipment can deter companies from reinvesting their windfall revenues back into the upstream. This is also a feature of deepwater developments where there are constraints on available rigs. Companies such as Petrobras that have actively tendered in recent years for deepwater drilling equipment and rigs have been in a position to move ahead with their upstream ambitions – in Petrobras' case its large offshore pre-salt fields.

Windfall gains in 2022 have led to increased investment, but trends differ markedly between regions

Most large oil and gas companies have announced higher planned spending on upstream projects in 2023 from the levels seen in 2022, but only a handful are investing more in this area today than they did prior to the Covid-19 pandemic.

There are major differences between regions. The increase in spending is concentrated mainly among large Middle Eastern NOCs. Notably, Saudi Aramco and ADNOC, invested considerably more in 2022 than in 2019 (prior to the Covid-19 pandemic) and plan to boost investment further in 2023. Both companies are spending to meet announced capacity expansion targets for 2027 – Saudi Aramco to reach 13 million barrels per day (mb/d) and ADNOC 5 mb/d – and are also looking to boost local supply chains and manufacturing capacity. Since 2015 Saudi Aramco has been looking to source an increasing share of its procurement domestically as part of the In-Kingdom Total Value Add programme. As of 2022, 63% of Saudi Aramco's spending was directed to domestic suppliers, up from 35% in 2015 (the target is to reach 75% by 2025). Saudi Aramco has announced a 30-60% increase in capital expenditure for 2023, to reach a total of USD 45-55 billion.

A number of NOCs in Asia announced increases in spending for 2023 on the back of robust revenues in 2022. In Southeast Asia, Malaysia's Petronas now plans to spend about USD 14 billion each year during 2023-2027, a rise of more than 40% compared with the average for the last five years. Indonesia's Pertamina and Thailand's PTTEP have also increased their planned expenditure for the coming years. Natural gas is the prime target for the region's NOCs given the squeeze on supply and high prices during the energy crisis in 2022, with Malaysia's floating ZLNG project and Indonesia's Tangguh UCC project among those likely to move forward.

Upstream investment by Chinese NOCs is expected to be broadly similar to levels seen in 2022 at around USD 60 billion per year. China's leading oil and gas companies are expanding their transition investments but their core mandate remains to ensure oil and gas security on their home market. Higher revenues may allow China's NOCs to target higher-cost domestic resources such as shale or coalbed methane.

There is also a push by some Latin American companies to increase upstream oil and gas spending in 2023. These could come under pressure as some of the largest producers – including Petrobras and Ecopetrol – could be tasked by new government administrations to balance upstream investment with an increase in renewables and downstream investment. Currently, exploration and production account for three quarter of Petrobras' total capital investment.

US and European majors announced record profits in 2022, but have not substantially modified the investment plans they made prior to the energy crisis. One notable exception is BP, which recalibrated its plans to cut upstream production by 40% and will now target a 25% reduction in output by 2030. By and large the European majors have been trading a lower multiple of share price to earnings compared with their US counterparts, with European companies not getting much credit thus far from investors for their higher transition-related commitments.

For US tight oil and shale gas, the number of rigs in operation rose steadily throughout the first half of 2022, but has since remained around this level. Companies continue to emphasise capital discipline and the importance of returning revenue to shareholders. Cost inflation has also dampened the appetite to increase investment. Investment in the shale sector in 2023 is expected to be similar to 2019 levels, although the number of wells drilled and completed is likely to be substantially lower.

The oil and gas investment picture in Russia is subject to a high degree of uncertainty, and as with many aspects of Russia's energy sector, has been noticeably less transparent over the last year, as companies stopped providing much detail on their financial performance or plans. The information that is available highlights some of the strains, including regular complaints from companies about higher taxes.

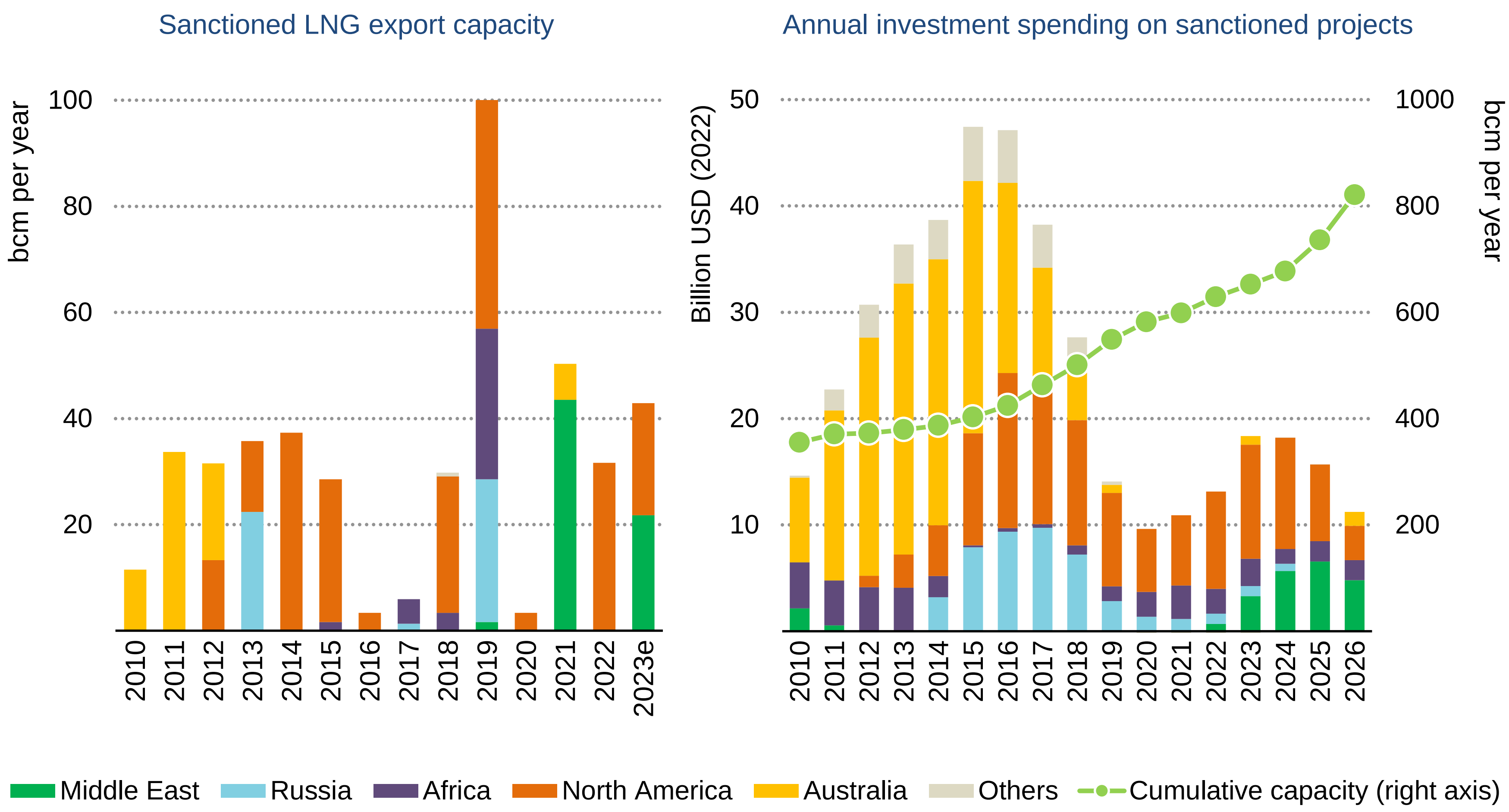
Investments in Russia's upstream sector rebounded from Covid-19-induced lows in 2020 but as Russia becomes increasingly shut off from the global energy market, investments have sunk well below levels seen in the pandemic-affected years of 2020 and 2021.

Rosneft managed to keep spending around 2021 levels, but the company has not provided any information on its 2023 investments. On noticeable exception is Gazprom which announced a 16% increase in investment in 2023 from 2022 levels, focusing mainly on the development of new production and gas processing centres as well as the Power of Siberia pipeline. Other large Russian companies, including Lukoil, Gazpromneft, Tatneft and Sibur, announced at different points that their investment programmes are under review, but have not disclosed any further information.

In the meantime, many of the upstream investments by western companies in Russia are in legal limbo, with the investors having announced their exits and written down the value of these investments. They are also facing official restrictions on their ability to divest from Russian assets. For the moment, there are few signs of other non-western players stepping in to take their places.

Midstream and downstream oil and gas

Investment in new LNG projects is picking up, with a long line of projects looking to move ahead, but spending remains well below the levels seen in the 2010s



Note: Investment spending is profiled assuming a three-to-six-year construction period. 2023e = estimated values for 2023.

Interest in contracting for new LNG supply has risen following Russia's invasion of Ukraine, but European buyers are wary of long-term commitments

Despite key gas price benchmarks reaching record highs, 2022 was far from a bumper year for investment in LNG. FIDs were made for two projects in the United States (Plaquemines and Corpus Christi Stage 3) and a small floating LNG project in Malaysia (ZLNG Sabah). The total committed capital investment was USD 24 billion, similar to levels in 2021. Investment in regasification facilities, however, saw a large uptick in 2022 as EU-based companies announced, revived or accelerated plans for around 130 bcm of new LNG import capacity, including more than 20 projects based on floating storage regasification units (FSRUs). Around 45 bcm of new regasification capacity is expected to come online by the end of 2023, with Germany the focal point.

The long-lived nature of gas infrastructure, alongside Europe's 2050 climate target, has prompted a debate about the risk of lock-in or stranded assets for new LNG import infrastructure. Regasification terminals typically cost around USD 250/tonne of capacity, around a fifth of the cost of liquefaction terminals. Long-term capacity rights are usually held by private companies, who take the marketing risk and can see utilisation rates vary substantially over the long term.

The recent flurry of investment in LNG import capacity in Europe has not been matched by a parallel wave of long-term supply contracting. Of the 100 bcm of new LNG term contracts signed in 2022, almost half were by portfolio players, while buyers in Asia picked up a third, leaving around 20% earmarked for Europe. This share is well above historical levels, but total firm contracted volumes (around 70 bcm) remain well below annual requirements: buyers in Europe have mainly been relying on spot and flexible LNG to cover the shortfall left by reduced Russian gas deliveries.

Two LNG export projects have so far seen a FID in 2023, both in the United States: the USD 8 billion expansion of Plaquemines LNG (contracted mainly to US portfolio players and independents), and the USD 13 billion Port Arthur terminal (a large proportion of which is contracted to Europe-focused players). There are additional projects in North America – as well as Qatar's North Field South expansion – that have made progress towards an eventual FID; in the US alone more than 20 pre-FID sale and purchase agreements (totalling around 40 bcm) have been signed since Russia's invasion of Ukraine. Portfolio players have contracted around 40% of this total, with Chinese and European buyers each signing up for around 20%.

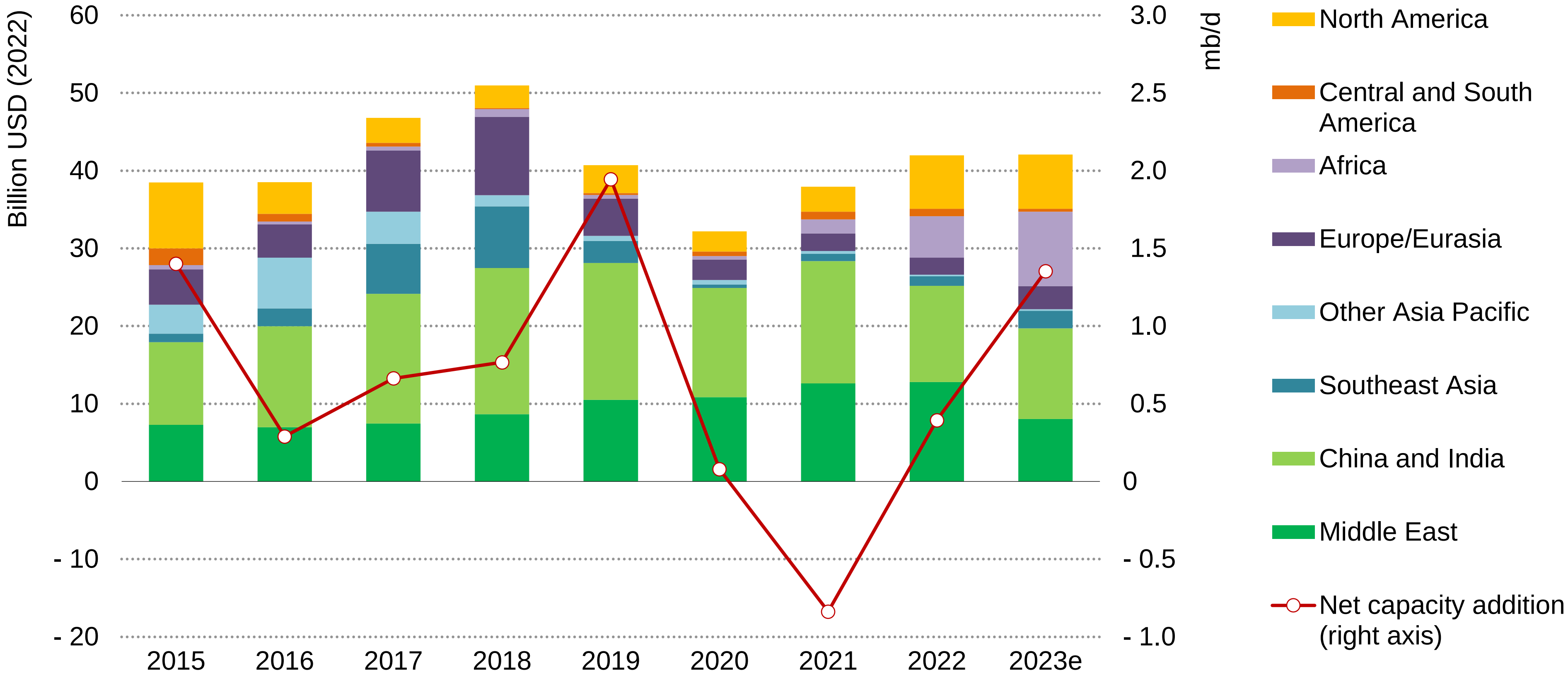
The proliferation of LNG projects due to come online in the 2025-2027 period raises the possibility of cost inflation, as multiple projects compete for a limited pool of specialised contractors. There will be trade-offs between value and speed, and the deadlines for some of the approved projects may well slip further into the latter part of the 2020s.

Investing in LNG remains a complex value proposition, as there is a near-term need for additional capacity but far less certainty about future requirements, especially as an unprecedented wave of around 170 bcm of new capacity is due online between 2025 and 2027 (even though some large projects such as Mozambique LNG and Arctic LNG may be at risk of delay). Accelerated climate ambitions and sensitivity to high gas prices also loom large in the backdrop: we assess the net present value (NPV) of LNG plants currently under construction at over USD 300 billion, assuming prices remain in the range of around USD 9-11/MBtu over a 30-year economic lifetime (consistent with STEPS prices). However, lowering the assumed gas price by 20% would bring the NPV down to zero.

Investment in long-distance gas pipelines remained muted in 2022. Russian state-controlled transport companies such as Gazprom and Transneft have announced plans for double-digit growth in investment for 2023; this reflects a sense of urgency to redirect export flows from Europe to Asia, rather than to bring online new upstream developments. However, there was no firm announcement from Russia and China about new gas pipeline infrastructure, notably the Power of Siberia 2 project, which would connect Russia's major existing fields in Western Siberia and the Yamal peninsula with China. India remains the key market for new gas distribution network investment, but high import prices and growing domestic competition from electricity in the transport and industrial sectors have dampened annual investment levels in the sector.

Investment in oil refining continued to rise in 2022, but is expected to slow from 2023 onwards

Investment in oil refineries (greenfield and upgrades) by region and net refining capacity additions, 2015-2023e



Notes: Investment figures do not include maintenance capital expenditure. 2023e = estimated values for 2023.

The current healthy margins may not necessarily translate into higher investment levels in the coming years, highlighting the importance of demand-side measures to curb demand growth

The very tight oil product market in 2022 stemmed from a strong rebound in oil product demand, a net reduction in refining capacity, high natural gas prices and lower inventory levels. These factors combined to push refining margins to record highs, especially for middle distillates such as diesel and kerosene. Margins have moderated since late 2022 due to weakened demand. Middle distillate cracks in particular have eased further in early 2023 due to the limited cuts in Russian diesel exports, and have been overtaken by gasoline cracks in the Atlantic Basin. However, despite the recent fall, refining margins remain healthy compared with past averages.

The effects of sanctions and embargoes on Russian oil trade flows were a key variable in global oil markets. Shipments of Russian crude oil to Europe declined visibly following the import ban in December 2022, but these were offset by the surge in imports into India and China, keeping overall Russian export volumes stable. A similar pattern is being observed in product trade flows following the enforcement of the European products embargo in February 2023. While Russian product exports to Europe are falling, some of the volumes are being rerouted to Asia, Africa and the Republic of Türkiye. Despite sustained volumes, Russia's export revenues are nonetheless dwindling. Export revenue in April 2023 is estimated at USD 15 billion compared with nearly USD 20 billion a year ago.

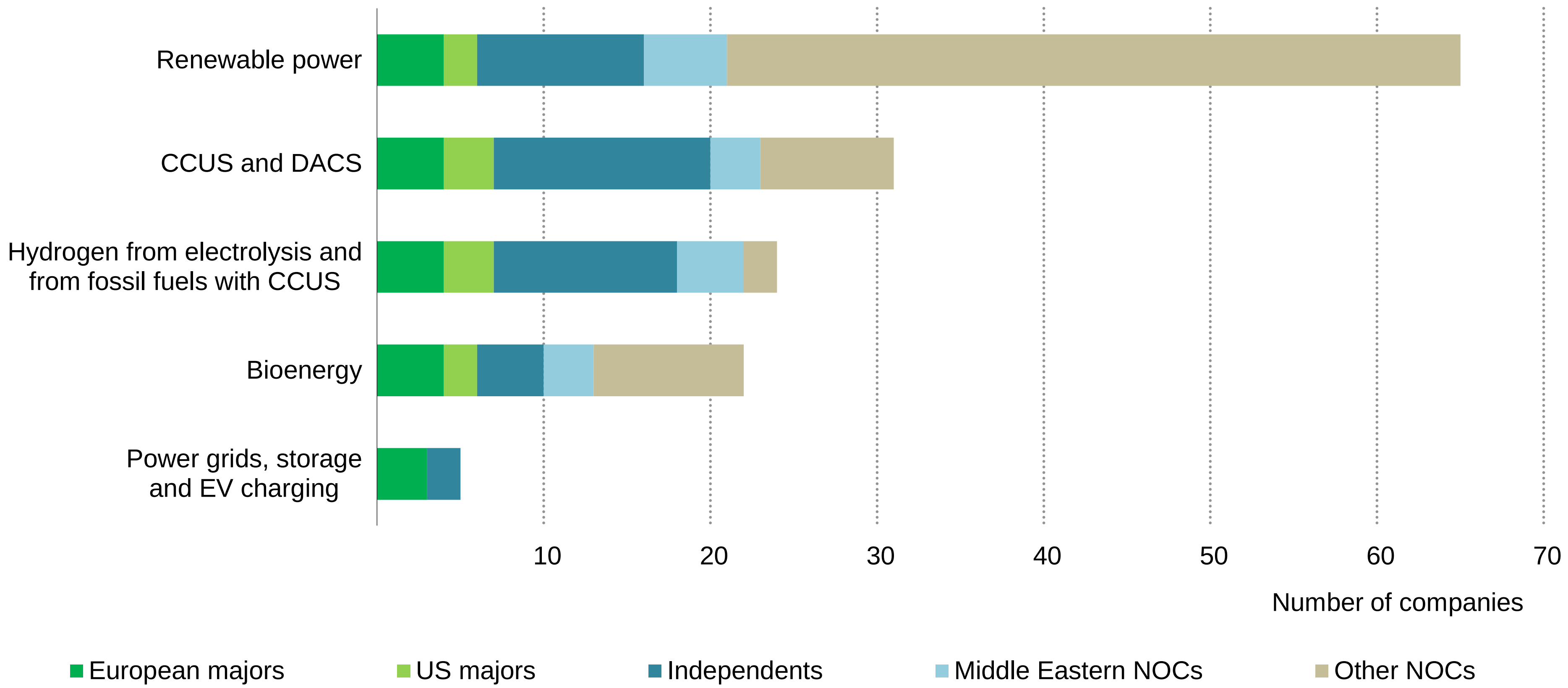
Thanks to healthy margins and tight market conditions, investment in oil refineries (excluding maintenance spending) continued its growth in 2022, reaching USD 40 billion. The increase was primarily driven by the Middle East, China, India and North America, where several large-capacity plants (e.g. the Al-Zour refinery in Kuwait, and the Jieyang and Shenghong refineries in China) started operations or are expected to come online in 2023. After the net reduction in capacity in 2021, the refining industry increased its net capacity by around 0.4 mb/d in 2022 and is set to add a larger amount in 2023.

As the current wave of new capacity additions reaches completion, investment is expected to wane in the coming years. Despite the current healthy margins, it is likely to become increasingly challenging to commit multi-billion dollar investment in new capacity given lingering uncertainty around the long-term outlook for oil demand. Rather, investment in new growth areas, such as low-emission hydrogen, biofuels and petrochemicals, and plastic recycling, is set to account for a larger share of overall investment by refiners. Refining companies already represent around 80% of today's renewable diesel production capacity and over half of the planned projects. This highlights the risk of a potential tightening of refined product supplies in the medium term and the importance of demand-side and efficiency measures to ease such tensions.

Oil and gas industry transitions

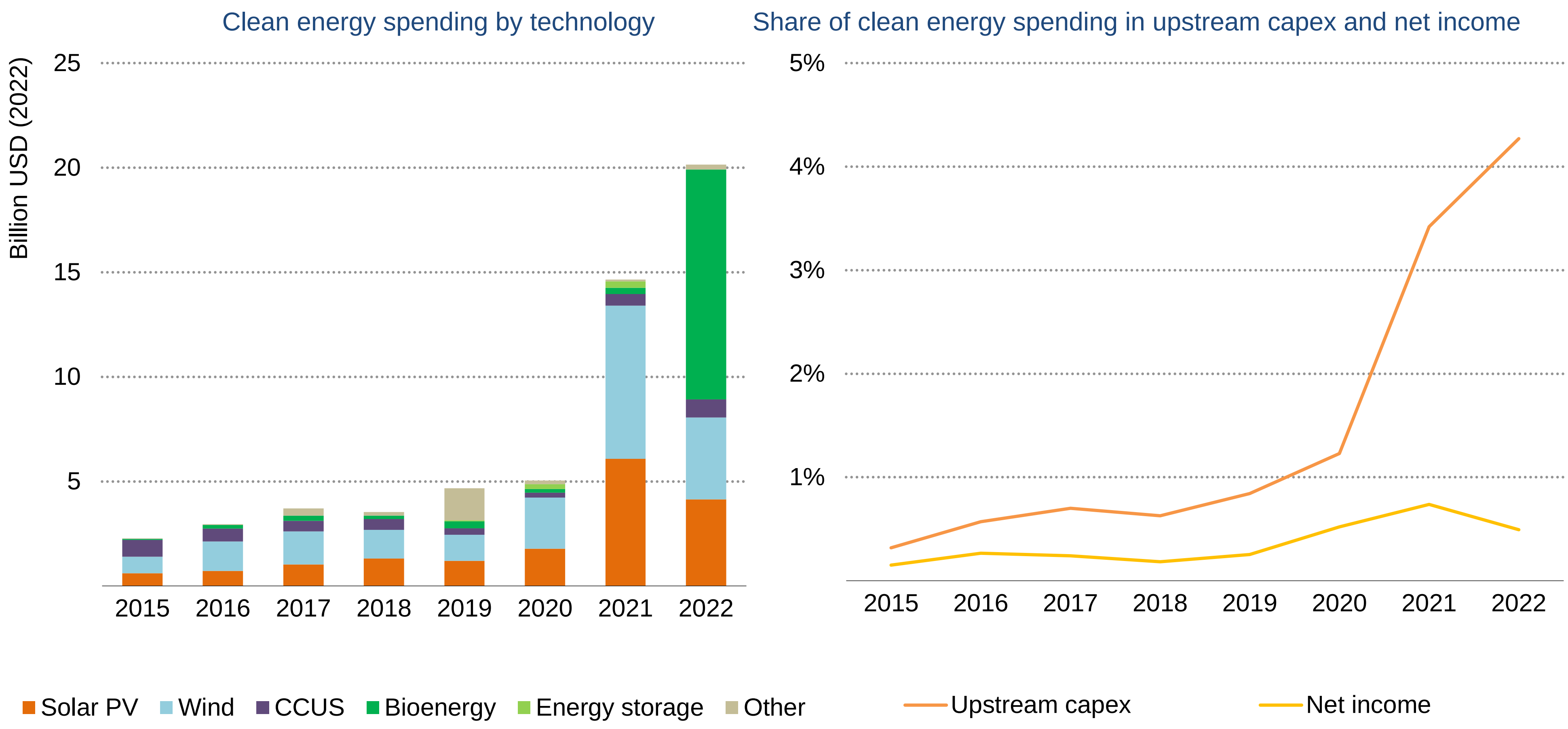
Renewable power is the diversification option being pursued by the largest number of oil and gas companies

Number of oil and gas companies with strategic plans and realised investments



Notes: Takes into account companies having made investments and/or strategic pledges. Low-emission hydrogen includes hydrogen from electrolysis and from fossil fuels with CCUS
Sources: IEA analysis using annual reports, BNEF and Clean Energy Pipeline.

Clean energy investment by oil and gas companies doubled in 2022 to around USD 20 billion, around 4% of their upstream capital investment and 0.5% of net income



Notes: Spending in this figure includes mergers and acquisitions (investment figures in the rest of this chapter do not); Other = hydrogen, geothermal, small hydro and hybrid projects.
Sources: IEA analysis using annual reports, Clean Energy Pipeline, BNEF, Rystad and IJ Global.

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Oil and gas companies' investment in clean energy is increasing but remains small relative to overall capital investment; bioenergy investment rose significantly in 2022

Our tracking of oil and gas company expenditure shows that around 4% of their upstream capital expenditure in 2022 went to areas outside traditional supply, such as clean fuels, CCUS and clean power. This was 3 percentage points higher than the respective share in 2020. Bioenergy accounted for more than half of clean energy spending by the industry in 2022 as oil and gas companies took major stakes in several bioenergy producers. Our preliminary estimate is that investment levels will remain broadly constant in 2023 although much depends on the number and size of mergers and acquisitions.

There are wide company-by-company variations in this area, but an increasing number of oil and gas companies have now made some sort of commitment to reducing emissions or to diversify their investment spend (typically European majors and independents). The most common type of pledge relates to the emissions associated with the companies' own operations, whether directly (Scope 1) or indirectly (Scope 2). Our assessment is that oil and gas industry operations are responsible for just under 15% of energy-related GHG emissions today. Companies accounting for just under half of global oil and gas production today have announced plans or targets to reduce their Scope 1 and 2 emissions.

For many companies, the pick-up in non-core spending is aimed at reducing the company's own emissions. ExxonMobil, for example, announced plans to spend USD 17 billion on emission reduction initiatives until 2027; of this, 40% will be directed to initiatives with third parties (with a primary emphasis on CCUS, biofuels and hydrogen), but the majority will be towards reducing the company's Scope 1 and 2 targets.

Reducing flaring and methane leaks has to be a core priority. The methane emissions intensity of oil and gas production is edging downwards, but the IEA's Global Methane Tracker underlines that these leaks remain unacceptably high. Likewise, global gas flaring decreased slightly in 2022, largely thanks to reductions in Nigeria, Mexico and the United States, as well as consistent efforts from Kazakhstan and Colombia, but almost 140 bcm of gas was nonetheless wasted in a year when gas supplies were very tight and prices exceptionally high.

There is a growing realisation that leading oil and gas companies' active participation in emission reduction efforts is preferable to them simply selling off their most carbon-intensive assets to meet emission reduction goals. Analysis by the Environmental Defense Fund highlights the general movement of upstream assets in recent years towards companies with weaker climate commitments. From 2018 to 2021, more than twice as many deals moved assets away from operators with net zero commitments than the reverse.

Renewable power remains the main outlet for non-core oil and gas company spending, but investment in clean fuels, such as bioenergy, hydrogen and CCUS, is picking up

The pipeline of clean energy investment projects that have oil and gas industry participation is picking up. The past several years have seen oil and gas companies – particularly European majors – build up a portfolio of renewable assets through acquisitions, joint ventures and direct investment. The early focus was on wind and solar developments, and there have been large moves into offshore wind: TotalEnergies announced in 2022 a project pipeline of 6 GW of offshore wind, taking the total to 11 GW, Shell also has around 9 GW in the pipeline and Equinor has ambitions to install 12-16 GW by 2030. If realised, these capacity additions would rival those of pure-play offshore wind developers such as Ørsted over the same period. More recently, oil and gas companies have increased their focus on bioenergy, spending around USD 11 billion in 2022, mainly on the acquisition of biomethane and biodiesel producers.

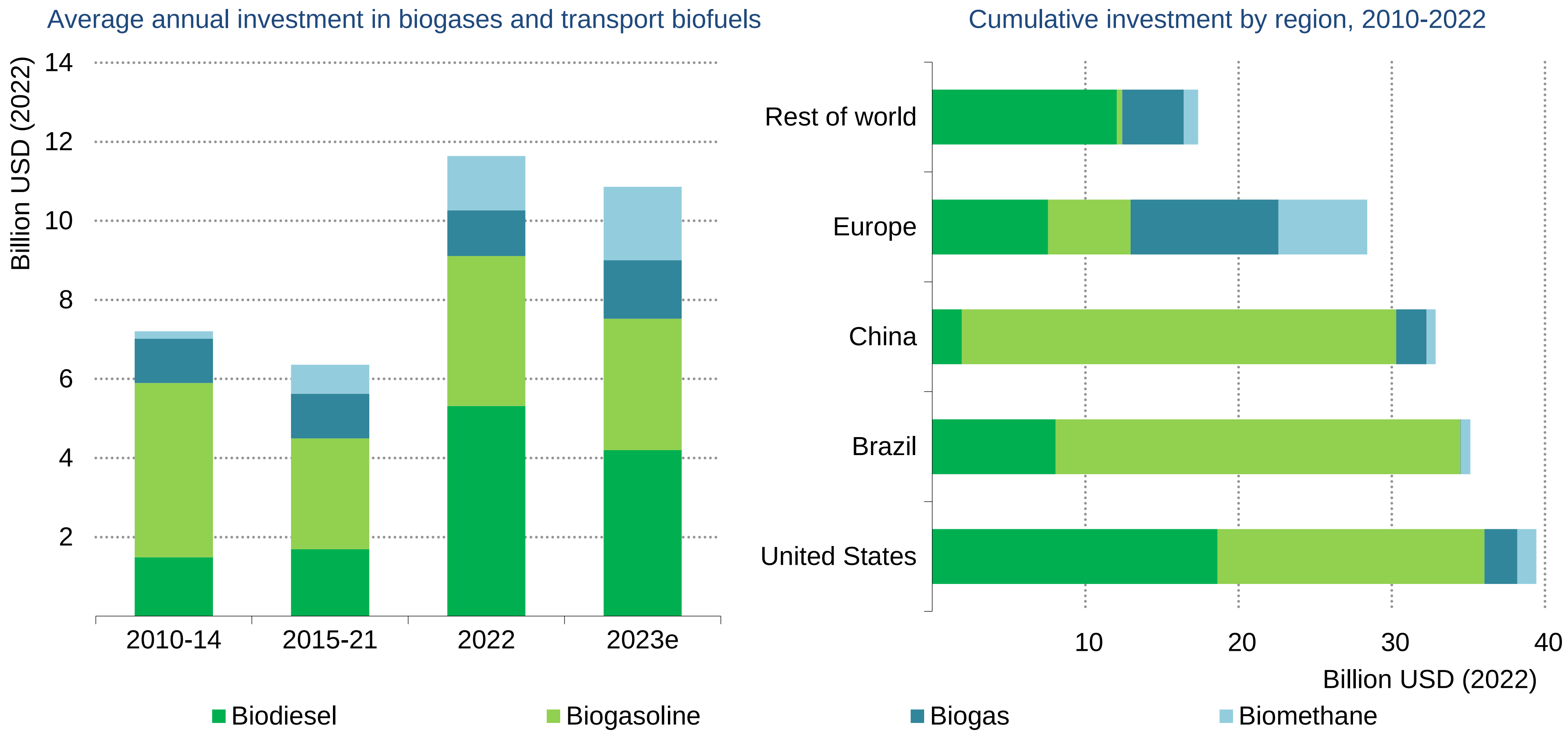
There is increasing policy support for CCUS, biogases and low-emission hydrogen, all of which are a good match for the engineering and project management strengths of oil and gas companies, as well as their experience in handling liquids and gases.

Several oil and gas companies have announced large-scale capital-intensive flagship projects in these sectors in recent years. For example, in 2022 BP took a 40% stake in the hydrogen-focused Western Green Energy Hub in Australia, set to be one of the largest renewable projects in the world. This was followed by BP's USD 2 billion commitment to develop hydrogen, biofuels and renewable energy around its refining operations in Valencia, Spain. Shell in 2022 took a FID for an integrated hydrogen project in the Netherlands – Holland Hydrogen I, one of the largest hydrogen projects in Europe.

NOC activity in this area is also picking up. ADNOC is developing two CO_2 recovery projects at existing gas plants and, along with BP and Masdar (the state-owned renewable energy company in the United Arab Emirates), is participating in the United Kingdom's H2Teesside project for hydrogen from natural gas with CCUS. In 2022 Saudi Aramco announced plans for a CCUS hub with a target to reach 9 Mt CO_2 capacity by 2027. The company's first sustainability report, released in mid-2022, also contains a target to reach 11 Mt of hydrogen production capacity by 2030. Petronas reached a FID on the 3.3 Mt CO_2 Kasawari offshore CCUS project.

Low-emission fuels

Modern gaseous and liquid bioenergy saw a sharp uptick in investment spending in 2022, led by advances in renewable diesel and biomethane



Note: Biomethane investment includes the cost of producing biogas as an interim step before upgrading to biomethane. 2023e = estimated values for 2023.

A flurry of acquisitions in recent years has seen the oil and gas industry take major stakes in bioenergy producers

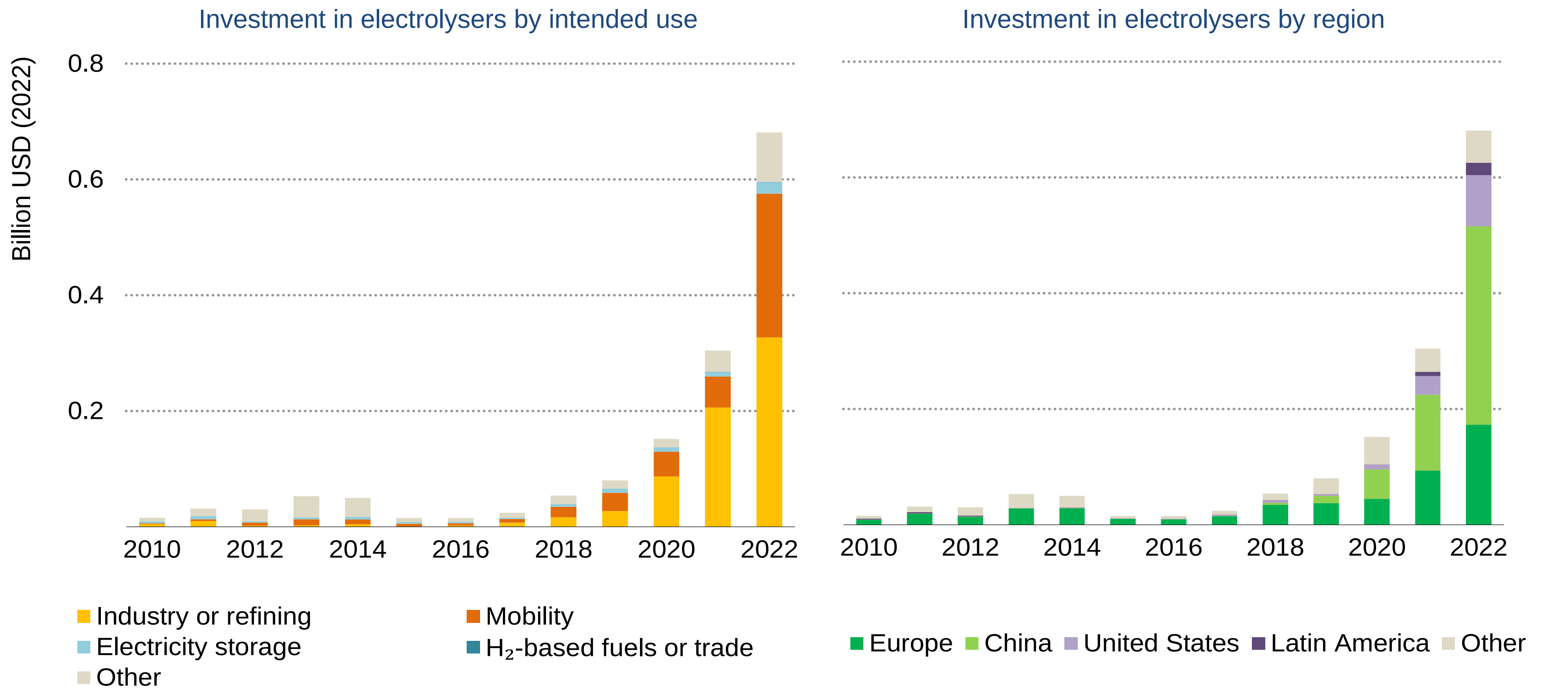
Global transport biofuel capacity expanded by 7% in 2022, its largest annual increase in over a decade. Biorefineries focused on renewable diesel made up the bulk of the growth, thanks to attractive policies in the United States and Europe, while bioethanol capacity saw notable increases in Brazil, Indonesia, India and China.

Biofuels investment saw a large uptick in 2022 as capacity additions reached a decade high of around 260 kb/d. Large investments were announced in renewable diesel refining, notably the Marathon-Neste USD 1.2 billion joint venture in California and Imperial's USD 720 million investment in Canada. Several large companies are also making forays into sustainable aviation fuels; this underpinned Neste's USD 2.2 billion expansion of its renewable fuels plant in Rotterdam. In the European Union alone there are over 30 advanced biorefinery projects in operation, and a further 10 are slated for operation before 2025; several are developing sustainable aviation fuels and renewable diesel production capabilities. The United States is likely to lead growth in this sector in the near term, thanks to generous fiscal incentives; the Inflation Reduction Act includes an estimated USD 9.4 billion in tax credits and financial support for new production capacity and biofuel infrastructure generally.

Through a series of acquisitions and new partnerships, oil and gas majors are increasingly gaining a foothold in the biomethane industry. BP bought Archaea Energy in late 2022 for USD 4 billion, Shell acquired Denmark-based Nature Energy for USD 2 billion, and Chevron bought biofuel-focused Renewable Energy Group in a USD 3 billion acquisition (alongside the acquisition of Beyond6, a compressed natural gas refuelling network). TotalEnergies has made a series of smaller acquisitions, such as the purchase of Poland-based biogas producer PGB, and entered into an agreement with Veolia to produce biomethane from waste treatment plants.

Vigorous debate continues about the sustainability of different feedstocks for bioenergy; currently around 90% of liquid biofuels and the majority of biogases are derived from conventional food crop feedstocks. The EU Renewable Energy Directive II foresees a 7% cap on these feedstocks, favouring those derived from waste streams instead. The cost of bioenergy feedstocks has also been rising in recent years due to volatile crop prices and high demand for biofuels as countries enact more ambitious blending mandates. There is a possibility of a feedstock supply crunch over the coming years, as demand for vegetable oil and waste and residue oils and fats for transport biofuels is expected to grow by nearly 60% to 80 Mt by 2027.

Spending on electrolysis projects for hydrogen is growing fast, led by end uses in mobility, oil refining and industry, especially for iron and steel



Notes: 2022 values are estimated annualised spending on projects that are under construction and due to enter operation in 2023. Estimates are based on capital cost assumptions and announced capacities of electricity input or hydrogen output volumes per project and include electrolysers for hydrogen supply used for energy purposes or as an alternative to fossil fuel use in industry (such as chemical production and oil refining). "Mobility" includes projects for which the hydrogen output is intended for use in vehicles; hydrogen intended for conversion to hydrogen-based fuels is included in "H_2-based fuels".

Sources: IEA analysis based on IEA hydrogen project database and recent announcements.

Hydrogen spending is driven by major projects in China and Europe that are due to start up in 2023-2025; US policy incentives are yet to translate into FIDs

Global electrolyser capacity additions fell by one-third in 2022, yet this trend does not reflect the amount of capital committed, nor does it imply a slowdown stemming from weaker macroeconomic conditions. A single 150 MW expansion in China in 2021 almost equalled total new capacity in 2022, and no new additions of that size began operation in 2022. Another major Chinese project – a 260 MW facility at a refinery in Xinjiang – is scheduled to start in mid-2023. Our estimate of spending on projects nonetheless shows significant growth due to the ongoing construction of projects not yet in operation.

Overall, there remains a positive expectation among hydrogen developers that investment will grow exponentially in the near future, driven by government incentives. However, it is too early to see any boost to spending from recent flagship hydrogen policies in Europe and the United States, for which rules are still being finalised.

A sign of the rising investment appetite for hydrogen projects in the energy sector are the FIDs taken in 2022 for more industrial-scale projects. All are linked to dedicated renewable electricity capacity. The largest among these, in Saudi Arabia, will have electrolyser capacity of 2 GW in 2026 if completed to plan, eight times larger than the next biggest in the world. As most of its output is intended for export to users outside the Middle East, it is an example of the entry of serious new players in low-emission hydrogen that are not driven by local decarbonisation policies. Egypt, Oman and the United Arab Emirates are also proposing to become exporters.

The next largest group of projects are all integrated into the use of the hydrogen. Shell's Holland Hydrogen I in the Netherlands and Air Liquide's Normand'Hy in France, at 200 MW each, will have capacities ten times that of Europe's biggest existing plant and are aiming to supply existing refineries by 2025. The Shell FID was taken without government support. In China, Sinopec started constructing a roughly 200 MW electrolyser in Inner Mongolia with associated hydrogen storage to supply a coal-to-chemicals facility. State-owned Dalian Capital Investment began building 60 MW of electrolysis capacity that will run on seawater. In Sweden, an FID could be taken in 2023 for the first new steel mill in Europe since the 1970s, equipped with 720 MW of electrolysis, backed by a public loan guarantee.

Two projects for producing hydrogen from natural gas equipped with CCUS also took FIDs in 2022. A Hydrogen Energy Complex is under construction by Air Products in Canada, to produce around 0.5 Mt of hydrogen for power generation and other uses, with 95% of the CO_2 captured and stored from 2024. The capacity is equivalent to 3 GW of electrolysis running 100% of the time. It has grant funding from the federal and Alberta governments. In the United States, financial close was reached in February 2023 on a facility in Texas to produce 0.2 Mt of hydrogen for fertiliser production from 2025 with over 90% CO_2 capture. The capacity is equivalent to around 1.7 GW of electrolysis. The destination of the captured CO_2 has not been yet disclosed. While several similar projects are well advanced in Europe and the Middle East, the more favourable investment environment in North America has made it the leader in hydrogen production with CCUS.

Additional major FIDs in Europe and the United States are widely expected to flow from major policy initiatives stemming from post-pandemic stimulus funding, the ongoing energy crisis and regional ambitions to secure value chains. Under the Important Projects of Common European Interest (IPCEI) scheme, the Commission approved EUR 10.6 billion in country-level support to projects focused on technology and infrastructure in 2022. For example, the delayed 100 MW REFHYNE 2 project at a refinery in Germany is on the IPCEI list and could take FID once funding is clarified, as long as electrolyser manufacturing also scales up. The United Kingdom's March 2023 budget promised GBP 20 billion over 20 years for electrolysis and CCUS-equipped hydrogen production; 408 MW of electrolysis projects were shortlisted in March 2023 for a first GBP 340 million funding round.

The biggest boost to investment is likely to stem from the 2022 US Inflation Reduction Act, coupled with the Hydrogen Hubs initiative launched the year before. Among other provisions, the act provides tax credits of up to USD 3/kg of hydrogen produced in line with certain emission and other criteria, and up to USD 85/tonne of CO_2 stored (noting, however, that this CCUS provision is worth the equivalent of just under USD 1/kg of hydrogen and cannot be claimed in addition to the hydrogen tax credit). The act also provides credits for investment in the manufacturing of related equipment, plus grants and loan guarantees for demonstration projects.

The pay-for-performance approach and magnitude of the tax credit system compared to project-based funding competitions has led to speculation that the act might lead to the relocation of projects to the United States, especially electrolyser and component factories. Uncertainty about the environmental requirements for hydrogen to qualify for EU incentives has also fuelled this opinion. While many new US projects have recently been announced, there is only anecdotal evidence to date that these developers' other projects outside the United States no longer have their full commitment. In early 2023 Johnson Matthey and Plug Power announced an electrolyser manufacturing partnership for a 5 GW factory by 2025 that would more than double existing US capacity and be five times the size of the largest operational factory in the world today. However, Plug Power has also announced an expansion in Korea and, of the 38 electrolyser factory plans announced with a capacity of over 1 GW, only six are in the United States, of which three were announced after the passing of the Inflation Reduction Act. On balance, the act is likely to raise international hydrogen investment and pull its centre of gravity of towards North America in the near term, but this will depend on how EU countries respond and whether developers, suppliers and service providers can service multiple large projects in parallel.

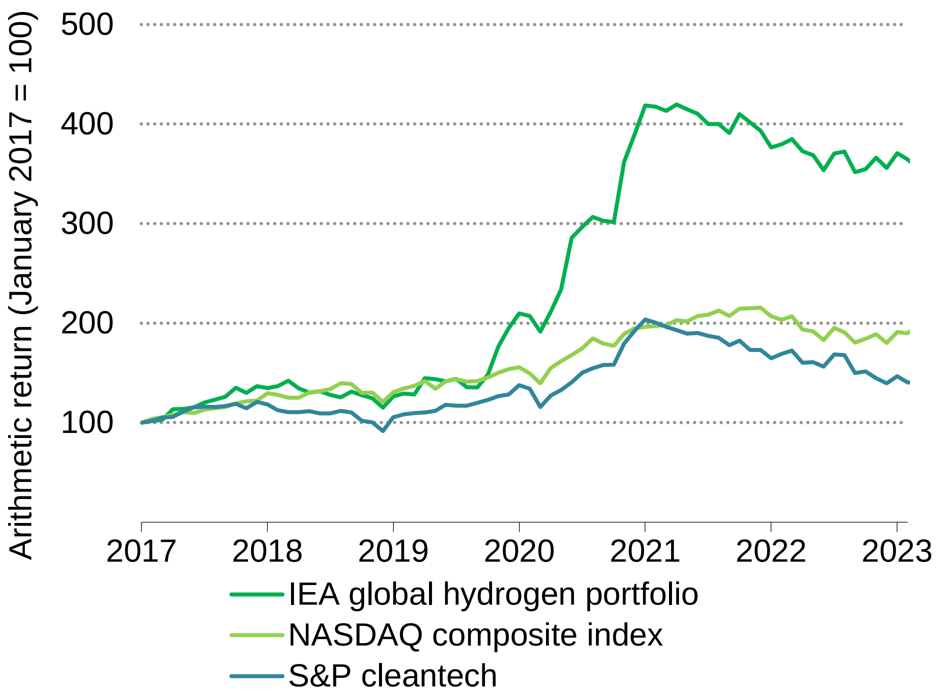
Other notable announcements of public support include AUD 2 billion in payments for hydrogen production from renewable-based electrolysis to 2030 and USD 1.6 billion granted by Japan to the Hydrogen Energy Supply Chain in Australia. That project would combine lignite, CCUS and seaborne shipping of hydrogen to Japan from around 2029 if approved by Australian stakeholders. India announced USD 11 million in funding available for consortiums developing hydrogen projects. The European Commission published a concept for a European Hydrogen Bank that could contract with hydrogen producers and consumers to fill the gap between production costs and tolerable purchase prices, whether the producer is in the European Union or outside. EUR 800 million is suggested for an initial auction, echoing a similar model used by the German initiative H2Global, which has a EUR 900 million initial budget and launched an ammonia auction in 2022.

Several investments were also made into hydrogen-related infrastructure. These include an FID by fertiliser company OCI to expand by 200% its 0.4 Mt ammonia import terminal in the Netherlands by the end of 2023. In mid-2022 the US Department of Energy Loan Program Office finalised a USD 504 million loan guarantee for an electrolysis and large-scale underground hydrogen storage project.

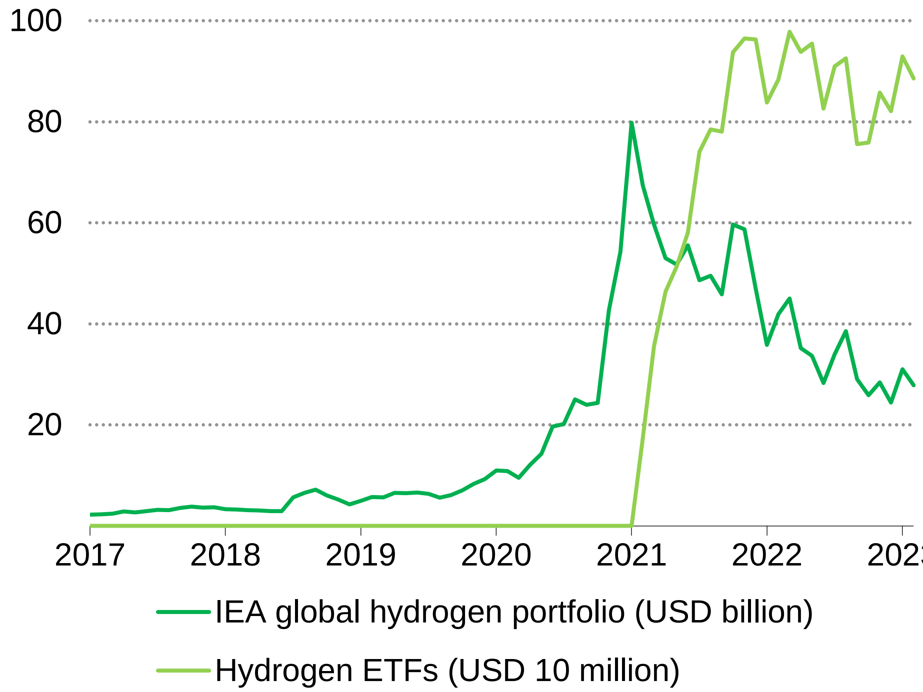
In 2022 multilateral development banks indicated their willingness to finance hydrogen projects. Announcements included: a World Bank and IFC facility for concessional finance for projects (Barbados, Mexico and South Africa) and governments (Chile, India and Namibia); an agreement for a potential loan of EUR 500 million from the European Investment Bank (EIB) to Namibia; and two loans from the Inter-American Development Bank (USD 400 million) and World Bank (up to USD 350 million) to Chile. Since these loans to Chile were announced in November 2022, some consolidation of projects in the country appears to have begun, as fewer of the consortiums shortlisted for public funding have progressed through to the environmental assessment phase than expected. This outcome is likely to be repeated in other countries as the long lists of announced projects are winnowed by commercial, regulatory and public budget hurdles.

Since mid-2022, returns from a portfolio of 41 low-emission hydrogen firms have stabilised, but their market capitalisation has suffered in line with lower valuations for technology firms

Monthly returns of hydrogen companies and funds



Market capitalisation of hydrogen companies and funds



Notes: ETFs = exchange-traded funds; portfolio member tickers: 0051720D US, 288620 KS, 332142Z LN, 336260 KS, 702 HK, ACH NO, ADN US, AFC LN, ALHRS FP, AMMPF US, BE US, BLDP CN, CASAL SW, CI SS, CWR LN, F3C GY, FCEL US, FHYD CN, GNCL IT, GREENH DC, H2O GY, HDF FP, HTOO US, HYON NO, HYPRO NO, HYSR US, HYZN US, HZR AU, IMPC SS, ITM LN, LHYFE FP, MCPHY FP, NEL NO, NHHH CV, NXH CN, PCELL SS, PHE LN, PLUG US, PPS LN, PV1 AU, SPN AU, TECO NO, VIHD US, VYDR US.

Source: IEA calculations based on Bloomberg (2023).

Despite uncertainties facing some early-stage "pure play" hydrogen companies, funds that raise money to invest in hydrogen projects have held their value over the past year

Unprecedented levels of investment in hydrogen companies have been mobilised as near-term expectations for hydrogen projects have risen. To track this trend, we assembled a portfolio of publicly traded companies whose success depends on demand for low-emission hydrogen growing. To try to be as representative as possible since WEI 2022, we have expanded the portfolio from 33 to 41 members. These companies span a range of sectors, including electrolyser and fuel cell manufacturing, low-emission hydrogen and ammonia project development, hydrogen distribution infrastructure and hydrogen-fuelled vehicles.

The total market capitalisation of the portfolio tracks some of the major clean energy trends since 2019: initial hopes for high growth were buoyed through the Covid-19 pandemic by expectations that governments would ensure a quick recovery, but rising interest rates in 2022 were compounded by the energy crisis and this led investors to withdraw equity from sectors struggling to meet shareholder requirements. By the end of February 2023, the market capitalisation of the portfolio had dropped back to its level in November 2020. Meanwhile, the monthly investor returns and revenues of this portfolio are almost three times higher than five years ago, and they continue to outperform more general cleantech indices. This suggests that investors treat hydrogen stocks as high-tech innovative businesses (as represented by the NASDAQ composite index), which gives them preferential access to government programmes focused on future competitiveness.

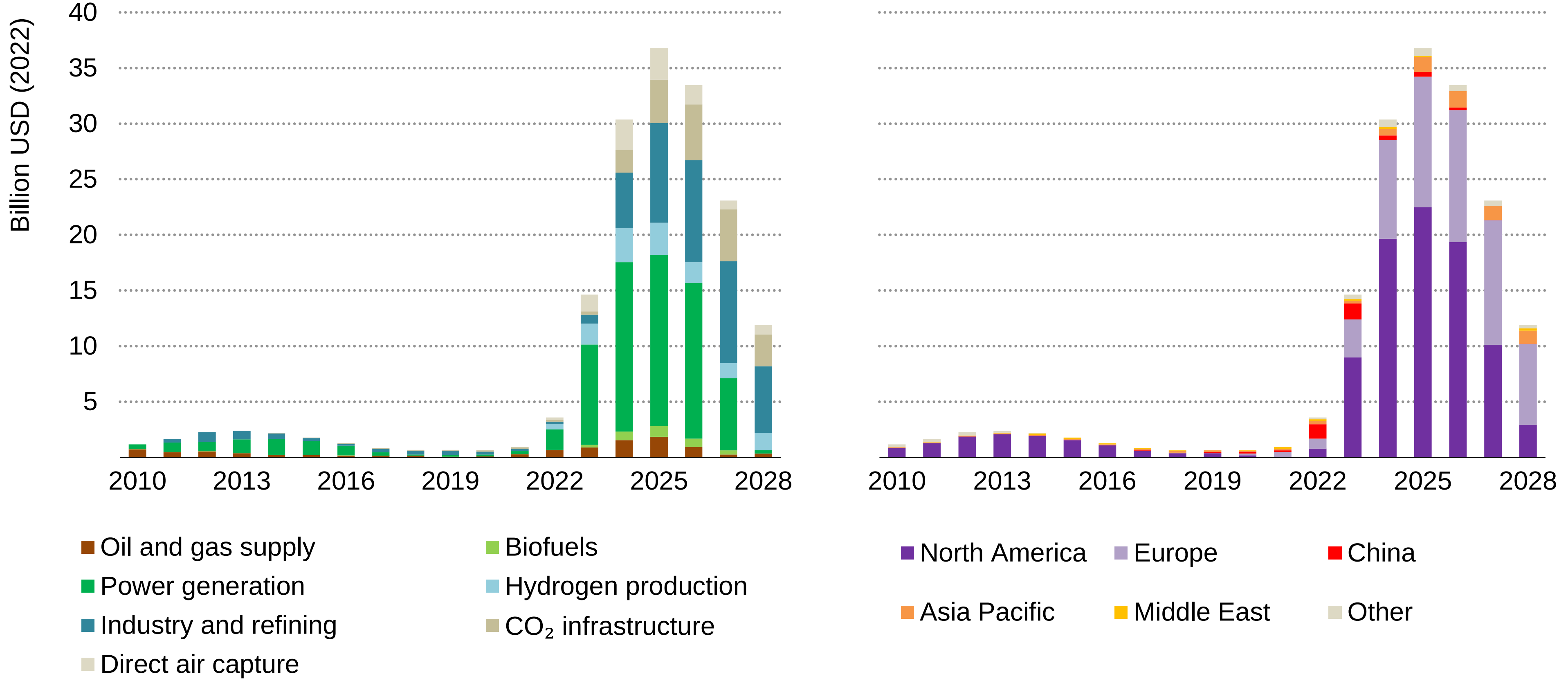
Even as the value of listed hydrogen companies has been adjusted downwards, publicly traded dedicated hydrogen funds have maintained their value. These funds are established to invest equity in a blend of private companies and projects that are scaling up low-emission hydrogen supply and use. Since 2022 these funds have shifted their attention more towards projects, which they now expect to yield higher returns relative to technology companies in the medium term. For example, HydrogenOne Capital Growth has invested EUR 17 million in the project developers Strohm and HH2E since mid-2022. The unlisted Clean Hydrogen Infrastructure Fund, which raised over USD 1 billion in early 2022, has not expanded further but in early 2023 it took a 49% stake in a new EUR 200 million venture to develop hydrogen infrastructure in Nordic countries. Since WEI 2022, United Hydrogen Limited joined these other investors; it has a stronger focus on company ownership and, despite a lower valuation at USD 39 million, a goal of becoming the world's largest diversified hydrogen conglomerate. Funds are also being raised in regions that have been less active to date: in April 2023, Avaada, a solar project developer, raised USD 1 billion from a Canadian investment fund for hydrogen-related projects in India.

Start-ups working on hydrogen-related technologies and businesses raised record amounts of early-stage and growth-stage equity in 2022. At USD 660 million, early-stage deals were only marginally higher than in 2021, but this was over ten times higher than the annual average of the previous five years. Notable deals included those for Hysata, an Australian electrolyser developer raising USD 29 million, Hygenco, an Indian project developer raising USD 24 million, and Levidian, a British developer of methane cracking raising USD 13 million. Growth-stage funding rounds, which tend to be much larger than early-stage, rose by 150% in 2022, to USD 2.9 billion. This is an even more impressive achievement in light of only a 1% increase overall in growth-stage equity funding for energy firms. The largest deal, at over USD 300 million, was for Monolith, a US developer of methane pyrolysis.

As the size of hydrogen projects grows, the share of start-ups that are project developers, not technology owners, has risen. However, growth-stage investment and acquisitions still tend to favour technology companies. In an analysis of 391 start-ups founded since 1990 with activities related to hydrogen, 70% were found to hold at least one patent application. More than 80% of the growth-stage investment in hydrogen start-ups since 2000 was in companies that had already filed a patent application. Overall, 55% of all venture capital funding for hydrogen start-ups went to the 117 companies that had filed patent applications in the period 2011-2020.

Recent FIDs for CCUS projects are set to push 2023 spending to a new record

Annualised historical and potential spending on advanced CCUS projects based on announced project timelines



Notes: Includes commercial capture and full-chain CCUS projects with a capacity of over 0.1 Mt CO_2 per year; projected spending represents the capital costs of projects with announced capacities based on their planned FID and operational dates; spending is estimated where project-level cost data are unavailable; Other includes Africa, South and Central America and the Middle East.

Source: IEA analysis based on IEA CCUS projects database.

CCUS project announcements have been galvanised by public support packages in the United States, which support the trend towards risk management by breaking up the value chain

When the Taizhou power station CCUS project enters operation – it is scheduled to do so this year – it will become the third facility in China since 2018 to capture more than 0.5 Mt CO_2 per year. One of the other two plants, at the Qilu refinery, started operating just last year, establishing China as the centre of CCUS investment recently.

However, the coming years will be dominated by significant growth in investment in the United States, spurred by government support policies that close the cost gap. Since November 2021, five US projects that will each handle over 0.5 Mt CO_2 per year took FID. The entry of these projects into the construction phase likely helped push CCUS investment to a record USD 3.1 billion in 2022. They also provide confidence that CCUS spending will continue to grow.

If all advanced projects take FID in line with their schedules, global CCUS spending could reach USD 34 billion in 2025. This dramatic potential ramp-up reflects the extent to which the CCUS project pipeline has expanded recently. Over 180 projects have been announced since January 2022 along the CCUS value chain. CO_2 capture projects are shared between different sectors, with many relating to hydrogen or bioethanol production. The higher unit cost of projects in the power sector led to its roughly 50% share of total possible investment in 2023-2028. The full project pipeline could raise global CO_2 capture capacity from around 45 Mt CO_2 per year today to over 300 Mt CO_2 per year by 2030. But this would still fall short of the 1 200 Mt/yr envisaged by the NZE Scenario in that year. While 30% of the announcements since the start of 2022 were in the United States, the project pipeline is becoming more global. New projects are planned in Bulgaria, Croatia, Libya, Portugal, Singapore and Thailand, among others.

Most developers expect to rely on direct public support to make projects profitable, in some cases via the backing of state-owned enterprises. To date, FIDs have typically been enabled by grant funding, and many recent announcements follow this pattern. Newly available US grant support for developers of so-called H2Hubs has prompted CO_2 transport and storage projects that could link to multiple CO_2 sources, not just hydrogen production. Among the recent US FIDs is the Central Louisiana Regional Carbon Storage project, which reached financial close in early 2023 on up to 10 Mt CO_2 of storage capacity.

This is reflective of a wider trend towards splitting the different parts of the CCUS value chain into separate projects. While "full-chain" projects (where CO_2 is transported from one capture facility to one injection site, sometimes involving a single operator) were a natural response to calls for demonstration projects, they suffer from high investment needs, cross-chain risks and liabilities that are borne by a single developer. Breaking up the CCUS value chain can help mitigate these hurdles. In 2022, projects to develop over 210 Mt of new dedicated CO_2 storage capacity were announced, more than double the amounts in 2020 and 2021. One of most advanced projects under construction is Northern Lights, in Norway, which is developing large-scale CO_2 storage that can accept CO_2 from multiple sources that have incentives to reduce emissions. In May 2023, Denmark awarded around USD 1.2 billion to meet the costs of capturing 0.4 Mt CO_2 per year from biomass combustion for storage at the Northern Lights site from 2026. Separately, pilot CO_2 injection began offshore in Denmark in 2023.

Recent policy developments support this trend by offering financial rewards for storage of CO_2 or production of clean products. Mechanisms such as tax credits, contracts for difference and public procurement create bankable demand for CO_2 transport and storage services, which reduces the risks associated with infrastructure development. Among these, the tax credits offered by the US Inflation Reduction Act – up to USD 85/t CO_2 stored or USD 3/kg of hydrogen – are set to stimulate the most investment, supported by proposed emissions rules for power plants. A different model is found in the European Commission's proposed Net Zero Industry Act, which links the production of fossil fuel to a requirement to develop CO_2 storage capacity. The act's suggested target of 50 Mt CO_2 of available storage capacity by 2030 is ambitious but falls well short of that required in the NZE Scenario. Together, these initiatives begin to address a long-standing issue over where the responsibilities and rents will lie in a commercial CCUS value chain.

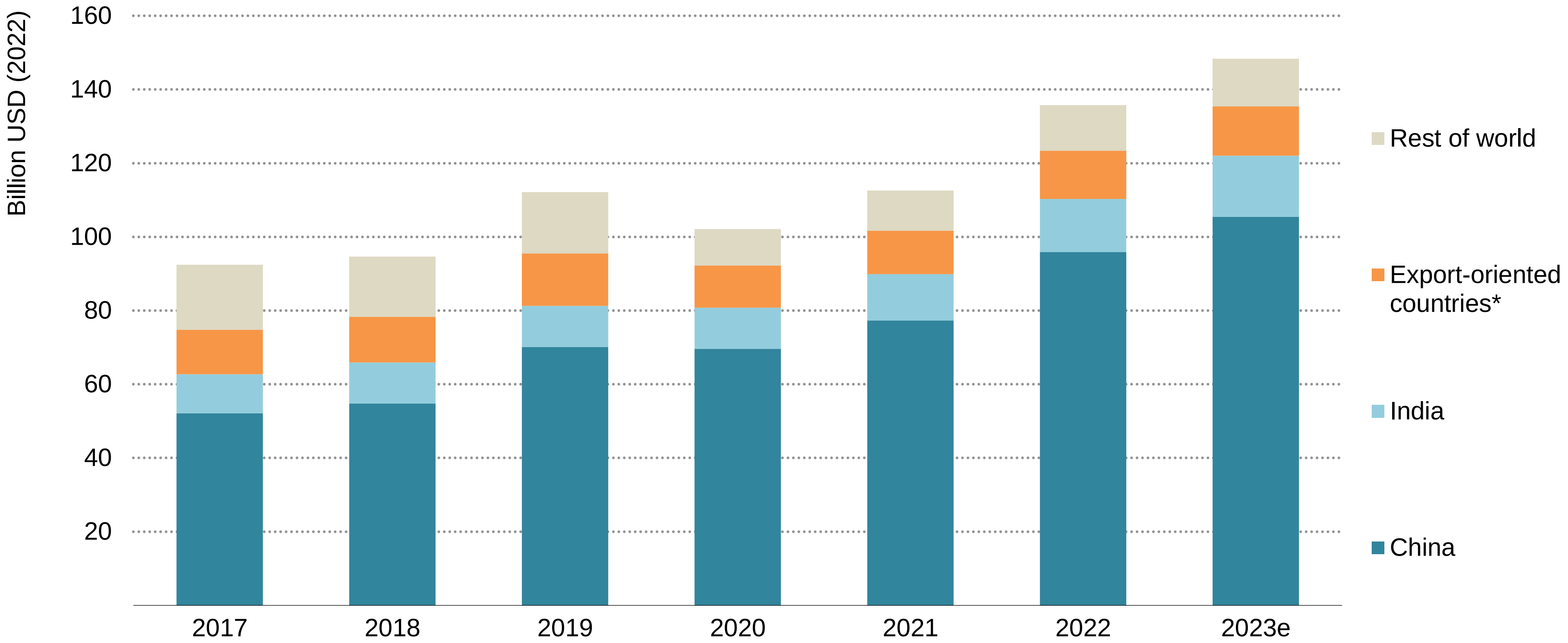
Policies are also taking shape in some EMDEs. For example, in March 2023 Indonesia issued its first regulation governing the procedures and responsibilities for proposed projects that integrate CCUS with natural gas extraction and processing. Fifteen projects have been identified that could advance under this regulation. Malaysia, where raw natural gas also has a high CO_2 content, has signalled that it will also proceed along similar lines. CCUS is also expected to play a key role in delivering the net zero emissions pledges of many EMDEs, including in coal-related sectors, where policy development has been slower.

Start-ups working with CCUS technologies raised more early-stage and growth-stage funding in 2022 than in any previous year. Most of the USD 440 million of early-stage equity went to the area of CO_2 capture, followed by hydrogen-based fuels that utilise CO_2. Notable growth-stage deals included a USD 318 million investment in Svante by Chevron and co-investors including the Oil & Gas Climate Initiative, and a USD 300 million investment in Entropy; both are Canadian firms with new CO_2 capture methods. Direct air capture (DAC) developers continued to attract investment bets in 2022, bolstered by US policy incentives. These included Climeworks (USD 650 million), Carbon Direct (USD 60 million), Mission Zero (USD 5 million) and RepAir (USD 1.5 million). Paebbl, a Dutch start-up making construction material from CO_2, raised USD 8 million.

Coal

Global coal investment rose in 2022 – surpassing 2019 levels – and is set to rise again in 2023

Global investment in coal production by region, 2017-2023e



* Export-oriented countries = Australia, Indonesia, Russia, Colombia and South Africa.
Note: 2023e = estimated values for 2023.

Strong demand and high prices sent a powerful signal for new investment – especially in China and India – although cost inflation has muted some of the impact on production capacity

Global coal demand reached an all-time high in 2022, with prices rising to unprecedented levels in October 2021 and reaching record highs on several occasions in 2022. Globally, coal investment increased to USD 135 billion in 2022, a 20% increase on 2021 levels. Almost 90% of investment occurred in the Asia Pacific region, predominantly in China and India.

The majority of coal investment in 2022 was used to maintain production at existing mines, with smaller amounts used to expand production at brownfield developments. New greenfield projects are limited in most parts of the world amid investor and company concerns over the impacts of coal on climate change, environmental social and corporate governance issues, slow permitting and public opposition limiting the availability of finance. The exception to this is China and India, where energy security concerns and power shortages have led to the development of new mines as well as the expansion of existing mines.

China saw power shortages in December 2020, mainly caused by a lack of power capacity adequacy, and there were shortages and rolling blackouts in 10 provinces over the summer of 2021, mainly because of shortages in coal supply. The government has pledged to avoid a repeat of these events and coal capacity has increased substantially since October 2021. Annual mining capacity increased by around 300 Mt per year in 2022, half from new mines and half from expanding production at existing mines – more than the rest of the world combined. The four major producing regions of Shanxi, Inner Mongolia, Shaanxi and Xinjiang are the focus of investment and capacity additions.

India's government has been looking to reduce coal imports by boosting domestic production and improving logistics. A key pillar of the strategy is to task government-owned Coal India to increase production both by its own means and by outsourcing it to "Mining Developers cum Operators". The strategy also aims to increase commercial mining and a number of auctions for blocks have taken place: since 2020, 87 mines have been awarded licences to commence production, and a further 106 mines were offered in the seventh round of auctions in March 2023.

Coal industry profits in 2022 were mainly returned to shareholders or used to diversify into other commodities, meaning increases in investment in 2023 are likely to be more muted

Coal producers announced large profits in 2022 despite higher energy prices and other price pressures driving up production costs. The largest share of these profits was returned to shareholders through dividends and share buybacks. Profits were also used to help producers diversify into other commodities and pay off debt. Some companies also used profits to buy coal assets from other companies looking to reduce their exposure to coal. For example, Glencore purchased shares in the El Cerrejón coal mine from Anglo American and BHP, and Thungela bought Idemitsu's stake in Ensham mine in Australia. Companies are also investing to reduce their Scope 1 and 2 emissions.

Global coal investment is expected to increase by around 10% in 2023 to just under USD 150 billion. In China, increases are likely to be more muted following the large ramp-up seen since October 2021, given the government's goal of reaching peak coal demand before 2030. Investment to modernise mines will continue and overall coal production is likely to stabilise before starting to decline. In India, the government expects that total production in the country will surpass 1 billion tonnes by 2023-2024; Coal India alone targets to produce 1 billion tonnes by 2025-2026. Mining Developers cum Operators and commercial operators will be important if India is to achieve its target.

Indonesia's flexible export-oriented supply chain allowed it to ramp up production quickly in response to recent price spikes, but this has not required new large-scale investment. In Australia, investment increased by around 10%, driven by high prices, but it is still at half its 2012 level, in part given mounting development difficulties, especially for greenfield projects.

In the United States, coal demand has been falling for more than a decade. Some producers are looking to expand exports, particularly for metallurgical coal, but a lack of finance and labour force, as well as bottlenecks in the supply chain, have slowed investment and this trend is likely to continue.

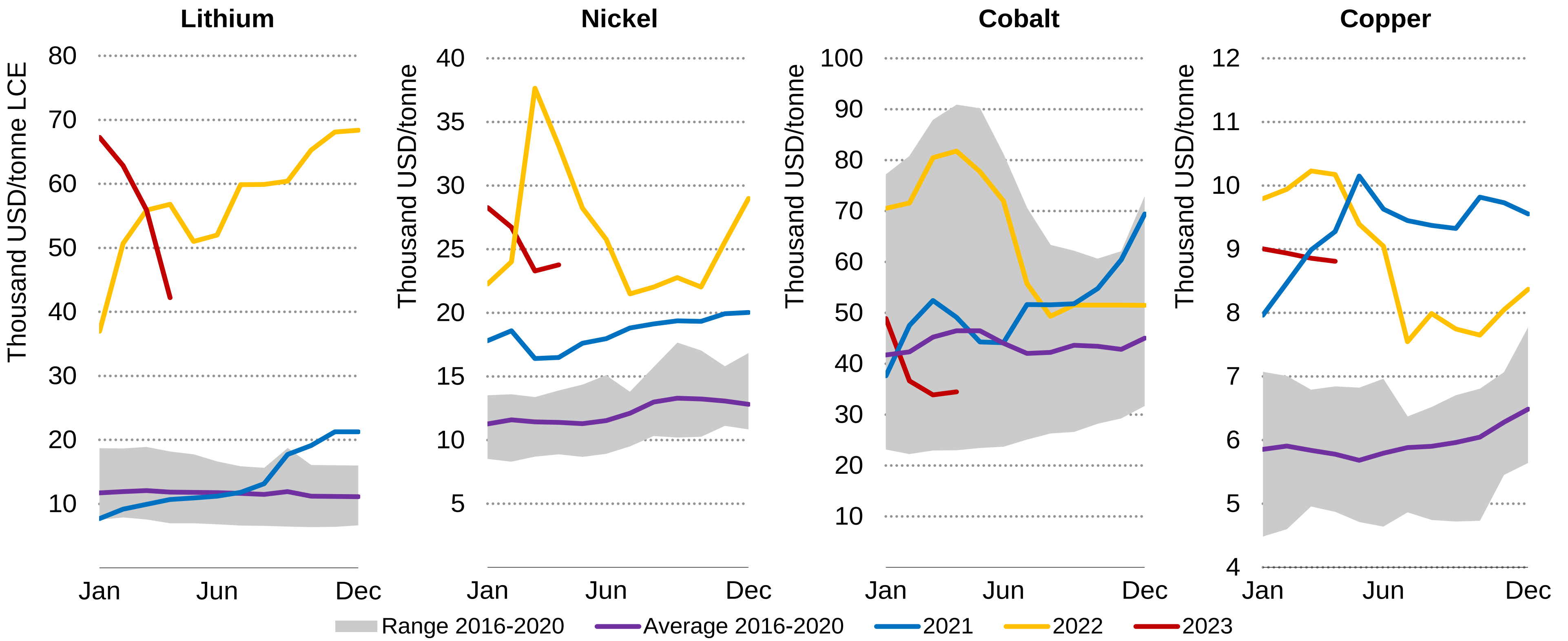
In Russia, producers are increasing their focus on eastern markets following the country's invasion of Ukraine. This will require investment in new infrastructure, but the prospects for this are very uncertain.

Logistical challenges and electricity loadshedding in South Africa have been impeding new large-scale investment. The public electricity utility Eskom is unable to finance coal mining itself given its financial difficulties, while the private sector, Development Finance Institutions and local banks are reluctant to finance coal in South Africa.

Critical minerals

After the surge in 2021 and 2022, many critical mineral prices started to moderate in 2023 but remain well above the historical averages

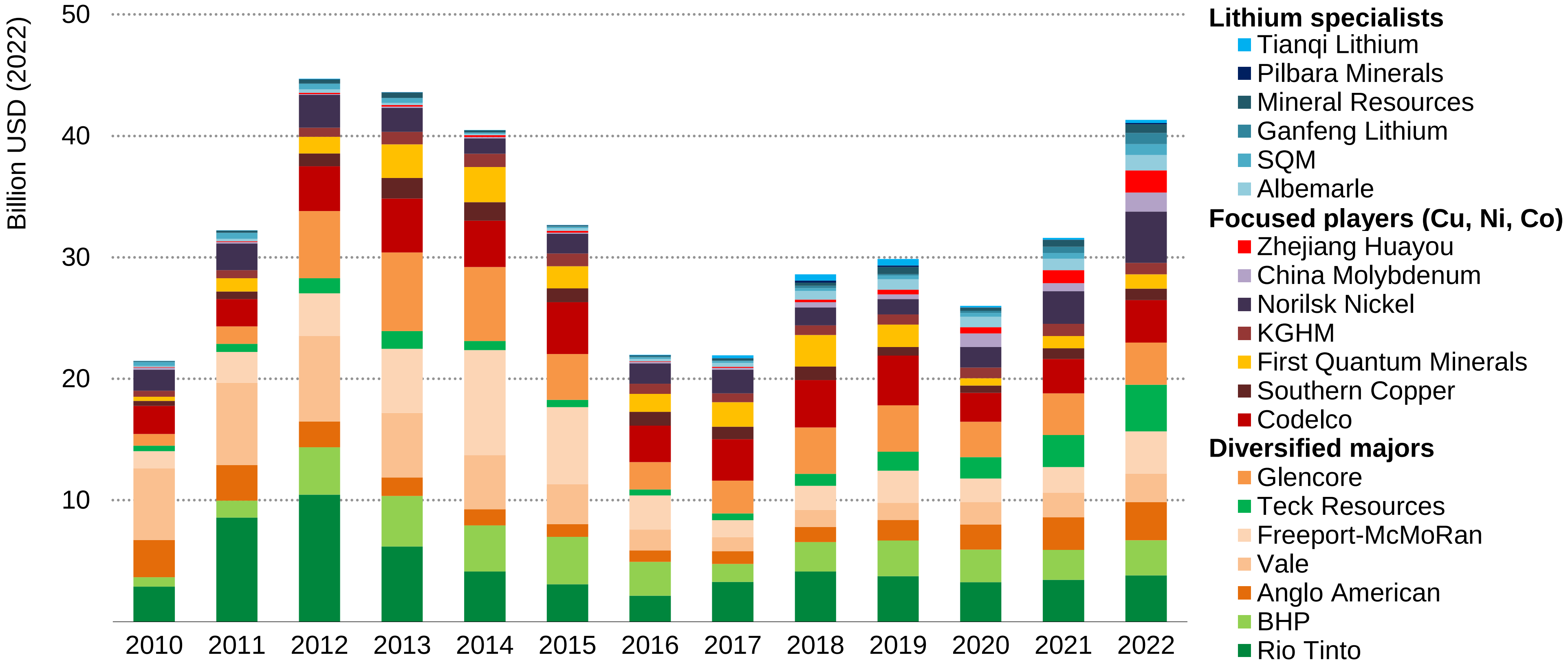
Price development for selected energy transition minerals and metals, 2016-2023



Notes: Assessment based on LME Lithium Carbonate Global Average, LME Nickel Cash, LME Cobalt Cash and LME Copper Grade A Cash prices; LCE = lithium carbonate equivalent.
Source: S&P Global (2023).

Investment in critical mineral mining rose by 30% in 2022 as strengthening momentum for energy transitions offers prospects for robust demand growth

Capital expenditure on non-ferrous metal production by major mining companies, 2010-2022



Notes: Co = cobalt; Cu = copper; Ni = nickel; for diversified majors, capex on the production of iron ore, coal and other energy products is excluded.
Sources: IEA analysis based on company annual reports and S&P Global (2023).

The need for continued investment in critical minerals development to support rapid energy transitions remains firm, despite the recent fall in prices

Many of the critical minerals that are vital for clean energy technologies registered broad-based price increases in 2021 and early 2022, which had the effect of reversing a decade-long trend of cost declines for solar panels, wind turbines and batteries. Except for lithium, most prices started to moderate in the second half of 2022. Expectations of China's reopening underpinned a brief rally at the end of 2022, but prices resumed their fall in 2023, including lithium, on the back of weak consumption, new supply plans and concerns over possible recession. The impact of EV subsidy reductions and price cuts on conventional cars in China added to pressure on prices.

Nonetheless, prices remain well above their historical averages and medium-term pressures persist as schedule delays or cost overruns remain a possibility for many announced projects. Cobalt is a notable exception, as the rapid adoption of lithium-ion phosphate in battery chemistries is weighing on the demand outlook for cobalt.

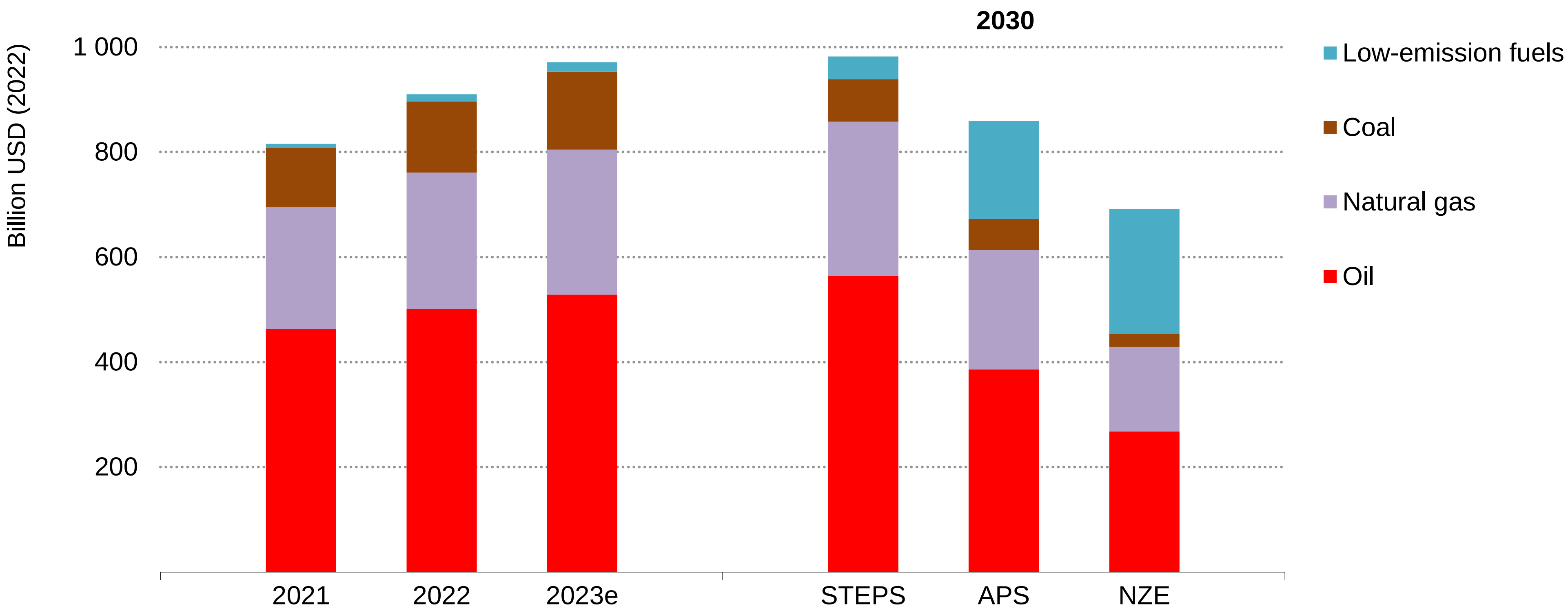
Thanks to high prices and growing policy support (e.g. the US Inflation Reduction Act and the EU Critical Raw Materials Act), many mining companies are increasing investment in critical mineral development. We have assessed the aggregate investment levels of 20 major mining companies that have a strong presence in developing energy transition minerals. Following the 20% increase in 2021, investment spending recorded another sharp uptick of 30% in 2022. Companies specialising in lithium development increased their spending by 50%, followed by those focusing on copper and nickel development. Companies in China almost doubled their investment spending in 2022. Exploration spending also continued its upward march in 2022, largely driven by the record pace of growth in lithium exploration, followed by copper and nickel. Canada and Australia led this growth, especially in hard-rock lithium plays, but activities are also growing in Africa and Brazil.

While the increase in investment and exploration spending will translate into production growth in the coming years, the expected rate of growth still does not match the pace of manufacturing capacity additions for batteries, solar modules, electrolysers and so on. This triggered concerns among automakers, battery cell makers and equipment manufacturers about securing raw material supplies. Long-term offtake agreements became a norm in the industry's procurement strategies and many companies started to be involved directly in the raw material value chain in order to safeguard their production pipelines. For example, in February 2023 General Motors announced investment of USD 650 million in Lithium Americas to develop Nevada's Thacker Pass lithium mining project. In the same month, LG Energy Solutions took a financial stake in Piedmont Lithium to secure lithium from Canada.

Implications

Fossil fuel investment in 2023 is close to 2030 levels in the STEPS and more than double the amount needed in 2030 in the NZE Scenario

Global investment in fuel supply, 2021-2023e, and in IEA scenarios in 2030



Notes: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario; NZE = Net Zero Emissions by 2050 Scenario. Low-emission fuels = modern bioenergy, low-emission hydrogen and hydrogen-based fuels. 2023e = estimated values for 2023.

There are upside and downside risks to fossil fuel demand but if clean energy momentum is maintained, far less fossil fuel investment will be needed

Oil and gas investment in 2023 is now about the level needed in 2030 in the STEPS, a scenario that reflects today's policy settings. Oil and gas demand in the STEPS rises by around 0.5% each year on average from 2024 to 2030, much lower than the 1.3% annual average increase in the 2010s. This depends on continued robust global growth in clean energy investment – most notably solar PV and electric cars – to arrest fossil fuel demand growth. If today's policy settings change or if some clean energy deployment does not materialise globally at the anticipated pace and scale, future fossil fuel demand growth would be greater than in STEPS and additional oil and gas investment would be needed to balance markets.

Conversely, enhanced efforts to tackle climate change would represent a major downside risk to fossil fuel demand and a commercial risk for producers. Fossil fuel investment is now more than double the amount needed in 2030 if the world is to limit the long-term temperature rise to 1.5°C (the NZE Scenario). Today's coal investment is far above the levels required in the STEPS and six times higher than the 2030 requirements in the NZE Scenario. This creates the clear risk of locking in fossil fuel use and pushing the 1.5°C temperature limit out of reach.

Our scenarios illustrate the dynamic relationship between spending on clean energy and fossil fuels. In the STEPS, investment in clean energy grows to more than USD 2 trillion in 2030, meaning that for every USD 1 spent on fossil fuels in 2030, USD 2 is spent on clean energy. In the NZE Scenario, the ratio of clean-to-fossil investment is more than nine-to-one in 2030.

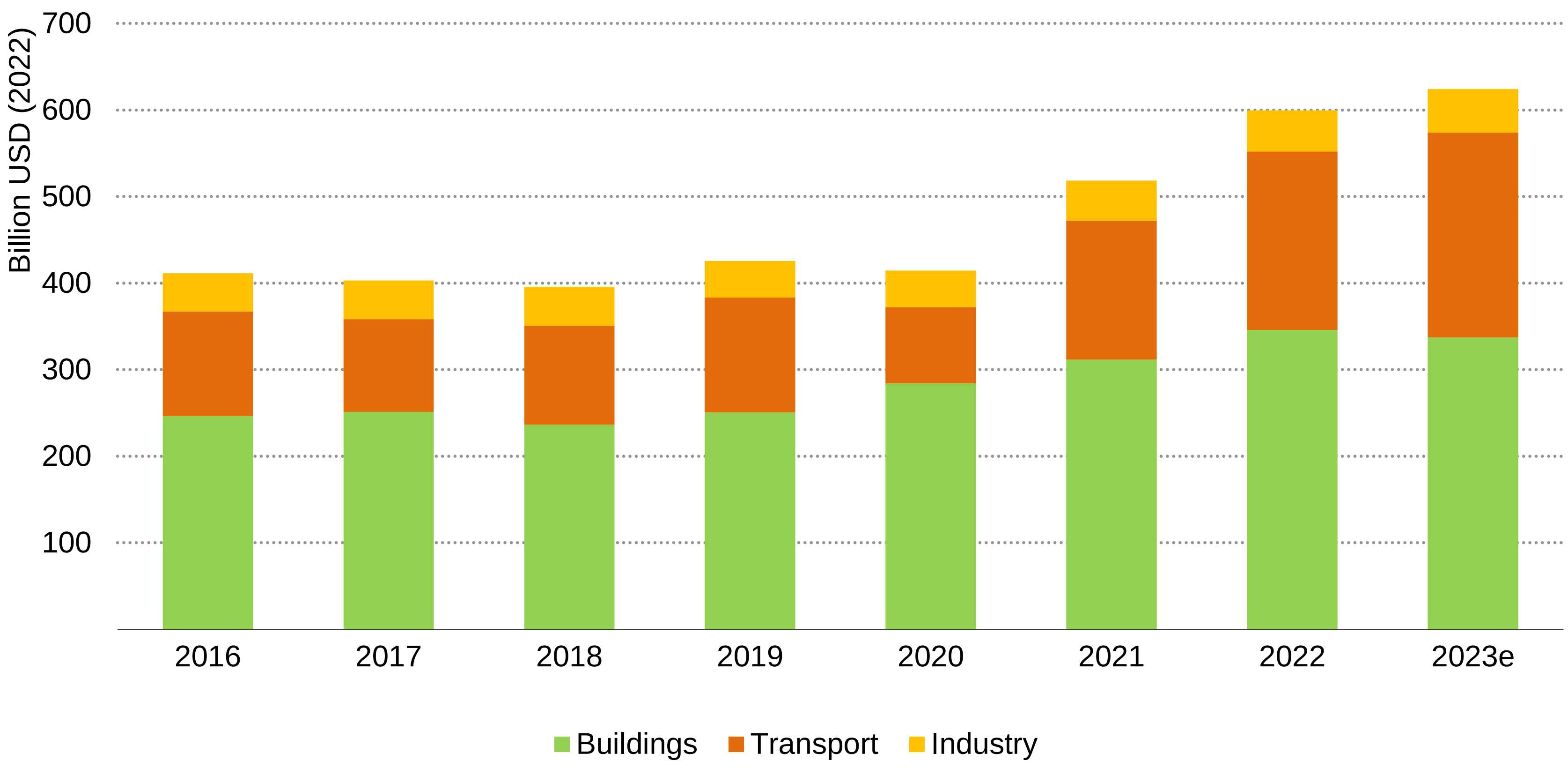
The declines in fossil fuel demand in the NZE Scenario are sufficiently steep that they can be met in aggregate without supply from any new oil and gas fields. Still, investment in oil and gas is still required in 2030, both to minimise the emissions intensity of production and for some low-cost extensions to existing fields. A strong policy push to reduce oil and gas demand whilst scaling up investment in clean energy is crucial to orderly, secure and rapid energy transitions.

Oil and gas companies can help drive the necessary reallocation of capital by devoting more of their resources to clean energy including to low-emission fuels. Investment in these fuels – such as bioenergy, hydrogen and CCUS – is picking up but needs to increase nearly twentyfold in the NZE Scenario. This may appear a daunting challenge, but it is by no means out of reach of the financial and technological resources of the oil and gas industry. The USD 1.5 trillion returned to shareholders in the form of dividends and buybacks from 2020 to 2022 could have fully covered the investment requirements in all clean fuels in the NZE Scenario between 2023 and 2030.

Energy end use and efficiency

Global efficiency, electrification and end-use investment reached record levels in 2022, driven by the buildings sector and strong EV sales, but the rise in spending could slow in 2023

Global investment in energy efficiency, electrification, and renewables for end uses by sector, 2016-2023e



Notes: Investments which are aimed at reducing energy consumption in buildings, industry, and transportation sectors are grouped under the end use category. They include energy efficiency, electrification, and direct use of renewables for heating, cooling, or industrial processes. Energy efficiency investments refer to spending on new energy-efficient equipment or refurbishments that decrease energy usage. Electrification encompasses electric vehicles in transportation and heat pumps in buildings and industrial sectors; 2023e = estimated values for 2023.

The global energy crisis boosted spending on efficiency, electrification and end uses in 2022, but efficiency investment faces headwinds in 2023

The global energy crisis boosted investment in energy efficiency, electrification and end-use renewables by 16% in 2022, reaching new highs across all three end-use sectors that are tracked in the *World Energy Investment* report (buildings, transport, and industry).

The buildings sector experienced 11% growth in investment due to government initiatives in Europe and the United States responding to gas shortages, rising electricity prices and higher inflation. Emerging market and developing economies (EMDEs) saw a 19% increase in investment, with China being the only country experiencing a decrease in energy efficiency investment due to continuing Covid-19 lockdowns and the real estate crisis. 2022 also saw double-digit growth for heat pump installations.

Investment in electrification of the transport sector grew by 60% in 2022, with EV sales hitting record levels, passing 10 million units globally. Growth came from all parts of the world including EMDEs, which have seen exponential growth from a low base. Maintaining this trend in 2023 will depend on increased model availability, investment in charging infrastructure, and a well-managed phase-down of government incentives for EVs as upfront costs become closer to internal combustion engine (ICE) models.

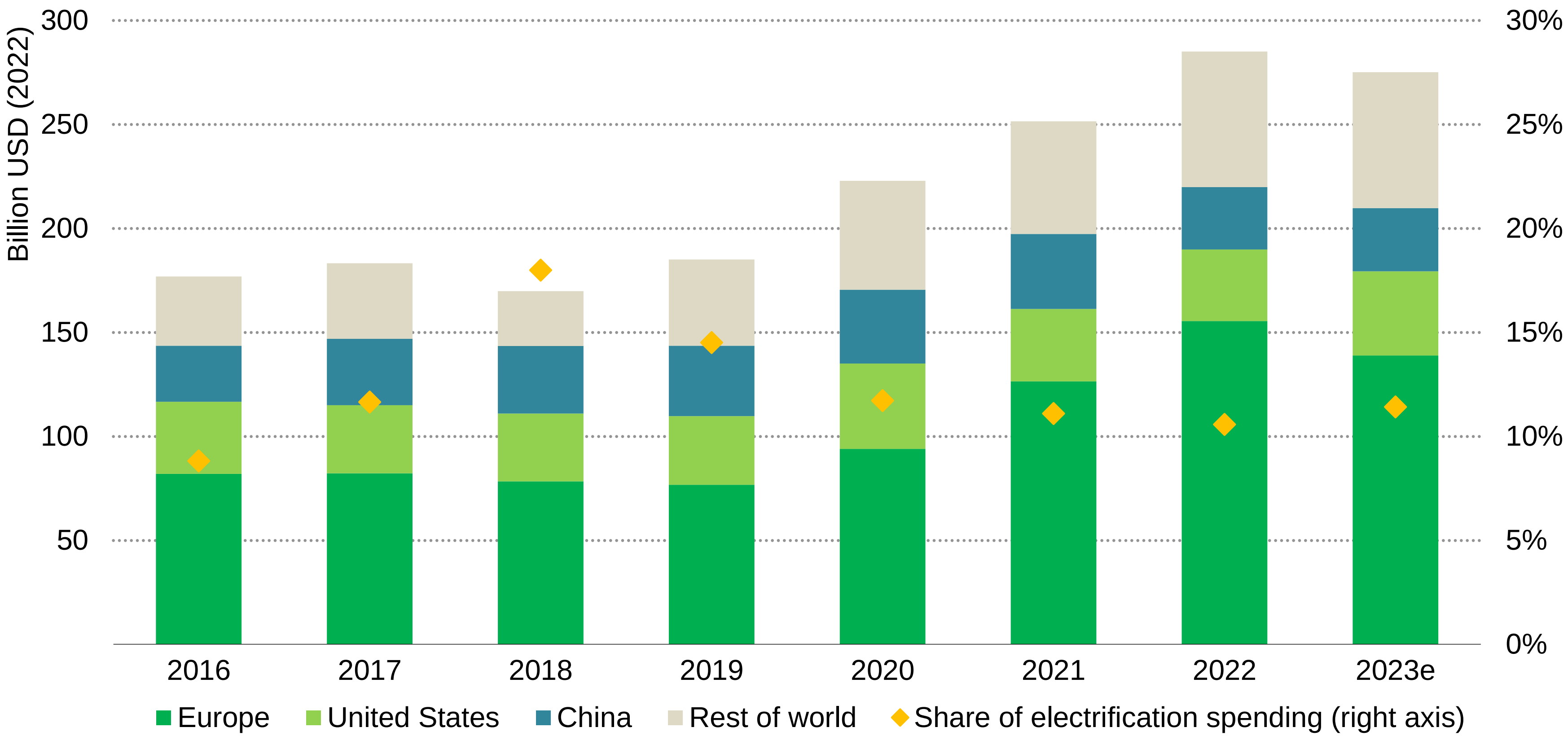
The industrial sector experienced high input prices, including gas and electricity, leading some factories to curtail production and investment in Europe and China. However, renewed activity in EMDEs and the United States led to an 3% growth in energy efficiency investment in the sector in 2022. While some of the technologies needed for complete decarbonisation of industrial processes are still being developed, high energy prices could lead to new investment in industrial efficiency and electrification in 2023.

Investment in energy efficiency could face headwinds in 2023 across all sectors. The global indicators that typically offer insights into investment trends were sending mixed signals in the early stages of the year. The European Union's housing lending market has almost ground to a halt in recent months. Inflation also remains high in many regions. Much will depend on the extent to which robust government interventions and regulatory policies in the United States and Europe offer support for continued efficiency and end-use investment, notably for the electrification of heat and transport. At this stage, we anticipate that overall spending on energy efficiency, electrification and end-use renewables will grow modestly by 4% in 2023, with electrification remaining the most dynamic sector and efficiency spending lagging behind.

Buildings

Energy efficiency spending on buildings rose in 2022, but the ongoing cost-of-living crisis and economic uncertainty could reduce investment in 2023

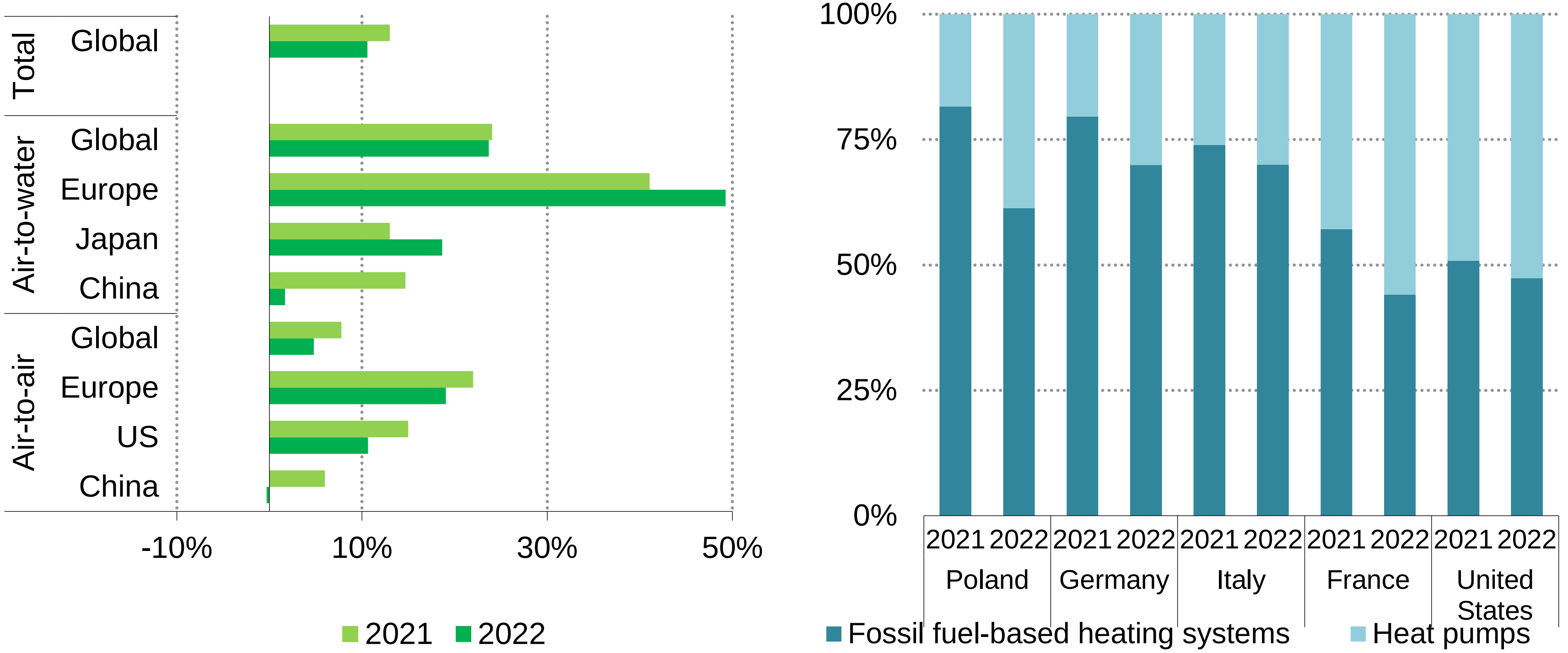
Investment spending on energy efficiency and electrification by region in the buildings sector, 2016-2023e



Notes: Spending on electrification (e.g., Heat pumps) is included in the total spending, and represented as a share of total spending on the right axis; 2023e = estimated values for 2023

Heat pump sales experienced double-digit growth for a second year in a row in many areas as they start to replace fossil fuel-based heating systems

Rate of growth of heat pump sales in 2021 and 2022 (left) and market share of heat pumps in global heating system sales (right)



Notes: Air-to-water units include heat pump water heaters; total also includes ground- and water-source heat pumps.

Sources: IEA (2023), Global heat pump sales continue double-digit growth, based on data from AHRI, Assoclima, Assotermica, BDH, CHPA, ChinaIOL, EHPA, JRAIA, SPIUG and Uniclima.

Investment in buildings energy efficiency in 2022 was underpinned by direct public investment to tackle energy insecurity, alongside a cautious reopening of the global construction sector

In 2022 energy efficiency investment in the global buildings sector increased by around 14% on 2021 levels, continuing the strong growth trend of the past few years. Spending on efficiency is projected to fall back in 2023 as the effects of increased borrowing costs and economic uncertainty reduce market activity.

The total investment of around USD 285 billion in 2022 marks a strong increase in efficiency spending and electrification from the previous year and is the result of a continued effort, led by Europe, in response to the energy crisis triggered by the Russian invasion of Ukraine, along with policy- and price-driven increases in spending in other countries, for example in the in the United States within the Inflation Reduction Act.

The increase in 2022 was in line with recent trends, but early signals suggest a slowdown in spending in 2023 as the global economy experiences increased uncertainty due to the continuing conflict in Ukraine, the growing impacts of the cost of borrowing on construction demand in economies across the world, uncertainty of credit availability and lending, and several large government programmes seeing curtailment.

The increased efficiency investment in 2022 was the result of sustained spending in major markets such as the United States, Germany and Italy. Over USD 33 billion was spent in the United States through the continued funding of the Department. of Energy efficiency programmes (e.g., weatherisation) or utility demand-side management. Government led efficiency spending in the United States is expected to further expand by USD 970 million in 2023 through the newly created State and Community Energy Office under the Inflation Reduction Act. Budget allocation dedicated to efficiency by the German government moderated in 2022 to around USD 51 billion, which was accompanied by changes to the design of some support programmes. The conditions for the federal funding for efficient buildings programme (BEG) were adjusted in several stages, starting from end of July 2022, to facilitate better access to funding and streamline application processes. The KfW loan programmes continued but the grants were discontinued, and single measures are now only subsidised directly by BAFA, with reduced rates (on average by 5% of the given measure) to allow more applicants to benefit from available funds. A new subsidy scheme for “climate friendly new construction” entered into force at the beginning of 2023, introducing a expanded coverage of eligible expenses under the BEG, including material costs for own work and a broader definition of eligible investors.

The Italian Superbonus programme resulted in a near doubling of investment in energy efficiency between 2021 and 2022 in Italy, from USD 23 billion to around USD 57 billion. However, the recent announcement of major changes to the programme means spending beyond 2023 is unclear and expected to fall. The maximum tax credit rate has been lowered from 110% to 90% and, as of 17 February 2023 homeowners applying for the bonus will no longer be able to directly transfer eligible tax credits to a bank or directly to their construction company to receive a discount on the final invoice.

Another major change affecting spending in 2022 resulted from a 10% reduction in real estate development investment in China compared with 2021, resulting in a slowdown in the delivery of green buildings. This slowdown is also expected to further affect the delivery of buildings reaching China's green standard, which were initially set to be around 50% of all new dwellings by 2020 in the country's 13th Five-Year Plan. Likewise, France's investment in efficiency fell somewhat due to a slowdown in construction sector output. The United Kingdom also saw a modest fall in efficiency spending due to a slowing construction sector and changes to the Affordable Warmth Scheme, although the government has added USD 186 million under the Green Homes Grant scheme. Japan's focus on delivering new buildings that achieve the zero energy housing (ZEH) standard and that approach ZEH has seen the proportion of new green buildings increase from 19% of construction in 2018 to over 34% in 2021. Japan has a target of 63% of new buildings achieving the ZEH standard by 2025.

Some emerging markets saw an overall increase in construction activity and investment in buildings energy efficiency. India, for example, doubled spending to USD 3.25 billion. Most countries, however, only saw a modest increase in 2022, which was primarily related to construction activity picking up from pandemic-level lows. Overall, Europe experienced a very modest uptick of around 3%, while Central and South America saw an increase of around 5% in construction sector spending, which might hinder further investment in energy efficiency for 2023.

International concessional finance continues to support investment in the global building stock. For example, the European Bank for Reconstruction and Development committed over EUR 67.5 million to Lithuania to finance energy efficiency renovations in residential buildings, and EUR 40 million to support improving school buildings efficiency in Albania. Financing through the International Finance Corporation's EDGE programme also continues to benefit energy efficiency, including a USD 65 million green bond in South Africa and a USD 60 million loan to support green mortgages in Peru.

Green products offered by commercial banks are also slowly gaining traction, with 19 of the top 100 largest banks globally offering green mortgages to their clients, although their level of utilisation and overall impact remains unclear. Of these, five are located in the United Kingdom where the market for green financial products has been quite dynamic in recent years. In Hungary, the Magyar Nemzeti Bank's Green Home Programme and Green Mortgage Bond

Purchase Programme were launched to provide refinancing against green home loans at 0% interest and encourage the issuance of higher-quality green mortgage bonds.

Addressing building fabric efficiency performance remains a major part of spending, but recent efforts are directing investment towards technologies that can more easily enable zero-carbon ready buildings, such as heat pumps. Data for Europe in 2022 suggest that around 3 million heat pumps were installed in buildings, an increase of almost 40% compared with the previous year. The European heat pump market is estimated to be worth around USD 14 billion. According to the latest IEA analysis, global heat pump sales grew by 11% in 2022 in unit terms, marking a second year of double-digit growth for the central technology in the transition to secure and sustainable heating.

In order for the growth of heat pump deployment to continue, it is important to have secure and resilient supply chains. The global market for heat pumps is dominated by companies with headquarters in Japan and China, accounting for nearly 70% of the market. While the five largest global manufacturers are based in the Asia Pacific region, only about half of their production capacity is located there. Supply chains are currently strained, particularly for crucial components like chips. Manufacturers have already committed to expanding heat pump production capacity, with investment totalling more than EUR 4 billion as of November 2022. However, an additional USD 15 billion in global investment would be needed to close the 60% gap that exist between the expected output from announced projects and the 2030 Net Zero Emissions by 2050 Scenario needs for the technology. There are also new incentives that are likely to drive further manufacturing announcements, such as the Defense Production Act and Inflation Reduction Act in the United States and the upcoming Net Zero Industry Act and European Sovereignty Fund in the European Union.

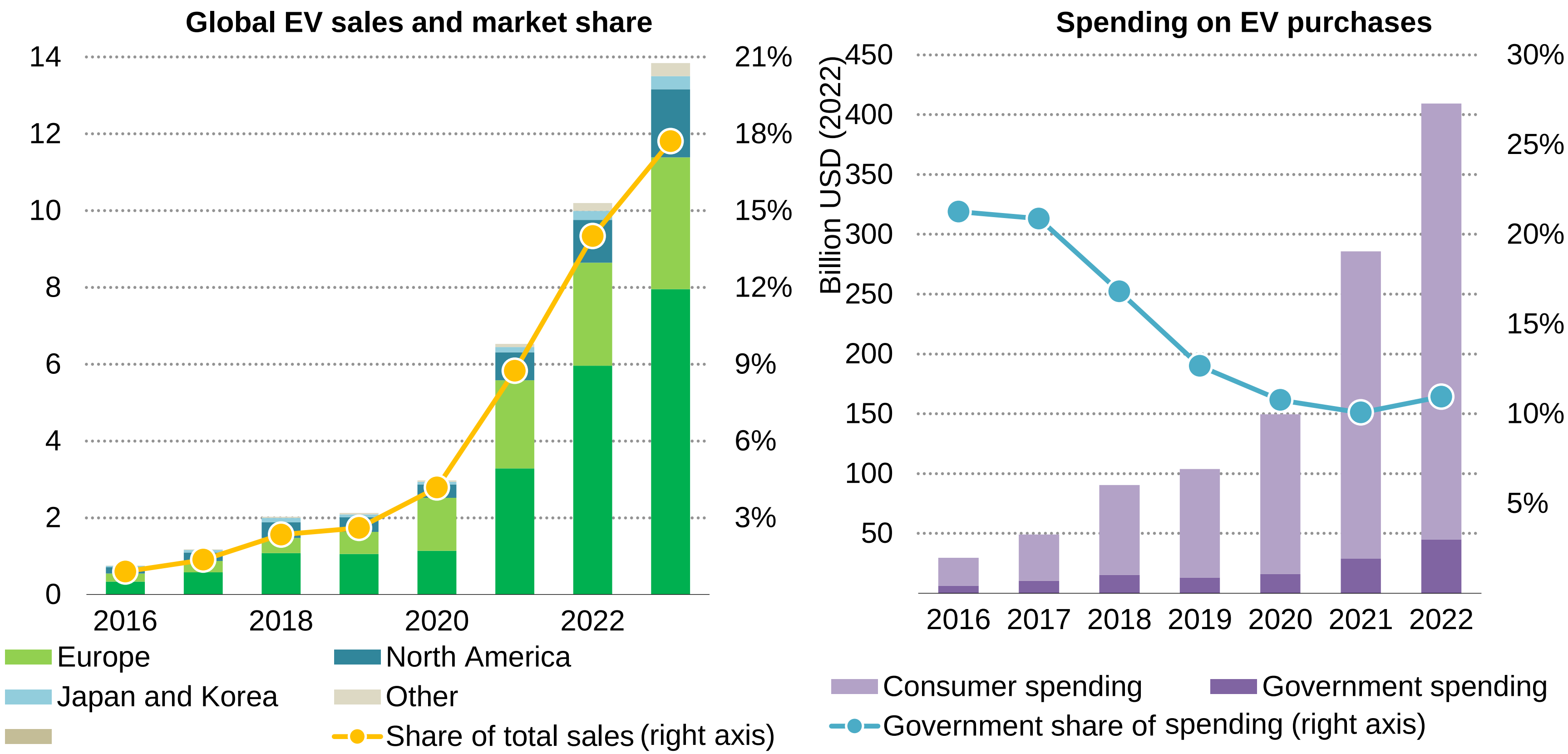
As a result, investment in electrification is the most resilient area of overall spending on buildings, increasing by about 4% in 2023, and increases its share in the total. Efficiencies in technology costs mean that every dollar spent goes further and we estimate a faster growth of heat pumps in unit terms.

Fiscal stimulus measures from the pandemic period have also begun to be wound down, and further reductions in government and private-sector spending due to increased borrowing costs mean that 2023 is likely to see a reduction in efficiency spending. Investment in global energy efficiency in the building sector is projected to drop by up to 5% due to both construction market uncertainty in Asia, South America and Europe, and changes to several large European programmes. This potential change in direction for investment in the buildings sector is problematic given that energy efficiency measures not only reduce demand but also shield households and businesses from the impacts of future fuel price volatility.

Transport

Sales of passenger EVs passed the 10 million mark for the first time in 2022…

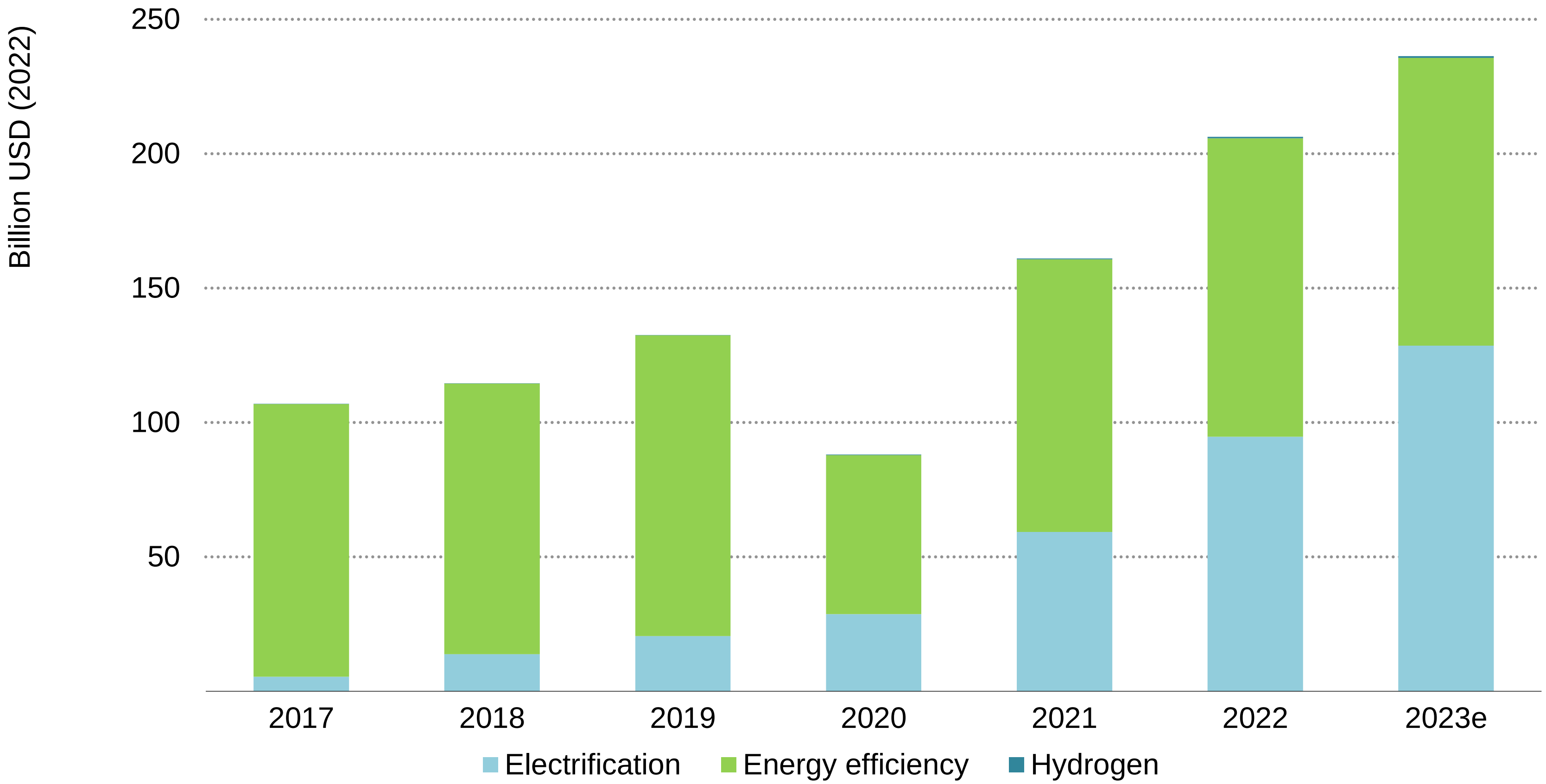
Global trends in electric passenger light-duty vehicle markets, 2015-2023e



Note: EV includes battery electric and plug-in hybrid passenger vehicles; 2023e = estimated values for 2023.
Sources: IEA (2023), Global EV Outlook; Marklines.

…driving investment in road transport efficiency and electrification to record highs

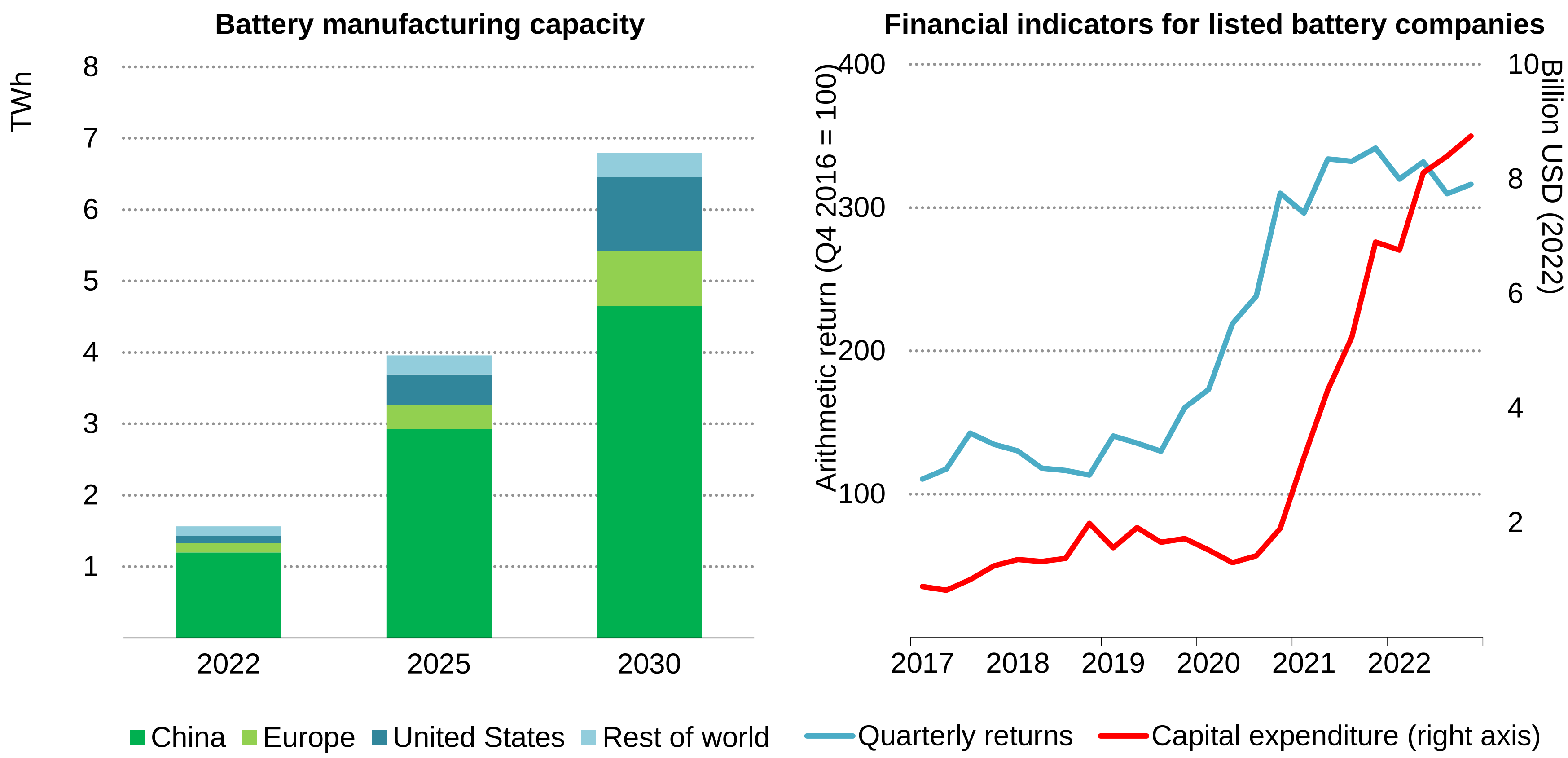
Investment in energy efficiency, electrification, and hydrogen in the road transport sector



Note: 2023e = estimated values for 2023.

Capital expenditure by listed battery manufacturing companies surged to USD 9 billion in Q4 2022, sharply lifting production capacity

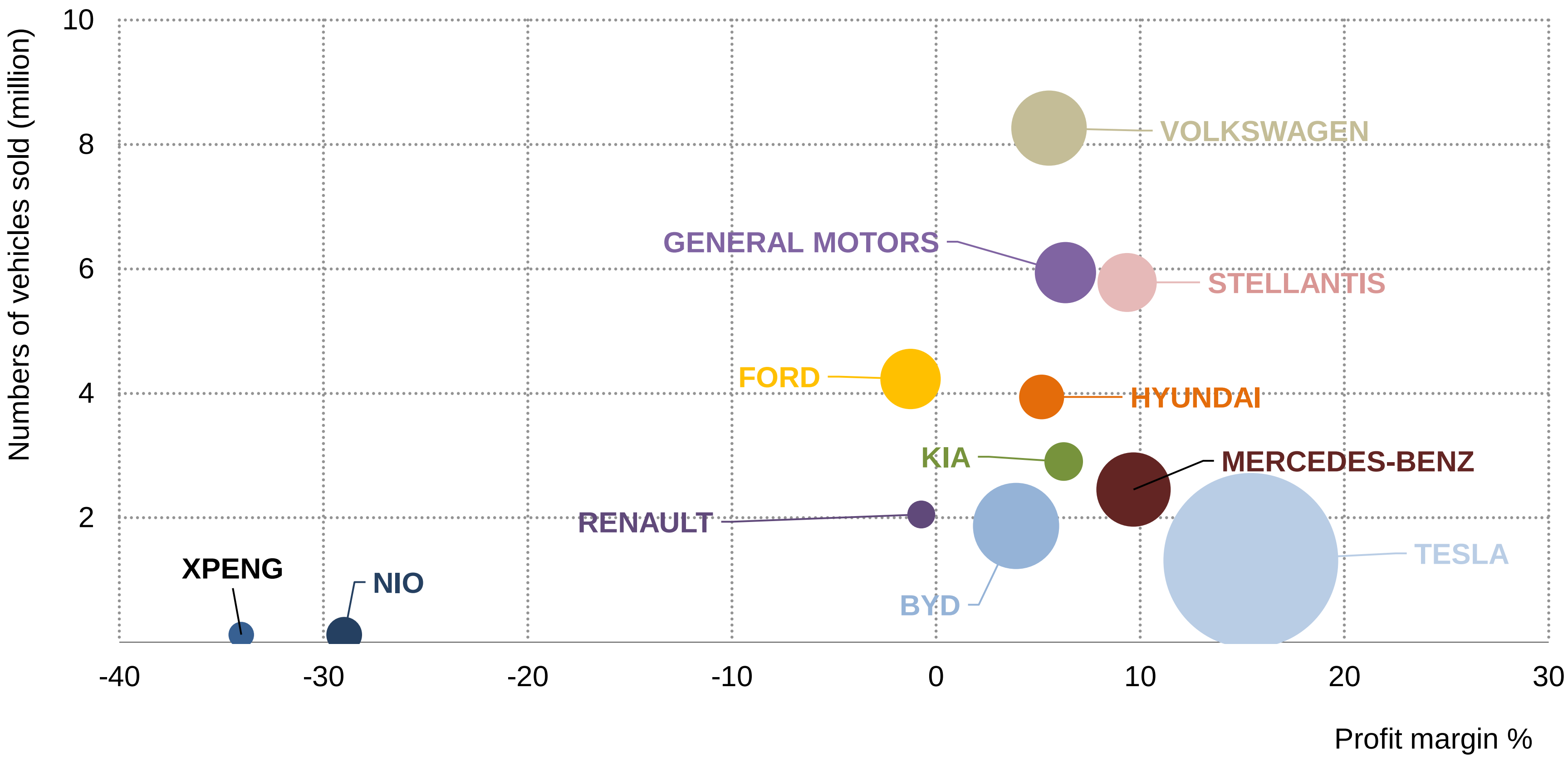
Global trends in the battery manufacturing industry, 2017-2025



Notes: Listed battery companies include LG Energy Solution, BYD, Contemporary Amperex Technology, Samsung SDI, Gotion High-tech, Eve Energy and Farasis Energy Gan Zhou; 2022 values are based on fully commissioned capacity; 2025 values are based on announced, under construction and fully commissioned capacity.
Sources: IEA calculations based on Benchmark Mineral Intelligence and Bloomberg Terminal (2023).

With growth in sales and market share, profitability is consolidating for the largest EV manufacturers but remains elusive for new entrants and smaller companies

Number of vehicles sold and profit margin of selected automakers in 2022



Notes: Margin reflects sales of both EVs and ICE vehicles; bubble size corresponds to market capitalisation.
Source: IEA analysis based on data from Bloomberg Terminal.

The future is electric: spending on EVs and battery manufacturing remains strong amid uncertainties with volatile raw material costs and diminishing subsidies

Sales of electric cars saw yet another record year in 2022, even in the context of supply chain disruptions, macroeconomic and geopolitical shocks, high commodity and energy prices, and a global contraction in the car market. Registrations of battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) surpassed 10 million, representing a 55% increase from 2021. This 10-million figure is greater than the total number of cars sold in the entire European Union (9.4 million vehicles) and half the number sold in China in 2022. The percentage of electric cars in total car sales increased from 9% in 2021 to 14% in 2022, which is more than five times their share before the Covid-19 pandemic.

Europe provides an illustration of this trend: 2.7 million EVs were sold in 2022, the 15% increase on 2021 representing slower year-on-year growth compared with that seen in recent years. The tail end of supply chain disruptions caused by the pandemic, high inflation and weakening consumer confidence, and the instability caused by the war in Ukraine compounded the challenge of maintaining high growth rates as the European market matures. Fossil fuel subsidies aimed at shielding consumers from peak oil prices, delays in implementing low-emission zones and uncertainty over the European 2035 ICE ban may also have played a role.

In 2022 China saw an 80% increase in EV sales compared with 2021, reaching 6.2 million vehicles. The country accounted for almost 60% of all new electric car registrations worldwide, and for the first time in 2022 it had over 50% of all the electric cars on the world's roads, totalling 13.8 million. This impressive growth can be attributed to consistent policy support for early adopters, and the extension of incentives until the end of 2022, which were originally planned to be phased out in 2020. However, sales fell in January 2023 as the central government decided to end a 10-year-old national subsidy for EV purchases, before rebounding somewhat in February. How this will affect the market for the rest of 2023 remains unclear.

Sales in the United States surged by 50% in 2022 as compared with 2021, registering robust growth for the second consecutive year after a slump in 2019-2020. Overall, the country accounted for 10% of the global growth in electric car sales, as model availability grew and incentives remained strong. The trend is expected to be sustained and even to accelerate in 2023, largely supported by a regulatory boost. For instance, several EV manufacturers announced plans to invest USD 28 billion in North American EV supply chains, as the Inflation Reduction Act ties purchase subsidies to vehicles manufactured domestically.

The three regions described above represent more than 95% of new EV sales globally. From a low base, 2022 also saw increased sales in some other parts of the world, especially in Asia, where countries such as India saw sales tripling, and Viet Nam where sales went from close to zero in 2021 to 7 000 units in 2022 and where a quadrupling is expected for 2023. The penetration of EVs in EMDE markets faces challenges stemming from the lower ability to pay and the limited availability of affordable EV models, as many are geared towards higher-end consumers, such as SUVs. Smaller electromobility models, such as two- and three-wheelers are relatively more successful in these countries.

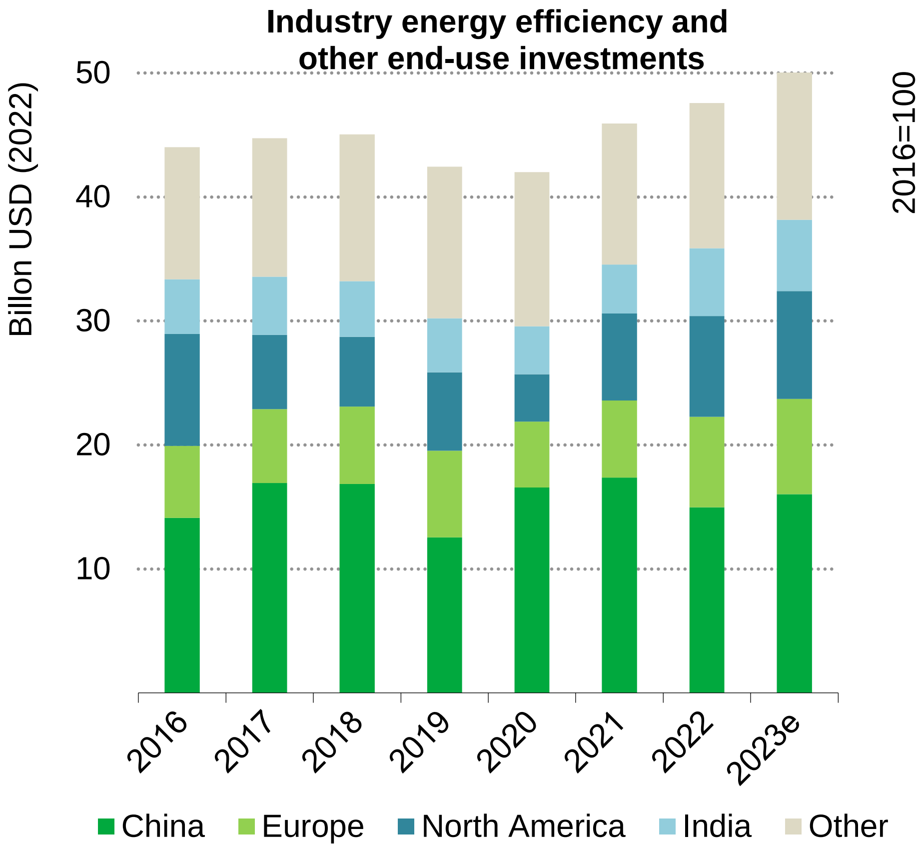
On the financing side, as government blanket subsidies are tending to wind down, new types of financial products are being designed to encourage EV adoption. For instance, interest-free loans with a repayment term of up to 10 years are available in Australia. Lower-income households in France will have access to interest-free loans for a two-year trial period starting in 2023 if they wish to switch to EVs. The Canada Infrastructure Bank has been offering low or zero-interest loans for the purchase of zero-emission buses since 2022, with repayments sourced from the savings generated by lower operating costs. Additionally, Slovenia offers subsidised loans for people interested in purchasing an EV through its Eco Fund programme.

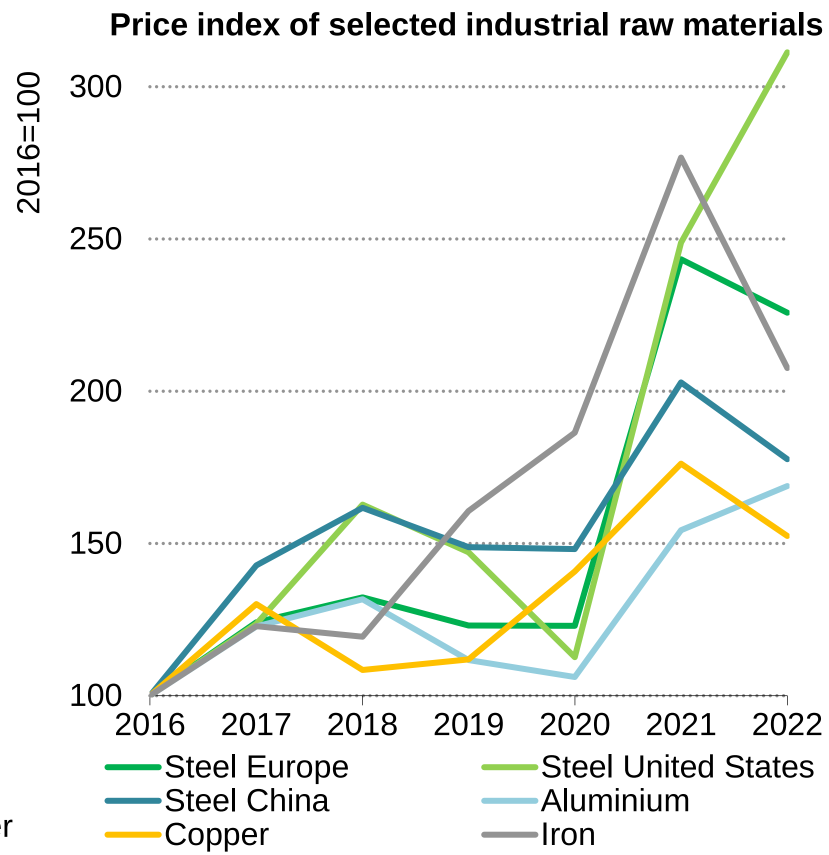
For the first time in recent years the average price of a battery pack has seen an increase, at about 2% in 2022, reflecting a broader trend of chip and material shortages, as well as increasing commodity prices. However, the trend seemed to be reversing in early 2023 with lithium prices easing and capex investment by battery manufacturers remaining at high levels to reach close to USD 9 billion in the last quarter of 2022. In response to continuing demand growth and incentives offered by governments, which are gradually switching from consumers to charging infrastructure and battery manufacturing, record investment in new battery manufacturing capacity were made in 2022, increasing available capacity by 60% compared with 2021, and reaching close to 1.6 TWh. If all announcements were to materialise, 2.5 TWh of new capacity could be available by 2025 and 6.8 TWh of total capacity would be commissioned by 2030, three-quarters in China, but partly as a result of the Inflation Reduction Act, a growing share is in the United States.

Industry

Investment in the industrial sector remained stable in 2022 as China continued to experience supply chain constraints, while the United States and India picked up

Energy efficiency investment in the industrial sector, 2016-2023e, and cost index for selected raw materials, 2016-2022





Note: EV includes battery electric and plug-in hybrid passenger vehicles; 2023e = estimated values for 2023.
Source: IEA calculations based on data from Oxford Institute of Economics and Statistics Global Economics database.

High energy prices and policy support in key markets are putting a floor under industrial efficiency investments

Investment in energy efficiency and electrification in the industrial sector grew modestly in 2022, consolidating the record gains experienced in 2021, despite an adverse macroeconomic environment.

Industrial output came under pressure in China as strict Covid-19-related restrictions remained in force for a large part of 2022. Steel production fell by 16% from 2020, while cement fell even more sharply. A recovery in construction activity is held back by an overhang in the stock of buildings as a result of the housing bubble. We estimate that industrial energy efficiency investment in China was down by 14% year-on-year. The lifting of Covid restrictions and the slow revival of economic demand in the last quarter of 2022 should be conducive to a strong rebound in the early months of 2023.

In Europe the war in Ukraine and sky-high gas prices forced industry to adapt and to cut its natural gas demand by over 25 bcm compared with 2021 levels. Half of this reduction came from production curtailment, for instance in the steel sector where factories produced 25% less than before the Russian invasion. As gas is a key component in the production of ammonia, the fertiliser industry was probably the most affected by the price rise, resulting in approximately 70% of capacity being taken offline at some point during the past year. Another 7 bcm of savings came from gas to oil switching, and only 3 bcm from energy efficiency measures. Industrial processes that require high temperatures are more challenging to replace with cleaner energy sources. However, some large European industrial businesses have already announced plans to accelerate investment in energy efficiency and green electrification as a result of volatility in energy prices. For now, however, capex by major industrial companies has remained stable in Europe.

The story is different in the United States, where the enactment of the Inflation Reduction Act is set to generate renewed tailwinds for industrial efficiency and abatement. The legislation contains a wide variety of incentives for industrial decarbonisation, making clean technology investments financially accessible for carbon-intensive sectors, such as steel, cement and chemicals manufacturing. The act includes a 10-year clean hydrogen production tax credit for facilities constructed before 1 January 2033, charting the path for competitive zero-emission steel production. The act also provides essential incentives to decarbonise cement manufacturing and provides for government priority purchasing of green products, sending a strong long-term message to the industry. A strong rebound in production in China, India and Southeast Asia is anticipated for 2023 compared with other parts of the world.

The EU Green Deal Industrial Plan and the Net Zero Industry Act

In February 2023 the European Commission presented a Green Deal Industrial Plan in a multipronged effort to meet its clean energy transition commitments, respond to the US Inflation Reduction Act and address the continent's high reliance on China for clean energy technologies. The strategy has four main pillars: 1) a predictable and simplified regulatory environment, 2) quicker access to finance, 3) enhanced skills, and 4) open trade for resilient supply chains.

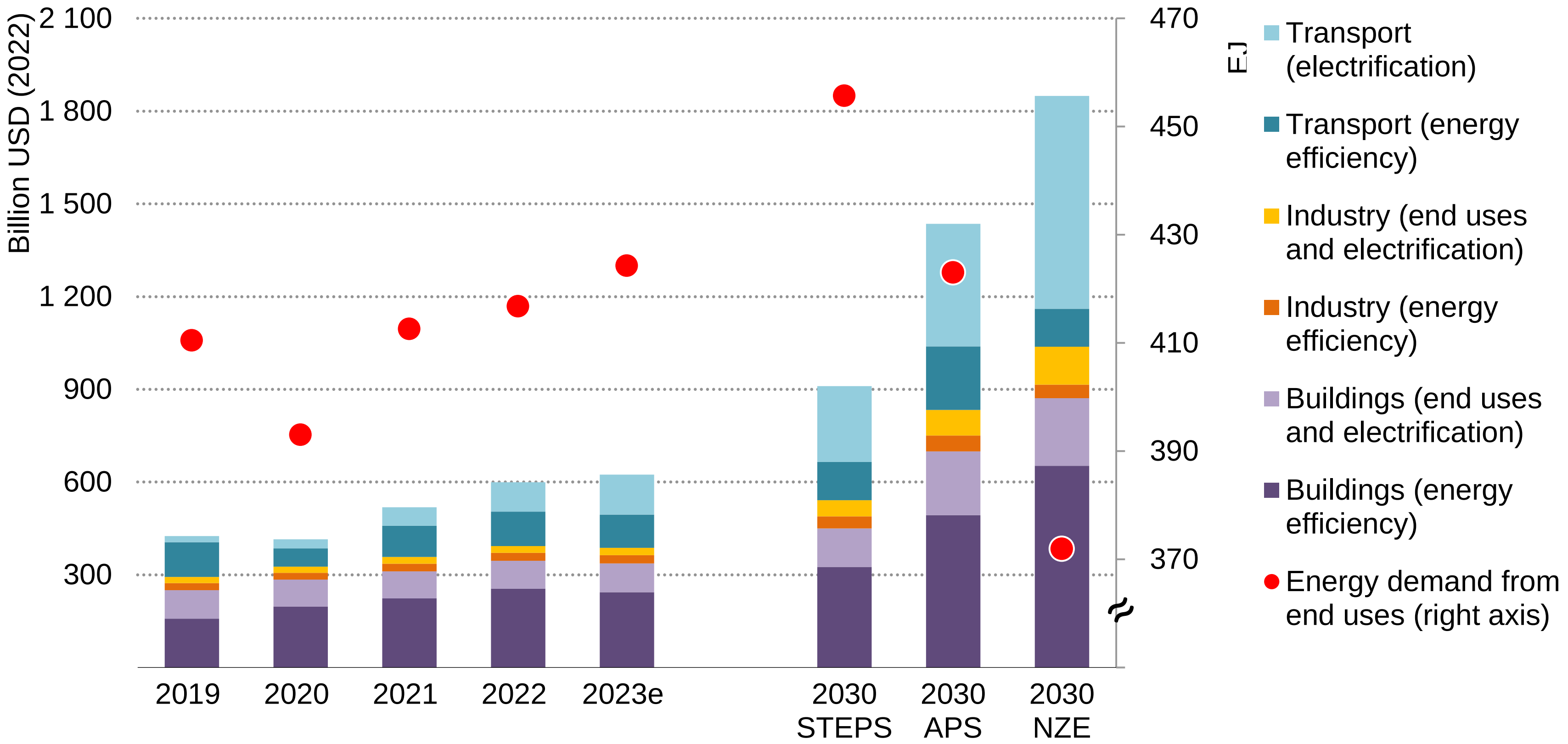
As part of the first pillar, the Net Zero Industry Act, proposed in March 2023, aims to provide a regulatory environment suited to the scale-up of the net zero industry, with the overall target of domestically manufacturing at least 40% of Europe's clean energy technology by annual deployment by 2030. Additionally, the act sets out ambitious 2030 manufacturing targets for eight strategic net zero technologies: solar PV and thermal, batteries, heat pumps and geothermal technologies, electrolysers and fuel cells, sustainable biogas/biomethane technologies, CCUS, and grid technologies. In addition, other technologies such as advanced nuclear and small modular reactors, stand to benefit from the act's measures, but are not assigned 2030 targets. To achieve the targets, the act introduces specific policy measures, including fast-tracking permitting for net zero technologies by establishing "one-stop shops", including supply chain criteria in public tenders to favour diversification, and investment in the upskilling of the European labour force.

Contrary to the Inflation Reduction Act, however, the Net Zero Industry Act does not provide direct funding or subsidy schemes to spur domestic manufacturing (Article 15 highlights that further support can be made available via resources from the European Investment Bank Group or other international financial institutions including the European Bank for Reconstruction and Development). According to the second pillar of the Green Deal Industrial Plan, most of the cost is expected to be shouldered by member states, at least partially through a redirection of ETS revenues. The plan grants more flexibility for member states to support clean manufacturing, including through higher notification thresholds for state aid and the possibility to allocate targeted aid for major new production projects in strategic net zero value chains. The realisation of the EU act's targets would, however, come at a cost. For most of the technologies listed, importing from third countries is much cheaper than EU production. For example, estimates point to an extra cost of USD 11.9 billion to meet the act's target of 550 GWh of domestically produced batteries by 2030, compared to a scenario where demand is entirely met by batteries made in China.

Implications

Spending on energy efficiency and electrification is reaching new highs thanks to dynamic growth in electrification of the transport sector

Global investment in energy efficiency, electrification and renewables for end uses and energy demand for end uses compared with annual average investment needs in 2030, by scenario



Notes:.APS = Announced Pledges Scenario; NZE = Net Zero Emissions by 2050 Scenario; STEPS = Stated Policies Scenario; includes end-use renewables in the buildings and industrial sectors; 2023e = estimated values for 2023.

But there are some clouds on the horizon, notably for efficiency spending: overall investment would need to triple by the end of the decade to keep the 1.5-degree target in sight.

The rapid progress made on EVs sales, heat pumps and energy efficiency investments in 2022 and the transformative legislation passed in the United States and Europe as a response to the global energy crisis means than the world has taken steps in the right direction towards achieving the investment levels for efficiency, electrification and end-use spending required to hit climate goals. Last year we reported that investment in these sectors needed to quadruple from 2021 levels by 2030, but we are now able to show that "only" a tripling of annual investment by 2030 would put the world on track with the NZE Scenario, while the gap with announced pledges (the APS) has come down to a 2.5-time increase.

The size of the gap is largest in emerging and developing economies (outside China), where annual investment in end uses is 10 times higher than today in the NZE Scenario in 2030. This reflects the need for a sharp rise in EV sales in such a scenario, alongside wide-ranging investment in more efficient industrial processes, transport and buildings, for example a huge increase in zero carbon ready buildings in response to rapid urbanisation. This tenfold increase compares with less than a twofold increase in China and a two and a half-time rise in advanced economies.

In terms of sectors, annual investment in the transport sector is five times higher than today by 2030 in the NZE Scenario. This level is achievable if the growth of electric vehicles sales observed in the last two years persists, and if investment in charging infrastructure follows, but ensuring such consistent and broad-based growth remains an enormous task.

The incentives for continued investment in energy efficiency in the building and industry sectors will continue to depend on long-term, predictable, and ambitious signals from policy makers as well as a favourable macroeconomic outlook. The current headwinds in the construction sector, high energy prices in the industrial sector, high inflation and tightened access to finance all complicate the prospects for achieving a consistent ramp-up in spending in these areas. By 2030, investment in energy efficiency in the building sector in the NZE Scenario is seven times what it is today as mandatory building codes and retrofit mandates become the norm globally and investment in energy efficiency and electrification of the industrial sector doubles.

Ensuring the long-term viability of incentive mechanisms will be crucial, especially as many countries face fiscal constraints in a higher interest rates environment. Although the use of capital markets and commercial finance is quite at an early stage in this space, it will have to play an increasing role in providing access to larger pools of finance for energy efficiency investments.

R&D and technology innovation

Did the world spend enough on clean energy innovation when money was cheap?

The market and policy context for energy innovation is changing. On the one hand, macro conditions are getting tougher, with rising interest rates and other headwinds typified by the collapse in 2023 of Silicon Valley Bank (SVB), a US-based provider of finance to innovative start-ups. On the other hand, policy support in many countries is stepping up as governments respond to the energy crisis and seek more resilient and diversified clean energy supply chains. The US Inflation Reduction Act, for example, provides a huge boost to clean energy innovation funding.

This government stimulus for clean energy innovation comes at a time when financing for innovative small companies is under severe pressure and co-operation on technology between some major economies is increasingly shaped by geopolitical considerations. Concerns that investors will retreat from riskier bets on new technologies are legitimate. Overall, the world may regret not spending more on clean energy R&D and early-stage innovators when capital was cheap over the past 15 years.

The fallout from the failure of SVB shows how inflation can rapidly hit start-up funding, which is the mechanism by which many ideas are tested and, if successful, launched on the market. It highlights how fragile the balance between the financial needs of innovative start-ups and the financial entities that provide their capital can become at times of stress. In 2022 the value of non-venture capital (VC) assets in the portfolios of many large financers fell as interest rates rose and revenue forecasts were revised down. This increased the share of VC assets in portfolios above the institutional targets of these financers (so-called limited partners), who began to withdraw from VC funds and indicate that they would invest less in the near future. A nervous atmosphere has permeated a previously buoyant part of the innovation system.

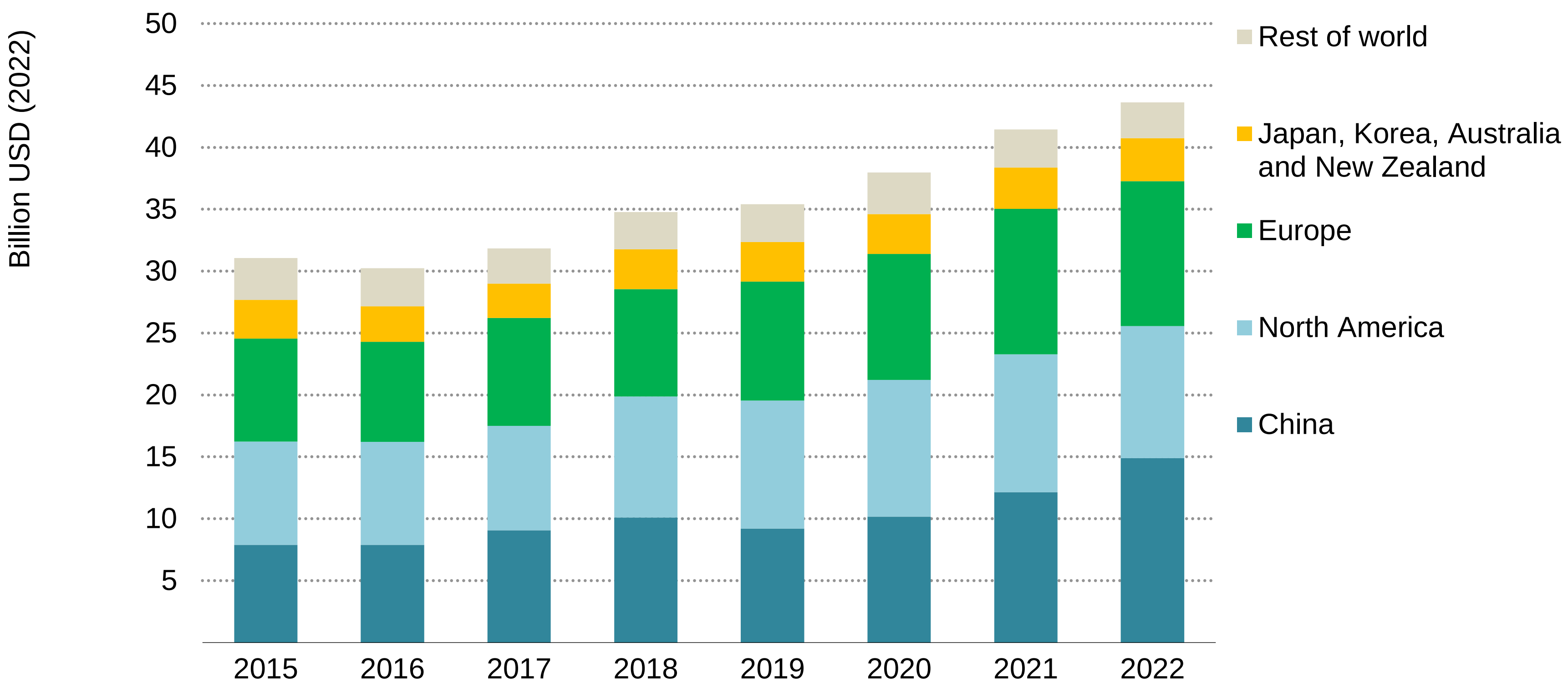
However, there are bright spots relating to clean energy innovation. Government policies provide investors with confidence that effective new technologies can find receptive buyers for clean energy products. Early-stage VC investment into clean energy start-ups reached a new high of USD 6.7 billion in 2022.

In real terms, public spending on energy R&D grew by 10% in 2022, an outcome largely driven by growth in China, while increases in other regions were offset by inflation. Expectations for public funding for pre-commercial technologies soared with the passing of the US Inflation Reduction Act, especially in areas such as hydrogen, CCUS and critical minerals. The advent of new industrial strategies and the priority attached to reshoring clean energy supply chains will have multiple implications for innovation, reinforcing policy support in key countries while also having the potential to fragment aspects of international technology learning.

Spending on energy R&D

Government spending on energy R&D continued to rise in 2022, as marked growth in China outpaced modest progress in other regions

Government spending on energy R&D, 2015-2022



Notes: Includes spending on demonstration projects (i.e. RD&D) wherever reported by governments as defined in IEA documentation; 2022 is a preliminary estimate based on data available by mid-May 2022; state-owned enterprise funds comprise a significant share of the Chinese total, for which the 2022 estimate is based on reported company spending where available; IEA estimates for countries including India and Russia include state-owned enterprise R&D, which was not included in WEI 2022; the IEA Secretariat has estimated US data from public sources.

Source: IEA Energy Technology RD&D Budgets: Overview.

Growth in direct public R&D spending is being supplemented by a jump in support for projects that will indirectly catalyse innovation

Globally, public spending on energy R&D rose by 10% in in 2022, to nearly USD 44 billion according to our estimates, with 80% devoted to clean energy topics. This continues a trend that has buoyed innovation in recent years despite macroeconomic uncertainty. However, growth in China masks sluggishness elsewhere. China's 14th Five-Year Plan (2021-2025) includes a planned increase in energy R&D spending of 7% per year, which we estimate it to have exceeded, based on policy statements and recent filings by Chinese state-owned enterprises. This maintains China's status as the largest public spender on energy R&D. Australia, Belgium and Norway have also reported notable increases, but they do not offset an overall dip of 1.5% in real terms among those IEA countries for which 2022 data are available. Such a stagnation does not bode well for countries that are seeking to invigorate their competitiveness in clean energy supply chains and manage inflationary pressures.

However, while some governments are struggling to increase direct R&D funding – we estimate that it fell 3% in the United States in 2022, for example – most attention in the past year has focused on some major policy packages for countercyclical investment. These could significantly accelerate the competitiveness of pre-commercial clean energy technologies but also, in some cases, could erect barriers to knowledge sharing between regions.

The US Inflation Reduction Act, adopted in August 2022, is perhaps the largest single boost to clean energy innovation funding in recent history. Its mix of direct R&D funding and support for the scale-up of near-commercial technologies and induced innovation (i.e. creation of a more lucrative and less risky market, thereby incentivising companies to develop better products) is expected to raise the pace of technology development. Direct R&D funding in the act includes USD 2 billion for improvements to federal laboratories up to 2027, which is likely to be additional to normal annual expropriations. An easier path to scaling up will be supported by USD 3.6 billion to guarantee up to USD 40 billion of loans to innovative technology projects, 50% grants to demonstration projects for industrial decarbonisation by 2026, and tax credits up to 2045 that offer up to USD 180/t CO_2 that is captured from the atmosphere and geologically stored. Induced innovation is likely to be spurred dramatically by a wide range of tax credits and rebates for the domestic manufacturing of clean energy equipment, low-emission fuel production, home retrofits and vehicle purchases. These incentives are additional to the Infrastructure Investment and Jobs Act measures described in WEI 2022, for which the rules and numerous calls for projects have since been published. There are indications from companies that the levels of support will be sufficient to make otherwise uncompetitive technologies attractive.

In the European Union, a similar package of measures will take shape as countries implement the Net Zero Industry Act and Green Deal Industrial Plan. These include targets for EU-based manufacturing of clean energy technologies, public procurement guidelines and endorsement of certain regulatory exemptions granted to clean energy technology projects. However, while the financing for these strategies is not yet clear, a more long-standing EU programme, the Innovation Fund, awarded EUR 1.8 billion of direct funding to 17 large projects in mid-2022. These cover batteries, hydrogen, solar and wind. As a response to the ongoing energy crisis, the budget for the fund's next round has been doubled to EUR 3 billion.

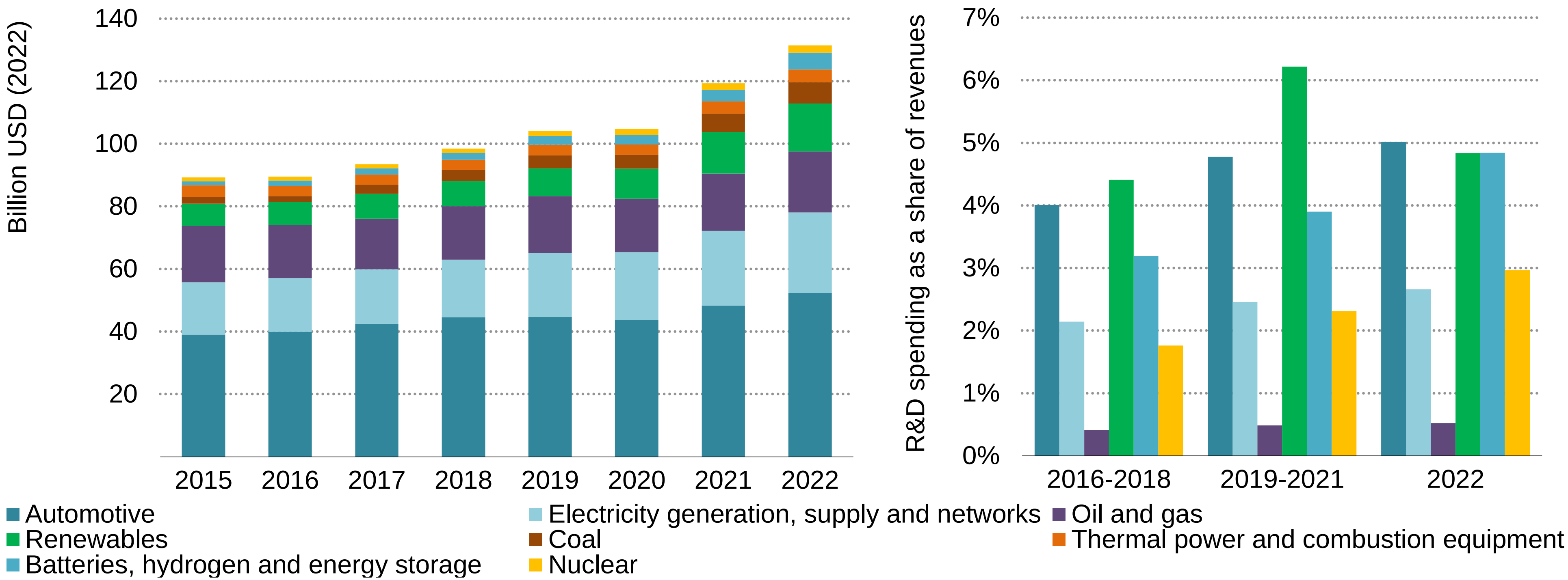
Individual countries are also expanding *indirect* innovation support by directing attention to supply chains. Canada's 2023 budget proposes a 30% tax credit and a halving of corporate income tax for makers of clean energy equipment and higher credits for hydrogen and CCUS projects. Germany has taken a lead in establishing funds for large, early commercial hydrogen projects as a means of stimulating the market. Italy's Recovery and Resilience Plan allocates EUR 2 billion for investments to 2026 to pursue Italian leadership in selected energy technology areas, including financial support for clean energy start-ups. France published calls for projects under its EUR 1 billion fund for building solar PV and floating wind sectors. In 2022 Australia unveiled a Critical Minerals Accelerator Initiative for projects that build new supply chains.

New programmes for research and demonstration were also announced over the past year. Funding for new nuclear reactor designs was boosted by higher budgets in France, where EUR 1 billion was made available to 2030, and the United Kingdom, which plans to spend GBP 0.4 billion. Canada's 2023 budget proposes an additional CAD 0.5 billion for its main clean energy research programme. In December 2022 Germany announced over EUR 150 million for battery research projects, including for digitalisation and recycling techniques. In China, a national innovation platform is proposed to unite university and industry R&D efforts to implement the development plan for large-scale commercialisation of new energy storage technologies by 2030, complemented by new policies in Guangdong and Inner Mongolia.

The Sixth Assessment Report of the Intergovernmental Panel on Climate Change concluded that clean energy innovation systems in EMDEs need strengthening. In late 2022 India advanced its plan for hydrogen, one of its strategic innovation priorities, with a USD 11 million call for proposals from regional consortiums, while its Green Hydrogen Mission earmarked USD 200 million for R&D and pilot projects. Indonesia signed an agreement with Japan to accelerate technological innovations relating to hydrogen, ammonia and CCUS. Also in 2022, the United Kingdom expanded its six-year GBP 1 billion fund for energy R&D projects in EMDEs to include hydrogen and critical mineral topics. Brazil launched processes in 2023 for new strategies for innovation in general and electricity sector innovation specifically.

Corporate energy R&D spending rose by 10% in 2022, returning to its pre-Covid trajectory, but it did not keep pace with higher revenues

Spending on energy R&D by listed companies (left) and R&D budgets as a share of revenues (right), by sector of activity, 2015-2022

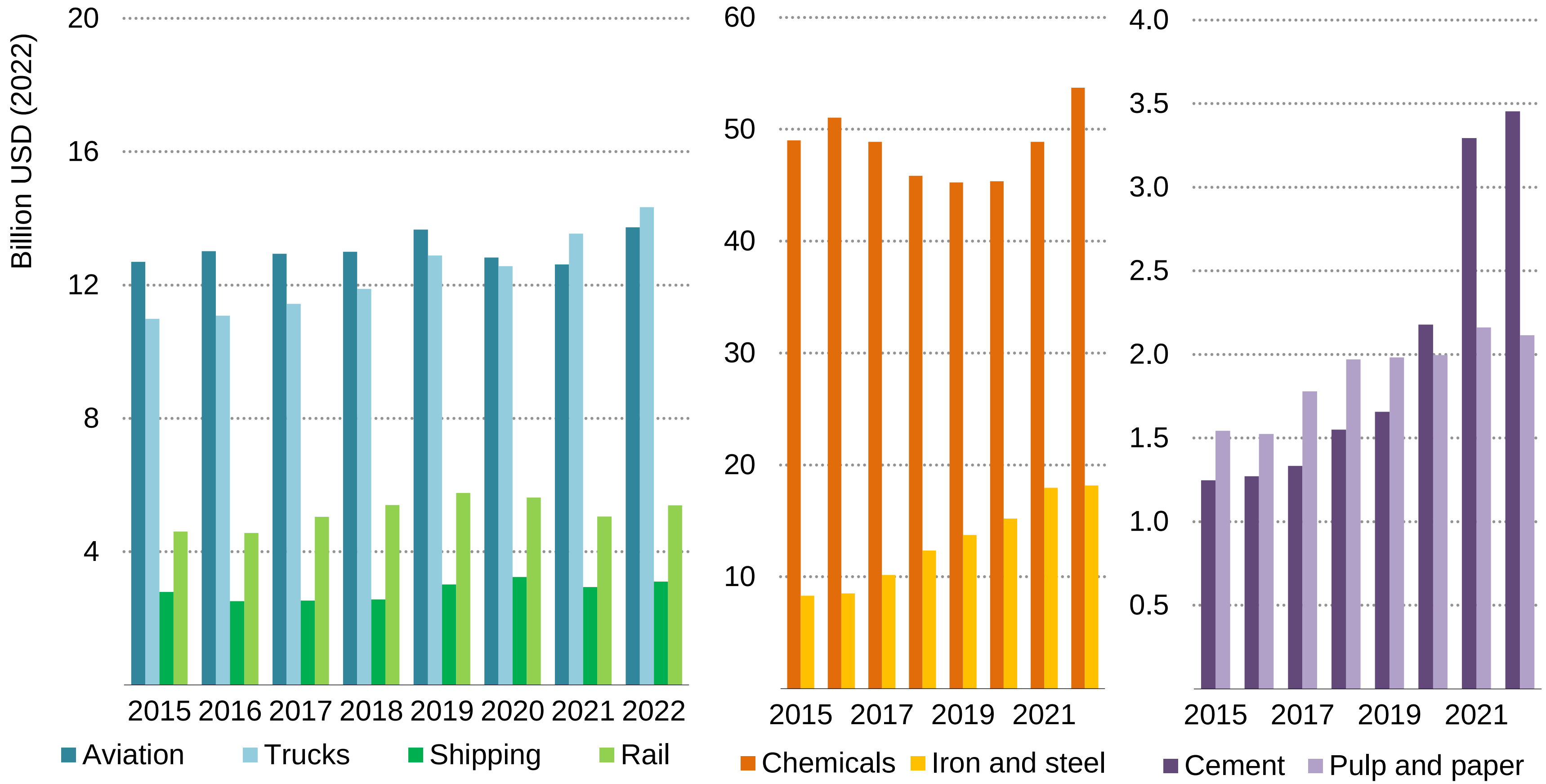


Notes: Values for 2022 are estimates based on reported data at the time of drafting; includes only publicly reported R&D expenditure by companies active in sectors that are dependent on energy technologies, including energy efficiency technologies where possible, based on the Bloomberg Industry Classification System; automotive includes technologies for fuel economy, alternative fuels and alternative drivetrains; fuel cells are included with hydrogen; to allocate R&D spending for companies active in multiple sectors, shares of revenue per sector are used in the absence of other information; values may include both capitalised and non-capitalised costs, including for product development; the right-hand figure considers the top 20 companies earning over half of their revenues in each sector, and represents average R&D spending as a share of revenues weighted by the sectoral R&D spending of each company.

Source: IEA analysis based on data from Bloomberg (2023).

Corporate spending on R&D keeps rising in most "hard-to-decarbonise" sectors

R&D spending by globally listed companies in heavy and long-distance transport (left) and industry (middle, right) by activity, 2015-2022

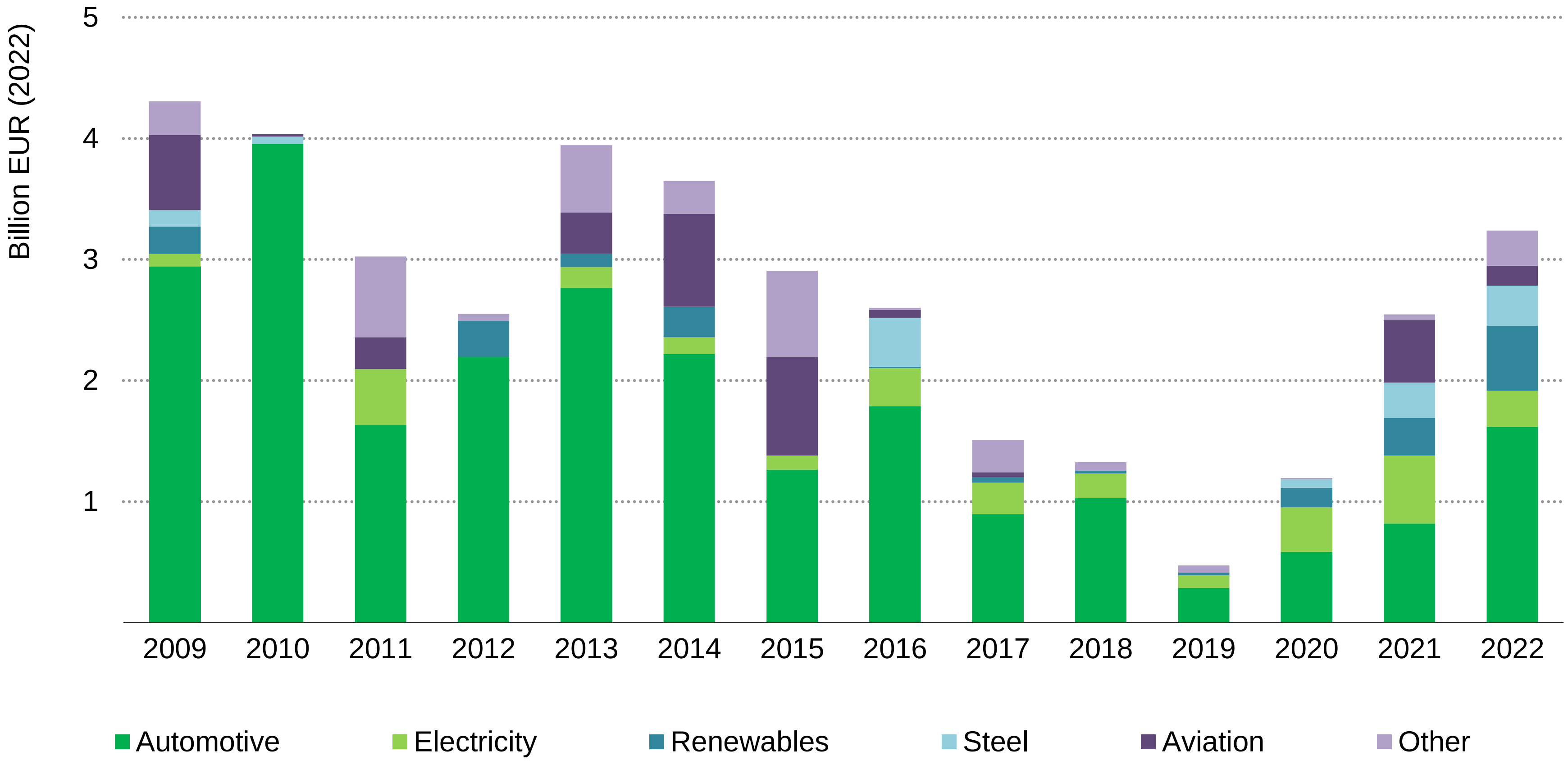


Notes: Values for 2022 are estimates based on reported data at the time of drafting; classifications are based on the Bloomberg Industry Classification System; trucks include recreational vehicles, but not industrial vehicles. Year-on-year changes can result from new companies entering the dataset or companies ceasing operations, as well as changes in R&D spending. Some changes compared to WEI 2022 relate to avoiding double-counting of parent and subsidiary companies.

Source: IEA analysis based on data from Bloomberg (2023).

Public-sector credit for corporate R&D can sustain innovation during times of macroeconomic uncertainty, steering it towards clean energy, as illustrated by European Investment Bank loans

EIB loans to companies for energy-related R&D, by sector, 2009-2022



Notes: "Other" includes cement, energy efficiency, energy storage, hydrogen, marine transport, fossil fuels and rail.
Source: IEA analysis based on data provided to the IEA by the European Investment Bank.

Companies are reacting to the competitive pressures of energy transitions by funding more R&D and higher revenues in 2022 offer a further opportunity to support clean innovation

Preliminary data show positive news for the R&D outlays of listed companies in energy-related sectors. The 10% year-on-year growth in 2022 was high relative to recent years despite economic uncertainty and higher costs of capital. While the trends and competitive pressures vary across sectors, in the aggregate this can be interpreted as a response of companies to the threats and opportunities of the energy transition. As the technological basis of these sectors shifts, R&D is a central strategy for growing, or simply maintaining, market share. The shift in the automotive market is already very pronounced and increasingly globalised, and it is the growth in this segment of energy R&D that steers the overall trend.

A bumper year for energy sector corporate revenues in 2022 offers a further chance to increase spending. This was not yet reflected in research budgets, reflecting the fact that these are typically set in advance and that high energy prices were unanticipated. Therefore, a major opportunity arises for energy companies to increase clean energy R&D budgets in 2023 and beyond, even if just to keep the average ratio of R&D to revenue stable. There is also a good strategic case for a spending increase in areas like clean energy manufacturing: the ability to pair internal R&D with new public funding sources for energy innovation can make this capital more productive in an environment of greater capital discipline.

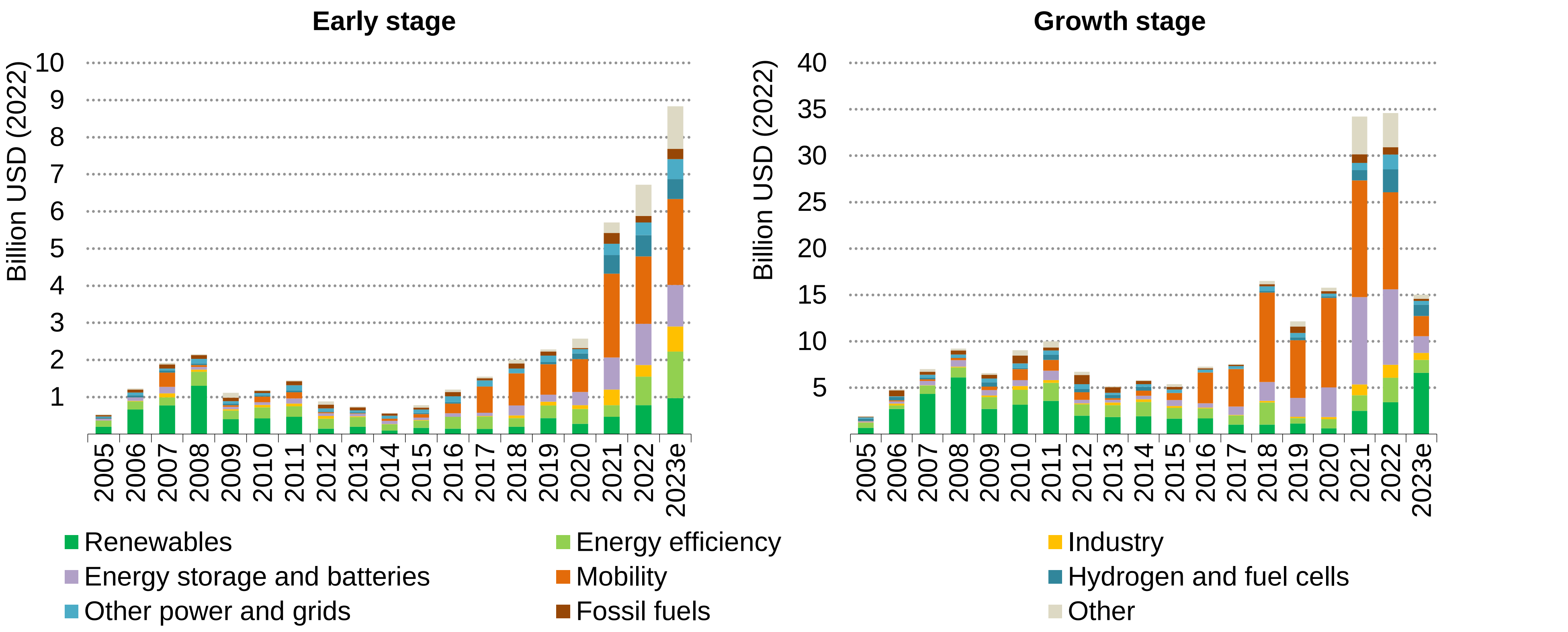
Outside the typical scope of the energy sector, corporate R&D is rising in so-called hard-to-decarbonise sectors. This is a positive signal that companies in the industrial sectors are embracing the challenge of rapidly changing their long-standing technological practices. Most spending in these sectors is by Chinese firms. With no uptick in R&D spending yet, the long-distance transport sectors (aviation, rail, shipping and trucks) remain outliers, however.

In times of economic uncertainty, governments can adopt measures to protect corporate R&D budgets from the threat of cuts arising from lower revenues or more expensive capital. This can bolster competitiveness through a downturn and can also be a chance to direct companies towards specific policy priorities. Since 2020 the EIB has extended EUR 7 billion in loans to support the energy-related R&D programmes of 45 firms. In 2022 new energy R&D credit from the EIB reached its highest value since 2013, when such loans were a response to the global financial crisis. The recent focus is less on the automotive electrification than in 2012-2017 and more on renewable energy and industrial decarbonisation. Germany's federal R&D tax credit, launched in 2020, has so far attracted applications from over 2 000 mechanical engineering projects, among 14 000 overall. The US Infrastructure Investment and Jobs Act delays the need to amortise corporate R&D until 2025.

VC funding of early-stage energy technology companies

Early-stage equity funding for energy start-ups is booming, led by clean mobility and renewables, but 2023 could be leaner for later-stage deals

VC investment in energy start-ups, by technology area, for early-stage and growth-stage deals, 2004-2023e

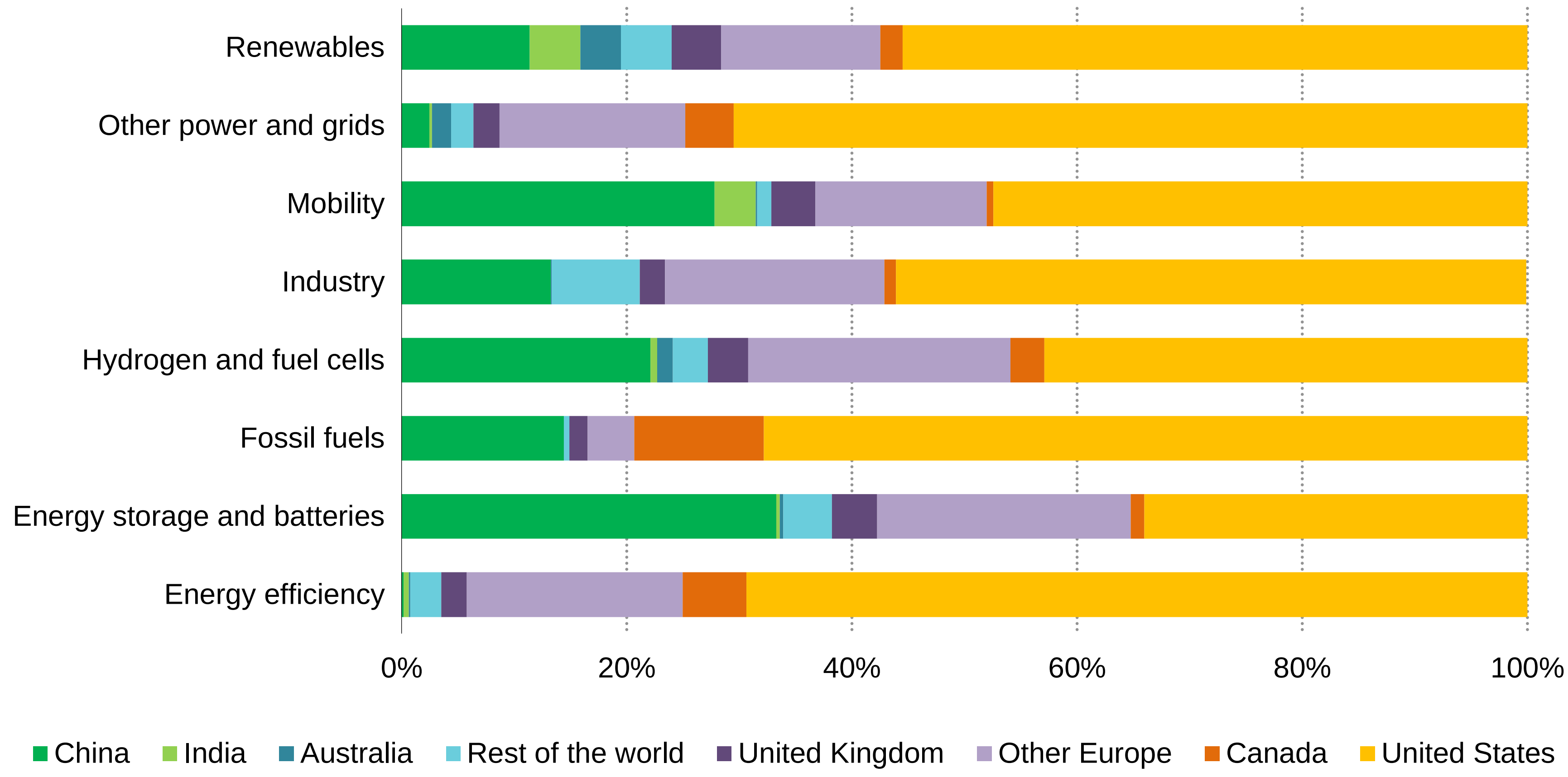


Notes: 2023e is an estimate based on Q1 data; early-stage deals are defined as seed, Series A and Series B deals; very large deals in these categories – above a value equal to the 90th percentile growth equity deals in that sector and year – are excluded and reclassified as growth-stage investments; industry includes start-ups developing alternative routes to materials such as building materials, steel and chemicals; mobility includes technologies specific to alternative powertrains, their infrastructure and vehicles, but not generic shared mobility, logistics or autonomous vehicle technology; "Other" includes CCUS, nuclear, critical minerals and heat generation; fossil fuels cover start-ups whose businesses aim to make fossil fuel use cheaper or otherwise more attractive, including fossil fuel extraction and fuel economy of hydrocarbon combustion vehicles; a review of the data classifications for *WEI 2023* has modified trends published by the IEA in prior years

Source: IEA analysis based on Cleantech Group (2023) and Crunchbase (2023).

Most VC funding for energy technologies has flowed to US-based start-ups, with Europe having a strong presence in hydrogen and China active in mobility and batteries

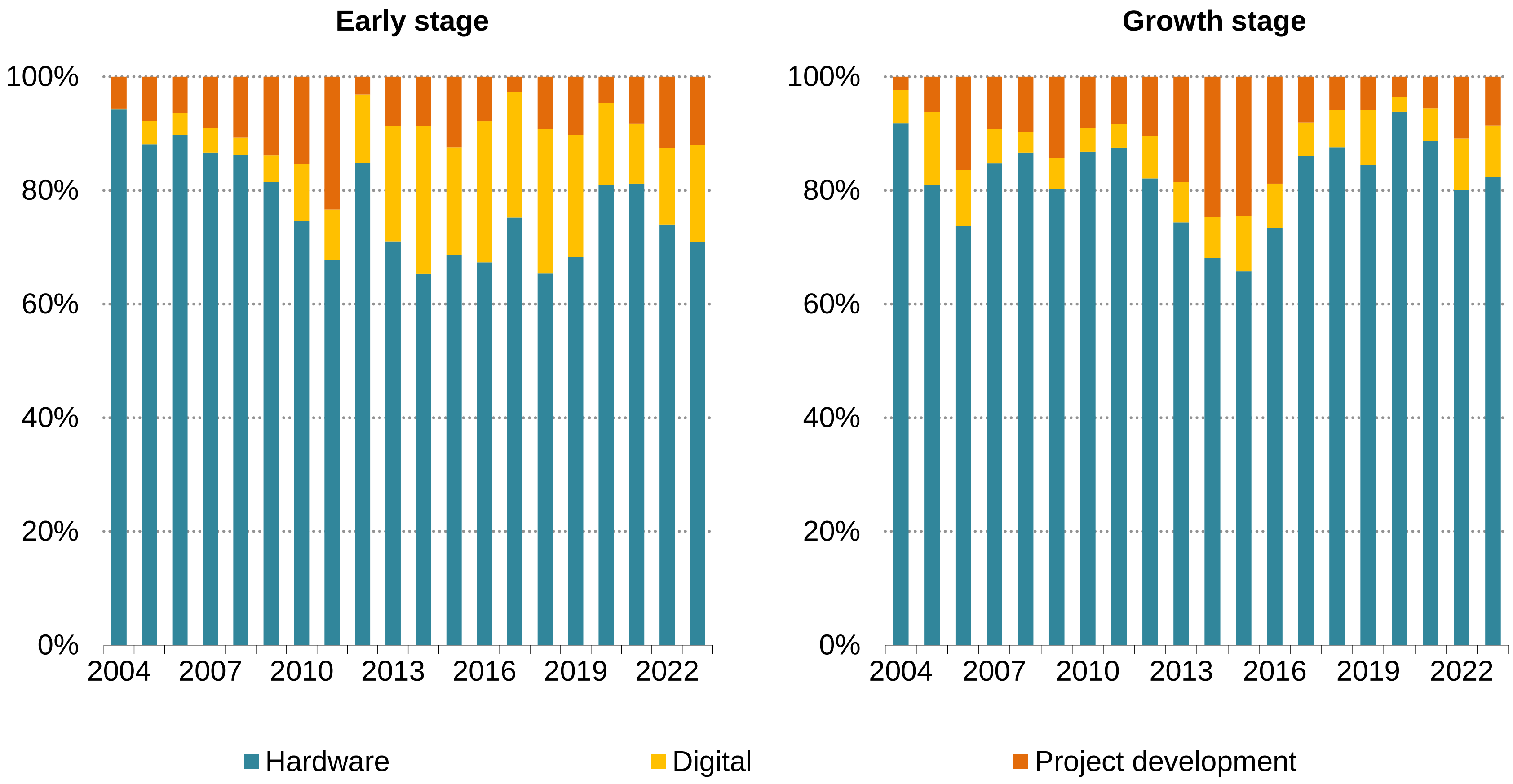
Early- and growth-stage equity investment in energy start-ups by region and technology area, 2020-2022



Note: Regions are presented according to the headquarters of the start-up receiving investment.
Source: IEA analysis based on Cleantech Group (2023) and Crunchbase (2023).

Most of the recent VC investment boom in energy is for companies working on hardware improvements, but more than 25% went to less risky digital technology and project developers

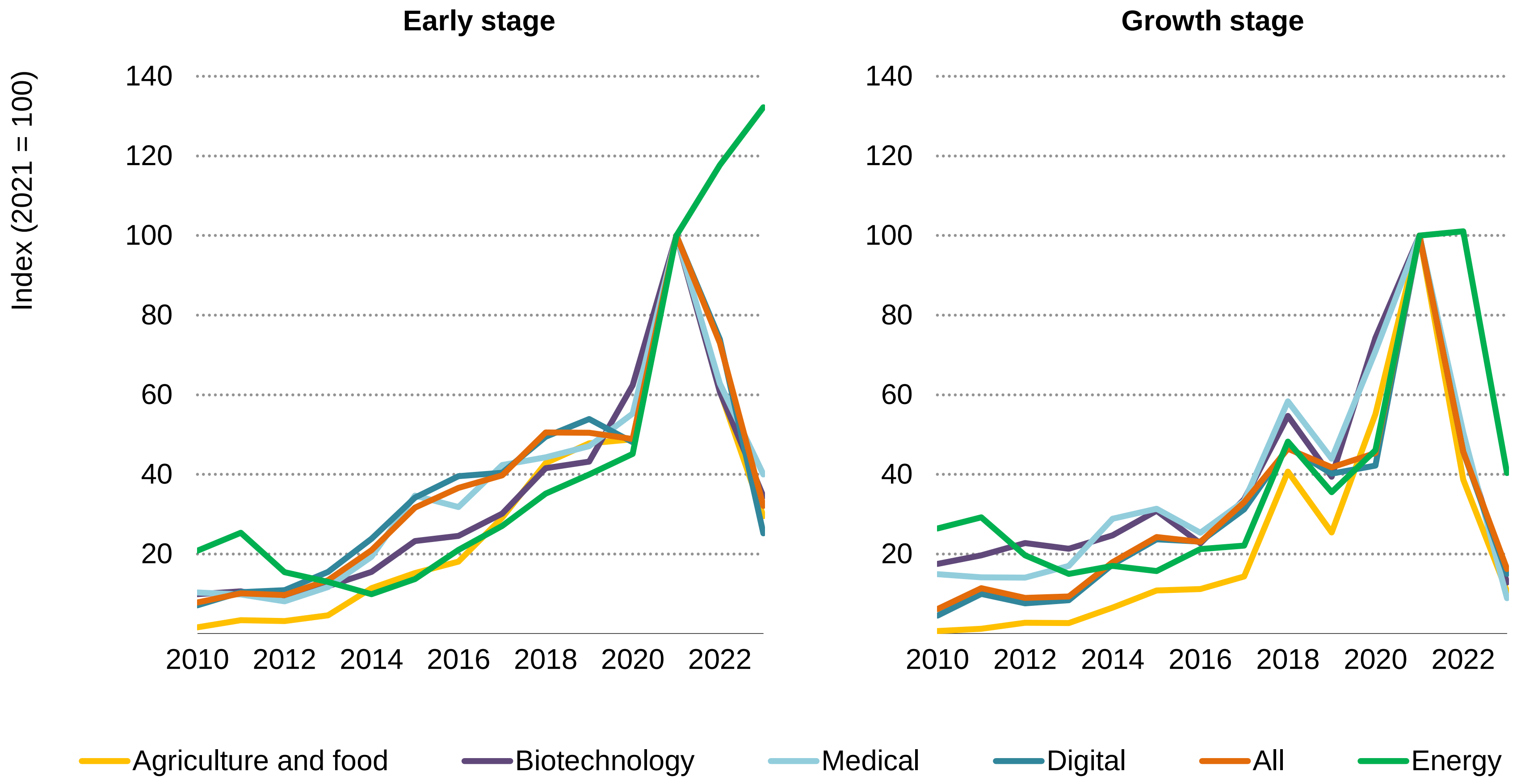
Share of early and growth-stage VC investment in energy start-ups, by type of start-up, 2004-2023



Note: 2023 data are for Q1 only.
Source: IEA analysis based on Cleantech Group (2023) and Crunchbase (2023).

Energy has outperformed other VC segments since 2021, particularly for early-stage equity funding for start-ups, which has experienced growth while VC investment has fallen in general

Growth in global VC investment by sector of start-ups, 2010-2023



Note: 2023 trend is based on the rate of change between Q1 2022 and Q1 2023.
Source: IEA analysis based on Cleantech Group (2023) and Crunchbase (2023).

Clean energy continues to outperform other VC segments, demonstrating investor confidence in energy transitions, but it is not escaping the slowdown in the wider technology sector

For energy start-ups, 2022 was the biggest year to date for early-stage equity funding, with increases in most clean energy technology areas. Most notably, start-ups in CO_2 capture, energy efficiency, nuclear and renewables nearly doubled or more than doubled their 2021 level of funding, which was already much higher than the average for the preceding decade. This type of funding supports entrepreneurs with technology testing and design, and plays a critical role in honing good ideas and adapting them to market opportunities. Growth-stage funding, which requires more capital but funds less risky innovation, rose by only 1% in 2022 and was very weak in Q1 2023. If Q1 is a good guide to the annual trend, the value of growth-stage deals for energy start-ups could fall by nearly 60% in 2023.

Prevailing macroeconomic conditions have dented the amount of capital available and raised the cost of scaling up nascent businesses. This is despite higher fossil fuel prices in 2022 that could have pushed many clean energy start-ups closer to market. With ongoing restraint in the banking sector, investment is not expected to bounce back quickly. Limited partners, the primary backers of VC funds, will continue to rebalance their portfolios to manage risk exposure, leaving more intense competition between start-ups for early-stage funding. In addition, banking services and loans are likely to become more costly for small, innovative firms. While the downward cycle for technology companies in North America was underway before the collapse of Silicon Valley Bank, the trends have now become more pronounced. It is expected that start-ups will have to survive longer between funding rounds or before an "exit" (becoming a public listed company or being acquired by a larger firm), with less access to bridging capital. For hardware start-ups, there will be difficult decisions relating to retention of research staff and investment in prototyping and testing.

However, the prospect of lower growth-stage investment is not reflected in the early-stage trend. Deals in Q1 2023, if maintained, indicate that early-stage VC funding in 2023 could continue to grow strongly. In addition, clean energy is set to continue to outperform other segments for which VC investment has fallen dramatically since 2021, a sign of how much clean energy VC investing has matured.

Much of the need for clean energy technology innovation relates to the development of hardware solutions, yet growth in early-stage funding for energy start-ups developing hardware is flat. For growth-stage investment, VC funding for hardware companies fell in 2022.

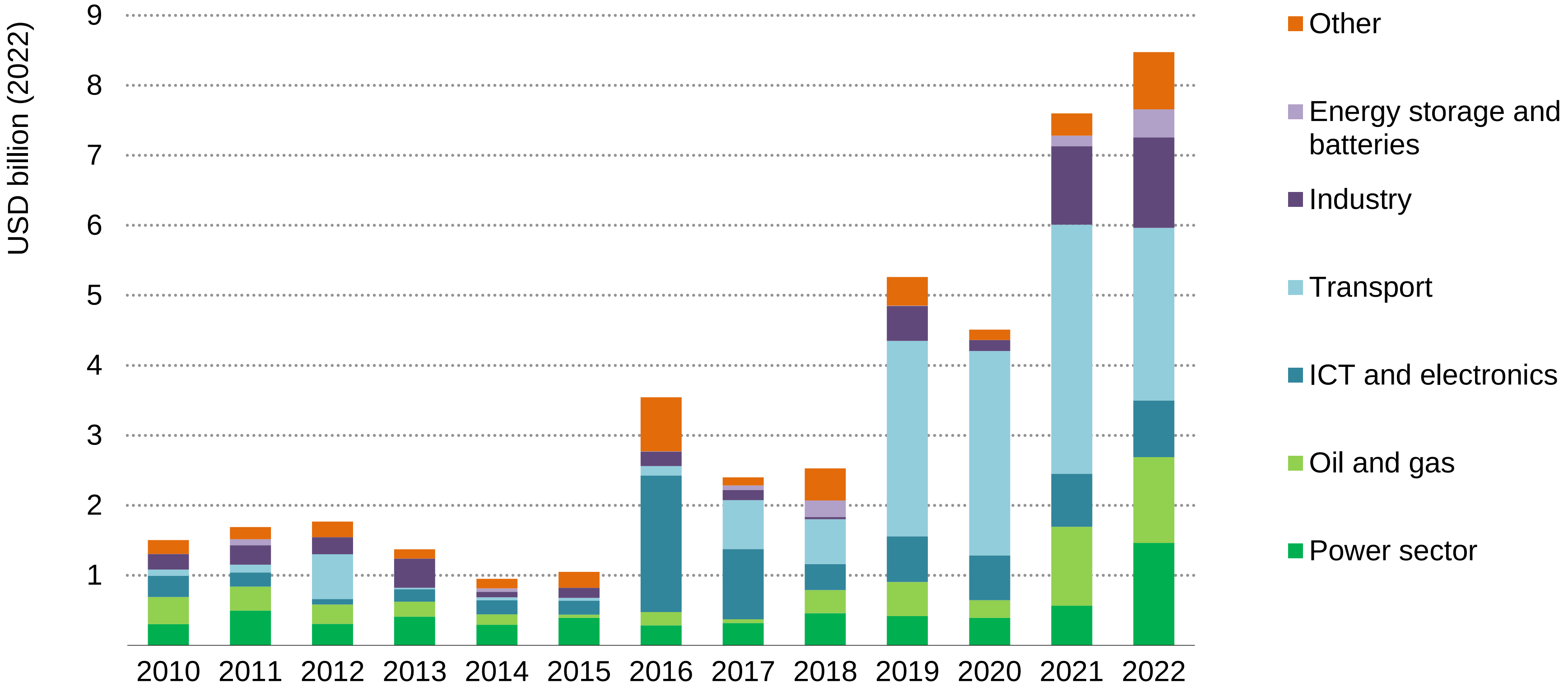
While funding for hardware developers remained dominant, at almost 75%, their share of early- and growth-stage deals tends to shift with changing risk perceptions. In the aftermath of the "cleantech bust" in 2010-2011, the share of funding for hardware dropped dramatically, to around 65% of early- and growth-stage equity investment in energy start-ups at its lowest point. Hardware products can take many years of VC funding to be developed to meet customers' needs, but these start-ups can achieve high valuations and pay-offs for investors. By contrast, energy software and project development companies can have a quicker path to market but offer lower returns. The share of hardware climbed up again in 2020-2021, but has declined in 2022-2023, likely reflecting lower willingness among VC funds to make large, long-term bets. As an indicator, the proportion of energy VC going to digital, hardware and project development can help track investor preferences and the investment climate for solving hardware challenges. In a given technology area, the share represented by project developers can indicate technology and policy maturity.

Regionally, start-ups based in the United States raised more than those in other regions in every technology area between 2020 and 2022. The investors in the vast majority of these deals were US-based. While China, Europe and India have consistently represented growing shares of the total as investment has increased in recent years, this is not evenly spread between funding stages or technologies. When looking at early-stage investment only, European start-ups attracted 29% of the global total, but this falls to 22% for growth-stage funding. China has become a major location for the scale-up of energy storage and electric vehicle companies, but barely registers in the data for energy efficiency and power grid technologies. Indian start-ups are most present in renewable energy and mobility technologies, especially electric two/three-wheelers and charging.

Among hardware technologies, early-stage funding was mostly directed to electric vehicle start-ups, but these represented a much lower share of the total in 2022 than in the past five years. This is potentially due to the greater challenges facing start-ups looking to break into a more mature electric vehicle market. Gains were made in areas including nuclear (exemplified by Newcleo raising USD 294 million), batteries (exemplified by Greater Bay Technology, USD 150 million, Verkor USD 118 million, and Lithion Recycling USD 116 million), geothermal (exemplified by Quaise raising USD 52 million), and heating and cooling (exemplified by Exergyn and Submer raising USD 33 million apiece).

Corporate VC investment in clean energy start-ups remains high, with a higher contribution in 2022 from electricity, oil and gas, and heavy industry companies

Corporate VC investment in energy start-ups, by sector of corporate investor, 2010-2022



Notes: Includes early- and growth-stage deals; includes only investment by private-sector investors; where there are several investors, deal value is evenly split across them; ICT = information and communications technology; Industry includes chemicals, cement, commodities, construction (excluding real estate), iron and steel, and other equipment suppliers; Power sector includes independent power producers, and electricity and renewables equipment and services; "Other" includes food, health, research and mining; values are slightly lower than in WEI 2022 due to some reclassifications by the IEA of start-ups and investors.

Source: IEA analysis based on Cleantech Group (2023) and Crunchbase (2023).

Higher strategic corporate investment in energy start-ups indicates how firms are seeking to stay competitive or break into a fast-moving landscape

Corporate venture capital (CVC) investment in clean energy start-ups stayed at historic highs in 2022, exceeding USD 8 billion. With the technological landscape changing rapidly, companies increasingly use CVC investments in start-ups to enter new technology areas. The increase in 2022 was led by investors from the industrial, electricity and energy storage sectors.

Mirroring our findings about the high share of energy VC funding for firms developing digital products between 2013 and 2020, CVC investment in energy start-ups by ICT firms grew markedly from 2016 (as these start-ups became closer to the market). However, the ICT sector's share of energy-related CVC was not maintained and in 2022 there was a more even spread of CVC among corporate sectors than previously. Industry sectors like chemicals, construction materials, and iron and steel are playing a larger role in CVC investment in clean energy start-ups with hardware products.

While CVC remains lower than corporate R&D budgets, it has been growing quickly since 2015. In an energy sector that anticipates disruption from mass-produced, modular and quick-to-scale technologies, CVC can be particularly attractive as a lower-cost and quicker means of acquiring knowledge, new technologies and business models. The nimbleness of start-ups and the "optionality" for investors can be particularly valuable under conditions of uncertainty, competition and budget pressures.

For start-ups, CVC complements other sources of funding and can accelerate scaling up by providing access to corporate experience and resources, especially for manufacturing, as well as access to consumers around the world. This is most evident in the case of fossil fuel companies, which increased their energy-related CVC activity in 2022. Oil and gas companies invested USD 2 billion between 2020 and 2022, mostly in CCUS, energy efficiency and renewable energy developers. Start-ups must weigh the benefits of CVC against the possibility that their agility and rapid growth ambitions may not always fit with the strategies of the firms that take stakes in them.

Notable investments in 2022 included equity from Chevron and the Oil & Gas Climate Initiative into Svante, a Canadian CO_2 capture firm that raised USD 318 million of growth equity, and Sinopec's participation in a USD 130 million growth-stage round for Kuntian New Energy, a Chinese battery component maker. Equinor invested in Solid Power, a US solid-state battery firm. Repsol invested in Enerkem, a Canadian waste-to-energy company. Eni invested in C-Zero, a US natural gas-to-hydrogen start-up. Gerdau and Asahi Kasei invested in Plant Prefab, a Dutch maker of efficient buildings. Holcim invested in Blue Planet, a CO_2 mineralisation start-up.

Implications

Energy innovation investment has largely remained resilient to shocks in a turbulent 2022, but more tests lie ahead and capital availability varies between regions and types of innovation

The latest investment data for energy R&D and innovation are broadly positive, and reflect some of the themes running through the chapters of this report. The impacts of the Russian invasion of Ukraine are yet to become fully apparent, with government support for clean energy helping it to buck macroeconomic trends so far. In innovation, this is most evident in the resilience of VC funding for clean energy, despite a downturn in VC funding for technology start-ups more generally. Similarly, corporate R&D spending data echo the findings for capital expenditure in the energy sector: there is little evidence from 2022 that spending will rise in line with higher revenues, but there is a strong case for an increase in, for example, oil and gas company R&D in coming years.

Any outlook for clean energy innovation globally must accommodate several competing drivers that have become more pronounced in the past year. Firstly, any reduction in bilateral co-operation and trade between major regions restricts flows of knowledge, thereby slowing the advance of the technology frontier. Secondly, regulatory preferences for more local supply chains could lead equipment suppliers, such as vehicle manufacturers, to relax their efforts to keep up with technological developments abroad. Thirdly, and in contrast with the previous two points, hindrances may be counteracted by industrial policies inspired by competition in international clean energy value chains. By projecting stronger market signals over the medium term, industrial policies can steer significant new capital to selected technology challenges, which spurs eligible innovators to compete with each other to secure contracts and win market share.

Regional differences are set to widen, not converge

Unlike in some other areas of energy investment, China's share of innovation spending does not tower over global spending. Public R&D spending is quite even across China, Europe and North America, while VC investment is more concentrated in the United States, followed by Europe. These three regions, plus Japan and Korea for R&D spending, play an outsized role in energy innovation compared with their future energy investment needs.

The NZE Scenario requires over half of clean energy investment to be in EMDEs. However, in 2022 EMDEs (excluding China) accounted for just 5% of public energy R&D, 3% of corporate energy R&D (by country of headquarters) and 5% of energy VC (by country of start-up).

Government support is crucially important for stimulating R&D investment, and policy incentives for clean energy innovation are expanding impressively in the regions that are already leaders. Costs of capital are diverging between advanced economies and EMDEs in a way that could entrench this difference at a time when innovation co-operation between regions appears more challenging.

Innovation in EMDEs is typically more targeted to their specific social, economic and climatic contexts. In addition, it can help to position them in clean energy technology value chains, thereby boosting economic growth and accelerating global efforts towards climate goals. Advanced economies and multilateral development banks have a role to play in ensuring that investment opportunities for energy innovators are as global as possible, even as competition intensifies in areas from batteries to energy management software, hydrogen, heavy industry, heat pumps and air conditioning.

The scope of energy innovation investment is expanding, signalling more VC appetite for hardware developers

The recent surge in VC investment in clean energy has been accompanied by a high share of bets on hardware-focused start-ups. However, the innovation efforts devoted to digital solutions seen during 2013-2019, which drew the world's biggest IT companies into energy-related research, remain important. Rather, the share of hardware has risen along with a broadening range of hardware areas attracting funding from public and private sources. Investors in clean energy technologies now cover aerospace, critical minerals, direct air capture, industrial feedstocks and manufacturing techniques.

Demonstration project funding grabs headlines, but underlying innovation systems also need attention

In the coming years, editions of *World Energy Investment* will track how the major government funding announcements translate into public budgets, project awards, project expenditure and then technology improvements. For first-of-a-kind demonstration projects, the extent to which tax credits and performance incentives attract private capital will be watched closely. The magnitude of this spending, especially with many incentives in the US Inflation Reduction Act being uncapped, will ensure publicity for these projects.

However, energy transitions depend just as heavily on functioning innovation systems that channel appropriate types of capital to researchers and entrepreneurs as they develop new ideas. Effective innovation systems balance public spending, intellectual property rights, knowledge networks, market opportunities and incentives for the private sector to put capital at risk. For a decade, cheap capital has lowered barriers to investment in long-term, risky bets and thereby concealed weaknesses in innovation systems. With the cost of money set to rise, the health of these systems will be a more critical determinant of whether new technology ideas continue to flow in line with the "learning curve" assumptions of decarbonisation scenarios. There is plenty that governments can do to nurture good ideas and give them the highest chance of being available to apply for the next waves of VC or demonstration funding in 5 or 10 years' time. This includes guiding the brightest minds towards key policy challenges for clean energy technologies.

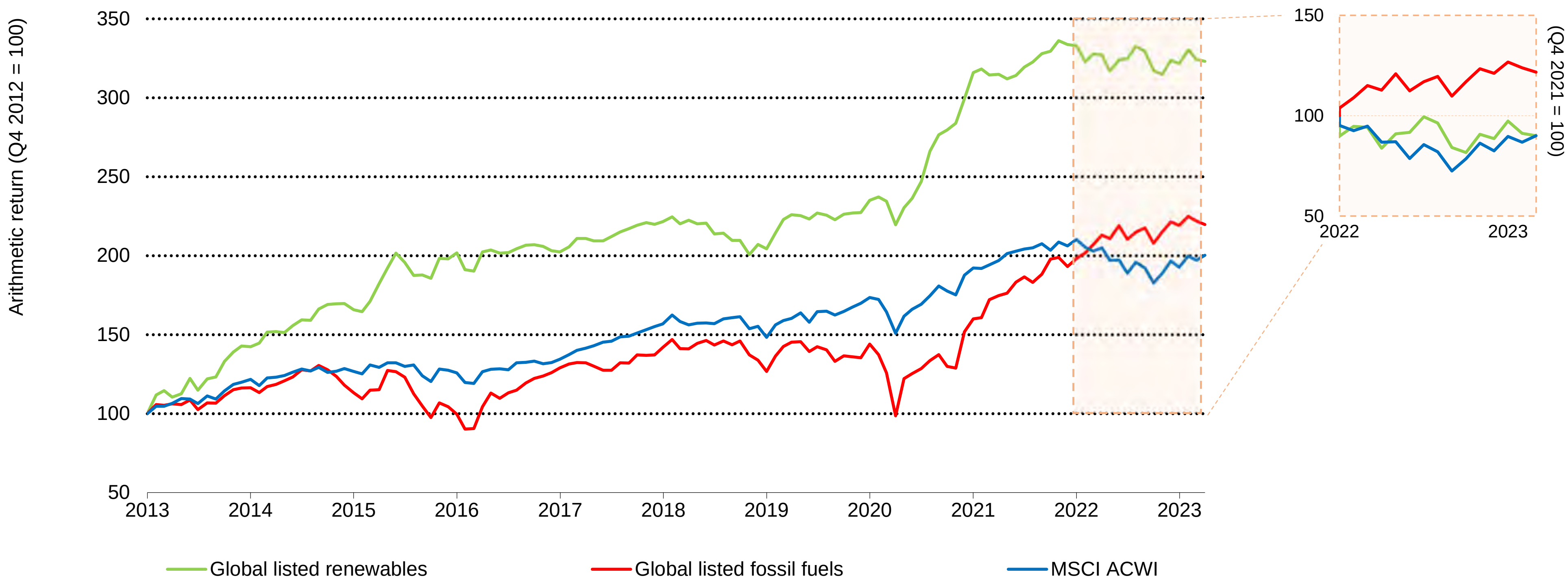
More than in other parts of the energy sector, innovation investment reflects the balance between long-term thinking (to mitigate the risks of long-term unsustainability and uncompetitiveness) and near-term shocks. Despite positive outlooks in some areas (such as public R&D and demonstration funding, and fundraising by project developers), others face headwinds (including the cost of capital for early-stage hardware start-ups, and international knowledge flows). All stakeholders in successful energy transitions are therefore bound by a need to address weaknesses and keep the investment balance in favour of seeking long-term opportunities.

Sustainable finance

Overview

The energy crisis led fossil fuel companies to significantly outperform the benchmark last year, although renewables proved resilient following years of strong returns

Monthly returns of energy-related sample portfolios, 2013-2023 (left) and Q4 2021-Q1 2023 (right)



Note: MSCI ACWI = MSCI All Country World Index.
Source: IEA analysis based on data from Bloomberg (2023).

Investing in clean energy has faced challenges due to the strong performance of fossil fuels in 2022, but the continuing development of sustainable finance regulation can act as a tailwind

The financial community has a critical role to play in the massive ramp-up of clean energy spending needed to meet climate goals and the orderly reallocation of capital away from fossil fuels. The proliferation of sustainable finance practices is a strong indicator of this direction of travel, with a growing number of financial institutions pledging to align their financing with net zero scenarios.

Last year represented a major challenge to these practices, with the Russian invasion of Ukraine causing fossil fuel companies to significantly outperform the market. This put short-term pressure on investment strategies that underweighted or excluded these entities. Despite this, signs from European and North American shareholder voting season (March-June) show that actors within the financial community remain concerned about climate risks and the implications of rapid transitions for fossil fuel assets. Climate-related proposals, particularly on emissions targets, are up compared to last year – although the test will be how many win a majority vote. There are also more proposals to cut off or phase out fossil fuel financing at banks and insurers, although last year all nine such proposals that went to vote in the United States failed to receive support above 20%, and the current energy security climate is likely to soften support.

The continuing appetite for sustainable finance practices in such a challenging market demonstrates the important foundation laid by regulators globally. Regulators are strengthening sustainable finance architecture by issuing clear definitions of green or sustainable activities and guidelines to prevent "greenwashing", while mandating granular sustainability disclosures and reflective risk and opportunity assessments. Some of the major trends and developments are:

Green taxonomies: In 2022 green taxonomies were introduced in South Korea, Indonesia, South Africa, Colombia, Sri Lanka and Georgia. Mexico also announced a new taxonomy in March 2023, with several other countries announcing that taxonomies are under development, as in Australia. Meanwhile China, one of the largest green finance markets, published the Green Bond Principles in July 2022 and later the Common Ground Taxonomy, which outlines commonalities with the EU taxonomy.

Transparency and labelling: There has been growing concern around the use of "ESG" (environmental, social and governance), "sustainable" and "green" terminology on financial products and the data that go into it. Regulators from at least 13 jurisdictions have proposed or introduced disclosure requirements on ESG or sustainable funds to improve labelling. Regulators have also looked at individual companies, with cases brought against DWS (Germany) and Goldman Sachs (United States) over the alleged misleading of investors in green or ESG investments. Regulators are also increasingly looking at ESG data and ratings providers; Japan, the United Kingdom and the European Union are publishing either codes of conduct or proposing future regulation for ratings providers.

Disclosures: The proliferation of non-financial reporting standards and regulation generally emphasises emission and climate risk disclosures. The International Sustainability Standards Board issued two voluntary standards on climate-related reporting – IFSR 1 and 2 – in June 2022, becoming effective in January 2024. EU sustainable finance regulations also advanced with the Corporate Sustainability Reporting Directive, which will require large and listed companies to report on, among other things, their environmental risks, opportunities and impacts. The Sustainable Finance Disclosures Regulation (SFDR) also entered its second phase in early 2023 whereby sustainability disclosures and reporting on climate and environmental impacts became mandatory for financial market participants. A report by ISS also found that countries in Asia – notably Malaysia, Singapore, India and Japan – had been particularly active in introducing sustainable finance-related regulation, including around disclosures, sustainable lending and stewardship practices.

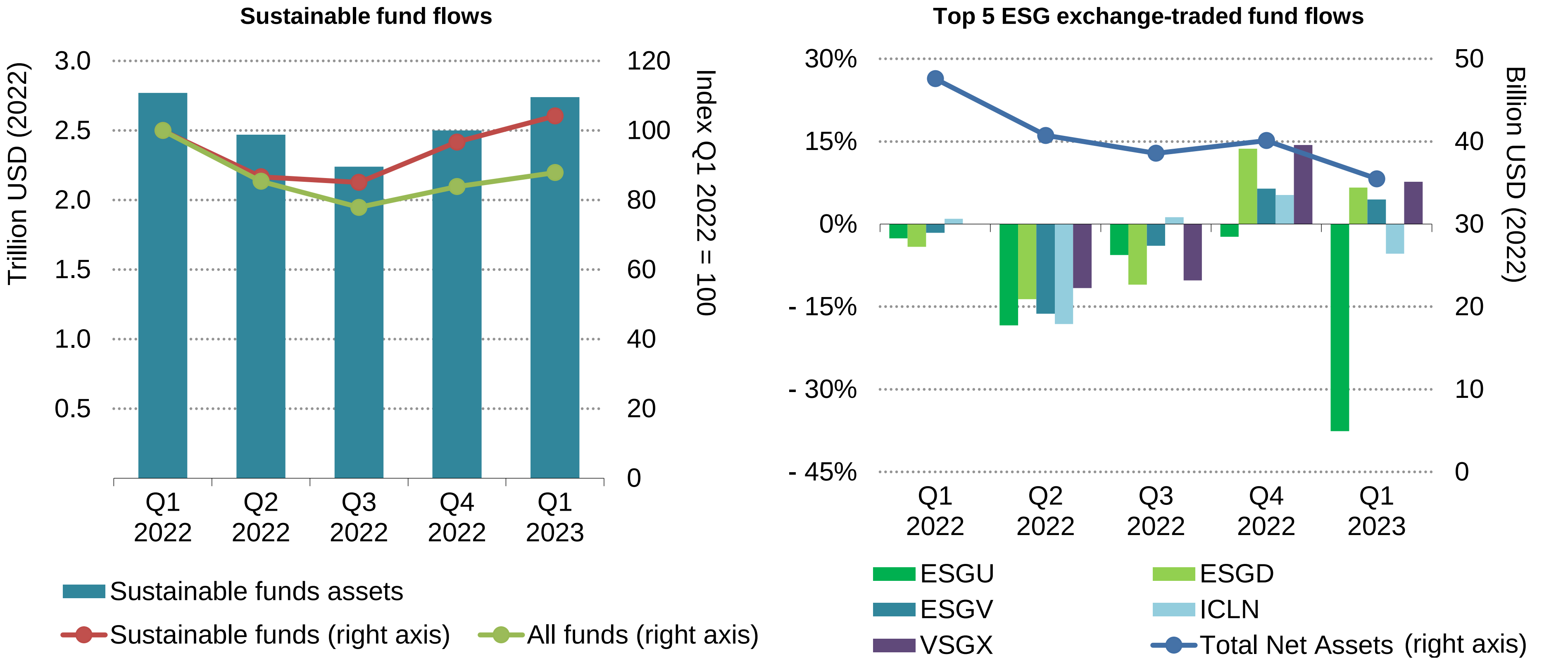
Climate stress testing: A growing number of central banks are conducting climate stress tests and in at least 18 jurisdictions banks either are or will soon be subject to requirements to implement such testing. A climate risk stress test by the European Central Bank conducted in 2022 found that around 60% of the 104 participant banks did not have a climate stress testing framework in place, and that about two-thirds of banks' income from non-financial corporate customers stemmed from greenhouse gas-intensive industries. The Network for Greening the Financial System, which provides central banks and supervisors with climate scenarios and guidance for such tests, found that there are multiple different approaches to stress testing across jurisdictions and encouraged greater co-ordination. Equally, they highlighted that the lack of availability and comparability was reducing the quality of stress testing. As a result, stress tests currently serve primarily as learning exercises, with no immediate requirement for follow ups, but they show that banks stand to experience notably higher credit losses under a disorderly transition.

Achieving the NZE Scenario requires clean energy spending to rise nearly threefold by 2030, with an estimated 65% of this needing to come from the private sector. Sustainability-related regulation and guidance act as a tailwind for these investments. This chapter explores the alignment between growth in sustainable finance and clean energy investment, particularly in relation to EMDEs, which account for 55% of clean energy investment by 2030 under the NZE Scenario. While the emphasis here is on private investment, numerous other public finance initiatives are also underway that are likely to support an increase in clean energy spending. Notably, these include the Bridgetown Initiative announced by Barbados Prime Minister Mia Mottley at COP27, which proposes several steps to reform development and climate finance.

Sustainable investing

The value of assets in funds globally fell during 2022, although sustainable funds showed more resilience and have rebounded in early 2023 despite major outflows from some large ESG funds

Trends in sustainable fund and ESG exchange-traded funds (ETF) flows, Q1 2022-Q1 2023



Notes: ESGU = iShares ESG Aware MSCI USA ETF; ESGD = iShares ESG Aware MSCI EAFE ETF; ESGV = Vanguard ESG US Stock ETF; ICLN = iShares Global Clean Energy ETF; VSGX = Vanguard ESG International Stock ETF; ETF = exchange-traded fund.
Sources: IEA analysis based on data from Refinitiv (2023), Morningstar (2022, 2023).

Sustainable funds weathered a challenging year despite the pressure on investment strategies that limited exposure to high-performing fossil fuels

After years of inflows, in 2022 ESG funds recorded their first net outflows since 2011. Outflows were particularly heavy in the first half of the year, as fossil fuel prices spiked and concerns around inflation, interest rates and recession hit the market as a whole. How these pressures impacted ESG funds varied significantly according to their chosen approach. Funds that focused on screening – which often involves underweighting or excluding fossil fuel companies and overweighting high-performing sectors with lower ESG risks like technology – faced particularly tough questions around their performance compared to the market.

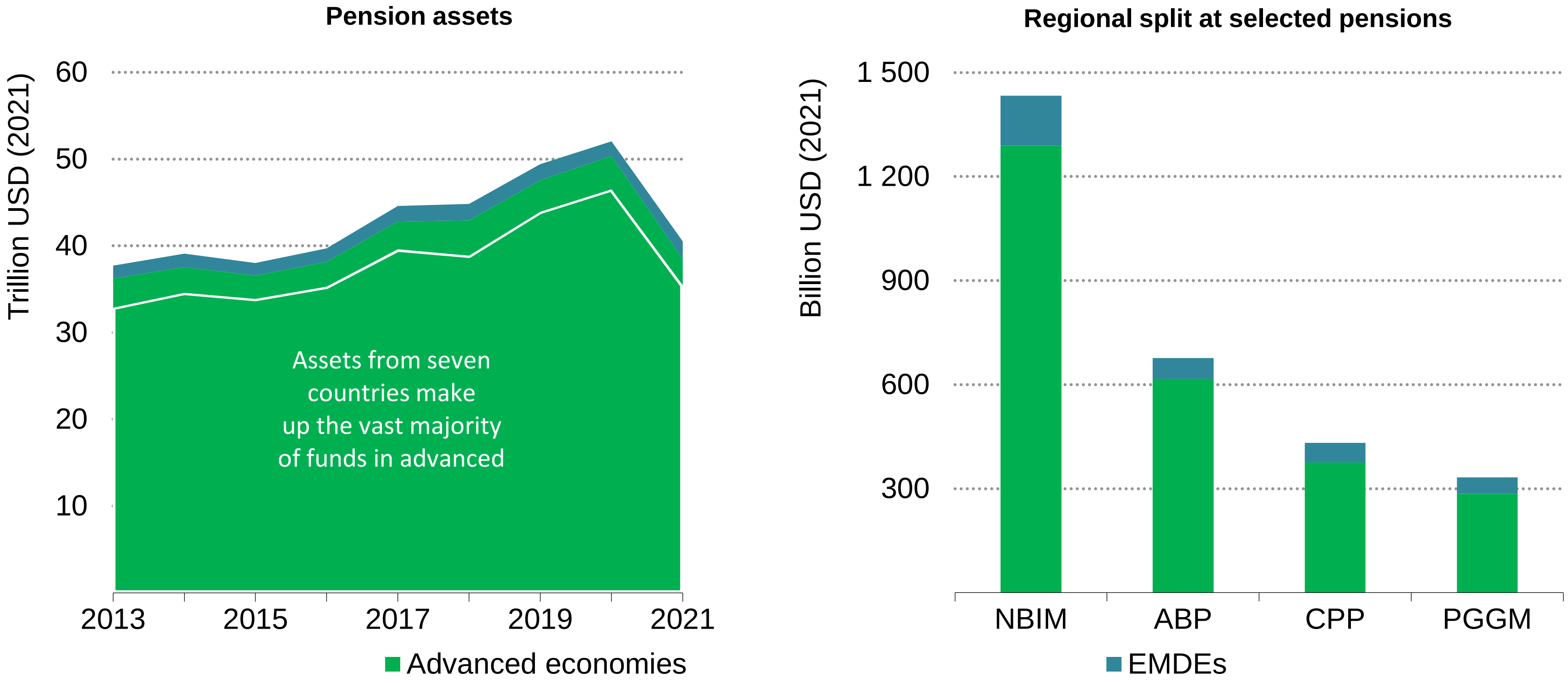
Large one-off outflows from ESG ETFs in early 2023 have also highlighted the impact of concentration risk within certain areas of sustainable investing. In March, nearly USD 4 billion was withdrawn from iShares ESG Aware MSCI USA ETF (ESGU), the largest ESG ETF, contributing to a 38% fall in the ETF's asset value in Q1. This quarter also saw withdrawals from other major funds, including iShares Global Clean Energy ETF, which saw a USD 260 million outflow triggering a 5% loss in asset value. Several analysts have attributed these outflows to risk rebalancing by institutional investors who own large portions of these funds. In 2022 Bloomberg estimated that roughly 22% of new investment in ESG ETFs went to just 10 funds, and most of these investments were made as one-off allocations. This indicates that choices among certain large investors or by key funds or indexes that ETFs track can skew trends within the market.

Despite these challenges, sustainable funds generally proved resilient against market conditions, based on quarterly reviews by Morningstar. Throughout the year and into the first quarter of 2023, the valuation of sustainable funds saw less volatility than all funds globally, and thanks to a rebound in equity valuations in early 2023, sustainable funds have almost returned to levels seen in early 2022.

The impact these trends have on alignment with investment under the NZE Scenario is mixed. The correlation between a push for sustainable investment practices and a reduction in fossil fuel spending is clear, but questions remain over the extent to which sustainable investing is driving the necessary increase in clean energy investment. For example, the EU SFDR groups funds into three broad categories based on their level of sustainability. Article 9 funds are the most ambitious, whereby funds demonstrate they have a "sustainable investment objective". In Q4 2022 there was a series of reclassifications, with 40% of Article 9 funds downgraded to the less ambitious Article 8, where funds must "promote environmental or social characteristics". Notably, these included the iShares Global Clean Energy ETF, suggesting that Article 9 alignment is not a prerequisite to supporting the energy transition.

Institutional capital is heavily concentrated in advanced economies with only a small share being allocated to EMDEs…

Pension asset regional spread and allocations to EMDEs at selected pensions

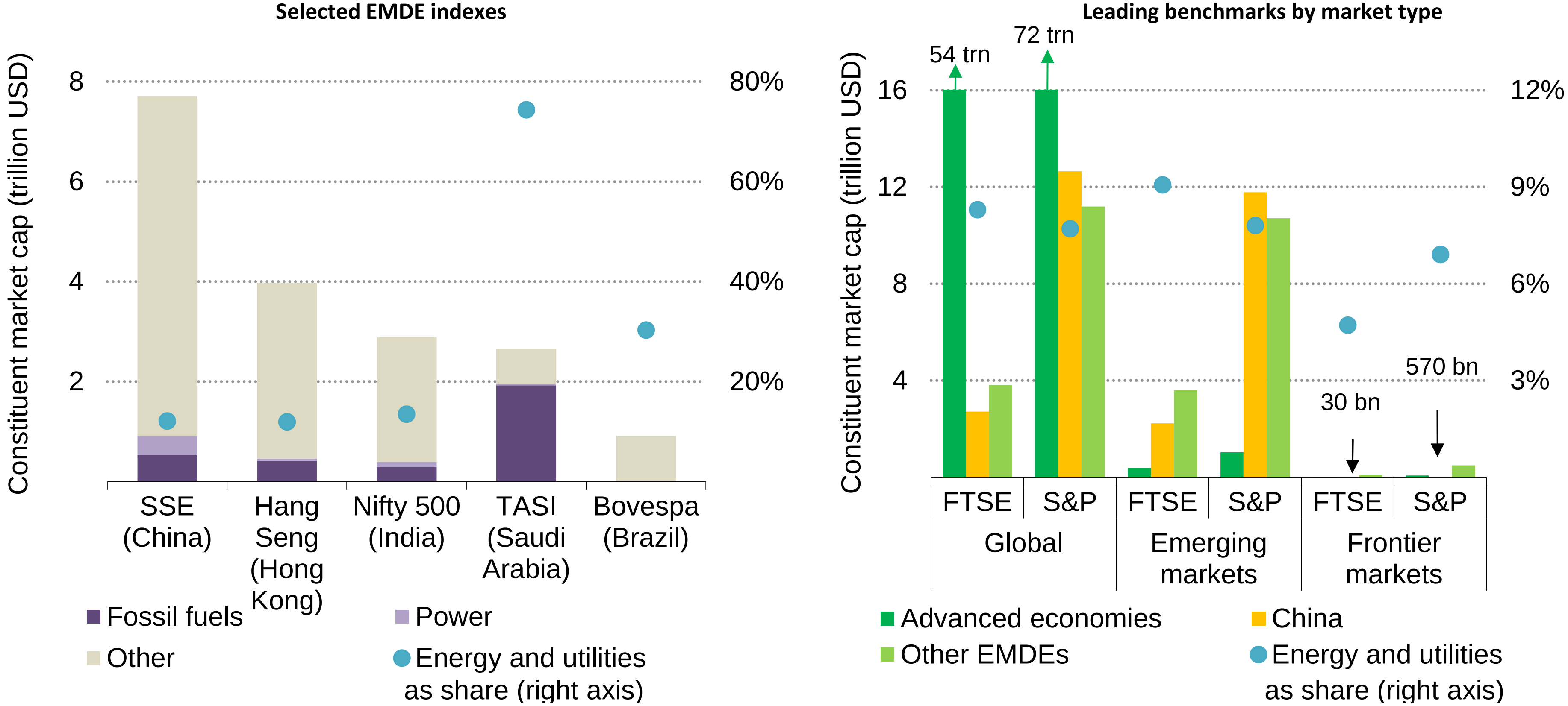


Notes: The seven countries that make up the majority of pension assets are Australia, Canada, Japan, the Netherlands, Switzerland, the United Kingdom and the United States; NBIM = Norges Bank Investment Management; ABP = Stichting Pensioenfonds; CPP = Canada Pension Plan; these four funds were selected based on their inclusion in an OECD survey on pension fund assets in developing countries.

Sources: OECD, Pension Markets in Focus; World Bank, World Development Indicators; Annual report from NBIM, ABP, CPP and PGGM.

… and increasing these allocations is complicated by the lack of accessible investable assets

Characteristics of indexes in selected EMDEs and leading benchmark providers



Notes: EMDE indexes were selected based on the size of the local stock markets and availability of data; benchmark indexes do not include MSCI, the third major provider, because constituent country data were not publicly available.

Sources: IEA analysis based on data from Refinitiv; World Bank, World Development Indicators; Index factsheets from S&P and FTSE Russell.

Structural issues and the limited pool of investable assets are preventing capital from flowing to key areas needed to meet the Net Zero Emissions by 2050 Scenario

In the NZE Scenario, clean energy investment in EMDEs triples by 2030, by which time it accounts for over half of the global total. This represents a sharp break from current trends; clean energy investment in EMDEs has risen by only around 30% in the past five years (most of which has been in China).

The imbalances are unsurprising when you consider that around 80% of financial assets are held in advanced economies, according to estimates by the Financial Stability Board. Looking at pension funds, which can provide a valuable source of patient capital, seven advanced economies accounted for nearly 90% of global pension assets in 2021 (latest data available). An OECD survey found that only around 8% of surveyed pension assets were allocated to developing countries and 85% of these assets came from just four funds.[1] According to these funds' latest reporting, allocations to EMDEs totalled roughly USD 300 billion in 2021, or 11% of their combined portfolios. These allocations may have fallen over 2022 due to changing risk perceptions in the wake of Russia's invasion of Ukraine and the subsequent energy crisis, and the worsening macroeconomic environment in many EMDEs.

One of the major constraints on further investment in EMDEs from such institutions is the lack of projects that meet their size and liquidity requirements. Entities from EMDEs (excluding China) account for less than 15% of the global market capitalisation of listed companies. Indexes tracking the 10 largest EMDE stock exchanges, excluding Saudi Arabia whose exchange is dominated by Aramco, show that energy and utility companies on average account for 15% of the indexes by market capitalisation, and within this fossil fuel companies are on average two and a half times larger than power companies. Combined with their different risk–return profiles, this puts power companies at a disadvantage when seeking to attract investment.

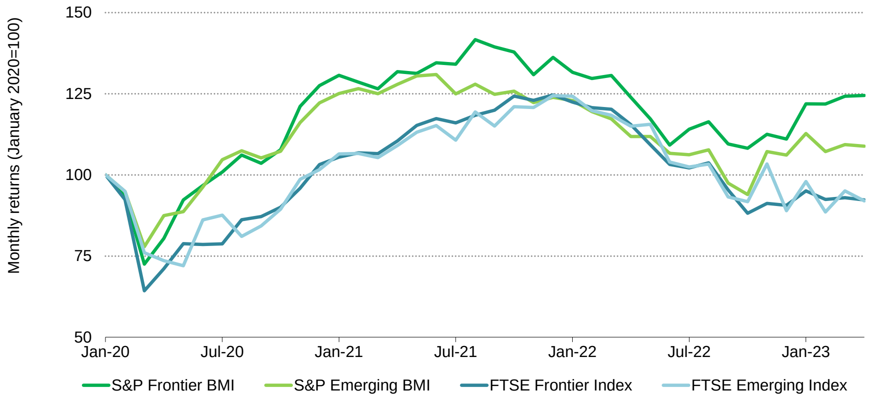
The difficulty of accessing investable projects is also visible when reviewing major equity indexes. Indexes play a key role as benchmarks and as the basis for passive investment, which has risen in popularity in recent years. Indexes are generally split into developed, emerging and frontier market categories, and although performance of the latter two has been relatively similar, many mainstream investors will limit their exposure to frontier markets. There are currently 40 EMDEs[2] included in emerging or frontier indexes from the top three index providers, but frontier market

[1] The survey did not include US, UK or Japanese pensions, which are some of the largest globally.

[2] Based on the IEA categorisation. Please see glossary in methodology for further details.

indexes are on average less than 5% the size of their emerging market peers, based on net market capitalisation. Frontier market indexes also tend to be a lot more concentrated. For example, the top 10 constituents account for 37% of the S&P Frontier BMI Index, compared to 14% in the Global BMI Index. This therefore limits the number of companies that investors can access within these riskier markets.

Performance of key emerging and frontier benchmarks



Source: IEA analysis based on data from Bloomberg (2023).

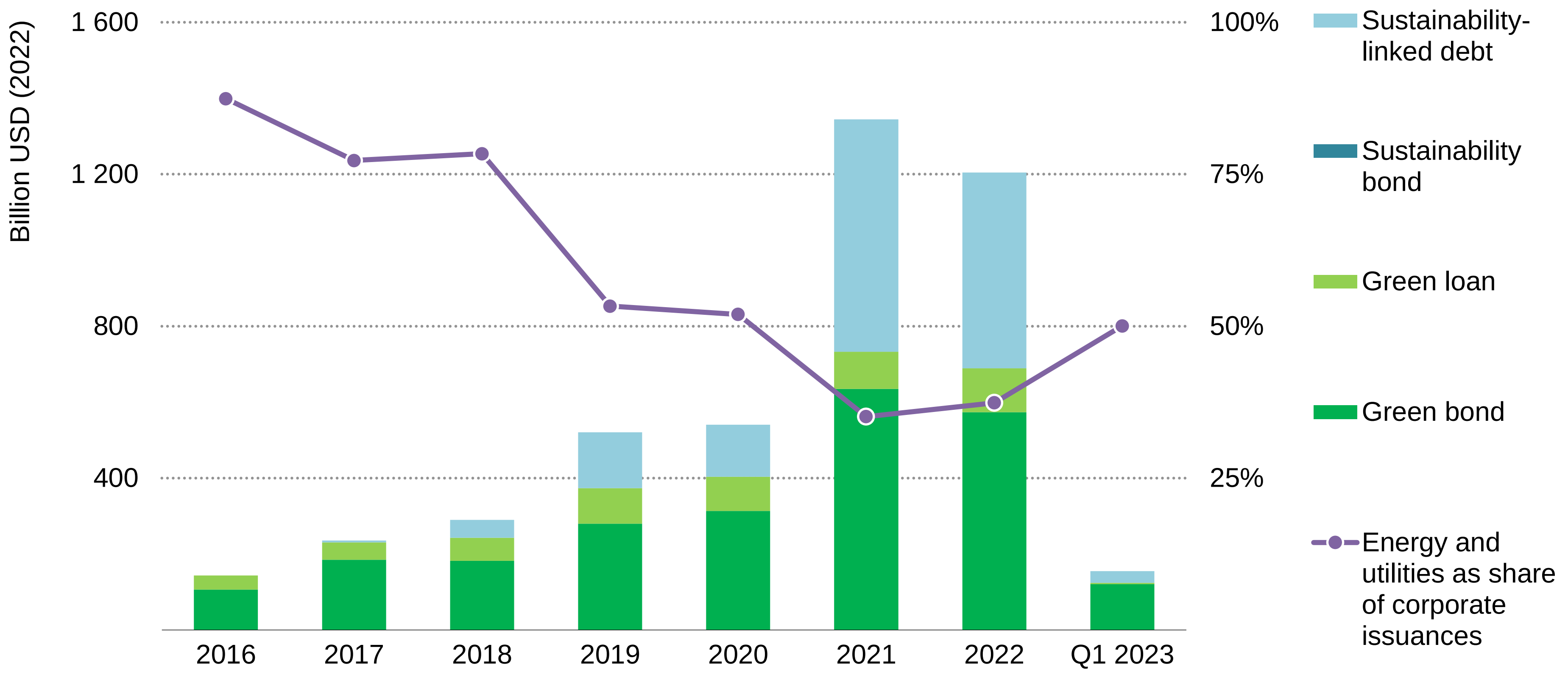
When looking at climate-aligned benchmarks, the investable universe in EMDEs shrinks even further. MSCI's Emerging Markets Climate Paris Aligned Index includes only 427 constituents compared with 1 377 in their Emerging Markets Index that it is based on. There is no Paris aligned version of MSCI's Frontier Markets Index, which makes it very challenging for investors to access these markets while also pursuing a strategy based on Paris-alignment. Even without the index challenge, there is a risk that the move to decarbonise financial portfolios will disadvantage EMDEs since ESG and climate-related data are less widely available in these markets. For example, of the nearly 5 000 companies that have committed to set science-based targets, only 16% are in EMDEs (and 29% of those are China). Where ESG scores do exist, the IMF recently found that listed EMDE firms tend to have lower scores on average than their advanced economy peers and that allocations to EMDEs by ESG funds are lower than non-ESG funds.

All of these limitations restrict the amount of equity investment from large institutional capital into clean energy in EMDEs. Such capital can play a key role in supporting on-balance sheet financing, refinancing or the acquisition of existing assets. Institutional investors need to balance regional and sector risk across their portfolios, which is always likely to act as a ceiling on their investment in clean energy in EMDEs. Further efforts to increase the pool of listed clean assets in EMDEs would support diversification, but these must happen in tandem with other strategies to reduce perceived and actual risk in those markets. Public capital, as well as concessional tools such as guarantees or blended finance approaches, will play a key role here. Over the longer term, growing domestic institutional capital will also be vital. This has the advantage of not creating a currency mismatch and is also likely to be better aligned given the smaller size of many domestic finance sources in EMDEs.

Sustainable debt issuances

Labelled sustainable debt issuances fell in 2022 for the first time, but were still significantly higher than in 2020, including from issuers of corporate energy and utility debt

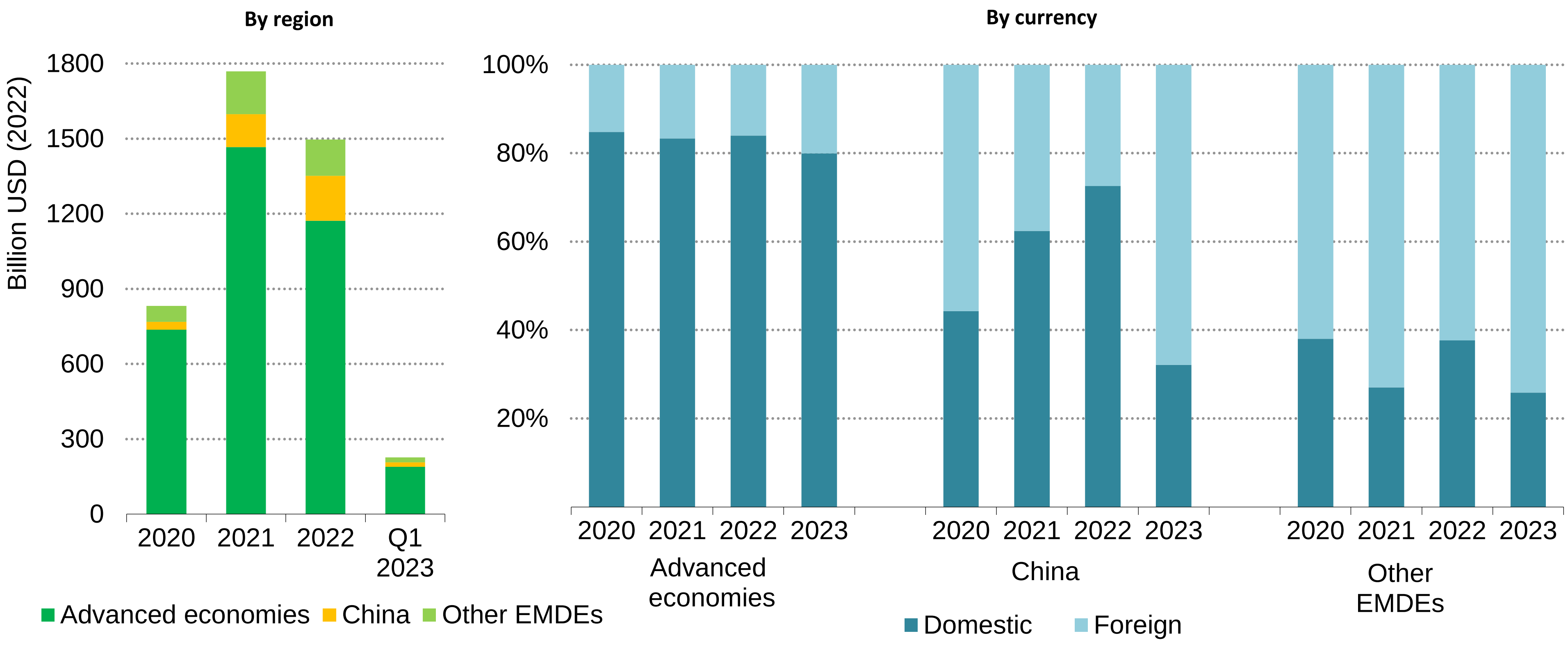
Sustainable debt issuances by type, 2016-Q1 2023



Source: IEA analysis based on data from Bloomberg (2023).

Advanced economies continue to dominate issuances, and in EMDEs (excluding China) most issuances are still in foreign currency, primarily USD and EUR

Sustainable debt issuances by region and currency, 2020-2023



Sources: IEA analysis based on data from Bloomberg and Refinitiv (2023).

Despite a difficult year, early indications show a positive outlook for sustainable issuances in 2023, including in the growing green-labelled loan space

Labelled sustainable debt issuances remained significantly higher in 2022 than the 2016-2020 average, but saw a decline in issuances for the first time since their inception. This reflected trends across the fixed income market, with sustainable issuances holding steady at 5% of the global market in both 2021 and 2022. Green bonds still make up the largest share of issuances at 40%, closely followed by sustainability-linked bonds, despite questions around their real-world impact (see Box below). Although corporate issuances in the energy and utility sectors fell slightly from 2021 levels, they were nearly double the level seen in 2020, showing the general upward trend.

Advanced economies still account for over 80% of issuances, although China has been the second largest issuer since 2021. Issuances in other EMDEs marginally increased from 8% in 2020 to 10% in 2022. Where EMDE issuances do occur, they are still dominated by hard currency, making them more appealing to international investors but exposing them to foreign exchange risk.

Trends in Europe, China and the United States indicate that 2023 is likely to see a continuing high level of issuances. In Europe, the European Central Bank – the largest buyer of corporate bonds – has committed to tilt its corporate bond purchases to green, which is likely to result in higher spreads for heavy emitters, and further demonstrate the pricing benefits of green issuances. Meanwhile the release of China's Green Bond Principles in July 2022 and the Common Ground Taxonomy that outlines commonalities with the EU taxonomy is likely to spur further growth in China's green bond market. Green bond issuances in the United States are also likely to be boosted by the Inflation Reduction Act, as incentives drive clean energy project development. Alongside these regulatory tailwinds, higher interest rates are likely to push more towards sustainable debt issuances due to the possibility of a "greenium", i.e. a pricing benefit based on the issuance's green credentials.

An interesting development is that labelled green loans had been relatively static since 2019, totalling between USD 90-100 billion, but rose by nearly 20% in 2022 as more sectors outside energy and utilities began adopting them. Green loans play an important role in part because they are smaller instruments than bonds and hence have a wide array of uses, including in EMDEs. Despite the rise in green loans, banks are still providing more support to fossil fuels. A report from Bloomberg found that in 2021 (latest available data), banks lent 81 cents for financing low-carbon energy supply for every one dollar they provided to fossil fuels. The report found large regional variations based on supply conditions and regulations, ranging from a ratio of 2.6:1 in Europe to 0.1:1 in Africa and the Middle East.

Sustainability-linked bonds

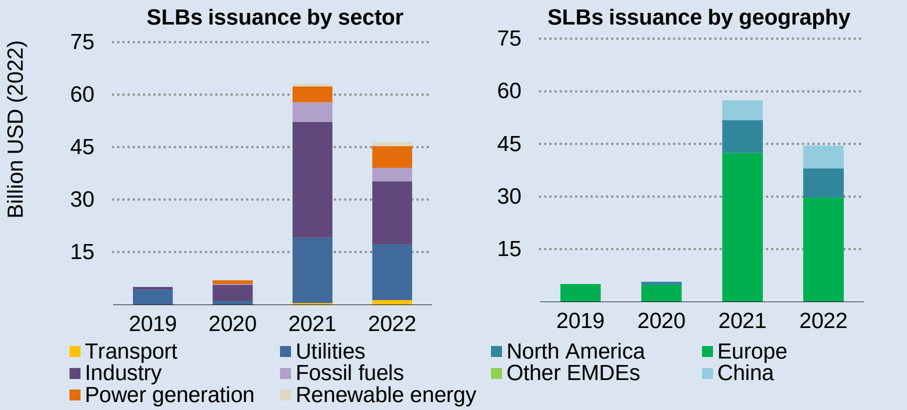
Sustainability-linked bonds (SLBs) provide a flexible way for companies or governments to access the green debt market, especially those in sectors that are difficult to decarbonise or those that need to implement organisation-wide decarbonisation measures. These bonds are like traditional bonds but have a unique structure where the interest paid to bondholders can vary based on the issuer's achievement of certain sustainability targets, such as reducing emissions intensity or absolute emissions reductions.

Unlike green bonds, SLBs do not require strict reporting on the use of proceeds, making them available to a wider range of companies and governments who may otherwise struggle to identify enough projects that would meet the use of proceeds limitations. SLBs have been used by a wide variety of industries including fossil fuel power operators, notably in China, and utilities in Europe. Chile and Uruguay piloted the issuance of sovereign SLBs linked to GHG reduction targets.

SLBs can serve as valuable source of transition finance, although there have been occasional instances where concerns have been raised regarding the perceived justification of the financial benefits enjoyed by issuers, for instance in the case where the specified sustainability targets are already met at the time of issuance. Or when companies with higher emission profiles use these bonds while having less ambitious decarbonisation targets than their peers.

Analysis has also shown that, on average, the savings from reductions in the cost of debt tended to exceed the maximum potential penalty that issuers would need to pay in case of failure of the sustainability performance target. The credibility of SLBs would benefit from standardisation and clearer regulation, through initiatives such as the ICMA Sustainability-Linked Bonds Principles that help hold governments and companies to their climate commitments.

SLB issuance by sector and country, 2019-2022



Source: IEA analysis based on data from BNEF (2023).

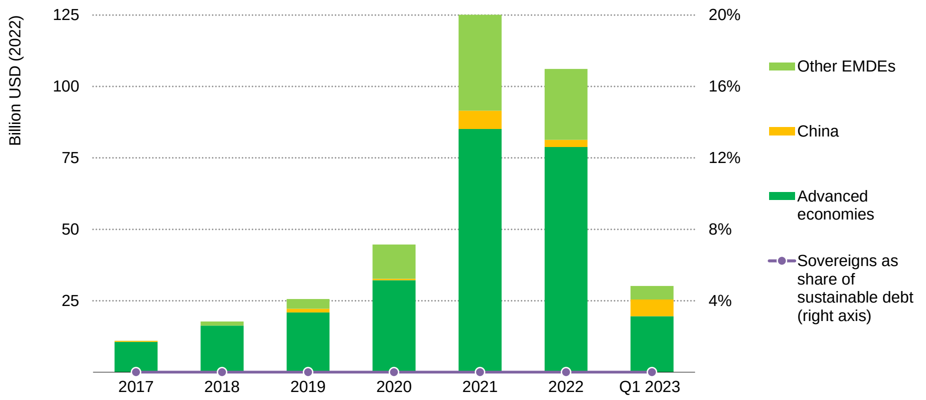
After a slow start, sovereigns issuances have more than doubled since 2020, providing a useful tool to raise lower-cost capital and to drive sustainable practices within local capital markets

The first sovereign green bonds were issued in 2017 by Poland and France, and since then there have been 41 new issuers, many of whose bonds have been oversubscribed. Sovereigns have grown from 4% of total sustainable debt issuances in 2017 to 7% in 2022. Much of the growth has been in hard currency, and European governments make up over half of issuances. There is significant potential for further growth, with sustainable debt issuances between 2017 and 2021 accounting for only 0.5% of total sovereign issuances.

The long tenors and pricing advantages of sustainable debt make them a useful tool for governments. The longest green bond issuance came from Singapore in August 2022 when the government raised SGD 2.4 billion (USD 1.7 billion) with a 50-year tenor. As with corporate issuances, most sovereign green bonds have attracted lower yields than comparable vanilla bonds. This can be particularly valuable in middle-income countries that do not have easy access to concessional debt but where the debt burden remains high.

Despite their benefits, challenges remain. “Use of proceeds” bonds have been slower to take hold with sovereigns because of concerns around fungibility. Public finance management practices, sometimes enshrined in law, may preclude the use of funds for a specific purpose. This is driving the rise of sustainability or sustainability-linked bonds, which provide more flexibility.

Sovereign sustainable debt issuances, 2017-Q1 2023

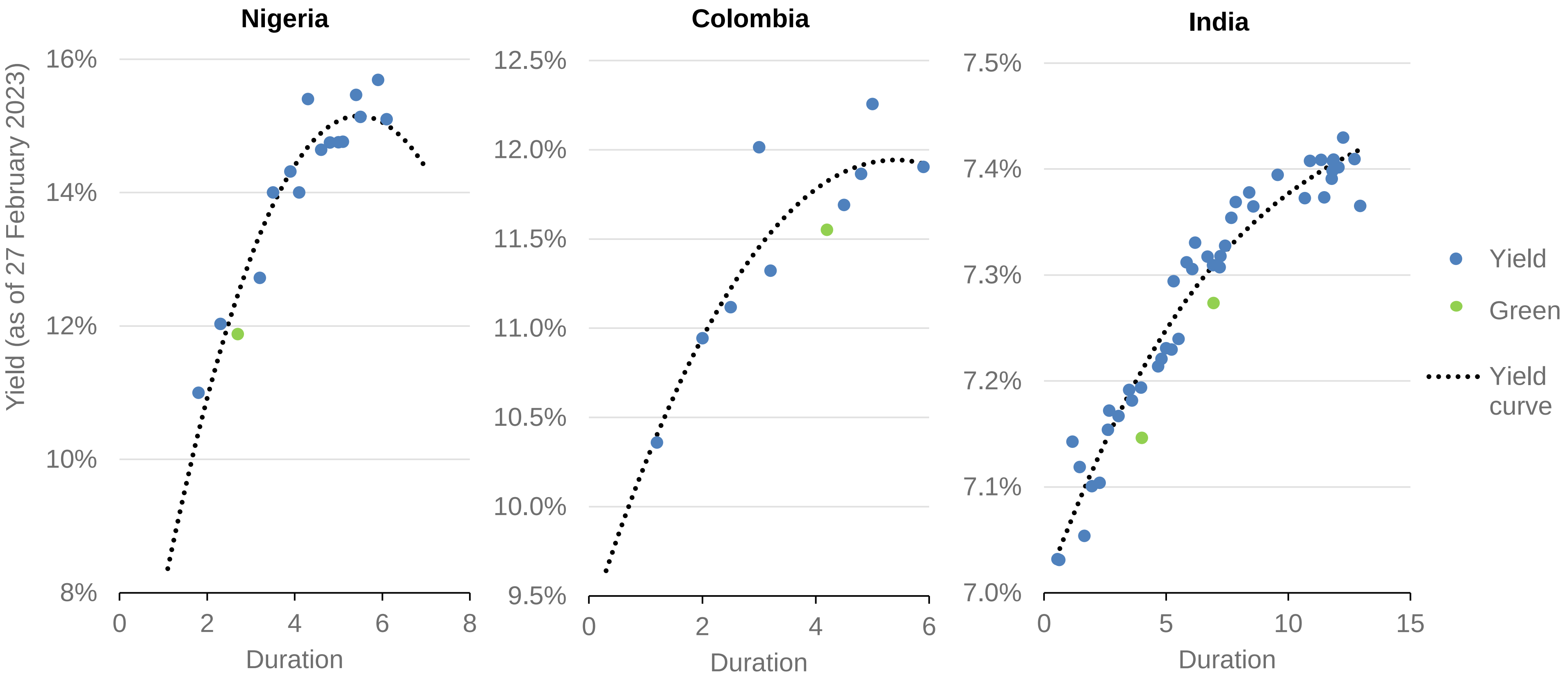


Sources: IEA analysis based on data from Bloomberg and Refinitiv (2023).

Beyond providing a useful source of public finance, sovereign issuances play a key development role for local capital markets. Notably, 38 countries that have issued sovereign green or sustainable bonds have also announced green bond frameworks in line with the International Capital Market Association principles. Often facing higher levels of scrutiny, sovereign issuances are able to demonstrate best practices, such as the use of external reviewers, mandatory impact assessments, and rules on the share of capital raised that can be used for refinancing versus new investments.

Sovereign green bonds in EMDEs have benefited from a greenium, demonstrating their value as a tool for governments that already have high debt burdens

Yield curve of sovereign bonds from selected emerging and developing countries



Sources: IEA analysis based on data from Refinitiv and Bloomberg (2023).

Sovereign bonds can have knock-on effects for green corporate bonds and domestic currency financing from both local and international sources

EMDE governments have used green bonds to raise local currency financing for infrastructure projects, and even without an investment-grade rating, they have benefited from the greenium. Green bonds are likely to be most applicable to countries that have reasonable debt sustainability and have a growing domestic capital market.

Nigeria: The Nigerian government launched the Green Bond Market Development Programme in 2017. So far, under the programme there have been two sovereign issuances with a combined value of NGN 25.7 billion (USD ~70 million) and four corporate issuances totalling NGN 32.7 billion (USD ~72 million). The 2017 sovereign green bond was the first of its kind in Africa and was followed by a second in 2019. Both bonds achieved a greenium and were used to support projects in renewable energy, primarily rooftop solar and rural electrification, and afforestation. However, questions have been raised about the implementation of projects and reporting has not been made available on the environmental impact of the bond proceeds. Ensuring best practices on reporting is likely to increase confidence in the market, particularly among international investors.

Colombia: In September 2021 the Colombian government released a national green taxonomy, followed by a COP 750 billion (USD 200 million) green bond. Originally planned at COP 500 billion, the bond was upsized after being 4.6 times oversubscribed by investors. At the time of issuance, it was estimated that the bond secured a greenium of 7 basis points (bps). A second sovereign green bond was issued a month later, with the government estimating a 15 bps greenium. Roughly 40% of the bond investors were domestic, demonstrating their comfort with this type of instrument and having knock-on positive effects for corporate green issuances. Proceeds from the bonds will support the development of sustainable transport systems and renewables, among other environmental goals.

India: In late 2022 the Indian government launched the country's first green bond – an INR 80 billion (USD 1 billion) deal divided equally into a 5-year and a 10-year tranche. The deal was 4 times oversubscribed, and a month after the initial offering, both tranches were reopened for a further INR 40 billion (USD 500 million). The proceeds will be spent on a variety of renewable power projects, low-emissions hydrogen, public transport and afforestation. Both the initial offerings and the reopening attracted a greenium of 5-6 bps, although these have reduced over time due to illiquidity in the market. Alongside pricing, one of the primary benefits of these instruments is tapping into new financing sources. Many of the corporate green bond issuances in India have previously been in US dollars, and it is likely that the government is hoping the sovereign issuances will help develop a local market. The majority of investors were domestic, with foreign investors seemingly deterred by the currency risk.

Annex

Acknowledgements

This report was prepared by the Energy Investment Unit in the Energy Supply and Investment Outlook (ESIO) Division of the Directorate of Sustainability, Technology and Outlooks (STO). It was designed and directed by Tim Gould, Chief Energy Economist, and Jonathan Coppel, Head of the Energy Investment Unit. Tanguy de Bienassis coordinated the report and led the section on end use and efficiency. Lucila Arboleya, David Fischer and Alana Rawlins Bilbao led the analysis of the power sector. Christophe McGlade, Paul Grimal and Peter Zeniewski were the main authors of the section on fuel supply; Simon Bennett led the R&D and technology innovation section; Emma Gordon led the section on energy finance; Ryszard Pospiech co-ordinated modelling and data across sectors. Musa Erdogan contributed to the overview and data visualisation. Eleni Tsoukala provided essential administrative support.

The report benefited greatly from contributions from other experts within the IEA: Carlos Alvarez (coal), Heymi Bahar (renewables), Jose Miguel Bermudez Menendez (hydrogen), Piotr Bojek (renewables), Stéphanie Bouckaert (demand modelling), Eric Buisson (critical minerals), Clara Camarasa (buildings), Elizabeth Connelly (transport), France d'Agrain (cross-cutting support), Chiara Delmastro (buildings), Michael Drtil (power), Stavroula Evangelopoulou (hydrogen), Mathilde Fajardy (CCUS), Alexandre Gouy (batteries), Ian Hamilton (buildings), Jérôme Hilaire (oil and gas), Paul Hugues (industry), Marco Iarocci (industry), Tae-Yoon Kim (refining & critical minerals), Silvia Laera (buildings), Jean-Baptiste Le Marois (R&D and technology innovation), Suzy Leprince (R&D and technology innovation), Yannick Monschauer (heat pumps), Aloys Nghiem (R&D and technology innovation), Sungjin Oh (buildings), Francesco Pavan (hydrogen), Apostolos Petropoulos (transport), Amalia Pizarro (R&D and technology innovation), Cornelia Schenk (buildings), Siddharth Singh (cross-cutting support), Jacob Teter (transport), Brent Wanner (power).

Internal reviewers:

Alessandro Blasi, Toril Bosoni, Laura Cozzi, Dan Dorner, Rebecca Gaghen, Kevin Lane, Gergely Molnar, Brian Motherway, Uwe Remme, Thomas Spencer and Daniel Wetzel.

Thanks also to Jad Mouawad, Curtis Brainard, Poeli Bojorquez, Astrid Dumond, Jethro Mullen, Isabelle Nonain-Semelin and Therese Walsh of the Communications and Digital Office. Justin French-Brooks edited the manuscript and Charner Ramsey designed the cover.

This report could not have been achieved without the support and co-operation provided by donors to the IEA Clean Energy Transitions Programme (CETP) that endorsed the 2022 Joint Commitment, notably: Australia, Belgium, Canada, Denmark, France, Germany,

Ireland, Italy, Japan, the Netherlands, Spain, Sweden, Switzerland, United Kingdom, United States and the European Commission, on behalf of the European Union. The financial assistance of the European Union was provided as part of its funding of the Clean Energy Transitions in Emerging Economies (CETEE) program within the CETP.

Many experts from outside of the IEA provided input, commented on the underlying analytical work, and reviewed the report. Their comments and suggestions were of great value. They include:

Marina Albuquerque	BTG Pactual
Antoni Ballabriga	BBVA
Harmeet Bawa	Hitachi Energy
Nathan Bock	Chevron
Rina Bohle Zeller	Vestas, Denmark
Barbara Buchner	Climate Policy Initiative
Mick Buffier	Glencore
Anne-Sophie Castelnau	ING
Ryan Castilloux	Adamas Intelligence
Kanika Chawla	SE 4 All
Michael Chen	Oxford Institute for Energy Studies
Deirdre Cooper	Ninety-One
Charlie Donovan	Impax Asset Management
Masayuki Fujiki	MUFG, Japan
Charlotte Gardes	International Monetary Fund
Pablo Gonzalez Gascon	Iberdrola
Francesca Gostinelli	ENEL
Adil Hanifa	EBRD
Lucy Heintz	Actis
Jim Henderson	Oxford Institute for Energy Studies, United Kingdom
Andrew Herscowitz	U.S. International Development Finance Corporation
Ronan Hodge	GFANZ
Sean Kidney	Climate Bonds Initiative
Francisco Laveron	Iberdrola
Evan Li	HSBC
Akos Losz	Columbia University
Elchin Mammadov	MSCI
Antonio Merino Garcia	Repsol
Irene Monasterolo	EDHEC Business School
Peter Morris	Minerals Council, Australia

Arjun N. Murti	Warburg Pincus LLC
Baysa Naran	Climate Policy Initiative
Tiago Oliveira	EBRD
Filippo Ricchetti	Eni
Simone Ruiz-Vergote	MSCI
John Scott	Zurich Insurance Group
Gireesh Shrimali	Oxford University
Bjarne Steffen	ETH Zurich
Jonathan Stein	Hess Corporation
Akhilesh Tilotia	National Investment and Infrastructure Fund
Swami Venkataraman	Moody's Investors Service
Namita Vikas	auctusESG
Gerhard Wagner	Swisscanto
Rachel Williams	Oxford University
Betsy Winnike	Boston Counsulting Group
Kelvin Wong	DBS Bank
Ryo Yamasaki	Mizuho Financial Group

Abbreviations and acronyms

ADNOC	Abu Dhabi National Oil Company
APS	Announced Pledges Scenario
BEV	Battery-Electric Vehicles
CAGR	Compound Annual Growth Rate
CCGT	Combined-Cycle Gas Turbine
CCUS	Carbon Capture, Utilisation and Storage
CO_2	Carbon Dioxide
CVC	Corporate Venture Capital
DAC	Direct Air Capture
EMDE	Emerging Markets and Developing Economies
ESG	Environmental, Social, and Governance
ETF	Exchange-Traded Fund
ETS	Emissions Trading Scheme
EUR	Euro
EV	Electric Vehicle
FID	Final Investment Decision
FSRU	Floating Storage Regasification Unit
GBP	British Pound Sterling
GHG	Greenhouse Gas
ICE	International Combustion Engine
ICT	Information and Communications Technology
IPCEI	Important Projects of Common European Interest
IT	Information Technology
LCE	Lithium Carbonate Equivalent
LCOE	Levelized Cost of Electricity
LNG	Liquified Natural Gas
MENA	Middle East and North Africa
NOC	National Oil Companies
NZE	Net Zero By 2050 Scenario
OCGT	Open-Cycle Gas Turbine
OECD	Organisation For Economic Co-Operation and Development
OPEC	Organization of The Petroleum Exporting Countries
PACE	Property-Assessed Clean Energy
PHEV	Plug-In Hybrid Electric Vehicle
PV	Photovoltaic
R&D	Research and Development
RD&D	Research, Development and Demonstration
SES	Solid Energy Systems
SOE	State-Owned Entity
STEPS	Stated Policies Scenario
USD	United States Dollar
VC	Venture Capital
WEI	World Energy Investment

Units of measure

g	Gram
GW	Gigawatt
GWh	Gigawatt Hour
kg	Kilogram
mb/d	Million Barrels of Oil per Day
MBtu	Million British Thermal Units
Mt	Million Tonnes

MW	Megawatt
MWh	Megawatt Hour
TWh	Terawatt Hour

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Typeset in France by the IEA – May 2023

Cover design: IEA

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Revised version, May 2023

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Attachment 75

Comments of Environmental and Public Health Organizations on:

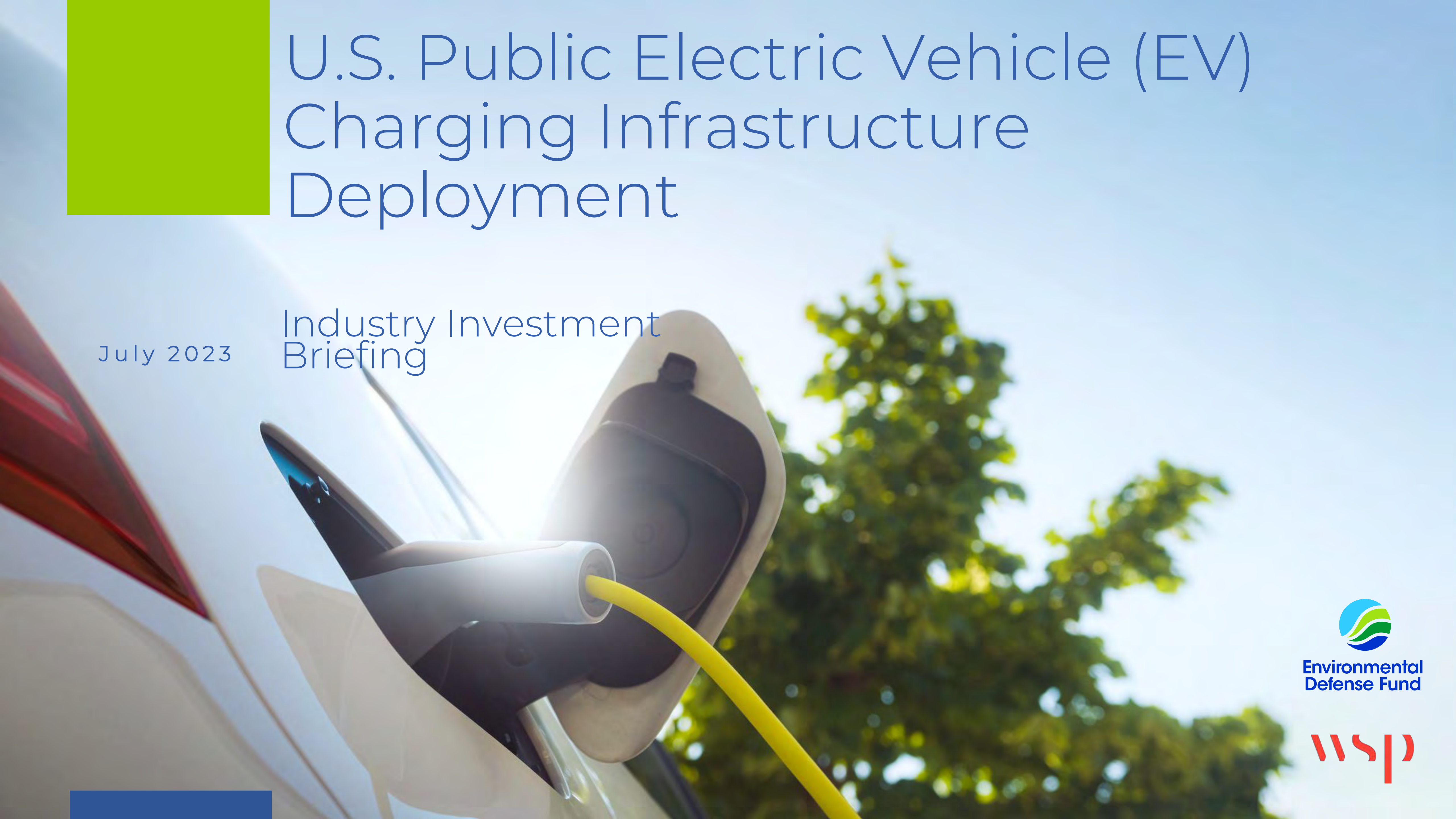
EPA, California State Motor Vehicle Pollution Control Standards; Advanced Clean Cars II Regulations; Request for Waiver of Preemption; Opportunity for Public Hearing and Public Comment, 88 Fed. Reg. 88908 (December 26, 2023); Docket ID No. EPA–HQ–OAR–2023–0292

Submitted February 27, 2024

U.S. Public Electric Vehicle (EV) Charging Infrastructure Deployment

Industry Investment Briefing

July 2023



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Key Takeaways

- An extensive survey found a **dramatic expansion and acceleration of investments in public electric vehicle (EV) charger deployments across the U.S.**
- Since 2021, based on a conservative estimate considering only the most concrete announcements, **more than $21.5 billion** in investments have been announced, which will result in the deployment of **over 800,000 new charger ports** by 2030. Announcements made since the passage of the Inflation Reduction Act will implement **4.5 times** the number of current public chargers, underscoring the impact of recent federal policy in spurring expansion.
- Based on concrete announcements, existing and already announced public EV charger deployments will provide at **least 70% of the public chargers needed in the U.S. by 2030** under EPA's current proposed light-duty (LD) vehicle rule. For direct current fast chargers (DCFCs), existing and announced chargers account for **more than 100% of the needed DCFC chargers past 2032**.
- When 25% of soft announcements and 50% of unawarded grants are also included, these investments would result in the deployment of more than 100% of the required public chargers in 2030.

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Key Takeaways (cont.)

- Market forces together with incentives from recent federal policy have attracted **a wide array of players to invest in public charger deployments**. The analysis identified investments by 18 charge network providers, 10 retailers, 7 vehicle manufacturers, 6 toll road operators, along with public utilities, truck and service station operators, and fleet owners
- EV owners across the U.S. will have increased access to public charging. The NEVI program along with 3 additional federal programs, and 21 nationwide announcements by companies will result in **nationwide expansion of the existing charging network and deployment of new infrastructure in all states**, including in rural communities

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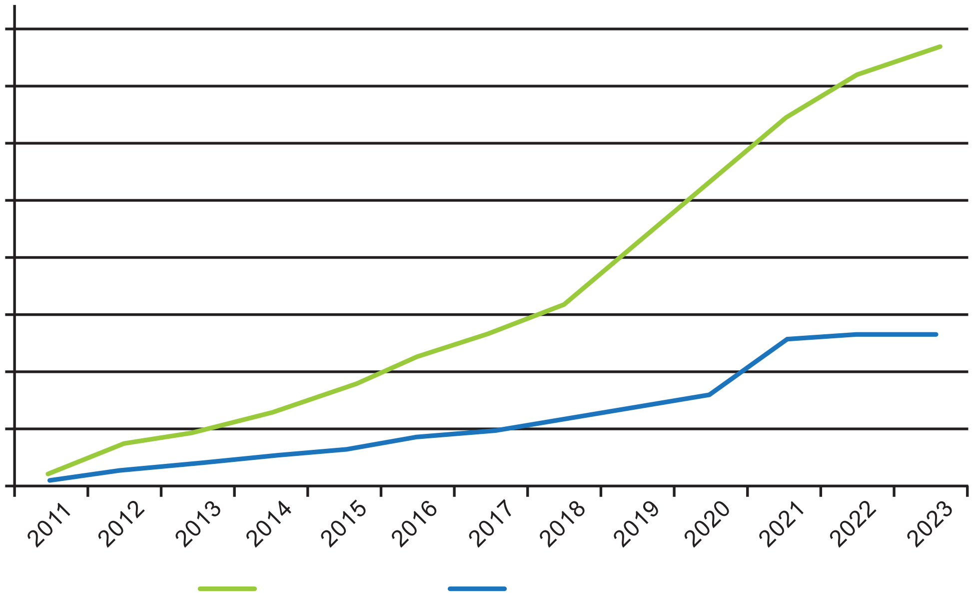
Existing Public Charging Infrastructure

June 2023

- 58,000 Stations – *Physical Location where charging occurs*
- 155,700 Ports – *Providing electricity to vehicles*
  - Level 1: 2,900 *2%*
  - Level 2: 121,500 *78%*
  - DCFC: 31,300 *20%*

Charging infrastructure is available today, but much more will be needed by 2030



Source: U.S. Department of Energy, Alternative Fuel Database, June 19, 2023

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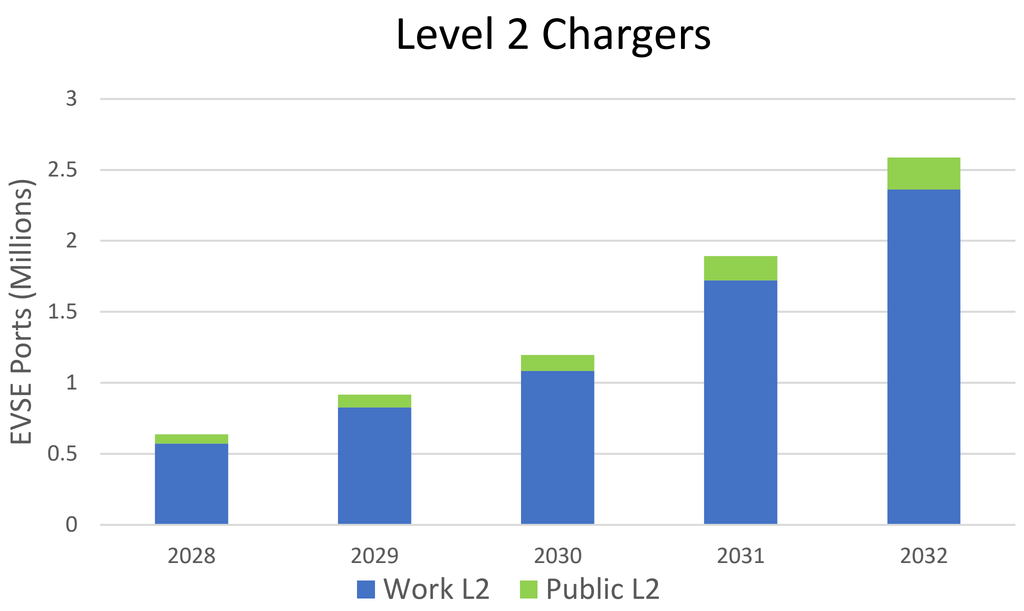
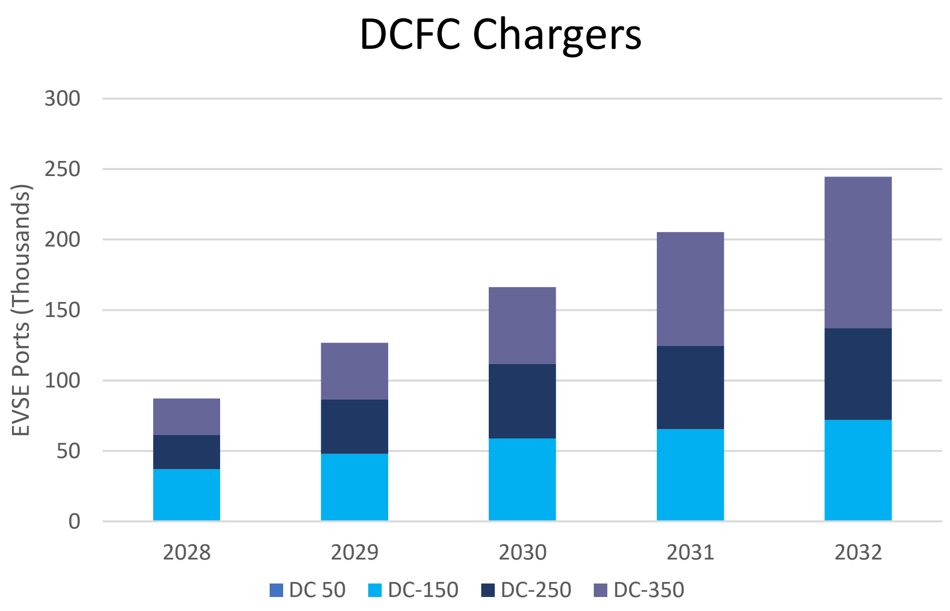
Future U.S. Public Charging Infrastructure Needs





EPA projects that approximately 1,075,000 new Level 2 chargers and 135,000 new DCFC chargers will be needed by 2030 to accommodate increasing numbers of EVs on the road with its proposed emission standards

Source: U.S. Environmental Protection Agency (EPA) *Multi-Pollutant Emissions Standards for Model Year 2027 and Later Light-Duty and Medium-Duty Vehicles Draft Regulatory Impact Analysis*, April 2023, Figure 5-15

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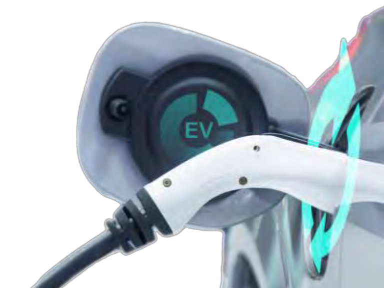

Announced EV Charger Deployment

WSP estimated the number of public chargers that will be added to the current network by 2030 based on extensive desktop research identifying 86 public announcements and commitments to invest in new public chargers that have already been by the following types of organizations:

- U.S.DOT National Electric Vehicle Infrastructure(NEVI) Program ***1***
- State Governments ***29***
- Charge Network Providers ***18***
- Retailers ***10***
- Vehicle Manufacturers ***7***
- Toll Road Operators ***6***
- Utilities ***4***
- Truck Stop Developer/Operators ***4***
- Service Station Operators ***2***
- Fleet Owners ***2***

Walmart and General Motors have announced they will install publicly available DCFC chargers at all of their retail locations in the U.S. – 90% of Americans live within 10 miles of a Walmart or GM dealership.

Environmental Defense Fund

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Announced Public EVSE Deployment as of June 2023

- 806,300 new charging ports
  - 552,900 Level 2 ports *(68.6%)*
  - 253,400 DCFC ports *(31.4%)*
- Over $21.5 billion in investment

Charger Type	Ports	Investment *($ billions)*
Level 2	552,900	$2.1
DCFC	171,200	$6.7
DCFC 150	16,500*	$8.4
Supercharger 250	4,800	$1.7
Supercharger 350	60,900	$2.1

*Includes a conservative estimate of 6,000 NEVI Ports

75,000-mile network / 50-mile intervals = 1,500 stations with 4 ports / station = 6,000 ports

Based on specific, concrete projects already announced, our conservative estimate is that there will be at least a 4.5-time increase in Level 2 ports and an 8-time increase in DCFC ports by 2030

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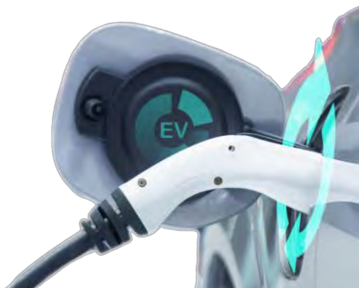
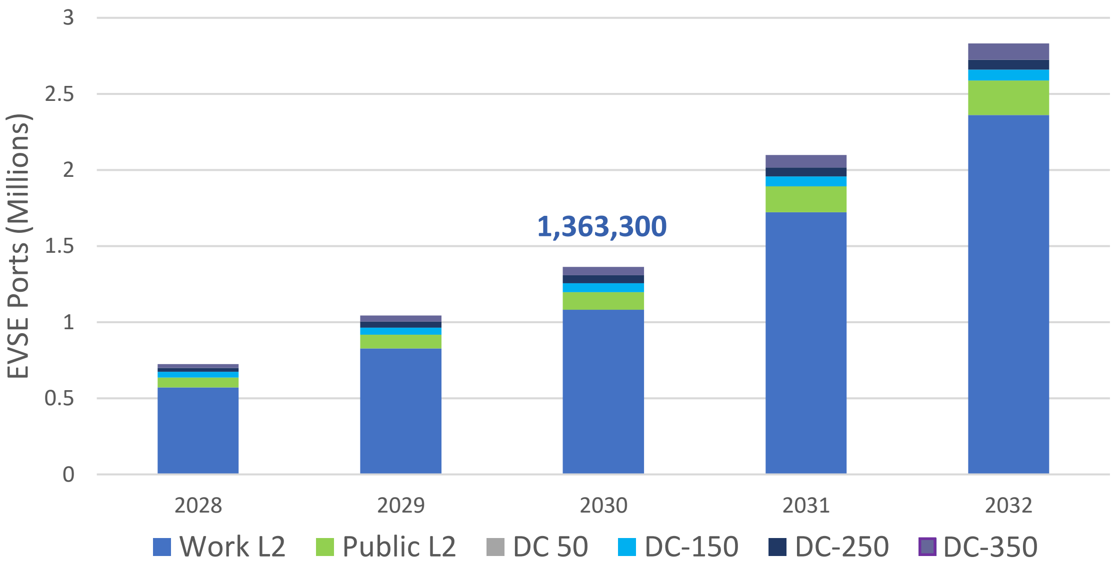


Existing and Announced Public Charger Deployment

▸ Existing Public Ports	152,700
▸ Announced Public Ports	806,300
Total Ports	959,000

Existing and already announced public EV charger deployments as of June 2023 will provide at least 70% of the public chargers needed in the U.S. by 2030, even though announcements do not seem to capture most workplace charging



EPA Forecasted Public Charging Needs

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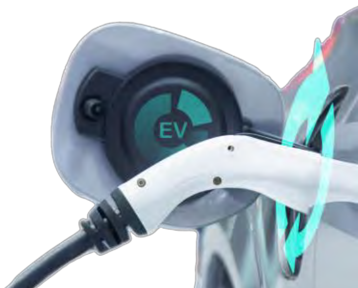
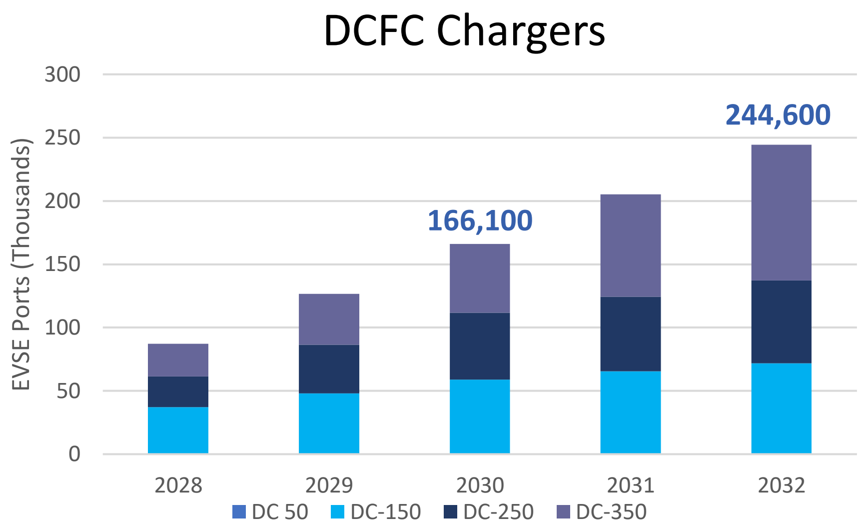


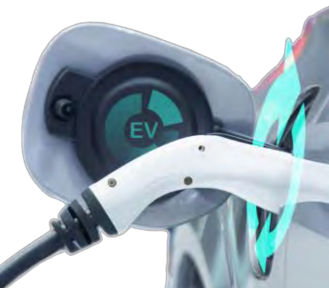
Existing and Announced DCFC Charger Deployment

	Number of Ports	Charging Capacity *(Gigawatts)*
Existing DCFC Ports	31,300	3.1
Announced DCFD Ports	253,400	35.3
TOTALS	***284,700***	***38.4***



EPA Forecasted Public Charging Needs

Existing and already announced DCFC charger deployments as of June 2023 will provide over 170% of the DCFC ports needed in the U.S. by 2030 and 116% of the ports needed by 2032. It will also deliver 93% of the DCFC charging capacity needed by 2030 and 59% of the DCFC charging capacity needed by 2032



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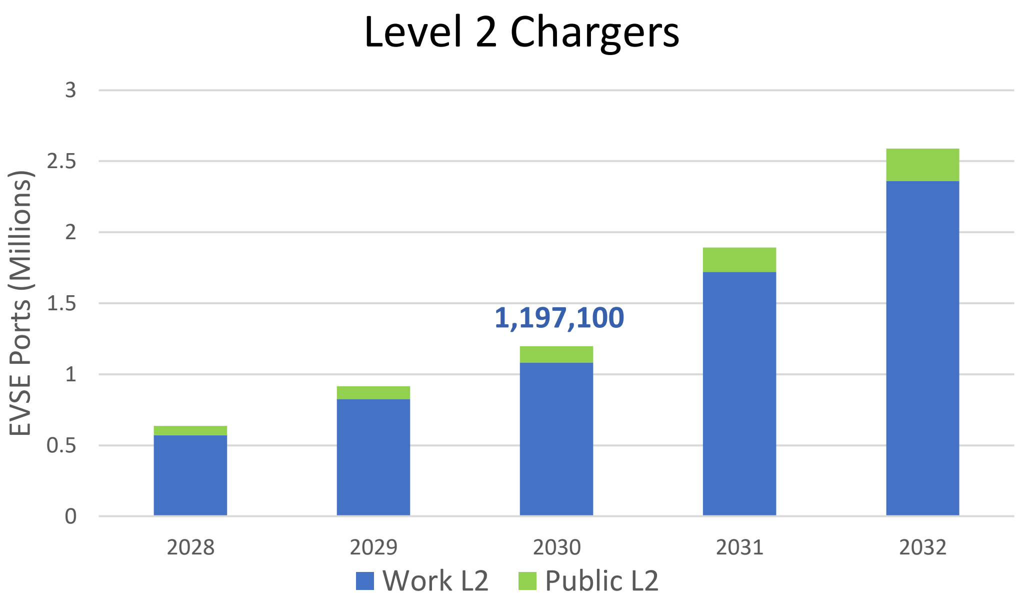
Existing and Announced Workplace and Public Level 2 Charger Deployment

- Existing Level 2 Ports 121,500
- Announced Level 2 Ports 552,900

Total Level 2 Ports 674,400

Existing and already announced public Level 2 EV charger deployments as of June 2023 will provide 56% of the workplace and public DCFC chargers needed in the U.S. by 2030. However, the analysis does not fully capture workplace charger deployments because employers do not normally make this information available to the public.



EPA Forecasted Public Charging Needs

Environmental Defense Fund

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Additional Announcements

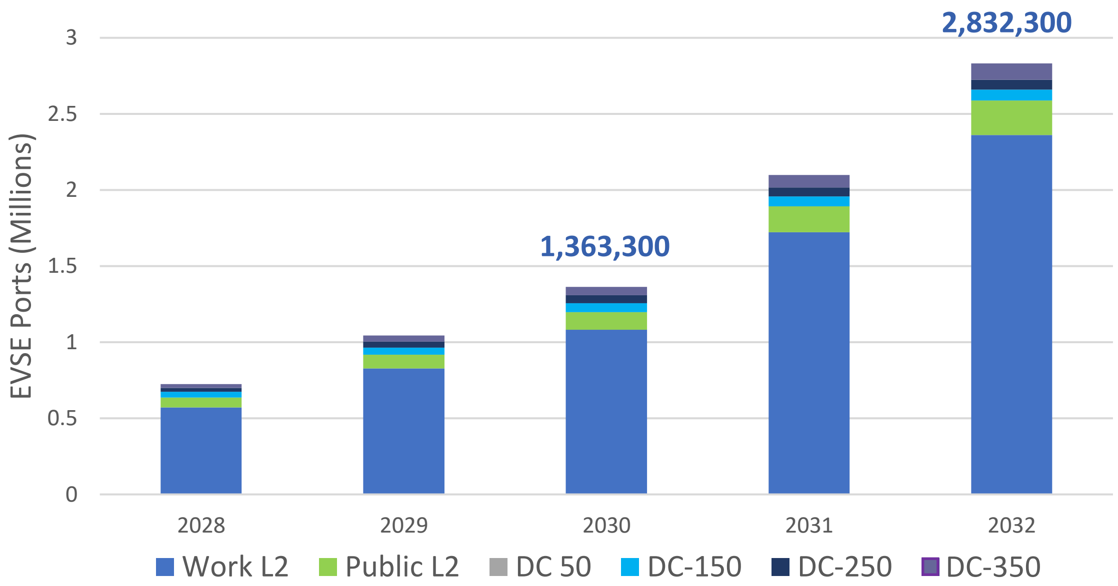
WSP's estimate of new charging ports is conservative and is based on public announcements with enough specific detail to estimate the number and type of ports that will be installed and total estimated investment. In addition, it does not capture all workplace charging, it does not account for the fact that announcements will continue to occur, and it does not include the following less specific information:

- 2,750,000 additional ports announced by 21 firms
  Companies including Cumberland Farms, Enel X Way, Francis Energy, Kohl's Kroger, Prologis, Siemens, Shell, Subway, Target and Wawa have announced major EV charger deployments, but these softer announcements have not provided enough detail to determine their type, location, the precise number of ports, or the level of investment

- $4.9 billion in EVSE grants announced but not yet awarded
  The federal government and 10 states have announced grants that will fund approximately 100,000 ports, some of which may already be included in WSP's deployment forecasts

Possible Public Charger Deployment

▸ Existing Public Ports	152,700
▸ Announced Public Ports	806,300
▸ Other Possible Ports *(discounted)*	687,500
▸ Awarded Grant Ports *(discounted)*	50,000
Total Possible Ports	1,696,500



EPA Forecasted Public Charging Needs

Assuming 25% of these softer announcements and 50% of announced grant ports are built in addition to concrete announcements, possible deployments as of June 2023 will provide at least 124% of the public chargers needed in the U.S. by 2030

Environmental Defense Fund

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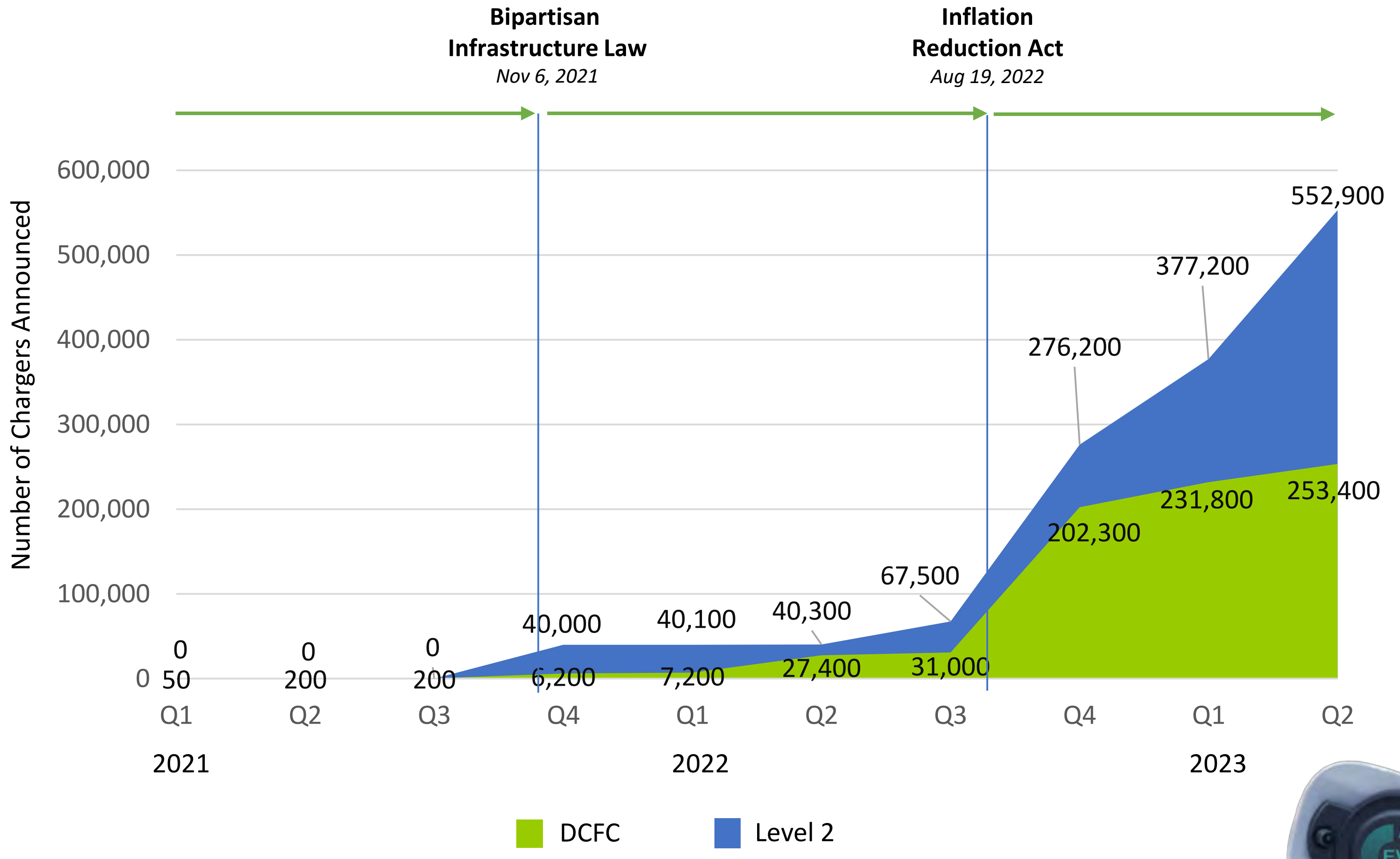
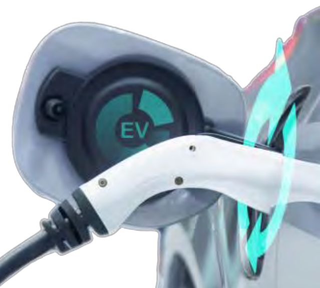
Charger Announcement Timing

The pace of charger announcements increased markedly following the Passage of the Inflation Reduction Act





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Geographic Expansion Is Nationwide

- The NEVI Formula Program will install DCFC chargers at 50-mile intervals across a national network of 75,000 miles of highway
- The NEVI Discretionary Grant Program will incentivize charger deployment in rural and low- and moderate-income neighborhoods
- The review also identified 21 nationwide announcements by companies including General Motors, Ford, Tesla, Rivian, Mercedes Benz, Walmart, Walgreens, Hertz, Ikea, Whole Foods, Macy’s, Blink, EVgo, and Electrify America
- The analysis also identified 63 additional confirmed investments in 24 states

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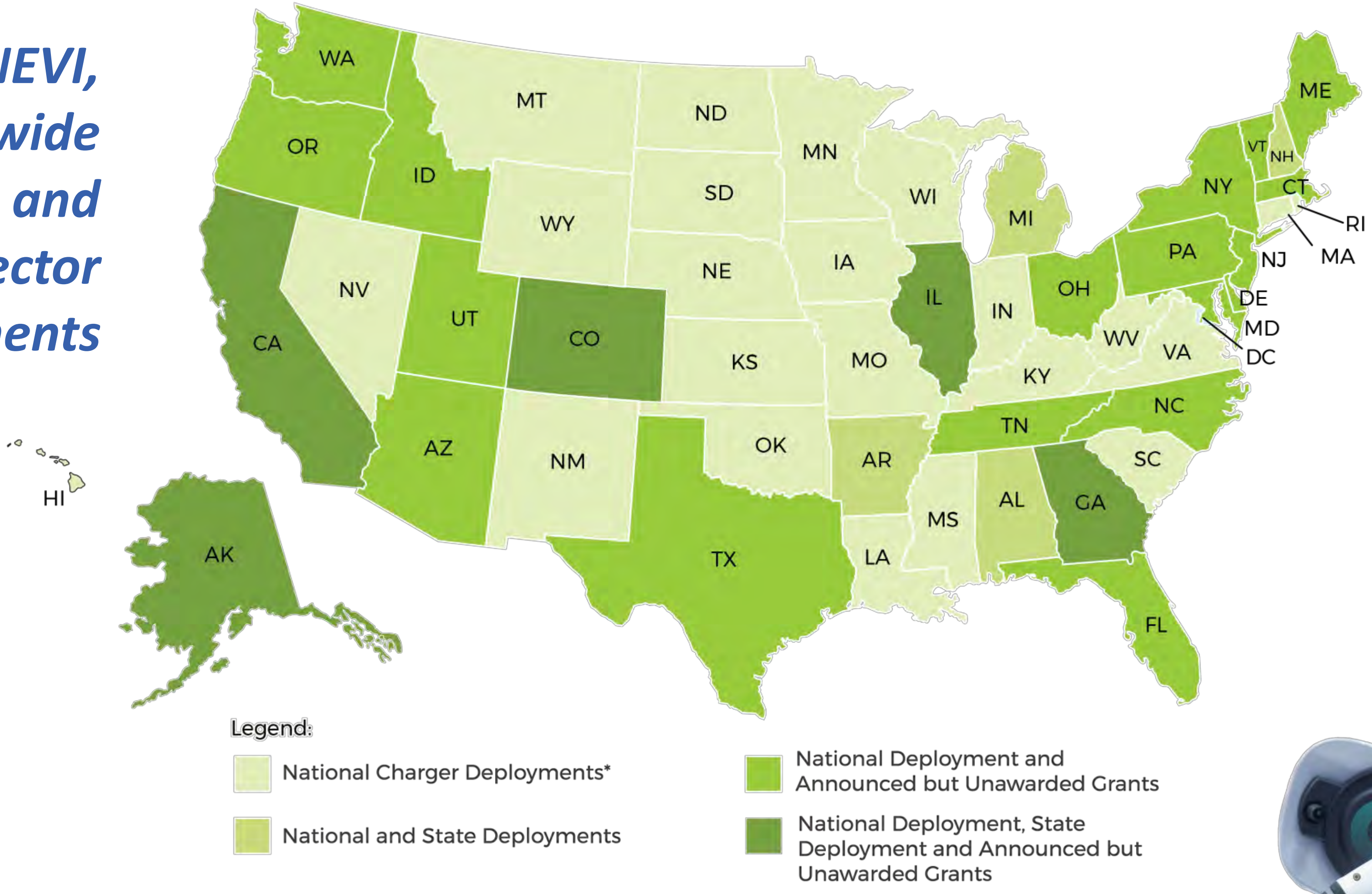
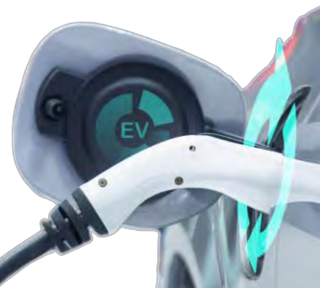
Geographic Distribution of Announced Charger Deployments and Grants

In addition to NEVI, 3 additional nationwide federal grant programs, and 21 additional private sector nationwide deployments



*NEVI, 3 additional Federal grant programs, 21 private nationwide deployments.



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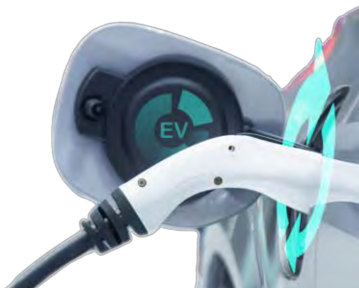
Methodology

The research team conducted desktop research to identify current announcement of charger deployments. The team identified three Whitehouse Briefing Room FACT SHEETS on electric vehicles (EV) and related infrastructure released on February 15, April 17, and June 27 2023. We investigated each of the public EV charging infrastructure announcements contained in the FACT SHEETs and created an Excel spreadsheet to track their attributes including:

- Charger Type
- Charging Stations
- Ports
- Charging Rate (kW)
- Cost
- Date of Announcement
- Project Completion
- Data Sources (URLs)

We augmented this information by conducting additional searches on EV charger announcements made by all 50 states, electric vehicle supply equipment (EVSE) manufacturers, charging network providers, vehicle manufacturers, retailers, fleet owners, major employers, toll road and travel plaza operators, service station operators, and electric utilities. The research team incorporated all information obtained in the Excel spreadsheet.



Methodology

These searches revealed a total of 86 announcements with enough detailed information for the research team to identify or estimate the number and type of chargers to be deployed and the implementation cost. For certain projects, the information that was available was incomplete. When this was the case, the research team used the following attributes derived from The analysis utilized the projections of future charger needs prepared by the U.S. Environmental Protection Agency (EPA) for its *Draft Regulatory Impact Analysis (DRIA)* for the proposed Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles, together with the research team's experience to calculate the cost, number of chargers, or charging rates. The following costs and charging rates were used:

Charger Type	Power	Average Cost
Work Level 2	8 kW	$ 5,900
Public Level 2	8 kW	$ 5,900
DCFC	60 kW	$112,000
NEVI /DCFC-150	150 kW	$242,000
Super Charger-250	250 kW	$306,000
Super Charger-350	350 kW	$370,000

In instances where the number of DCFC charging stations was available, but the number of ports was not specified it was assumed that one to four ports would be provided per charging location.

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Methodology

In several cases, charger announcements simply discuss the deployment of DCFC chargers, but do not specify their charging rate. To keep the analysis conservative, the research team assumed that they would be 60 kW chargers. In other cases, chargers with other charging rates were referred to, 175 kW for example. When this occurred, the research team tabulated these chargers with those in the next lowest charging rate category, in this case 150 kW.

The research team employed two methodologies to calculate the number of chargers that will be provided by the NEVI formula program. The first assumed that charging stations would be located at 50-mile intervals along a 75-000mile highway network. This would provide 1,500 charging stations with a minimum of four ports each, creating 6,000 ports. The second methodology was based on cost and assumed that a four-port charging station, the NEVI standard, would cost $1.6 million. Dividing the total amount of NEVI funding – $5.0 billion in federal funding and a required $1.25 billion in local matching funds – by the per-station cost would provide 3,900 four-port stations, or a total of 15,600 ports. The research team used the lower 6,000 port figure to keep the analysis conservative.

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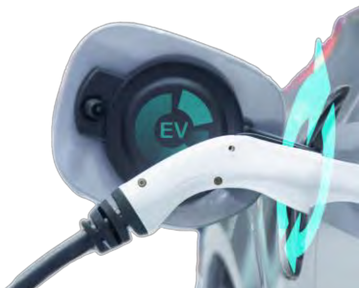

Methodology

The analysis identified concrete announcements to deploy the following EVSE infrastructure by 2030:

Charger Type	Stations	Ports	Investment ($ millions)
Level 2	15,963	552,949	2,101
DCFC	15,089	171,178	6,713
DCFC-150	3,300	16,454	8,357
Super Charger-250	69	4,834	1,663
Super Charger-350	737	60,900	2,064
Totals	35,131	806,315	21,538

Of these figures, the following percentages were calculated using the factors provide above:

Charger Type	Stations	Ports	Investment ($ millions)
Level 2	1%	30%	60%
DCFC	0%	10%	53%
DCFC-150	10%	36%	11%
Super Charger-250	13%	7%	76%
Super Charger-350	0%	2%	76%
Totals	35,131	806,315	21,538

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Methodology

In addition to these specific charger announcements, the research revealed 20 other announcements that provided less information such that it was not possible for the research team to determine the full complement of information: charger type, stations, ports and investment. The research team compiled information on these soft announcements separately. They include announcements identifying the deployment or intent to sell 2.1 million level 2 chargers, 610,000 DCFC chargers, and over 50,000 charger whose type could not be identified. Investment information was only available for six of the 20 other announcements, which together represent an investment of over $13 billion. To include these announcements in the main analysis, the conservative assumption that 25 percent of these projects would be built by 2030, resulting in nearly 690,000 additional ports.

The research also identified 24 national and state specific grant programs providing funding for the provision of charging infrastructure. These programs – including the NEVI Discretionary Grant Program – have been announced, but not yet awarded. For instance, grant applications for the first cycle of the $2.5 billion NEVI Discretionary Grant Program were due to USDOT on May 30, 2023 and are still being reviewed at the time of this writing. The research identified a total of nearly $4.9 billion in pending EVSE grants that are estimated to fund approximately 100,000 charging ports. Recognizing that some of these ports may duplicate other charger announcements already captured in the analysis, the research team assumed conservatively that half of these chargers, or 50,000 additional ports would be installed by 2030.

Methodology

The analysis utilized the projections of future charger needs provided in the EPA *DRIA* for the proposed Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles. The analysis also utilized a June 2023 search of the U.S. Department of Energy Alternative Fuels Data Center EVSE database to identify current charger deployments in the U.S. The analysis then quantified the number of current and announced chargers and compared this figure to the estimated charger needs identified in the DRIA for the years 2030 and 2032. This comparison is made for the concrete charger deployment announcements, as well as the concrete announcements together with 25% of the less specific charger announcements and 50% of the announced but not yet awarded grants.

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Attachment 76

Comments of Environmental and Public Health Organizations on:

EPA, California State Motor Vehicle Pollution Control Standards; Advanced Clean Cars II Regulations; Request for Waiver of Preemption; Opportunity for Public Hearing and Public Comment, 88 Fed. Reg. 88908 (December 26, 2023); Docket ID No. EPA–HQ–OAR–2023–0292

Submitted February 27, 2024

COMMENTS ON:

Proposed Advanced Clean Cars II Regulation

California Air Resources Board
Submitted May 31, 2022
by the
<u>Natural Resources Defense Council (NRDC)</u>

Kathy Harris, Clean Vehicles and Fuels Advocate, Clean Vehicles and Fuels Program
Simon Mui, Director, Clean Vehicles and Fuels Program

Table of Contents

I. Executive Summary

The Natural Resources Defense Council (NRDC) strongly supports the California Air Resources Board's (ARB or CARB) Advanced Clean Cars 2 (ACC II) proposal and urges the Board to adopt these regulations quickly. Climate change is an ever increasing threat to California– as exemplified from the increase in wildfires and droughts. As the transportation sector is the largest source of greenhouse gas emissions in California, eliminating emissions from this sector is a key strategy to alleviating and preventing the most adverse effects of climate change, while also improving air quality and health in California communities.

The proposed regulations– which would move the state towards 100% Zero Emission Vehicle (ZEV) sales by 2035 while increasing greenhouse gas and criteria pollutant standards, in line with California climate and air quality goals– are necessary and feasible. California has the opportunity to become a global leader and help to accelerate the transition to a fully zero-emission transportation future. Based on the pace of growth of California's ZEV market (which reached 12% of vehicle sales in 2021), as well as the increase in ZEV makes and models, as well as customer demand, NRDC has concluded that the staff-proposed stringency is appropriate for the initial years of the program, and an even more aggressive 2030 target of 75% ZEV sales—versus the proposed 68% level—is achievable in California and supported by the ARB staff analysis. This more aggressive stringency will add 1.4 million more ZEVs onto the road through 2035, which will further reduce air pollution and improve air quality, while also increasing the number of ZEVs available in the used vehicle market.

ARB should utilize this vital opportunity to ensure that the ZEV requirements, as a part of the ACC II program, are delivering emission reductions to those communities most historically overburdened with transportation emissions, and where the public health needs are among the greatest. NRDC shares the objectives of our equity partners to have a strong proposal that increases the emissions and public health benefits of the ZEV program overall, results in more vehicles being placed in pollution-burdened communities or regions than would otherwise occur, and that maximizes participation by automakers in these programs. Increased participation in or expansion of these equity-centered programs – as driven by the provisions in the ZEV program - could increase overall public health benefits.

The battery labeling and state-of-health requirements proposed in these regulations are also vital pieces that will not only help to improve drive confidence in ZEVs but help increase and facilitate secondary use of batteries after their useful vehicle battery life.

ACC II is feasible– NRDC analysis has found that there is sufficient funding available to support the needed charging infrastructure over the next five years in California, but additional actions and funding will be needed to meet the 2030 and 2035 public and shared private light duty charging infrastructure needs. Further, research shows that ZEVs are able to be integrated onto the electric grid at nominal costs and can in fact put downward pressure on rates for all utility customers.

For these reasons, and those further outlined in these comments, ARB should move to adopt a ACC II program that increases the stringency of the rule to 75% by 2030 no later than August 2022.

II. Introduction

The Natural Resources Defense Council (NRDC) appreciates the opportunity to comment on the proposed Advanced Clean Cars 2 (ACC II) regulation. NRDC is a national, nonprofit organization of scientists, lawyers and environmental specialists dedicated to protecting public health and the environment. Founded in 1970, NRDC has over 3 million members and online activists. Roughly 400,000 of these members and activists live and work in California. Our members from across the state are impacted daily by the various air quality and climate threats present in California, including the pollution from cars and trucks this rule seeks to address.

The transportation sector is the largest source of greenhouse gas emissions in California, accounting for over 40 percent of total emissions.[1] Over 28 percent of the statewide GHG emissions come from passenger vehicles.[2] As significant portions of the state are in non-attainment with federal Clean Air Act (CAA) ozone and particulate matter standards, reducing air pollution and greenhouse gas emissions from the state's cars and trucks is vital to meet its state and federal requirements

The proposed ACC II program updates the current Advanced Clean Cars program for greenhouse gas emissions, criteria pollutants, and zero-emission vehicle (ZEV) sales mandates. The proposed ZEV sales mandate requires manufacturers to sell an increasingly higher percentage of ZEVs in each subsequent model year, cumulating in 100% ZEV sales by 2035. Through this requirement, ARB is formalizing Governor Newson's Executive Order N-79-20, which mandates that 100% vehicle sales must be electric by 2035.[3] The proposed regulation starts at 35% ZEV sales in model year 2026 with an interim target of 68% sales by 2030. This would ensure that approximately 6 million ZEVs are on California's roads in 2030 and almost 14 million in 2035.[4]

By adopting ACC II, California would become the second jurisdiction globally, after British Columbia, to set legally-binding 100% ZEV standards for passenger vehicles. According to ARB's calculations, the proposed rule will provide significant improvements to air quality and

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[1] California Air Resources Board, Current California GHG Emission Inventory Data, https://ww2.arb.ca.gov/ghg-inventory-data (last viewed May 26, 2022)
[2] *Id.*
[3] Executive Department, State of California, "Executive Order N-79-20, September 23, 2020, https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf
[4] Compliance analysis prepared by Shulock Consulting, based on EMFAC 2020 projected total California sales.

greenhouse gas (GHG) reductions, including a cumulative reduction of 69,569 tons NOx, 4.469 tons PM2.5, and 383.5 MMT of CO2 from 2036-2040.[5]

ARB's current proposed regulations are vital for the state to adopt in order to improve air quality and health, reduce climate causing pollution, and to ensure California remains a global clean transportation leader. The proposed ramp up of ZEV sales is feasible in California, and based on projected sales data and manufacturer commitments, the state could in fact be more aggressive in their stringency of ACC II to increase the number of ZEVs on the road through 2035. The current Advanced Clean Cars Program's ZEV mandate levels out ZEV sales at approximately 7-8% starting in model year 2025, in perpetuity. Due to the current level of ZEV sales in California (which reached 12% sales at the end of 2021)[6], across the United States, and globally, it is clear that this 7-8% sales target is far below the current state of the market and does not reflect real-world sales. These data highlight that it is not only feasible, but necessary to set more aggressive sales targets to drive the transition of the market to ZEVs. Having more ZEVs on the road in the near term is important to moving towards zero-emissions from the transportation sector, as ARB says in the 2016 Mobile Source Strategy:

> "It can take decades for a new propulsion system to capture a large fraction of the LDV fleet because new technologies require time for vehicle manufacturers to incorporate them into numerous vehicle models with consumer acceptance. Once new technologies are widely available, it can take over 15 years for these new vehicle models to fully replace existing vehicles in the fleet with natural turnover."[7]

Further, additional ZEV in the market in the near term will allow vehicles to flow into the used secondary market sooner, allowing for ZEVs to be more accessible to lower income drivers.

ARB's staff analysis – together with auto industry statements – has shown that the ramp up in standards is feasible and cost-effective. The standards would not only significantly cut pollution, but also *reduce* transportation costs for the average household in the state, leading to significant economic benefits. California's Advanced Clean Cars 2 standards provide the industry with adequate lead time and in many ways, are consistent with automaker's own commitments and product plans as described more below.

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[5] California Air Resources Board, "Public Hearing to Consider the Proposed Advanced Clean Cars II Regulations, Staff Report: Initial Statement of Reasons", April 12, 2022, at 134, ACC II ISOR

[6] Inside EVs, "California Surpasses 1 Million Plug-In Electric Car Sales", February 26, 2022, https://insideevs.com/news/570116/california-1million-plugin-car-sales/

[7] California Air Resources Board, "Mobile Source Strategy", May 2016, at 64, https://ww3.arb.ca.gov/planning/sip/2016sip/2016mobsrc.pdf

III. Rationale for Aggressive ZEV Action

A. CARB Has the Authority to Adopt the Standards Pursuant to Federal Law

Under the federal Clean Air Act (CAA), California is eligible to seek and receive a waiver of preemption under the terms of section 209(b)(1) "if the state determines that the state standards will be, in the aggregate, at least as protective of public health and welfare as applicable Federal standards."[8] The U.S. EPA Administrator has consistently interpreted Section 209(b) as requiring the issuance of a waiver unless the Administrator finds that:

(A) the determination of the state is arbitrary and capricious,

(B) the state does not need the state standards to meet compelling and extraordinary conditions, or

(C) the state standards and accompanying enforcement procedures are not consistent with section 202(a) of the Act.

Under the Clean Air Act Amendments of 1977, Congress also permitted States under Section 177 of the Act to adopt California new motor vehicle emission standards, so long as:

(1) such standards are identical to the California standards for which a waiver has been granted for such model year, and

(2) California and such States adopt such standards at least two years before commencement of such model year (as determined by regulations of the Administrator).

The California Air Resources Board's regulatory process, and the Initial Statement of Reason (ISOR) and associated documents, have been conducted through an open, deliberative, and factual manner. The basis for the ACC II regulation has been well reasoned and rational, and in many instances, staff has used conservative assumptions as described below. The process has also allowed for considerable public and stakeholder input through numerous public workshops since September of 2020, with NRDC and other affected stakeholders participating in many of these.

Pollution from motor vehicle engines and vehicle tailpipes continue to harm the public's health, welfare, as well as the broader environment and is a major source of criteria pollutants as well as greenhouse gas emissions. California is home to five of the ten metropolitan centers with the worst ozone pollution in the country (a precursor to smog) as well as seven of the ten centers with the worst year-round particle pollution.[9] Transportation is now the single largest source of greenhouse gas (GHG) emissions as well in the state, contributing 41 percent of the overall inventory in 2019, the latest data available.[10] This figure reflects tailpipe emissions and does not

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[8] US Environmental Protection Agency, "Vehicle Emissions California Waivers and Authorizations, https://www.epa.gov/state-and-local-transportation/vehicle-emissions-california-waivers-and-authorizations

[9] American Lung Association (2022), *State of the Air*, https://www.lung.org/research/sota/city-rankings/most-polluted-cities . Last viewed 5/15/2022.

[10] California Air Resources Board, *Current California GHG Emission Inventory Data*,

include the emissions from production and refining of fuels used for transportation, which would make the share even higher. Passenger vehicles comprise 28 percent of the GHG emissions from the transportation sector.[11]

The State of California must enact this next round of Advanced Clean Car Standards to fight against the severe and significant harm tailpipe pollution presents. California already faces compelling and extraordinary conditions with respect to emissions of health-harming criteria pollutants. But the addition of GHGs into the atmosphere, and the corresponding increases in temperatures and extreme heat events suffered across the state, is now exacerbating the impacts from criteria pollutants, as well as creating new climate-related harms and health problems of their own. California's decades of progress tackling smog is now threatened as the rising temperatures from climate change speed up smog-forming chemical reactions between sunlight and pollution from sources such as transportation.[12]

There is a vicious cycle of harm created from the release of these collective pollutants, with a major source being passenger vehicles. In California, the state faces a variety of increasing health problems from GHG emissions and resulting climate change such (1) the alteration of seasonal patterns making hot days hotter, (2) increasing severity of droughts and other extreme events.

If California's adoption of stricter-than-federal standards were needed in past decades, there is more reason than ever for the state to adopt new standards to meet these compelling and extraordinary conditions.

Thankfully, the technologies to address both air pollution and climate change are here today and are being deployed throughout the world. Cleaner technologies such as electric vehicles (EVs) have already become part of the mass market in Europe and China and are increasingly part of the automakers' product mix in the U.S.

B. ZEVs Improve Air Quality and Health

California has had decades of history adopting stricter-than-federal standards which have helped the state make progress on cleaning up the air. However, due to a mix of geographical and atmospheric conditions– together with population growth and increases in travel– the state remains one of the most polluted states in the country. According to the latest American Lung Association's State of the Air report, 14 counties in California received failing grades for ozone, short term-particle pollution and year-round particle pollution: Butte, Fresno, Imperial, Kern, Kings, Los Angeles, Madera, Merced, Riverside, San Bernardino, San Joaquin, Stanislaus, and Tulare.[13]

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https://ww2.arb.ca.gov/ghg-inventory-data. Last viewed 5/15/2022.

[11] California Air Resources Board, GHG Emission Inventory Graphs. https://ww2.arb.ca.gov/ghg-inventory-graphs

[12] NRDC (2019), *Climate change and health in California*, Issue Brief, February 2019, https://www nrdc.org/sites/default/files/climate-change-health-impacts-california-ib.pdf.

[13] American Lung Association, State of the Air 2022, "Most Polluted Places to Live", (last accessed May 26, 2022)https://www.lung.org/research/sota/key-findings/most-polluted-places

To combat this pollution from the transportation sector, the American Lung Association has explicitly stated that adopting Advanced Clean Car regulations is an important strategy to clean up air quality.[14]

But cleaning up the transportation sector does more than improve air quality, it can also provide significant health benefits as well. According to the State of the Air report, more than 137 million people in the United States live in counties with unhealthy levels of ozone or particulate pollution.[15] Air pollution, including that from the transportation sector, can cause asthma attacks, lung cancer, shortness of breath, heart attacks and stroke, preterm births, and premature death. By moving towards 100% electric vehicles, which emit zero-tailpipe emissions when driving on electricity, these health concerns will be alleviated.

ARB estimates that in California the proposal will lead to 1,242 fewer deaths, 208 fewer hospitalizations for cardiovascular illness, 249 fewer hospital admissions for respiratory illness, and 639 fewer emergency room visits for asthma.[16] ARB estimates that this will result in $14.52 billion in health benefits.[17] The largest health benefits – approximately 98%-- are expected to be in the South Coast, San Francisco Bay, San Diego, San Joaquin Valley, and South Central Coast areas.[18] It is important that these areas are anticipated to receive the largest health benefits, as they are some of the most polluted in the state.

C. Climate Change is a Major Threat

In addition to improving air quality and health, reducing emissions from the transportation sector is also a key strategy to combating the negative effects of climate change, as the transportation sector–not including upstream emissions from vehicle fueling– accounts for about 40 percent of the state's emissions.[19] California, in particular, is acutely feeling the negative effects of climate change, namely through increased drought and wildfires. As noted by academic researchers and experts at ARB, "some of the weather extremism, such as droughts and heat waves, can exacerbate air pollution episodes and exert severe impacts on human health (increase of morbidity and mortality and losses of work productivity), wildfires, agriculture pollution, and ecosystem productivity."[20]

If California does not take action to drastically cut GHG emissions, in collective action with other jurisdictions, the number of extreme heat days will continue to rise. Sacramento, for example, could see 24 days per year above 103.9 degrees Fahrenheit by the 2070s, compared to

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[14] American Lung Association, "Comments on the Advanced Clean Cars II Workshop", November 5, 2021, ALA ACC II Workshop Comments

[15] https://www.lung.org/research/sota/air-quality-facts

[16] ISOR at135

[17] ISOR at 139

[18] ISOR at 137, Table VI-1

[19] California Air Resources Board, Current California GHG Emission Inventory Data, op. cit..

[20] Zhao, Z., Di, P., Chen, Sh. *et al.* Assessment of climate change impact over California using dynamical downscaling with a bias correction technique: method validation and analyses of summertime results. *Clim Dyn* 54, 3705–3728 (2020). https://doi.org/10.1007/s00382-020-05200-x

4 days per year from 1961 to 1990.[21] Heat already poses a range of threats to California residents, from minor illnesses like heat cramps to potentially deadly conditions such as heatstroke or heat-related heart attacks.[22] During the 2006 California heat wave, Sacramento, Modesto, and Woodland Hills broke records for the longest stretch of days over 100 degrees Fahrenheit.[23] Six locations also set new records for all-time highest temperatures. Woodland Hills, for instance, hit 119 degrees Fahrenheit on July 22, 2006, exceeding its 1985 record by 3 degrees. Over the entire heat wave, there were approximately 655 premature deaths, more than 1,600 excess hospitalizations, and more than 16,000 excess visits to emergency rooms statewide related to the heat.[24] In total, the heat wave generated more than $5.3 billion in health costs.[25]

This is just one example and does not include the recent increases in summer wildfires in California exacerbated by climate change and drought. A study of California's 2018 wildfire season estimated the economic toll at $148.5 billion in that year alone.[26] Last year, California reached a record number of 4,902 wildfires in the first half of the year – more than any time in the last 20 years.[27] This is just one example of the increasing impacts that releasing large amounts of pollution into the atmosphere contributes.[28]

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[21] California Energy Commission, "Cal-Adapt: Extreme Heat Days & Warm Nights," 2018, www.cal-adapt.org/tools/extreme-heat/ (accessed August 8, 2018)

[22] Marcus C. Sarofim et al., "Temperature-Related Death and Illness," chapter 2 in The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment, USGCRP, 2016, https://s3.amazonaws.com/climatehealth2016/low/ClimateHealth2016_02_Temperature_small.pdf .

[23] Daniel R. Kozlowski and Laura M. Edwards, "An Analysis and Summary of the July 2006 Record-Breaking Heat Wave Across the State of California," Western Regional Climate Center, 2007, www.cnrfc.noaa.gov/publications/heatwave_ta.pdf .

[24] Carmen Milanes et al., Indicators of Climate Change in California. Kim Knowlton et al., "Six Climate Change-Related Events in the United States Accounted for About $14 Billion In Lost Lives and Health Costs," Health Affairs 30, no. 11 (November 2011): 2167-2176, www healthaffairs.org/doi/pdf/10.1377/hlthaff.2011.0229

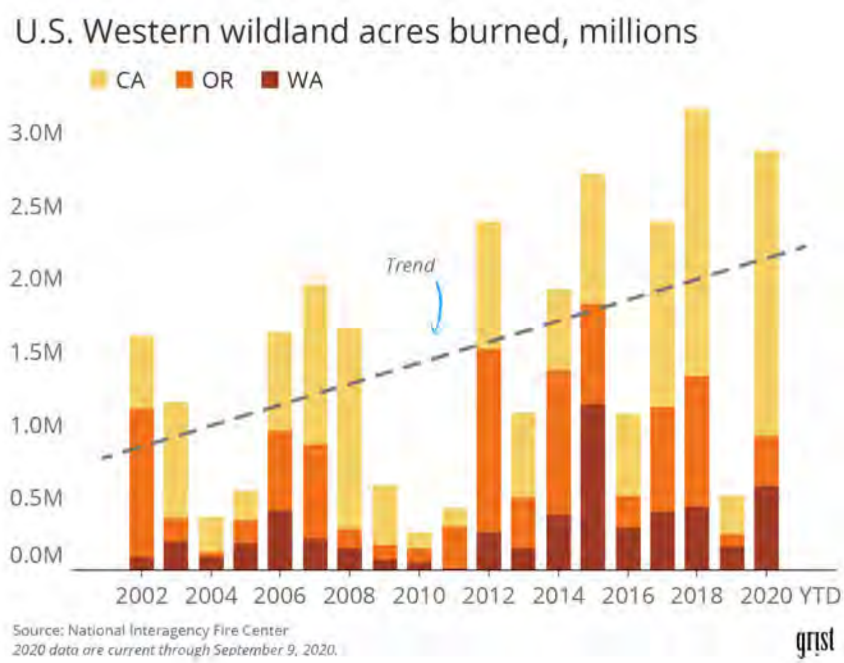
[25] Health costs include mortality costs based on the "value of a statistical life" approach, and morbidity costs calculated from medical expenses ("hospitalization, emergency department visits, outpatient visits, and other medical services") and lost work productivity. Kim Knowlton et al., "Six Climate Change-Related Events in the United States."

[26] Wang, D., Guan, D., Zhu, S. *et al.* Economic footprint of California wildfires in 2018. *Nat Sustain* **4,** 252–260 (2021). https://doi.org/10.1038/s41893-020-00646-7

[27] Paul Rodgers, "How bad is this fire season in California really going to be?" *San Jose Mercury News*, July 11, 2021.

[28] Shannon Osaka, "How apocalyptic this fire season is – in 1 flaming chart," *Grist*, September 10, 2020. https://grist.org/climate/how-apocalyptic-this-california-western-fire-season-is-in-1-flaming-chart/

Figure 1: Number of acres burned annually (in millions) across California, Oregon, and Washington[29]



D. Ensuring Strong Standards, Regardless of Federal Action.

During the Trump Administration, the National Program on GHG tailpipe emissions and fuel economy standards for passenger vehicles faced an unprecedented attack and rollback which Trump agency appointees called "the largest deregulatory initiative" of this administration.[30] As part of those attacks, the prior Administration rescinded CA's waiver in an attempt to undermine California and state authority.[31]

The U.S. EPA, under the Biden Administration, reversed much of the damage to federal and state vehicle emission programs for model years (MY) 2023 through 2026, while National Highway Traffic Safety Administration (NHTSA) updated fuel economy standards for model year (MY) 2024 to 2026 in order to reduce our nation's reliance on oil and harmonize with EPA's program. We wish to see progress and collaboration continue, but we are also cognizant that foundational progress must be made at the state level given the recent history of changing political winds at the federal level.

Therefore, more than ever, California—together with other states—must provide long-term certainty through its programs to protect public health and the environment. States have the

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[29] *Id.*

[30] Washington Post, "Trump administration rolls back rules on mileage standards, dealing a blow to Obama-era climate policy", March 31, 2020 Trump Administration rolls back rules

[31] Environmental Protection Agency and National Highway Traffic Safety Administration, Department of Transportation, "The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule Part One: One National Program", September 27, 2019, https://www.federalregister.gov/documents/2019/09/27/2019-20672/the-safer-affordable-fuel-efficient-safe-vehicles-rule-part-one-one-national-program

obligation and authority to ensure continued progress occurs on reducing GHG and other air pollutants. Providing long-term certainty to the industry, as this proposed rule does, will be important not only today, but in future environments where federal inaction on climate could occur again.

E. Volatile Oil Prices and Prices at the Pump

Although the upfront costs of some electric vehicles are currently higher compared to comparable gas-powered vehicles, many EV owners already see cost savings over the lifetime of their vehicles. This is because operating expenses—including fuel and maintenance costs—are typically lower for electric cars. A recent survey by Consumer Reports found that battery electric vehicle and plug-in hybrid electric vehicle owners pay around half as much to maintain and repair their vehicles compared to owners of conventional cars.[32] The same Consumer Reports study found that fuel savings alone for an EV compared to a gasoline powered vehicle can be $4,700 or more over the first seven years.[33] A U.S. Department of Energy study found that the estimated scheduled maintenance cost for a light-duty battery-electric vehicle totals about 6.1 cents per mile, while a conventional gasoline powered vehicle is around 10.1 cents per mile, which amounts to roughly 40% cost savings on maintenance on a per mile basis.[34]

In addition, EV owners spend 60 percent less on average by charging with electricity rather than filling up with gas. Taking the full cost of ownership into account, for all nine of the most popular EVs on the market below $50,000, lifetime ownership costs were "many thousands of dollars lower than all comparable ICE vehicles' costs, with most EVs offering savings…between $6,000 and $10,000."[35] These savings were even more pronounced for used electric vehicles, which will become increasingly available as EV adoption rates increase in the state. Similarly, in 2021 the Massachusetts Institute of Technology calculated the full lifetime cost of almost every new car model on the market and found that electric cars often had the lowest costs over time.[36] An analysis by Atlas Public Policy found that "total cost of owning the forthcoming electric version of the Ford F-150 (the F150 Lightning) is 17 percent lower than the gas-powered version, the cost of the electric Volkswagen ID.4, an SUV, is 15 percent less than the Honda CRV, a Tesla Model 3 costs almost 5 percent less than a similar Lexus, and the Chevy Bolt costs 6 percent less than a Toyota Corolla."

The price of gasoline is volatile– and with gasoline prices surging, more Americans are considering purchasing EVs, which provide a cleaner, cheaper, and more stable alternative to the oil market and wildly fluctuating gas prices. Unlike gasoline, which varies wildly in price,

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[32]Chris Harto, Consumer Reports, Electric Vehicle Ownership Costs: Today's Electric Vehicles Offer Big Savings for Consumers, October 2020, page 9; https://advocacy.consumerreports.org/wpcontent/uploads/2020/10/EV-Ownership-Cost-Final-Report-1.pdf .

[33] *Id.*

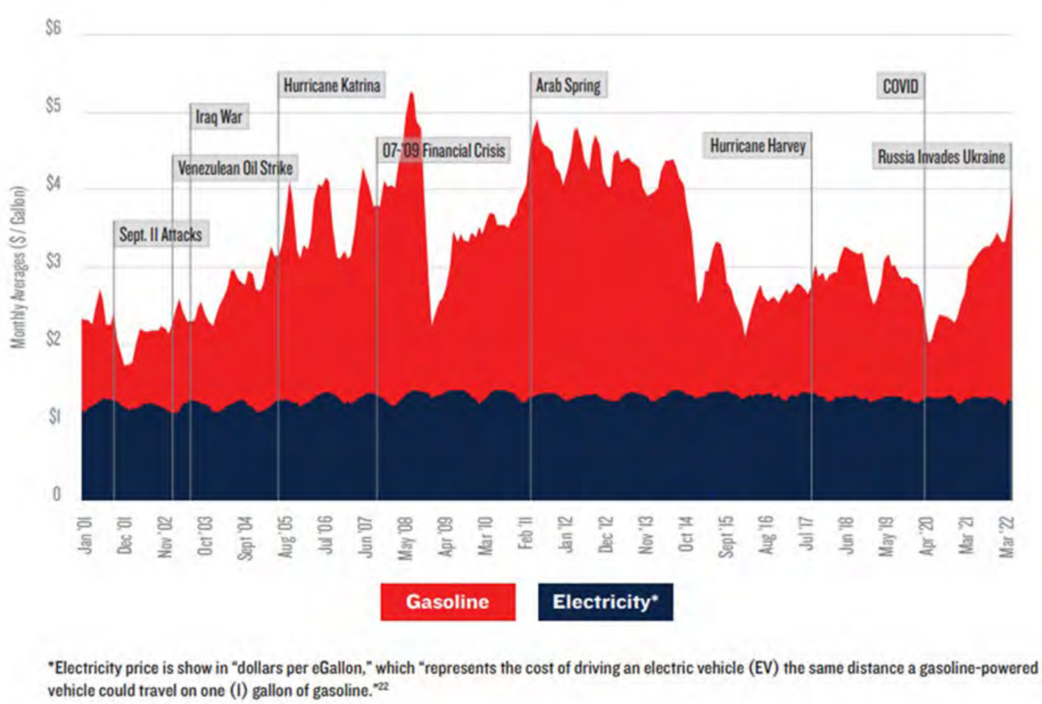
[34]Burnam, Andrew et. al., Argonne National Lab for the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy (EERE), Transportation Office. Vehicle Technologies Office, Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains, April 2021; https://doi.org/10.2172/1780970 .

[35] See Note 32.

[36] Veronica Penney, "Electric Cars are Better for the Planet – and Often Your Budget, Too," *The New York Times* 15 January 2021; available at https://www nytimes.com/interactive/2021/01/15/climate/electric-car-cost.html

the average price of residential electricity throughout the United States, adjusted for inflation, has stayed close to the dollar-a-gallon equivalent mark for over 26 years, as depicted in the chart below.[37] Switching to EVs provides Californians with predictable, stable, and cheaper fueling costs. On May 13, 2022, gasoline prices in California averaged $5.87 per gallon– in some counties rising as high as $6.65 a gallon.[38] In PG&E's service territory, by comparison, the cost to charge an EV during off-peak hours under the EV-B Time-Of-Use Rate is akin to paying $1.96/ gallon of gasoline.[39] In Southern California Edison's service territory, driving a Nissan Leaf would cost approximately $77 per month to "fill-up," which is over $260 cheaper than a comparable gasoline vehicle.[40]

Figure 2: Average Price of Gasoline compared to the Dollars per eGallon price of electricity [41]



[37] Max Baumhefner, natural Resources Defense Council, "Fight Fascists & Save Money: go Electric", May 11, 2022 https://www.nrdc.org/experts/max-baumhefner/fight-fascists-save-money-electric

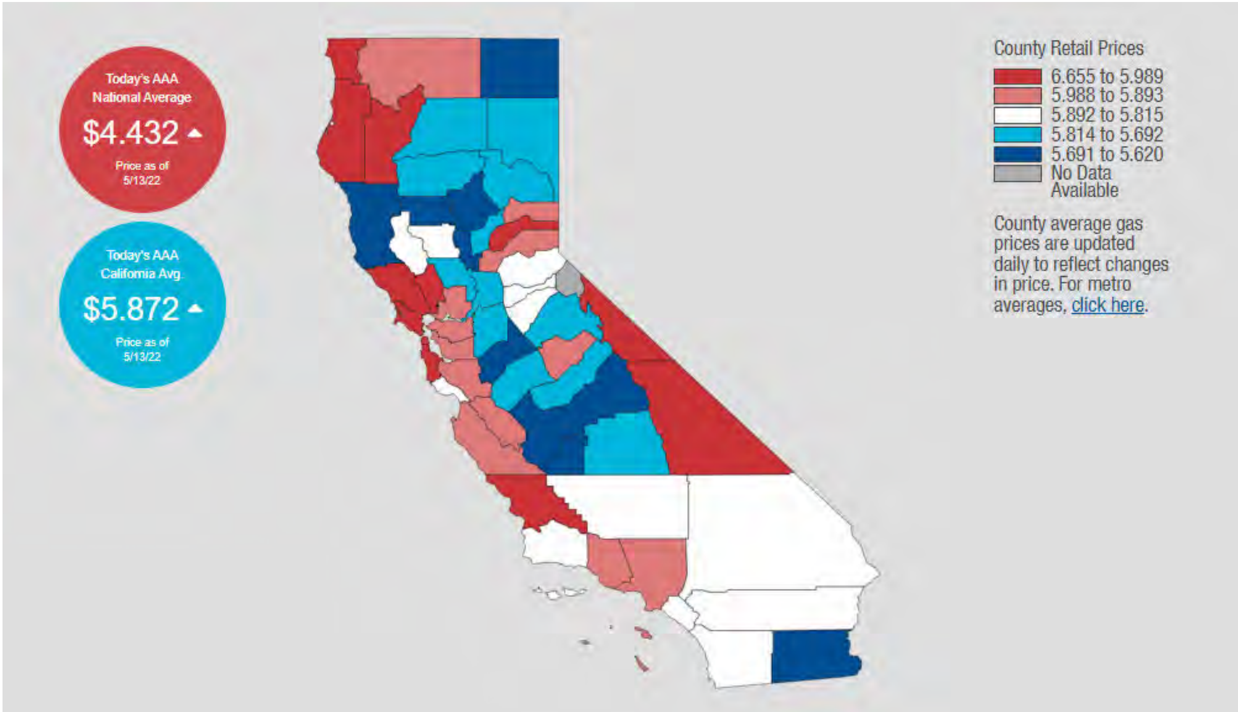
[38] American Automobile Association, "Gas Prices", https://gasprices.aaa.com/?state=CA (Accessed May 13, 2022)

[39] Pacific Gas & Electric, "Electric Vehicle (EV) Rate plans", https://www.pge.com/en_US/residential/rate-plans/rate-plan-options/electric-vehicle-base-plan/electric-vehicle-base-plan.page

[40] Southern California Edison, "Your guide to electric vehicles", https://cars.sce.com/ Accessed on May 19, 2022.

[41] *Id.*

Figure 3: Average Gas prices in California as of May 2013, 2022[42]



F. California Has the Opportunity to Maintain Its Clean Car Leadership

California has long been known as a climate and clean transportation leader. In addition to the Clean Cars Program, the state has set aggressive goals and policies to move the state to a zero emission future. In 2006, AB 32– the Global Warming Solutions Act– was signed into law, which set a goal of reducing greenhouse gas emissions by 2020.[43] In 2017, the updated AB 32 Climate Change Scoping plan laid out a plan to achieve at least 40 percent below 1990 levels by 2030, in line with Governor Edmund's Brown Executive Order B-30-15.[44] The draft 2022 Scoping Plan goes even further than this by adding a target of carbon neutrality by 2045 or sooner.[45] As the transportation sector accounted for about 40 percent of greenhouse gas emissions in the state in 2019, reducing emissions from this sector is key to achieve these goals.[46]

To reduce emissions from the transportation sector, in 2021 Governor Newsom signed a groundbreaking Executive Order that directs the state to have 100% ZEV sales by 2035, the first

[42] American Automobile Association, "Gas Prices", https://gasprices.aaa.com/?state=CA (Accessed May 13, 2022)
[43] California Air Resources Board, "AB 32 Global Warming Solutions Act of 2006, https://ww2.arb.ca.gov/resources/fact-sheets/ab-32-global-warming-solutions-act-2006
[44] Office of Governor Edmund G. Brown Jr., "Governor Brown Establishes Most Ambitious Greenhouse Gas Reduction Target in North America, April 29, 2015, https://www.ca.gov/archive/gov39/2015/04/29/news18938/index html
[45] California Air Resources board, "Draft 2022 Scoping Plan Update", May 10, 2022, https://ww2.arb.ca.gov/sites/default/files/2022-05/2022-draft-sp.pdf
[46] California Air Resources Board, Current California GHG Emission Inventory Data, op. cit.

state in the United States to do so.[47] In the 2020 Mobile Source Strategy, ARB laid out policy pathways and programs the state should consider to achieve these goals.[48]

The original Advanced Clean Cars program helped to accelerate lower-emission and zero-emission vehicles in the United States, with California now having more than 1 million ZEVs on the road, as well as hundreds of thousands more throughout other Section 177 states. As California is the only state that can set standards more stringent than the federal government, other states throughout the country who want to take stronger action against transportation sector pollution rely on California to create the strongest program possible.

The current Advanced Clean Car ZEV requirements level out after Model Year 2025 at about 7-8% sales. However, real world sales data shows that in Q1 of 2022, California is already at about 16.3% ZEV sales,[49] indicating that while the market is performing higher than anticipated, there is still a major adjustment in sales targets needed to stimulate the ZEV market and ensure the state can achieve 100% ZEV sales by 2035. As discussed further below, this also indicates that California's proposed ACC II stringency is feasible and may in fact be able to be strengthened.

IV. The Staff Proposal is Reasonable and Feasible

ARB Staff has proposed a standard starting with 35% (nominal) sales in Model Year 2026, ramping up to 68% sales in 2030 based on the credit requirements, and culminating in 100% sales in 2035. These numbers are an improvement and stronger than what was originally proposed by staff.[50] As highlighted in the sections below, these rules are reasonable and feasible, and they will increase the number of EVs on the road. After reviewing the proposed trajectory, NRDC has concluded that the staff-proposed stringency is appropriate for the initial years of the program, and an even more aggressive 2030 target of 75% ZEV sales—versus the proposed 68% level—is achievable in California and supported by the CARB staff analysis.

The proposed ZEV sales requirements are feasible based on staff's own analysis, prior information and data provided in NRDC's October 2021 letter submitted to ARB,[51] and the publicly available evidence. This evidence - some of which we describe below - includes automakers' own EV targets and investments, current and past EV sale growth rates observed in other jurisdictions and expected baseline sales already being driven by federal GHG emission

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[47] Office of Governor Gavin Newsom, "Governor Newsom Announces California Will Phase Out Gasoline-Powered Cars & Drastically Reduce Demand for Fossil Fuel in California's Fight Against Climate Change", September 23, 2020, https://www.gov.ca.gov/2020/09/23/governor-newsom-announces-california-will-phase-out-gasoline-powered-cars-drastically-reduce-demand-for-fossil-fuel-in-californias-fight-against-climate-change/

[48] California Air Resources Board, 2020 Mobile Source Strategy, October 28, 2021, https://ww2.arb.ca.gov/sites/default/files/2021-12/2020_Mobile_Source_Strategy.pdf

[49] California Energy Commission, "New ZEV Sales in California", https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/new-zev-sales (accessed on May 13, 2022)

[50] California Air Resources Board, advanced Clean Cars II Workshop, May, 6, 2021. https://ww2.arb.ca.gov/sites/default/files/2021-05/acc2_workshop_slides_may062021_ac.pdf

[51] NRDC, "Comments on Advanced Clean Cars II Public Workshop (October, 13, 2021), October 27, 2021, https://www.arb.ca.gov/lists/com-attach/26-accii-comments-w3-ws-VDpdKVYzWWkGXwJh.pdf

standards.[52] In addition, ARB staff also proposes to provide manufacturers with a number of flexibilities to help auto manufacturers comply.

A. ZEV Sales Growth in Other Jurisdictions Show CA's Standards Are Very Achievable

Our prior comment letter submitted to ARB (October 27, 2021) included an extensive section comparing the sales growth rate observed in other jurisdictions (EU countries, China) versus staff's earlier proposal.[53] The observed growth rates from those jurisdictions greatly exceeded the growth rates being considered by ARB at the time. The International Energy Agency's recent report capturing the full 2021 calendar year, together with current 2022 sales data, only strengthens the points we made last October.[54] Since then, we have commissioned further research on Germany's EV sale trends, which we provide below.

Germany has seen rapid growth in ZEV sales over the past several years, far exceeding ZEV sales growth in California. Figure 4 below shows that German ZEV sales went from 3.1% in 2019 to 26.4% in 2021, an increase of more than 23% in two years. That takeoff in German ZEV sales coincided with the "Euro 6" CO_2 emission performance standards taking effect, under which 95% of MY 2020 vehicles and 100% of MY 2021 vehicles must meet a fleet average of 95 g/km of CO2 emissions.[55] The German experience demonstrates that manufacturers can accelerate ZEV sales quickly given a strong policy push. A similar 23% increase over two years, applied to California's 2021 sales level, would result in California ZEV sales of more than 36% in 2023–thus reaching the 35% ACC II sales requirement well ahead of the MY 2026 start date.

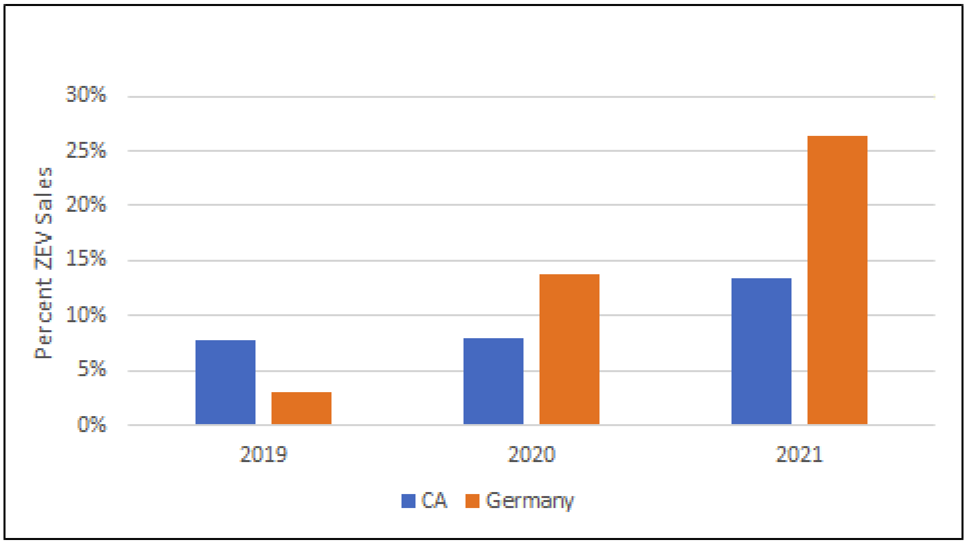
[52] Environmental Defense Fund, "Automakers Worldwide Will Spend More Than Half a Trillion dollars on Electric Vehicles This Decade—New Report", April 7, 2022, https://www.edf.org/media/automakers-worldwide-will-spend-more-half-trillion-dollars-electric-vehicles-decade-new

[53] See Footnote 50.

[54] International energy Agency, "Global electric car sales have continued their strong growth in 2022 after breaking records last year", May 23, 2022, https://www.iea.org/news/global-electric-car-sales-have-continued-their-strong-growth-in-2022-after-breaking-records-last-year

[55] European Commission, "CO2 emission performance standards for cars and vans", https://ec.europa.eu/clima/eu-action/transport-emissions/road-transport-reducing-co2-emissions-vehicles/co2-emission-performance-standards-cars-and-vans_en (Accessed May 26, 2022)

Figure 4: 2019-2021 ZEV Sales, California and Germany



We recognize that the California and German vehicle fleets are different, which must be considered in any comparison. For example, small cars, which have been early targets for electrification, accounted for 34% of total 2021 sales in Germany but only 15.4% in California. On the other hand, pickup trucks, which are just beginning to be available in electrified form, made up 15.2% of California 2021 sales whereas German sales of pickup trucks were negligible. There are also differences within each market segment, in particular for small cars. In Germany, about 37% of the small car ZEVs are Class A vehicles, which are considered subcompacts in the US. Subcompacts (e.g. Kia Soul, Honda Fit, or Fiat 500L) are less popular in California and made up only 1.4% of 2021 total sales.[56] Thus there is less potential to achieve large increases in fleetwide California ZEV sales from this segment alone.

To better understand the status of these markets NRDC obtained sales data from EV Volumes which was then compiled and analyzed by Baum & Associates. Our analysis of the data concludes that only a small portion of the discrepancy in sales rates can be explained by differences in the California and German vehicle fleets. Table 1 provides several metrics for each market segment for California and Germany:

- Market segment sales percent of total sales
- ZEV sales percent of market segment sales
- Market segment ZEV sales percent of total sales
- Market segment ZEV sales percent of total ZEV sales

[56] Carsalesbase, US Car Sales Analysis 2021—Subcompact Cars,https://carsalesbase.com/us-car-sales-analysis-2021-subcompact-cars/ (Accessed May 26, 2022)

Table 1: Sales Fractions by Market Segment, US and Germany, 2021

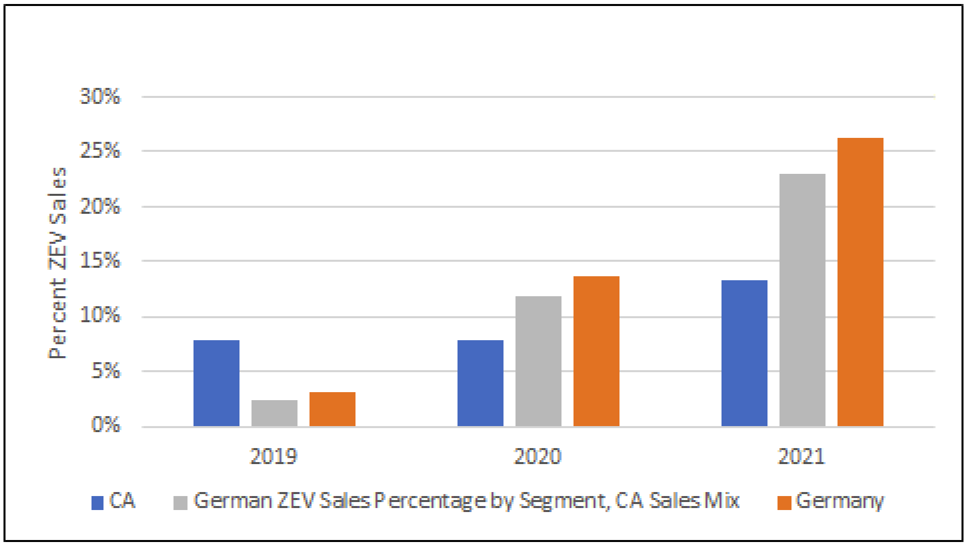
Market Segment		Segment Sales		ZEV Sales Percent of		Segment ZEV Sales		Segment ZEV Sales	
		California	Germany	California	Germany	California	Germany	California	Germany
Car	Small	15.4%	34.0%	31.2%	26.3%	4.8%	8.9%	36.0%	33.9%
	Midsize	9.5%	3.3%	7.9%	22.9%	0.7%	0.8%	5.6%	2.9%
	Luxury	11.4%	16.2%	1.4%	31.7%	0.2%	5.1%	1.2%	19.5%
Crossover	Small	16.7%	18.4%	8.1%	20.5%	1.3%	3.8%	10.1%	14.3%
	Midsize	8.7%	5.3%	63.3%	22.3%	5.5%	1.2%	41.1%	4.5%
	Luxury	12.9%	9.6%	0.0%	46.4%	0.0%	4.5%	0.0%	16.9%
SUV	Midsize	4.6%	0.9%	13.5%	4.6%	0.6%	0.0%	4.7%	0.2%
	Large/Luxury	3.5%	2.9%	0.9%	31.4%	0.0%	0.9%	0.2%	3.5%
Other	Large Van	1.4%	5.3%	0.8%	10.5%	0.0%	0.6%	0.1%	2.1%
	Minivan	2.1%	4.1%	2.0%	14.8%	0.0%	0.6%	0.3%	2.3%
	Pickup	13.7%	0.0%	1.3%	0.0%	0.1%	0.0%	0.8%	0.0%

Even taking the different sales mixes into account, however, a substantial gap remains. As the "ZEV Sales Percent of Segment Sales" columns in Table 1 show, in many market segments a higher percentage of segment sales are ZEVs in Germany as compared to in California.[57] To explore this factor in more detail, Shulock Consulting projected what California ZEV sales would be if the German ZEV sales fractions for each market segment, excluding subcompacts, were achieved here. This analysis applied the German ZEV sales fractions to California sales for the corresponding market segment.[58] Figure 5 shows the results for California ZEV sales, the German ZEV sales percentages applied to the California sales mix, and German ZEV sales. Just achieving the current German ZEV sales percentages in each segment would substantially increase California ZEV sales.

[57] The one notable exception (higher California ZEV sales in the Midsize Crossover segment) is due to large California sales of the Tesla Model Y.

[58] Using the small crossover segment as an example, this projection starts with the 21,9% California small crossover market share, then assumes that the 20.5% German ZEV sales fraction for small crossovers is achieved in California instead of the California ZEV sales fraction of 8.1%. The same calculation is then performed for all segments. The German ZEV sales fraction for small cars was reduced by 9.7% (36.9% of the 26.3% German small car ZEV sales fraction) to account for German Class A ZEV sales that would have no counterpart in the US.

Figure 5: ZEV Sales in California with German Sales Percentages by Segment, and Germany

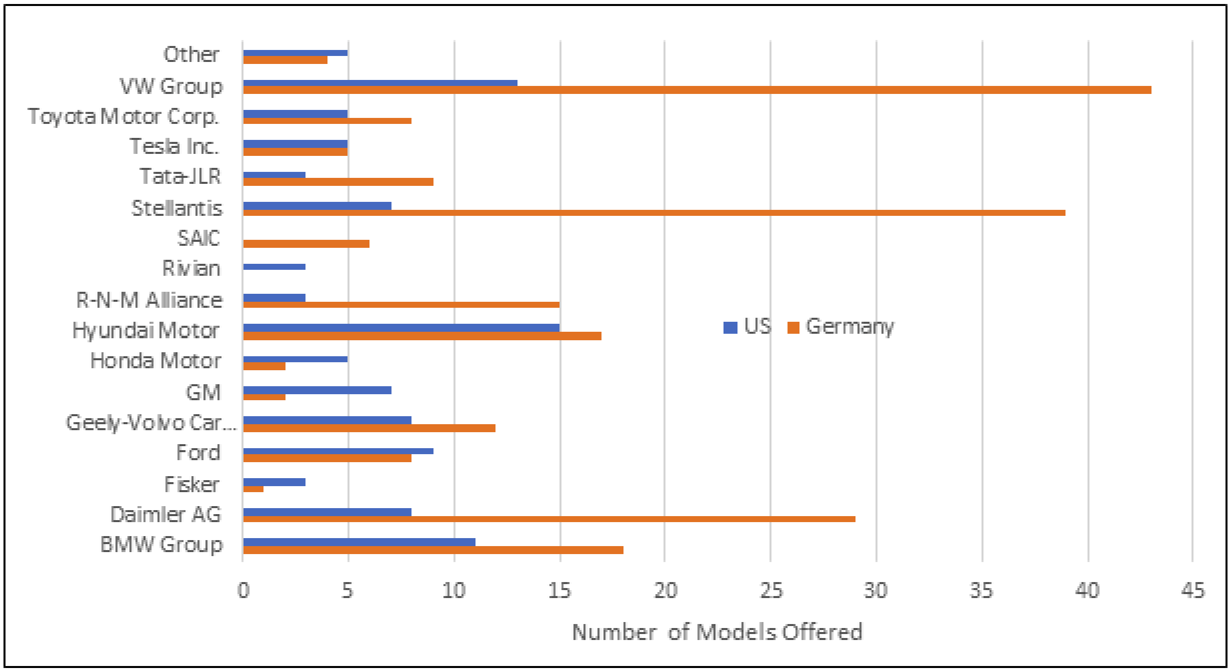


B. Increased Model Availability—Driven by Standard Requirements—Can Cause Large Sale Growth

Another likely reason for the greater ZEV penetration in Germany is the much larger number of ZEV models available. Availability, rather than customer demand, is fast becoming the limiting factor in ZEV deployment. In a special report prepared for COP26, BloombergNEF noted that "A lack of EV models to choose from, combined with weak fuel economy standards, are among the reasons for the U.S. lagging China and Europe in ZEV deployment."[59] Figure 6 shows the number of models offered in Germany and the US by each manufacturer. In most cases many more models are offered in Germany, and the total number of models offered in Germany, at 218, is nearly twice the US total of 110.

[59] BloombergNEF, "Zero-emission Vehicles Factbook", November 10, 2021, slide 27, [BNEF Zero-Emission Vehicle Factbook]

Figure 6: Model Availability, US and Germany



Model availability can also be affected by policy. Baum & Associates noted that US electric volumes have been reduced given the more stringent requirements in Europe and China, with available production being directed to those markets. Thus, we can anticipate that more stringent ZEV requirements in California and Section 177 states would induce manufacturers to provide more supply here and lead to increased sales.

The evidence for this is already observed in a number of EU countries and China, where in 2016 model availability was relatively low. Increasing EV model availability (or supply) led to significantly increased sales by 2021, as implied by the International Energy Agency figure below.[60]

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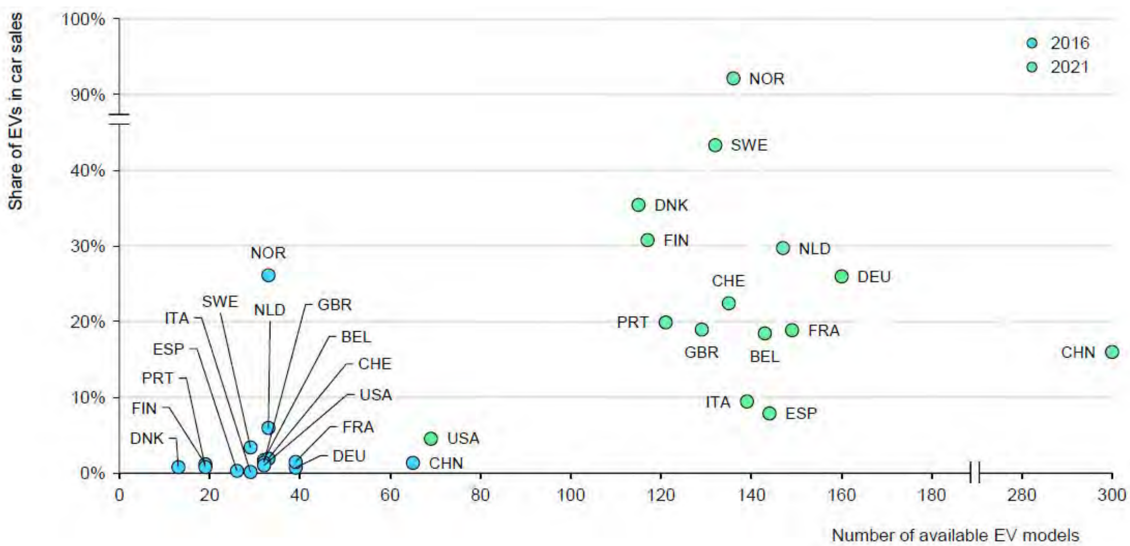
[60] Global EV Outlook 2022, International Energy Agency, https://iea.blob.core.windows.net/assets/e0d2081d-487d-4818-8c59-69b638969f9e/GlobalElectricVehicleOutlook2022.pdf

Figure 7: Number of Available EV Models Relative to EV Sales Shares, 2016-2021[61]



While the U.S. (and California) still are relatively EV model limited, this will be changing by the time ACC II begins. Bank of America's Global Research (BofA) forecasts for the U.S. show that over MY2022 through 2025, 119 out of the 383 nameplate offerings will have an electric powertrain (or 31%) not including fuel cell and hybrid offerings.[62] A number of automakers (e.g., VW, BMW, GM) will have upwards of 35% to 66% of their models with electric powertrains. ARB's standards—together with those of other jurisdictions—will also likely drive some of the laggards (Toyota, Honda, Nissan) to increase their ambition. ARB should set standards to push and reward and reflect growth of the market leaders, rather than to design its standards to accommodate laggards. Staff should also not presume that automakers can only stay with traditional product cadence (design cycles and turnover rates) and product refresh rates. The rapid growth by EV-only manufacturers, changes to design and manufacturing processes, increased competitive pressures, and global regulatory requirements are resulting in fundamental shifts.

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[61] *Id.*

[62] John Murphy, "U.S. Automotive Product Pipeline: Car Wars 2022-2025: Electric Vehicles shock the product pipeline, June 10, 2021, BofA Global Securities, https://s3-prod.autonews.com/2021-06/BofA%20Global%20Research%20Car%20Wars.pdf (last viewed 5/25/2022).

Figure 8: Electrification of Powertrains over MY2022-2025.[63]

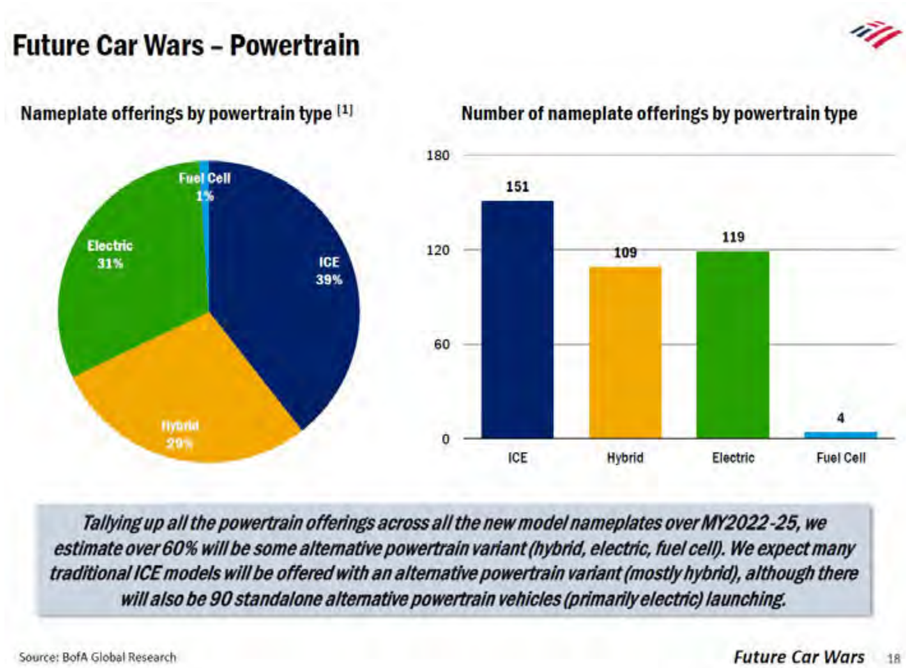
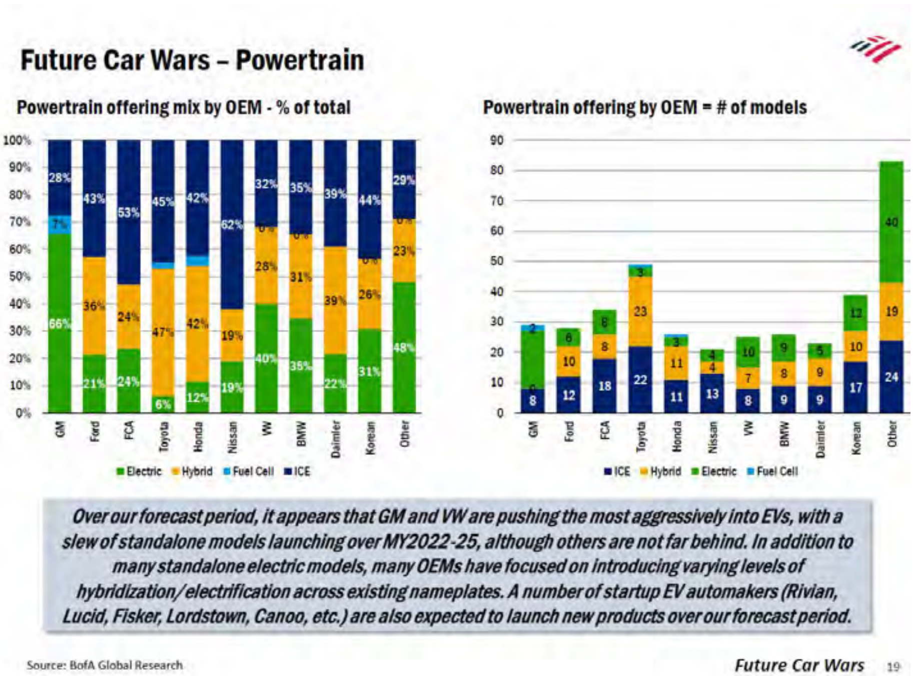


Figure 9: Electrification of Powertrains by OEM over MY2022-2025.[64]



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63 *Id.*

64 *Id.*

C. The Compliance Flexibilities Provided in the Program Are Generous

As the Staff ISOR reflects, there are a number of provisions that allow each automaker - regardless of their current sales position - great flexibility to comply fully with the program in California (and in other Section 177 states).

Based on independent analysis conducted by Shulock Consulting, NRDC concludes that sales in California will be close to the nominal ZEV requirement, with sales in Section 177 sales being lower as noted below.

The real-world ZEV sales for individual manufacturers and for the state as a whole will vary depending on which manufacturers take advantage of which specific flexibilities. To reliably project the aggregate impact, we would need detailed information on manufacturer long-term compliance strategies both in California and in the Section 177 States. Lacking that, we have used the available data to narrow the range of possible outcomes. Data sources include:

- Manufacturer-specific California ZEV sales projections for MYs 2022 through 2025 from Baum & Associates, LLC
- Staff's projected "business as usual" ZEV sales in California through MY 2025
- ZEV sales history in Section 177 states
- The ZEV market share through 2026 assumed in the recently adopted federal GHG tailpipe standards

Taking all this information into account, our best assessment is that ZEV sales in California will be close to the nominal standard, with lower sales in the Section 177 states as noted below.

D. ARB can Increase Stringency for MYs 2029 through 2034

The ZEV stringency levels, and nominal sales required, in the initial years of the staff proposal are reasonable and achievable. Based on the Alan Baum & Associates data and recent actual ZEV sales we project that in MY 2026, under a business-as-usual approach manufacturers accounting for about one-third of California total sales will have ZEV sales in excess of the 35% requirement, while the remaining manufacturers with about two-thirds of California sales will fall short.[65] Thus, the regulation will require manufacturers with two-thirds of California sales to take additional steps to meet the requirement by placing additional ZEVs, acquiring vehicle values from another source, placing ZEVs in environmental justice applications, and/or utilizing the limited use of converted credits, through the flexibility described above.

In future years, however, the requirement can and should be more aggressive. NRDC recommends that the MY 2030 requirement be set at 75% (rather than 68%), with MYs 2029

[65] In this projection ZEV-only manufacturers account for 6.6% of total California sales in MY 2026.

through 2034 adjusted per that checkpoint. The resulting trajectory is shown in Figure 10 and Table 2.

Figure 10 : Proposed Increased Stringency Compared to Staff Proposal

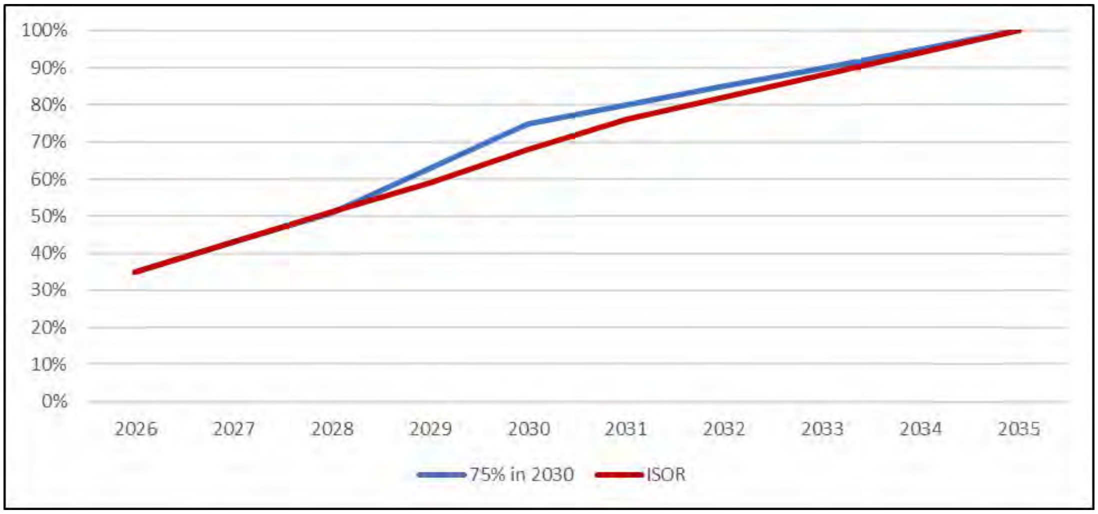
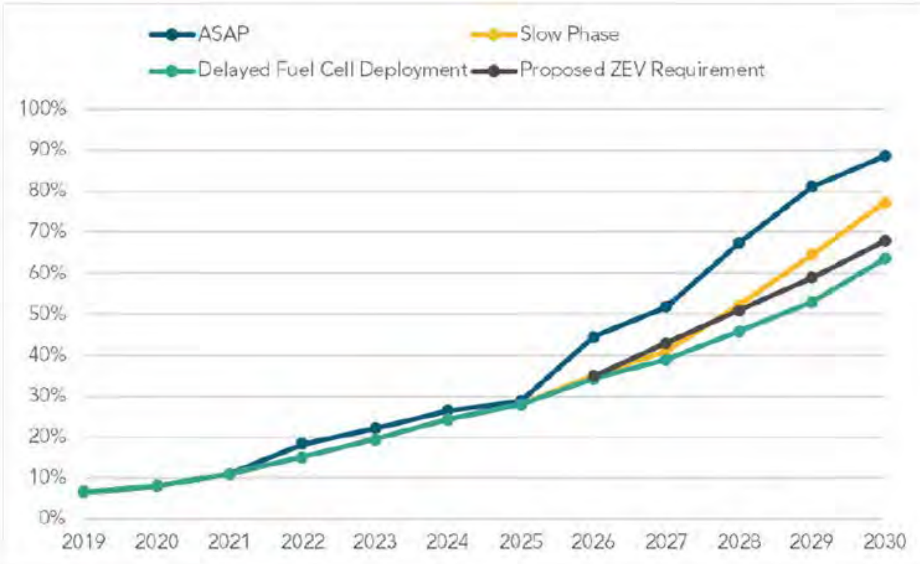


Table 2: Comparison of NRDC's Stringency Proposal vs. Staff's ISOR proposal.

	Percent Sales									
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
75% in 2030	35.0%	43.0%	51.0%	63.0%	75.0%	80.0%	85.0%	90.0%	95.0%	100.0%
ISOR	35.0%	43.0%	51.0%	59.0%	68.0%	76.0%	82.0%	88.0%	94.0%	100.0%

NRDC recommends the 75% by 2030 target for a number of reasons. First, it is necessary. Prior portions of these comments have outlined the rationale for aggressive action. Second, it is achievable. Support for our recommended stringency is provided in the ISOR. In its discussion of feasibility, staff outlines several "model turnover" scenarios which assess how rapidly manufacturers can introduce new ZEV models into the fleet. As shown in Figure 8 of the ISOR, shown below, the "slow phase" scenario closely mirrors the proposed ZEV requirement through MY 2028, after which the current ZEV requirement begins to fall short. Given the urgency of the climate crisis, the ramp rate should not be slower than what staff has concluded to be feasible.

Figure 11: CARB Analysis of Model Turnover Scenarios[66]



Moreover, once again the European experience is instructive. A May 2021 study by Bloomberg New Energy Finance assessed the feasibility of all EU countries reaching 100% ZEV sales by 2035 with appropriate policy support.[67] The study divided the EU into four groups: Nordic, Western Europe, Southern Europe and Eastern Europe. The study concluded that the Nordic group could reach 100% sales as early as 2030, while Western Europe could reach 72% battery electric vehicles (BEVs) sales in 2030. The Southern and Eastern countries lagged behind but EU sales as a whole in 2030 at 67% projected sales. Given California's substantial investment in and support for electrification, the Nordic countries and Western Europe are the best comparisons, and their sales potential can be replicated here.

Finally, experience has shown that if the ZEV requirement turns out to be infeasible, the board can readily make a correction well in advance of the effective date. But it is all but impossible to accelerate an adopted rule given the lead needed by automakers. Past boards adopted groundbreaking technology-forcing ZEV regulations which on several occasions then needed to be relaxed. That was not a failure, but rather an appropriate exercise in decision-making under uncertainty. Given how much more is known today about the urgent need for aggressive action and the inevitability of ZEV technology, this Board likewise should push the envelope.

i. <u>Recommended Increased Stringency Would Increase the Number of ZEVs</u>

Adopting the 75% in 2030 recommendation would increase the number of ZEVs in California and the Section 177 states. Table 3 shows the projected annual and cumulative increase in the

[66] ISOR, p. 41.

[67] Break-up with combustion engines, A briefing by Transport & Environment, study conducted by Bloomberg New Energy Finance. Breakup with Combustion Engines

number of vehicles placed in California, the Section 177 states and nationwide under this proposal.[68] The recommended change has no impact until MY 2029, and similarly has no annual impact in MY 2035 when both trajectories reach 100% sales. But for MYs 2029 through 2034 the NRDC recommendation would result in almost 1.4 million cumulative additional ZEVs nationwide.

Table 3: Additional ZEV Placements, NRDC Recommendation vs. Staff Proposal

California	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Annual	0	0	0	76,184	134,787	79,114	58,603	39,264	20,218	0
Cumulative	0	0	0	76,184	210,971	290,086	348,689	387,953	408,171	408,171
177 States	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Annual	0	0	0	162,880	288,420	201,450	156,682	105,723	53,489	0
Cumulative	0	0	0	162,880	451,300	652,751	809,433	915,156	968,645	968,645
Total	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Annual	0	0	0	239,064	423,208	280,565	215,285	144,987	73,707	0
Cumulative	0	0	0	239,064	662,272	942,836	1,158,121	1,303,109	1,376,816	1,376,816

These additional ZEV placements will likewise increase the emission reductions achieved through ACC II. At this time NRDC does not have the capability to directly model the emission impact of additional ZEVs, but to provide a first-cut approximation we started with Table 9 from Appendix D of the Initial Statement of Reasons, which shows total emission benefits for the ZEV and the LEV components of the proposed regulation but does not differentiate between the ZEV and LEV components. To separate out the ZEV contribution to the total reduction we calculated the ZEV fraction of cumulative total sales (ZEV plus ICE) in each model year under the staff proposal and then attributed that fraction of the total emission reduction in that model year to the ZEV component. We then increased the annual ZEV benefit in each model year based on the percent increase in cumulative ZEV sales in that year. The results for MYs 2030, 2040 and 2050 are shown in Table 4.

Table 4: Initial Projection, Additional California Emission Reductions, NRDC Recommendation

	2030	2035	2040
NOx (TPD)	0.18	1.65	4.55
PM 2.5 (TPD)	0.01	0.10	0.29
CO2 (MMT per Year)	0.33	3.16	8.78

As the table indicates, even a relatively small increase in annual ZEV sales has a significant cumulative GHG impact. The reductions in health-damaging PM 2.5 and NOx will also lead to improved public health.

[68] The calculations for Table 3 are based on projected total California sales as used for the Mobile Source Strategy and may not exactly match the total sales projections used in the ISOR.

ii. Ensuring that ZEV Requirements are Delivering Emission Reductions to Disadvantaged Communities

ARB should utilize this vital opportunity to ensure that the ZEV requirements, as a part of the ACC II program, are delivering emission reductions to those communities most historically overburdened with transportation emissions, and where the public health needs are among the greatest. NRDC shares the objectives of our equity partners to have a strong proposal that increases the emissions and public health benefits of the ZEV program overall, results in more vehicles being placed in pollution-burdened communities or regions than would otherwise occur, and that maximizes participation by automakers in these programs. Increased participation in or expansion of these equity-centered programs – as driven by the provisions in the ZEV program - could increase overall public health benefits.

The inclusion of equity provisions that can expand the supply of zero-emission vehicles to car-share programs, Clean Cars 4 All (CC4A), and the Clean Vehicle Assistance Program (CVAP) can deliver additional public health benefits to communities that experience disproportionate emissions. We urge the Board to adopt equity crediting provisions in ways to maximize the potential for these additional public health benefits.

By having more ZEVs placed into programs such as Clean Cars 4 All,[69] where old, internal combustion engine vehicles are scrapped and replaced with ZEVs, additional benefits are expected to be delivered as the vehicles displaced may be older, and more polluting, than the average California vehicle being replaced. As a November 5, 2021, South Coast Air Quality Management District report notes, "The old vehicles [being replaced] have an average of 178,800 miles and an average age of 21 years at the time of retirement" and the program "is achieving the goal to replace the dirtiest vehicles in the region while serving low-income households and disadvantaged communities."[70] This compares against the average replacement age of vehicles in the U.S. being closer to 12 years.[71] The older vehicles replaced by CC4A likely have been certified to less stringent emission standards compared to newer vehicles, together with increased likelihood of emission control systems malfunctioning or degrading.

In the case of EV community car sharing, studies have generally found that these categories of programs reduce the need for vehicle ownership, leading to avoided vehicle miles traveled and the associated reduced pollution. In addition, the use of ZEVs leads to further GHG reduction benefits compared to conventional vehicle carsharing.[72] Introducing ZEVs into community

[69] California Air Resources Board, Clean Cars 4 All, Clean Cars 4 All

[70] South Coast Air Quality Management District, Board Meeting Date November 5, 2021, Agenda No. 8, http://www.aqmd.gov/docs/default-source/Agendas/Governing-Board/2021/2021-nov5-008.pdf?sfvrsn=2

[71] United States Department of Transportation, Bureau of Transportation Statistics, Average Age of Automobiles and Trucks in Operation in the United States, https://www.bts.gov/content/average-age-automobiles-and-trucks-operation-united-states

[72] Rodier, C., Randall, C., Garcia Sanchez, J., Harrison, M., Francisco, J., & Tovar, A. (2022). Challenges and Opportunities for Publicly Funded Electric Vehicle Carsharing. UC Davis: National Center for Sustainable Transportation. http://dx.doi.org/10.7922/G29C6VRC Retrieved from https://escholarship.org/uc/item/5nf0m5mc

mobility programs also allows drivers to gain experience with ZEVs and resolve questions about their practicality and capabilities, leading to increased future uptake.

Similarly, the inclusion of credits for the Clean Vehicle Assistance Program, which targets clean mobility access for low- and moderate- income (LMI) households, can allow for increased expansion of that program and allow for this market-segment to convert to ZEVs faster than might otherwise occur. This is especially true if consumer adoption is expected to be slower in LMI households, and as higher-income households reach 100% ZEV market saturation.

We anticipate that directionally there may also be additional local benefits from avoided PM2.5 and other air toxics, especially in non-attainment communities through the described mechanisms above. We also recognize that there are important ancillary, co-benefits of increasing ZEVs in these communities, such as increasing mobility and access to clean cars in environmental justice and other pollution-impacted communities.

Analysis by Shulock Consulting estimates that if the proposed equity provisions are used by all manufacturers, in 2026 over 11,000 ZEVs could go into Community Car-Share Programs, increasing to over 50,000 vehicles in 2030– when the equity provisions are set to expire. Additionally, over 7,400 ZEVs could be added to the Clean Cars For All Program in 2026, increasing to 11,024 in 2028. This would effectively double the number of available vehicles in the Clean Cars for All Program.[73]

As proposed, the equity credit provisions are specifically tailored towards California's current programs, and it is important that ARB also consider the ability of Section 177 states to implement these same provisions to accelerate public health and air quality benefits across Section 177 states. Since all Section 177 states may not have specific equity programs akin to California, such as Clean Cars for All, ARB should incorporate language that identifies the primary objectives for state programs to qualify, such as accelerating ZEV deployment particularly in overburdened communities or air basins. State agency officials or the equivalent Executive Officer counterparts, subject to their state administrative procedures, could identify those specific programs that meet the objectives of the equity provisions.

iii. The ZEV Assurance Measures Will Increase Transparency and Support Second Life Battery Applications

In addition to the emissions and ZEV standards proposed in ACC II, CARB has also proposed ZEV assurance measures related to the vehicle's batteries to increase transparency, ensure that the vehicles continue to retain value in the long-term and remain viable options for consumers, provide support for second-life battery applications and importantly, to provide used ZEV purchasers with peace of mind about the vehicle they are purchasing.

NRDC is supportive of these measures to provide assurance to drivers–especially in the used vehicle market– that the ZEVs they purchase will last and that the technology is manageable

[73] EFMP Retire and Replace Program Statistics, https://ww2.arb.ca.gov/sites/default/files/2022-04/EFMP%20Website%20Statistics%20Tables%20Cumulative%202021_Q4_0.pdf

and safe. We are especially supportive of the on-vehicle data standardization to provide drivers and mechanics the ability to understand the battery's state of health, and battery labeling to improve recyclability.

In regard to data standardization, ARB notes that "access to data has been an important cornerstone of CARB regulations for gasoline vehicles…"[74] but thus far, there have not been similar requirements for access to data for ZEV vehicles. The proposed On-Vehicle Data Standardization measures– particularly the battery state of health provisions– would help to ensure that technicians and ZEV drivers are able to diagnose and understand how their vehicle's battery is operating and functioning. This data can also be used for appraisals in the used vehicle market and to assist in transitioning batteries into secondary life applications.

As the number of ZEVs increase, there will be additional need for battery recycling and second life applications for the batteries after their useful life in vehicles has ended. Requiring labeling of the vehicle batteries that includes important information on the battery system, including the chemistry, voltage, capacity, and safety information are key pieces of information to not only increase driver's confidence in their ZEV, but to also help facilitate greater battery reuse and recycling. ARB notes that improved recycling through battery labeling could provide savings of more than $200 billion through 2040.[75]

Together, these proposed assurance measures will increase confidence of ZEV drivers in the new and used vehicle markets that the vehicles they purchase are "healthy," while also facilitating greater use of battery recycling and other end-of-life battery technologies. For these reasons, NRDC supports these proposals.

E. ZEV Requirement– Section 177 States

i. Section 177 States Look to California's Leadership

As of May 2022, eighteen other states have adopted California's Advanced Clean Cars program, accounting for an additional 29% of the United States' light-duty vehicle market beyond California's 11%.[76] Thus, the emission impact of California's rules is almost tripled when the Section 177 states are taken into account. As California is the only state that can set more stringent standards than the United States Environmental Protection Agency for transportation sector emissions, these "Section 177" states look to California to lead and develop strong programs that will help states move faster to reduce transportation sector emissions, which are often the largest source of emissions in these states.

States such as New York and Washington have already set aggressive goals to achieve 100% electric vehicle sales by 2035 and 2030 respectively but need strong Advanced Clean Cars standards to achieve these goals, and have expressed their intent to move forward with ACC II

[74] ISOR at 71

[75] ISOR at 88

[76] California Air Resources Board, States that have Adopted California's Vehicle Standards under Section 177 of the Federal Clean Air Act, Section 177 States. In addition, Virginia (2.3% of US sales), Nevada (0.8%) and New Mexico (0.5%) have adopted ACC I but are not included in the CARB table.

as soon as California has adopted it. Other states, such as Massachusetts, have also indicated that they will move forward with the regulation this year as well.

However, it is important to note that not all current Section 177 states will be able to adopt the regulation this year, and therefore some states will miss the first compliance year for ACC II– likely having to start the regulation in MY2027 or later. The flexibilities in the regulation are applicable to all states, including California, but one provision is more relevant to these "delayed" Section 177 states– the Early Compliance Credit mechanism. This flexibility allows states that may need to start adoption in later model years to still utilize credit flexibility mechanisms in the 2 previous model years prior to joining the program. In addition, the flexibilities available to all states, including California, are structured such that they can help states with lower current ZEV sales achieve the aggressive ACC II standards. As noted in the discussion of California stringency above, our best assessment is that ZEV sales in California will be close to the nominal standard, with lower sales in the Section 177 states. Figure 12 and Table 5 show ZEV sales for a typical Section 177 state for both the staff proposed requirement and the NRDC increased stringency recommendation. This projection is based on California sales reaching the nominal regulatory requirement. Under that scenario, and with the proposed flexibilities approved, Section 177 states will be able to comply with ZEV sales levels.

Figure 12: Projected ZEV Sales in Section 177 States

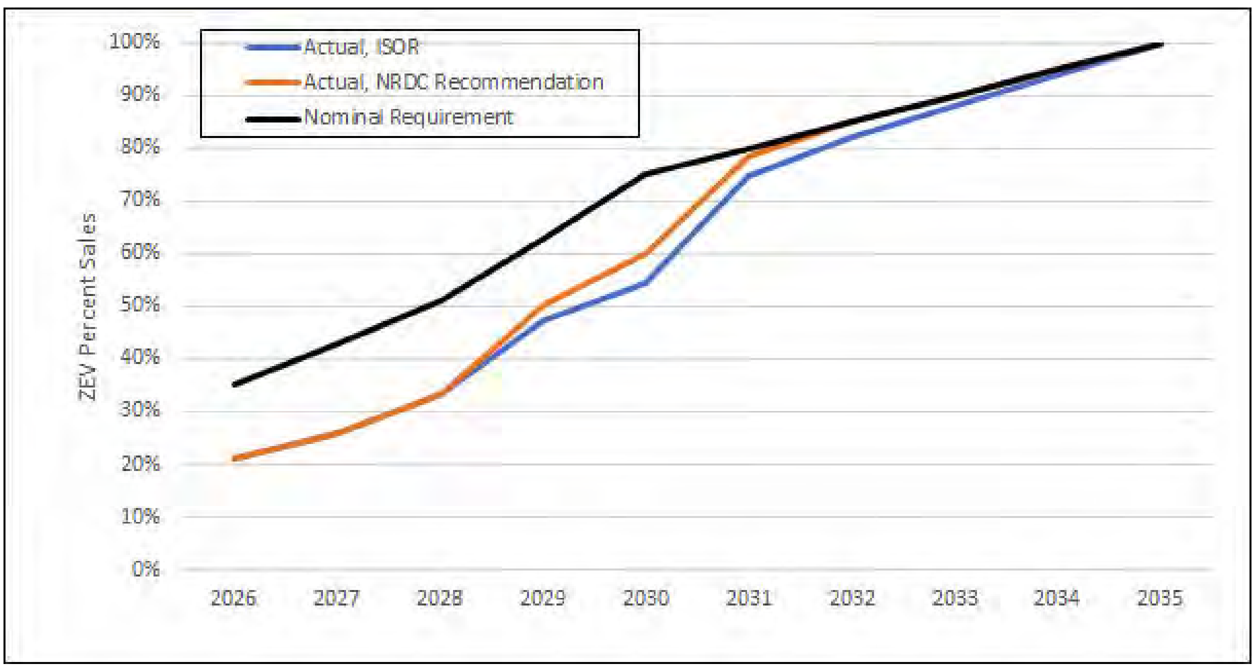


Table 5: Projected ZEV Sales in Section 177 States with Flexibilities Utilized

	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Actual, ISOR	21%	26%	33%	47%	55%	75%	82%	88%	94%	100%
Actual, NRDC Recommendation	21%	26%	33%	51%	60%	79%	85%	90%	95%	100%
Nominal Requirement	35%	43%	51%	63%	75%	80%	85%	90%	95%	100%

F. Feasibility of Advanced Clean Cars 2

i. Funding Available to Support Infrastructure Over the Next Five Years, but More is Needed in the Future

As part of NRDC's assessment of the feasibility of the ACC II standards, we commissioned two consultancies, Atlas Public Policy and Dean Taylor Consulting (Consultants), to evaluate the EV charging infrastructure needed to support the EVs expected to be on the road. The Consultants utilized the National Renewable Energy Laboratory's Electric Vehicle Infrastructure Projection Tool (EVI-Pro) Lite to evaluate the charging infrastructure needs under ACC II and also overlaid cost estimates based on the type of infrastructure needed. Four scenarios were run using EVI-Pro, with the most conservative (in terms of charging infrastructure needs) presented here.

EVI-Pro outputs include public DC fast charging direct current fast chargers (DCFC- 150 kW), public Level 2 charging, and workplace charging. However, to capture the additional needs from multi-unit dwellings (MUDs), the Consultants also assumed shared EV chargers would be installed. The methodology is further described in Appendix A: Assumptions Around Charging Infrastructure Analysis.

The analysis revealed that investments from the state, the federal government, Low Carbon Fuel Standard, and electric utilities are currently projected to deliver $3.2 billion in support for charging infrastructure over the next five years in California. This amount could meet the state's public, workplace, and shared multi-unit dwelling charging needs over the next five years based on a conservative estimate, provided that the Legislature passes the Governor's ZEV investment proposal; the utilities implement their approved investments; federal funds are dispersed; and the Public Utilities Commission approves filings on Low Carbon Fuel Standard (LCFS), near-term priorities and Pacific Gas and Electric's new proposal.[77,78] Continued investments will likely be needed to meet the 2030 and 2035 public and shared private light duty charging infrastructure needs, including up to another $1.4 billion in public investments needed between now and 2030, and up to $6.3 billion between now and 2035, based on the most conservative case under the analysis. We note these amounts do not include consideration of potential funding needs for charging by fleets, single-family homes, or dedicated (assigned) parking in multi-unit dwellings. It is assumed under ACC II that much of these infrastructure categories will be borne by the EV driver and the private sector (including potential site-hosts).

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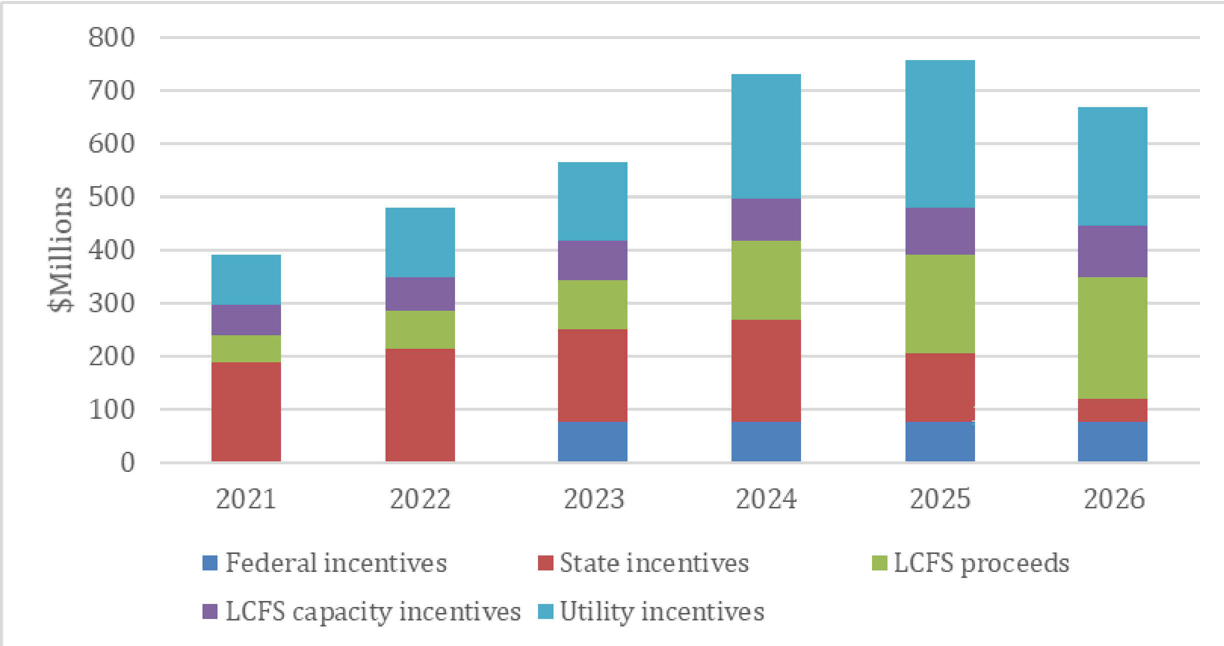
[77] Assumes 100 percent of the cost would be paid for. However, private funds can likely pay for 20 to 50 percent of the cost. Source: California Energy Commission, *Draft Zero-Emission Vehicle Infrastructure Plan (ZIP)*, April 2022, CEC-600-2022-054, Thanh Lopez and Madison Jarvis, page 6, https://www.energy.ca.gov/sites/default/files/2022-04/CEC-600-2022-054.pdf. [Accessed April 14, 2022.]

[78] See the technical appendix for further details on the analysis by Atlas Public Policy and Dean Taylor Consulting.

Figure 13: State, Federal, and Utility Funding for Public and Shared Private Charging Infrastructure for Light-duty EVs Compared to the Needed Infrastructure



These findings are also consistent with recent analysis by California agencies showing sufficient infrastructure funding likely exists to meet the state's 2025 goal.[79] If California continues its investment trends, it could also be on a path to meet its ZEV and ZEV infrastructure goals for 2030 and beyond.[80] Furthermore, the evaluation reveals that:

- **Significant public and shared-private EV chargers already exist in California:** Currently 79,000 EV public and shared private chargers exist in the state, including direct current fast chargers (DCFC), level 2 chargers, and level 1 chargers. This does not include the estimated 800,000 private chargers at homes and for fleets.[81]
- **Significant increases in funding and incentives for public and shared-private chargers are expected**: A mix of new federal incentives for charging infrastructure, existing and proposed state incentives, utility investments, and LCFS credits are expected to provide about $3.1 billion in support for light-duty charging infrastructure,

[79] California Energy Commission, Commission Final Report: 2021–2023 Investment Plan Update for the Clean Transportation Program, December 2021, CEC-600-2021-038-CMF, Table ES-1, https://www.energy.ca.gov/publications/2021/2021-2023-investment-plan-update-clean-transportation-program [Accessed April 13, 2022.] Table ES-1 does not include the 2021 state budget, the proposed 2022 state budget, new private funds, or recent federal funds from the Infrastructure Investment and Jobs Act. Also see California Energy Commission, CEC Approves $1.4 Billion Plan for Zero-Emission Transportation Infrastructure and Manufacturing, November 21, 2021, https://www.energy.ca.gov/news/2021-11/cec-approves-14-billion-plan-zero-emission-transportation-infrastructure-and [Accessed April 13, 2022]

[80] California Energy Commission, Draft Report 600-2022-054, page 1.

[81] California Energy Commission, Data and Reports, "Electric Vehicle Chargers in California", https://www.energy.ca.gov/data-reports/energy-insights/zero-emission-vehicle-and-infrastructure-statistics/electric-vehicle. [Accessed March 31, 2022]. Note: this fact sheet does not consider fuel cell EVs and hydrogen stations. The private charging stations are estimated for both level 1 and level 2 charging that are currently in use.

as shown in the figure below. It should be noted that the figure below does not include additional funding sources such as settlement funds, private company funding or match (e.g., Tesla, Electrify America), future state funding or ballot measures, such as the Clean Cars and Clean Air ballot measure expected in November of 2022**.** According to the California Energy Commission (CEC), fewer than half the public and shared private chargers in California today have received public funding from the state, utilities, or settlement agreements.[82]

- **The investments include funding to increase access for frontline communities most burdened by tailpipe pollution.** To date, about 40 percent of utility investments have been designated for disadvantaged communities. However, more can be done by the legislature to ensure that state investments in infrastructure prioritize build-out in frontline communities, often low-income communities and communities of color facing the largest pollution burdens in the state.[83]
- **Continuing the trends to increase funding for infrastructure will enable California to meet its EV goals.** The expected public EV infrastructure investments will put the state on a very strong path to meet the infrastructure needs through 2027. Increasing public and private investments over time will be needed to facilitate even faster market growth in the future.
- **California's electricity grid can accommodate these ZEV goals with planning.** If there are 5 million ZEVs on the road by 2030, the CEC forecasts that EVs will account for approximately seven percent of annual electricity usage and one percent of the system peak demand.[84] The CEC's draft Zero Emission Vehicle Infrastructure Plan finds that "California's electric grid can accommodate near-term infrastructure goals and longer-term goals can be achieved with planning, which is already underway."[85] State agencies and policymakers are implementing policies to encourage grid-friendly, beneficial load growth, such as time-of-use rates and programs to encourage charging when renewables are in excess.[86]
- **Continued Smart Investments and Policy Action by California Are Needed On Infrastructure** California's agencies including the CEC, the Public Utilities Commission (CPUC), and CARB must continue working in partnership to establish

[82] California Energy Commission, Draft Report 600-2022-054, page 6. https://www.energy.ca.gov/sites/default/files/2022-04/CEC-600-2022-054.pdf. [Accessed April 14, 2022.] Note that much of this comes from Tesla chargers and on page 38 the CEC notes that its grant program is only paying for about half the cost of level 2 chargers and two-thirds of the cost of DC fast chargers.
[83] Invest in Clean Air, '"Gas Prices. Drought. Smog. Fires. Invest in Equitable EV Programs Now" https://www.investincleanair.com/. [Accessed April 28, 2022.]
[84] California Air Resources Board, " Governor Newsom's Zero-Emission by 2035 Executive Order (N-79-20)" January 2021, https://ww2.arb.ca.gov/resources/fact-sheets/governor-newsoms-zero-emission-2035-executive-order-n-79-20 [Accessed March 31, 2022.]
[85] California Energy Commission, Draft Report 600-2022-054, page 1. https://www.energy.ca.gov/sites/default/files/2022-04/CEC-600-2022-054.pdf [Accessed April 14, 2022.]
[86] California Air Resources Board, "Governor Newsom's Zero-Emission by 2035 Executive Order (N-79-20)," January 19, 2021, https://ww2.arb.ca.gov/resources/fact-sheets/governor-newsoms-zero-emission-2035-executive-order-n-79-20. [Accessed March 31, 2022.]

infrastructure policies and goals, and to reduce all barriers to meeting the charging infrastructure needs. To stay on track, we recommend that:

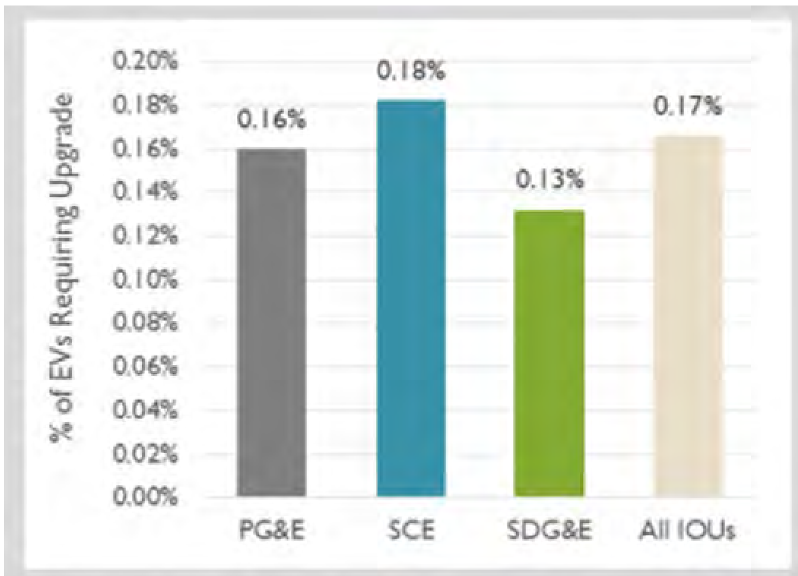
- The CEC and the CPUC accelerate their investments in customer-side public and shared-private charging infrastructure at needed levels through 2035. We note, however, the CPUC in their Transportation Electrification Framework proceeding is considering scaling back their funding of customer side incentives for charging infrastructure which could harm progress after 2025 in particular. The recent Revised Staff Proposal in that proceeding has created significant regulatory and market uncertainty about future utility support.
- California state agencies fully implement:
  - Recommendations from the EV Infrastructure Strike Force, a public-private partnership between the state agencies, private industry, and the nonprofit organizations that have worked to identify the necessary investments to support charging infrastructure deployment over the next decade and beyond.
  - The principles of the broad-based, 36-member National EV Charging Initiative.
  - The 2022 Zero Emission Vehicle Infrastructure Plan developed by the CEC with eight other state agencies (currently draft) including recommendations on streamlining of construction permits and utility interconnections, additional standardization and reliability of charging stations, and expanded minimum requirements in building codes for charging infrastructure.
- The Governor's Office of Business and Economic Development (GO-BIZ) continue to support and cultivate opportunities to accelerate the ZEV market growth including through EV charging infrastructure deployment.
- CARB staff report back to its Board on its existing statutory authority regarding regulations to increase ZEV charging infrastructure as well as participating in research to further reduce the cost of charging.
- The California Legislature pass and the Governor sign AB 2700 which would expedite the build out of distribution infrastructure anticipated by California's goals and regulations for ZEVs.

ii. <u>The Electric Grid Can Support the Proposed Increase in ZEVs</u>

ZEVs—specifically battery electric and plug-in hybrid vehicles (EVs)– need to utilize the electric grid to recharge the onboard batteries. However, the California electric grid can handle the influx of EVs that will result from ACC II and EVs can further be used as a grid resource and as battery storage to alleviate electricity outages, especially with proper utility investments and rate designs that shift charging to time when the grid is underutilized.

The costs of accommodating EV charging have been de minimis to date. A 2017 analysis of EV grid integration costs in California found that utilities collectively spent less than $610,000 on upgrades out of a collective distribution capital budget greater than $5 billion—one hundredth of one percent of total distribution capital expenditures from 2012 to 2017.[87] In 2017, the number of EVs in three of California's utilities service territories (Pacific Gas & Electric (PG&E) and Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E)) increased by more than 22%, but the number of needed upgrades to support these vehicles dropped to only 0.17% for a cost of $500,000. Put simply, very few EVs required any distribution system or service line upgrades, as shown in Figure 14.

Figure 14: Percentage of EVs Requiring Distribution or Service Line Upgrades[88]



The 2020 Joint Utilities EV Infrastructure Report included an analysis of historical upgrade costs through 2018 for the different Investor Owned Utilities (IOUs).[89] As shown in the table below, even as EV usage has increased significantly in California since 2012, the necessary upgrade costs for utilities has not been inflated relative to the increase in the number of EVs.

Table 6: Historical Upgrade Costs through 2018 from California's Investor Owned Utilities[90]

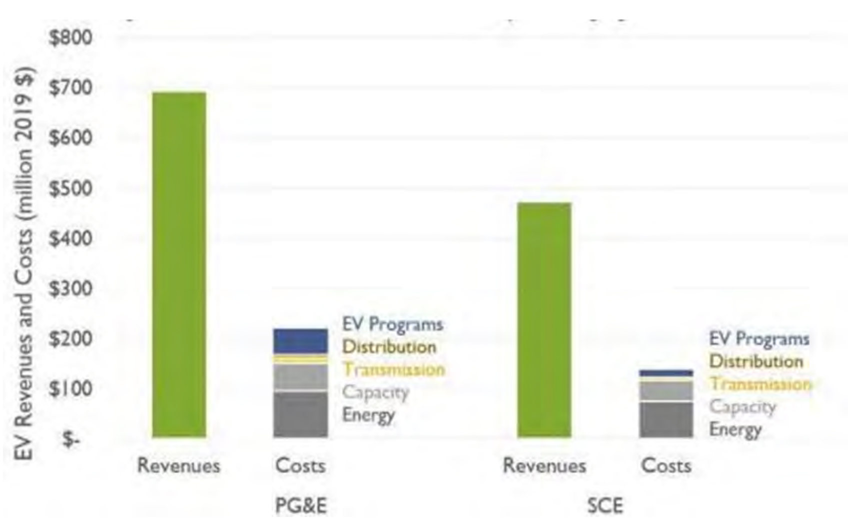
		2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018
Historical Upgrade Costs[1]	Total Distribution System Costs Incurred by Utility for Upgrades	$ 282,719	$ 598,172	$ 1,476,647	$ 798,367	$ 404,236	$ 1,734,016	$ 927,375
	Total Service Line costs Incurred by Utility for Upgrades	$ 39,924	$ 69,380	$ 103,259	$ 41,377	$ 37,500	$ 27,706	$ 52,349
	Total Customer Portion of Utility Costs Covered by the exemption	$ 9,226	$ 34,125	$ 76,046	$ 19,669	$ 3,856	$ 3,983	$ 29,618

[87] Synapse Energy Economics, *Electric Vehicles Are Not Crashing the Grid: Lessons from California*, available at www.synapse-energy.com/sites/default/files/EVs-Not-Crashing-Grid-17-025_0.pdf
[88] *Id.*
[89] Joint IOU Electric Vehicle Charging Infrastructure cost Report, 8th Report Filed on April 1, 2020, Joint IOU Report
[90] *Id.*

Considering utilities spend upwards of $5 billion annually to maintain their systems, these upgrade cost figures for EVs are a drop in the bucket compared to other utility costs. However, while the grid costs have been nominal thus far, the revenues that have accrued from EV charging are significant.

EV investments, including those by utilities, can put downward pressure on rates for all utility customers—regardless of whether they own an EV. A recent analysis by Synapse Energy Economics entitled "Electric Vehicles are Driving Electric Rates Down" analyzed real-world data from the two utility service territories with the highest number of EVs in the country, PG&E and SCE and found that EVs are already putting downward pressure on rates. Accordingly, the benefits of EVs are not just environmental; as that study appropriately concluded: "EVs offer a key opportunity to reduce harmful emissions and save customers money at the same time."[91] Synapse evaluated the revenues and costs associated with EVs from 2012 through 2019 in PG&E and SCE service territories. They compared the new revenue the utilities collected from EV drivers to the cost of the energy required to charge those vehicles, plus the costs of any associated upgrades to the distribution and transmission grid and the costs of utility EV programs that are deploying charging stations for all types of EVs. In total, EV drivers contributed an estimated $806 million more than the associated costs. And this finding is not merely a result of the fact that most EV drivers in PG&E and SCE's territories remain on default rates and pay high upper-tier prices as a result. Even if three in four were on time-of-use rates designed for EVs, those drivers would still have provided approximately $621 million in net-revenues.

Figure 15: PG&E and SCE Revenues and Costs of EV Charging, 2012-2019[92]



[91] Frost et al., Synapse Energy Economics, "Electric Vehicles Are Driving Electric Rates Down", at 1 (June 2020), *available at*: https://www.synapse-energy.com/sites/default/files/EV_Impacts_June_2020_18-122.pdf.
[92] *Id.* at 4.

This indicates that EV charging can be integrated onto the electric grid without substantial costs and can in fact provide additional revenue and downward pressure on rates for all customers. This trend is expected to continue as more EVs are added onto California's roads. A peer-reviewed study in California observed what would happen if all households in a residential region in North California were driving an electric vehicle.[93] The analysis looked at 39 representative feeders and found that if just 30% of EVs shift charging to off-peak times, only 15% of the feeders would need to be upgraded– showing that the state can achieve high EV penetration without major grid upgrades, so long as smart grid integration strategies are implemented, such as time-of-use rates and dynamic price signals, which all three of California's large investor-owned-utilities already offer.[94]

Additionally, the IOUs in the state have begun to explore the role of Vehicle-Grid-Integration (VGI) technologies as another mechanism to support the electric grid as EVs continue to penetrate the market, while also preventing grid disturbances from turning into outages and supporting additional renewable energy integration onto the grid. In April, 2022, several California based entities, including the California Energy Commission, PG&E, SDG&E, SCE, and the City of Los Angeles signed onto a United States Department of Energy Memorandum of Understanding to establish a Vehicle-To-Everything Collaboration.[95] The intent of this Collaboration is to "explore opportunities for research, engineering, and infrastructure investments that will accelerate and enable bidirectional PEV integration into the electrical grid…" as well as to provide technical assistance to accelerate VGI deployment, within the next two years.[96] Additionally, under Senate Bill 676, the California Public Utilities Commission was directed to establish strategies to integrate electric vehicles into the grid.[97] As a result, in 2020, the Commission directed the state's IOU's to develop Vehicle-to-grid (V2G) pilot programs. In May 2022, the Commission approved three VGI pilot programs– totaling $11.7 million– for PG&E.[98] SDG&E and SCE have also filed annual reports based on their VGI pilot programs.[99]

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93 J. Coignard, P. MacDougall, F. Stadtmueller and E. Vrettos, "Will Electric Vehicles Drive Distribution Grid Upgrades?: The Case of California," in IEEE Electrification Magazine, vol. 7, no. 2, pp. 46-56, June 2019, doi: 10.1109/MELE.2019.2908794.

94 Pamela Macdougall, Natural Resources Defense Council, Steering EV Integration Forward, June 12, 2019, https://www nrdc.org/experts/pamela-macdougall/steering-ev-integration-forward

95 Memorandum of Understanding to Establish the Vehicle-to-Everything Collaboration, https://www.energy.gov/sites/default/files/2022-04/OTT%20V2X%20MOU%20Final.pdf

96 *Id.*

97 California Public Utilities Commission, Vehicle-Grid Integration Activities, https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/transportation-electrification/vehicle-grid-integration-activities

98 UtilityDive, Dive Brief, "California approves 11.7M vehicle-to-grid pilots in PG&E footprint", April 1, 2022, updated May 6, 2022 https://www.utilitydive.com/news/california-approves-117m-vehicle-to-grid-pilots-in-pge-footprint/621393/

99 San Diego Gas & Electric Company, Before the Public Utilities Commission of the State of California, Rulemaking 18-12-006, "San Diego Gas & Electric Company (U 902 M) Vehicle Grid Integration Activities Mid-

iii. ZEV Demand Continues to Increase in the United States

The current Advanced Clean Car ZEV requirements level out after Model Year 2025 at about 7-8% sales. However, real world sales data shows that the demand for these vehicles is much higher than the current standard. In Q1 of 2022, California is already at about 16.32% ZEV sales[100] (up from about 12% 2021[101]). In 2018, ZEV sales in California already met the 2025 ZEV goals by reaching 7.84% sales. Across the United States, in 2021, EVs nearly doubled from 308,000 vehicles in 2020 to 608,000 in 2021.[102] The US Department of Energy notes that "The rapid growth in plug-in electric vehicle sales from 2020 to 2021 is remarkable in the context of overall light-duty vehicle sales, which increased by only 3% during the same period."[103] And this trend has been consistent for the past few years: While overall auto sales fell by 14.6 percent in 2020 relative to 2019, EV sales only fell by 4.6 percent relative to EV sales in 2019.[104] EV sales in January and February of 2021 resulted in all-time records for those months, exceeding the respective monthly totals from 2020 by 43 percent and 100 percent.[105]

Term Report for 2021", https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M407/K951/407951056.PDF and https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M407/K998/407998634.PDF

100 California Energy Commission, New ZEV Sales in California, https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/new-zev-sales (accessed on May 13, 2022)

101 Office of Governor Gavin Newsom, "California Leads the Nation's ZEV Market, Surpassing 1 Million electric Vehicles Sold, February 25, 2022, https://www.gov.ca.gov/2022/02/25/california-leads-the-nations-zev-market-surpassing-1-million-electric-vehicles-sold/

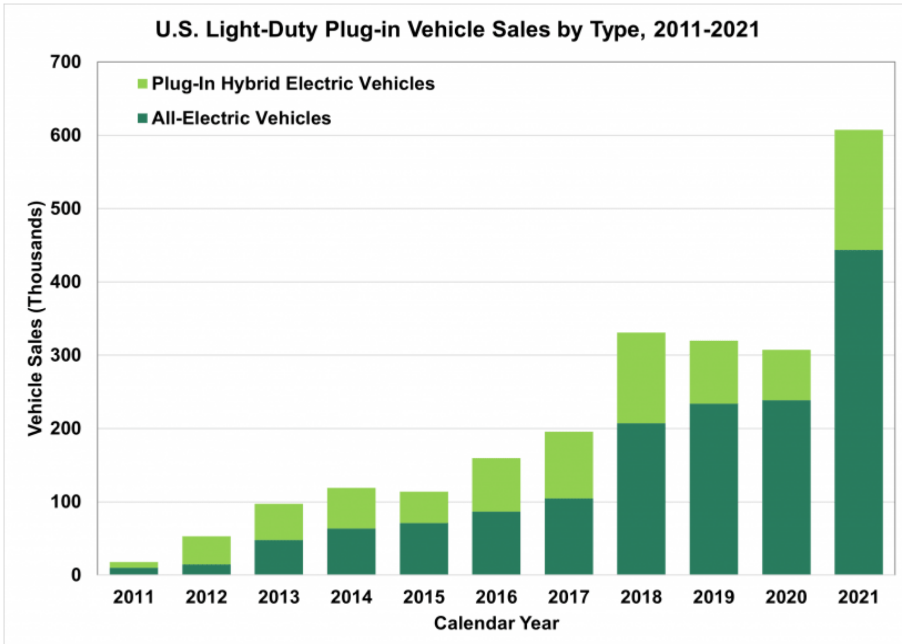
102 US Department of Energy, Office of Energy Efficiency & Renewable Energy, Vehicle Technologies Office, "Light-Duty Plug-In Electric Vehicle Sales in the United States Nearly Doubled from 2020 to 2021", February 28, 2022, https://www.energy.gov/eere/vehicles/articles/fotw-1227-february-28-2022-light-duty-plug-electric-vehicle-sales-united

103 *Id.*

104 *See* Byron Hurd, *2020 sales wrap-up: The good and the bad of an ugly year*, Autoblog (Jan. 5, 2021), https://www.autoblog.com/2021/01/05/2020-year-end-auto-sales/; EV Hub, Sales data from the Atlas EV Hub Automakers Dashboard, at 1, https://www.atlasevhub.com/materials/automakers-dashboard/

105 *Id.*

Figure 16: United States Plug-in Light-Duty Vehicle Sales[106]



This growth is also due in part to the increase in ZEV models available to drivers, and that almost every major vehicle manufacturer in the United States has committed to increasing the number of EVs in their model lineup, with some manufacturers committing towards 100% electrification within the next two decades. These commitments are important but indicate why ACC II is imperative– to ensure that manufacturers actually achieve these goals.

For example, in January 2021, General Motors announced it would strive to phase out its sales of gasoline-powered cars and trucks entirely by 2035.[107] Ford Motor Company, already the most forward-thinking of U.S. traditional automakers with regards to supporting stricter emissions standards,[108] followed with its own announcement in February doubling investment in electric vehicles to $22 billion through 2025.[109] Finally, in early March Volvo pushed the envelope a bit further by declaring its intention to phase out sales of any vehicle with an internal combustion engine by 2030 and "only sell fully electric cars."[110]

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[106] US Department of Energy, op. cit.

[107] Boudette and Davenport, *G.M. Will Sell Only Zero-Emission Vehicles by 2035,* New York Times (January 28, 2021)

[108] David Shepardson, *Ford says automakers should consider backing California emissions deal,* Automotive News (November 30, 2020)

[109] Ford Motor Company, *Ford Raises Planned Investment in EV, AV Leadership to $29 Billion; Further Advances Turnaround of Global Automotive Business in Q4*, press release at 4 (February 4, 2021).

[110] Volvo Cars, *Volvo Cars to be fully electric by 2030,* press release (March 2, 2021)

iv. Consumer Acceptance of ZEVs is Increasing

The demand for ZEVs is also driven in part by consumer acceptance and interest in this new technology. For example, the Ford F-150 Lighting, the electric version of the company's popular pick-up truck (the gasoline version of which is the best-selling car in the United States),[111] has received so many reservations (200,000) that the Company had to halt the reservation process in order to fulfill orders.[112] A 2020 survey by Consumer Reports found that 71% of drivers in the United States were interested in purchasing an electric vehicle in the future, with nearly a third of respondents stating that they would purchase an EV as their next vehicle.[113]

G. Recommended Modifications to Staff Analysis

i. Methodology and Assumptions

In general, the methodology and assumptions employed by staff in the ISOR follow standard CARB practice and provide a sound basis for regulatory adoption. Staff uses the latest version of the various analytical tools, updated as needed for this application.

Turning to more specific observations, NRDC has significant concerns with ZEV the cost analysis and minor comments on two other aspects of the analysis—the treatment of MY 2026 tailpipe GHG reductions and the assumed business as usual ZEV sales through MY 2026. Neither of the latter two have a significant impact but are noted for staff's consideration.

a. The ISOR's ZEV Costs are Too High

The ZEV technology package costs used in the ISOR have been reduced relative to those used for the Standardized Regulatory Impact Assessment (SRIA). NRDC appreciates staff's engagement on cost issues and use of more recent data. Even with those changes, however, the projected ZEV costs used in the ISOR are significantly greater than those derived by other recent authoritative analyses. Table 7 shows year-by-year cost estimates from ISOR Appendix G (ACC II ZEV Technology Assessment) as compared to parallel estimates derived from a 2019 study by the International Council on Clean Transportation (ICCT) which projected ZEV costs through 2030.[114] Results are shown for the ICCT cost categories of car, crossover and SUV.[115] Highlighted cells show years in which ZEVs reach or exceed cost parity with

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[111] CNBC, "Ford pickup remains Americas top selling truck for 45th year", https://www.cnbc.com/2021/12/02/ford-pickup-remains-americas-top-selling-truck-for-45th-year html

[112] Business Insider, "If you didn't reserve an electric F-150 Lightning already, get ready to wait years to buy one", December 9, 2021, https://www.businessinsider.com/ford-f150-lightning-electric-truck-reservations-closed-production-release-date-2021-12

[113] Consumer Reports, "Consumer Reports Survey Shows Strong Intereest in Electric Cars, Updated December 18, 2020, https://www.consumerreports.org/hybrids-evs/cr-survey-shows-strong-interest-in-evs-a1481807376/

[114] Nic Lutsey and Michael Nicholas, *Update on electric vehicle costs in the United States through 2030*, International Council on Clean Transportation, April 2, 2019, https://theicct.org/wp-content/uploads/2021/06/EV_cost_2020_2030_20190401.pdf .

[115] The ISOR vehicle categories (small and medium car, small and medium SUV) are mapped onto the ICCT as shown in the table. ICCT provided cost projections for 200 and 250-mile BEVs. NRDC extrapolated the cost of a

conventional vehicles. As the table shows, ICCT projects more rapid cost declines and earlier cost parity.

Table 7: CARB vs. ICCT Projected Incremental Cost, 300-Mile BEV

		2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Car	CARB Small + Medium	2344	1816.5	1325	867.5	521.5	214.5	-78	-355	-620	-872
	ICCT	886	-398	-1,571	-2,645	-3,730					
Crossover	CARB Small SUV	2779	2222	1703	1221	856	533	226	-66	-345	-610
	ICCT	2,786	1,304	-51	-1,291	-2,644					
SUV	CARB Medium SUV	2314	1647	1027	449	15	-369	-734	-1,081	-1,412	-1,726
	ICCT	1,627	-349	-2,148	-3,788	-5,418					

The November 2021 Zero-Emission Vehicles Factbook prepared by Bloomberg New Energy Finance (BNEF) also projects more rapid cost parity.[116] Slide 34 from the BNEF study, reproduced below, shows the year of expected cost parity for four vehicle types in several countries. BNEF projects US cost parity in 2023 and 2024, even sooner than ICCT and at least 6 years in advance of the ISOR.

Figure 17: BNEF Projections on Year of Expected Upfront Price Parity for BEVs compared to Internal Combustion Engines.[117]

The higher projected costs used in the ISOR have several negative consequences:

- Using the ISOR estimates, ZEVs reach price parity with conventional vehicles much later than in the other analyses referenced below. Although staff's recommended

300-mile BEV by adding to the ICCT 250-mile cost the projected incremental cost needed to go from a 200 to a 250 mile range.

116 Zero-Emission Vehicles Factbook: A BloombergNEF special report prepared for COP 26, November 10 2021. [BNEF Zero Emission Factbook]

117 *Id.* at 35.

stringency is not directly tied to price parity, more rapid cost reduction would provide additional support for the accelerated MY 2029-2034 trajectory recommended by NRDC.

- The overstated technology costs used in the ISOR directly result in overstated negative economic impacts. The SRIA, using staff's initial cost estimates, showed that ACC II adoption would have negative impacts on California employment, output, and gross domestic investment. Using the updated costs, the ISOR shows smaller impacts, but the results are still negative. NRDC does not have the capability to conduct a macroeconomic analysis using more appropriate cost projections but such an analysis would reduce or eliminate the purported negative impacts.
- The ISOR's conclusion that ACC II has negative macroeconomic impacts could adversely affect ACC II adoption in Section 177 states as well as the development of the next round of federal standards. Opponents of the regulations will cite California's projected negative economic impacts to support their case. California's ability to influence other jurisdictions to adopt aggressive standards is undermined.

b. MY 2026 Tailpipe GHG Reductions

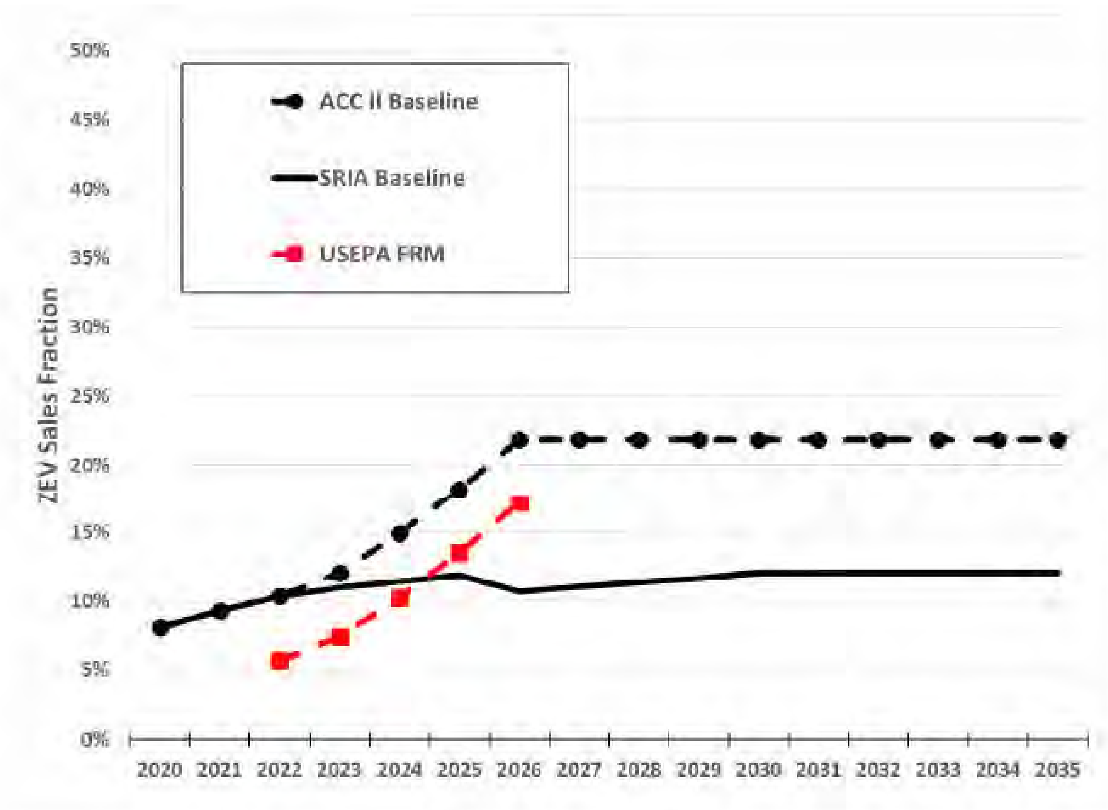
Although it is not stated explicitly, the emission reduction analysis shown in Appendix D of the ISOR appears to include a GHG tailpipe reduction in MY 2026 due to increased ZEV penetration.[118] However, in MY 2026 manufacturers will be governed by the existing GHG tailpipe fleet average standards imposed by the ACC I GHG regulation or the recently adopted federal standards. Those standards allow manufacturers to include ZEVs in the fleet average, which means that emission reductions from ZEVs can be offset by emission increases elsewhere in the fleet. NRDC does not have manufacturer-specific compliance plans for MY 2026 but as a general rule we have not assigned any GHG tailpipe reductions to increased ZEV penetration under ACC I. Manufacturers may choose to voluntarily over comply with the GHG tailpipe fleet average in MY 2026 in anticipation of a future rule that removes the ability to include ZEVs in the fleet average, but our understanding is that from a legal standpoint they are not required to do so. Assuming that new federal and/or state GHG tailpipe standards are adopted for MY 2027 and beyond, this issue only applies to MY 2026.

c. Baseline ZEV Sales Through MY 2026

Figure 30 in the ISOR, reproduced below, shows staff's updated estimate of ZEV baseline (business-as-usual) ZEV sales as compared to the baseline used in the SRIA. Staff updated the baseline by applying the ZEV sales increase assumed in the recently adopted USEPA standards to California baseline sales, beginning in MY 2022.

[118] Emissions Inventory Methods and Results for the Proposed Amendments, https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/accii/appd.pdf

Figure 18: ZEV Fractions in the Updated ACC II Baseline, SRIA baseline, and U.S. EPA FRM[119]



Although applying the United States EPA rate of increase is reasonable, the baseline ZEV sales trajectory shown above clearly understates actual MY 2021 California ZEV sales and very likely understates MY 2022 sales. NRDC suggests that a more appropriate trajectory would start with actual MY 2021 ZEV sales (a known quantity) and apply the United States EPA growth rate from there. That results in the trajectory shown in Figure 19 and Table 8 below.

[119] ISOR, Figure 30

Figure 19: ZEV Sales Trajectory Utilizing Actual MY 2021 Sales Numbers

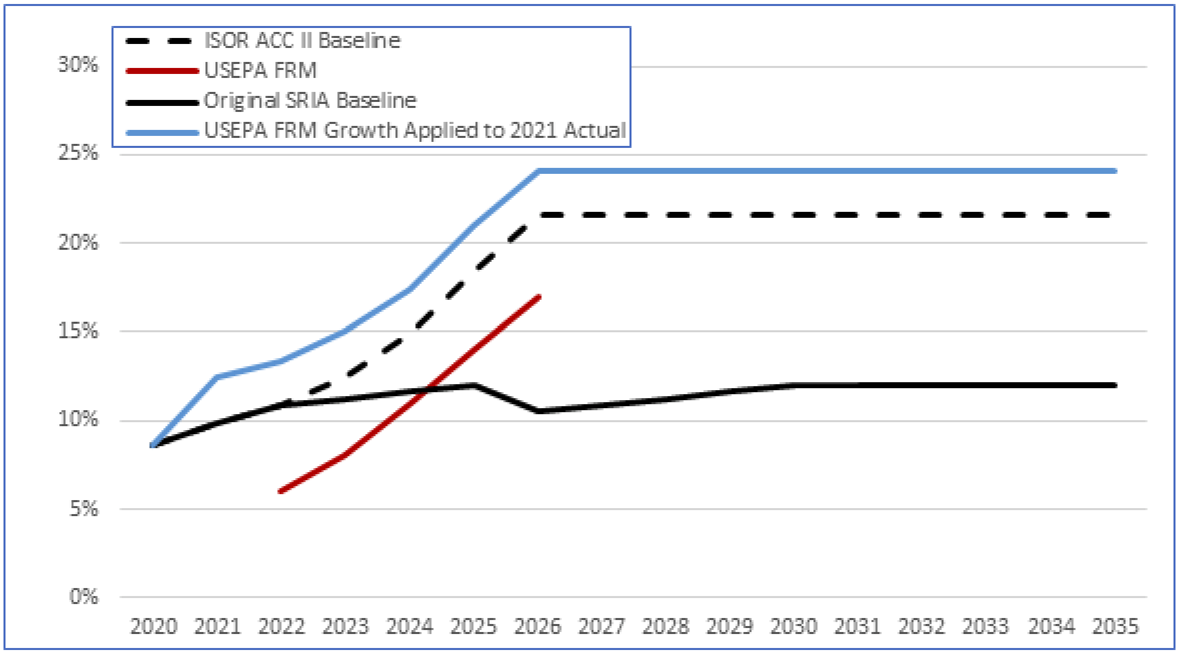


Table 8: ZEV Sales Trajectory Utilizing Actual MY 2021 Sales Numbers

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
ISOR ACC II Baseline	8.6%	9.9%	10.9%	12.5%	14.9%	18.5%	21.6%	21.6%	21.6%	21.6%	21.6%	21.6%	21.6%	21.6%	21.6%	21.6%
Original SRIA Baseline	8.6%	9.9%	10.9%	11.2%	11.6%	12.0%	10.5%	10.5%	10.5%	10.5%	10.5%	10.5%	10.5%	10.5%	10.5%	10.5%
USEPA FRM			6.0%	8.0%	11.0%	14.0%	17.0%									
USEPA FRM Growth Applied to 2021 Actual	8.6%	12.4%	13.4%	15.0%	17.4%	21.0%	24.1%	24.1%	24.1%	24.1%	24.1%	24.1%	24.1%	24.1%	24.1%	24.1%

Increasing the baseline would reduce both the incremental cost and the emission benefits of the ACC II rule, because fewer additional ZEVs would be needed to comply. But it would not change the fundamental rationale for adoption.

V. Conclusion

Transitioning California’s light-duty vehicle fleet to 100 percent zero-emissions vehicles is vital for the state to achieve its climate, air quality, and health goals. Given the increased ZEV vehicle sales in California, as well as the increased vehicle demand and planned infrastructure investments, ARB should strengthen the proposal in Model Years 2029- 2034 to increase the number of ZEV vehicles on California’s roads and stimulate the secondary ZEV market.

ARB now has the opportunity to solidify California’s global leadership in zero-emission transportation. We look forward to continued engagement throughout the regulatory process to put California on an accelerated path towards a zero-emission transportation future.

VI: Appendix A: Assumptions Around Charging Infrastructure Analysis

Background on funding and investment streams for electric vehicle charging infrastructure.

The sources of funding considered include the following:

Low Carbon Fuel Standard (LCFS) credits for owners of charging stations:

- Credits for owners of charging stations: The current California LCFS program is making it highly economical for stations to be installed. For the past three years, LCFS credits for non-residential charging resulted in a market value of about $0.16 per kWh, a very valuable source of income for the owners of the L2 or DC chargers. Assuming current LCFS credit prices of $200 per metric ton, this can be worth about $1500-$3000 per year for a typical level 2 chargers and 10 to 20 times that for DC fast chargers.[120] However, Figure 1 conservatively assumed $100 per metric ton for LCFS credits.
- Credits for owners of DC fast charging stations: Currently, 1,949 DC fast chargers at 318 sites have been approved for the LCFS program's ZEV infrastructure capacity credits, and high potential exists for more (e.g., supporting the 10,000 DC fast chargers by 2025 in the Executive Order B-48-18).[121] Assuming CARB extends this program from 2026-2035 the potential could be for another 10,000 or more DC fast chargers.[122]

Utility programs:

- Currently, the CPUC has approved almost $1.2 billion by investor-owned utilities that have been proposed or already spent to partially pay for about 75,000 chargers at multi-unit dwelling or public charging, with another $240 million proposed by CPUC staff (through 2029).[123] In addition, about $320M or 40 percent of funds are dedicated for disadvantaged communities. The costs on the "utility-side" of the meter can typically represent 30 percent of total costs shown above, but with the new AB 841 law (enacted 2020) these costs are treated like other investor-owned utility costs and no longer assigned to the site and do not need to be requested in special filings as in the past.[124] Publicly owned utilities are also investing tens of millions per year utilizing LCFS credit proceeds to support non-

[120] Applies to level 2 uses cases such as curbside or public lot charging or workplace charging for Level 2 chargers where several EVs charge each day on charger.

[121] The LCFS regulation limits these credits to 2.5 percent of total deficits. Source: California Air Resources Board, Transportation Fuels Branch, Zero-Emission Vehicle (ZEV) Infrastructure Crediting within the LCFS: How Does it Wo*rk?* August 2021, Slide 4, [Accessed March 29, 2022.] https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/guidance/zev_infra_crediting_overview.pdf.

[122] Ibid, Slide 3.

[123] California Public Utilities Commission, *Energy Division Staff Proposal to Establish Transportation Electrification Funding Cycles and Statewide Behind-the-Mete Program*, February 2022. See Figure 1 and endnote 4 for details. The analysis also assumes $200M out of $1B in the Energy Division Staff proposal goes to non-charger programs (e.g., evaluations, outreach) and thirty percent goes to fund customer side costs for multi-unit dwelling related chargers.https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M453/K952/453952700.PDF

[124] California Public Utilities Commission, *Decision Authorizing Southern California Edison Company's Charge Ready 2 Infrastructure and Market Education Programs*, D-20-08-045, September 2, 2020, Table 1, CPUC D-20-08-045. Also see California Legislative Information, Assembly Bill 841, September 30, 2020, LegInfo AB 841. Also see California Public Utilities Commission, Resolution E-5167, October 7, 2021, CPUC Resolution E-5167. [Accessed April 12, 2022.]

residential light duty EV charging programs, such as for medium and heavy-duty truck charging infrastructure.[125]

State Incentives:

- The California Energy Commission (CEC) has spent about $200 million to date on public and shared private chargers with almost 50% for disadvantaged communities.[126] Out of the $10 billion state budget for ZEVs (FY 2021-22 and proposed FY 2022-23), up to $0.9 billion could benefit public and shared private charging for passenger EVs.[127]
- State ballot initiative: A potential ballot measure (The Clean Cars and Clean Air Act) could be voted on in November 2022, and would provide approximately $35 billion for EV charging infrastructure, half of which is reserved for low-income and disadvantaged communities.[128]

Federal funding:

- The Infrastructure Investment and Jobs Act (enacted 2021) provided $5 billion in formula funding for corridors and an additional $2.5 billion for other charging and fueling infrastructure through a competitive program. California will receive at least $348 million and potentially as much as $940 million over the next 5 years for community and corridor charging.[129]

Private investments (automakers, retailers, 3rd party service providers, TNCs):

- Private companies are playing an increasing role over time (e.g., Tesla, Electrify America, EVgo, ChargePoint, Rivian) which suggests that incentives can come down over time. In addition, more and more companies are entering the public charging station business and some evidence exists that prices to drivers for away-from-home charging are coming down a little.[130]

Trends: Public investment from state and federal budgets and from utility programs will likely continue. The LCFS program does not expire, and the residential LCFS credits (which increase with the number of EVs) could become a new source of funds, if needed.

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[125] California Energy Commission, Draft Report 600-2022-054, page 11.Also see endnote 4.

[126] California Energy Commission, December 2021, CEC-600-2021-038-CMF, Table 1 and Figure 2,, https://www.energy.ca.gov/publications/2021/2021-2023-investment-plan-update-clean-transportation-program. [Accessed April 13, 2022.]

[127] Combines $314M for FY 2021/2022 state budget and $600M for proposed FY 2023/2023 state budget for light-duty public and shared private charging and excluding equitable home charging. California Energy Commission December 2021, https://www.energy.ca.gov/news/2021-11/cec-approves-14-billion-plan-zero-emission-transportation-infrastructure-and California Energy Commission, April 2022, CEC-600-2022-054, page 13, https://www.energy.ca.gov/sites/default/files/2022-04/CEC-600-2022-054.pdf

[128] Martin Wisckol, "California ballot proposal would raise billions for electric cars, charging stations" *The Mercury News*, January 17, 2022, https://www.mercurynews.com/2022/01/17/ballot-proposal-would-raise-billions-for-electric-cars-charging-stations/. Additional funds would go to single family home chargers , chargers for electric trucks and other ZEV incentives, but these are not included in the analysis The analysis assumes $3B per year would be raised. [Accessed April 18, 2022]

[129] See endnote 4.

[130] Jamie Dunckley and Chanakya Valluri, "Presentation on Cost to Charge from the Plugshare Data Set" *EPRI*, December 31, 2017 https://www.epri.com/#/pages/product/3002011098/ and David Trinko, Emily Porter ,Jamie Dunckley, Thomas Bradley, and Timothy Coburn, "Combining Ad Hoc Text Mining and Descriptive Analytics to Investigate Public EV Charging Prices in the United States," *Energies 2021 Special Issue on Data Mining Applications for Charging of Electric Vehicles*, August 24, 2021, https://www.mdpi.com/1996-1073/14/17/5240/htm. [Accessed April 11, 2022.]

<u>The specific assumptions for the development of Figure 1 include the following</u>:

- <u>Federal incentives</u>: Low case shown: $384M in funds from National EV Charging Infrastructure formula funding comes to CA. Source: California Energy Commission, CEC-600-2022-054, page 41, https://www.energy.ca.gov/sites/default/files/2022-04/CEC-600-2022-054.pdf. [Accessed April 14, 2022.] This analysis is conversative by assuming this scenario: $4.5 of the $5B in formula funds for corridor charging reaches the states and CA receives 12 percent proportional to its population, and CA receives 16 percent of the competitive charging and fueling infrastructure for public and shared private charging out of $2.5B nationally by providing higher matching funds in competitive bids.
- <u>State incentives</u>: See endnotes 23 and 24 below.
- <u>LCFS proceeds</u>: Assume $100 per credit (or metric ton) which is much lower than historic electricity credits and LCFS credit prices. Source: California Air Resources Board, Transportation Fuels Branch, *Data Dashboard*, Figure 4: Monthly LCFS Credit Price and Transaction Volumes, https://ww3.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm. [Accessed March 31, 2022.] The analysis assumes 20 percent of total electricity credits go to public and shared private charging (not including multi-unit dwellings, single family homes or fleets). LCFS increases with number of EVs registered in state. For future years assume trajectory from Shulock Consulting to 8 million EVs in 2030, but due to EVs moving out of state or being removed due to crashes or retirement, the EV adoption trajectory only reaches 6.7 million EVs registered in 2030.
- <u>LCFS capacity credit proceeds</u>: Assume developers reach full potential which is 2.5 percent of LCFS deficits. Source: California Air Resources Board, Transportation Fuels Branch, *Zero-Emission Vehicle (ZEV) Infrastructure Crediting within the LCFS: How Does it Work?* August 2021, Slide 4. https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/guidance/zev_infra_crediting_overview.pdf. [Accessed March 29, 2022.]
- <u>Utility incentives</u>: Includes approved light duty programs by SCE, PG&E, SDG&E, Liberty, Bear Valley and NRG from SB 350, settlements, AB 1082 and AB 1083(e.g., Charge Ready 1 and 2 Light-Duty, Power Your Drive 1 and 2, EV Charge Network, PG&E DC Fast Charge, Priority review projects). Source: California Public Utilities Commission, *Transportation Electrification*, https://www.cpuc.ca.gov/zev/. [Accessed March 31, 2022.] Assumes all pending or staff proposed projects move forward for light duty EV public and shared charging including approval of LCFS holdback funds and extending PG&E's EV Charge Network. Source: California Public Utilities Commission, *Pacific Gas and Electric Company Electric Vehicle Charge 2 Prepared Testimony*, See https://docs.cpuc.ca.gov/PublishedDocs/SupDoc/A2110010/4240/417398449.pdf. [Accessed April 4, 2022.] In addition, the analysis assumes $240M for customer-side charging rebates in multi-unit dwellings from 2025-2029 (or $48M per year) based on CPUC's staff proposal. See endnote 20 for details. For public electric distribution utilities assumes half of $50M per year for LADWP and smaller POUs goes to public and shared private light duty charging. See California Energy Commission, Draft Report CEC-600-2022-054, page 11, https://www.energy.ca.gov/sites/default/files/2022-04/CEC-600-2022-054.pdf. [Accessed April 14, 2022.]
- The above assumptions for Figure 1 are conversative and reasonable. For example, LCFS prices are assumed to be $100 per credit (MT) which is low compared to prices for the last three years. Federal funds are estimated at the lowest number in the literature. Regarding the proposed state budget for FY

21/22, the analysis assumed that $300M for home charging was not included. The investor-owned utility funds do not include funds for utility side costs. The publicly owned utility funds were reduced by 50 percent to account for spending on charging for medium and heavy duty EVs. Many sources of funds (e.g., private, future state and ballot measures) are excluded. Does not assume any funds from community choice aggregators.

The assessment of EV charging infrastructure and investment needs conducted by Atlas Public Policy and Dean Taylor Consulting utilized the following methodology:

- The consultancies utilized the U.S. Department of Energy's Electric Vehicle Infrastructure Project Tool (EVI-Pro) Lite model to assess the charging infrastructure needed.
- The consultancies utilized the California Air Resources Board's Advanced Clean Cars II proposed adoption curves for battery EVs and plug in hybrid EVs (PHEVs) sourced from Shulock Consulting to determine the need for shared private charging at multi-unit dwellings and workplaces, Level 2 public charging and DCFC public charging out to 2050.
- The need did not include DCFC for long trips or transportation network company charging, or private assigned parking at homes, condos, apartments, and fleets.
- For PHEVs, the need assumed that a dwindling number of PHEVs will use away from home level 2 charging for 50 percent of trips rather than 100 percent used in CEC reports.
- Cost per port were derived for level 2 charging from CPUC decisions and are a weighted average of PG&E's EV Charge Network's average costs ($17,956), SDG&E's Power Your Drive ($21,605), SCE's ($13,731), reduced by 30 percent in order to exclude utility make-ready costs (based on utility estimate) due to it being covered by AB 841's requirements. See footnote 21. Source for cost per port for DCFC: Michael Nichols, *Estimating Electric Vehicle Charging Infrastructure Costs Across Major U.S. Metropolitan Areas*, International Council on Clean Transportation, August 12, 2019, https://theicct.org/publication/estimating-electric-vehicle-charging-infrastructure-costs-across-major-u-s-metropolitan-areas/. [Accessed March 31, 2022.]
- Atlas Public Policy further assumed PHEVs with 50 mile all electric range and battery EVs with 250-mile range, that 71 percent of drivers had access to home charging, that two EVs shared multi-unit dwelling chargers, that chargers were in place two years prior to BEV adoption and did not include existing port counts from the CEC.

Attachment 77

Comments of Environmental and Public Health Organizations on:

EPA, California State Motor Vehicle Pollution Control Standards; Advanced Clean Cars II Regulations; Request for Waiver of Preemption; Opportunity for Public Hearing and Public Comment, 88 Fed. Reg. 88908 (December 26, 2023); Docket ID No. EPA–HQ–OAR–2023–0292

Submitted February 27, 2024

CALIFORNIA ENERGY COMMISSION

California Energy Commission

COMMISSION REPORT

2021–2023 Investment Plan Update for the Clean Transportation Program

December 2021 | CEC-600-2021-038-CMF

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ACKNOWLEDGEMENTS

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Jose Lopez — Private Citizen

Bill Magavern — Coalition for Clean Air

Robert Meyer — Employment Training Panel

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Neena Mohan — California Environmental Justice Alliance

Miles Muller — Natural Resources Defense Council

Samantha Houston— Union of Concerned Scientists

Lori Pepper — California State Transportation Agency

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Russell Teall — Private Citizen

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Lucas Zucker — Central Coast Alliance United for a Sustainable Economy

ABSTRACT

The *2021–2023 Investment Plan Update for the Clean Transportation Program* guides the allocation of program funding for Fiscal Years 2021–2023. The California Energy Commission (CEC) reviews the proposed allocations annually and makes adjustments as needed.

This 2021–2023 investment plan covers the thirteenth year of the program and reflects laws, executive orders, regulations, and other funding programs to reduce greenhouse gas emissions, petroleum dependence, and criteria pollution emissions for all Californians. Program priorities are determined with input from stakeholders, the Disadvantaged Communities Advisory Group, the Clean Transportation Program Advisory Committee, and by CEC analyses such as the *Electric Vehicle Charging Infrastructure Assessment* and the *Electric Vehicle Charging Infrastructure Assessment-Analyzing Charging Needs to Support Zero-Emission Vehicles in 2030*. These priorities are consistent with the overall program goal "to develop and deploy innovative technologies that transform California's fuel and vehicle types to help attain the state's climate change policies."

This 2021–2023 investment plan establishes funding allocations based on identified needs and opportunities, including a focus on zero-emission vehicles and infrastructure. The investment plan also prioritizes jobs, economic stimulus, and equity in light of the challenges presented by the COVID-19 pandemic.

This Commission Report represents the last step in developing the *2021–2023 Investment Plan Update* and was adopted at an Energy Commission business meeting on November 15, 2021.

Keywords: California Energy Commission, Clean Transportation Program, AB 118, AB 8, funding program, alternative transportation fuels, investment plan, equity, electric vehicles, hydrogen, biofuels, biomethane, biodiesel, renewable diesel, diesel substitutes, gasoline substitutes, renewable gasoline, ethanol, natural gas, federal cost-sharing, disadvantaged communities, workforce, training, sustainability, fueling stations, fuel production, alternative fuel infrastructure, manufacturing, COVID-19

Please use the following citation for this report:

Brecht, Patrick. 2021. *2021–2023 Investment Plan Update for the Clean Transportation Program.* California Energy Commission. Publication Number: CEC-600-2021-038-CMF

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EXECUTIVE SUMMARY

California has led the nation in combating climate change through aggressive greenhouse gas (GHG) emission reduction goals and innovative funding programs. The California Energy Commission's (CEC) Clean Transportation Program is one of the first transportation-focused grant programs created by the California Legislature to help achieve the state's climate change policies. The program has made significant progress through steady investments designed to transform California's fuel and vehicle types. Now in the thirteenth year, the Clean Transportation Program has provided over $1 billion to projects covering a broad spectrum of alternative fuels and technologies and in communities that can immediately accrue health, environmental, and economic benefits from these investments.

In this time, California has experienced rapid growth in the sales of plug-in electric vehicles, the introduction of hydrogen fuel cell electric vehicles, and a notable increase of in-state production and use of low-carbon alternative fuels. The Clean Transportation Program has supported this emerging revolution in the transportation sector with significant investments in zero-emission vehicle infrastructure and supporting projects and will continue to do so with this *2021–2023 Investment Plan Update*.

The CEC also recognizes the continued effects COVID-19 has had on the health, livelihood, and finances of Californians, especially the most vulnerable. The CEC will prioritize funding opportunities that put Californians back to work in good jobs building out the infrastructure needed for a clean transportation future while promoting equitable access to the benefits of a cleaner transportation system.

Purpose of the Clean Transportation Program

Since 2006, California has set several pivotal goals to reduce GHG emissions, address the threat posed by global climate change, and improve the public health of its residents. These goals require incremental progress that will ultimately lead to major emission reductions, including:

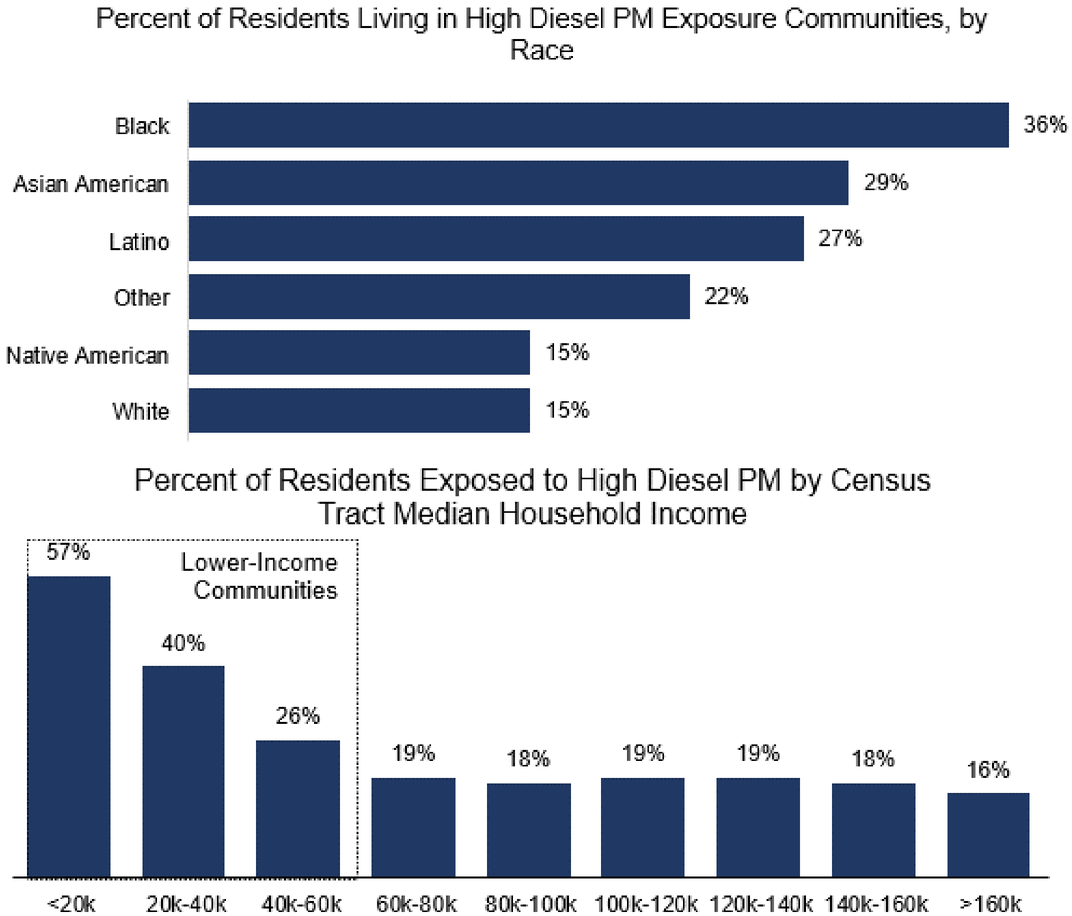
- Reducing GHG emissions to 40 percent below 1990 levels by 2030. (Senate Bill 32 in 2016).
- Reducing short-lived climate pollutant emissions, such as methane, to 40 to 50 percent below 2013 levels by 2030. (Senate Bill 1383 in 2016).
- Achieving a carbon-neutral economy by 2045. (Executive Order B-55-18).
- Setting specific goals to boost the supply of zero-emission vehicles (ZEVs) as well as charging and fueling stations, including:
    - By 2025,
        - Having at least 1.5 million ZEVs on the road. (Executive Order B-16-12).
        - Installing 200 hydrogen-fueling stations and 250,000 battery-electric vehicle chargers, including 10,000 direct-current fast chargers, by 2025. (Executive Order B-48-18).
    - By 2030,

        - Having 5 million ZEVs on the road. (Executive Order B-48-18)
        - Having 8 million ZEVs on the road. (California Air Resources Board estimate to meet Executive Order N-79-20).
    - By 2035,
        - Transitioning 100 percent of new sales of passenger vehicles and trucks to ZEVs. (Executive Order N-79-20).
        - Transitioning 100 percent of drayage trucks to zero emission. (Executive Order N-79-20).
        - Transitioning 100 percent of operating off-road vehicles and equipment to zero emission everywhere feasible. (Executive Order N-79-20).
    - By 2045,
        - Transitioning 100 percent of operating medium- and heavy-duty trucks and buses to zero emission by 2045 everywhere feasible. (Executive Order N-79-20).
- Ensuring Clean Transportation Program investments benefit communities of color, disadvantaged communities, low-income communities, rural communities, tribal communities, and those living in multifamily housing.

Achieving these goals will require significant state and federal investments to support and accelerate the market transformation that is underway within the transportation sector, which accounts for roughly 50 percent of state greenhouse gas emissions when considering “upstream emissions” from fuel production.

In addition to these GHG emission reduction goals, the state must reduce emissions of criteria pollutants to attain federal and state ambient air quality standards. Reducing air pollution is important to improve equitable outcomes, given that air quality burdens fall disproportionately on vulnerable and disadvantaged communities (Figure ES-1).

Figure ES-1: Disparities in Transportation-Related Pollution Exposure by Race and Income



To help address these goals, the California Legislature passed Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007). This legislation created the Clean Transportation Program, to be administered by the CEC. With funds collected from vehicle and vessel registration, vehicle identification plates, and smog-abatement fees, the Clean Transportation Program funds projects that will "transform California's fuel and vehicle types to help attain the state's climate change policies." Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) subsequently extended the collection of fees that support the Clean Transportation Program to January 1, 2024.

Description of the Investment Plan

As part of the Clean Transportation Program, the CEC prepares and adopts an annual investment plan update that identifies the funding priorities for the coming fiscal year. Assembly Bill 1314 (Wieckowski, Chapter 487, Statutes of 2011) reduced the scope of the annual Clean Transportation Program investment plan to an update. The update builds on the work of previous investment plans while highlighting differences from previous years. The resulting funding allocations are intended to reflect the unique technological and market conditions for each of these fuels and technologies, as well as state goals, policies, and directives.

Last fiscal year, the CEC prepared the first ever multi-year Investment Plan update to provide a more consistent signal about the state's planned clean transportation investments. The update covered investments through the Clean Transportation Program's expiration at the end of 2023. For the second year in a row, the CEC proposes a multiyear funding plan to provide the public and stakeholders improved funding certainty and convey short-term and long-term transformative goals of the Clean Transportation Program. There will be modest annual updates to evaluate whether adjustments should be made to the allocations.

Funds appropriated to the CEC for the Clean Transportation Program are available for encumbrance by the CEC for up to four years from the date of the appropriation and for liquidation up to four years after expiration of the deadline to encumber. Each annual investment plan update allows the program to be responsive and shift funds to capitalize on new opportunities and priorities.

The funding recommendations in this report are guided by, and complementary to, the state's energy policies, executive orders, regulations, and actions by other state agencies. The CEC is committed to ensuring that the Clean Transportation Program funding is complementary to policies and grant programs administered by other agencies, including the California Air Resources Board (CARB) and the California Public Utilities Commission (CPUC).

Highlights of Investments

The Clean Transportation Program has been an essential part in making California a leader in near- and zero-emission transportation. The program has provided grants to ZEV manufacturers, like electric vehicle bus manufacturer Proterra, to help them scale up in-state operations and support economic development. California is home to more than 360 companies with 70,000 employees that work directly on zero-emission transportation, including vehicles, components, infrastructure, and research (CALSTART's California ZEV Jobs Study, January 2021). In addition to jobs, these companies are stimulating the state economy; in 2020, ZEVs were California's number one export.

The Program has also funded the buildout of ZEV infrastructure, helping California create the largest electric vehicle charger and hydrogen refueling networks in the nation. These investments in ZEV infrastructure are critical to support California's growing market for ZEVs. California comprises about half of U.S. ZEV sales and the state is on track to reach 1 million light-duty ZEVs sold in 2021. If California were a country, it would be the sixth-largest market for ZEVs in the world, after China, Germany, the United States as a whole, France, and the United Kingdom (World Economic Forum, February 2021).

Since the first Clean Transportation Program investment plan was released in 2009, the CEC has invested more than $1 billion in projects supporting the advancement and use of alternative fuels and advanced vehicle technologies. Key highlights through August 2021 from the Clean Transportation Program include:

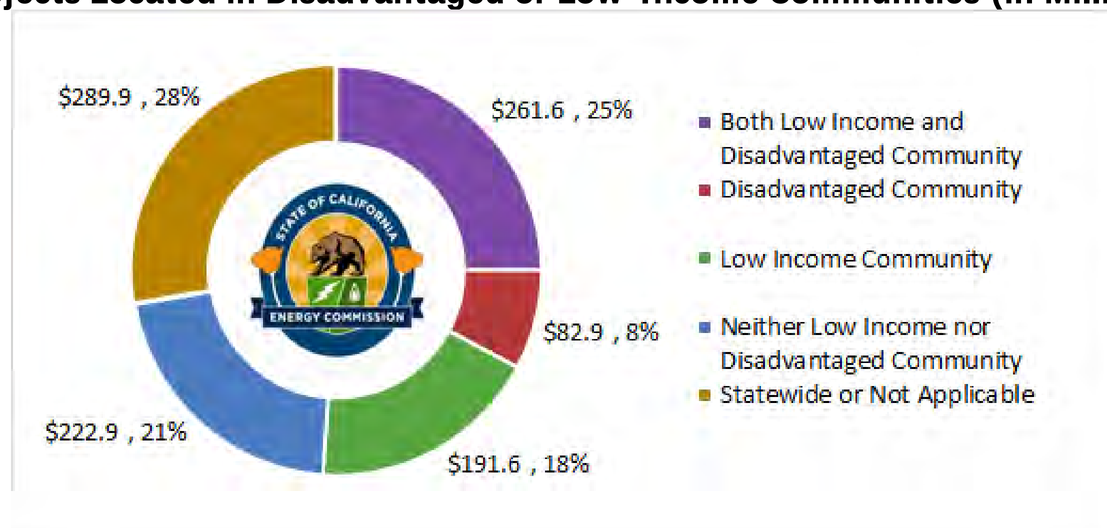
- Installed or planned 15,154 chargers for plug-in electric vehicles, including 4,277 at multi- and single-family homes, 155 for fleets, and 419 at workplaces; 8,454 public and shared private Level 2 and Level 1 chargers; and 1,601 public direct-current (DC) fast-chargers and 248 Level 2 chargers along highway corridors and urban metropolitan areas. Level 1 chargers provide charging through a 120-volt alternating-current (AC) plug, whereas Level 2 chargers provide charging through a 240-volt (typical in residential applications) or 208-volt (typical in commercial applications) AC plug. DC fast chargers provide charging through a DC plug, typically at a rate of 50 kilowatts or higher.
- Created the California Electric Vehicle Infrastructure Project (CALeVIP) to provide streamlined Clean Transportation Program incentives for light-duty electric vehicle charging infrastructure.
- Funded 83 new or upgraded publicly available hydrogen-fueling stations, and approved funding for an additional 73 stations based on deployment progress, funding availability, and Clean Transportation Program Investment Plan funding allocations, in addition to 23 privately funded stations under development, to help serve an emerging population of fuel cell electric vehicles. Once built, the 179 stations will exceed the 100 hydrogen-fueling stations called for by AB 8. As of November 2021, 52 hydrogen fueling stations were open retail in California.
- Developed retail fueling standards to enable hydrogen sales on a per-kilogram basis.
- Launched the nation's first commercial vehicle fleet incentive project titled "EnergIIZE" to accelerate the deployment of infrastructure needed to fuel zero-emission trucks, buses, and equipment. The project will use a concierge-like model working directly with eligible applicants to help plan and fund the purchase of charging and hydrogen fueling infrastructure. The $50 million multiyear project will help communities most impacted by transportation-related pollution by meeting essential infrastructure needs.
- Funded 27 manufacturing projects supporting in-state economic growth while reducing the supply-side barriers for alternative fuels and advanced technology vehicles, primarily in electric drive-related components and vehicles.
- Provided workforce training for more than 20,000 trainees and 277 businesses, helping prepare workers for the clean transportation economy and the opportunity to earn sustainable wages and expanded employment opportunities.
- Launched 71 projects to promote the production of sustainable, low-carbon alternative fuels within California, with a cumulative annual production capacity equivalent to more than 158 million gallons of diesel fuel. Most of the projects use waste-based feedstocks such as dairy manure and municipal solid waste, which have some of the lowest carbon intensity pathways recognized under the Low Carbon Fuel Standard, a 2009 CARB regulation with a goal of reducing the overall carbon intensity of fuels within the transportation sector by 20 percent by 2030.
- Announced the availability of up to $7 million in grant funds for projects to design, engineer, construct, install, test, operate, and maintain a hydrogen plant in California that will produce 100 percent renewable hydrogen from in-state renewable resources.

The hydrogen will be used for on-road fuel cell electric vehicles, both light-duty and medium-/heavy-duty.

Commitment to Inclusion, Diversity, Equity, and Access

The CEC is committed to inclusion, diversity, equity, and access, ensuring that all Californians have an opportunity to participate in and benefit from programs and services, and supporting in-state employment, in-state manufacturing, and economic development. In 2015, the CEC adopted a resolution committing the CEC to improving fair and equal opportunities to participate in and benefit from CEC programs. Furthermore, the CEC will seek to provide more than 50 percent of Clean Transportation Program funds from this investment plan toward projects that benefit low-income and disadvantaged communities. The CEC will seek to quantify these benefits in ways that go beyond measuring funding within a given location and will continue to investigate new metrics to ensure these investments enhance equity within the state. As depicted in Figure ES-2, roughly 51 percent of Clean Transportation Program project funds have been awarded to projects within disadvantaged or low-income communities or both.

Figure ES-2: Proportion of Clean Transportation Program Funding Awarded to Projects Located in Disadvantaged or Low-Income Communities (in Millions)



Source: California Energy Commission. Totals may not match due to rounding. As of August 1, 2021. "Disadvantaged communities" are defined as communities within the top 25 percent scoring areas under CalEnviroScreen, as well as areas of high pollution and low population (such as ports). "Low-income communities" are defined as communities that are at or below 80 percent of the statewide median income.

The CEC recognizes project location is just one metric for evaluating the equity impacts of specific projects. The Disadvantaged Communities Advisory Group (DACAG), established under Senate Bill 350 (De León, Chapter 547, Statutes of 2015), consults with and advises the CEC and the CPUC in determining how programs can be more effective and beneficial in disadvantaged and other communities.

In its comment letter to the CEC on June 28, 2019, the DACAG included a recommendation to "prioritize and invest in proper community outreach and engagement" and encouraged investment into outreach to disadvantaged communities in partnership with local community-based organizations. This outreach is particularly important for smaller, tribal, or rural communities that may not have the resources to compete for funding opportunities, nor the information and awareness of state program offerings.

Strengthening outreach and education efforts can provide more equitable opportunities to participate in the Clean Transportation Program Advisory Committee, and allow the identification of funding needs and priorities (such as developing the program investment plan update), the development of more equitable funding solicitation criteria, and the application and award-making process. In addition to other equity related efforts, the CEC established the Inclusive, Diverse, Equitable, Accessible, and Local (IDEAL) Communities Partnership to put in place technical assistance, conduct a ZEV community survey and outreach forum, and implement a ZEV student ambassador program in partnership with the Foundation for California Community Colleges. The CEC also continues to coordinate with its Public Advisor's Office and Tribal Program to better reach underrepresented and underserved communities.

The Advisory Committee for the Clean Transportation Program has 34 members and reflects a broad array of stakeholders representing community-based organizations, social and environmental justice advocates, alternative vehicle technologies, as well as workforce and labor interests. The perspectives and recommendations of the members and other stakeholders help guide an inclusive approach for Clean Transportation Program investments.

Senate Bill 1000 (Lara, Chapter 368, Statutes of 2018) requires the CEC to assess whether chargers are disproportionately deployed. Staff published the first *SB 1000 Electric Vehicle Charging Infrastructure Deployment Assessment* on December 30, 2020. The report found that electric vehicles and public chargers are collocated with populations and that low-income communities have the fewest public chargers per capita. Analysis done this year shows that about half of Californians live within a five-minute drive from a public fast charger. Low-income communities have the widest range of drive times, with a significant number of communities having to drive more than 30 minutes to reach the nearest DCFC station. Rural areas have some of the longest drive times to a DCFC, of up to four hours. Staff will continue to analyze charger deployment to help inform Clean Transportation Program investments in charging infrastructure, including project and grant funding design. Further details of this analysis can be found in Chapter 4.

Zero-Emission Vehicle Infrastructure Gap

Executive Order B-48-18 calls for the installation and construction of 250,000 electric vehicle charging ports, including 10,000 DC fast charging ports, and 200 hydrogen-fueling stations by 2025. Clean Transportation Program staff estimates that the sum of existing and expected future charging ports will not be enough to meet the state's goal of 250,000 chargers and 10,000 DC fast chargers by 2025. As depicted in Table ES-2, the identified investments leave a gap of more than 54,000 Level 2 chargers and 385 DC fast chargers by 2025.

Executive Order N-79-20, signed by Governor Gavin Newsom on September 23, 2020, provides even more ambitious goals and requirements for vehicles, and tasked the CEC with providing an updated assessment of the infrastructure needed to support this level of ZEV adoption. In response, the CEC adopted the *Assembly Bill 2127 Electric Vehicle Charging Infrastructure Assessment — Analyzing Charging Needs to Support Zero-Emission Vehicles in 2030.* For passenger vehicle charging in 2030, this report projects that more than 700,000 public and shared private chargers will be needed to support 5 million ZEVs, and nearly 1.2 million to support the roughly 8 million ZEVs anticipated under Executive Order N-79-20. An additional 157,000 chargers are needed to support 180,000 medium- and heavy-duty vehicles anticipated for 2030.

In addition to the charging infrastructure gap, there is a need to address the hydrogen infrastructure gap. Table ES-1 shows the number of hydrogen fueling stations from existing and allocated funds, indicating a gap of 21 hydrogen stations from the state's goal of 200 stations.

Table ES-1: Progress Toward 250,000 Chargers and 200 Hydrogen Stations by 2025

Category	Level 2 Chargers	DC Fast Chargers	Hydrogen Fueling Stations
Existing Chargers/Open Retail Hydrogen Fueling Stations (Estimated)*	66,770	6,008	52
Number of Chargers/Fueling Stations For Which Funding Has Been Allocated (includes anticipated funding from Clean Transportation Program)**	118,950	3,607	127
Total	185,720	9,615	179
2025 Goal (Executive Order B-48-18)	*240,000*	*10,000*	*200*
Gap From Goal	54,280	385	21

Source: California Energy Commission. Analysis as of July 2021. *Existing charging ports estimated based on available data from U.S. Department of Energy's Alternative Fuels Data Center and surveys to electric vehicle network service providers, utilities, and public agencies in California. Not included in this table are an estimated 665 statewide public or shared-private Level 1 chargers, which are included in the CEC ZEV and Infrastructure Statistics page (available at https://www.energy.ca.gov/data-reports/energy-insights/zero-emission-vehicle-and-charger-statistics) but not the goal of 250,000 chargers. **Estimate of ports from other state programs derived from public presentations and statements by utilities, CPUC, CARB, other entities, and CEC. Does not include funding for new charging infrastructure under State Budget Act of 2021.

The 2021-2022 State Budget for Transforming Transportation in California

Accelerate Charging, Hydrogen Refueling Station Deployment, and In-State Zero-Emission Vehicle and Related Manufacturing

On July 12, 2021, Governor Gavin Newsom strengthened California's commitment to a clean transportation future by approving the 2021–2022 budget (Senate Bill 129, Skinner, Budget Act of 2021), which includes a three-year, $3.9 billion budget for ZEV-related investments by CARB, the Governor's Office of Business and Economic Development (GO-Biz), and the CEC. The budget prioritizes diesel emission reduction by earmarking funding to replace 1,125 drayage trucks, 1,000 school buses, and 1,000 transit buses with zero-emission alternatives and refueling infrastructure. Of that package amount, the CEC will administer $1.165 billion over three years and $785 million in the current fiscal year.

The CEC funding is for infrastructure deployment to accelerate charging and hydrogen fueling station deployment and grants to promote instate ZEV and ZEV-related manufacturing, such as infrastructure equipment and ZEV components. The investments will help the markets for ZEVs and infrastructure grow to scale and, more importantly, serve as a foundation for an equitable and sustainable economic recovery by drawing private investments to California and creating jobs in manufacturing, construction, and engineering. The ZEV Package is also a multiagency investment that requires ongoing coordination with the CARB, California Governor's Office of Business and Economic Development, California State Transportation Agency, and others, for each program to complement each other and maximize the benefits to Californians.

As indicated, a lack of ZEV fueling infrastructure remains one of the largest barriers to meeting California's clean transportation goals. An immediate focus and sustained investment in zero-emission infrastructure are needed to ease the transition of California's vehicle fleet to zero-emission and ensure equitable access for all Californians. Sufficient, ubiquitous infrastructure and access to convenient and reliable zero-emission charging and fueling will be necessary to provide California drivers and businesses the confidence to adopt zero-emission vehicles for their transportation needs.

Investments in infrastructure beyond previous funding amounts under the Clean Transportation Program are necessary. Previous Clean Transportation Program funding levels were not sufficient to properly support light-duty and medium- and heavy-duty at the required pace and scale. The additional funding will allow the CEC to concurrently administer programs across vehicle segments. For example, for the passenger vehicle segment, the CEC could support a block grant, similar to CALeVIP, while administering programs focused specifically on rural communities and on apartments, condos, and other multifamily housing units. The budget will create jobs and invest in ZEV refueling infrastructure for passenger vehicles, big rigs, port equipment, transit, and school buses while supporting more domestic ZEV manufacturing. These investments will allow California to lead the nation and pave the way to a cleaner, more healthy transportation system.

Funding Allocations for 2021–2023

For the second year in a row, the CEC proposes a multiyear funding plan to provide the public and stakeholders improved funding certainty and convey short-term and long-term transformative goals of the Clean Transportation Program. There will be modest annual updates to evaluate whether adjustments should be made to the allocations.

The allocations for the *2021-2023 Investment Plan Update* combine both Clean Transportation Program funding and the general fund ZEV Package investments. Table ES-2 shows the funding allocations for FY 2021–2022, as well as funding projections for the remainder of the Clean Transportation Program as well as the $1.165 billion ($785 million in current budget) over three years made available through the general fund ZEV Package. The rationale for funding allocations is focused on ZEVs (both battery-electric and hydrogen fuel cells) infrastructure and ZEV manufacturing. The allocations reflect the state's goals for ZEVs, as well as near- and long-term carbon reduction, improved air quality, and equity, with a focus on providing benefits for disadvantaged communities.

Table ES-2 shows an allocation of about $317 million to support light-duty passenger vehicles and about $391 million to support medium- and heavy-duty vehicles in FY 2021–2022. During the full three-year allocation represented in the table, the funding would total nearly $382 million to support light-duty passenger vehicles and about $695 million to support medium- and heavy-duty vehicles. Relative to the prior revised staff report version of the *2021–2023 Investment Plan Update*, this represents a one-time shift of $18 million toward medium- and heavy-duty ZEV infrastructure in recognition of the need to swiftly transition the most polluting vehicles toward zero-emission technologies in the most sensitive regions of the state.

For light-duty charging infrastructure, the CEC allocates $270.1 million in the current fiscal year and an additional $43.9 million in the remaining two years of the program, which should be sufficient to meet the state's goal of having 250,000 chargers by 2025 and put the state on course to reach 2030 goals. For light-duty hydrogen infrastructure, the CEC allocates $47 million for the current fiscal year and an additional $30 million in future years, which will be sufficient to meet the state goal of having 200 stations open by 2025. These stations should have the capacity to refuel about 280,000 fuel cell electric vehicles (FCEVs)s. The auto industry estimates that the population of fuel cell vehicles will grow from 7,129 in 2021 to 61,000 by the end of 2027, so station capacity will no longer be a barrier to near-term deployment.

General fund investments prioritize light-duty and medium- and heavy-duty infrastructure as well as in-state manufacturing. Furthermore, it is vital to front-load funding to ensure the public adoption of ZEVs is not stymied by lack of infrastructure.

Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) directs the CEC to allocate $20 million annually, not to exceed 20 percent of the funds appropriated by the Legislature, from the Clean Transportation Program to deploy hydrogen fueling stations until there are at least 100 publicly available stations. The CEC allocates $20 million annually in Fiscal Years 2021–2022 through 2022–2023 to support light-duty, medium-duty, and heavy-duty hydrogen infrastructure. Staff expects there will be in excess of 100 light-duty stations in operation by the end of 2023, exceeding the AB 8 target, and 200 stations shortly after, thanks to the additional general fund investments allocated by the California Comeback Plan. With these targets in mind, the funding allocations of this investment plan propose a $10 million allocation (which equates to 20 percent of the expected funds for the Clean Transportation Program in 2023) for hydrogen fueling infrastructure. The CEC will evaluate whether the proposed allocation for the final year of the program is sufficient to meet the needs of the FCEV market and will adjust as needed in annual updates to the Investment Plan Update. This evaluation will be informed by CARB's *Annual Evaluation of Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development* (AB 8 Report) as well as input from the Advisory Committee, Disadvantaged Communities Advisory Group, and other stakeholders.

Table ES-2: Investment Plan Allocations for FY 2021–2022 and Subsequent Fiscal Years (in Millions)

Category	Funded Activity	2021-2022	2022-2023 [1/]	2023-2024 [1/ 2/]
Clean Transportation Program Zero-Emission Vehicles and Infrastructure	Light-Duty Electric Vehicle Charging Infrastructure and eMobility	$30.1	$30.1	$13.8
General Fund Zero-Emission Vehicles and Infrastructure	Light-Duty Electric Vehicle Charging Infrastructure	$240.0	-	-
Clean Transportation Program Zero-Emission Vehicles and Infrastructure	Medium- and Heavy-Duty Zero-Emission Vehicles and Infrastructure	$30.1	$30.1	$13.8
General Fund Zero-Emission Vehicles and Infrastructure	Medium- and Heavy-Duty Zero-Emission Vehicles and Infrastructure	$208.0	-	-
General Fund Zero-Emission Vehicles and Infrastructure	Drayage	$80.75	$85.0	$80.0
General Fund Zero-Emission Vehicles and Infrastructure	Drayage and Infrastructure Pilot	$25.0	-	-
General Fund Zero-Emission Vehicles and Infrastructure	Transit	$28.5	$30.0	$30.0
General Fund Zero-Emission Vehicles and Infrastructure	School Bus	$19.0	$15.0	$15.0
Clean Transportation Program Zero-Emission Vehicles and Infrastructure	Hydrogen Fueling Infrastructure	$20.0	$20.0	$10.0 [3/]
General Fund Zero-Emission Vehicles and Infrastructure	Hydrogen Fueling Infrastructure	$27.0	-	-
Clean Transportation Program Alternative Fuel Production and Supply	Zero- and Near Zero-Carbon Fuel Production and Supply	$10.0	$10.0	$5.0
General Fund Manufacturing	ZEV Manufacturing	$118.75	$125.0	-
Clean Transportation Program Related Needs and Opportunities	Workforce Training and Development	$5.0	$5.0	$5.0
	Total Clean Transportation Program Fund	**$95.2**	**$95.2**	**$47.6**
	Total General Fund	**$747 [4/]**	**$255 [5/]**	**$125 [5/]**

Source: California Energy Commission.

1/ Subject to future Budget Act appropriations.

2/ The Clean Transportation Program is authorized through December 31, 2023; therefore, only half of the revenues/appropriations are anticipated in this fiscal year.

3/ The final column of proposed funding is a half year due to the program expiring in middle of the fiscal year.

4/ The FY 2021–2022 funding amount from the general fund is reduced by $38 million, which is the maximum administrative costs the CEC is authorized to incur associated with that funding. The CEC is working to minimize the administrative costs to the greatest extent possible and reserves the ability to use unused administrative costs to fund additional projects within each funding allocation. The anticipated general fund amounts in FY 2022–2023 and FY 2023–2024 have not been reduced to reflect administrative costs. Those fiscal year allocations will be reduced in accordance with direction in the associated Budget Act.

5/ Actual pass-through funding amounts resulting from future general fund allocations are expected to be reduced to cover CEC administrative expenses.

CHAPTER 1: Introduction

California has been at the forefront of national efforts to combat climate change since the passage of the Global Warming Solutions Act of 2006, which established a goal of reducing statewide greenhouse gas (GHG) emissions to 1990 levels by 2020.[1] Senate Bill 32 established a goal of 40 percent below 1990 levels by 2030.[2] Executive Order B-55-18 established a goal to achieve carbon neutrality as soon as possible, and no later than 2045, and achieve and maintain net negative emissions thereafter.[3]

The state's efforts against global climate change have begun to show progress, and in 2016, California achieved its goal of reducing GHG emissions to 1990 levels, four years ahead of schedule. Despite the overall reduction in GHG emissions, emissions from the transportation sector have increased over the last several years, as Californians purchased more light trucks (sport utility vehicles, pickups, and vans) instead of cars and drove more miles.[4] When including upstream emissions, the transportation sector is the largest source of GHG emissions in California, with vehicles, oil extraction, and oil refining accounting for roughly 50 percent of in-state emissions.[5]

In addition to greenhouse gases, the transportation sector is also a major emitter of criteria pollutants, with mobile sources responsible for nearly 80 percent of nitrogen oxide emissions and 90 percent of diesel particulate matter emissions statewide.[6] Protecting and improving public health in the state will require substantial reductions in criteria pollutant emissions. The California Air Resources Board (CARB) estimates that attaining federal air quality standards in 2023, 2024, 2031, and 2037 will require significant reductions of nitrogen oxide emissions in parts of the state.[7]

To help address state climate change and air quality objectives, the California Legislature passed Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007). This legislation created the

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1 Assembly Bill 32 (Núñez, Chapter 488, Statutes of 2006), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200520060AB32.

2 Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB32.

3 Executive Order B-55-18. September 10, 2018. Available at https://www.ca.gov/archive/gov39/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf.

4 California Air Resources Board. 2019. *California Greenhouse Gas Inventory for 2000-2017*. Available at https://ww2.arb.ca.gov/ghg-inventory-data.

5 California Air Resources Board. July 11, 2018. *California Greenhouse Gas Emission Inventory*. Available at https://www.arb.ca.gov/cc/inventory/data/data.htm.

6 California Air Resources Board. May 2016. *Mobile Source Strategy*. Available at https://www.arb.ca.gov/planning/sip/2016sip/2016mobsrc.pdf.

7 Ibid.

Clean Transportation Program (formerly known as the Alternative and Renewable Fuel and Vehicle Technology Program). With funds collected from vehicle and vessel registration, vehicle identification plates, and smog abatement fees, the Clean Transportation Program funds projects that will "transform California's fuel and vehicle types to help attain the state's climate change policies." Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) extended the collection of fees that support the Clean Transportation Program to January 1, 2024.

As part of the Clean Transportation Program, the California Energy Commission (CEC) prepares and adopts an annual Investment Plan Update that identifies the funding priorities for the coming fiscal year. The funding allocations reflect the potential for each alternative fuel and vehicle technology to contribute to the goals of the program, the anticipated barriers and opportunities associated with each fuel or technology, and the effect of other investments, policies, programs, and statutes. The Investment Plan Update also describes how the allocations will complement existing public and private efforts, including related state programs.

Moving Forward

This *2021–2023 Investment Plan Update* is the thirteenth investment plan in the history of the Clean Transportation Program and builds on the analyses and recommendations contained in prior documents. The Commission Report is the final version of the *2021–2023 Investment Plan Update*. As part of the development process for the *2021–2023 Investment Plan Update,* the CEC holds two public meetings with the Clean Transportation Program Advisory Committee. The first meeting was held April 29, 2021, and the second was held September 16, 2021. The advisory committee was reconstituted in early 2020 to include a broader representation of interests, better reflect California communities, and provide increased representation of program beneficiaries, environmental justice communities, rural communities, tribes, and others. Representatives from the advisory committee, other stakeholders, and the public are encouraged to discuss and comment on drafts of this document during these meetings and through the CEC's docket system.[8]

The unexpected conditions brought on by the COVID-19 pandemic will continue to impact CEC's near-term implementation of the Clean Transportation Program and related investment plan. Long-term Clean Transportation Program priorities remain the same, but the program must also play an immediate role in addressing job creation and economic recovery. Prioritizing investments in ZEV infrastructure, especially in the short term, can spur near-term employment and economic development.

Chapter 2 of this document provides the context for the current investment plan, including an update on the CEC's implementation of the Clean Transportation Program to date and a review of related policies and programs. Chapter 3 summarizes the funding allocations for FY 2021–2023. The subsequent chapters are organized by specific investment areas. Chapter 4 focuses

8 The Energy Commission's docket for the *2020–2021 Investment Plan Update for the Clean Transportation Program* (Docket #19-ALT-01) can be found at https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-ALT-01.

on zero-emission vehicles and the infrastructure necessary to support them. Chapter 5 addresses the types of opportunities for zero- and near-zero-emission fuel production and supply within California. Chapter 6 describes related opportunities to support the development and deployment of alternative fuels and advanced technology vehicles and supporting infrastructure.

CHAPTER 2:
Context of the 2021–2023 Investment Plan

Implementation of the Clean Transportation Program

Since the inception of the program, the CEC has followed a consistent approach toward implementing the Clean Transportation Program. Each annual Investment Plan Update allows the program to be responsive and can shift funds in response to gaps in investments by utilities, the private sector, and settlement agreements. As summarized in Figure 1, the process begins with an investment plan that determines the coming fiscal-year funding allocation for categories of projects.

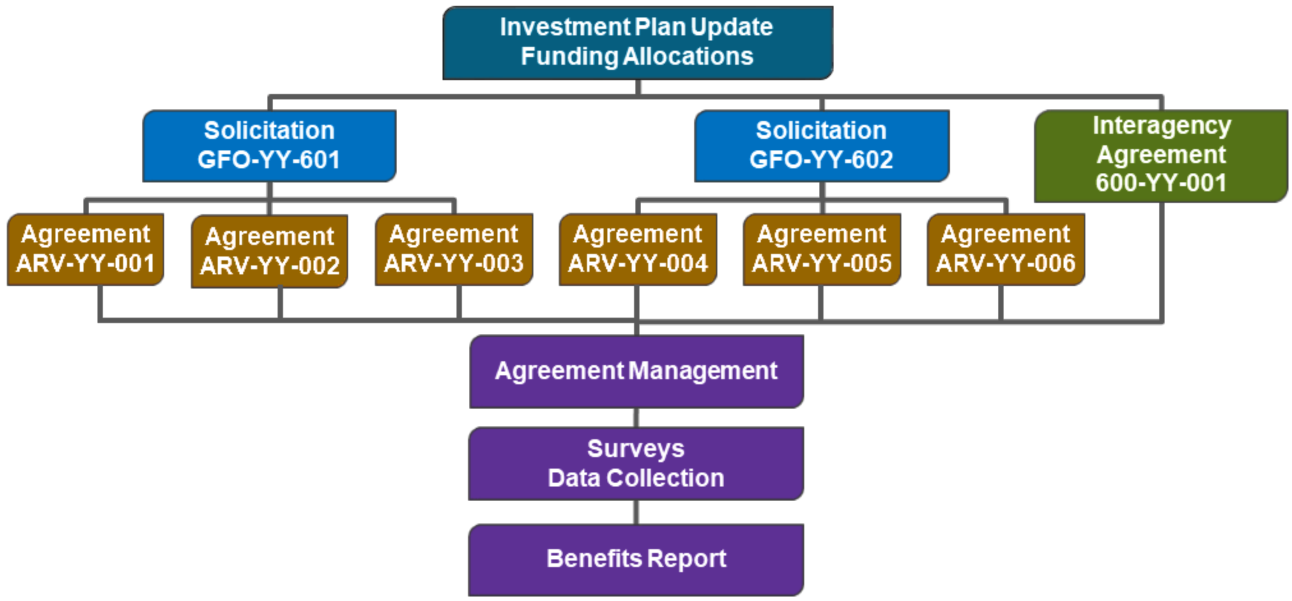
The funding allocations typically do not determine the specific funding solicitations and grant programs that will be issued. Rather, based on these funding allocations, the CEC subsequently issues a series of competitive solicitations, known as "grant funding opportunities" (GFOs).

CEC staff reviews, scores, and ranks the proposals for each solicitation using the evaluation criteria developed for the solicitation. Based on the total scores of each application, the CEC releases a notice of proposed awards (NOPA) for each solicitation. For specialized agreements with certain partner agencies, the CEC may develop interagency agreements without using the solicitation process.

Each funded application becomes a funding agreement once it has been approved and signed by the CEC and the applicant. CEC staff oversees completion of these agreements according to the respective schedules, budgets, scopes of work, and terms and conditions.

Data collection and project review are also key parts of the Clean Transportation Program implementation. The CEC surveys funding recipients on the anticipated results of their projects, with questions relating to alternative fuel use, petroleum displacement, GHG emission reductions, air quality benefits, and in-state economic benefits.

Figure 1: Schematic of the Clean Transportation Program Implementation



Source: California Energy Commission

Description of Funding Mechanisms

To date, the CEC has predominantly used grants to distribute funding, with awardees selected through competitive solicitations. As alternative fuels and technologies have matured in the marketplace, the CEC has also implemented other funding and financing mechanisms, when appropriate. Each of these mechanisms has respective strengths and weaknesses, and the CEC weighs these options when developing the funding implementation strategy for each allocation. The most prominent funding mechanisms used for the Clean Transportation Program by the CEC are described below.

- **Competitive Solicitation for Grants** — This type of solicitation represents the most common funding mechanism for the Clean Transportation Program to date. It is flexible, as project requirements and scoring criteria can be adapted for a broad variety of commercial and technological maturity levels. Competitive scoring allows increased scrutiny on key issues for each project type. However, it also requires significant time and attention to review each application and oversee each subsequent funding agreement.
- **Block Grants** — The CEC has used this funding mechanism to distribute Clean Transportation Program funding through other organizations such as local and regional governments, academic institutions, or nonprofit groups. Block grants allow the CEC to select another organization to administer Clean Transportation Program funding while following set procedures for project and applicant eligibility.
- **Revolving Loans** — CEC is embarking on an in-depth examination of one or more revolving loan programs to be administered by the California Infrastructure and Economic Development Bank (IBank) on CEC's behalf. Similar to block grants, IBank will

handle the operational aspects of the revolving loan program(s), while CEC provides the technical and market expertise to ensure the programs are successful.

- **First-Come, First-Served** — This type of funding mechanism has been used by the Clean Transportation Program for vehicle and infrastructure incentives. Once eligibility requirements are established, the funding can be administered relatively quickly and can provide greater market certainty for a project type.
- **Production or Operation Incentives** — The CEC has used these types of incentives for in-state ethanol production and hydrogen fueling station operation and maintenance. The primary aim of these incentives is to provide greater market certainty, which encourages further investment from nongovernment sources.
- **Direct Agreements** — The CEC may make a single-source award for applied research. The CEC may also enter into interagency agreements or contracts with public entities to obtain technical, scientific, or administrative services to support the Clean Transportation Program.
- **Federal Cost Sharing** — This mechanism will provide match funding support to applicants of federal funding opportunities.
- **Alternative Financing Mechanisms** — Pursuing innovative financing methods could increase private capital investment in projects that will be cofunded by the CEC's Clean Transportation Program. The CEC will explore pathways to redirect some projects to other financing options.

In general, the most important factor in considering the appropriate funding mechanism for an activity has been the technological and market maturity of the fuel or technology. Public subsidies, most commonly in the form of grants, are vital to advancing early-stage technologies because private financiers are often unwilling to accept the high risks associated with these projects. They are also key in targeting equity investments that may not be made by the private sector. As a technology or market matures, however, alternative financing mechanisms become a more effective method of support and can better leverage public funds with private financing.

Staff is exploring additional financing strategies. As part of the effort, CEC staff is coordinating with other state agencies, such as the California Governor's Office of Business and Economic Development (GO-Biz), IBank, and the California Pollution Control Financing Authority. CEC is also establishing a loan-funding working group with GO-Biz, IBank, and CEC staff to identify technology market segments that may be ready to shift from grants to loans, credit enhancements, and other funding support. This group will also assess the demand for debt programs, evaluate the level of Clean Transportation Program funding for loans, and make recommendations for Investment Plan Updates. For instance, funding from this or future Investment Plan Updates could be used to support a loan program administered by IBank.

Program Outreach and Engagement

The CEC seeks to increase the participation of disadvantaged and underrepresented communities from a diverse range of geographical regions. The CEC also seeks to effectively engage communities disproportionately burdened by pollution and improve economic resiliency, including rural and tribal communities. This effort includes:

- Diversifying the Clean Transportation Program Advisory Committee, as accomplished in 2020, to better reflect California communities and provide increased representation of program beneficiaries, environmental justice communities, rural communities, tribes, and others.
- Consulting with the Disadvantaged Communities Advisory Group[9] for guidance and recommendations on program effectiveness as it relates to disadvantaged communities and other vulnerable and underrepresented groups.
- Consulting with the CEC's Tribal Program and the Tribal Lead Commissioner for assistance with outreach and promotion of transportation-related funding opportunities to tribes.
- Hosting a presolicitation workshop on potential funding opportunities to provide light-duty charging infrastructure that can serve rural and multifamily housing residents.
- Assessing whether electric vehicle charging station infrastructure is disproportionately distributed as examined in the SB 1000 analysis. The first iteration of the *SB 1000 Electric Vehicle Charging Infrastructure Deployment Assessment* was published December 30, 2020. The major results were that electric vehicles and public chargers are collocated with populations and low-income communities have the fewest public chargers per capita. Analysis done this year shows that about half of Californians live within a five-minute drive from a public fast charger. Low-income communities have the widest range of drive times, with a significant number of communities having to drive more than 30 minutes to reach the nearest DCFC station. Rural areas have some of the longest drive times to a DCFC, of up to four hours. Staff will continue to analyze charger deployment to help inform Clean Transportation Program investments in charging infrastructure, including project and grant funding design. Further details of this analysis can be found in Chapter 4.

In addition to the above actions, the CEC has provided a scoring preference for projects located in or benefitting disadvantaged communities, as defined by the California Communities Environmental Health Screening Tool (CalEnviroScreen3.0).[10] These preferences have been used in recent Clean Transportation Program solicitations, where appropriate, and nearly half of site-specific Clean Transportation Program funding is located in or benefitting disadvantaged communities.

In 2020, the IDEAL Communities Partnership was launched through an agreement with the Foundation for California Community Colleges (FCCC). The FCCC provides disadvantaged communities outreach and engagement for the California Climate Investments (CCI), a cap-

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9 More information available on the Disadvantaged Communities Advisory Group Page. Available at https://www.energy.ca.gov/about/campaigns/equity-and-diversity/disadvantaged-communities-advisory-group.

10 The CalEnviroScreen 3.0 tool is available online from the California Office of Environmental Health Hazard Assessment at https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30.

and-trade program that helps fund clean technologies and innovative ways to reduce pollution, and is an equity implementation partner for CARB's Access Clean California.[11] The IDEAL Communities partnership will assess the development of a technical assistance program, conduct outreach and engagement with disadvantaged communities to better understand and support clean transportation, establish an IDEAL Student Ambassador Program, and conduct an IDEAL Community Forum for underrepresented communities to express their clean transportation needs.

Highlights of Investments

As of August 2021, the CEC has invested more than $1 billion in Clean Transportation Program funding. In many cases, projects are in progress, with ongoing siting, installation, construction, and demonstrations. Table 1 summarizes program investments, including the following highlights:

- Installed or planned 15,154 chargers for plug-in electric vehicles, including 4,277 at multi- and single-family homes, 155 for fleets, and 419 at workplaces; 8,454 public and shared private Level 2 and Level 1 chargers; and 1,601 public DC fast chargers and 248 Level 2 chargers along highway corridors and urban metropolitan areas.
- Created the California Electric Vehicle Infrastructure Project (CALeVIP) to provide streamlined Clean Transportation Program incentives for light-duty electric vehicle charging infrastructure.
- Funded 83 new or upgraded publicly available hydrogen-fueling stations, approval to fund an additional 73 stations based on deployment progress, funding availability, and Clean Transportation Program Investment Plan Update funding allocations, in addition to 23 privately funded stations under development, will help serve an emerging population of fuel cell electric vehicles. Once built, the 179 stations will exceed the 100 hydrogen-fueling stations called for by AB 8. As of November 2021, 52 hydrogen fueling stations were open retail in California.
- Developed retail fueling standards to enable hydrogen sales on a per-kilogram basis.
- Launched the nation's first commercial vehicle fleet incentive project titled "EnergIIZE Commercial Vehicles" to accelerate the deployment of infrastructure needed to fuel zero-emission trucks, buses, and equipment. The project will use a concierge-like model working directly with eligible applicants to help plan and fund the purchase of charging and hydrogen fueling infrastructure. The $50 million multiyear project will help communities most impacted by transportation-related pollution by meeting essential infrastructure needs.
- Funded 27 manufacturing projects supporting in-state economic growth and job creation, developing a supply chain for electric drive technology vehicles and infrastructure, and positioning businesses for growth and scale.
- Provided workforce training for more than 20,000 trainees and 277 businesses and invested in preparing workers for the clean transportation economy that lead to

11 Access Clean California, https://accesscleanca.org/.

sustainable wages and translate clean technology investments into sustained employment opportunities.

- Launched 71 projects to promote the production of sustainable, low-carbon alternative fuels within California, with a cumulative annual production capacity equivalent to more than 158 million gallons of diesel fuel. Most will use waste-based feedstocks, such as dairy manure and municipal solid waste, which have some of the lowest carbon intensity pathways recognized under the Low Carbon Fuel Standard (LCFS). The LCFS is a 2009 CARB regulation with a goal of reducing the overall carbon intensity of fuels within the transportation sector by 20 percent by 2030.
- Announced the availability of up to $7 million in grant funds for projects to design, engineer, construct, install, test, operate, and maintain a hydrogen plant in California that will produce 100 percent renewable hydrogen from in-state renewable resource(s). The facility, once constructed and operational, will be a source of 100 percent renewable hydrogen that will be used for transportation fuel. Projects will produce hydrogen that will meet California regulations when dispensed at the station for use in on-road fuel cell electric vehicles, both light-duty and medium-/heavy-duty.

Table 1: Clean Transportation Program Investments as of August 2021

Funded Activity	Cumulative Awards to Date (in Millions)*	# of Projects or Units
Alternative Fuel Production		
Biomethane Production	$67.86	26 Projects
Gasoline Substitutes Production	$26.94	14 Projects
Diesel Substitutes Production	$63.91	26 Projects
Renewable Hydrogen Production	$7.93	2 Projects
Alternative Fuel Infrastructure		
Electric Vehicle Charging Infrastructure**	$192.60	15,154 chargers
Hydrogen Fueling Infrastructure (Including Operations and Maintenance)	$166.82	83 Public Fueling Stations
Medium- and Heavy-Duty ZEV Infrastructure	$99.11	75 Projects
E85 Fueling Infrastructure	$3.61	21 Fueling Stations
Upstream Biodiesel Infrastructure	$3.98	5 Infrastructure Sites
Natural Gas Fueling Infrastructure	$24.11	70 Fueling Stations
Alternative Fuel and Advanced Technology Vehicles		
NG and Propane Vehicle Deployment, Hybrid and ZEV Deployment (Including CVRP, HVIP, and Low-Income Mobility Incentives), and Advanced Technology Freight and Fleet Vehicles	$250.40	14,516+ NG, Propane, Hybrid and ZEVs and 54 Demonstrations
Related Needs and Opportunities		
Manufacturing	$55.32	27 Manufacturing Projects
Workforce Training and Development	$33.33	20,000 Trainees
Fuel Standards and Equipment Certification	$3.90	1 Project
Sustainability Studies	$2.04	2 Projects
Regional Alternative Fuel Readiness	$24.15	55 Regional Plans
Centers for Alternative Fuels	$5.41	5 Centers
Technical Assistance and Program Evaluation	$17.52	n/a
Total	**$1.049 Billion**	**-**

Source: California Energy Commission. *Includes all agreements that have been approved at a CEC business meeting or are expected for business meeting approval following a notice of proposed award. For canceled and completed projects, includes only funding received. **Includes $176.68 million for the California Electric Vehicle Infrastructure Project to provide EV incentives throughout California, which will fund a yet-to-be-determined number of EV chargers.

Using funds from the Clean Transportation Program, the CEC has also leveraged the additional investment of more than $734 million in private and other public funds. However, this amount represents only the minimal, contractually obligated amount of match funding provided toward Clean Transportation Program projects; the actual amount of investment prompted by the Clean Transportation Program funding exceeds this amount.

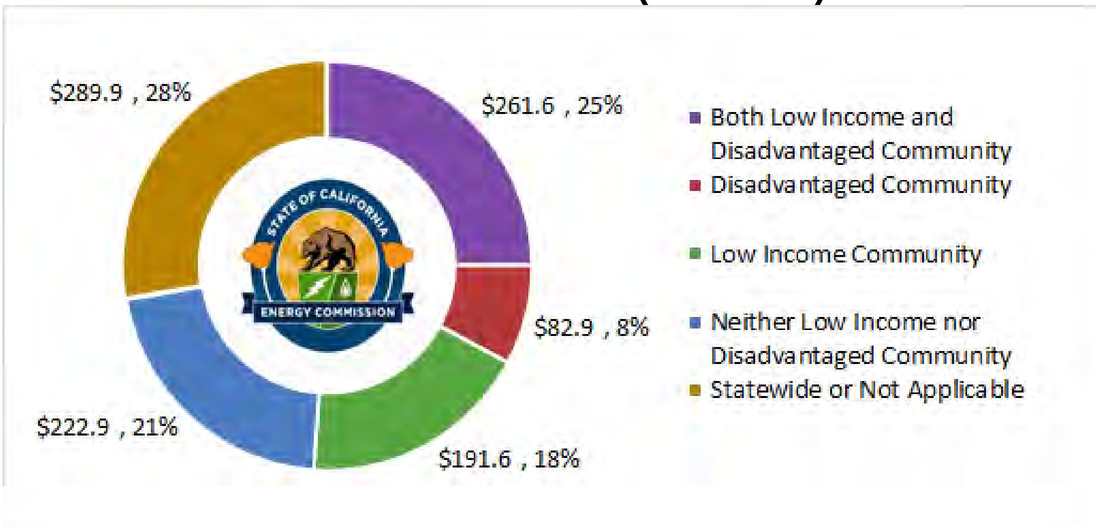
Summary of Program Funding for Disadvantaged Communities

The CEC seeks to increase participation and benefits to disadvantaged and underrepresented communities from a diverse range of regions in implementing the Clean Transportation Program. As depicted in Figure 2, roughly 51 percent of Clean Transportation Program project funding has gone into disadvantaged communities or low-income communities or both.[12] The CEC seeks to invest more than 50 percent of funding to support projects benefitting low-income and disadvantaged communities for the remainder of the Clean Transportation Program.

The CEC recognizes that the location of a project is not the only metric of whether a project will benefit low-income and disadvantaged communities. The CEC will continue to work with the Clean Transportation Program Advisory Committee, DACAG, communities, and stakeholders to define, measure, and track project benefits to increase program equity and inclusion. These efforts include engaging in partnerships with community-based organizations and community organizers in project scoping and grant applications. Efforts also include identifying new qualitative and quantitative metrics beyond project location to evaluate the effects of projects on local communities and continuing to work with other state and local agencies to share critical lessons and community needs.

12 New to this investment plan update, these funding percentages incorporate CARB's Priority Population Maps, which show disadvantaged communities and low-income communities as defined for California Climate Investments. This map provides a more precise geospatial analysis tool for finding which projects fell within low-income or disadvantaged communities' boundaries. Previous CEC analysis used older demographic data and less granular GIS mapping. In conjunction with the SB 1000 Report (published December 2020) analysis, the demographic data and mapping have been refined to provide more accurate mapping and better count low-income and disadvantaged communities investments.

Figure 2: Clean Transportation Program Funding in Disadvantaged and Low-Income Communities (in Millions)



Source: California Energy Commission. As of August 1, 2021.

Related Policies and Goals

The CEC's implementation of the Clean Transportation Program reflects the effect of numerous policies and goals. Table 2 highlights examples of the significant policy goals and milestones developed to address these issues, reduce emissions, and reduce petroleum use in California. CEC staff consulted with other state agencies and considered these policies when developing this Investment Plan Update.

Table 2: Greenhouse Gas, Fuel, and Air Quality Goals and Milestones

Policy Origin	Objectives	Goals and Milestones
Assembly Bill 32	GHG Reduction	Reduce GHG emissions to 1990 levels by 2020
Senate Bill 32	GHG Reduction	Reduce GHG emissions to 40 percent below 1990 levels by 2030
Executive Order B-55-18	GHG Reduction	Achieve carbon neutrality by 2045
Low Carbon Fuel Standard	GHG Reduction	Reduce carbon intensity of transportation fuels in California by 20 percent by 2030 Increase zero-emission vehicle infrastructure
Clean Air Act; California State Implementation Plans	Air Quality	80 percent reduction in NOx by 2031
Senate Bill 1275; Executive Order B-16-2012; Executive Order B-48-18; Executive Order N-79-20	Increase Zero-Emission Vehicles	Infrastructure to accommodate 1 million electric vehicles by 2020 1 million zero-emission and near-zero-emission vehicles by 2023 1.5 million electric vehicles by 2025 250,000 electric vehicle chargers, including 10,000 DC fast chargers, and 200 hydrogen fueling stations by 2025 5 million zero-emission vehicles by 2030 100% of new passenger cars and trucks will be ZEVs by 2035 100% of operating drayage trucks, off-road vehicles, and equipment will be ZEVs by 2035 100% of operating medium- and heavy-duty trucks and buses will be ZEVs by 2045
Zero-Emission Vehicle Regulation	Increase Zero-Emission Vehicles	Increase the deployment of plug-in hybrid, battery, and fuel cell electric vehicles
Innovative Clean Transit Regulation	Increase Zero-Emission Vehicles	100 percent of all new transit buses will be zero-emission by 2029; all operating buses will be zero-emission by 2040
Advanced Clean Trucks Regulation	Increase Zero-Emission Vehicles	Requires truck manufacturers to transition from diesel trucks and vans to zero-emission trucks beginning in 2024. By 2045, every new truck sold in California will be zero-emission.

Source: California Energy Commission

Federal Law: Clean Air Act, State Implementation Plans, and Mobile Source Strategy

The federal Clean Air Act of 1970 (42 U.S.C. 7401) authorizes the U.S. Environmental Protection Agency (U.S. EPA) to establish National Ambient Air Quality Standards (NAAQS) for criteria air pollutants that are harmful to public health. To achieve these standards, the Clean Air Act directs states to develop State Implementation Plans (SIPs) that describe how an area will attain the NAAQS.

CARB reports that 28 million Californians live in communities that exceed the ozone and particulate matter standards set by the U.S. Environmental Protection Agency (EPA) and that the South Coast and San Joaquin Valley are the only two areas in the nation in extreme nonattainment for the federal ozone standard. The concepts described in the *Draft 2020 Mobile Source Strategy* intend to address these problems through transitioning the mobile fleet to zero-emission, where feasible.[13]

State Laws

Assembly Bill 32, Senate Bill 32, and the Greenhouse Gas Reduction Fund

Assembly Bill 32 (Núñez, Chapter 488, Statutes of 2006), also known as the Global Warming Solutions Act of 2006, required CARB to adopt a statewide GHG emission limit for 2020 equivalent to the statewide GHG emission levels in 1990. Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016) amended the Global Warming Solutions Act of 2006 to expand the emission targets of AB 32. The amendment set a statewide GHG emission limit for 2030 equivalent to 40 percent below emission levels in 1990. AB 32 and SB 32 directed CARB to develop a climate change scoping plan to describe the approach that California will take to reduce GHG emissions and achieve the state's climate change goals. *California's 2017 Climate Change Scoping Plan*, published by CARB in November 2017, helped inform and guide the development of this Investment Plan Update.[14]

Senate Bill 350 and the Disadvantaged Communities Advisory Group

SB 350, the Clean Energy and Pollution Reduction Act of 2015, requires that the CPUC and the CEC create a Disadvantaged Communities Advisory Group (DACAG) to advise on programs proposed to achieve clean energy and pollution reduction.

At a June 21, 2019, meeting of the DACAG, Clean Transportation Program staff solicited feedback on the March 27, 2019, draft of the *2019–2020 Investment Plan Update* from the DACAG members.[15] In response, the DACAG provided comments on the *2019–2020 Investment Plan Update* on June 28, 2019.[16] These comments included recommendations on how the *2019–2020 Investment Plan Update* can effectively benefit communities disproportionately burdened by pollution and socioeconomic challenges. On April 16, 2020, DACAG provided comments on the *2020–2023 Investment Plan Update.*[17] Recommendations

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13 Draft 2020 Mobile Source Strategy is available at https://ww2.arb.ca.gov/sites/default/files/2020-11/Draft_2020_Mobile_Source_Strategy.pdf.

14 California Air Resources Board. November 2017. *California's 2017 Climate Change Scoping Plan*. Available at https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf. CARB is in the process of developing the 2022 Scoping Plan Update.

15 DACAG meeting materials available at https://www.cpuc.ca.gov/DACAG/. The previous version of this Investment Plan Update (Lead Commissioner Report version) is available at https://www.energy.ca.gov/altfuels/2018-ALT-01/documents/.

16 SB 350 Disadvantaged Communities Advisory Group. June 28, 2019. "SB 350 Disadvantaged Communities Advisory Group Comments on 2019-2020 Investment Plan Update." Submitted to Docket 18-ALT-01, TN# 228878. Available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=228878&DocumentContentId=60238.

17 SB 350 Disadvantaged Communities Advisory Group, "SB 350 Disadvantaged Communities Advisory Group comments on 2020-2023 Investment Plan Update," written on April 16, 2020, and submitted April 30, 2020, to Docket 19-ALT-01, TN# 232879. Available at https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-ALT-01.

from both DACAG letters are included in Table 3, along with actions taken by the Clean Transportation Program to better address equity. Members of the Clean Transportation Program Advisory Committee (newly reconstituted in 2020 to include greater representation from community and equity groups as well as other stakeholders), DACAG, and others will also have the opportunity to provide recommendations for the *2021–2023 Investment Plan Update,* as well as all future investment plans.

Table 3: Recommendations From the Disadvantaged Communities Advisory Group and Others, Along With the Actions Taken by the Energy Commission

Recommendations From DACAG	Actions Taken by CEC
Moving 100 percent of program funding toward zero-emission fuels.	The Clean Transportation Program is supporting the emerging revolution in the transportation sector with significant investments in zero-emission vehicle infrastructure (both battery-electric and hydrogen fuel cell). Relative to previous Investment Plans, recent allocations have shifted significantly toward zero-emission fuels and technologies relative to non-zero-emission alternatives.
Funding projects exclusively in and benefiting disadvantaged communities.	Committed 50 percent of funding to support projects benefitting low-income and disadvantaged communities for the remainder of the Clean Transportation program. Working to better define, measure, and track community benefits from the Clean Transportation Program.
Expanding the definition of disadvantaged communities beyond the CalEnviroScreen definition.	Expanded solicitation eligibility to explicitly include California Native American tribes. Through the CEC's CALeVIP program, some projects will require 25% of funds be spent in unincorporated towns, and 50% of funds be spent in low-income and/or disadvantaged communities.
Increasing transparency and tracking expanded metrics to measure how projects "benefit" disadvantaged communities.	CEC staff continues to work with the CEC's Public Advisor's Office to inform and receive input from DACAG during solicitation development. The CEC is also expanding focus and methods used in the biennial Benefits Report, including documentation of 1) benefits for underrepresented communities and 2) air quality impacts and associated health outcomes.
Prioritizing and investing in community outreach and engagement.	1) Explicit inclusion of scoring criteria for drayage truck projects located in disadvantaged communities and low-income communities and development of an equity outreach and engagement plan[18] and 2) Established the IDEAL Communities Partnership focused on community engagement activities such as the establishment of technical assistance, conduct a ZEV Community Survey and Outreach Forum, and implement a ZEV Student Ambassador Program in partnership with the Foundation for California Community Colleges.

18 GFO-20-606 Zero-Emission Drayage Truck and Infrastructure Pilot Project: https://www.energy.ca.gov/solicitations/2020-11/gfo-20-606-zero-emission-drayage-truck-and-infrastructure-pilot-project.

Expanding support for workforce development.	Dedicated Clean Transportation Program funding allocations that will expand workforce development beyond investments in state entities to include community-based workforce training and development in and near ZEV deployments in priority communities. The IDEAL ZEV Workforce Pilot is a new CEC community-based workforce initiative where CARB is a partner and is contributing $1 million.
Expanding the Clean Transportation Program Advisory Committee to increase representation of program beneficiaries, environmental justice communities, rural communities, tribes, and others.	Reconstituted and diversified the Clean Transportation Program Advisory Committee in 2020 to better reflect California communities and provide increased representation of program beneficiaries.
Prioritize investments in the medium- and heavy-duty vehicle category and target disadvantaged communities.	Funding allocation for this activity will increase dramatically after Fiscal Year 2021–2022 to meet the growing needs of charging and hydrogen fueling infrastructure for medium- and heavy-duty ZEVs, as well as demonstrate the state's commitment to improving air quality, especially in low-income and disadvantaged communities.

Source: California Energy Commission

Assembly Bill 841: Electric Vehicle Infrastructure Training Program

The Electric Vehicle Infrastructure Training Program (EVITP) is "a collaboration of industry stakeholders including automakers, electric vehicle supply equipment (EVSE) manufacturers, educational institutions, utility companies, electric industry professionals, and key EV industry stakeholders."[19] Assembly Bill 841 (Ting, Chapter 372, Statutes of 2020) requires that at least 25 percent of total installation crew members of any state-funded electric vehicle charging infrastructure be certified under the EVITP. As part of AB 841, the CEC, in consultation with the CPUC, is tasked with conducting joint public workshops to determine if the EVITP curriculum and testing should be supplemented to include updated or additional topics necessary to ensure safe installation of charging infrastructure. The CEC, CARB, and CPUC held a public workshop April 16, 2021, and solicited public comments. The CEC is using the findings from the workshop and public comment to determine if the EVITP curriculum should be supplemented, and EVITP will have six months to implement the supplemented curriculum.

Executive Orders (EO)

EO B-55-18: Carbon Neutrality

EO B-55-18 established a goal to achieve carbon neutrality, or achieving net-zero carbon dioxide emissions, as soon as possible and no later than 2045. The executive order also requires the state to achieve and maintain net negative greenhouse gas emissions thereafter.

EO B-16-12, B-48-18, and N-79-20: Zero-Emission Vehicles

19 Electric Vehicle Infrastructure Training Program is available at https://evitp.org/about-us/.

EO B-16-12 set a target of 1.5 million zero-emission vehicles on the road by 2025 and tasked various state agencies with specific actions needed to support this goal.[20] Subsequently, in January 2018, EO B-48-18 set an expanded target of 5 million zero-emission vehicles on the road by 2030, as well as a network of 200 hydrogen fueling stations and 250,000 electric vehicle charging stations, including 10,000 DC fast chargers, installed or constructed by 2025.[21] These executive orders have been part of the guidance for the electric vehicle charging and hydrogen fueling infrastructure investments of the Clean Transportation Program to date.

Executive Order N-79-20, signed by Governor Gavin Newsom on September 23, 2020, provides even more ambitious goals and requirements. These include 100 percent of in-state sales of passenger cars and trucks being ZEVs by 2035; 100 percent of operating medium- and heavy-duty vehicles being ZEVs by 2045, where feasible; and 100 percent of drayage trucks and off-road vehicles and equipment being ZEVs by 2035. The order also tasks CEC with providing an updated assessment of the infrastructure needed to support this level of ZEV adoption.

To meet the ambitious statewide targets set in Executive Order N-29-20, Governor Newsom tasked the Governor's Office of Business and Economic Development (GO-Biz) with collaborating with several agencies and partners to shepherd the administration's ZEV Market Development Strategy. The *California Zero-Emission Vehicle Market Development Strategy*[22] was published in February 2021 and is part of the ongoing effort to turn California's 100 percent ZEV vision into reality. The strategy is centered around four market pillars: vehicles, infrastructure, end users, and workforce. The pillars must all be fully supported and are built upon a foundation of five core principles: equity in every decision, embracing all zero-emission pathways, collective problem-solving, public actions driving greater private investment, and designing for system resilience and adaptability. GO-Biz continues to work with the CEC, CARB, and other state agencies through this process to determine what actions can be taken to meet ZEV market goals and anticipates sharing additional information on its website moving forward.[23]

Regulations by the California Air Resources Board

Low Carbon Fuel Standard

CARB adopted the Low Carbon Fuel Standard (LCFS) regulation in April 2009 with a goal of reducing the overall carbon intensity of fuels within the transportation sector by 20 percent by 2030. The LCFS sets a carbon intensity standard (or benchmark) that declines each year.

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20 Executive Order B-16-12 available at https://www.ca.gov/archive/gov39/2012/03/23/news17463/index.html.

21 Executive Order B-48-18 available at https://www.ca.gov/archive/gov39/2018/01/26/governor-brown-takes-action-to-increase-zero-emission-vehicles-fund-new-climate-investments/index.html.

22 The California Zero-Emission Vehicle Market Development Strategy is available at https://static.business.ca.gov/wp-content/uploads/2021/02/ZEV_Strategy_Feb2021.pdf.

23 Zero-Emission Vehicle Market Development Strategy is available at https://business.ca.gov/industries/zero-emission-vehicles/zev-strategy/.

Providers of low-carbon fuels earn credits under the LCFS by producing fuels with a carbon intensity below the annual carbon intensity standard.

LCFS credits and deficits are denominated in metric tons of carbon dioxide equivalent (CO_2e). Credit prices reached all-time highs in 2019 and 2020, ranging from a low of $22 in May 2015 to a high of $206 in February 2020.[24] Prices remained near $200 through February 2021.

In September 2018, CARB adopted changes to the LCFS regulations that will benefit ZEVs and ZEV infrastructure. The amendments allow publicly accessible hydrogen fueling stations to earn hydrogen fueling infrastructure credits based on the capacity of the station. The amendments also provide credits for DC fast-charging equipment based on the power rating of the equipment. On the vehicle side, the amendments also restructure the approach for providing PEV rebates through utilities at the time of purchase, funded through LCFS credit proceeds. The vehicle program is known as the Clean Fuel Reward (CFR).

Zero-Emission Vehicle Regulation

CARB's Advanced Clean Cars program consists of a suite of regulations for reducing emissions from the state's light-duty fleet. One element of the Advanced Clean Cars program is the ZEV Regulation, which requires auto manufacturers to offer for sale specific numbers of the cleanest cars available, including full battery-electric vehicles, hydrogen fuel cell electric vehicles, and plug-in hybrid electric vehicles. CARB is working on updates to the ZEV Regulation under the Advanced Clean Cars II rulemaking, which will look at regulatory actions beyond 2025 that help ensure zero- and near-zero-emission technology options continue to grow in the market and are accessible to all consumers.

Innovative Clean Transit Regulation

The Innovative Clean Transit Regulation[25] was adopted in December 2018 to replace the Fleet Rule for Transit Agencies. The regulation requires all public transit agencies to transition gradually to a 100-percent zero-emission bus fleet and encourages them to provide innovative first- and last-mile connectivity and improved mobility for transit riders.

Within California, trucks are the largest source of air pollution among all vehicles, responsible for one-third of statewide oxides of nitrogen (NO_x) emissions and 25 percent of statewide diesel particulate matter (PM) emissions, despite numbering only 2 million among the 30 million registered vehicles in the state. To address this sector, on June 25, 2020, CARB adopted a first-in-the-world rule requiring truck manufacturers to transition trucks and vans toward zero-emission technologies beginning in 2024.[26]

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24 California Air Resources Board. April 2021. *LCFS Monthly Credit Price and Transaction Volumes Spreadsheet.* Available at https://www.arb.ca.gov/fuels/lcfs/dashboard/creditpriceserieswithoutargusopis.xlsx.

25 California Air Resources Board Innovative Clean Transit. Available at https://ww2.arb.ca.gov/our-work/programs/innovative-clean-transit/about.

26 California Air Resources Board. California Takes Bold Step to Reduce Truck Pollution. Available at https://ww2.arb.ca.gov/news/california-takes-bold-step-reduce-truck-pollution.

Complementary Funding Programs

California Energy Commission's School Bus Replacement Program

In the November 2012 California general election, voters approved Proposition 39 to improve energy efficiency and expand clean energy generation in schools and community colleges. Senate Bill 110 (Committee on Budget and Fiscal Review, Chapter 55, Statutes of 2017) allocated funds from the implementation of Proposition 39 to improve energy efficiency at California schools. The energy efficiency measures in SB 110 include one-time funding of $75 million for the retrofit or replacement of school buses.

The CEC administers this funding, and priority is given to school districts operating the oldest and most polluting diesel school buses, as well as to school buses operating in disadvantaged and low-income communities. The $75 million in funding provided by SB 110 is being used exclusively for the purchase of battery-electric school buses, and this amount is being supplemented with more than $14 million in Clean Transportation Program funds to provide the necessary charging infrastructure to operate the buses.

California Air Resources Board Funding Programs

In addition to the CEC's Clean Transportation Program, AB 118 also created the Air Quality Improvement Program (AQIP), which CARB administers. The CEC and CARB have complementary responsibilities, with CARB serving as the lead agency on ZEV deployment and the CEC as the lead agency on ZEV fueling infrastructure and vehicle-grid integration. Coordination between agencies continues to be paramount to ensure strategic use of limited state funds. Since 2009, AQIP has provided deployment incentives for light-duty electric vehicles through the Clean Vehicle Rebate Project (CVRP); deployment incentives for alternative medium- and heavy-duty vehicles through the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP); the Truck Loan Assistance Program, which helps small business truckers to secure financing for newer trucks to meet compliance deadlines; as well as funding for other advanced emission-reduction vehicle technologies for vehicles.

CARB also distributes Greenhouse Gas Reduction Fund (GGRF) capital through its Low Carbon Transportation Investments. The Legislature appropriated more than $2.1 billion to CARB for Low Carbon Transportation Investments between 2013 and 2019. Projects initially funded by AQIP, such as CVRP, are now funded by Low Carbon Investments because demand has exceeded available funding from AQIP.

In December 2020, CARB approved the *Proposed FY 2020–21 Funding Plan for Clean Transportation Incentives* that included $28.64 million in clean transportation investments from AQIP, of which $25 million is dedicated to HVIP. CARB's recommendations for AQIP allocations focused on determining which projects most critically needed an immediate influx of funding. The Heavy-Duty Investment Strategy and the Three-Year Plan for CVRP, ZEV Market, Clean Transportation Equity Investments, and Outreach played key roles in this assessment. CARB also considered which projects have funds allocated in previous fiscal years remaining, other available funding sources, and stakeholder input.

Table 4: FY 2019–2020 and FY 2020–2021 CARB Clean Transportation Incentives Allocations

Project Category	Funding Allocation (in Millions)
Low Carbon Transportation Vehicle Purchase Incentives and Clean Mobility Projects	
Clean Vehicle Rebate Project	$238.0
Clean Transportation Equity Projects	$55.5
Low Carbon Transportation Heavy-Duty and Off-Road Equipment Investments	
Clean Truck and Bus Vouchers (HVIP)	$119.9
Heavy-Duty Advanced Technology Demonstration and Pilot Projects	$33.9
AQIP Investments	
Clean Truck and Bus Vouchers (HVIP)	$25.0*
Clean Cars 4 All	$3.0*
Truck Loan Assistance Program	$48.0

Source: California Air Resources Board. *FY 2020–2021 Funding Plan

For FY 2021-22, the state budget includes $1.5 billion in ZEV Package funding appropriated to CARB to accelerate an equitable ZEV transition in the light-duty and heavy-duty sectors. CARB is developing the FY 2021-22 Funding Plan for Clean Transportation through a public process. The plan will describe CARB's proposed investments and is slated for board consideration in late 2021.

Investor-Owned Utility Investments in Electric Vehicle Charging Infrastructure

In 2014, the CPUC adopted Decision 14-12-079 to allow consideration of utility ownership of electric vehicle charging stations and infrastructure on a case-specific basis. Subsequently, the CPUC approved infrastructure pilot programs for Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric Company (SDG&E), and Southern California Edison (SCE) to install a total of up to 12,500 charging stations with initial budgets up to $197 million.[27] In December 2018, the CPUC approved $22 million in bridge funding for the Charge Ready Pilot to build at least 1,000 more Level 2 chargers. In August 2020, the CPUC approved SCE's Charge Ready 2 infrastructure program, with a $436 million budget that will fund about 38,000 electric vehicle chargers in the utility's service territory. In April 2021, the CPUC approved SDG&E's Power Your Drive Extension Program for $43.5 million that will fund nearly 2,000 electric vehicle chargers.

27 California Public Utilities Commission. Decisions (D.)16-01-023, D.16-01-045, and D.16-12-065. Available at http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442454831.

Assembly Bills 1082 (Burke, Chapter 637, Statutes of 2017) and 1083 (Burke, Chapter 638, Statutes of 2017) allowed, but did not require, the utilities to file applications to support charging infrastructure at schools and state parks and beaches. In late 2019, the CPUC approved a total of $54.5 million for eight pilot programs to install up to 800 charging ports at parks, beaches, and schools. The utilities are working on finalizing program designs for the two-year pilot programs with expected launch in 2021.

Much of the CPUC's current ZEV work is focused on Senate Bill 350 implementation. The CPUC directed the six investor-owned electric utilities under the CPUC's jurisdiction to propose portfolios of transportation electrification programs and investments. To date, the CPUC has authorized about $774 million in ratepayer spending on Senate Bill 350 transportation electrification programs.

Volkswagen Diesel Emissions Settlement

California received about $423 million from the Volkswagen Environmental Mitigation Trust for projects to reduce the lifetime excess NO_X emissions caused by illegal devices installed in certain 2.0- and 3.0 liter-diesel vehicles to defeat emissions tests. In May 2018, CARB approved a Beneficiary Mitigation Plan outlining how these funds will be spent.[28] In addition, Volkswagen has an $800 million ZEV Investment Commitment in the state and must offer and sell additional battery-electric vehicle models in California between 2019 and 2025.

California's Beneficiary Mitigation Plan includes five funding categories: $130 million for zero-emission transit, school, and shuttle buses; $90 million for zero-emission Class 8 freight and drayage trucks; $70 million for zero-emission freight and marine projects; $60 million for combustion freight and marine projects; and $10 million for ZEV infrastructure for light-duty vehicles. California's three largest air districts are administering these projects statewide. The first instalment from each project category has been made available starting with the release of zero-emission bus money in fall 2019.

Volkswagen's $800 million ZEV Investment Commitment will occur over a 10-year period. Eligible projects include the design, planning, construction, and operation and maintenance of fueling infrastructure for plug-in electric vehicles and hydrogen fuel cell electric vehicles; brand-neutral education and public outreach to increase consumer awareness of ZEVs; programs or actions to increase public exposure or access or both to ZEVs without requiring a consumer purchase or lease (for example, car-share and ride-hail services); and two "Green City" initiatives that may include the operation of ZEV car-sharing services, transit applications, and freight transport projects. Volkswagen has submitted the first three of four 30-month, $200 million ZEV investment plans to CARB for approval. In June 2021, CARB approved Electrify America's third 30-month ZEV Investment Plan, which will begin January 1, 2022.

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28 California Air Resources Board. June 2018. *Beneficiary Mitigation Plan for the Volkswagen Environmental Mitigation Trust.* Available at https://ww2.arb.ca.gov/resources/documents/californias-beneficiary-mitigation-plan.

CHAPTER 3: Funding Allocations for 2021–2023

The funding allocations for FY 2021–2022, and the projected funding allocations for subsequent fiscal years, are outlined in Table 5. For FY 2021–2022, $95.2 million of Clean Transportation Program funds may be available for the purposes described in this Investment Plan Update. If a different amount of funding is available, the allocations in this document may be amended either before or after final adoption. On July 12, 2021, Governor Gavin Newsom approved Senate Bill 129 — the Budget Act of 2021 (Skinner, Chapter 69, Statutes of 2021),[29] which includes $785 million to be administered by the CEC. The additional funds will help close funding gaps in infrastructure deployment, accelerate charging and hydrogen fueling station deployment, and promote instate ZEV and ZEV-related manufacturing, including infrastructure manufacturing and ZEV components.

The investments will help the markets for zero-emission vehicles and infrastructure grow to scale and, more importantly, serve as a foundation for an equitable and sustainable economic recovery by drawing private investments to California and creating jobs in manufacturing, construction, and engineering. The increased funds will create jobs and invest in ZEV refueling infrastructure for passenger vehicles, big rigs, port equipment, transit, and school buses while supporting more domestic ZEV manufacturing. These investments will allow California to the lead the nation and pave the way to a cleaner, more healthful transportation system.

The CEC will seek to provide 50 percent of Clean Transportation Program funds toward projects that benefit low-income and disadvantaged communities, and will continue to investigate new metrics to ensure these investments enhance equity within the state.

As shown in Table 5, the CEC directs investments in light-duty ZEVs for Fiscal Years 2021–2022 and 2022–2023 to narrow the charging and hydrogen refueling gaps as described in earlier analysis, with further depth later in this report. In parallel, the CEC will also concentrate significant investments toward medium- and heavy- duty zero-emission vehicles and infrastructure for battery-electric and hydrogen fuel cell electric technologies.

Table 5 shows an allocation of about $317 million to support light-duty passenger vehicles and about $391 million to support medium- and heavy-duty vehicles in FY 2021–2022. During the full three-year allocation represented in the table, the funding would total nearly $382 million to support light-duty passenger vehicles and about $695 million to support medium- and heavy-duty vehicles. Relative to the prior revised staff report version of the *2021–2023 Investment Plan Update*, this represents a one-time shift of $18 million toward medium- and heavy-duty ZEV infrastructure, in recognition of the need to swiftly transition the most polluting vehicles toward zero-emission technologies in the most sensitive regions of the state.

The following chapters describe each funded activity.

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29 Senate Bill 129 (Skinner, Budget Act of 2021) is available at https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220SB129.

Table 5: Investment Plan Allocations for FY 2021–2022 and Subsequent Fiscal Years (in Millions)

Category	Funded Activity	2021-2022	2022-2023 [1/]	2023-2024 [1/ 2/]
Clean Transportation Program Zero-Emission Vehicles and Infrastructure	Light-Duty Electric Vehicle Charging Infrastructure and eMobility	$30.1	$30.1	$13.8
General Fund Zero-Emission Vehicles and Infrastructure	Light-Duty Electric Vehicle Charging Infrastructure	$240.0	-	-
Clean Transportation Program Zero-Emission Vehicles and Infrastructure	Medium- and Heavy-Duty Zero-Emission Vehicles and Infrastructure	$30.1	$30.1	$13.8
General Fund Zero-Emission Vehicles and Infrastructure	Medium- and Heavy-Duty Zero-Emission Vehicles and Infrastructure	$208.0	-	-
General Fund Zero-Emission Vehicles and Infrastructure	Drayage	$80.75	$85.0	$80.0
General Fund Zero-Emission Vehicles and Infrastructure	Drayage and Infrastructure Pilot	$25.0	-	-
General Fund Zero-Emission Vehicles and Infrastructure	Transit	$28.5	$30.0	$30.0
General Fund Zero-Emission Vehicles and Infrastructure	School Bus	$19.0	$15.0	$15.0
Clean Transportation Program Zero-Emission Vehicles and Infrastructure	Hydrogen Fueling Infrastructure	$20.0	$20.0	$10.0 [3/]
General Fund Zero-Emission Vehicles and Infrastructure	Hydrogen Fueling Infrastructure	$27.0	-	-
Clean Transportation Program Alternative Fuel Production and Supply	Zero- and Near Zero-Carbon Fuel Production and Supply	$10.0	$10.0	$5.0
General Fund Manufacturing	ZEV Manufacturing	$118.75	$125.0	-
Clean Transportation Program Related Needs and Opportunities	Workforce Training and Development	$5.0	$5.0	$5.0
	Total Clean Transportation Program Fund	**$95.2**	**$95.2**	**$47.6**
	Total General Fund	**$747** [4/]	**$255** [5/]	**$125** [5/]

Source: California Energy Commission.

1/ Subject to future Budget Act appropriations.

2/ The Clean Transportation Program is authorized through December 31, 2023; therefore, only half of the revenues/appropriations are anticipated in this fiscal year.

3/ The final column of proposed funding is a half year due to the program sunsetting in middle of the fiscal year.

4/ The FY 2021–22 funding amount from the general fund is reduced by $38 million, which is the maximum administrative costs the CEC is authorized to incur associated with that funding. The CEC is working to minimize the administrative costs to the greatest extent possible and reserves the ability to use unused administrative costs to fund additional projects within each funding allocation. The anticipated general fund amounts in FY 2022–2023 and FY 2023–2024 have not been reduced to reflect administrative costs. Those fiscal year allocations will be reduced in accordance with direction in the associated Budget Act.

5/ Actual pass-through funding amounts resulting from future general fund allocations are expected to be reduced to cover CEC administrative expenses.

CHAPTER 4: Zero-Emission Vehicles and Infrastructure

The mass adoption of zero-emission vehicles (ZEVs), including plug-in electric vehicles (PEVs) and fuel cell electric vehicles (FCEVs), is critical to California's decarbonization goals, air quality standards goals, and petroleum reduction goals.

The expansion of ZEVs will depend on the availability of fueling infrastructure that meets consumers' needs and expectations. In recognizing this dependence, Executive Order B-48-18 also set goals for installing 250,000 electric vehicle chargers (including 10,000 DC fast chargers) and 200 hydrogen fueling stations by 2025.

To meet the ambitious statewide targets set in Executive Order N-79-20, GO-Biz published the *California Zero-Emission Vehicle Market Development Strategy* [30] in February 2021. The ZEV Strategy is a multiagency, partner, and stakeholder collaboration and is an ongoing effort to turn California's 100 percent ZEV vision into reality. The strategy focuses on the opportunities and priorities to build the infrastructure network, bring more vehicle types to market in all vehicle classes and applications, increase economic development and high-road jobs, build a skilled workforce, and enable consumers and fleets to adopt ZEVs.

Every year, each state agency will submit a brief action plan to GO-Biz, setting the priorities under their ZEV strategy objectives and communicating key equity strategies that the agency is seeking to implement, advance, or improve. On March 15, 2021, the CEC submitted its state agency action plan.[31] This plan includes efforts to expand charging and hydrogen fueling infrastructure, vehicle-grid integration, and planning for resilient transportation systems powered by renewable energy. The plan also includes funding research, development, and deployment of next-generation ZEV technologies and investments in ZEV-related manufacturing.

The CEC is the lead agency on ZEV infrastructure investment and analysis and will catalyze the development and deployment of economically and environmentally sustainable ZEV infrastructure, with focus on gaps in access for California's most impacted communities. The CEC investments will enable and leverage private sector investment in ZEV infrastructure.

Light-Duty Electric Vehicle Charging Infrastructure

Cumulative sales of PEVs, which include battery-electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), are growing rapidly in California, with more than 800,000 cumulative

30 The California Zero-Emission Vehicle Market Development Strategy is available at https://static.business.ca.gov/wp-content/uploads/2021/02/ZEV_Strategy_Feb2021.pdf.

31 The CEC's action plan, along with those of other agencies, is available at https://static.business.ca.gov/wp-content/uploads/2021/03/CEC-ZEV-Action-Plan.pdf.

sales at the end of 2020.[32] These sales account for about half of the PEVs sold in the United States.

Quantifying Charging Infrastructure for Light-Duty Vehicles

To track progress toward the state's 2025 goal, the CEC conducts quarterly surveys, starting in July 2020, to obtain combined counts of public- and shared-access chargers existing within California. The CEC also tracks recent and proposed charging infrastructure investments of the Clean Transportation Program and other key state funding mechanisms. Table 6 below provides estimates of the existing number of public or shared Level 2 and DC fast chargers within the state as of December 2020. The table also provides estimates of the number of chargers to be installed from allocated or upcoming Clean Transportation Program funds, as well as the number of connectors to be installed based on announced plans from other major funding programs. Finally, the table summarizes the estimated shortfall in charging infrastructure relative to the goals of Executive Order B-48-18. This estimate does not consider the additional funding from the ZEV Package under Senate Bill 129 — Skinner Budget Act of 2021, which provides light-duty electric vehicle charging infrastructure funding with the purpose of reducing the shortfall to the goal.

Table 6: Progress Toward 250,000 Chargers by 2025

	Level 2 Chargers	**DC Fast Chargers**
Existing Chargers (Estimated)*	66,770	6,008
Anticipated Chargers for Which Funding Has Been Allocated (including anticipated funding from Clean Transportation Program)**	118,950	3,607
Total	185,720	9,615
2025 Goal (Executive Order B-48-18)	*240,000*	*10,000*
Gap From Goal	54,280	385

Source: California Energy Commission. Analysis as of July 2021. *Existing charging ports estimated based on available data from U.S. Department of Energy's Alternative Fuels Data Center surveys to electric vehicle network service providers, utilities, and public agencies in California. Not included in this table are an estimated 665 statewide public or shared-private Level 1 chargers. **Derived from public presentations and statements by utilities, California Public Utilities Commission, CARB, other entities, and the CEC, including an estimated 2,000 Level 2 chargers pending CPUC approval from San Diego Gas & Electric. Does not include funding for new charging infrastructure under State Budget Act of 2021.

As indicated in the final row of Table 6, CEC staff estimates that there is a sizable gap (more than 54,600) between the number of charging connectors needed in 2025 and the number of expected charging connectors available that year.

32 Based on CEC staff analysis of data from the California Department of Motor Vehicles. Cumulative PEV sales through end of 2020 (regardless of vehicle status) were estimated at more than 800,000.

Light-Duty Vehicle Findings From the *AB 2127 Electric Vehicle Charging Infrastructure Assessment*

Assembly Bill 2127 (Ting, Chapter 365, Statutes of 2018) requires the CEC, working with CARB and the CPUC, to prepare and update biennially a statewide assessment of the electric vehicle charging infrastructure. The assessment must focus on the number and types of charging infrastructure needed to support levels of electric vehicle adoption required for the state to meet its goals of deploying at least 5 million ZEVs on California roads by 2030 and reducing emissions of GHGs to 40 percent below 1990 levels by 2030. The assessment will also provide the CEC direction on charging infrastructure priorities that relate to special location types, such as ports, airports, and railyards. Executive Order N-79-20 directs the CEC to update the AB 2127 statewide assessment to evaluate the ZEV infrastructure needed to meet the new targets.

The inaugural *Assembly Bill 2127 Electric Vehicle Charging Infrastructure Assessment — Analyzing Charging Needs to Support Zero-Emission Vehicles in 2030* [33] (*AB 2127 Report)* was adopted by the CEC in June 2021.

To quantify the number of charging stations needed to service the growing population of light-duty PEVs in California, the CEC has partnered with the National Renewable Energy Laboratory (NREL) and the University of California, Davis, to develop three quantitative analysis tools covering various vehicle classes, use cases, and local conditions: Electric Vehicle Infrastructure Projections 2 (EVI-Pro 2), Electric Vehicle Infrastructure for Road Trips (EVI-RoadTrip), and Widespread Infrastructure for Ride-hailing EV Deployment (WIRED).

EVI-Pro developed by NREL is a planning tool that helps determine the number, locations, and types of chargers required to meet the needs of California's light-duty PEV drivers. The original EVI-Pro 1 analysis formed the basis for the Executive Order B-48-18 target of 250,000 chargers statewide by 2025. An update to the model, EVI-Pro 2, expands infrastructure projections to support 5 million ZEVs and beyond by 2030 and incorporates evolving technology and market conditions. In addition to the 5 million ZEVs by 2030 scenario, the *AB 2127 Report* included an additional scenario using CARB's *Draft 2020 Mobile Source Strategy* that projected nearly 8 million ZEVs by 2030. This scenario is roughly the trajectory needed to achieve the Executive Order N-79-20 target of 100 percent light-duty ZEV sales by 2035.

Separate from EVI-Pro 2, the EVI-RoadTrip model also developed by NREL projects the number and locations of DC fast chargers needed specifically to enable long-distance (100+ mile) interregional road trips for BEVs within and across California's borders. Moreover, the WIRED model, developed by UC Davis, assesses the need for charging infrastructure demanded by Transportation Network Company (TNC) vehicles, initially in three major

33 Alexander, Matt, Noel Crisostomo, Wendell Krell, Jeffrey Lu, and Raja Ramesh. July 2021. Assembly Bill 2127 Electric Vehicle Charging Infrastructure Assessment: Analyzing Charging Needs to Support Zero-Emission Vehicles in 2030 – Commission Report. California Energy Commission. Publication Number: CEC-600-2021-001-CMR. Available at https://www.energy.ca.gov/programs-and-topics/programs/electric-vehicle-charging-infrastructure-assessment-ab-2127.

California regions: San Diego County, the Greater Los Angeles Region, and the San Francisco Bay Area.

For passenger vehicle charging in 2030, combining the results of these three models, the *AB 2127 Report* projects that more than 700,000 public and shared private chargers will be needed to support 5 million ZEVs and nearly 1.2 million to support the roughly 8 million ZEVs anticipated under Executive Order N-79-20.

In addition to providing quantitative discussions of charging infrastructure needs, the *AB 2127 Report* provides a qualitative review of charging infrastructure needs.[34] Highlights of such qualitative findings include the following:

- North American market players are generally moving toward a unified DC fast charging standard known as the Combined Charging System (CCS). There are three connectors (CCS, CHAdeMO, and Tesla) used for DC fast charging in North America today. The movement toward a single connector type will reduce network costs and maximize convenience.
- Given the additional load plug-in electric vehicles represent for the electric grid, vehicle-grid integration will be a valuable tool to support grid reliability and ensure that drivers can access the cleanest and cheapest electricity possible. Convenient, interoperable, and widespread vehicle-grid integration depends on standardized communication protocols to enable seamless communication among vehicles, chargers, and other actors.
- Charger deployments should be targeted toward the needs of the local community, built environment, and use case. This targeting means there is no one-size-fits-all charging solution. Generally speaking, the best-fit charging solution will maximize electric miles enabled by a charger at the lowest overall cost while reflecting local needs and constraints, and supporting equitable access for all Californians. Fostering innovative or unique charging products and opportunities will help ensure that these solutions proliferate.

Findings From the *California Electric Vehicle Charging Infrastructure Assessment: Senate Bill 1000 Report*

Senate Bill 1000 (Lara, Chapter 368, Statutes of 2018) requires the CEC, as part of the development of the Clean Transportation Program Investment Plan Update, to assess whether chargers are disproportionately deployed by income level, population density, and geographical area. If the CEC finds that chargers have been disproportionately deployed, the CEC shall use Clean Transportation Program funds, to the extent authorized by law, and other mechanisms to deploy chargers more proportionately, unless the CEC finds that the disproportionate deployment was reasonable and furthered state energy and environmental policies as articulated by the CEC.

34 Ibid. For more information on these qualitative findings, see Chapter 5: Meeting California's Technological Charging Infrastructure Needs.

Staff published the first *SB 1000 Electric Vehicle Charging Infrastructure Deployment Assessment* on December 30, 2020.[35] The distributions of PEVs, public chargers, and populations are correlated, but public chargers are unevenly distributed by income, population density, and geography. On average, low-income communities have fewer public Level 2 and DC fast chargers combined per capita than middle- or high-income communities.[36] High-population-density communities have fewer public chargers within their census tract boundaries than lower-density communities.

This year, staff considered drive times from community centers to the nearest public DCFC. Low-income communities have some of the longest drive times to DCFCs (Figure 3). Middle- and high-income communities can also have long drive times, but there is more variation across low-income communities. Disadvantaged communities vary in drive times to DCFC (Figure 4).[37] Rural communities have some of the longest drive times to DCFCs. The longest drive time for a rural community in California is twice that of the longest drive time for an urban community. Figure 5 shows drive times by rural communities.

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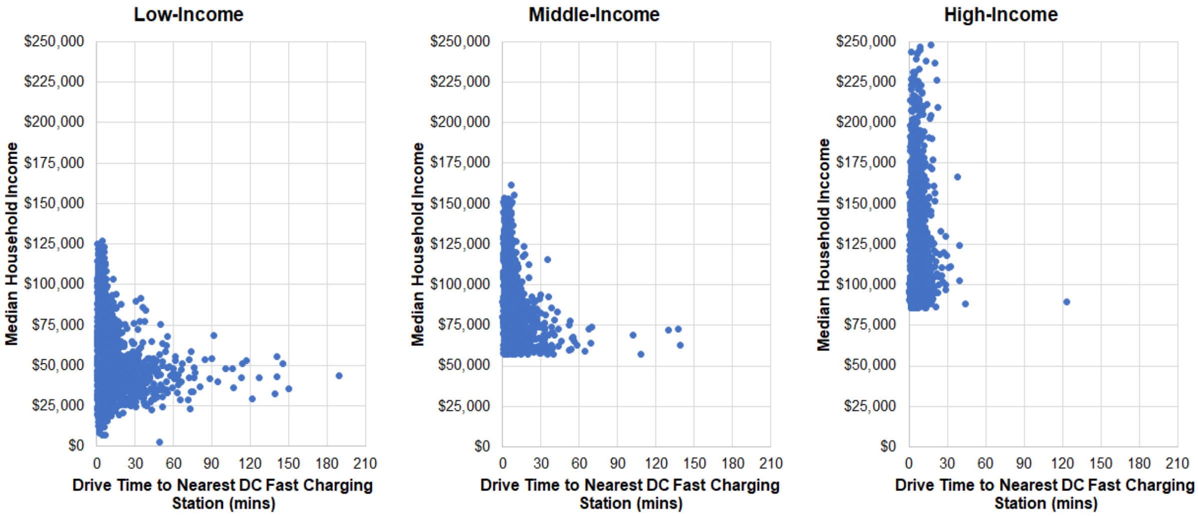
35 California Electric Vehicle Infrastructure Deployment Assessment: Senate Bill 1000 Report, https://www.energy.ca.gov/publications/2020/california-electric-vehicle-infrastructure-deployment-assessment-senate-bill.

36 Low-income communities are "census tracts with median household incomes at or below 80 percent of the statewide median income or with median household incomes at or below the threshold designated as low income by the Department of Housing and Community Development's list of state income limits adopted pursuant to Section 50093" (Assembly Bill 1550, Gomez, Chapter 369, Statues of 2016). Middle-income communities census tracts with median household incomes between 80 to 120 percent of the statewide median income or with median household incomes between the threshold designated as low and moderate income by the Department of Housing and Community Development's list of state income limits adopted pursuant to Section 50093. High-income communities are census tracts with median household incomes at or above 120 percent of the statewide median income or with median household incomes at or above the threshold designated as moderate income by the Department of Housing and Community Development's list of state income limits adopted under Section 50093.

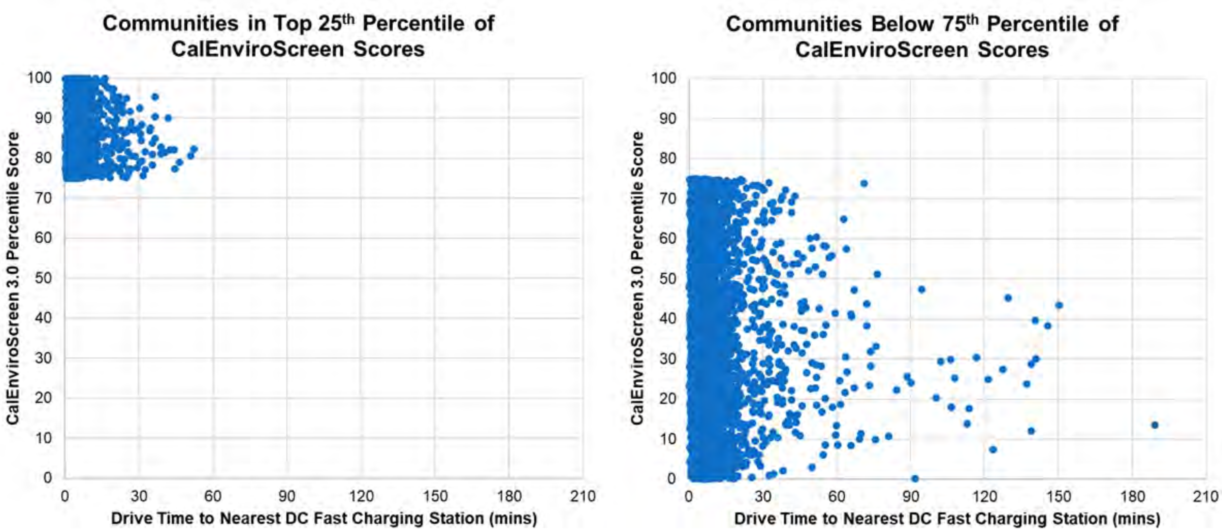
37 Disadvantaged communities are census tracts that score within the top twenty-fifth percentile of CalEnviroScreen 3.0 scores. Rural communities are defined using the Census Bureau's 2010 urban and rural classifications. Rural blocks include all population, housing, and territory that is not included within an urban area. Blocks with no population were removed before conducting the drive-time analysis.

Figure 3: Community Drive Times to DC Fast Charging Stations by Income Level



Source: U.S. Census Bureau 2014–2018 American Community Survey Median Household Income 5-Year Estimates, U.S. Department of Energy's Alternative Fuels Data Center Charger Data as of February 2021, and California Air Resources Board California Hydrogen Infrastructure Tool Roadway Data.

Figure 4: Community Drive Times to DC Fast Charging Stations by CalEnviroScreen 3.0 Percentile Scores



Source: California Environmental Protection Agency CalEnviroScreen 3.0, U.S. Department of Energy's Alternative Fuels Data Center Charger Data as of February 2021, and California Air Resources Board California Hydrogen Infrastructure Tool Roadway Data.

Figure 5: Map of Rural Community Drive Times to DC Fast Charging Stations

Source: U.S. Census Bureau 2010 Urban and Rural Classifications, U.S. Department of Energy's Alternative Fuels Data Center Charger Data as of February 2021, and California Air Resources Board California Hydrogen Infrastructure Tool Roadway Data.

Staff held a workshop July 8, 2021, to receive public feedback on new analysis. This work is being used to inform design of solicitations for charging that serves multifamily housing residents and rural drivers.

Clean Transportation Program Funding

The CEC has supported the rollout of light-duty PEVs by awarding more than $188 million in Clean Transportation Program funding for electric vehicle charging infrastructure. Partly because of these investments, California has the largest network of publicly accessible electric vehicle chargers in the nation.

Clean Transportation Program investments have funded EVCS at many types of locations, as detailed in Table 7. The "private access" chargers include home chargers that are generally dedicated to serving only one vehicle; the CEC has moved away from providing incentives for these chargers. The "shared access" chargers include fleets, workplaces, and multifamily housing chargers that may serve multiple vehicles but are not necessarily public. The "public access" chargers include public Level 2 chargers, as well as corridor and urban metropolitan DC fast chargers. Finally, the "mixed access" chargers include shared private and public access chargers.

Table 7: Chargers Funded by the Clean Transportation Program as of May 31, 2021

	Private Access	Shared Private Access	Shared Private Access	Shared Private Access	Public Access	Public Access	Mixed Access	Total
Charger Type / Setting	Level 2 - Residential (Single & Multifamily)	Level 2 - Fleet	Level 1 and Level 2 - Workplace	Level 2 - Residential (Multifamily)	Level 1 and Level 2 - Public	Level 2 and DCFC - Corridor/ Urban Metro	Level 2 and DCFC - CALeVIP*	-
Installed	3,936	155	419	341	3,090	482	950	**9,373**
Planned	0	0	0	0	18	52	5,711	**5,781**
Total	**3,936**	**155**	**419**	**341**	**3,108**	**534**	**6,661**	**15,154**

Source: California Energy Commission. Does not include chargers that have yet to be approved at a CEC business meeting or connectors that have yet to be funded under CALeVIP. * Planned CALeVIP chargers = number of chargers with rebate funding reserved. Mixed Access includes shared private and public access chargers.

California Electric Vehicle Infrastructure Project (CALeVIP)

In December 2017, the CEC introduced the California Electric Vehicle Infrastructure Project (CALeVIP) to provide streamlined Clean Transportation Program incentives for light-duty electric vehicle charging infrastructure. The incentives provided through CALeVIP simplify the funding process and accelerate charger deployment compared to the previously used grant solicitations. Each CALeVIP project provides incentives for the purchase and installation of electric vehicle infrastructure in specific regions throughout the state, with funding targeted at regions that have low rates of infrastructure installation or lack adequate incentives from utilities and other sources.

Through 2021, the CEC has allocated $200 million ($186 million for rebates and $14 million for administrative fees) for charger rebates through CALeVIP; however, not all of these funds have been paid out to, or reserved by, incentive recipients. CALeVIP has launched 10 regional incentive projects covering 32 counties. An additional three incentive projects have been announced and will cover an additional four counties. Table 8 shows all the current CALeVIP projects, with more planned in 2021 and 2022. Dedicated funding amounts or higher incentive amounts or both are also available under CALeVIP for project sites within disadvantaged communities and multifamily complexes. CEC staff continues to coordinate closely with local governments and councils of governments to leverage other funding opportunities to increase chargers in focused locations to maximize the effectiveness of limited Clean Transportation Program funds.

Table 8: CALeVIP Investments Through 2021

Incentive Project	Launch Date	Counties	Funding (in Millions)	Funding From Partners (in millions)	Technologies
Fresno County	December 2017	Fresno	$4	-	Level 2
Southern California	August 2018	Los Angeles, Orange, Riverside, San Bernardino	$29	-	DC Fast Chargers
Sacramento County	April 2019	Sacramento	$15.5	$1.5	Level 2 and DC Fast Chargers
Northern California	May 2019	Shasta, Humboldt, Tehama	$4	-	Level 2 and DC Fast Chargers
Central Coast	October 2019	Monterey, Santa Cruz, San Benito	$9	$3 (over three years)	Level 2 and DC Fast Chargers
San Joaquin Valley	December 2019	San Joaquin, Kern, Fresno	$14	-	Level 2 and DC Fast Chargers
Sonoma Coast	July 2020	Mendocino, Sonoma	$6.75	$1.65 (over three years)	Level 2 and DC Fast Chargers
San Diego County	October 2020	San Diego	$21.7	$5.9 (over three years)	Level 2 and DC Fast Chargers
Peninsula-Silicon Valley	December 2020	San Mateo, Santa Clara	$55.23	$22.23 (over four years)	Level 2 and DC Fast Chargers
Inland Counties	May 2021	Butte, El Dorado, Imperial, Kings, Merced, Napa, Nevada, Placer, Solano, Stanislaus, Sutter, Tulare, Yolo	$17.5	-	Level 2 and DC Fast Chargers
		Totals	**$176.68**	**$34.28**	

Source: California Energy Commission.

Innovations in Charging Technology and Use Cases

Aligning charging with the availability of cheaper, cleaner energy resources is also a priority for the state. For instance, most charging at workplaces is expected to occur during the day, which is likely to create opportunities for electricity demand management at these sites. Electric vehicle charging with demand-side management can increase charging during times of excess electricity and decrease use during peak times. As more intermittent renewable energy is available to the electricity grid, such as solar and wind, the electricity supply available during the day will increase and possibly result in overgeneration. Vehicle-to-grid technologies and daytime PEV charging, especially at workplace and fleet-use stations, can increase the use of renewable energy. The CEC is committed to enabling “smart” charging (controlling when and how charging occurs) and vehicle-grid integration, which help reduce costs for PEV drivers and all electricity customers.

As expressed in one of the qualitative findings of the *AB 2127 Staff Report*, the CEC recognizes the need to support the development and demonstration of innovative charging technologies and use cases. There is no one-size-fits-all solution to charging needs, and there is instead a need to have a portfolio of charging solutions that complement one another. This need is reflected in the CEC's development and release of the "BESTFIT Innovative Charging Solutions" solicitation, which was released in August 2020. On April 16, 2021, the CEC announced a total of more than $4.1 million in light-duty sector awards.

eMobility

New mobility services, including car- and ridesharing and autonomous and connected vehicles, present other opportunities to expand the use of ZEVs. Thus far, ZEV use has been limited largely to those who have the means to purchase a new vehicle. Dedicated ZEV car- and ridesharing services, however, can provide zero-emission transportation options for drivers and passengers who would otherwise have no alternatives to conventional automobiles.[38]

The Clean Mobility Options (CMO) Program is a statewide administrator program that offers vouchers for shared mobility projects in traditionally underserved communities, aiming to increase residents' access to clean transportation and zero-emission mobility solutions. The CMO Program is a first-come, first-served voucher program that focuses on disadvantaged, low-income, and California native tribal communities. Mobility vouchers will fund clean transportation projects, including zero-emission vehicles, bicycles, charging infrastructure, site improvements, outreach, and capacity building. In addition, CMO provides funding for community transportation needs assessments for evaluating transportation gaps within the community to better understand residents' priorities and mobility needs before applying for shared mobility project vouchers. Furthermore, the CMO administrative team provides comprehensive technical assistance and support for applicants and voucher awardees. The CEC is partnering with CARB though an interagency agreement to expand program eligibility and funding. The interagency agreement will add $8 million to the original CARB funding of $37 million for additional vouchers, technical assistance, and outreach to communities not identified in the first round of funding. Projects are required to be operational for four years, and the interagency agreement will conclude in 2025.

Planning and Readiness

The CEC has provided funding to other project types to achieve the goals of the Clean Transportation Program, including regional alternative fuel readiness plans. The Regional Alternative Fuel Readiness Planning allocation provided a funding source for planning that prepares for and expedites the launch of alternative fuel infrastructure and vehicles.

The CEC has conducted six grant solicitations for regional readiness planning, providing more than $18 million for 55 agreements to prepare for and expedite the deployment of alternative fuel infrastructure and vehicles. Since the first regional readiness planning projects were approved in 2011, the zero-emission vehicle sector has matured significantly. Most regions in

California have developed regional readiness plans because of this funding, and the plans have aided the launch of the first generation of zero-emission vehicles and the continued installation of charging and fueling infrastructure.

On August 12, 2020, the CEC released the "Electric Vehicle Ready Communities Challenge Phase II — Blueprint Implementation Solicitation." This solicitation was Phase II of a two-phase effort for electric vehicle-ready communities. Phase I (GFO-17-604) provided funds to develop replicable blueprints that identify the actions needed to accelerate implementation of electrified transportation at the regional level.

Phase II was a competitive solicitation with $7.5 million in grant funding available to implement projects developed and identified in Phase I. Phase II was open only to entities that completed Phase I blueprints within one year of their agreement start date. Eight project teams submitted applications requesting $19,184,958. The solicitation resulted in four grant awards totaling $7,493,000, which include Contra Costa Transportation Authority, Kern Council of Governments, City of Sacramento, and Ventura County Regional Energy Alliance.

Increasing Consumer Awareness of EV Charging Opportunities Through Expanded Installation of Signs

Despite strong growth in ZEV sales and PEV charger installations, large numbers of Californians have limited awareness of PEV charging opportunities or ZEV mobility. Long-term attitudinal survey research from the UC Davis Institute for Transportation Studies indicates that more than 50 percent of Californians have limited awareness of ZEV purchase or PEV charging opportunities.[39] Informing larger numbers of California drivers about ZEVs will become increasingly important to meet California's vehicle and climate goals. One strategy to build consumer awareness is to increase the number of physical signs indicating nearby public PEV charging stations. Further, signs will aid existing PEV drivers by helping them locate stations near their homes or commute routes.

There are now more than 6,000 public DC fast chargers and 66,000 L2 chargers in California, yet many drivers of fossil fuel vehicles are unaware that there may be sizeable numbers of chargers within their daily commute and travel range. For example, for the more than 6,000 DC fast chargers already installed, there are just 50 indicator signs along California freeways. As a result, this sizable number of PEV chargers is invisible to most drivers. Lack of awareness contributes to range anxiety, the concern that a PEV cannot meet a driver's needs for range and convenient refueling. This lack of awareness constrains PEV sales. In contrast, gas stations are highly visible to urban, suburban, rural, and freeway drivers due to their large, colorful display signs. Fossil fuel drivers benefit from the big neon signs and large footprint of gas stations. Further, they benefit from highway, surface street, and off-ramp signs indicating where gasoline can be found.

CEC staff has begun an initiative to increase the number of physical signs throughout the state. Working collaboratively with staff from GO-Biz, California Department of Transportation

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39 Kurani, Ken. 2019. "The State of Electric Vehicle Markets, 2017: Growth Faces an Attention Gap." NCST Policy Brief, https://ncst.ucdavis.edu/research-product/state-electric-vehicle-markets-2017-growth-faces-attention-gap.

(Caltrans), CPUC, and CARB, and in consultation with major charger companies, CEC staff is investigating strategies to increase the installation of physical indicator signs. One possible strategy is to use grant funding opportunities, such as the Regional Readiness Planning Grants, to provide funding to install signs along freeways and roadways for previously installed chargers.

Summary

Issued in January 2018, Executive Order B-48-18 set a directive to install 250,000 ZEV charging ports, including 10,000 DC fast charging ports, in California by 2025. CEC staff estimates that the sum of existing charging ports and charging ports funding across all state funding programs will result in more than 183,000 Level 2 chargers and 9,570 DC fast chargers 2025, leaving gaps of more than 56,000 Level 2 chargers and 430 DC fast chargers by 2025.

Staff recommends an aggressive near-term funding solution to help close this gap. Staff will also consider land use, housing policies, and Sustainable Community Strategies as they relate to ZEV infrastructure investments. To help achieve this adoption, the CEC is allocating $30.1 million in Clean Transportation Program funding and $240 million in general funds for light-duty electric vehicle charging infrastructure for FY 2021–2022. These funding allocations will provide the buildout of EV infrastructure that can create much-needed jobs and support economic development in response to COVID-19 while narrowing the EVSE gap.

Medium- and Heavy-Duty Zero-Emission Vehicles and Infrastructure

Freight and transit vehicles serve as a pillar to the California economy, providing indispensable functions for domestic goods movement, international trade, mass transportation, and other essential services. Clean Transportation Program funding in this sector has historically focused on medium- and heavy-duty vehicles, defined here as vehicles with a gross vehicle weight rating above 10,000 pounds. These vehicles represent a small share of California registered vehicle stock, accounting for about 1 million out of 31 million vehicles, or 3 percent; however, this small number of vehicles is responsible for about 23 percent of on-road GHG emissions in the state because of comparatively low fuel efficiency and high number of miles traveled per year.[40] Medium- and heavy-duty vehicles additionally account for one-third of statewide NO_X and 25 percent of $PM_{2.5}$ emissions from on-road transportation in California.[41] For these reasons, medium- and heavy-duty vehicles represent a significant opportunity to reduce GHG emissions and criteria emissions while focusing on a small number of vehicles. Nonroad freight

40 Based on analysis from California Energy Commission Energy Assessments Division, with data from the California Department of Motor Vehicles. California Air Resources Board. June 22, 2018. "California Greenhouse Gas Inventory for 2000-2018." Available at https://ww3.arb.ca.gov/cc/inventory/data/tables/ghg_inventory_scopingplan_sum_2000-18.pdf.

41 California Air Resources Board. "Almanac Emission Projection Data." Available at https://www.arb.ca.gov/app/emsinv/2017/emssumcat_query.php?F_YR=2020&F_DIV=3&F_SEASON=A&SP=SIP105ADJ&F_AREA=CA#7.

vehicles, such as forklifts and other cargo handlers, have similar or supporting purposes and potential for emission reductions.

California moved dramatically further in reducing medium- and heavy-duty vehicle emissions when CARB adopted the Advanced Clean Truck Regulation (ACT) in June 2020. The ACT is modeled after the ZEV Regulation that CARB adopted for light-duty vehicles. Starting in 2024, the ACT will require truck manufacturers to sell an increasing proportion of zero-emission trucks in California. This is the first such regulation in the world.

Furthermore, with the adoption of the Innovative Clean Transit (ICT) regulation in 2018, large urban transit districts will need to have 25 percent of new bus acquisitions be zero-emission buses starting in 2023, rising to 100 percent in 2029. The goal is to transition the entire California transit fleet to zero-emission by 2040. The ICT regulation reduces GHG, PM, and NOx emissions, which will result in health benefits for individuals and communities in California. The CEC will play a pivotal role as the primary agency tasked with providing the infrastructure to support the targets for zero-emission vehicles, as described in ACT and ICT.

Charging Infrastructure for Medium- and Heavy-Duty Vehicles

As part of the analyses conducted for the *AB 2127 Report,* the CEC is evaluating infrastructure needs to support medium- and heavy-duty vehicles through the Medium- and Heavy-Duty Electric Vehicle Infrastructure Load, Operations, and Deployment (HEVI-LOAD) model in collaboration with Lawrence Berkeley National Laboratory. This model aims to characterize regional charging infrastructure needs for public, shared private, and private charging for on-road medium- and heavy-duty electric vehicles. It will determine the number, locations, and types of charger deployments and examine suitable power levels ranging from overnight charging (<50 kilowatts [kW]) to public fast charging (multimegawatt) for the range of applications envisioned in California's transition to ZEVs. HEVI-LOAD leverages CARB's *Draft 2020 Mobile Source Strategy*, which projects 180,000 medium- and heavy-duty electric vehicles will be needed in 2030 to achieve state climate and air quality goals and comply with Executive Order N-79-20. Preliminary modeling, which considered 50- kW and 350-kW charging power levels, suggests that to charge these vehicles, 157,000 DC fast chargers will be needed, of which 141,000 are 50 kW and 16,000 are 350 kW.

In addition to providing quantitative estimates of charging for medium- and heavy-duty vehicles, the *AB 2127 Report* also provides qualitative descriptions of the charging needs of medium- and heavy-duty vehicles.

While private light-duty vehicles typically see extended periods of downtime and have flexible usage requirements, medium- and heavy-duty vehicles often adhere to demanding operation patterns that make infrastructure planning for these vehicles a unique challenge. Charging infrastructure planning for the medium- and heavy-duty sector requires close attention to the specific vehicle uses and environments, high-power charging demands, lack of consistency in charging connectors, and landlord-tenant relationships. The result of such operator-specific complexities is that the most appropriate charger type — whether it be a conductive connector, pantograph, or wireless charger — may vary significantly from site to site, even for ostensibly similar vehicles.

Medium- and heavy-duty vehicles, being more massive than the light-duty counterparts, generally use more energy to operate and require higher charging power. Power levels to charge these vehicles may reach several megawatts, introducing significant challenges to local distribution grids and vehicle operators who face costly facility upgrades. A preliminary analysis using the CEC's EVSE Deployment and Grid Evaluation tool found that California's investor-owned utilities should plan to accommodate medium- and heavy-duty fleets, including grid upgrades or other mitigative actions. This finding indicates that charger deployments for larger vehicles may frequently require new utility grid hardware in addition to the charger itself. Furthermore, in some off-road applications such as construction or agriculture, access to the grid may be nonexistent, and mobile or other emerging charging solutions will need to be deployed.

Hydrogen Fueling Infrastructure for Medium- and Heavy-Duty Vehicles

Fuel cell electric vehicles using hydrogen offer another zero-emission transportation option for California's medium- and heavy-duty sectors and short-range and long-range applications. Hydrogen fuel cell and battery-electric technologies present different strengths and challenges, and hydrogen fuel cell vehicles may serve an important role in applications that would be difficult to transition to battery electric. Moreover, the further development and deployment of medium- and heavy-duty fuel cell vehicles will help accelerate the growth of hydrogen production and reach economies of scale earlier than with light-duty vehicles alone. These cost reductions would help support the further commercialization of all fuel cell vehicles, including light-duty fuel cell vehicles.

Companies are producing or planning to produce heavy-duty vehicles with hydrogen fuel cell electric powertrains, including transit buses and tractor-trailer trucks. These vehicles, and the fleets that operate them, may require dedicated fueling infrastructure to ensure the safety, security, and fuel supply of the vehicles. The CEC anticipates expanding its hydrogen focus toward hydrogen fueling infrastructure that is capable of supporting medium-duty and heavy-duty vehicles.

Clean Transportation Program Funding

In October 2019, CEC staff conducted a workshop to explore various solicitation concepts that prioritized infrastructure to support the use of zero-emission medium- and heavy-duty advanced vehicle technologies within the California freight system, transit bus fleets, and other sectors in need.[42] The concepts evolved into solicitations that cover a wide range of support for medium- and heavy-duty zero-emission vehicle infrastructure:

- "Block Grant for Medium-Duty and Heavy-Duty Zero-Emission Vehicle Refueling Infrastructure Incentive Projects." Under this grant solicitation, the CEC sought one block grant recipient to design and implement an incentive mechanism (similar to CALeVIP) for various medium- and heavy-duty zero-emission vehicle refueling

42 California Energy Commission. October 25, 2019. Staff workshop for Medium and Heavy-Duty Zero-Emission Vehicles. Available at https://www.energy.ca.gov/event/workshop/2019-10/staff-workshop-medium-and-heavy-duty-zero-emission-vehicles-and.

infrastructure incentive projects throughout California. The grant solicitation announced the availability of up to $50 million based on current and future fiscal years' funds. In December 2020, the CEC selected applicant CALSTART, Inc. to implement the block grant incentive with an initial budget of $17 million. On March 17, 2021, the project was approved at a CEC business meeting.

- "Zero-Emission Transit Fleet Infrastructure Deployment." Released in July 2020, this grant solicitation announced the availability of up to $20 million to fund the electric vehicle charging or hydrogen refueling infrastructure needed to support the large-scale conversion of transit bus fleets to ZEVs. No applications were received in the "Small fleet/Rural" or "Multiple fleets/Shared" categories. In the "Small fleet/Urban" category, $5 million awards were proposed for one electrification project and one liquid hydrogen refueling project. In the "Large fleet/Urban" category, a $6 million electrification and microgrid project was proposed for funding, as was a $4 million hydrogen refueling project.
- "BESTFIT Innovative Charging Solutions." This solicitation, previously described in the Light-Duty Electric Vehicle Charging Infrastructure section, included eligibility for projects to demonstrate innovative electric vehicle charging solutions for light-duty and medium- and heavy-duty vehicles and work to accelerate the successful commercial deployment of these solutions. On April 16, 2021, the CEC announced a total of more than $4.1 million in medium- and heavy-duty vehicle sector awards.
- "Zero-Emission Drayage Truck and Infrastructure Pilot Project." In a joint solicitation with CARB, the CEC allocated $20.1 million from the Clean Transportation Program to fund the zero-emission drayage truck infrastructure and installation, as well as any workforce training and development components. CARB allocated $24 million from its FY 2019–20 Funding Plan for Clean Transportation Incentives to fund the purchase of on-road zero-emission Class 8 trucks. This solicitation seeks to support large-scale deployments of on-road, zero-emission Class 8 drayage and regional haul trucks, as well as the infrastructure needed for service operation. On July 15, 2021, the CEC approved two projects at a CEC business meeting, one with South Coast Air Quality Management District for a battery-electric infrastructure project and one with the Center for Transportation and the Environment for a hydrogen refueling infrastructure project. For FY 2021–2022, the CEC proposes $25 million from the General Fund Drayage Truck & Infrastructure Pilot Project dedicated specifically to this joint solicitation with CARB to fully fund the passing projects in this solicitation.
- "Hydrogen Fuel Cell Demonstrations in Rail and Marine Applications at Ports." Released in July 2020, this solicitation was a collaborative effort between the CEC's Clean Transportation Program and the CEC's Natural Gas Research and Development Program. This solicitation sought to fund the design, integration, and demonstration of hydrogen fuel cell systems and hydrogen fueling infrastructure for locomotive and commercial harbor craft applications at California ports. In December 2020, the CEC announced several proposed awardees from this solicitation, including one $4 million award of Clean Transportation Program funding toward shared hydrogen refueling

infrastructure at the Port of West Sacramento. On March 17, 2021, three projects were approved at a CEC business meeting.

- "Blueprints for Medium- and Heavy-Duty Zero-Emission Vehicle Infrastructure." Released in July 2020, this solicitation offered up to $3 million to fund planning "blueprints" that will identify actions and milestones needed for the implementation of medium- and heavy-duty zero-emission vehicles and the related electric charging or hydrogen refueling infrastructure or both. The solicitation included a set-aside for public entities. On April 8, 2021, the CEC announced nearly $4 million in public agency proposed funding and nearly $2 million in private entity proposed funding.

Summary

To meet state GHG and air quality goals, this sector will need to transition to zero-emission technologies, and the resources required for this to be an equitable transition far exceed available funding. CEC staff expects an increasing demand for dedicated charging and fueling infrastructure for medium- and heavy-duty ZEVs funded through the Clean Transportation Program and by other state incentive programs. As the state's lead agency for ZEV infrastructure deployment, the CEC will focus on the infrastructure needs of medium- and heavy-duty ZEVs. In addition, the CEC will seek ways to include grid integration, integrated storage solutions, and charging management as complementary technologies. Staff will also consider land use, housing policies, and Sustainable Community Strategies[43] as they relate to medium- and heavy-duty ZEV infrastructure investments, as well from the forthcoming HEVI-LOAD assessments.

For FY 2021–2022, the CEC allocates $30.1 million in Clean Transportation Program funding and $208 million in general funds dedicated to medium- and heavy-duty to meet the growing needs of charging and hydrogen fueling infrastructure for medium- and heavy-duty ZEVs, as well as demonstrate the state's commitment to improving air quality. In accordance with Senate Bill 129, an additional $153.25 million is allocated to heavy-duty covering drayage, transit, and school bus applications.

Hydrogen Fueling Infrastructure

Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) directs the CEC to allocate $20 million annually, not to exceed 20 percent of the funds appropriated by the Legislature, from the Alternative and Renewable Fuel and Vehicle Technology Fund for planning, developing, and building hydrogen-fueling stations until there are at least 100 publicly available stations in California. The Clean Transportation Program funds the development of hydrogen fueling stations to support the fuel cell electric vehicle (FCEV) market. These annual allocations also support the goal of having 200 hydrogen fueling stations by 2025, which was established by Governor Edmund G. Brown Jr. in Executive Order B-48-18.

43 California Air Resources Board. Sustainable Communities Strategies. More information: https://ww2.arb.ca.gov/our-work/programs/sustainable-communities-program/what-are-sustainable-communities-strategies.

Evaluating the Deployment of FCEVs and Hydrogen Fueling Stations

Assembly Bill 8 requires CARB to evaluate the need annually for additional publicly available hydrogen fueling stations. This evaluation includes the quantity of fuel needed for the actual and projected number of hydrogen-fueled vehicles (based on DMV registrations and automaker projections), geographic areas where fuel will be needed, and station coverage.

Based on this evaluation, CARB reports to the CEC the number of needed stations; areas where additional stations will be needed; and minimum operating standards, such as number of dispensers, filling protocols, and pressure. CARB determines station and FCEV projections for up to six years in the future, based on mandatory survey information provided by vehicle manufacturers for the next three model years and voluntary information for an additional three following model years.

CARB released the *2020 Annual Evaluation of Fuel Cell Electric Vehicle Deployment & Hydrogen Fuel Station Network Deployment* (annual evaluation) report in September 2020 to comply with the requirements of Assembly Bill 8.[44] In this assessment, CARB determined that "California's hydrogen fueling station network has continued to add new, highly capable stations" and that "[t]he hydrogen fueling industry is responding favorably to the State's maturing support mechanisms." Manufacturer surveys conducted in 2020 project that 48,900 FCEVs will be on California roads by the end of 2026. This projection remains roughly the same as reported for 2025 in 2019.

Table 9 shows a compilation of reported data in CARB's annual evaluation reports from 2018 to 2020. The information in the table shows the number of FCEVs registered with DMV in 2020 is less than what auto manufacturers had projected in their mandatory reporting periods so far.

Table 9: Deployment of FCEVs and Hydrogen Fueling Stations as Reported in CARB's Annual Evaluation Reports

Report Year	Number of FCEVs Registered with DMV	Number of Projected FCEVs in Mandatory Period	Number of Stations Reported
2018	4,411	10,500 (projected in 2015)	36
2019	5,923	13,500 (projected in 2016)	41
2020	7,172	13,400 (projected in 2017)	42

Source: California Energy Commission staff compiling data from CARB's 2015–2020 Annual Evaluation reports.

In December 2020, the CEC and CARB released the *Joint Agency Staff Report on Assembly Bill 8: 2020 Annual Assessment of Time and Cost Needed to Attain 100 Hydrogen Fueling Stations*

44 California Air Resources Board. September 2020. *2020 Annual Evaluation of Fuel Cell Electric Vehicle Deployment & Hydrogen Fuel Station Network Development.* Available at https://ww2.arb.ca.gov/sites/default/files/2020-09/ab8_report_2020.pdf.

in California.[45] The report states that when all the 91 funded stations are open, the network will have enough fuel to support nearly 98,000 FCEVs. The 91 stations include 83 that are receiving grant funding and 8 that are privately funded under CEC agreement. The report also explains that the total number of stations approved at the December 9, 2020, CEC business meeting will result in CEC agreements and, if fully funded through future appropriations and Clean Transportation Program funds, will be 172 (including 16 to be privately funded under CEC agreement). In addition, 7 privately funded stations are anticipated outside CEC agreements, making for 179 stations expected in California. However, a gap of 21 stations from the goal set by Executive Order B-48-18 will remain after these 179 stations are opened. For FY 2021–2022, the CEC allocates $27 million from the general fund for this category dedicated to closing this gap in light-duty ZEV infrastructure.

With some of the stations resulting from GFO-19-602 planned to become open retail in the next few years, two of which are already opened, California is estimated to have in excess of 100 open retail stations by the end of 2023, thereby meeting the original AB 8 minimum requirement of 100 stations.

With the addition of stations from the most recent CEC funding solicitation (GFO-19-602), the state anticipates available fueling capacity will exceed the forecasted need in 2026. The additional capacity generates a vehicle deployment opportunity that has not existed previously in the state, which will help achieve the goal of having 5 million ZEVs in California by 2030, as well as the target of ensuring all new passenger vehicles sold are ZEVs by 2035.

The report also highlighted the ways in which the solicitation was designed to achieve economies of scale in hydrogen fueling equipment and showed that station costs could decrease while station capacity increased. California may benefit as countries around the world are pursuing hydrogen as a solution to decarbonize the transportation sector and other economic sectors.

Clean Transportation Program Funding to Date

Through the Clean Transportation Program, the CEC has provided nearly $160 million of funding to install or upgrade 83 publicly available hydrogen stations capable of light-duty vehicle fueling, including associated operations and maintenance. (One station has been taken out of service.). As of February 2021, 47 hydrogen fueling stations were open retail in California.

Furthermore, the three awardees under Solicitation GFO-19-602 can receive additional grant funds of up to $85.9 million for subsequent batches of stations approved at the December 9, 2020, CEC business meeting, depending on performance, funding availability, and Clean Transportation Program Investment Plan Update funding allocations to install additional publicly available hydrogen stations. If fully funded, the solicitation combined with privately

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45 Baronas, Jean, Gerhard Achtelik, et al. 2020. *Joint Agency Staff Report on Assembly Bill 8: 2020 Annual Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California*. California Energy Commission and California Air Resources Board. Publication Number: CEC-600-2020-008. Available at https://ww2.energy.ca.gov/2020publications/CEC-600-2020-008/CEC-600-2020-008.pdf.

funded stations should result in 179 stations, with at least 13 stations being capable of fueling light-, medium-, and heavy-duty vehicles. This leveraged infrastructure will address several markets and accelerate the development of commercial fuel cell electric trucks with the potential to reduce local air pollution from the goods movement sector.

Stations funded by the Clean Transportation Program before GFO-19-602 are required to dispense fuel with at least 33 percent renewable hydrogen content, and stations resulting from GFO-19-602 are mandated to reach at least 40 percent of the hydrogen from renewable sources. Many open retail stations are dispensing hydrogen with about 90 percent renewable content.

Other Sources of Project Support

The Hydrogen Refueling Infrastructure (HRI) credit provision of the Low Carbon Fuel Standard (LCFS) became effective in January 2019. This provision allows eligible hydrogen fueling station operators to earn HRI credits based on the capacity of the hydrogen station for a limited period, rather than being limited to credit generation based on the amount of hydrogen fuel dispensed.[46]

One hydrogen fueling station funding recipient will receive $5 million from the Volkswagen Mitigation Trust fund to support the development of five hydrogen refueling stations. The use of the $5 million mitigation trust funds and cooperation among CARB, BAAQMD, and the CEC will reduce the time and funding required to reach the statutory goal of at least 100 publicly available hydrogen fueling stations operating in California. This approach will fund additional stations to set California on the path toward 200 stations.

Summary

For FY 2021–2022, the CEC allocates $20 million of Clean Transportation Program funds for hydrogen fueling infrastructure, which is the maximum allocation allowable under current law.[47] Furthermore, for FY 2021–2022, the CEC allocates $27 million in general funds for this category dedicated to light-duty ZEV infrastructure to meet the goal of having 200 hydrogen fueling stations by 2025, which was established by Governor Edmund G. Brown Jr. in Executive Order B-48-18. These stations will have larger fueling capacities than most of the stations that the CEC funded early in the program. These stations should be able to provide fueling adequate to support more than the number of FCEVs that the original equipment manufacturers (OEMs) have projected will be on the roads in 2026 and enable additional FCEV market penetration beyond then.

46 California Air Resources Board Resolution 18-34 information is available at https://www.arb.ca.gov/fuels/lcfs/rulemakingdocs.htm. This modification to the LCFS provides credits to hydrogen fueling station owners for 15 years, with the credits being calculated based on the nameplate capacity of the station not to exceed 1,200 kilograms of hydrogen per day and the availability (or uptime) of the station relative to the permitted hours of operation. The amount of dispensed hydrogen is subtracted from the calculation of HRI credits so that credits are not double earned.

47 California Health and Safety Code Section 43018.9.

Staff expects there will be an excess of 100 stations in operation by the end of 2023, on the path to reaching the 200 station target enabled by economies of scale achieved through the Clean Transportation Program's recent multiyear, multistation funding approach (GFO-19-602); LCFS HRI credits; increased private investment; and a one-time general fund investment. With this in mind, the funding allocations of this investment plan propose a $10 million allocation (which equates to 20 percent of the expected funds for the Clean Transportation Program in 2023) for hydrogen fueling infrastructure for the final half-year of this multiyear investment plan. The CEC will evaluate whether the proposed allocation for the final year of the program is sufficient to meet the needs of the FCEV market and will adjust as needed in annual revisions to the plan. This evaluation will be informed by CARB's annual evaluation, as well as input from the Advisory Committee, Disadvantaged Communities Advisory Group, and other stakeholders.

CHAPTER 5: Alternative Fuel Production and Supply

Zero- and Near-Zero-Carbon Fuel Production and Supply

The California transportation sector relies largely on petroleum, which accounts for 89 percent of ground transportation fuel used in the state.[48] Any low-carbon substitute fuel that can displace the roughly 14 billion gallons of petroleum-based gasoline and 3.3 billion gallons of petroleum-based diesel used per year in California can provide an immediate and long-term opportunity to reduce GHG emissions and criteria air pollution.[49] Biofuels — defined in this document as nonpetroleum diesel substitutes, gasoline substitutes, and biomethane — represent the largest existing stock of alternative fuel in the California transportation sector.[50] In addition, production of and demand for renewable hydrogen are expected to increase in the coming years as more hydrogen fuel cell electric vehicles are sold and applications in other sectors expand.

The carbon intensity of renewable fuels can vary significantly depending on the pathway, which accounts for the specific feedstock and production process of the fuel. CARB provides carbon intensity values for most transportation fuels as part of the LCFS. The carbon intensity value accounts for the life-cycle GHG emissions of the fuel, including production, transportation, and consumption, and is reported in grams of carbon dioxide equivalent greenhouse gases per megajoule (gCO_2e/MJ).[51] Maximizing renewable fuel production from the lowest carbon pathways represents a key opportunity to reduce near-term GHG emissions in combustion engines and fuel cell electric vehicles. Clean Transportation Program funding uniquely drives innovative biofuel production plants to California, which may otherwise come from out of state through other funding mechanisms.

Fuel Type Overview

Renewable Diesel and Biodiesel

In 2019, renewable diesel was the most common diesel substitute in California, with 609 million diesel-gallon equivalents sold.[52] Renewable diesel that meets the fuel specification

48 Based on analysis from California Energy Commission Energy Assessments Division, with data from the California Department of Motor Vehicles.

49 Ibid.

50 The term "gasoline substitutes" refers to any liquid fuel that can directly displace gasoline in internal combustion engines, including ethanol and renewable drop-in gasoline substitutes. The term "diesel substitutes" refers to any liquid fuel that can significantly displace diesel fuel, including biodiesel and renewable diesel. These definitions differ from similar terms used by CARB under the LCFS, which are broader and include fuels such as electricity, natural gas, and hydrogen.

51 Consult the glossary for the definition of "megajoule."

52 California Air Resources Board. October 30, 2020. CARB Data Dashboard Available at https://ww3.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm.

requirements of ASTM International Standard D975 is fungible, or interchangeable, with conventional diesel fuel and can be used in existing diesel engines and fuel infrastructure. Biodiesel is another diesel substitute; however, unlike renewable diesel, it is not fully fungible with conventional diesel fuel.

Renewable diesel and biodiesel have carbon intensities up to 92 percent lower than diesel fuel, depending on the pathway used.[53] Together, renewable diesel and biodiesel accounted for about 45 percent of LCFS credits in 2019.[54] Of the 3.8 billion gallons of diesel fuel consumed in California in 2019, about 830 million (or 22 percent) were from low-carbon biodiesel or renewable diesel.

Within California, there are limited distribution methods for the different types of low-carbon fuels. As LCFS continues to encourage increased production and supply of low-carbon fuels in California, the infrastructure to distribute low-carbon fuels will have to be in place to meet California's low-carbon fuel production potential and consumption needs, as well as accomplish California's greenhouse gas emission goals.

Ethanol and Renewable Gasoline

Ethanol is the only widely available gasoline substitute and is used primarily as a fuel additive with gasoline. California limits ethanol blends in conventional gasoline to 10 percent, although the U.S. EPA permits blends of up to 15 percent for a conventional engine and 85 percent for a flex-fuel engine. Though ethanol continues to be the largest volume alternative fuel used in California, in-state ethanol use has not substantially changed since 2011.

Renewable gasoline is a potential gasoline substitute, although it is undergoing research and development and is not commercially available. Renewable crude oil products can serve as a fully fungible substitute for petroleum crude oil at refineries. Renewable crude oil is in the research and development phase and, if developed into a commercially viable product, may contribute significantly to California's environmental and energy goals.

Biomethane

Biomethane (or "renewable natural gas") is a commercially mature biofuel that serves as a low- or negative-carbon substitute for conventional natural gas. Biomethane from anaerobic digestion of wastewater sludge can reduce GHG emissions by as much as 92 percent below diesel. Biomethane derived from high-solids anaerobic digestion of prelandfill food and green wastes has a carbon intensity around *negative* 23 grams of carbon dioxide equivalent greenhouse gases per megajoule (gCO_2e/MJ) (or roughly 125 percent below diesel), indicating that the pathway contributes a net GHG emission reduction. Biomethane derived from dairy

53 Compared to California diesel (102.01 gCO2e/MJ), with biodiesel carbon intensity as low as 8.63 gCO2e/MJ and renewable diesel carbon intensity as low as 16.89 gCO2e/MJ. Based on data from the LCFS Fuel Pathway Table (April 16, 2019), available at https://www.arb.ca.gov/fuels/lcfs/fuelpathways/current-pathways_all.xlsx.

54 California Air Resources Board. April 30, 2019. "LCFS Quarterly Data Spreadsheet." Available at http://www.arb.ca.gov/fuels/lcfs/lrtqsummaries.htm.

biogas has the lowest carbon intensity approved under the LCFS — about negative 255 gCO_2e/MJ.[55]

The potential of low-carbon biomethane to replace natural gas in the transportation sector is based on the availability of waste-based feedstocks, and estimates vary on technical and economical availability. The University of California, Davis, Institute of Transportation Studies indicated an economically feasible potential of roughly 623 million diesel gallon equivalents (DGE). According to the U.S Department of Energy's *2016 Billion Ton Report*, slightly higher estimates indicate that waste residues from in-state dairies, landfills, food diversion, and wastewater treatment plants could be used to produce biomethane in volumes ranging from 750 million to 1.2 billion gallons DGE per year, which would displace 23 percent to 36 percent of the on-road diesel fuel consumption in California.[56] However, based on other studies provided by NREL, the technical availability (under preferable market conditions) could be four times higher.[57] Regardless, given the limited availability, the carbon reduction benefits from biomethane need to be prioritized for specific transportation applications (as well as other purposes), where zero-emission alternatives are not feasible.

Renewable Hydrogen

Senate Bill 1505 (Lowenthal, Chapter 877, Statutes of 2006) requires that at least 33.3 percent of hydrogen used for transportation come from renewable sources. As part of the Low Carbon Fuel Standard credits for ZEV infrastructure that took effect in January 2019, qualifying stations must have a renewable content of 40 percent or higher. Renewable hydrogen is typically produced through steam reformation of biomethane or through electrolysis using water and renewable electricity. Other renewable hydrogen production pathways are also being explored through research and development efforts globally.

According to the California Independent System Operator, increasing amounts of renewable power generation may result in electricity oversupply as California renewable power requirements grow from 33 percent to 50 percent.[58] Renewable hydrogen production is being investigated as a viable technology for beneficial use of this surplus renewable energy. While the capital costs of electrolyzers have decreased, the overall cost of renewable hydrogen remains high and is not expected to be competitive with fossil-based hydrogen for 10 years; however, the use of renewable electricity could contribute to reductions in capital costs for renewable hydrogen production. Additional cost reduction methods include improvements in

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55 California Air Resources Board. October 31, 2018. "LCFS Pathway Certified Carbon Intensities." Available at https://www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm.

56 U.S. Department of Energy. 2016 Billion Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy. July 2016. Available at https://www.energy.gov/sites/prod/files/2016/12/f34/2016_billion_ton_report_12.2.16_0.pdf.

57 California Energy Commission staff. 2017. *2017 Integrated Energy Policy Report.* California Energy Commission. Publication Number: CEC-100-2017-001-CMF. Available at https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2017-integrated-energy-policy-report.

58 California Independent System Operator. Managing Oversupply. http://www.caiso.com/informed/Pages/ManagingOversupply.aspx.

how hydrogen is treated, stored, and delivered, as well as economies of scale afforded by expanding applications of hydrogen fuel.

Clean Transportation Program Funding to Date

To date, the CEC has awarded nearly $210 million to 68 low-carbon fuel production projects. These awards are summarized by fuel type in Table 10.

Table 10: Summary of Clean Transportation Program Low-Carbon Fuel Production Awards as of April 16, 2021

Fuel Type	Qualifying Proposals* Submitted	Funds Requested by Qualifying Proposals* (in Millions)	Awards Made	Funds Awarded (in Millions)
Gasoline Substitutes	27	$68.8	14	$36.8
Diesel Substitutes	62	$187.1	26	$75.1
Biomethane	67	$212.4	26	$89.6
Renewable Hydrogen	4	$16.9	2	$7.9
Total	**160**	**$485.2**	**68**	**$209.4**

Source: California Energy Commission. Does not include results from GFO-19-601, which was funded through a separate source of funding called the California Climate Investment Fund. *The term "qualifying proposals" refers to proposals that received at least a passing score.

The Clean Transportation Program investments into low-carbon fuel production are typically focused on either smaller precommercial projects or large community- or commercial-scale projects. The smaller, precommercial projects have typically focused on transformative technology solutions that have the potential to increase yields, productivity, or cost-effectiveness of low-carbon fuel production. The CEC funds these pilot and demonstration projects with the expectation that, after successful operations at this scale, the technology will be suitable for commercial use. These precommercial projects are focused on advanced new technologies and approaches that can subsequently be expanded into wider markets.

Outside the Clean Transportation Program in August 2019, the CEC released GFO-19-601 titled "Low-Carbon Fuel Production Program." The solicitation was an offer to fund ultralow-carbon transportation fuel production at new and existing advanced fuel production plants. The solicitation provided $12.5 million from the Greenhouse Gas Reduction Fund, and in January 2020, the CEC issued a NOPA of four grants to fully use the funding. The solicitation produced $53 million in requested funds, indicating a strong interest in the sector.

Other Sources of Funding

Other state and federal programs also provide support and incentives to low-carbon fuel producers. The California Department of Resources Recycling and Recovery (CalRecycle) Organics Grant Program conducted three grant cycles in 2014, 2017, and 2018, which awarded $32.9 million to nine biomethane-producing projects. For Fiscal Year 2018–2019, CalRecycle awarded about $15.8 million to six projects for waste diversion using greenhouse gas reduction funds.

The California Department of Food and Agriculture awarded $35.2 million in October 2017 for anaerobic digesters at dairies through the Dairy Digester Research and Development Program and awarded $72.4 million for additional dairy digester projects in 2018. For 2019, the California Department of Food and Agriculture (CDFA) awarded an additional funding more than $67.3 million for these activities. In October 2020, the CDFA awarded nearly $25.4 million in grant funding to methane reduction projects across the state. These projects, part of the Dairy Digester Research and Development Program (DDRDP) and the Alternative Manure Management Program (AMMP), will reduce greenhouse gas emissions from manure on California dairy and livestock farms. Twelve DDRDP projects totaling $16.5 million and 13 AMMP projects totaling $8.9 million are being funded through the most recent round of funding. The CEC will work with these agencies to ensure future funding awards are complementary.

In addition, the LCFS and RFS requirements can support low-carbon fuel producers by creating markets for carbon credits and renewable fuels. The incentives earned through the LCFS provide steady financial support to low-carbon fuel producers, distributors, and blenders in California. In 2019, about 81.3 percent of LCFS credits were granted for biofuels including biomethane, ethanol, biodiesel, and renewable diesel.[59] These credits equate to an incentive of more than $1.36 billion for biofuel producers and retailers if sold at the average credit price of $191 for 2019.[60] CARB and CEC staff expects that the LCFS will serve as the state's primary source of financial support for low-carbon fuel production and distribution.

Summary

Given the near-term petroleum and GHG emission reduction potential of any low-carbon, drop-in gasoline or petroleum replacement, future solicitations under this category may emphasize renewable gasoline, renewable crude oil, and similar products to accelerate development. There may also be opportunities to expand or otherwise improve the limited distribution of liquid biofuels (whether for drop-in substitutes or blending), which impedes the state's supply of low-carbon transportation fuel.

Some fuel types and pathways have shown minimal improvement in carbon intensity or cost-effectiveness in recent funding solicitations, which may indicate that the technology or process has fully matured. The CEC may evaluate renewable fuel types and production pathways to determine when state incentives are no longer necessary. As the market for low-carbon fuels continues to develop, the CEC may also consider alternative funding mechanisms, such as revolving loan or loan guarantee programs, which may be more suitable for large projects and developed industries.

For FY 2021–2022, the CEC allocates $10 million in Clean Transportation Program funding for zero- and near-zero-carbon fuel production and supply. Funding priorities for this allocation may include increasing the in-state production of low-carbon fuels from waste-based

59 California Air Resources Board. March 26, 2021. "LCFS Quarterly Data Spreadsheet." Available at http://ww3.arb.ca.gov/fuels/lcfs/dashboard/figure2_053120.xlsx.

60 Ibid.

feedstocks such as woody biomass from forest or agricultural sources, supporting upstream blending infrastructure, and improving the state's supply of renewable hydrogen from renewable electricity overgeneration or biomethane.

CHAPTER 6: Related Opportunities

Manufacturing

Electric vehicles were the number one California export in 2020.[61] California is also home to more than 360 companies with 70,000 employees that work directly on zero-emission transportation, including vehicles, components, infrastructure, and research.[62] The range of ZEV platforms includes light-, medium, and heavy-duty on- and off-road vehicles. Some of the Clean Transportation Program-funded companies are completely vertically integrated, such as Proterra and Zero Motorcycles. Other companies manufacture parts and components, such as electric vehicle chargers, electric powertrains, and battery control systems, as represented by ChargePoint, Motiv Power Systems, and Freewire Technologies. Products from these companies are sold predominantly in domestically and globally distributed markets. Support for California's ZEV supply chain companies can be seen by the incentives offered through the California Alternative Energy and Advanced Transportation Financing Authority, California Competes, and the CEC's Clean Transportation Program.

Since the inception of the Clean Transportation Program, five solicitations have been issued under the manufacturing category totaling $55 million for 24 projects. Clean Transportation Program grants have been invaluable in attracting companies to California, leveraging the state's policy objectives, and scaling growth in-state and abroad.

Some California ZEV manufacturers have established formal worker relationships with organized labor. BYD Coach and Bus in Lancaster (Los Angeles County) has established an apprenticeship program with Sheet Metal Workers Local 105 and Antelope Valley College. Proterra Inc. in the City of Industry (Los Angeles County) announced in November 2019 it's joining the United Steelworkers. Manufacturing jobs are critical to disadvantaged communities, low-income communities, and small businesses. More than 800 manufacturing jobs have been created or retained or both under the Clean Transportation Program manufacturing portfolio.

Senate Bill 129 provides $250 million in general fund money. This money, less administrative costs, is to be used for manufacturing grants to "increase in-state manufacturing of zero-emission vehicles, zero-emission vehicle components, and zero-emission vehicle charging or refueling equipment."

Implementation of a successful grant program for in-state manufacturing requires collaboration and alignment with state agencies that provide funding and support, such as the California Business Investment Services in the Governor's Office, the California Alternative Energy and Advanced Transportation Financing Authority in the State Treasurer's Office, and

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61 State Export from California is available at https://www.census.gov/foreign-trade/statistics/state/data/ca.html.

62 CALSTART's California ZEV Jobs Study. January 2021. Available at https://calstart.org/wp-content/uploads/2021/02/CA-ZEV-Jobs-Study-Final-0203.pdf.

the California Employment Training Panel. Program success will also include engagement with the economic and business development entities of local cities and counties who provide frontline services to manufacturing companies. To this end, staff will immediately begin working with these entities to promote ZEV manufacturing and will conduct workshops to allow public input and deeper engagement with ZEV manufacturers and supply chains to leverage this opportunity.

As previously noted, SB 129 provides $250 million ($125 million for FY 2021–2022 and $125 million for FY 2022–2023) in general funds for manufacturing. As a result of this significant funding increase, the CEC finds it appropriate to shift Clean Transportation Program funding from manufacturing in FY 2021–2022 to workforce training and development.

Workforce Training and Development

Clean Transportation Program investments into workforce training and development are central to the advancement of clean transportation technologies in commercial markets. More than $35 million has been invested in workforce projects for more than 20,000 trainees. The primary workforce delivery systems for Clean Transportation Program funding have been through state entities such as the Employment Development Department, the California Employment Training Panel, and the California Workforce Development Board.

The CEC has a long-standing partnership with California community colleges primarily through its Advanced Transportation and Logistics Initiative (ATL). This partnership includes:

- ZEV Curricula — College faculty developed ZEV curricula for degrees, credit, and certificates at their college for zero-emission vehicle technology for light-duty and truck/bus platforms. A new training project focuses on ZEV curricula in community colleges serving students in disadvantaged communities and low-income populations.
- Electric School Bus Training Project — The CEC awarded funding to school districts to replace diesel school buses with electric school buses in 2019. School districts will receive customized training from nearby experienced community college faculty on these buses for maintenance/service technician staff and school bus operators.
- ZEV High School Pilot Career Opportunity Project — In 2018, ATL, led by Cerritos Community College, developed a pilot training project for high school automotive programs. The project builds on existing high school automotive programs and increases awareness for the state’s high school students in clean transportation careers. Twenty-seven high schools have been awarded funds to establish “Auto 3: ZEV Technology” technical training programs that have a career pathway to programs offered at California community colleges.

These projects have already provided a significant return on investment, especially in underserved communities where schools are located. As an example, for the high school project, early results show more than 1,800 students have enrolled in these programs and more than 36 faculty have been trained in ZEV technology. These results are critical as ZEV employers are partners and offer immediate job employment opportunities with sustainable wages.

Based on the state's development of zero-emission transportation regulations, the continued deployment of ZEVs for on- and off-road markets, and the need to meet critical ZEV training needs especially in equity communities in FY 2021–2022, the CEC allocates $5 million for workforce training and development projects. The CEC will continue to explore new public-private partnerships and leverage limited resources to determine how Clean Transportation Program funding can best be invested to maximize the benefits of this funding. Workforce training and development investments will prioritize disadvantaged communities, low-income communities, underrepresented populations, and economically disadvantaged high schools to ensure equitable participation in the clean transportation economy.

GLOSSARY

AIR POLLUTANT — Amounts of foreign or natural substances occurring in the atmosphere that may result in adverse effects to humans, animals, vegetation, or materials or any combination thereof.

ANAEROBIC DIGESTION — A biological process in which biodegradable organic matter is broken down by bacteria into biogas, which consists of methane (CH_4), carbon dioxide (CO_2), and trace amounts of other gases. The biogas can be further processed into a transportation fuel or combusted to generate heat or electricity.

BATTERY-ELECTRIC VEHICLE — A type of electric vehicle that derives power solely from the chemical energy stored in rechargeable batteries.

BIODIESEL — A transportation fuel for use in diesel engines that is produced through the transesterification of organically derived oils or fats. Transesterification is a chemical reaction between oil and alcohol that forms esters (in this case, biodiesel) and glycerol.

BIOMETHANE — A pipeline-quality gas that is fully interchangeable with conventional natural gas and can be used as a transportation fuel to power natural gas engines. Biomethane is most commonly produced through anaerobic digestion or gasification using various biomass sources. Also known as renewable natural gas (RNG).

BRITISH THERMAL UNIT (Btu) — A unit of heat energy. One Btu is equal to the amount of energy required to raise the temperature of 1 pound of water by 1 degree Fahrenheit at sea level. One Btu is equivalent to 252 calories, 778 foot-pounds, 1,055 joules, or 0.293 watt-hours.

CALENVIROSCREEN — A screening method that can be used to help identify California communities that are disproportionately burdened by multiple sources of pollution. The CalEnviroScreen tool combines different types of census tract-specific information into a score to determine which communities are the most burdened or "disadvantaged."

CARBON DIOXIDE EQUIVALENT — A measure used to compare emissions from various greenhouse gases based upon the related global warming potential. The carbon dioxide equivalent for a gas is derived by multiplying the mass of the gas by the associated global warming potential.

CARBON INTENSITY — A measure of greenhouse gas emissions by weight per unit of energy. A common measure of carbon intensity is grams of carbon dioxide equivalent greenhouse gases per megajoule of energy (gCO_2e/MJ).

CRITERIA AIR POLLUTANT — An air pollutant for which acceptable levels of exposure can be determined and for which the U.S. Environmental Protection Agency has set an ambient air quality standard. Examples include ozone (O_3), carbon monoxide (CO), nitrogen oxides (NO_X), sulfur oxides (SO_X), and particulate matter (PM_{10} and $PM_{2.5}$).

DISADVANTAGED COMMUNITIES — Disadvantaged communities refers to the areas throughout the state which most suffer from a combination of economic, health, and environmental burdens. These burdens include poverty, high unemployment, air and water pollution, presence of hazardous wastes, as well as high incidence of asthma and heart disease.

DIRECT CURRENT FAST CHARGER — Equipment that provides charging through a direct-current plug, typically at a rate of 50 kilowatts or higher.

ELECTRIC VEHICLE — A vehicle that uses an electric propulsion system. Examples include battery-electric vehicles, hybrid electric vehicles, and fuel cell electric vehicles.

ELECTROLYSIS — A process by which a chemical compound is broken down into associated elements by passing a direct current through it. Electrolysis of water, for example, produces hydrogen and oxygen.

EQUITY — Refers to the fair treatment, meaningful involvement, and strategic investment of resources through clean transportation programs, incentives, and processes for all Californians so that race, color, national origin, or income level are not barriers to increased opportunities and participation.

ETHANOL — A liquid that is produced chemically from ethylene or biologically from the fermentation of various sugars from carbohydrates found in agricultural crops and cellulosic residues. Used in the United States as a gasoline octane enhancer and oxygenate, or in higher concentration (E85) in flex-fuel vehicles.

FEEDSTOCK — Any material used directly as a fuel or converted into fuel. Biofuel feedstocks are the original sources of biomass. Examples of biofuel feedstocks include corn, crop residue, and waste food oils.

FLEX-FUEL VEHICLE — A vehicle that uses an internal combustion engine that can operate on alcohol fuels (methanol or ethanol), regular unleaded gasoline, or any combination of the two from the same fuel tank.

FUEL CELL — A device capable of generating an electrical current by converting the chemical energy of a fuel (for example, hydrogen) directly into electrical energy.

FUEL CELL ELECTRIC VEHICLE — A type of electric vehicle that derives power from an onboard fuel cell.

GREENHOUSE GAS — Any gas that absorbs infrared radiation in the atmosphere. Common examples of greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), halogenated fluorocarbons (HCFCs), ozone (O_3), perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs).

HIGH-SOLIDS ANAEROBIC DIGESTION — High-solids anaerobic digestion process is one in which the percentage of total solids of the feedstock is greater than 15 percent, and little or no water is added to the digester.

HYBRID VEHICLE — A vehicle that uses two or more types of power, most commonly using a combustion engine together with an electric propulsion system. Hybrid technologies typically expand the usable range of electric vehicles beyond what an electric vehicle can achieve with batteries alone and increase fuel efficiency beyond what an internal combustion engine can achieve alone.

INTELLIGENT TRANSPORTATION SYSTEM — The application of advanced information and communications technology to surface transportation to achieve enhanced safety, efficiency, and mobility while reducing environmental impact.

INVESTOR-OWNED UTILITY — A private company that provides a utility, such as water, natural gas, or electricity, to a specific service area. The California Public Utilities Commission regulates investor-owned utilities that operate in California.

LANDFILL GAS — Gas generated by the natural degradation and decomposition of municipal solid waste by anaerobic microorganisms in sanitary landfills. The gases produced, carbon dioxide and methane, can be collected by a series of low-level pressure wells and processed into a medium-Btu gas that can be further processed into a transportation fuel or combusted to generate heat or electricity.

LEVEL 1 CHARGER — Equipment that provides charging through a 120-volt alternative-current plug.

LEVEL 2 CHARGER — Equipment that provides charging through a 240-volt (typical in residential applications) or 208-volt (typical in commercial applications) alternative-current plug. This equipment requires a dedicated 40-amp circuit.

LOW-INCOME COMMUNITIES/HOUSEHOLDS — Defined as the census tracts and households, respectively, that are either at or below 80 percent of the statewide median income, or at or below the threshold designated as low-income by the California Department of Housing and Community Developments 2018 Income Limits.

METRIC TON — A unit of weight equal to 1,000 kilograms (2,205 pounds).

MEGAJOULE — One million joules. A joule is a unit of work or energy equal to the amount of work done when the point of application of force of 1 newton is displaced 1 meter in the direction of the force. One British thermal unit is equal to 1,055 joules.

METHANE — A light hydrocarbon that is the main component of natural gas. It is the product of the anaerobic decomposition of organic matter or enteric fermentation in animals and is a greenhouse gas. The chemical formula is CH_4.

MICROMETER — One millionth of a meter, equal to roughly 0.00004 inches.

NATIONAL AMBIENT AIR QUALITY STANDARDS — A set of standards established by the U.S. EPA for six criteria air pollutants, measured by the amount of each pollutant for a specified period.

NATURAL GAS — A hydrocarbon gas found in the earth composed of methane, ethane, butane, propane, and other gases.

NO_X — Oxides of nitrogen, a chief component of air pollution that is commonly produced by the burning of fossil fuels.

OVERGENERATION — A condition that occurs when total electricity supply exceeds total electricity demand. This condition may negatively affect the reliable operation of the regional, state, or interstate electrical grid.

PARTICULATE MATTER — Any material, except pure water, that exists in a solid or liquid state in the atmosphere. The size of particulate matter can vary from coarse, wind-blown dust particles to fine-particle combustion products.

PATHWAY — A descriptive combination of three components including feedstock, production process, and fuel type.

PLUG-IN ELECTRIC VEHICLE — A type of vehicle that is equipped with a battery than can be recharged from an external source of electricity. It may or may not also have an internal combustion engine.

PLUG-IN HYBRID ELECTRIC VEHICLE — A type of hybrid vehicle that is equipped with a larger, more advanced battery that can be recharged from an external source of electricity. This larger battery allows the vehicle to be driven on battery power alone, gasoline fuel alone, or a combination of electricity and gasoline.

ZERO-EMISSION VEHICLE — A vehicle that produces no pollutant emissions from the onboard source of power.

APPENDIX A:
LIST OF ACRONYMS

AB	Assembly Bill
AMMP	Alternative Manure Management Program
AQIP	Air Quality Improvement Program
ARPA-E	Advanced Research Projects Agency – Energy
ASE	Automotive Serve Excellence
ATL	Initiative Advanced Transportation and Logistics Initiative
BEV	battery-electric vehicle
CaFCP	California Fuel Cell Partnership
CA-GREET	California Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model
CALeVIP	California Electric Vehicle Infrastructure Project
CalRecycle	California Department of Resources Recycling and Recovery
CARB	California Air Resources Board
CEC	California Energy Commission
CHIT	California Hydrogen Infrastructure Tool
CMO	Clean Mobility Options
CNG	compressed natural gas
CO_2e	carbon dioxide-equivalent greenhouse gases
COE	county office of education
CPUC	California Public Utilities Commission
CSFAP	California Sustainable Freight Action Plan
CVRP	Clean Vehicle Rebate Project
DAS	Division of Apprenticeship Standards
DC	direct current
DDRDP	Dairy Digester Research and Development Program
DGE	diesel gallon-equivalent
EPIC	Electric Program Investment Charge
ETAP	Energy Transit Apprenticeship Program
EVs	electric vehicles
EVCS	electric vehicle charging station
EVI-Pro	Electric Vehicle Infrastructure Projections
EVITP	Electric Vehicle Infrastructure Training Program
FCEV	fuel cell electric vehicle
FY	fiscal year
GFO	grant funding opportunity
GGE	gasoline gallon-equivalent
GGRF	Greenhouse Gas Reduction Fund
gCO_2e/MJ	grams of carbon dioxide-equivalent greenhouse gases per megajoule
GO-Biz	California Governor's Office of Business and Economic Development

GHG	greenhouse gas
HVIP	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project
HRI	hydrogen fueling infrastructure
I-Bank	Infrastructure and Economic Development Bank
ICT	Innovative Clean Transit
LCFS	Low Carbon Fuel Standard
LCTI	Low Carbon Transportation Investment
LIC	Low-income communities
MJ	megajoule
$MMTCO_2e$	million metric tons of carbon dioxide-equivalent greenhouse gases
NAAQS	National Ambient Air Quality Standards
NO_X	oxides of nitrogen
NOPA	notice of proposed award
NREL	National Renewable Energy Laboratory
$PM_{2.5}$	particulate matter, 2.5 micrometers and smaller
PEV	plug-in electric vehicle
PG&E	Pacific Gas and Electric Company
PHEV	plug-in hybrid electric vehicle
PON	program opportunity notice
RFS	Renewable Fuel Standard
SB	Senate Bill
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric Company
SIP	State Implementation Plan
SoCal Gas	Southern California Gas Company
U.S. EPA	United States Environmental Protection Agency
USW	United Steelworkers
VTA	Santa Clara Valley Transport
ZEV	zero-emission vehicle

Attachment 78

Comments of Environmental and Public Health Organizations on:

EPA, California State Motor Vehicle Pollution Control Standards; Advanced Clean Cars II Regulations; Request for Waiver of Preemption; Opportunity for Public Hearing and Public Comment, 88 Fed. Reg. 88908 (December 26, 2023); Docket ID No. EPA–HQ–OAR–2023–0292

Submitted February 27, 2024

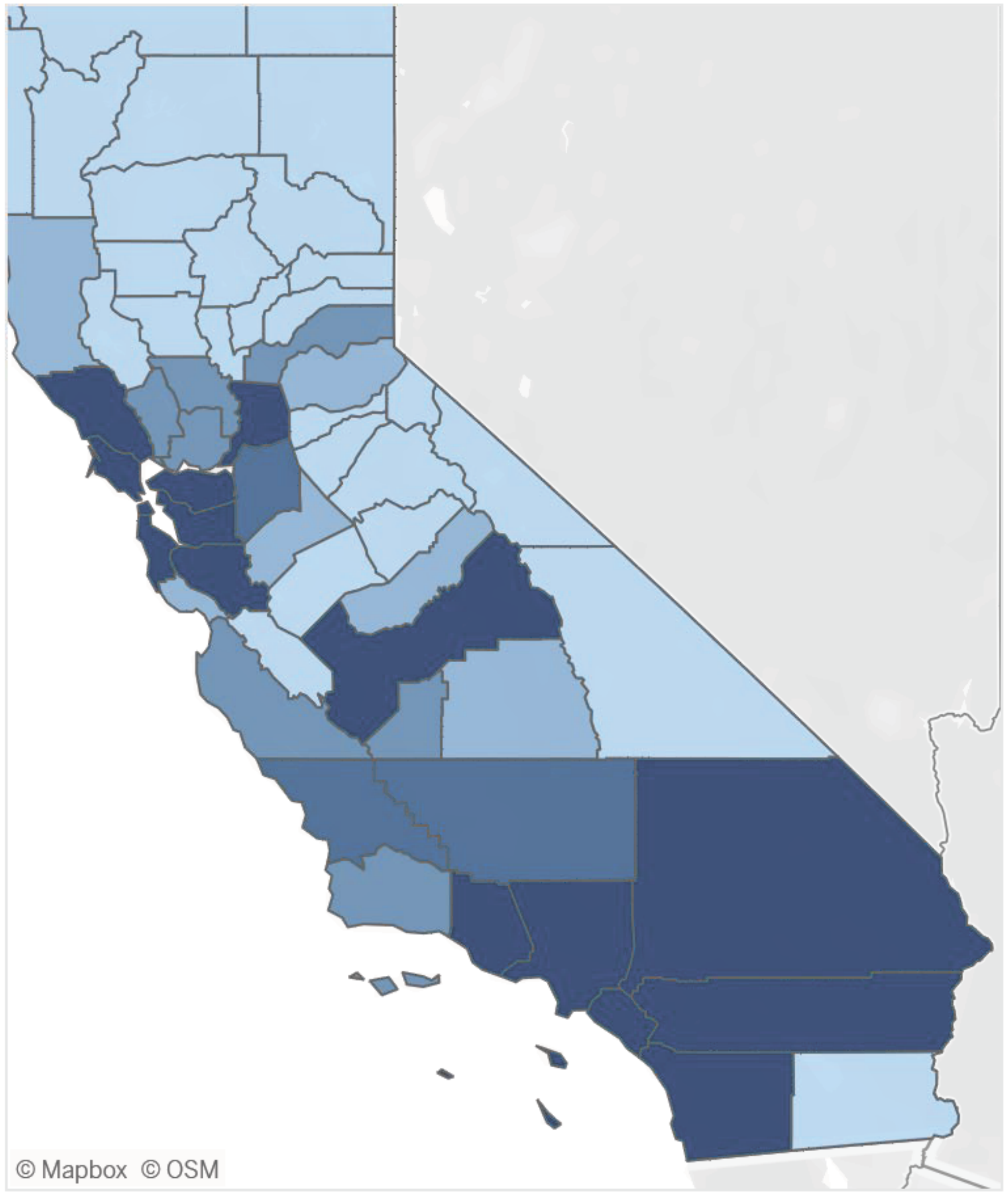
ELECTRIC VEHICLE CHARGERS

Total Public and Shared Private Electric Vehicle Chargers

93,855

Public
44.09%
41,384

Shared Private
55.91%
52,471



Number of Chargers

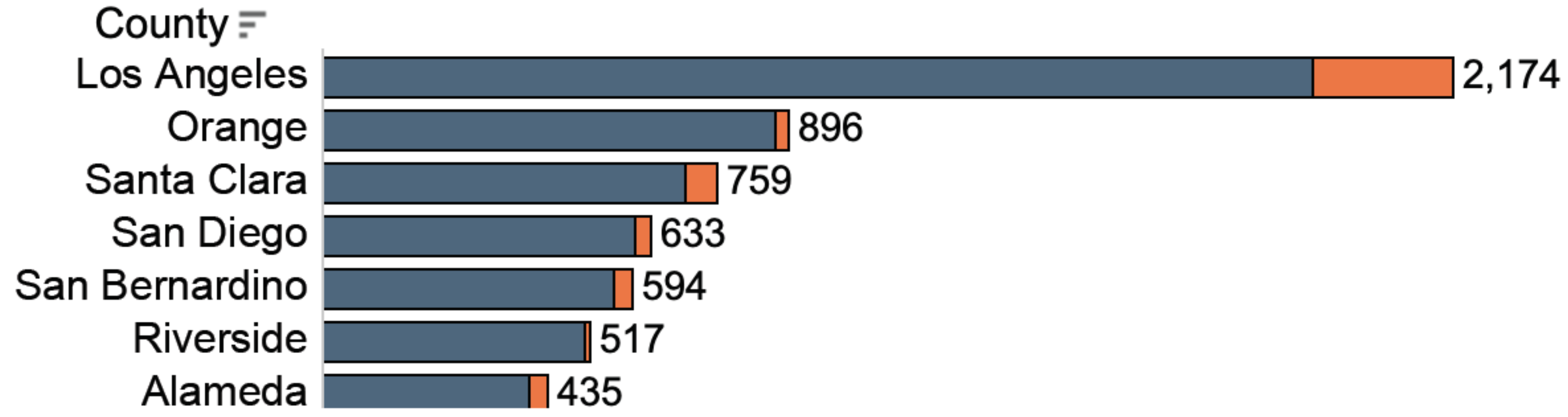
1 1,000

County
(All)

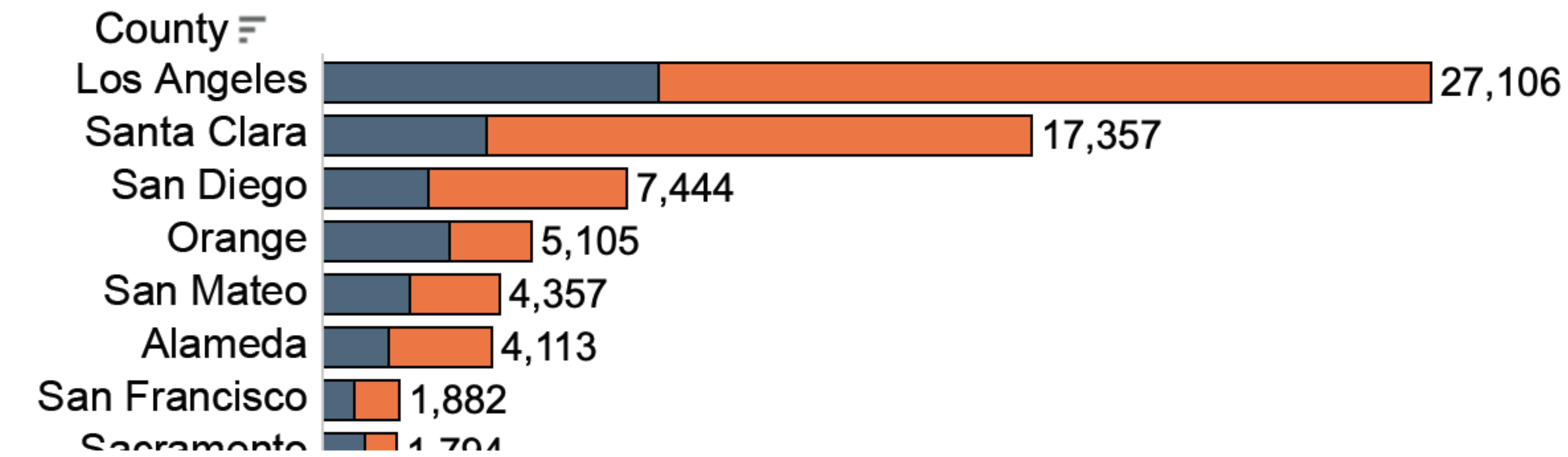
Access
(All)
Public
Shared Private

Legend
Public
Shared Private

DC Fast Chargers by County



Level 2 Chargers by County



	Public	Shared Private	Grand Total
Level 2	31,779	51,818	83,597
DC Fast	9,605	653	10,258
Total Chargers	41,384	52,471	93,855

STATE OF CALIFORNIA ENERGY COMMISSION

For additional information about the data and how to cite this visualization, see the dashboard.

Attachment 79

Comments of Environmental and Public Health Organizations on:

EPA, California State Motor Vehicle Pollution Control Standards; Advanced Clean Cars II Regulations; Request for Waiver of Preemption; Opportunity for Public Hearing and Public Comment, 88 Fed. Reg. 88908 (December 26, 2023); Docket ID No. EPA–HQ–OAR–2023–0292

Submitted February 27, 2024

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles **88 Fed. Reg. 29184 (May 5, 2023)**	Docket No. EPA–HQ–OAR–2022–0829; FRL 8953–03–OAR *Via regulations.gov* *July 5, 2023*

COMMENTS OF ENVIRONMENTAL AND PUBLIC HEALTH ORGANIZATIONS

Center for Biological Diversity, Conservation Law Foundation, Environmental Law & Policy Center, Natural Resources Defense Council, Public Citizen, Sierra Club, and the Union of Concerned Scientists respectfully submit these comments in response to the Environmental Protection Agency's (EPA) Proposed Rule titled Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles, 88 Fed. Reg. 29184 (May 5, 2023). Most of the materials referenced in this comment letter have already been submitted to the docket via Regulations.gov. Other key sources that contain original research conducted specifically for these comments are attached as appendices to this letter. These sources are: Benchmark Mineral Intelligence, Lithium Mining Projects - Supply Projections (June 2023); ERM, Impacts of EPA Light- & Medium-Duty Multi-Pollutant Standards: National Scenario Results (June 2023); and Roush (Himanshu Saxena, et al.), Electrification Cost Evaluation of Class 2b and Class 3 Vehicles in 2027–2030 (May 2023).

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I. Introduction

EPA has both an opportunity and an obligation to dramatically reduce emissions of greenhouse gases (GHGs) and other pollutants from light-duty vehicles (LDVs) and medium-duty vehicles (MDVs). The Agency's mandate to protect public health and welfare is made urgent by the ever more dire impacts of climate change, as well as the continuing harms to public health from vehicle criteria pollution. And the opportunity to significantly reduce these impacts is clear. Zero-emission vehicles (ZEVs) are not only feasible and cost-reasonable—they are rapidly penetrating the fleet, with more than 250,000 fully battery electric vehicles sold in the first quarter of 2023 alone, a 44.9% increase over the same period last year.[1] In addition, numerous emission control technologies for combustion vehicles are also feasible, cost-reasonable, and already extensively deployed on the fleet, yet still have potential for greater application within the fleet of new combustion vehicles that will continue to be produced.

In addition, Congress affirmed its commitment to achieving ambitious reductions in GHG and criteria pollutant emissions from motor vehicles in the Bipartisan Infrastructure Law (BIL)[2] and the Inflation Reduction Act (IRA),[3] which provide unprecedented financial support for ZEV technology and infrastructure.

The feasibility of greater pollution control, as well as growing consumer demand for ZEVs, is demonstrated by automaker commitments to increase the number of ZEV models and by their own investments and sales targets for these vehicles. Indeed, numerous projections of the light-duty fleet show high levels of ZEVs in the coming years, with several predicting more than 50% ZEVs as a portion of light-duty vehicle sales by 2030 even in the absence of new EPA regulations, which is also consistent with automaker announcements.[4]

While the market is clearly heading in the right direction, EPA's standards should facilitate even greater deployment of zero-emission and combustion vehicle technologies to help protect the public from the destructive effects of climate change and air pollution generally. To this end, we urge EPA to finalize the strongest possible emission standards. While we do not believe it is necessary for EPA to set standards beyond 2032 at this point, it is critical that the final standards are sufficiently stringent through model year 2032 to ensure that the U.S. is on track to reach 100% new ZEV sales in 2035. <u>The standards in Alternative 1, but with greater stringency after 2030, are feasible and would better serve EPA's statutory mandate to address the</u>

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[1] Cox Automotive, *Another Record Broken: Q1 Electric Vehicle Sales Surpass 250,000, as EV Market Share in the U.S. Jumps to 7.2% of Total Sales* (Apr. 12, 2023), https://www.coxautoinc.com/market-insights/q1-2023-ev-sales/.
[2] Infrastructure Investment and Jobs Act of 2021, Pub. L. No. 117–58, 135 Stat. 429 (2021), www.congress.gov/bill/117thcongress/house-bill/3684/text.
[3] Inflation Reduction Act of 2022, Pub. L. No. 117–169, 136 Stat. 1818 (2022), www.congress.gov/bill/117th-congress/house-bill/5376/text.
[4] *See, e.g.*, U.S. EPA, Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles; Proposed rule, 88 Fed. Reg. 29184, 29189, 29192-93 (May 5, 2023).

environmental and health impacts of air pollution from light- and medium-duty vehicles. Finalizing such standards will provide feasible, critical air pollution emission reductions, as directed by Congress in the Clean Air Act.

II. EPA Must Establish Strong Emission Standards to Meet Its Obligations Under the Clean Air Act.

To carry out its statutory mandate, EPA must promulgate emission standards that protect public health and welfare by minimizing harmful air pollution. In passing the Clean Air Act, Congress found that "the growth in the amount and complexity of air pollution brought about by urbanization, industrial development, and the increasing use of motor vehicles, has resulted in mounting dangers to the public health and welfare."[5] Congress thus declared that the express purpose of the Clean Air Act is to "protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare."[6] As detailed throughout this comment letter, EPA must use this clear statutory authority to meet its mandate to protect public health and welfare by finalizing standards more stringent than it proposed.

A. Section 202 requires EPA to set standards that protect public health and welfare from the dangers of GHGs, criteria pollutants, and air toxics.

Section 202(a)(1)[7] of the Clean Air Act directs EPA to promulgate motor vehicle standards that "prevent or control" emissions of air pollutants that "cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare."[8] The criteria and toxic pollutants at issue in this Proposal[9] have long been subject to regulation based on their harmful effects. And the Supreme Court held in *Massachusetts v. EPA* that Congress clearly provided EPA with "the statutory authority to regulate the emission of [greenhouse] gases from new motor vehicles" pursuant to Section 202(a)(1)–(2).[10] In response to this decision, in 2009 EPA found that greenhouse gas emissions from motor vehicles "contribute to the total greenhouse gas air pollution, and thus to the climate change problem, which is reasonably anticipated to endanger public health and welfare."[11]

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[5] 42 U.S.C. § 7401(a)(2).

[6] *Id.* § 7401(b)(1). Congress affirmed this goal in the 1977 amendments to the Clean Air Act, which "emphasize[d] the preventive or precautionary nature of the act, i.e., to assure that regulatory action can effectively prevent harm before it occurs; [and] emphasize[d] the predominant value of protection of public health." *Lead Industries Ass'n v. EPA*, 647 F.2d 1130, 1152 (D.C. Cir. 1980) (quoting H.R. Rep. No. 95-294, 95th Cong., 1st Sess. 49 (1977)); *see also* 74 Fed. Reg. 66496, 66507 (Dec. 15, 2009).

[7] EPA's specific statutory authority to set standards for emissions of criteria pollutants from medium-duty vehicles is addressed in Section VIII.B.

[8] 42 U.S.C. § 7521(a)(1).

[9] The terms "Proposal" and "Proposed Standards" are used interchangeably to refer to this proposed rulemaking and the standards that EPA is proposing to establish.

[10] 549 U.S. 497, 532 (2007).

[11] 74 Fed. Reg. at 66499.

Once EPA makes an endangerment finding, it must set standards that are commensurate to the magnitude of the danger to public health and welfare posed by the covered emissions.[12] The Clean Air Act defines "effects on welfare" broadly, including "effects on . . . weather . . . and climate."[13] The dangers to public health and welfare posed by GHGs that EPA originally cited in the 2009 Endangerment Finding—"risks associated with changes in air quality, increases in temperatures, changes in extreme weather events, increases in food- and water-borne pathogens, and changes in aeroallergens,"[14] to name a few—have only increased. EPA recognized that this was likely to happen in the Endangerment Finding itself, finding that these "risk[s] and the severity of adverse impacts on public welfare are expected to increase over time."[15] As for criteria pollutants and air toxics—PM, ozone, VOCs, NOx, SOx, CO, diesel exhaust, formaldehyde, acetaldehyde, acrolein, benzene, butadiene, ethylbenzene, naphthalene, and POM/PAHs—their harmful health and environmental effects have long been known, and EPA has recognized the need for continued reductions in their emissions.[16]

Given that the danger to public health and welfare from GHG emissions continues to intensify, and in light of the ongoing harm from criteria pollutant and air toxics emissions, EPA must use its authority under Section 202(a) to set strong emission standards. Section 202(a)(2) provides that standards promulgated pursuant to Section 202(a)(1) "shall take effect after such period as the Administrator finds necessary to permit the development and application of the requisite technology."[17] As the D.C. Circuit has recognized, this language embodies Congress's intent that EPA "press for the development and application of improved technology rather than be limited by that which exists today."[18] Here, adopting more stringent standards would not require EPA to press for the development of new technologies; zero-emission and combustion vehicle technologies have reached technological maturation and are on the market for light- and medium-duty vehicles. Because greater deployment of those technologies within the fleet is feasible and readily achievable, EPA must go further to address the dangers to public health and welfare wrought by GHG, criteria pollutant, and air toxics emissions from these vehicles—specifically, by finalizing Alternative 1 with a steeper increase in stringency after

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[12] *See Massachusetts*, 549 U.S. at 532 (noting that Section 202(a) "charge[s] [EPA] with protecting the public's 'health' and 'welfare'"); *Coal. for Responsible Regulation v. EPA*, 684 F.3d 102, 117, 122 (D.C. Cir. 2012) (stating that EPA must carry out "the job Congress gave it in § 202(a)—utilizing emission standards to prevent reasonably anticipated endangerment from maturing into concrete harm"). *See also* S. Rep. No. 91-1196, at 24 (1970), reprinted in A Legislative History of the Clean Air Amendments of 1970, at 424 (1974) (Section 202(a) requires EPA to "make a judgment on the contribution of moving sources to deterioration of air quality and establish emission standards which would provide the required degree of control."). *Cf.* 74 Fed. Reg. at 66505 ("the Administrator is required to protect public health and welfare, but she is not asked to wait until harm has occurred. EPA must be ready to take regulatory action to prevent harm before it occurs.").
[13] 42 U.S.C. § 7602(h).
[14] 74 Fed. Reg. at 66497.
[15] 74 Fed. Reg. at 66498–66499.
[16] 88 Fed. Reg. at 29186, 29208-24.
[17] *Id.* § 7521(a)(2).
[18] *NRDC v. EPA*, 655 F.2d 318, 328 (D.C. Cir. 1981) (quoting S. Rep. No. 91-1196 (1970)).

2030.[19] As detailed in Section III below, greenhouse gas emissions from light- and medium-duty vehicles contribute massively to the worsening climate crisis, while criteria pollutant and air toxics emissions from those vehicles continue to threaten public health. EPA should therefore choose a regulatory response that will better address the pollution responsible for the "endanger[ment]" that these vehicles pose to public health and welfare.[20]

Congress directed EPA, the expert agency with authority over air pollution from vehicles and engines, to develop a record and apply the Section 202(a) criteria to the facts to develop standards.[21] In doing so, the Agency is "not obliged to provide detailed solutions to every engineering problem, but ha[s] only to identify the major steps for improvement and give plausible reasons for its belief that the industry will be able to solve those problems in the time remaining."[22] Indeed, courts have consistently upheld EPA's vehicle and engine regulations over manufacturers' objections about technological readiness.[23] And manufacturers have consistently risen to the challenge, complying with the very standards they previously claimed were impossible to meet.[24]

B. The Clean Air Act authorizes EPA to rely on zero-emission technologies in standard-setting.

We agree with EPA's assessment of its statutory authority to set vehicle emission standards that rely on the full spectrum of technologies to prevent and control tailpipe pollution, including both zero-emission and combustion vehicle technologies.[25] As set forth in detail in the Proposal, the Clean Air Act authorizes EPA to consider zero-emission technologies when setting emission standards and to finalize standards at levels that will lead to greater deployment of ZEVs.[26] Section 202(a) does not give preference to any particular emission control technology, propulsion system, or powertrain type.[27] And far from enshrining the status quo or protecting the

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[19] Granted, Section 202(a) provides discretion to EPA as to the exact *manner* of "prevent[ing] or control[ing]" emissions of dangerous air pollutants. And Section 202 places certain limitations on EPA in setting standards. EPA's standards pursuant to Section 202(a) must allow lead time for technical feasibility and must give "appropriate consideration to the cost of compliance." 42 U.S.C. § 7521(a)(2). Accounting for these requirements, EPA must promulgate standards that adequately address the danger to public health and welfare caused by the pollutant at issue.
[20] *See Massachusetts*, 549 U.S. at 532; 74 Fed. Reg. at 66525–26.
[21] *See Coal. for Responsible Regulation*, 684 F.3d at 126.
[22] *Nat'l Petrochemical & Refiners Ass'n v. EPA*, 287 F.3d 1130, 1136 (D.C. Cir. 2002) (cleaned up).
[23] *Id*. at 1136–41 (upholding NOx and PM regulations predicated on future developments in pollution control technology); *NRDC v. Thomas*, 805 F.2d at 428–34 (upholding PM regulation over manufacturers' concerns about the feasibility of trap-oxidizer technology); *NRDC v. EPA*, 655 F.2d at 331–36 (same).
[24] *See, e.g.*, 87 Fed. Reg. 17414, 17536 (explaining that manufacturers deployed technologies that EPA had not predicted to meet the 2001 heavy-duty criteria pollutant standards, which they had unsuccessfully challenged in *National Petrochemical & Refiners Association*).
[25] *See* 88 Fed. Reg. at 29232-33.
[26] *See id.* at 29231–33 (relying on statutory language, legislative materials, case law, and regulatory history).
[27] *See* EPA Br. 7-10; Oge & Hannon Amicus Br. 17-18; Final Br. of State & Pub. Int. Respondent-Intervenors, *Texas v. EPA*, Case No. 22-1031 (D.C. Cir. Apr. 27, 2023), ECF No. 1996908, 6-8, 28-29 [hereinafter "State & Pub. Int.

market share of polluting vehicles, Congress intended that EPA set standards that drive improvements in emission control technologies.[28] Indeed, Congress was intensely interested in electrification and other emerging vehicle technologies as far back as the 1960s and 1970s, and it expected EPA to consider emission reductions that could be achieved through the use of alternative fuels and propulsion systems (including electrification) that control air pollution more effectively than combustion vehicle technologies.[29] As "complete systems…to prevent" air pollution,[30] ZEVs fall well within the scope of Section 202(a)(1).[31]

Accelerating the deployment of zero-emission technologies through this rulemaking would also build on EPA's long and consistent practice of both considering and incentivizing these technologies in its Section 202(a) rulemakings.[32] EPA began doing so more than two decades ago when it finalized the "Tier 2" criteria pollutant standards.[33] That rule required manufacturers to certify all new light-duty vehicles into one of eight emissions profiles, or "bins."[34] A sales-weighted average of those bins determined the manufacturer's compliance with the fleet-average NOx standard.[35] Bin 1 was designated for ZEVs.[36] EPA recognized that including ZEVs in the fleet average would "provide a strong incentive" for manufacturers to develop and introduce ultra-clean vehicle technologies, serving as "a stepping stone to the[ir] broader introduction."[37] (EPA's prediction has proven correct, as ZEVs have grown to comprise

Br."]; Br. of Sen. Thomas R. Carper & Rep. Frank Pallone, Jr. as Amici Curiae in Support of Respondents, *Texas v. EPA*, Case No. 22-1031 (D.C. Cir. Mar. 2, 2023), ECF No. 1988363, 12-16, 19-22 [hereinafter "Carper & Pallone Amicus Br."].

[28] *See Int'l Harvester Co. v. Ruckelshaus*, 478 F.2d 615, 640 (D.C. Cir. 1973) (recognizing that Congress's choices in the 1970 Clean Air Act Amendments may lead to "fewer models and a more limited choice of engine types"). As EPA explained in its brief in *Texas v. EPA*, Section 202(a), "by design, seeks innovation and change." EPA's Final Answering Br., *Texas v. EPA*, Case No. 22-1031 (D.C. Cir. Apr. 27, 2023), ECF No. 1996730, at 43-44 [hereinafter "EPA Br."]. Indeed, over the decades, EPA's emission standards have led to significant technological innovation and advancements in the auto industry. *See id.* at 7; Br. of Amici Curiae Margo Oge & John Hannon in Support of Respondents, *Texas v. EPA*, Case No. 22-1031 (D.C. Cir. Mar. 8, 2023), ECF No. 1989149, 7-8, 21-22, 26-27 [hereinafter "Oge & Hannon Amicus Br."].

[29] *See* 88 Fed. Reg. at 29232-33; EPA Br. at 7-10, 40-46; State & Pub. Int. Br. at 6-8, 28-29; Carper & Pallone Amicus Br. at 12-16, 19-22.

[30] 42 U.S.C. § 7521(a)(1).

[31] Section 202(a)(4), which references an "emission control device, *system, or element of design*," 42 U.S.C. § 7521(a)(4)(A) (emphasis added), provides further evidence that Congress envisioned that EPA may consider, and that manufacturers may use, a wide variety of emission control technologies and approaches. Electrification is a "system" and an "element of" motor vehicle "design."

[32] Oge & Hannon Amicus Br. at 14-15, 24-25, 28-30.

[33] 65 Fed. Reg. 6698 (Feb. 10, 2000). Even before the Tier 2 standards, EPA included ZEVs in its 1997 National Low Emission Vehicle Program regulation. Those standards, however, were voluntary. 62 Fed. Reg. 31192, 31208, 31211-12, 31224 (June 6, 1997).

[34] 65 Fed. Reg. at 6734.

[35] *Id.*

[36] *Id.* at 6746.

[37] *Id*.

ever-greater portions of the light-duty[38] and heavy-duty fleets[39] since that time.) Later, in a series of GHG emission rulemakings spanning three presidential administrations, the Agency continued to include ZEVs in fleet average standards for light- and heavy-duty vehicles, as shown in the table below. EPA took the same approach in 2014 for its Tier 3 criteria pollutant standards for light-duty vehicles.[40]

Table II.B-1: Electrification, fleet-average standards, and averaging, banking, and trading in prior GHG rulemakings[41]

Rule	Fleet-average standard	Averaging, banking, and trading	Considering electrification
Light-duty (model-year 2011 and later), 75 Fed. Reg. 25324 (May 7, 2010)	25405/1, 25412/1-3	25412/3	25328/3, 25456 (tbl. III.D.6-3)
Heavy-duty (model-year 2014 and later), 76 Fed. Reg. 57106 (Sept. 15, 2011)	57119/1	57238/2-39/1	57204/3-05/2, 57220/1-21/2, 57224/3-25/1, 57246/1
Light-duty (model-year 2017 and later), 77 Fed. Reg. 62624 (Oct. 15, 2012)	62627/3-28/1	62628/1-2	62705/1-06/1, 62852/2-61
Heavy-duty (model-year 2021 and later), 81 Fed. Reg. 73478 (Oct. 25, 2016)	73730/2-3, 73733/2-34/1	73495/2-3, 73568/2-69/3	73751/1-3
Light-duty (model-year 2021 and later), 85 Fed. Reg. 24174 (Apr. 30, 2020)	24246/3-47/3	25206/3-07/1, 25275/1-76/2	24320/1, 24469/1-524/3
Light-duty (model-year 2023 and later), 86 Fed. Reg. 74434 (Dec. 30, 2021)	74446/3-51/1	74453/1-56/1	74493/1-94/3, 74484/2-87/3

Finally, we agree with EPA that recent actions by Congress reinforce the Agency's authority to set emission standards that rely on and accelerate the deployment of zero-emission

[38] EPA, *The 2022 Automotive Trends Report*, at 74, Table 4.1 (2022), https://www.epa.gov/system/files/documents/2022-12/420r22029.pdf (production share by powertrain, showing increasing shares of hybrids, plug-in hybrids, and battery electric vehicles).
[39] 88 Fed. Reg. 25926, 25939-43.
[40] 79 Fed. Reg. 23414, 23454, 23471 (Apr. 28, 2014).
[41] Reproduced from EPA Br. at 16.

vehicle technologies.[42] As members of Congress have emphasized, the BIL and IRA provide "a clear signal of Congress' intent to support vehicle electrification and robust EPA authority to accelerate it."[43] By increasing the market penetration of ZEVs[44] and significantly lowering the cost of zero-emission technologies, the BIL and IRA assist EPA in setting standards that will achieve ambitious reductions in GHG, criteria pollutant, and air toxics emissions.[45] EPA should use its clear authority under the Clean Air Act to do so here by finalizing standards more stringent than it has proposed.

III. Further Reductions in Emissions of GHGs and Criteria Pollutants from Motor Vehicles Are Necessary to Protect Public Health and the Environment.

A. Vehicular emissions of greenhouse gases gravely endanger public health and welfare by intensifying the climate crisis.

Emissions of GHGs from the transportation sector pose mortal dangers to public health and the environment; EPA's exercise of its responsibilities under the Clean Air Act must take account of and mitigate these dangers. Over thirteen years ago, based upon a massive scientific record, the EPA found that new motor vehicles and engines contribute to emissions of GHGs that drive climate change and endanger the health and welfare of current and future generations.[46] Specifically, EPA found that the intensifying climate crisis increased the frequency of warmer temperatures, heat waves, and other extreme weather, worsened air quality by increasing regional ozone pollution, increased the spread of food and water-borne illnesses, increased the frequency and severity of seasonal allergies, and increased the severity of coastal storm events due to rising sea levels.[47]

Since EPA issued the Endangerment Finding in 2009, dire evidence of the current and future impacts of climate change has continued to accumulate. Recent studies demonstrate that climate change continues to cause heat waves and extreme weather events across the United States.[48] Between May and mid-September, 2022, "nearly 10,000 daily maximum temperature

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[42] *See* 88 Fed. Reg. at 29233.
[43] Carper & Pallone Amicus Br. at 29; *see generally id.* At 29-35.
[44] As EPA notes, pre-IRA projections predicted that PEVs would make up nearly 40% of U.S. market share by 2030. 88 Fed. Reg. at 29189. In contrast, post-IRA projections by the International Council on Clean Transportation (ICCT) estimate that battery-electric vehicles will increase to 56 to 67% of market share in the U.S. by 2032. *Id.* at 29189 n.40.
[45] *See* Greg Dotson & Dustin J. Maghamfar, *The Clean Air Act Amendments of 2022: Clean Air, Climate Change, and the Inflation Reduction Act*, 53 Env't L. Rep. 10017, 10018, 10029 (2023).
[46] 74 Fed. Reg. at 66496.
[47] 74 Fed. Reg. at 66525–26.
[48] U.S. Dep't of Health & Hum. Serv. (HHS), Off. Climate Change & Health Equity, *Climate and Health Outlook* (May 2023) [hereinafter HHS, *Climate and Health Outlook*], https://www.hhs.gov/sites/default/files/climate-health-outlook-may-2023.pdf. *See also* Andrew Hoell et al., *Water Year 2021 Compound Precipitation and Temperature Extremes in California and Nevada*, 103 Bull. of the Am. Meteorological Soc'y E2905, E2910 (Dec. 2022), https://journals.ametsoc.org/view/journals/bams/103/12/BAMS-D-22-0112.1.xml?tab_body=fulltext-display

records were broken."[49] Additionally, 2022 was "one of the top 10 hottest years on record for daily maximum temperatures" in 13 states, as well as one of the top 10 hottest for daily minimum (nighttime low) temperatures for 31 states.[50] Warmer temperatures endanger public health by increasing the risk of heart disease, worsening asthma and chronic obstructive pulmonary disease from increases of ground-level ozone, and causing dehydration and many other ailments.[51] Studies have also found that heat waves and extreme weather events cause severe psychiatric and mental health impacts.[52] Climate change continues to lead to higher than normal pollen concentrations and earlier and longer pollen seasons, causing worse allergies and asthma.[53] The intensifying climate crisis also increases the risk of drought across the U.S, which impacts water supply, agriculture, transportation, and energy, and increases the risk and magnitude of wildfires.[54] And recent projections show that sea level rise is anticipated to be on the high end of model projections.[55] Studies have found that many of the dangers wrought by climate change exact a higher toll on people with low incomes and people of color.[56]

(human-caused climate change led to increased extreme high temperatures in 2021 in California and Nevada); Kristy Dahl, Union of Concerned Scientists, *Summer of 2022 Was a Hot One. What was Climate Change's Impact on Heat?*, The Equation (Sept. 21, 2022), https://blog.ucsusa.org/kristy-dahl/summer-of-2022-was-a-hot-one-what-was-climate-changes-impact-on-heat/.

[49] Dahl.

[50] *Id*.

[51] HHS, *Climate and Health Outlook*, at 2; Christopher Nolte et al., U.S. Global Change Rsch. Program, *Air quality*, in II *Impacts, risks, and adaptation in the United States: Fourth national climate assessment* 512, 515 (2018), https://nca2018.globalchange.gov/downloads/NCA4_Ch13_Air-Quality_Full.pdf (climate change leads to worsened air quality by increasing concentrations of ozone and particulate matter in many parts of the U.S.); Am. Lung Ass'n, *State of the Air 2023 Report* 19 (2023), https://www.lung.org/getmedia/338b0c3c-6bf8-480f-9e6e-b93868c6c476/SOTA-2023.pdf?ext=.pdf (describing worsened air quality resulting from climate change).

[52] *See, e.g.*, Amruta Nori-Sarma et al., *Association Between Ambient Heat and Risk of Emergency Department Visits for Mental Health Among US Adults, 2010 to 2019*, 79 JAMA Psychiatry 341 (2022), https://jamanetwork.com/journals/jamapsychiatry/fullarticle/2789481?; Marshall Burke et al., *Higher temperatures increase suicide rates in the United States and Mexico*, 8 Nature Climate Change 723 (2018), https://gspp.berkeley.edu/assets/uploads/research/pdf/s41558-018-0222-x.pdf; Sarita Silveira et al., *Chronic Mental Health Sequelae of Climate Change Extremes: A Case Study of the Deadliest Californian Wildfire*, Int'l J. Env't Rsch. & Pub. Health, Feb. 4, 2021, https://www.mdpi.com/1660-4601/18/4/1487 (demonstrating that climate-related extreme weather events such as wildfires can have severe mental health impacts).

[53] HHS, *Climate and Health Outlook*, at 5.

[54] *See* Marco Turco et al., *Anthropogenic climate change impacts exacerbate summer forest fires in California* PNAS, June 12, 2023, https://www.pnas.org/doi/10.1073/pnas.2213815120; Ctr. for Climate & Energy Sol., *Drought and Climate Change*, https://www.c2es.org/content/drought-and-climate-change/ (last visited June 2, 2023). *See also* Nolte et al., at 521.

[55] Benjamin Hamlington et al., *Observation-based trajectory of future sea level for the coastal United States tracks near high-end model projections*, Commc'n Earth Env't, Oct. 6, 2022, https://www.nature.com/articles/s43247-022-00537-z.

[56] *See, e.g.*, Sameed Khatana et al., *Association of Extreme Heat With All-Cause Mortality in the Contiguous US, 2008-2017*, JAMA Network Open, May 19, 2022, at 1 https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2792389 (finding extreme heat was associated with higher mortality in the U.S., particularly among older adults and black individuals); Adam Schlosser et al., *Assessing Compounding Risks Across Multiple Systems and Sectors: A Socio-Environmental Systems Risk-Triage Approach*, Frontiers in Climate, Apr. 24, 2023, at 09, https://www.frontiersin.org/articles/10.3389/fclim.2023.1100600/full (identifying hot spots where flood risks and water stress disproportionately impact low-income and nonwhite communities); Dahl ("[M]ore than 80% of the counties with the most frequent heat alerts—21 or more days of heat

The transportation sector has been responsible for an increasing percentage of GHG emissions in the U.S. since 2009, thereby playing an outsized role in intensifying the climate crisis. When EPA made its Endangerment Finding for GHGs, the transportation sector was responsible for 23% of total annual U.S. GHG emissions.[57] Since then, transportation sector GHG emissions have only increased as a share of U.S. emissions, surpassing the electric power sector as the largest U.S. source of GHG emissions and contributing 27.2% of total GHG emissions in 2020[58] and 28.5% in 2021.[59] After dipping in 2020 due to the COVID-19 pandemic, carbon dioxide (CO_2) emissions from the transportation sector increased by 11.5% between 2020 and 2021.[60] Transportation as an end use sector "account[ed] for 1,757.4 [million metric tons] CO_2 in 2021 or 37.9% of total CO_2 emissions from fossil fuel combustion."[61] Adopting stringent GHG emission standards for light- and medium-duty vehicles will lead to massive public health benefits by limiting these pollutants.[62]

The IPCC's most recent synthesis of its Sixth Assessment Report confirms the danger to public health and welfare posed by GHG emissions from the transportation sector. The report found that global surface temperature was around 1.1°C higher in 2011-2020 than it was in 1850-1900.[63] While average annual GHG emissions growth has slowed in certain sectors such as energy supply and industry, growth in GHG emissions from the transportation sector has remained relatively constant at about 2% per year.[64] The latest IPCC report warned that "[d]eep, rapid and sustained GHG emissions reductions, reaching net zero CO_2 emissions and including strong emissions reductions of other GHGs . . . are necessary to limit warming to 1.5°C . . . or less than 2°C . . . by the end of the century."[65] To have a chance at limiting global temperature increase to 1.5℃ and avoid the worst impacts of climate change, current GHG emissions from the transportation sector must drop by 59% by 2050 compared to 2020 emissions.[66]

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alerts over the course of the summer—have moderate to high levels of social vulnerability."). *See generally* EPA, *Climate Change and Social Vulnerability in the United States, A Focus on Six Impacts* (2021), https://www.epa.gov/system/files/documents/2021-09/climate-vulnerability_september-2021_508.pdf.

[57] 74 Fed. Reg. at 66499.

[58] EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020*, EPA 430-R-22-003, at ES-21 (2022), https://www.epa.gov/system/files/documents/2022-04/us-ghg-inventory-2022-main-text.pdf.

[59] EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021*, EPA 430-R-23-002, at 2-19, 2-28 (2023), https://www.epa.gov/system/files/documents/2023-04/US-GHG-Inventory-2023-Main-Text.pdf.

[60] *Id.* at 2-13.

[61] *Id.* at 2-17.

[62] *See generally* Am. Lung Ass'n, Driving to Clean Air: Health Benefits of Zero-Emission Cars and Electricity (June 2023), https://www.lung.org/getmedia/9e9947ea-d4a6-476c-9c78-cccf7d49ffe2/ala-driving-to-clean-air-report.pdf.

[63] Intergovernmental Panel on Climate Change (IPCC), *Synthesis Report of the IPCC Sixth Assessment Report (AR6): Longer Report*, at 6 (2023), https://report.ipcc.ch/ar6syr/pdf/IPCC_AR6_SYR_LongerReport.pdf.

[64] *Id.* at 10.

[65] *Id.* at 33.

[66] IPCC, *Climate Change 2022: Mitigation of Climate Change* 32 (2022), https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_FullReport.pdf.

B. Emissions of criteria pollutants from light- and medium-duty vehicles harm the public health.

EPA's proposed reductions of non-methane organic gases ("NMOG") plus NOx, as well as particulate matter, are crucial to protecting the public from harmful air pollutants. As EPA notes, "[e]mission sources impacted by [its] proposal, including vehicles and power plants, emit pollutants that contribute to ambient concentrations of ozone, PM, NO2, SO2, CO, and air toxics."[67] These pollutants are linked to premature death, respiratory illness (including childhood asthma), cardiovascular problems, and other adverse health impacts. In particular, NOx emissions increase levels of ozone, because ground-level ozone forms when there are high concentrations of ambient NOx and VOCs, and when solar radiation is high.[68] NOx emissions also impact particulate matter by forming secondary particles through atmospheric chemical reactions.[69] Reductions in NOx emitted from LDVs will therefore result in reduced ambient levels of ozone and PM and improved health and environmental outcomes.

Air pollution has become so significant that the public health burdens attributable to air pollution are "now estimated to be on a par with other major global health risks such as unhealthy diet and tobacco smoking, and air pollution is now recognized as the single biggest environmental threat to human health."[70] Researchers at the University of Chicago studied the impact of air pollution on life expectancy and found that "the impact of particulate pollution on life expectancy is comparable to that of smoking, more than three times that of alcohol and unsafe water and sanitation, six times that of HIV/AIDS, and 89 times that of conflict and terrorism."[71]

There is consistent evidence showing the relationship between short-term exposure to PM and mortality, particularly cardiovascular and respiratory mortality. Short- and long-term exposure to $PM_{2.5}$ can cause harmful health impacts such as heart attacks, strokes, worsened asthma, and early death.[72] In addition, short-term PM exposure has been linked to increases in infant mortality, hospital admissions for cardiovascular disease, hospital admissions and emergency visits for chronic obstructive pulmonary disease, and severity of asthma attacks and

[67] 88 Fed. Reg. at 29211.
[68] Am. Lung Ass'n, State of the Air 2023 Report (2023) at 26, https://www.lung.org/getmedia/338b0c3c-6bf8-480f-9e6e-b93868c6c476/SOTA-2023.pdf?ext=.pdf.
[69] DRIA at 7-10.
[70] World Health Organization (WHO), WHO Global Air Quality Guidelines (2021) at xiv, https://apps.who.int/iris/bitstream/handle/10665/345329/9789240034228-eng.pdf.
[71] Michael Greenstone, Christa Hasenkopf, & Ken Lee, Air Quality Life Index Annual Update, Energy Policy Institute at the University of Chicago (2022) at 6-7, https://aqli.epic.uchicago.edu/wp-content/uploads/2022/06/AQLI_2022_Report-Global.pdf/.
[72] *See* EPA, Supplement to the 2019 Integrated Science Assessment for Particulate Matter (Final Report, 2022), at ES-ii, 2-3, 2-4, https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=354490; EPA, Integrated Science Assessment (ISA) for Particulate Matter (Dec. 2019), https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=347534.

hospitalization for asthma in children. Year-round exposure to PM is associated with elevated risks of early death, primarily from cardiovascular and respiratory problems such as heart disease, stroke, influenza, and pneumonia.[73] These findings show the critical need for EPA to minimize the harmful emissions from the transportation sector. Doing so will only improve public health and the environment.

C. More stringent standards would bring greater benefits to environmental justice communities.

This rulemaking will provide benefits to environmental justice communities by reducing harm from climate change and pollution exposure. And Alternative 1, with a faster ramp rate after 2030, would bring even greater benefits to vulnerable populations that suffer the brunt of pollution and climate change harms. EPA appropriately recognizes that environmental justice communities are disproportionately affected by climate change and pollution impacts related to light- and medium-duty vehicles and upstream emissions. Addressing these harms by providing these communities relief more quickly—a priority for this Administration—is a compelling reason why EPA should adopt Alternative 1 with a faster ramp rate after 2030.

Given the vast history of disproportionate environmental and public health burdens placed on communities of color and low-income communities, EPA appropriately included consideration of environmental justice, energy justice, and equity in its Proposal.[74] Communities that are overburdened with pollution from sources such as major roadways, industrial sites, and agriculture are predominantly low-income, and a large percentage of residents of these communities are people of color and non-English speakers.[75] With the improvements described in this comment letter, this rulemaking could bring about significant air quality and health improvements in communities that are disproportionately burdened with air pollution from motor vehicles and overburdened from pollution more broadly.[76]

EPA should set strong emissions standards to meet its obligations under presidential directives on environmental justice. Under Executive Order 12,898, EPA "shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs,

[73] Am. Lung Ass'n, State of the Air 2023 Report (2023) at 25, https://www.lung.org/getmedia/338b0c3c-6bf8-480f-9e6e-b93868c6c476/SOTA-2023.pdf?ext=.pdf.
[74] For more information on the history and definition of the environmental justice movement, see Initiative for Energy Justice, Section 1—Defining Energy Justice: Connections to Environmental Justice, Climate Justice, and the Just Transition (Dec. 23, 2019), https://iejusa.org/section-1-defining-energy-justice/.
[75] *See* Gina M. Solomon et al., Cumulative Environmental Impacts: Science and Policy to Protect Communities, 83 Annual Review of Public Health (Jan. 6, 2016), https://pubmed.ncbi.nlm.nih.gov/26735429/.
[76] *See* EPA, ISA for Particulate Matter at Ch. 12: Populations and Lifestages Potentially at Increased Risk of a Particulate Matter-Related Health Effect; Section 5: Sociodemographic Factors, https://www.epa.gov/isa/integrated-science-assessment-isa-particulate-matter.

policies, and activities on minority populations and low-income populations." 59 Fed. Reg. 7629 (Feb. 11, 1994). And Executive Order 14,008 directs EPA to develop "programs, policies, and activities to address the disproportionately high and adverse human health, environmental, climate-related and other cumulative impacts on disadvantaged communities, as well as the accompanying economic challenges of such impacts." 86 Fed. Reg. 7619, 7629 (Jan. 27, 2021). It also establishes the Administration's policy "to secure environmental justice and spur economic opportunity for disadvantaged communities that have been historically marginalized and overburdened by pollution." *Id*.

1. Reductions in greenhouse gas emissions will bring climate change benefits to environmental justice communities.

Reducing GHG emissions from light- and medium-duty vehicles will help reduce the significant harm that climate change inflicts on environmental justice communities. By 2055, the Proposed Standards would avoid 7,300 million metric tons (MMT) of CO_2 emissions, 88 Fed. Reg. at 29198, tbl. 3, and EPA's calculations show the Proposal would produce climate benefits of between $82 and $1,000 billion in 2020 dollars by 2055, depending on the values used for GHG emission reductions. *Id*. at 29200, tbl. 6 (using a 3% discount rate). As compared to the Proposed Standards, by 2055 Alternative 1 would achieve an additional 800 MMT of CO_2 savings, 88 Fed. Reg. at 29203, tbl. 14, and increase climate benefits by between $9 and $100 billion. *Id*. at 29205, tbl. 17. And adopting Alternative 1 with a faster ramp rate after 2030 would bring even more climate benefits to environmental justice communities. *See infra* Section V (detailing the societal benefits of more stringent standards).

These reductions are significant on a national and global scale because greenhouse gas emissions from light- and medium-duty vehicles are a consequential portion of both national and international GHG emissions. Emissions from the transportation sector are the largest source (29%) of GHGs in the country, and light- and medium-duty vehicles are the largest portion of that.[77] The United States is responsible for a large portion of global CO_2 emissions—approximately 14% as of 2019—and is the second largest emitter in the world.[78] Reducing GHG emissions from light- and medium- duty vehicles is therefore one of the most consequential steps EPA—or the United States—can take to mitigate climate change harm. And, as the Supreme Court found in *Massachusetts v. EPA*, "[a] reduction in domestic emissions would slow the pace of global emissions increases, no matter what happens elsewhere." 549 U.S. 497, 500 (2007).

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[77] EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021, EPA 430-R-23-002, at 2-35 (Apr. 2023). https://www.epa.gov/system/files/documents/2023-04/US-GHG-Inventory-2023-Main-Text.pdf.
[78] UCS, Each Country's Share of CO_2 Emissions (updated Jan. 14, 2022), at https://www.ucsusa.org/resources/each-countrys-share-co2-emissions.

Reducing climate harm will benefit environmental justice communities because, as EPA has aptly described, climate change disproportionately affects these communities. 88 Fed. Reg. at 29393-95. EPA recognized in the 2009 Endangerment Finding that vulnerable populations, including economically and socially disadvantaged communities and Indigenous or minority populations, are especially vulnerable to climate change. *Id.* at 29393. Reports from the U.S. and international climate bodies over the last decade add evidence to the conclusion that climate change disproportionately impacts environmental justice communities, including by "altering exposures to heat waves, floods, droughts, and other extreme events; vector-, food- and waterborne infectious diseases; changes in the quality and safety of air, food, and water; and stresses to mental health and well-being." *Id.* at 29394. Notably, the 2016 scientific assessment on the Impacts of Climate Change on Human Health predicts that people of color will suffer a disproportionate impact of climate exacerbations of air pollution. *Id.* at 29395. It also describes unique vulnerabilities of Native American communities because of expected impacts to their cultural resources, customs, and traditional subsistence lifestyles, including expected declines in food security for Alaskan Indigenous Peoples. *Id.*

Though EPA has included a significant number of publications in its literature review, it should also include its 2021 analysis of the disproportionate climate impacts on vulnerable populations. The study quantifies the increased risks of climate change on socially vulnerable populations in six categories: Air Quality and Health; Extreme Temperature and Health; Extreme Temperature and Labor; Coastal Flooding and Traffic; Coastal Flooding and Property; and Inland Flooding and Property, using data on where people live as an indicator of exposure.[79] The report concludes that Black and African American individuals will likely face higher impacts of climate change for all six impacts analyzed compared to all other demographic groups. Black and African Americans are 40% more likely to live in communities with the highest increase in premature mortality from extreme temperatures, and 34% are more likely to live in areas with the highest increases in $PM_{2.5}$ childhood asthma diagnoses with 2°C (3.6°F) of global warming.[80] Hispanic and Latinos are also significantly more likely to live in areas where impacts are projected to be highest.[81] Low-income individuals and those without a high school diploma have 25-26% greater risk of living in areas with the highest extreme temperature labor hours lost.[82]

And as we witness time and again with each unfolding disaster, vulnerable populations suffer the most from climate change-fueled extreme events. Taking recent events in this country as illustrative examples, economically disadvantaged individuals, low-wage outdoor workers,

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[79] EPA, Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts, EPA 430-R-21-003 (2021) at 9 (Six Impacts), https://www.epa.gov/system/files/documents/2021-09/climate-vulnerability_september-2021_508.pdf.
[80] *Id.* at 79.
[81] *Id.* at 76.
[82] *Id.* at 77.

and homeless and elderly people died from heat stroke in the Northwest heat wave in 2021,[83] an event that researchers found would have been "virtually impossible without human-caused climate change."[84] In New Orleans, the people who could not evacuate before disastrous Hurricanes Katrina and Ida struck land are those who did not have the means or ability to do so.[85] In New York City, many people who could only afford to live in illegal basement apartments died as a result of flooding during Ida.[86] During western wildfire season, those without homes or means do not have the luxury of filtered air to protect their lungs.[87] To help address the urgency of the climate crisis and its impacts on vulnerable populations, EPA must adopt the more stringent Alternative 1 with a faster ramp rate after 2030.

2. Reductions in criteria pollution emissions will bring health benefits to environmental justice communities.

This rulemaking presents a critical opportunity to mitigate the adverse health impacts plaguing communities that are overburdened by air pollution from motor vehicles and other sources. According to the American Lung Association's (ALA) 2023 State of the Air report, which grades counties on daily and long-term measures of particle pollution and daily measures of ozone, more than 119 million Americans live in places that received failing grades for unhealthy levels of ozone or PM in their air.[88] The report notes:

> Although people of color are 41% of the overall population of the U.S., they are 54% of the nearly 120 million people living in counties with at least one failing grade. And in the counties with the worst air quality that get failing grades for all three pollution measures,

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[83] *E.g.*, Irfan, U., Extreme heat is killing American workers, Vox (Jul. 21, 2021), https://www.vox.com/22560815/heat-wave-worker-extreme-climate-change-osha-workplace-farm-restaurant.; Geranios, N.K., Pacific Northwest strengthens heat protections for workers (Jul. 9, 2021), https://apnews.com/article/business-science-health-environment-and-nature-washington-c463fc55ab6b601cf70b2fd73644f973; Peterson, D., New data shows scope of heatwave-related homeless deaths, (Jul. 23, 2021), https://www.koin.com/news/special-reports/new-data-shows-scope-of-heatwave-related-homeless-deaths/; Bella, T., Historic heat wave in Pacific Northwest has killed hundreds in U.S. and Canada over the past week (Jul. 1, 2021), https://www.washingtonpost.com/nation/2021/07/01/heat-wave-deaths-pacific-northwest/

[84] World Weather Attribution, Western North American extreme heat virtually impossible without human-caused climate change (Jul. 7, 2021), https://www.worldweatherattribution.org/western-north-american-extreme-heat-virtually-impossible-without-human-caused-climate-change/.

[85] *E.g.,* Willingham, L., "We can't afford to leave": No cash or gas to flee from Ida, (Aug. 29, 2021), https://www.denverpost.com/2021/08/29/hurricane-ida-no-money-evacuate/*see also* Wade, L., Who Didn't Evacuate for Hurricane Katrina?, Pacific Standard (Aug, 31, 2015), *at* https://psmag.com/environment/who-didnt-evacuate-for-hurricane-katrina.

[86] Haag M. & J.E. Bromwich, Most of the apartments where New Yorkers drowned were illegal residences, New York Times (Sept. 3, 2021), https://www.nytimes.com/live/2021/09/03/nyregion/nyc-flooding-ida#nyc-illegal-basement-apartment-ida.

[87] *E.g.,* Kardas-Nelson, M., Racial and Economic Divides Extend to Wildfire Smoke, Too, (Sept. 21, 2020), *at* https://www.invw.org/2020/09/21/racial-and-economic-divides-extend-to-wildfire-smoke-too/.

[88] Am. Lung Ass'n, State of the Air 2023 Report (2023) at 12, https://www.lung.org/getmedia/338b0c3c-6bf8-480f-9e6e-b93868c6c476/SOTA-2023.pdf?ext=.pdf.

72% of the 18 million residents affected are people of color, compared to the 28% who are white.[89]

In addition to the disproportionate impact on people of color noted above, ALA outlines other "high-risk" groups that are impacted by the pollution in these regions. For example, low-income communities are particularly vulnerable and at risk of health impacts from pollution. More than 14.6 million people whose incomes meet the federal definition for living in poverty reside in counties that received a failing grade on at least one of the ALA's pollutant indicators, while nearly 2.6 million people living in poverty reside in counties that received failing grades on all three pollutant measures.[90] In addition, around 27 million children (under age 18) and 18 million older adults (age 65 or older) live in counties that received a failing grade on at least one pollutant.[91]

In fact, it is well established that communities of color and economically disadvantaged communities are disproportionately exposed to environmental burdens from a variety of sources. The White House Council on Environmental Quality (CEQ) released (and recently updated) a Climate and Economic Justice Screening Tool, which identifies communities around the country that are "marginalized, underserved, and overburdened by pollution"[92] and would therefore qualify for Justice40[93] investments (President Biden's key environmental justice initiative). The Screening Tool identifies census tracts as "disadvantaged" if they are above the threshold for one or more environmental or climate indicators (e.g., exposure to diesel PM or $PM_{2.5}$, traffic proximity and volume, or proximity to hazardous waste sites) and above the threshold for socioeconomic indicators related to income and education.[94] A recent analysis found that 64% of the population in census tracts the Screening Tool identifies as disadvantaged are Hispanic/Latino, Black or African American, or American Indian or Alaskan Native.[95] Overall, 50% of Hispanic/Latino, Black or African American, and American Indian or Alaskan Native

[89] *Id.*
[90] *Id.* at 20.
[91] *Id.*
[92] The White House, Biden-Harris Administration Launches Version 1.0 of Climate and Economic Justice Screening Tool, Key Step in Implementing President Biden's Justice40 Initiative (Nov. 22, 2022) https://www.whitehouse.gov/ceq/news-updates/2022/11/22/biden-harris-administration-launches-version-1-0-of-climate-and-economic-justice-screening-tool-key-step-in-implementing-president-bidens-justice40-initiative/. *See* CEQ, Preliminary Climate and Economic Justice Screening Tool*,* https://screeningtool.geoplatform.gov/en/#3/33.47/-97.5.
[93] The White House, *The Path to Achieving Justice40* (July 20, 2021), https://www.whitehouse.gov/omb/briefing-room/2021/07/20/the-path-to-achieving-justice40/.
[94] CEQ*, Climate and Economic Justice Screening Tool: Technical Support Document*, (Nov. 2022) at 4–8, https://static-data-screeningtool.geoplatform.gov/data-versions/1.0/data/score/downloadable/1.0-cejst-technical-support-document.pdf.
[95] Emma Rutkowski et al., Justice40 Initiative: Mapping Race and Ethnicity, Rhodium Group (Feb. 24, 2022), https://rhg.com/research/justice40-initiative-mapping-race-and-ethnicity/.

individuals in the country reside in disadvantaged communities, compared to just 17% of White, Non-Hispanic/Latino individuals.[96]

3. Significant decreases in vehicle and upstream non-GHG emissions over time will provide benefits to environmental justice communities.

In addition to securing GHG reductions, the Proposal will reduce non-GHG tailpipe emissions over time as well as upstream emissions from refineries, both of which will benefit environmental justice communities. 88 Fed. Reg. at 29393. Compared to the Proposal, Alternative 1 provides greater reductions in criteria pollutants and air toxics. *Compare id*. at 29198–99, tbls. 4 and 5, *with id*. at 29204–05, tbls. 15-16. EPA should adopt Alternative 1 with a faster ramp rate after 2030 to bring more relief more quickly to environmental justice communities.

Notably, the immediate benefits more stringent standards would provide from reductions over time in tailpipe and upstream refining emissions vastly outweigh any potentially small non-GHG emissions increases from upstream electric generation. By one measure, reducing refinery emissions may be more beneficial to environmental justice communities as a whole than reducing emissions from electric generation. EPA has concluded that refineries have far higher health benefits per ton of emission reductions than do electric generating units, due in part to greater proximity to populations.[97]

EPA correctly concludes that environmental justice communities are disproportionately harmed by the non-GHG criteria and air toxics emissions associated with vehicles and upstream sources, and therefore these communities will especially benefit from reduced tailpipe emissions. 88 Fed. Reg. at 29395–97. After conducting a literature review and its own analysis, EPA recognizes that higher percentages of communities of color and low-income communities live or attend school near major roadways, suffering the largest share of their emissions and associated adverse health impacts. *Id.* EPA also recognizes that higher percentages of communities of color and low-income communities live near electric generating units and refineries. *Id*. at 29397. EPA should, however, strengthen its statement that "[a]nalysis of populations near refineries also indicates there *may* be potential disparities in pollution-related health risk from that source." *Id*. (emphasis added). The study of socioeconomic factors near refineries cited by EPA itself concludes that "[m]inority and African American percentages are approximately twice as high as

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[96] *Id*.
[97] EPA, Office of Air and Radiation, Office of Air Quality Planning and Standards, Technical Support Document, Estimating the Benefit per Ton of Reducing PM2.5 Precursors from 17 Sectors, at 6, 16 (Feb. 2018), available at https://www.epa.gov/sites/production/files/2018-02/documents/sourceapportionmentbpttsd_2018.pdf (valuing electricity-generation-unit emissions of particulate matter in 2020 at $150,000–350,000 per ton and corresponding refinery emissions at $360,000–830,000 per ton).

national percentages" for cancer risk as a result of petroleum refinery emissions.[98] That study alone is enough evidence to warrant a conclusion that such populations *do* experience disparities in health risk. For further evidence, please see NGO coalition comments on the Proposed SAFE Vehicles Rule for Model Years 2021-2026.[99] Additionally, EPA should recognize here, as it did in its Proposed Rule for MY 2023-2026 Passenger Cars and Light Trucks, that "most anthropogenic sources of PM2.5, including industrial sources, and light- and heavy-duty vehicle sources, disproportionately affect people of color."[100] Finalizing strong standards will help mitigate these harms.

IV. EPA's Own Analysis Shows that Additional Stringency Is Feasible and Would Produce Greater Societal Benefits.

While we support the Proposed Standards, EPA must go further—specifically, by adopting Alternative 1 with a steeper increase in stringency after 2030 to ensure the country is on track to reach 100% new ZEV sales by 2035. As detailed throughout this comment letter, such standards are feasible and offer significantly more air pollution reductions, consumer savings, and societal benefits. And as EPA itself acknowledges, adopting less stringent standards where more stringent ones are achievable "would forgo feasible emissions reductions that would improve the protection of public health and welfare." 88 Fed. Reg. at 29201. In this section, we explain how EPA's own data show that final standards more stringent than the Proposed Standards are warranted. In the sections that follow, we detail the feasibility and superiority of Alternative 1 with a steeper increase in stringency after 2030.

Looking just at EPA's analysis (which did not analyze the costs and benefits of any standards more stringent than Alternative 1), standards more stringent than the Proposed Standards are feasible and would produce greater societal benefits. While average incremental vehicle costs increase under Alternative 1, those costs are recouped by the vehicle purchaser through reduced fueling, maintenance, and repair costs. And as EPA notes, "consumer savings would be … somewhat higher under Alternative 1" than under the Proposed Standards. *Id*. at 29203. The annualized vehicle technology costs through 2055 are $15 billion under the Proposed Standards and $17 billion under Alternative 1, using a 3% discount rate, or a difference of $2 billion. *Id*. at 29364-65, tbl. 160. But the annualized pretax fuel savings under Alternative 1 are

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[98] EPA, Risk and Technology Review—Analysis of Socio-Economic Factors for Populations Living Near Petroleum Refineries. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina at 6 (Jan. 2014).
[99] *See* NGO comment, Dkts. NHTSA-2018-0067, EPA-HQ-OAR-2018-0283, at 232-34, *available at* https://downloads.regulations.gov/EPA-HQ-OAR-2018-0283-5070/attachment_2.pdf. *See also* EIP, Monitoring for Benzene at Refinery Fencelines, 10 Oil Refineries Across U.S. Emitted Cancer-Causing Benzene Above EPA Action Level (Feb. 6, 2020), https://www.environmentalintegrity.org/wp-content/uploads/2020/02/Benzene-Report-2.6.20.pdf.
[100] 86 Fed. Reg. 43726, 43802 n. 213 (citing C.W. Tessum, D.A. Paolella, S.E. Chambliss, J.S. Apte, J.D. Hill, J.D. Marshall, PM2.5 polluters disproportionately and systemically affect people of color in the United States. Sci. Adv. 7, eabf4491 (2021)).

$5 billion higher than those under the Proposed Standards, at $51 billion under Alternative 1 and $46 billion under the Proposed Standards, also using a 3% discount rate. *Id*. at 19366, tbl. 164. Similarly, consumers' maintenance and repair costs are further decreased under Alternative 1—from an annualized value of $29.9 billion in savings under the Proposed Standards to $33.3 billion in savings under Alternative 1, both at a 3% discount rate.[101]

Alternative 1 also provides greater pollution reductions and societal benefits than the Proposed Standards. Under EPA's modeling, Alternative 1 would avoid 8,100 million metric tons (MMT) of CO_2 emissions through 2055 relative to the No Action scenario, *id*. at 29203, tbl. 14, in contrast to the 7,300 MMT avoided under the Proposed Standards, *id*. at 29198, tbl. 3. Alternative 1 also provides greater reductions in criteria pollutants and air toxics. *Compare id*. at 29198-99, tbls. 4 and 5, to *id*. at 29203-05, tbls. 13-16. In addition, Alternative 1 has greater societal net benefits: ranging from $1,500-2,500 billion through 2055, *id*. at 29205-06, tbl. 17 (3% discount rate), depending on the values used for the GHG emission reductions, versus a range of $1,400-2,300 billion under the Proposed Standards. *Id*. at 29200, tbl. 6.

EPA's analysis shows that Alternative 1 is also feasible. It relies on the same existing technology—vehicle electrification—at the core of the Proposed Standards, and the share of battery-electric vehicles (BEVs) in the new vehicle fleet projected by EPA under Alternative 1 is very similar to those under the Proposed Standards, with the share under Alternative 1 never exceeding those under the Proposed Standards by more than 3 percentage points through 2032. *Id*. at 29333, tbl. 99 (BEV penetration of 60% under the Proposed Standards in 2030, versus 63% under Alternative 1). While we are recommending that EPA finalize a modified version of Alternative 1 (which would yield higher levels of BEV penetration, as detailed in Section V below), EPA's analysis at least shows that BEV levels associated with Alternative 1 are eminently feasible.

According to the Alliance for Automotive Innovation, in the first quarter of 2023, there were 55 BEV models and 40 Plug-in Hybrid (PHEV) models available in the United States, representing a variety of vehicle types, including sedans, crossovers, SUVs, and light-duty trucks.[102] The technology is only improving, and the number of models of plug-in electric vehicles (PEVs, which include both BEVs and PHEVs) available in the U.S. is projected to reach 197 by the end of 2025.[103] Higher levels of PEV adoption are already driven by strong consumer

[101] *See* 88 Fed. Reg. at 29385-86, tbls. 196 and 197, adding $21 billion in avoided maintenance costs and $8.9 billion in avoided repair costs under the Proposed Standards, and the analogous values of $24 billion and $9.3 billion, respectively, under Alternative 1.

[102] Alliance for Automotive Innovation, *Get Connected: Electric Vehicle Quarterly Report, First Quarter, 2023* (2023), https://www.autosinnovate.org/posts/papers-reports/Get%20Connected%20EV%20Quarterly%20Report%202023%20Q1.pdf

[103] Rachel MacIntosh et al., *Electric Vehicle Market Update*, Environmental Defense Fund and ERM 7 (April 2023), https://www.edf.org/sites/default/files/2023-05/Electric%20Vehicle%20Market%20Update%20April%202023.pdf; *see also* Jeff S. Bartlett & Ben Preston, *Automakers are Adding Electric Vehicles to Their Lineups. Here's What's*

demand and greater model choice. And as is discussed throughout these comments, the charging infrastructure, electric grid, and vehicle supply chain will be able to accommodate the projected levels of BEVs—indeed, sending a strong regulatory signal will facilitate that process. Moreover, given the flexibility in EPA's program, as well as the fact that EPA's modeling did not include any PHEVs or improvements to combustion vehicle greenhouse gas emissions (and in fact projects increasing GHG emissions from the combustion vehicle fleet, as discussed in Section VI.A), it is likely that the levels of BEVs would be lower in the real-world than EPA projected as automakers employ such technologies to comply with the final standards. That is because making even minor improvements in combustion vehicle GHG emissions—or even simply holding the average emissions of the combustion vehicle fleet constant—or manufacturing PHEVs will allow automakers to achieve compliance with relatively fewer levels of ZEVs than EPA projected.

V. Outside Analysis Demonstrates the Significant Benefits of Stronger Emission Standards, Particularly Alternative 1 with a Steeper Increase in Stringency After 2030.

Outside analysis also shows the benefits of adopting final standards stronger than EPA proposed. Environmental Resources Management, Inc (ERM), one of the largest sustainability consultancies globally, was commissioned by NRDC to provide an independent, third-party analysis of EPA's proposed standards and alternative proposals, as well as a recommended approach. ERM's methodology, assumptions, and results are described throughout this section, and the ERM report is attached to this comment letter.[104] ERM's analysis shows that Alternative 1 with a steeper increase in stringency after 2030 would produce significant societal benefits.

ERM's analysis employed a modeling framework that leveraged EPA's tools to inform and develop inputs to ERM's Benefit-Cost Analysis (BCA) framework. It is important to note that while this analysis is based on EPA's "baseline" scenario, we believe this "baseline" is ultimately not an accurate reflection of a "No Action" scenario, as it is overly conservative. We explore this further in Section XV, but ultimately the most relevant of the analyses that EPA considered supports baseline ZEV sales greater than the baseline levels projected in the "*EPA No Action*" scenario.

Where possible, ERM mirrored EPA's methodology to keep its analytical approach and resultant comparisons consistent with EPA's approach in the Proposal, and to allow for an apples-to-apples comparison.

Coming, Consumer Reports (Jan. 6, 2023), https://www.consumerreports.org/hybrids-evs/why-electric-cars-may-soon-flood-the-us-market-a9006292675/.

[104] Dave Seamonds, et al., ERM, *Impacts of EPA Light-& Medium-Duty Multi-Pollutant Standards: National Scenario Results*, June 2023 [hereinafter ERM, *Impacts Report*] (attached to this comment letter).

A. Policy Scenarios

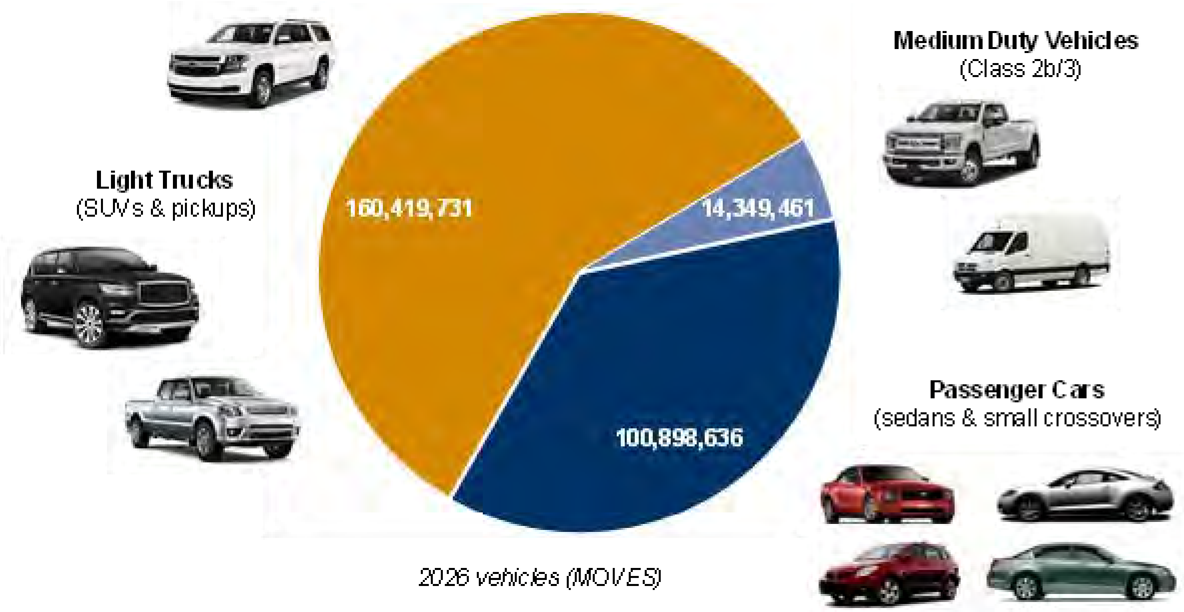
ERM investigated five different policy scenarios: EPA's no action "baseline" ("*EPA No Action*"); EPA's preferred approach ("*EPA Main Proposal*"); our recommended approach, which reflects greater increases in stringency after model year 2030 ("*Alternative 1+*"); EPA's strongest option ("*EPA Alternative 1*"); and EPA's weakest option ("*EPA Alternative 3*").

B. Modeling Background

EPA's updated MOVES model (MOVES3.R3[105]) was utilized to model electric vehicle (EV) adoption rates (sales and in-use), vehicle miles traveled (VMT), and pollutant emissions by vehicle type. Cost assumptions (battery costs, incremental vehicle costs, charging equipment costs, etc.) and vehicle classification/identification information and sales shares were incorporated into both ERM's BCA framework and its modification and application of MOVES3.R3 data outputs. ERM's BCA framework was applied to compare and evaluate the impacts across several policy scenarios as compared to the *EPA No Action* case.

[105] Although MOVES3.R1 was used for L/MD rulemaking, MOVES3.R3 reflects an updated version of MOVES3.R1 but maintains relevant L/MDV data and assumptions.

Figure V.B-1: National Light- and Medium-Duty Vehicle Fleet[106]



This pie chart is based on EPA's modified version of MOVES. EPA projects that the majority of vehicles subject to the rule will be SUVs and light trucks (~160 million), followed by passenger cars (i.e., sedans), which are projected to number just over 100 million vehicles. The remainder is made up of Class 2b (chassis-certified only) and Class 3 medium-duty vehicles, projected to number around 14 million vehicles nationwide; note that "incomplete" class 2b/3 vehicles covered by the proposed Phase 3 heavy-duty rulemaking were not included in this analysis.

ERM utilized EPA's CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool to assess the public health benefits of the scenarios.

ERM conducted five interconnected analyses as part of this BCA:

- **Fuel Use and Emissions**: Specifically, ERM assessed changes in fuel consumption (for diesel, gasoline, and electricity) and the tailpipe and upstream emissions associated with each fuel change for GHGs (CO_2, CH_4, N_2O) and criteria pollutants (NOx and PM) for the various policy scenarios. Reductions in emissions are then monetized using EPA's COBRA model and EPA's Social Cost of GHGs.[107] Because EPA's analysis (which this is intended to mirror) neither reflects any policies to clean up the grid nor a future grid consistent with the administration's climate goals, this likely understates disparities between scenarios with differing electric car/light-truck deployment.

[106] ERM, *Impacts Report* at 6.
[107] ERM utilized the interim social cost of GHG values presented by EPA in DRIA Tables 10-13, 10-14, and 10-15 (3 percent discount rate). Costs were escalated to 2021$ to be consistent with other costs in the ERM model.

- **Health Impacts**: This analysis assumes reductions in NOx and PM under the various policy scenarios to understand the resulting public health implications associated with reducing these emissions and calculates changes in premature deaths, hospital visits, and lost workdays. The analysis also monetizes these net health benefits. As above, these impacts are inherently understated in an effort to mirror EPA's work.

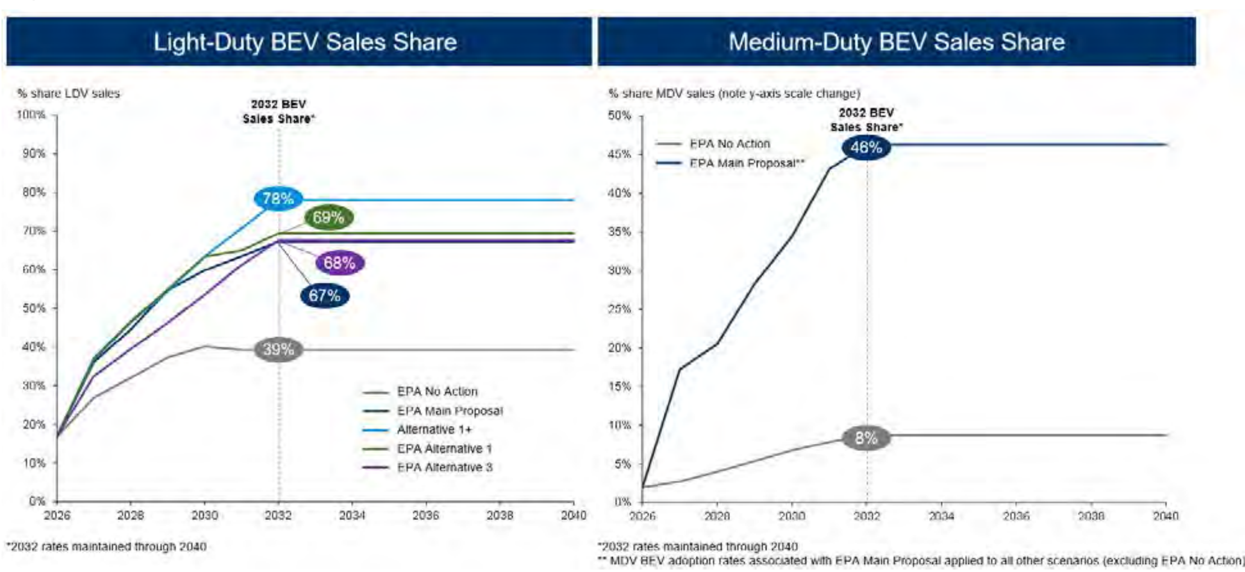
- **Economic Analysis**: ERM assessed changes in consumer purchasing behaviors and vehicle costs, fuel costs, and maintenance practices, and how these factors could change in a more electrified fleet. This analysis also examines capital expenditures for charging infrastructure investments (i.e., purchase, installation, and maintenance).

- **Utility Impacts Analysis**: ERM assessed impacts on utilities and their customers, including an analysis of electricity used to charge vehicles and the incremental load to the grid. The analysis also calculates utility net revenue (revenue minus costs) and potential reduction in electric bills for all utility customers that results from this net revenue. The gap analysis shows the infrastructure needs and associated costs under the different policy scenarios.

C. *Alternative 1+* Results in the Highest BEV Sales Share of All Scenarios

Alternative 1+ results in the highest BEV sales share of all scenarios at 78% by 2032, which helps spur higher in-use BEV share by 2040 (as depicted in Figure V.C-1). The BEV sales share for *Alternative 1+* is almost 10 percentage points more than what is projected to occur under *EPA Alternative 1* and 13 percentage points more than what is projected to occur under the *EPA Main Proposal* and *EPA Alternative 3* policy scenarios.

Figure V.C-1: Comparison of BEV Adoption Rate Scenarios: Sales Share[108]



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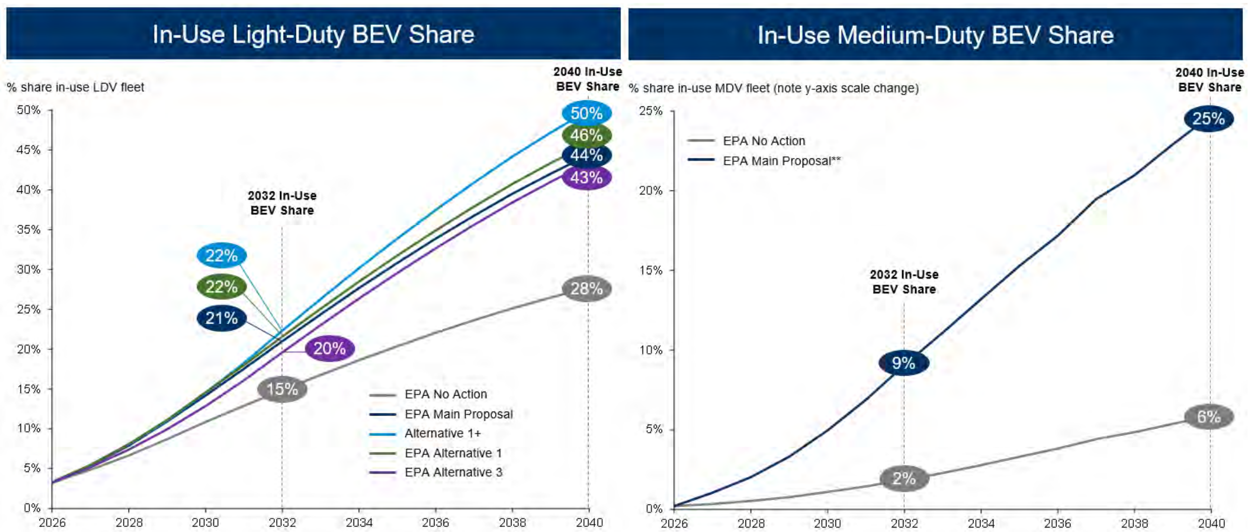
108 ERM, *Impacts Report* at 7-8.

Based on Sales Share (shown in the left side graph), in-use ZEVs will continue to increase under the Alternative 1+ scenario such that the 2040 in-use share is incrementally higher than all other scenarios analyzed.

D. *Alternative 1+* Achieves the Largest Share of In-Use BEVs of All Scenarios

The graphs in Figure V.D-1 show projected shares of in-use vehicles through 2040. As shown, a policy approach implementing our recommended *Alternative 1+* provides the highest in-use ZEV percentages of any scenario analyzed. Under this policy scenario, 50% of the light- and medium-duty (L/MD) vehicles on the road are expected to be BEVs by 2040.

Figure V.D-1: Comparison of BEV Adoption Rate Scenarios: In-Use Share[109]



E. *Alternative 1+* Results in Greater Emissions Reductions and Public Health Impacts than EPA's Preferred Approach

The ERM modeling results regarding GHG tailpipe and upstream emissions, shown below in Figure V.E-1, show the emissions reductions possible by taking an *Alternative 1+* approach from 2026-2040, as well as the cumulative reductions from the other policy scenarios and the monetized value of these reductions (shown in Table V.E-1). These benefits are compared to *EPA's No Action* scenario, which is quite conservative in its projections for what market conditions are expected to be in a no action scenario.

A final rule aligned with our recommended approach would be expected to achieve more than a 52% reduction in emissions of CO_2 by 2040 compared to 2026 and result in almost $148 billion in climate benefits by 2040 – approximately $35 billion more than would be possible from an *EPA Main Proposal* approach during the same timeframe. Accordingly, EPA's failure to

109 *Id.* at 7-8.

finalize a rule that aligns with our recommended approach would unnecessarily leave significant climate benefits on the table.

Figure V.E-1: Comparison of Projected Climate Benefits[110]

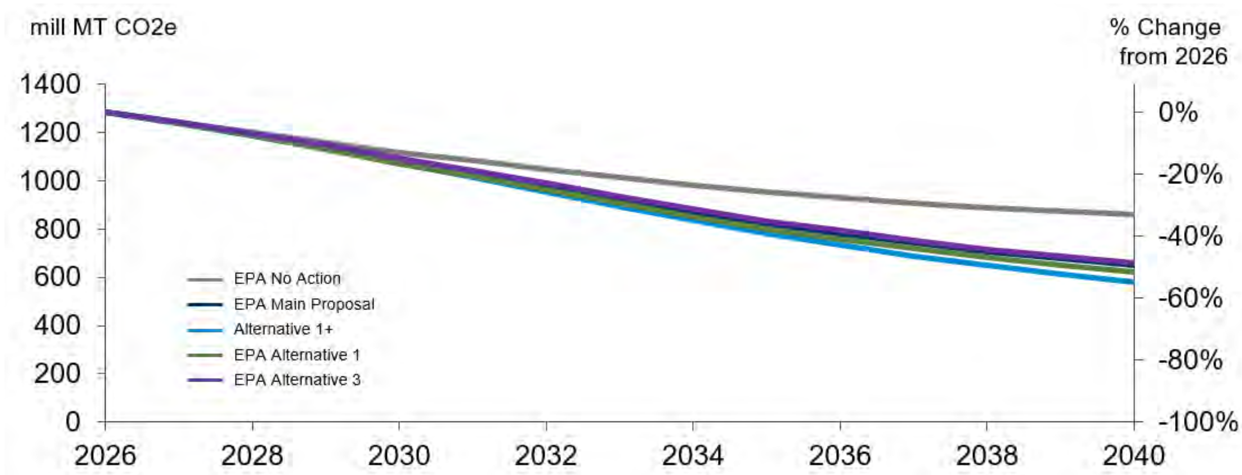


Table V.E-1: Projected Cumulative Reduction and Monetized Value (per policy scenario)[111]

Policy Scenario	Cumulative Reduction (million MT CO2e)		Monetized Value (2021$ bill)	
	2026 - 2032	2026 - 2040	2026 - 2032	2026 - 2040
EPA Main Proposal	211.3	1,544.5	$14.2	$113.1
Alternative 1+	268.6	2,018.1	$18.0	$147.8
EPA Alternative 1	275.3	1,793.2	$18.3	$130.8
EPA Alternative 3	143.6	1,373.2	$9.7	$101.1

COMPARED TO EPA's BASELINE

ERM analysis used EPA's identified Social Cost of Carbon as the basis for monetized social benefits. This analysis also used a 3% average discount rate and escalated the monetary values to 2021 levels to be consistent with other costs contained within the benefit cost model.

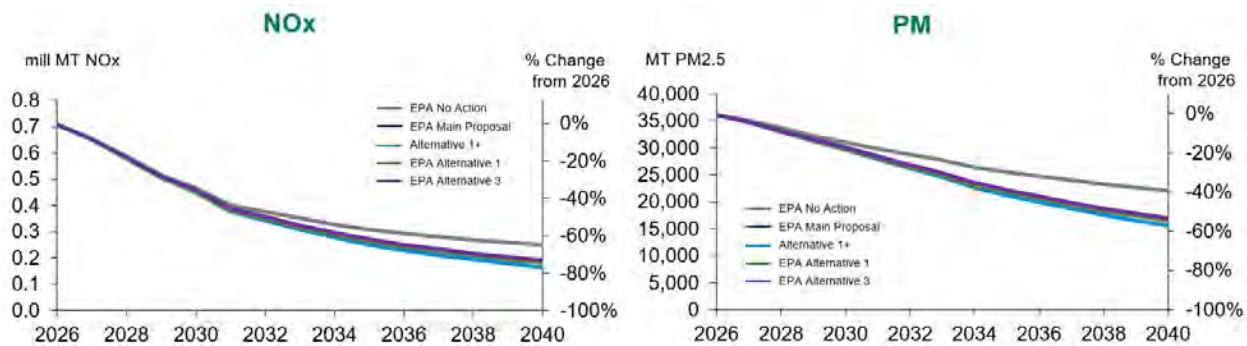
F. Comparison of Criteria Emissions and Possible Health Benefits

For this part of the analysis, ERM utilized EPA's COBRA model to estimate the public health benefits associated with all the policy scenarios. ERM's analysis shows that stricter standards and increased deployment of clean L/MD vehicles results in greater gains in terms of consumer savings and avoided public health impacts (such as premature death, hospital admissions and emergency room visits, respiratory symptoms, and reduced activity and lost

[110] *Id.* at 11.
[111] *Id.*

workdays). The policy scenario reflective of our *Alternative 1+* recommended approach achieves the most reductions: nearly an 80% reduction in NOx and a 60% reduction in PM in 2040 compared to 2026 levels. An *Alternative 1+* approach is also projected to achieve almost $42 billion in monetized value of reductions: nearly $8.5 billion more in monetized value than would occur under *EPA's Main Proposal* and preferred approach (as shown in Figure V.F-1).

Figure V.F-1: Comparison of Possible Health Benefits[112]



ERM's analysis incorporates: EPA's assumed changes in tailpipe emission reductions, EPA's upstream assumptions that rely upon the Integrated Planning Model (IPM) for electricity generated units, and ERM assumptions on changes from reduced demand on refining of finished products for diesel (and gasoline) based on the use of Argonne National Laboratory's Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies (GREET) model.

The benefits associated with the *Alternative 1+* approach are further depicted in Table V.F-1, which shows the various scenario criteria emissions (NOx and PM) aggregated from 2026-2040 for each of the policy scenarios, as well as possible reduced health incidents, and the monetized value of these reductions (if realized) compared to *EPA's No Action* scenario.[113]

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[112] *Id.* at 12.

[113] ERM's analysis results in slightly lower cumulative reductions of NOx and PM compared with EPA's net air pollutant impacts for the *EPA Main Proposal*, *Alternative 1*, and *Alternative 3* policy scenarios (Tables 9-37, 9-38 and 9-40 of the DRIA). However, despite the difference, *Alternative 1+* would correspond with approximately a 25% increase in benefits relative to the *EPA Main Proposal* and a similar increase would be expected under EPA's methodology.

Table V.F-1: Comparison of Possible Health Benefits[114]

Policy Scenario	2026 - 2040 Cumulative Reduction (MT)		Cumulative Reduced Incidents			2026 – 2040 Monetized Value (2021$ bill)
	NOx	PM	Mortality	Hospital	Minor	
EPA Main Proposal	648,558	47,320	2,909	2,729	1.7 million	$33.6
Alternative 1+	808,052	55,241	3,427	3,213	2.1 million	$42.0
EPA Alternative 1	696,420	49,687	3,058	2,868	1.8 million	$37.4
EPA Alternative 3	585,618	44,464	2,712	2,545	1.6 million	$33.2

COMPARED TO EPA's BASELINE

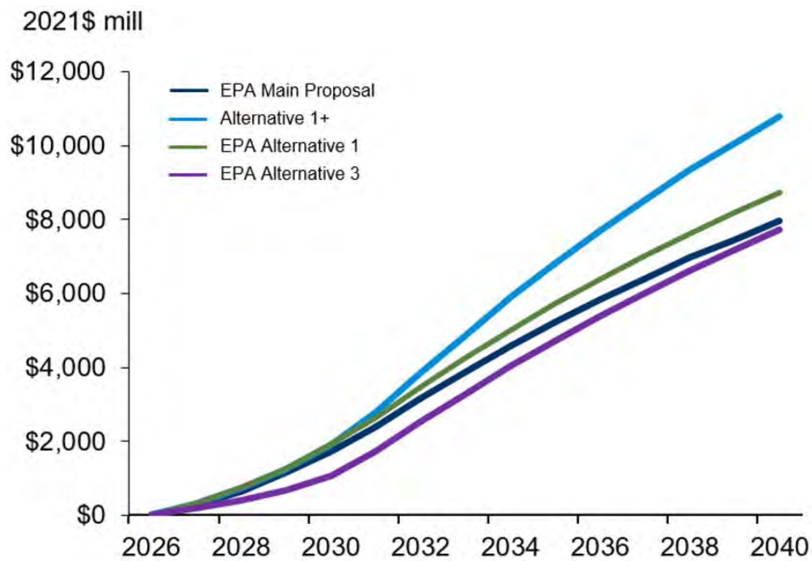
G. Comparison of Utility Impacts

ERM's results also point to the potential for net revenue (revenue in excess of the costs of serving PEV load) from PEV charging to reduce utility bills for all customers (see Figure V. G-1). Since most PEV charging can be accomplished when there is spare capacity on the grid, charging can spread the costs of maintaining the system over a greater volume of electricity sales, reducing the per-kilowatt-hour price of electricity to the benefit of all customers. Public utility regulations require additional revenues in excess of authorized revenue to be returned to all utility customers in the form of reduced rates and bills.

Electrifying L/MD vehicles (especially at the levels projected under an *Alternative 1+* approach) could lead to between $7.7 to $11.3 billion in net utility revenue, which could reduce electricity rates by 2.1% to 3.1% ($0.004/kWh to $0.006/kWh). This could save the average U.S. household $35 to $60 per year and the average commercial customer $253 to $428 per year on their electricity bills. This phenomenon has already been observed in the real world. PEV drivers have already contributed $1.7 billion in net revenue that has been returned to all utility customers in the form of rates and bills that are lower than they otherwise would have been.[115]

[114] ERM, *Impacts Report* at 12.
[115] Synapse Energy. 2022. "Electric Vehicles Are Driving Electric Rates Down." https://www.nrdc.org/sites/default/files/media-uploads/ev_impacts_december_2022_0.pdf.

Figure V.G-1: Incremental Reduced Utility Bills from L/MDV Charging[116]



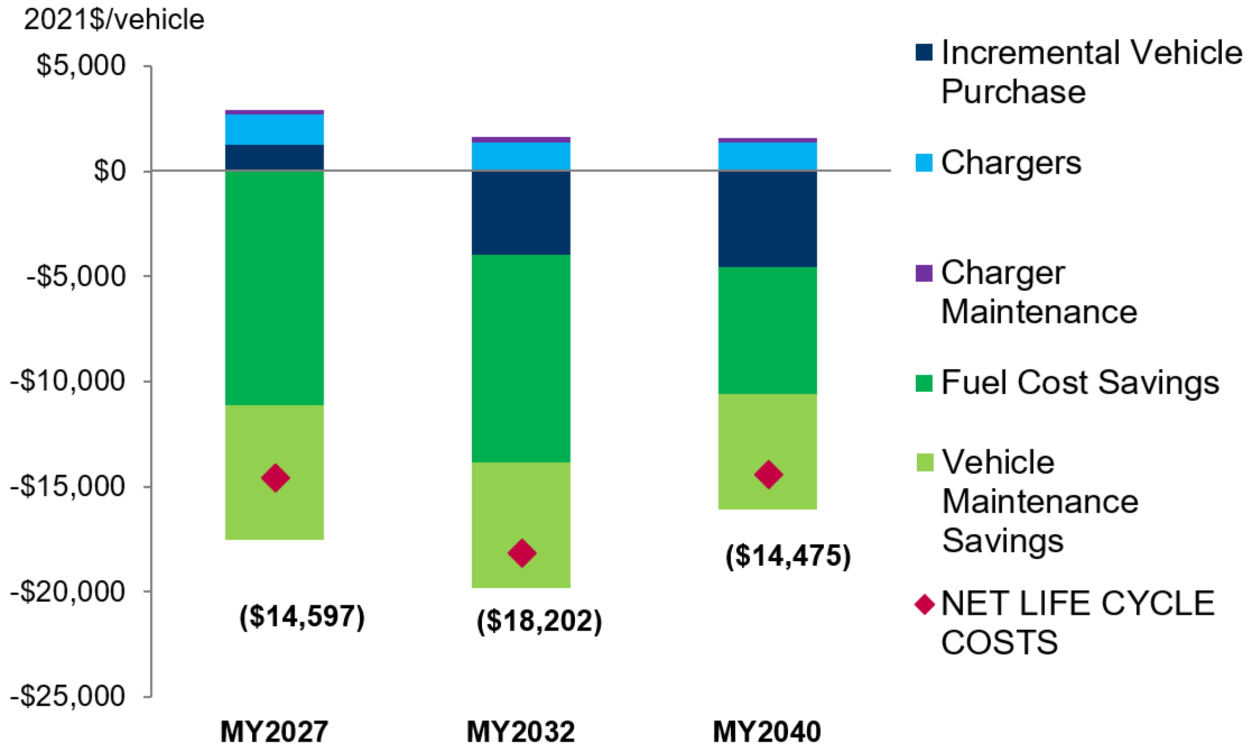
This analysis looks at all of the costs associated with providing and distributing electricity, as well as any revenue based on the identified utility rate from the Energy Information Administration (which is approximately 10.4 cents per kilowatt hour for commercial customers and 12.7 cents per kilowatt hour for residential customers).[117]

H. Comparison of Incremental Fleet Costs and Savings

While some manufacturers have raised unfounded concerns about the costs associated with shifting to ZEVs, the ERM analysis overall shows that the average BEV reaches life-cycle cost parity with diesel and gasoline vehicles before MY 2027. Additionally, from a cost and savings perspective, purchasing an average MY 2032 BEV would save an owner over $18,000 over the life of the vehicle (as seen in Figure V.H-1).

[116] *Id.* at 14.
[117] These electricity rates come from EIA's Annual Electric Power Industry Report (Form EIA-861 for 2021), using the State data tab and adding all Sales (MWh) divided by the Revenues (Thousand $) to obtain the average price ($/kWh) for both Residential and Commercial customers. https://www.eia.gov/electricity/data/eia861/

Figure V.H-1: Possible Net Lifecycle Costs of a BEV vs. a Comparable Diesel or Gasoline Alternative[118]



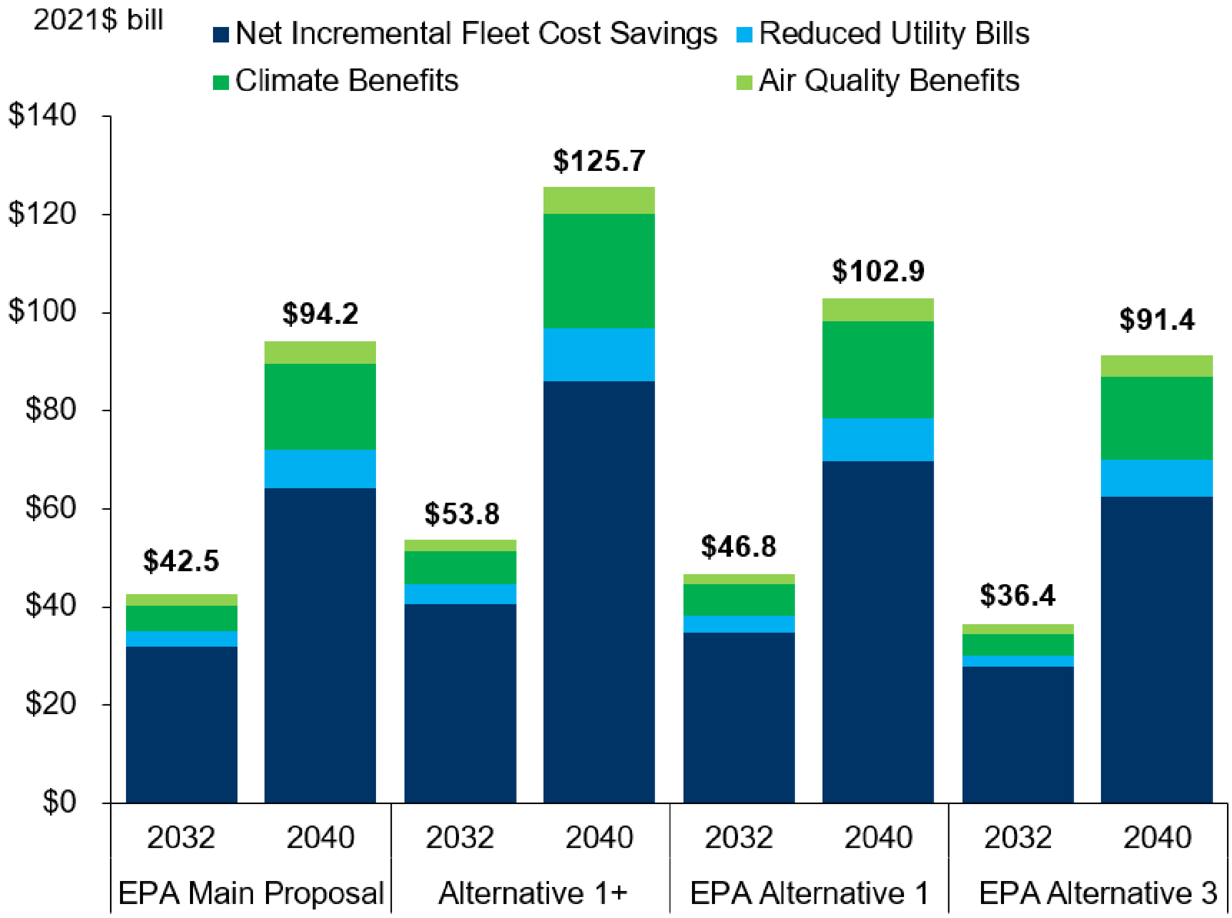
The analysis depicted in Figure V.H-1 incorporates several different cost categories (including purchasing chargers, charger maintenance, incremental purchase price between combustion vehicles and BEVs, vehicle maintenance savings associated with BEVs, and the difference in fuel costs between purchasing gasoline and diesel fuel versus electricity). For this calculation, fuel and maintenance cost savings are discounted at 3% over 16 years.

I. Comparison of Overall Societal Benefits

The results from ERM's analysis (depicted in Figure V.I-1) show that on a net societal basis—inclusive of the costs to fleets as well as air quality benefits, climate benefits, and reduced utility bills—the greatest benefits are seen with *Alternative 1+* at about $125.7 billion through the 2040 timeframe.

[118] *Id.* at 13.

Figure V.I-1: Comparison of Possible Annual Net Societal Benefits[119]



This figure depicts net annual societal benefits (which incorporates net incremental fleet cost savings, climate benefits, air quality benefits, and reduced utility bills).

VI. EPA's Proposed Standards Are Technologically Feasible at Reasonable Cost, as Are Alternative 1 Standards with a Faster Ramp Rate After 2030.

Not only does Alternative 1 with increasing stringency after 2030 yield significant societal benefits, it is also technologically feasible at reasonable cost. In this section, we detail the combustion vehicle and zero-emission technologies that can secure additional emissions reductions from the light-duty fleet, comment on EPA's modeling, and address technology costs. We also offer recommendations for the Tier 4 NMOG+NOx standards and PM requirements.

[119] *Id.* at 15.

A. EPA's modeling should more fully incorporate combustion vehicle technologies that reduce greenhouse gas emissions, which would further demonstrate technological feasibility and available compliance pathways.

1. EPA's modeling does not account for the full range of combustion vehicle technology availability and effectiveness.

The technologies EPA assesses to curb GHG emissions from light-duty vehicles are significantly reduced in number and effectiveness compared to the technology assessment supporting the MY 2023-2026 Rule, for which EPA used CCEMS as its modeling tool. In particular, OMEGA2, the modeling tool EPA now employs, omits the following technologies when modeling compliance: advanced 10-speed transmissions, turbocharging with cooled exhaust gas regulation, variable compression ratio engines, and others.[120] Moreover, the Agency has adopted many fewer technology packages: in contrast to the 6,500 packages available in the CCEMS modeling for each of the 10 vehicle types, the OMEGA2 modeling is limited to 108 packages for cars and 60 packages for trucks.[121]

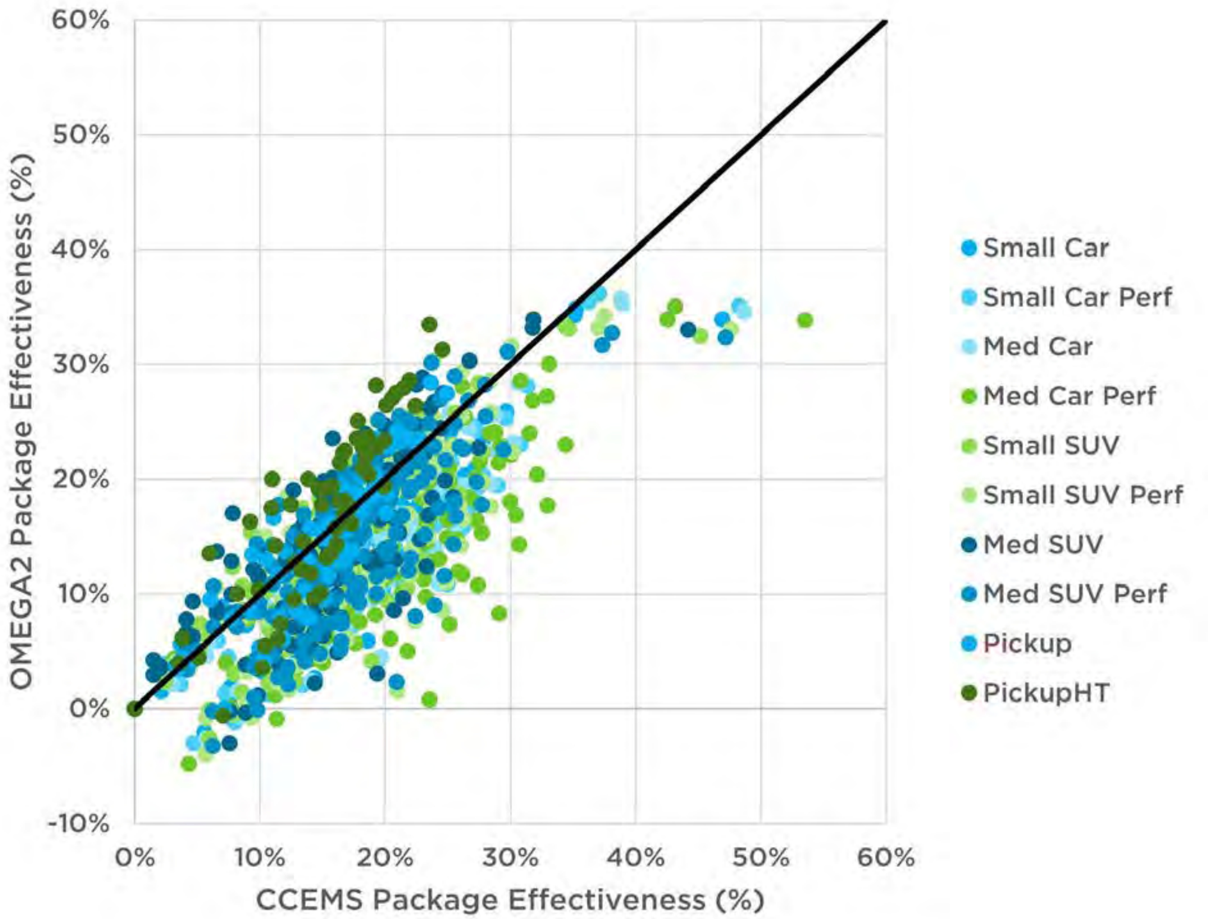
In and of themselves, these changes might not have a significant impact on the modeling if the technologies contained within the packages were sufficiently representative of the relative technical potential for reducing emissions from combustion vehicles. However, there are significant differences between the effectiveness of the packages analyzed by the OMEGA2 and CCEMS models, as well as the maximum improvement they can deliver (Figure VI.A-1).[122] Because the OMEGA2 model calculates absolute emissions, effectiveness of the packages is considered relative to the base gasoline package modeled in OMEGA2 for each body type, a direct-injection engine with continuously variable valve timing and five-speed automatic transmission.

[120] Compare DRIA Table 2-21 with the "Technologies" tab in technologies_NoHCR_LowBEV200_BatteryAdj2023_YearShift.xlsx, a file accompanying the Agency's final modeling supporting the FRIA, as well as Figures 2, 3, and 4 in NHTSA's 2020 CAFE Model Documentation, the documentation included with the agency's CAFE Compliance and Effects Modeling System (CCEMS). NHTSA, CAFE Model Documentation, DOT HS 812 934, EPA-HQ-OAR-2021-0208-0138 (Mar. 2020), at 24-28, Figs 2-4.

[121] Here we refer solely to changes in the powertrain. Throughout this section, we do not consider differences in how the road load reduction was modeled, since while that effect was considered discretely in the CCEMS modeling, it was modeled separately and continuously in the OMEGA2 model.

[122] Owing to differences in the model's architecture, we use representative vehicles from each of the CCEMS classes to obtain the OMEGA2 results using the response surface equations provided. The relevant parameters include the road load coefficients, test weight, and maximum horsepower. Representative vehicles were selected by sales volume, using the classification from the CCEMS model. The identified representative vehicles are: Toyota Corolla, Small Car; Hyundai Elantra, Small Car Perf; Ford Fusion, Med Car; Mercedes C 300, Med Car Perf; Honda CR-V, Small SUV; Ford Escape Titanium, Small SUV Perf; Mercedes GLC 300 4 MATIC, Med SUV; Jeep Grand Cherokee, Med SUV Perf; Toyota Tacoma, Pickup; and Ford F-150 4WD 3.5L EcoBoost, Pickup HT. For the car categories, only unibody packages were defined. For the pickups, only the truck packages were calculated. For SUVs, which can fall into either category, both the car and truck packages were included in the comparison, even if the representative vehicle itself may have been classified as only a light truck.

Figure VI.A-1: Comparison of the effectiveness of packages modeled by EPA to reduce emissions in the Proposal and the MY 2023-2026 Rule



The technology packages modeled in the Proposal using OMEGA2 show a markedly reduced effectiveness compared to the same packages modeled using the CCEMS supporting the MY 2023-2026 rulemaking, as indicated by the increased share of data falling below the X=Y line (black). 74% of the packages modeled in OMEGA2 show a reduced effectiveness. On average, a given OMEGA2 package shows a 3.9 ± 0.3% increase in emissions compared to the prior CCEMS modeling. The most efficient packages show an even greater disparity, with the maximum effectiveness for OMEGA2 showing just a 36% improvement compared to a 53% improvement in CCEMS.

Looking at the relative effectiveness of the modeled packages, it is clear that the CCEMS modeling generally finds a greater level of improvement than the more recent OMEGA2 modeling. Because the benchmark data for the ALPHA modeling supporting OMEGA2 is almost identical to that used to support the previous rulemaking (excepting the Volvo Miller cycle engine, which corresponds most accurately to the prior variable-geometry turbo technology package), and because the changes to the ALPHA model (vis-à-vis the response surface equations) are generally reasonable, as supported by the peer review process, the reason for the disparity in EPA's analysis is unclear. There are some general trends that may be illustrative in assessing the flaws in EPA's more recent modeling. Across all categories of vehicle, the 5-speed automatic transmission package (TRX10) was found to be more efficient than the basic 6-speed automatic (TRX11), which seems implausible and may speak to problems with how the scaling algorithm matches a modeled vehicle's transmission to different engine maps—all the more perplexing since the Agency claims to use the same model as before.[123] Similarly, there appears to be little difference in the effectiveness of any of the three hybrid packages, despite significant differences in the underlying engines.[124] This is particularly perplexing given that strong hybrids have continued to evolve with each successive generation, and yet, according to EPA's modeling, they appear to be stuck at the efficiency levels of the MY 2019 power-split fleet.[125]

In addition to the packages' lack of effectiveness, we question whether these packages cover a sufficiently robust opportunity for reductions from the internal combustion engine. Unfortunately, the answer appears to be that they are also now covering a narrower range than previous modeling (Figure VI.A-2, *infra*). As expected based on the results discussed above, the shift in the distribution of effectiveness for the current modeling is below that of the CCEMS, but the packages are also overweighted towards less effective packages, in contrast to the symmetric/Gaussian distribution of the CCEMS data. Also of note is the lack of a long tail out to higher effectiveness; as noted previously, while the few hybrid packages available in the CCEMS model can reduce emissions by over 50%, the OMEGA2 packages max out at 36%. This means that about one-third of the assessed maximum potential improvement previously modeled to be available to manufacturers for their combustion vehicle fleets has been eliminated due to unknown factors.

We believe that once these issues have been addressed, it will become apparent that the standards are considerably more feasible than EPA states; that combustion vehicle emissions can be reduced to a much larger degree than EPA assumes; and that even more technologically diverse compliance pathways are available to manufacturers, enabling them to meet the standards at PEV penetration levels lower than EPA projects.

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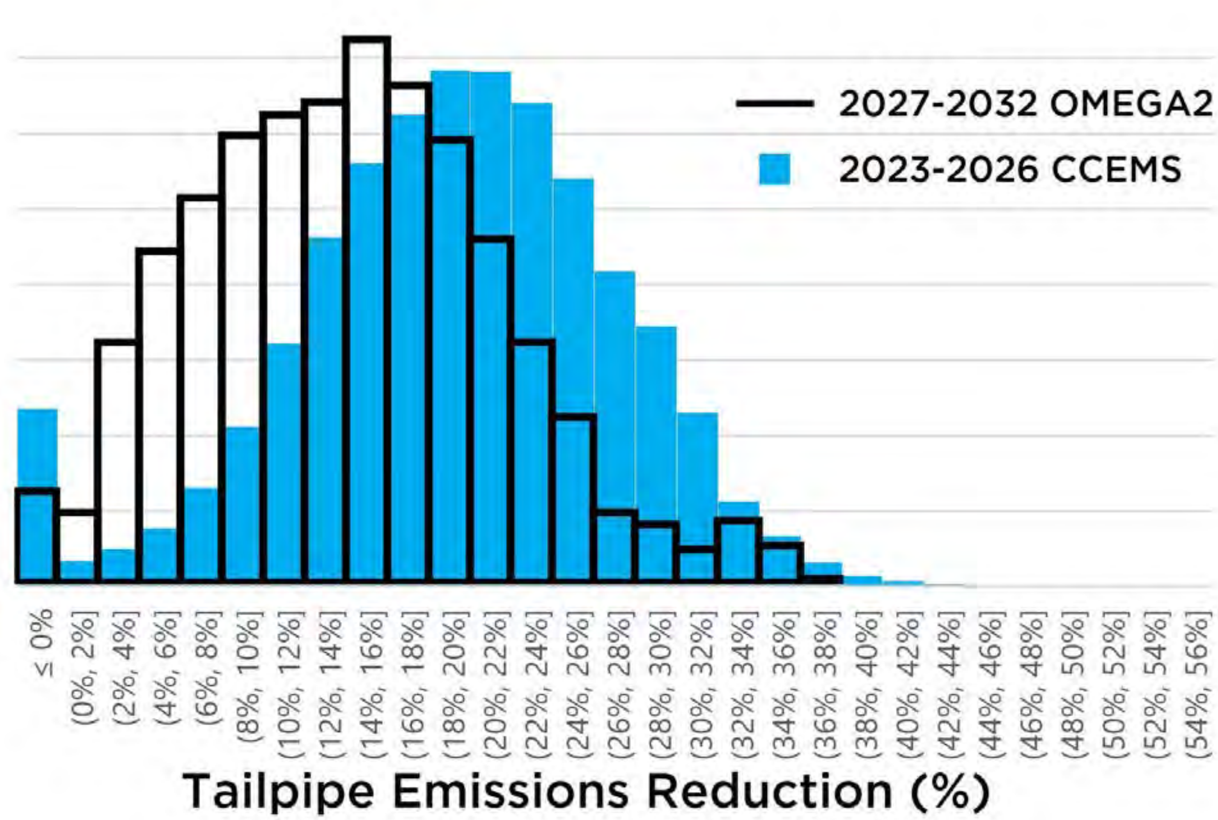
[123] DRIA at 2-29.
[124] *Id.* at Table 2-2.
[125] *Id.* at Section 2.4.8.6.

Figure VI.A-2: Available technology packages at different levels of effectiveness



A histogram comparing the share of packages in the current (OMEGA2) and previous (CCEMS) compliance modeling efforts from EPA, grouped by total package effectiveness relative to a GDI engine paired with a 5-speed transmission. It is clear that not only do manufacturers have significantly more package options at, on average, higher effectiveness, but the total absolute range has been condensed as well for the current modeling effort, limiting compliance flexibility for manufacturers in the model that does not reflect the broader range of options available.

2. The OMEGA2 model produces unlikely results for combustion vehicles.

As noted above, the OMEGA2 model suffers from significant shortcomings in terms of capturing the potential improvement available from technologies applicable to combustion vehicles. However, there is also a problem with the way in which the OMEGA2 model assumes manufacturers then apply those technologies: not only can manufacturers add new technology, but they can remove it. The level of so-called "decontenting" that occurs in the OMEGA2 model is neither unrealistic, and it drastically underestimates the improvements from combustion vehicles that would likely be deployed for a given PEV scenario.

In the Proposal modeling, 40% of the combustion vehicle models have worse 2-cycle tailpipe GHG emissions in 2032 than in 2022. On average, that 40% of the fleet has increased its emissions by 13%, or 27 g/mi. For reference, this decline in emissions performance approximates a return to 2016 levels of tailpipe emissions for those vehicles (i.e., those vehicles would achieve no net progress over a 16-year period). Of course, the remaining combustion vehicle fleet sees plenty of backsliding in this time as well. While manufacturers may not have fully slipped back to 2022 levels, OMEGA2 modeling finds that through the course of the 2022-2032 period, manufacturers are more than twice as likely to make the direct CO_2 emissions from a combustion vehicle *worse* year-to-year, increasing year-to-year emissions 22% of the time, keeping them unchanged 69% of the time, and reducing emissions just 9% of the time. And this percentage increases dramatically between the years governed by the current standards and the Proposal: the modeling shows that manufacturers are much more likely to decrease the emissions of a combustion vehicle to achieve compliance with the MY 2023-2026 standards (15%, compared to 9% for the proposed MY 2027-2032 standards), and are 6 times more likely to decontent a combustion vehicle in the 2027-2032 period than in the 2023-2026 period.

Notably, the modeling of manufacturer behavior described above does not distinguish between the magnitudes of the reduction/increase in emissions. On average, emissions reductions from the combustion vehicle fleet under the existing standards greatly outweigh the average increases, since improving combustion vehicles is a significant compliance mechanism for the current standards. Interestingly, the magnitude of the average increase vs. decrease does not vary substantially over the entire decade (2022-2032). Instead, the disparity in outcome (combustion vehicles increasing, rather than decreasing, emissions) is entirely driven by the massive increase in decontenting that begins to occur in the modeling in the post-2026 period.

EPA provides no explanation for this rapid shift in modeled manufacturer behavior in the documentation for the rule, and such behavior makes little sense, particularly when examining cases of decontenting that occur in the modeled compliance for the Proposal. To the extent that manufacturers may consolidate engine platforms as they reduce the number of available combustion vehicles, that consolidation is not likely to happen on the oldest, lowest technology options but rather on the newest engine platforms, in order to avoid accelerated depreciation of new investments. While there may be some simplification, it is more likely that the simplification would be elimination of a lower-volume technology package, such as a high-performance (and higher emission) option, which again would not result in increases in emissions. Below we present two examples to illustrate the unrealistic aspects of the compliance model for technology content, in consideration of industry behavior.

a. Example: Volvo S60

The Volvo S60 is available in multiple configurations and is represented by three different vehicles in the OMEGA2 model: two conventional vehicles (one of which is a high-performance trim with greater horsepower), and one strong hybrid (incidentally utilizing the Miller cycle engine benchmarked by EPA). The modeled technology packages for these vehicles are illustrated in Table VI.A-1. In 2026, the first redesign opportunity is available for the model. The vehicles undergo one major change to the platform (a shift from steel to aluminum cuts a significant amount of weight), and then the three engines move to the same exact configuration, a 48V mild hybrid with a high compression ratio (HCR) engine utilizing discrete cylinder deactivation. The power output for the former-hybrid and the high-performance trim are virtually identical, which is why the emissions numbers are so similar in 2026, effectively reducing the trims available to two. This type of consolidation could happen, though eliminating the high-tech Miller cycle engine (part of one of the most efficient technology packages implemented by EPA) from the vehicle after just one product cycle is unlikely. And, at least in this case, on net the former-hybrid vehicle still sees a reduction in emissions due to the weight reduction.

Table VI.A-1: Comparison of technology packages, fuel economy, and emissions for the Volvo S60 at each redesign

Volvo S60 T8 (313 hp)				
Year	Tech package	Body Material	Tailpipe CO_2 (lab) [g/mi]	Label Fuel Economy [mpg]
2021	SHEV-PS, Miller cycle	Steel	194	35.4
2026	MHEV (P0), HCR + continuous cyl. deac., advanced 8-speed AT	Aluminum	181	38.9
2031	HCR + continuous cylinder deactivation, 5-speed AT	Steel	236	33.5
Volvo S60 T5 (316 hp)				
Year	Tech package	Body Material	Tailpipe CO_2 (lab) [g/mi]	Label Fuel Economy [mpg]
2021	Start-stop, Turbo, advanced 8-speed AT	Steel	225	32.7
2026	MHEV (P0), HCR + continuous cyl. deac., advanced 8-speed AT	Aluminum	183	38.2
2031	HCR + continuous cylinder deactivation, 5-speed AT	Steel	268	30.7
Volvo S60 T4 (250 hp)				
Year	Tech package	Body Material	Tailpipe CO_2 (lab) [g/mi]	Label Fuel Economy [mpg]
2021	Start-stop, Turbo, advanced 8-speed AT	Steel	206	34.4
2026	MHEV (P0), HCR + continuous cyl. deac., advanced 8-speed AT	Aluminum	170	40.1
2031	HCR + continuous cyl. deac., 5-speed AT	Steel	237	32.2

In 2031, however, the vehicle platform reverts from aluminum back to steel, gaining weight in the process. All three vehicles drop the mild hybrid configuration but introduce three completely distinct engine technologies, again less efficient than the prior offerings, and now paired with a 2007-era 5-speed transmission instead of the advanced 8-speed transmission of the previous generation. To summarize, under EPA's modeling, the S60 in 2031 will: 1) revert to an old body platform and an ancient transmission; 2) adopt engine technology that will reduce fuel economy for consumers by 8 mpg, below what the vehicle started at in 2022 for all configurations; and 3) not do anything to consolidate engines or platforms, or do anything else that could justify decontenting, because there remain three distinct engine offerings. There is little reason to suppose that Volvo (or any other manufacturer) would be able to find consumers for a combustion vehicle, such as the modeled S60, that gets notably worse over time.

b. Example: Jeep Cherokee

A similar trajectory is observed in the case of the Jeep Cherokee (Table VI.A-2). In this case, the modeled vehicle does not correspond directly to each of the real vehicle's trims but is instead averaged into a high- and low-throughput engine option for the 2WD and 4WD versions.[126] However, the pattern of vehicle change in the modeling is the same: each vehicle is first upgraded and then downgraded, with 3 of the 4 model variants ending up worse than they started a decade prior.

Table VI.A-2: Comparison of technology packages, fuel economy, and emissions for the Jeep Cherokee at each redesign

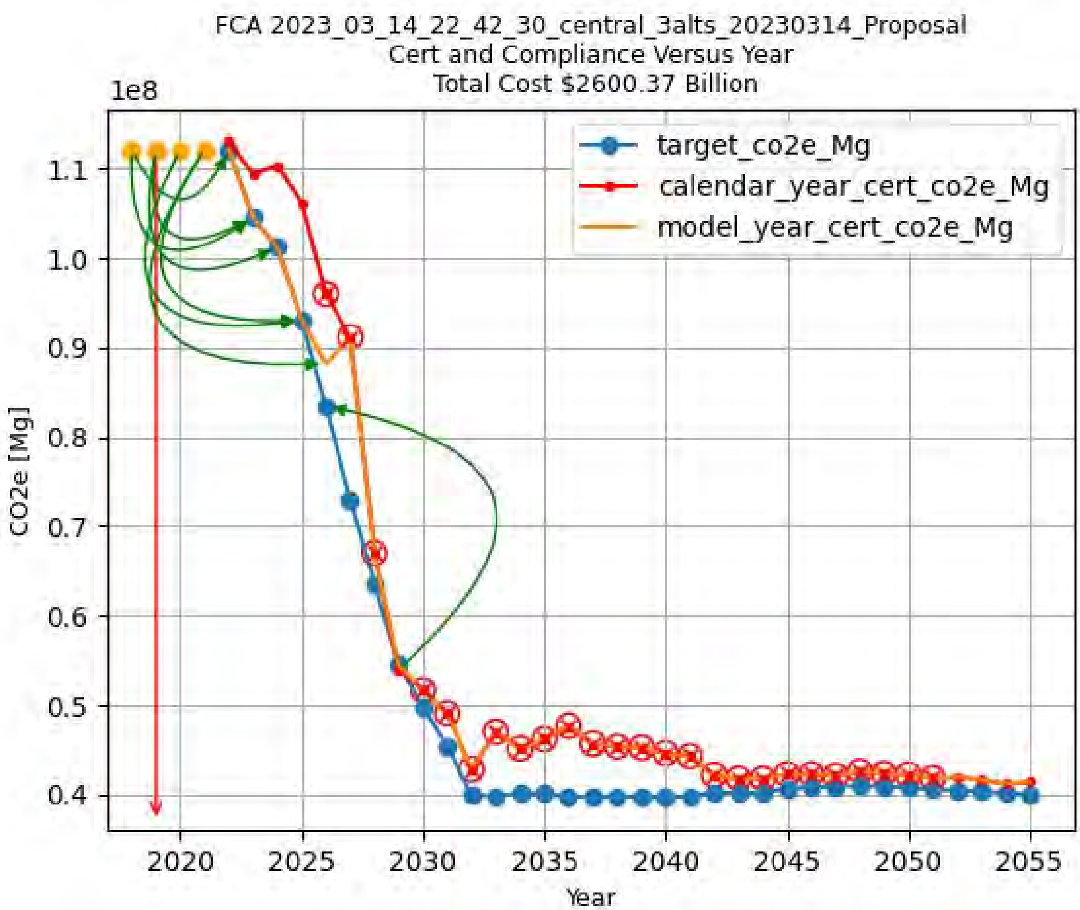
Jeep Cherokee 4x4 Premium (270 hp)				
Year	Tech package	Body Material	Tailpipe CO_2 (lab) [g/mi]	Label Fuel Economy [mpg]
2021	Start-stop, Turbo, advanced 8-speed AT	Steel	238	27.3
2026	HCR + continuous cylinder deactivation, advanced 8-speed AT	Steel	231	28.9
2031	HCR, 5-speed AT	Steel	276	26.4
Jeep Cherokee 4x4 Base (245 hp)				
Year	Tech package	Body Material	Tailpipe CO_2 (lab) [g/mi]	Label Fuel Economy [mpg]
2021	Start-stop, SGDI, advanced 8-speed AT	Steel	267	26.2
2026	HCR + continuous cylinder deactivation, advanced 8-speed AT	Steel	225	29.6
2031	HCR, 5-speed AT	Steel	266	27.1
Jeep Cherokee 4x2 Premium (256 hp)				

[126] While Jeep has since dropped the 2WD version of the Cherokee, this is not reflected in EPA's model due to the use of a 2019 baseline fleet.

Year	Tech package	Body Material	Tailpipe CO_2 (lab) [g/mi]	Label Fuel Economy [mpg]
2021	Start-stop, Turbo, advanced 8-speed AT	Steel	218	30.7
2026	HCR + continuous cylinder deactivation, advanced 8-speed AT	Steel	210	32.4
2031	Turbo, 5-speed AT	Steel	252	29.4
Jeep Cherokee 4x2 Base (196 hp)				
Year	Tech package	Body Material	Tailpipe CO_2 (lab) [g/mi]	Label Fuel Economy [mpg]
2021	Start-stop, SGDI, advanced 8-speed AT	Steel	233	29.8
2026	HCR + continuous cylinder deactivation, advanced 8-speed AT	Steel	200	33.1
2031	HCR, 5-speed AT	Steel	233	29.4

What makes this behavior particularly unrealistic in the case of the Jeep Cherokee is that the parent company (Stellantis) is, according to the model, purchasing credits from other manufacturers in order to comply with the standards after the 2029 model year (Figure VI.A-3). In other words, the model projects that it is in Stellantis' interest to increase emissions from its combustion-powered vehicles (even though there is no concurrent improvement in performance-related vehicle attributes), and this strategy results in the manufacturer falling short of its regulatory requirements, which then forces the company to purchase credits from its competitors.

Figure VI.A-3: Year-over-year average certification for Stellantis (formerly FCA), from EPA's Proposal modeling run



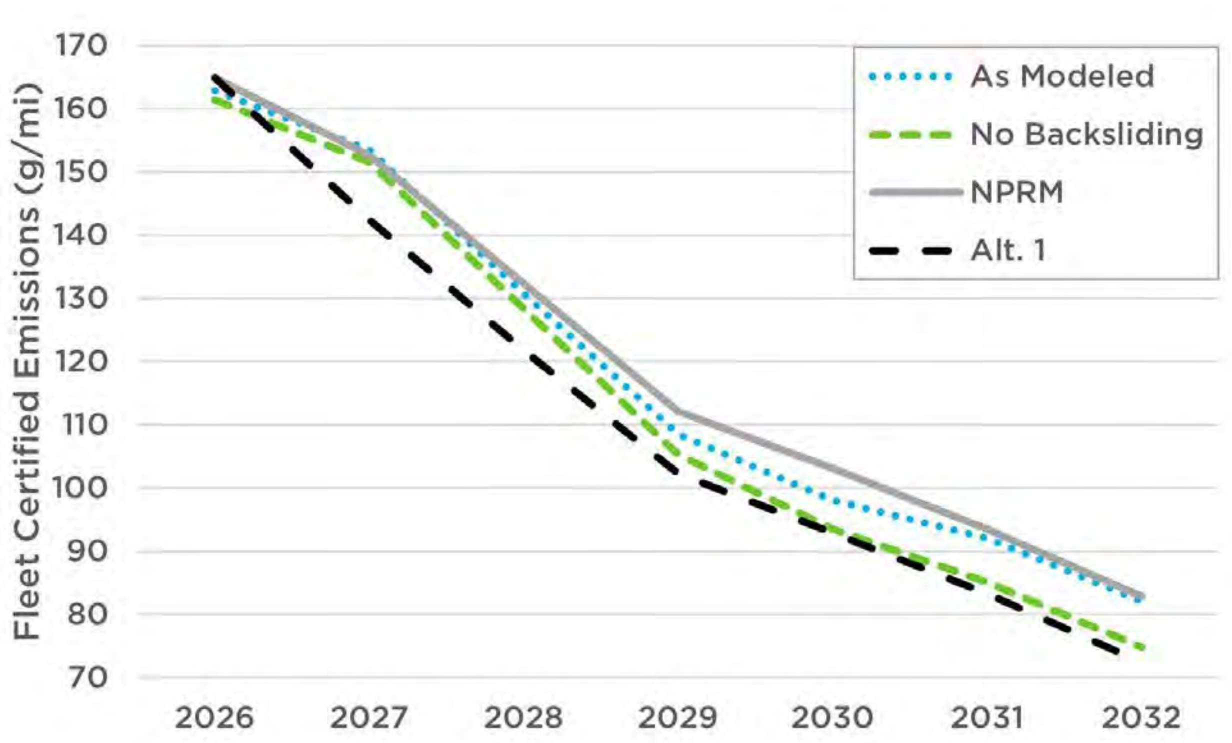
In all years modeled, Stellantis is reliant upon banked credits in order to comply with the standards, as indicated by the difference between the target curve (blue dots) and the calendar year certification (red circles). Stellantis is able to use its own banked credits (indicated through credit transactions via arrows) in order to comply with the standards through the 2026 model year, indicated by the overlap between the model year certification (orange line) and target curve. However, beginning with the 2026 model year, those credits (including credits carried back from the 2029 model year) are no longer sufficient for Stellantis to meet its requirements. Therefore, Stellantis is required to make up the remaining gap between model year and target year curves with credits purchased on the general market (not modeled explicitly by the Agency).

3. In allowing combustion vehicles to backslide, the OMEGA2 model fails to capture readily achievable emissions reductions; adjusting these features would further support the feasibility of stronger standards.

By allowing combustion vehicles to backslide in its modeling, EPA fails to consider a significant pathway for potential emissions reductions. By 2032, this backsliding results in nearly a 10% increase in tailpipe emissions from the fleet. In terms of feasibility, it is beyond question that the decontented combustion vehicle technologies can be deployed in the timeframe of the rule, since these technologies had previously been on those vehicles. Since manufacturers will not incur any new costs for research and development and will simply be elongating the period for which they can utilize their investments, it would be more reasonable for the model to assume that manufacturers would not remove such technologies, thus preserving emissions levels already achieved.

We urge EPA to take this "no backsliding" approach in its modeling for the final rule. The impact would be significant: if manufacturers simply adopted a strategy of not removing technology from their combustion vehicle fleet, they could nearly achieve the more stringent Alternative 1 standards with no increase in ZEV sales as compared to ZEV sales in the modeling supporting the Proposed Rule (Figure VI.A-4).

Figure VI.A-4: Fleet-wide average certification levels, as modeled compared to a scenario where manufacturers do not remove technology from combustion vehicles



4. Summary of available improvement for combustion vehicles

By leaving a significant amount of available and feasible combustion vehicle emission reduction technologies on the table—including technology improvements EPA identified in prior rulemakings—the Agency has underestimated the potential emissions reductions available to the fleet. This problem is compounded because the Agency's compliance model assumes that a large share of the combustion vehicle fleet will get worse over time, even for manufacturers that the model projects will fall short of compliance and therefore will be dependent upon purchasing credits from their competitors.

By adjusting its modeling to reflect the full range of combustion vehicle technology improvements available to manufacturers, and by aligning its modeled manufacturing behavior with a strategy that reflects continued deployment of the technologies already available and incorporated into vehicles instead of allowing backsliding, EPA's modeling would better capture the full range of emissions reductions pathways that are feasible. Improving the OMEGA2 modeling in this way will affirm that manufacturers can easily achieve a standard at least as stringent as Alternative 1, with little to no increase in ZEV penetration compared to the model runs supporting the Proposal.

5. Automakers can feasibly and inexpensively improve combustion vehicle emissions simply by shifting sales to the cleanest trims of popular models.

Yet another pathway that automakers could use to comply with stronger standards lies in shifting their sales to the cleanest trims of their popular combustion vehicle models. In 2022, 8.6 million sales – more than half of all new automotive sales – were from just twelve combustion vehicle nameplates. These top-selling vehicles were sold by five automakers: Ford, General Motors, Honda, Stellantis, Toyota. Within each nameplate, the automakers provided different powertrain options (such as engine size, transmission gearing, hybridization and other characteristics), and each had their own emissions performance – some better than others. These vehicle options are all in production, and selling more of any one powertrain could lead to reductions in sales volumes of the same nameplate with a different powertrain. These changes in volumes within a nameplate are a regular feature of the automobile market.

An automaker could improve the emissions performance of its vehicles simply by shifting sales within a nameplate to versions with cleaner powertrains. This shift could achieve emissions reductions without an investment in new emissions technologies or large-scale capital expenditures for factory retooling. Similar emissions improvements could also be achieved due to a consolidation or reduction in powertrain options as ZEVs replace sales of these combustion vehicle nameplates.

We estimated the emissions savings that could be achieved by shifting production in a nameplate from the mix of powertrains sold in 2022 to the cleanest powertrain currently available in that nameplate. Table VI.A-5 shows the top-selling twelve nameplates analyzed and the emissions reductions that could be achieved.

Table VI.A-5: Emissions Reductions in Top-Selling Nameplates by Focusing Sales on Cleaner Powertrains[127]

Automaker	Top-Selling Models	Fraction of Automaker's Sales	Emission Savings with Shift to Cleanest Models (gCO2/mi)	% Improvement from 2022 Automaker Fleet Average
Ford	F-150, Explorer	47%	39	13%
General Motors	Silverado, Sierra, Equinox	43%	15	5%
Honda	CRV	25%	32	14%
Stellantis	Ram pickup, Jeep Cherokee	44%	63	20%
Toyota	RAV4, Camry, Highlander, Tacoma	51%	42	17%

The high-volume nameplates analyzed comprise between 25% to 51% of each automaker's total sales in 2022. Adjusting sales within these nameplates toward the versions with the cleanest powertrains would provide significant emissions reductions.

B. EPA should include PHEVs in its modeling.

While EPA did not include any PHEVs in its modeling for the Proposal, we urge it to do so for the final rule. Modeling PHEVs will both account for manufacturers' plans and help demonstrate the technical and economic feasibility of strong final standards. Although BEVs are likely to continue to be the most common electric vehicle, PHEVs are part of some automakers' stated plans for achieving emissions reductions. PHEVs are currently more commonly used as a powertrain option for larger and less efficient vehicle models, and that trend is likely to continue with future models. Therefore, EPA should include PHEVs as a powertrain option in the final rule, but should focus on pickup trucks and SUVs as the most likely candidates to offer a PHEV variant.

When modeling PHEVs, EPA should examine vehicle parameters that span a range of battery capacities. In particular, EPA should examine vehicles with battery capacity that meets the minimum capacity (7 kWh) requirements for the IRA § 30D credit. PHEVs that are eligible for the full amount of that credit ($7,500) and have the required minimum capacity battery pack are likely to have a lower net cost than conventional vehicles with similar compliance CO_2 value.

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[127] This analysis relies on sales estimates of each powertrain version within each nameplate and total sales per manufacturer provided by Baum & Associates. Emissions rates per nameplate version were accessed from www.fueleconomy.gov.

When considering costs for PHEVs, EPA should assume L1 charging infrastructure for these vehicles with 50-mile or lower electric-only range. The traction battery capacity for these vehicles will likely be in the range of 7-25 kWh, and therefore they can be fully recharged in 4-13 hours using a L1 EVSE connected to a 20-amp, 120V circuit.

C. Battery costs will continue to decline, and EPA should include lithium-iron phosphate batteries in its modeling of battery pack costs.

Developments in battery technology and reductions in battery costs also support the promulgation of strong standards. EPA is correct that battery costs will continue to decline. Improvements in battery chemistries are one reason for that, and EPA should include batteries with lithium-iron phosphate (LFP) chemistry in its modeling.

1. EPA should include lithium-iron phosphate battery chemistries in its BatPaC modeling of battery pack costs.

When modeling the cost of BEV batteries, EPA should consider the use of iron-phosphate cathodes. The use of LFP batteries in current BEV models is growing; these batteries have potential benefits beyond lower material prices, including higher fast-charging rates and greater durability.[128]

EPA cites the lower specific energy and energy density of LFP batteries as being less appropriate to the 300-mile range BEVs modeled in its analysis. While there is demand for longer-range BEVs, there is still likely to be a role for BEVs with a range of 200-300 miles; in fact, many current BEV models have a rated range of less than 300 miles. Even if the average range of BEV vehicles is 300 miles, the actual product mix will include vehicles with ranges both above and below that average. And as fast-charging infrastructure with higher-power (>300 kW) EVSE is deployed, consumers may be more willing to choose a BEV with less than 300 mile range, as mid-trip recharging would require less time. Vehicles with lower range are good candidates for LFP batteries.

For these reasons, EPA should evaluate the potential cost savings if a portion of PEV models use LFP batteries. Using BatPaC version 5,[129] switching to LFP from the default of NMC811 reduces battery pack cost 7-10%, depending on battery production volume assumptions and battery capacity. As supported by findings in BloombergNEF's latest Electric Vehicle

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[128] Ford Media Center, Ford Taps Michigan for New LFP Battery Plant; New Battery Chemistry Offers Customers Value, Durability, Fast Charging, Creates 2,500 More New American Jobs (Feb. 13, 2023), at https://media.ford.com/content/fordmedia/fna/us/en/news/2023/02/13/ford-taps-michigan-for-new-lfp-battery-plant--new-battery-chemis.html (last accessed July 3, 2023).
[129] U.S. EPA, Battery Cost Estimation Spreadsheets for US EPA LMDV NPRM, EPA-HQ-OAR-2022-0829-0356_attachment_3, available at https://www.regulations.gov/document/EPA-HQ-OAR-2022-0829-0356.

Outlook, LFP batteries are forecasted to be used in an increasing number of passenger BEVs in the United States, reaching around 30% of new demand in 2032.[130]

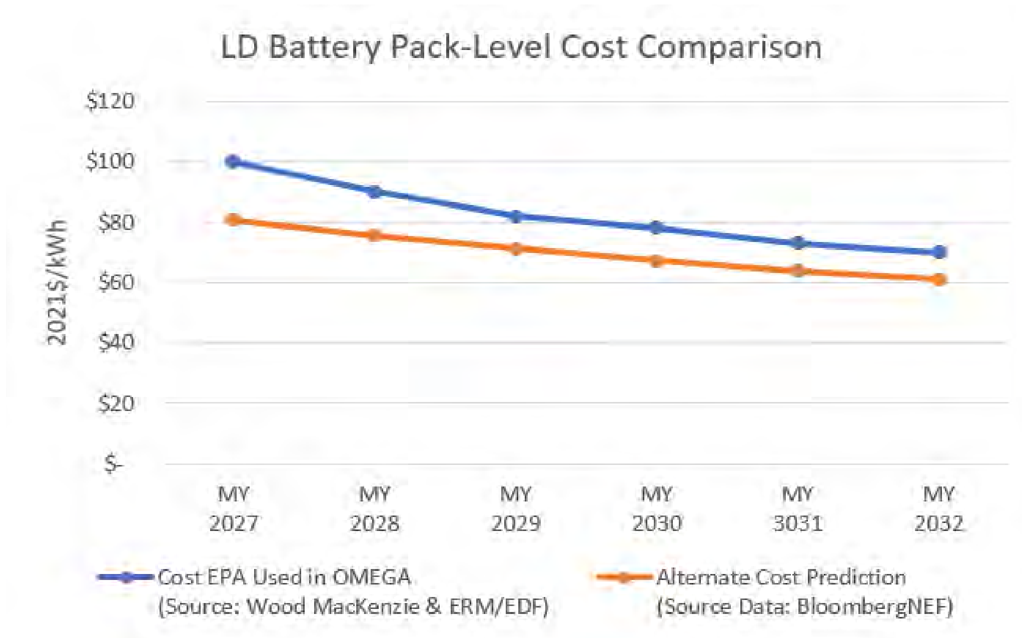
2. Battery costs will continue to decline.

We concur with EPA's assessment that battery costs will continue to decline. We provide support for EPA's battery cost-per-kWh inputs for its OMEGA modeling and the continued downward price trend of batteries.

In its modeling, EPA used an average battery cost ($/kWh) at the pack-level based on a proprietary analysis by Wood Mackenzie and a report by the Environmental Defense Fund (EDF) and Environmental Resources Management (ERM) compiling battery cost projections from a number of sources.[131] The Agency also noted that according to BloombergNEF, global average pack prices were expected to reach $100/kWh by 2026, as the price increase in 2022 due to mineral price volatility will be resolved within a couple of years.[132] We believe these costs are an appropriate representation of the market. Our own analysis based on data available to BloombergNEF subscribers in the Electric Vehicle Outlook 2023 yields numbers just slightly below the costs EPA used in its modeling, as shown in the table and figure below, assuming that EPA's costs were shown in 2021$.

Pack-Level Cost Comparison (2021$/kWh)						
	MY 2027	MY 2028	MY 2029	MY 2030	MY 3031	MY 2032
Cost EPA Used in OMEGA (Source: Wood MacKenzie & ERM/EDF)	$ 100	$ 90	$ 82	$ 78	$ 73	$ 70
Alternate Cost Prediction (Source Data: BloombergNEF)	$ 81	$ 76	$ 71	$ 67	$ 64	$ 61

[130] Dr. Andy Leach, Lithium-Ion Batteries: State of the Industry 2022, *US demand, chemistry mix, and recycling Capacity*, BloombergNEF, Sept. 9, 2022. Subscription required.
[131] *See* DRIA at 2-50.
[132] 88 Fed. Reg. at 29323



To develop our estimates, we used battery global cost data (2022$/kWh) for BEVs, global battery demand forecasts, and the most updated learning rate used by BloombergNEF after the 2022 price increase, as well as a 7.02% inflation rate between June 2021 and June 2022 to convert the data back to 2021$/kWh.[133]

Lastly, as EPA noted, its analysis does account for access to § 45X Advanced Manufacturing Production tax credits, but there are several other tax credits from the IRA available to battery manufacturers that will reduce costs below what is represented in EPA's analysis, such as the 10% tax credits for electrode active material or critical mineral production. As a result, this is a conservative assumption, which further supports the reasonableness of EPA's battery cost projections.

In sum, EPA's forecast of battery cost per unit of battery power output ($/kWh) aligns with the best available knowledge and prediction of the market at this time. However, EPA's forecast of some of the other factors related to battery technologies, like specific energy, are behind where the market is currently and where it is trending for the future. These inputs can therefore cause the full cost of a passenger BEV and the associated mineral demand to be modeled higher than the most likely real-world scenarios. Therefore, even though the cost per kWh input is appropriate, the cost and minerals needed per BEV are likely overestimated under the EPA's current approach meaning that technological feasibility and benefits are higher than predicted by the EPA.

[133] Evelina Stoikou, 2022 Lithium-Ion Battery Price Survey, BloombergNEF (Dec. 6, 2022), at 13-15 & 24-27 (Subscription required).

D. EPA should revise its non-battery BEV powertrain costs.

EPA should use the most recent data available to estimate non-battery BEV powertrain costs. The choice of electric motor cost equation used in the OMEGA modeling does not reflect the most recent data and will overestimate the cost of the BEV powertrain, especially in vehicles with higher-power electric motors. In the 2023 draft report "Cost Modeling for BEV Powertrain" by FEV Consulting, Inc., the cost for both induction and permanent magnet electric motors is estimated to have both a fixed cost and a power-dependent variable cost.[134] In contrast, the cost assumptions used in OMEGA for motors have no fixed costs and only have a power-dependent variable cost.[135] The effect of this choice is that OMEGA will overestimate the motor (and powertrain) costs relative to the most recent FEV Consulting analysis for BEVs as the power of the motors increases. This overestimation of costs will likely create the largest penalty for electric-drive pickups and SUVs, which will require higher-power electric motors in the modeling. Additionally, the FEV Consulting analysis differentiates the cost of gearboxes, wiring harnesses, and coolant circuits for sedans, SUVs, and pickups, which is not reflected in the OMEGA modeling. EPA should revise these costs in its modeling for the final rule, which would more accurately show the feasibility of strong standards.

E. EPA should revisit the teardown study it relied on for the proposed rule.

EPA must also ensure that teardown studies it relies on for its final rulemaking are accurate and defensible. While the use of teardown studies is appropriate to generate combustion vehicle and BEV manufacturing cost estimates, it is important that the comparison vehicles chosen are similar and that any performance differences are quantified. The report "Cost and Technology Evaluation, Conventional & Electrical Powertrain Vehicles, Same Vehicle Class and OEM" by FEV Consulting, Inc. prepared for EPA, presents a detailed comparison between combustion and battery-electric vehicles of similar size made by the same manufacturer.[136] While these vehicles have many similarities, there are major performance differences that were not quantified or assigned a cost. The largest variance in performance is in the power, torque, and resulting acceleration performance. The combustion model (VW Tiguan) has a 0-60 mph time of 9.7 seconds, while the more powerful BEV model (VW ID.4) accelerates to 60 mph in 5.4 seconds. If the BEV was designed to have similar performance as the combustion model, there would be downscaling of motor and power electronics, resulting in lower BEV powertrain costs. The teardown analysis should be revised to estimate the cost reductions associated with components that have similar performance as the combustion vehicle model. Similarly, the BEV model chosen has higher towing capacity than the combustion vehicle model, which results in

[134] FEV Consulting, Cost Modeling for BEV Powertrain (prepared for U.S. EPA) (Apr. 10, 2023), available at https://www.regulations.gov/document/EPA-HQ-OAR-2022-0829-0384 (as Attachment 1).
[135] DRIA at 2-74, Tbl. 2-39.
[136] FEV Consulting, Cost and Technology Evaluation, Conventional & Electrical Powertrain Vehicles, Same Vehicle Class and OEM (prepared for U.S. EPA) (Feb. 24, 2023), available at https://www.regulations.gov/document/EPA-HQ-OAR-2022-0829-0402 (as Attachment 3).

higher costs (e.g., from heavier bumpers). EPA should consider the value of the increased towing performance or adjust the costs of the BEV model to estimate the cost to build a vehicle with the same performance as the combustion vehicle model chosen.

F. EPA should strengthen the Tier 4 $NMOG+NO_X$ standards and finalize the proposed PM requirements.

We now turn to EPA's proposed criteria pollutant standards for LDVs. As detailed below, while the proposed $PM_{2.5}$ requirements are appropriate, EPA should strengthen the $NMOG+NO_X$ standards and consider ways to limit over-crediting.

1. EPA should increase the stringency of the proposed $NMOG+NO_X$ standards.

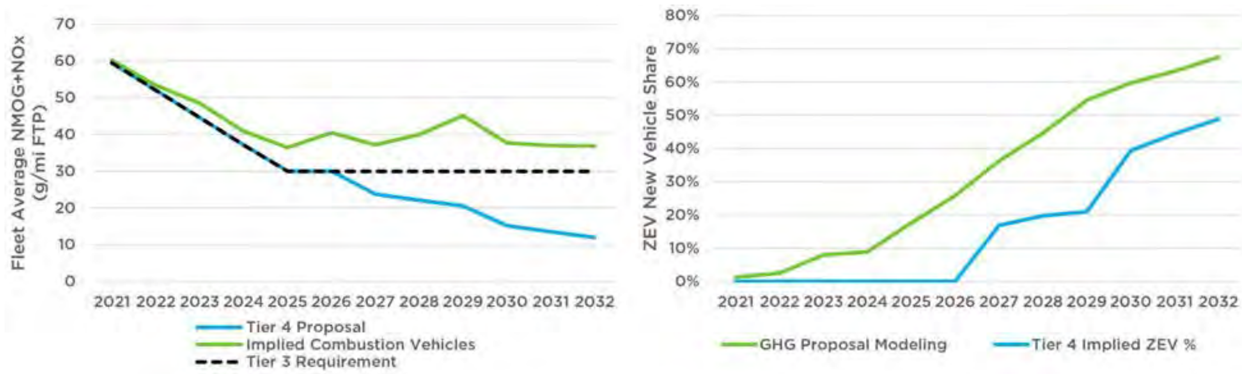
a. EPA should strengthen the $NMOG+NO_x$ standards to better reflect available, feasible, and cost-effective technologies.

EPA's 2014 Tier 3 emissions standards were set based on the deployment of technologies applicable to combustion vehicles. The $NMOG+NO_x$ standards are meant to continuously phase in from 2017-2025, ultimately reaching a fleet average of 30 mg/mile on the FTP and 50 mg/mile on the SFTP. However, over this time period, an increasing share of BEVs will be sold, which are certified to 0 mg/mile $NMOG+NO_x$. While the deployment of BEVs will not alter the tailpipe emissions reductions anticipated under the Tier 3 program, the additional BEVs, counted as 0 mg/mile, substantially reduce manufacturers' incentives to deploy the full extent of technologies EPA identified in the Tier 3 rulemaking to their combustion vehicles.

Two responses are possible from manufacturers: they either (1) deploy the same suite of internal combustion engine technologies to their combustion vehicle fleet, and therefore generate a significant amount of overcompliance credits that can be used to reduce their compliance obligations under the Tier 4 standards EPA is now proposing; or (2) reduce the deployment of technologies as EPA originally envisioned when setting the Tier 3 standards, leaving emissions reductions for their combustion vehicle fleet on the table. Either response weakens compliance with the standards. Strengthening the Tier 4 standards will help avoid these problems.

Therefore, EPA's proposed $NMOG+NO_x$ standards leave a significant gap between the feasible deployment of zero-emission technologies (indicated by the share of BEVs modeled for GHG compliance) and the feasible deployment of improvements to combustion vehicles (indicated by the achievement of a Tier 3 fleet average standard without the deployment of BEVs). Figure VI.F-1 illustrates, on the left, the implicit requirements on combustion vehicles under the proposed $NMOG+NO_x$ standards with EPA's modeled adoption of BEVs under the GHG standards; and, on the right, the implied share of BEVs required by the proposed Tier 4 standards if combustion vehicles achieve Tier 3 compliance. If BEVs are deployed at levels modeled by the Agency to comply with its GHG Proposal, $NMOG+NO_x$ emissions from combustion vehicles would remain about 30% higher than the Tier 3 requirement over the timeframe of the rule. If, instead, the combustion vehicle fleet matches the Tier 3 requirements in 2027-2032, far fewer BEVs would need to be deployed to meet the Tier 4 proposed targets. These scenarios demonstrate that numerous technological pathways are available to manufacturers to comply with the Tier 4 standards and that stronger standards are entirely feasible.

Figure VI.F-1. Emissions performance and ZEV market share implied by the combination of achieving the proposed GHG standards and Tier 3 / Proposed Tier 4 NMOG+NO_x standards



If manufacturers deploy ZEVs consistent with EPA's projection of compliance with the GHG standards, tailpipe emissions performance from the remaining combustion vehicles will exceed Tier 3 standards (left). If combustion vehicles instead achieve Tier 3 emissions standards, far fewer ZEVs will be required to meet the proposed Tier 4 fleet average standards than are modeled to comply with the GHG standards (right).

EPA should close this gap in relative stringency by setting a standard that reflects the full emissions reductions of the combustion vehicle technologies it has already identified as feasible (and which are readily available). Aligning the Agency's assessment of ZEV deployment and its analysis (covered primarily in the Tier 3 rulemaking) of what is achievable to reduce NMOG+NO_x emissions from combustion vehicles would yield a 2032 target of 10 mg/mi, a 17% reduction from its Proposal. Interim targets would then be adjusted accordingly.

Such a standard for LDVs would still be technology-neutral: The target corresponds to the lowest non-zero bin in the Proposal (Tier 4 Bin 10),[137] and the Agency has already identified combustion vehicles that have certified FTP emissions below 10 mg/mi.[138] Moreover, we expect that manufacturers seeking to comply with the multipollutant standards primarily through combustion vehicle technologies would be investing in further emission-reduction technologies from those vehicles, such as by ensuring their vehicles are more in line with the emissions

[137] 88 Fed. Reg. at 29419.
[138] DRIA at 3-41, Tbl. 3-14.

profiles of the industry-leading vehicles, including through deployment of hybridization and other EPA-identified strategies to reduce tailpipe emissions. Alternatively, for manufacturers that want to comply with the multipollutant standards through greater deployment of zero-emission technologies, this pathway would still allow flexibility for their combustion vehicle fleet to fall short of the Tier 3 requirements, provided they sell ZEVs beyond EPA's modeled industry average.

EPA has embarked on a multipollutant rulemaking precisely because technologies exist to simultaneously achieve reductions in GHGs and criteria pollutants.[139] Reducing the stringency of the final standards to 10 mg/mi NMOG+NO_x better aligns with the feasible and cost-appropriate technologies already identified by the Agency.

b. EPA should consider ways to limit over-crediting.

Figure VI.F-1 (left side) shows a non-monotonic behavior—that is, the allowable emissions profile of the combustion vehicles (green line) first increases significantly from 2026-2029, then decreases. This is largely due to the delay in increasing stringency for LDT3, LDT4, and MDPV classes (Class 2 light trucks), the result of EPA's interpretation of lead time requirements under the Clean Air Act.[140] The Agency has offered an optional "early compliance" pathway for manufacturers; however, this pathway increases the total stringency over the six years covered by the proposal, reducing the likelihood of manufacturers choosing this path to compliance.[141]

In an effort to induce manufacturers to align with the early compliance pathway and to acknowledge the reduced emissions benefits of the stagnant standard for Class 2 light trucks from 2025-2029 (a full five-year window corresponding to the lifetime of Tier 3 credits) under the default compliance pathway, EPA should condition manufacturers' full utilization of credits in this time period on their utilization of the early compliance pathway. For example, EPA could set a limit on the amount of averaging, banking, and trading (ABT) credits that could be utilized for compliance, in order to limit windfall credits from reductions in fleet emissions that occur during the 4-year period of stagnation. This would also ensure that manufacturers do not artificially prolong compliance through an overreliance on such credits.

2. The proposed $PM_{2.5}$ requirements are appropriate.

EPA is also proposing to set a limit on the allowable particulate matter ($PM_{2.5}$) emissions from all LDVs. This is an appropriate step under the Agency's authority and is well-grounded in both the need for additional emissions reductions and technical feasibility.

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[139] 88 Fed. Reg. at 29187.
[140] *See id.* at 29258.
[141] If EPA sets a 10 mg/mile standard in 2032 as recommended in Section VI.F.1.a, and thus reduces the step for Class 2 light trucks to 10 mg/mile, there would presumably be no such gap in stringency between the early and default compliance pathways.

Stoichiometric gasoline direct-injection is deployed in over half the new vehicle fleet in the United States and supports the deployment of turbocharged, downsized engines as well as high-compression ratio engines, both of which are key technologies to reduce GHG emissions.[142] At the same time, moving from port-fuel injection to direct-injection leads to an increase in both the amount of $PM_{2.5}$ and the particle count.[143] Addressing $PM_{2.5}$ emissions from the vehicles deploying these technologies is critical as they become a larger share of the on-road fleet.

Gasoline particulate filters (GPFs) have been successfully deployed globally for years to address these emissions, as EPA has documented in the Draft Regulatory Impact Analysis (DRIA).[144] Additionally, in-cylinder strategies can help mitigate emissions, including through the design of both the injector and the cylinder surface.[145] Aftertreatment design can also be used to mitigate cold-start emissions, in particular.[146] All of the technology developments described above are well-established, and many are analogous to technologies that have been deployed to limit $PM_{2.5}$ emissions from diesel engines.

As part of its Advanced Clean Cars program, California finalized a $PM_{2.5}$ standard of 1 mg/mile, to begin phasing in with the 2025 model year.[147] As part of its review, the California Air Resources Board (CARB) conducted tests demonstrating the feasibility of achieving this standard, including data on particle count, GPF effectiveness, and the ability to measure sub-mg quantities of $PM_{2.5}$.[148] While these standards have not gone into effect, the underlying data support EPA's proposed $PM_{2.5}$ program.

The benefits of the $PM_{2.5}$ standards are significant—depending on the assumed rate of deployment, EPA's Proposed Standards could cut tailpipe $PM_{2.5}$ emissions by up to 90% by 2050.[149] This could lead to cumulative health benefits of $85 to $160 billion over that same timeframe, at a 3% discount rate.[150] Importantly, it could also lead to measurable improvements

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[142] *See* U.S. EPA, The 2022 Automotive Trends Report: Greenhouse Gas Emissions, Fuel Economy, and Technology Since 1975, EPA-420-R-22-029 (Dec. 2022), Chapter 4, available at https://www.epa.gov/automotive-trends/download-automotive-trends-report.
[143] Omar I. Awad, et al, Particulate emissions from gasoline direct injection engines: A review of how current emission regulations are being met by automobile manufacturers, *Sci. Total Env.* 718, 137302 (2020), at https://doi.org/10.1016/j.scitotenv.2020.137302 (subscription required).
[144] DRIA, Section 3.2.5.
[145] See Awad. et al. 2020 for a review.
[146] *Id.*
[147] Cal. Code of Regs. Tit. 13, § 1961.2(a)(2)(A).
[148] For measurement capability, see CARB, An Update on the Measurement Of PM Emissions at LEV III Levels, (2015), available at https://ww2.arb.ca.gov/sites/default/files/2020-01/lev_iii_pm_measurement_feasibility_tsd_20151008_ac.pdf. For additional tests on GPF capability, see CARB, California[']s Advanced Clean Cars Midterm Review, Appendix K: PM Emission Testing Results (Jan. 8, 2017), available at https://ww2.arb.ca.gov/sites/default/files/2020-01/appendix_k_pm_test_results_ac.pdf.
[149] Oak Leaf Envtl., Impacts Analysis of a Revised Federal Light-Duty On-Road Particulate Matter Standard, Prepared for the Manufacturers of Emissions Controls Association (MECA) (June 2023), at 20, Fig. 7, available at https://www.meca.org/wp-content/uploads/2023/06/LDV_PM_Standard_Final_Report_06272023.pdf.
[150] *Id.* at 22-23, Figs. 9, 10 & "9" [Fig. 11 appears to be incorrectly labeled as Fig. 9].

in near-roadway air quality,[151] which could be significant for the more than 41 million people living within close proximity of high-traffic roadways.[152]

VII. Revisions to Elements of the Light-Duty Regulatory Program Are Warranted.

In addition to promulgating strong emission standards for light-duty vehicles, EPA should finalize important revisions to the light-duty regulatory program. As detailed below, we recommend that EPA revise the light-duty footprint curves and ensure that the final standards do not incentivize larger BEVs. We also urge EPA not to permanently foreclose the possibility of including upstream emissions in compliance accounting.

A. EPA is correct to address the misaligned incentives present in the current footprint attribute curves.

As EPA identified in its analysis of the market, sales of utility vehicles have greatly outpaced the sales of cars (sedans, coupes, etc.) over the past decade.[153] Unfortunately, the design of the footprint attribute curves underpinning the Agency's GHG standards has played a role in incentivizing manufacturers to shift market share towards utility vehicles, which generally have emissions targets much higher than passenger car equivalents.[154] EPA is appropriately proposing to revise the design of these curves by considering not just what is technically achievable but also how manufacturers would respond to a given attribute curve,[155] rather than starting from a broader view of makeup of the current fleet, as was used to originally define the attribute curves.[156]

1. EPA has appropriately characterized its footprint attribute curve for passenger cars.

In developing the car curve, EPA has appropriately balanced technology-driven emissions reductions for vehicles of different sizes and manufacturers' likely non-technology responses to its attribute curves. EPA should finalize these updates to the car curve.

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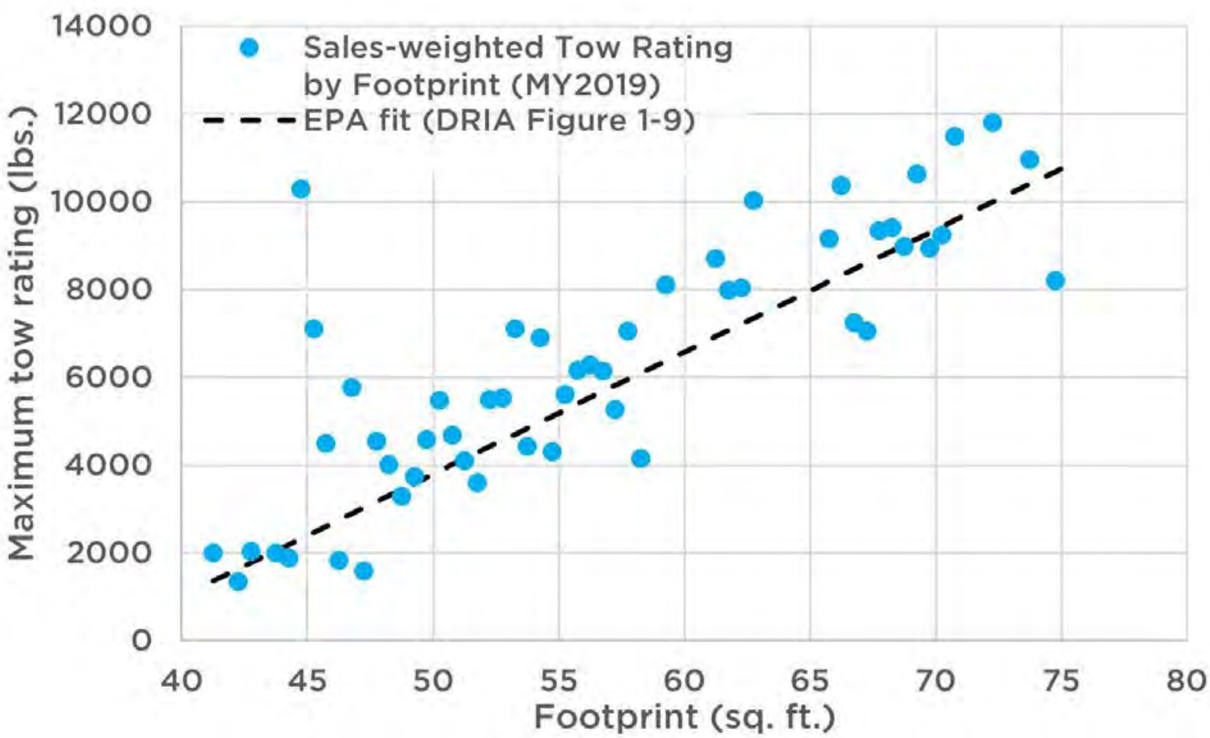
[151] *Id.* at 24, Tbl. 5.
[152] 88 Fed. Reg. at 26060.
[153] DRIA, Section 1.1.1 & 1-4, Figs. 1.1 & 1.2.
[154] A review of this evidence is available at Union of Concerned Scientists, *The SUV Loophole: How a changing sales mix is affecting the efficacy of light-duty vehicle efficiency regulations* (2016), https://downloads.regulations.gov/EPA-HQ-OAR-2015-0827-4016/attachment_2.pdf.
[155] "In determining an appropriate slope for the car curve, EPA modeled a range of car slopes to evaluate the footprint response – that is, to assess the tendency of the fleet to upsize or downsize as a compliance strategy." DRIA at 1-6.
[156] A full discussion is available in Section 3.2 of the RIA to EPA's MY 2012-2016 LDV GHG standards. U.S. EPA, Final Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards: Regulatory Impact Analysis. EPA-420-R-10-009 (Apr. 2010), available at https://nepis.epa.gov/Exe/ZyPDF.cgi/P1006V2V.PDF?Dockey=P1006V2V.PDF. *See also* U.S. EPA & NHTSA, Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule, 75 Fed. Reg. 35324, 25359-68 (May 7, 2010).

2. EPA has overestimated performance-related emissions when calculating the footprint attribute curves for light trucks.

In determining the shape of the light truck attribute curve, EPA has appropriately started from the passenger car curve, compensating for different features that distinguish a passenger car and light truck. However, EPA has overestimated the impacts of those factors.

The first characteristic it uses to distinguish a light truck is the addition of 4- or all-wheel-drive (4/AWD) to a crossover utility vehicle, which shifts a vehicle from the passenger car to light truck classification.[157] EPA estimated this value in a similar manner to previous work and arrived at a comparable but slightly reduced value for the difference in CO_2 values,[158] likely resulting from improvements in all-wheel-drive packages that have diminished the powertrain losses associated with the driveshaft and differential. This is a reasonable estimate to use as an offset, if the offset is applied solely to the share of light trucks with 4/AWD, as EPA has done.[159]

Figure VII.A-1. Maximum tow rating, by footprint (model year 2019)



The other additional criterion EPA uses to distinguish the light truck curve from the passenger car curve is the application of towing. Considering the maximum towing capacity, we

[157] This is true provided the vehicle also meets the requirements of 49 C.F.R. § 523.5(b)(2).
[158] Compare 12.5 g/mi (EPA, DRIA at 1-9) to 14.2 g/mi from UCS, *The SUV Loophole*, at 3.
[159] "Based on this analysis, EPA's proposed footprint curves reflect an offset between the car and truck curves of 10 g/mi for ICE vehicles equipped with AWD." DRIA at 1-9.

were largely able to reproduce the slope of the curve for maximum towing capacity vs. footprint independently (Figure VII.A-1). However, maximum towing capacity does not actually reflect the real towing capabilities of the fleet because the maximum towing capability for a large share of models is dependent upon additional equipment installation. As a result, EPA is unintentionally incorporating into its regulatory curves excess performance capability—while there may be variance for a vehicle's maximum tow capability based on powertrain and drivetrain, without a tow package (which may include a trailer hitch, changes to wiring to support connection to a trailer, and an upgraded rear axle), a vehicle's ability to tow may be significantly more limited (as illustrated in Table VII.A-1). With one ton or more difference between a vehicle's capability with and without the tow package, ascribing the maximum capability to all vehicles could unreasonably allow more than 20 g/mi additional GHG emissions based on the Agency's estimate of 9 g/mi per 1,000 pounds payload.[160] EPA should apply any adjustment only according to the capability of vehicles as sold in the final rule.

Table VII.A-1. Maximum towing capacity for 10 most popular light trucks with and without tow package[161]

Vehicle Make and Model	Maximum Towing Capacity (lbs.)	
	With Tow Package	Without Tow Package
Ford F-150	14,000	11,300
Chevy Silverado/GMC Sierra	13,300	9,900
Ram 1500	12,750	10,100
Toyota RAV-4	3,500	1,500
Honda CR-V	1,500	n/a
Toyota Tacoma	6,800	3,500
Jeep Grand Cherokee	7,200	3,500
Toyota Highlander	5,000	n/a
Chevy Equinox	1,500	n/a
Ford Explorer	5,600	3,000

In contrast to its application of the 4/AWD emissions factor, EPA did not apply its adjustment for towing-related emissions in a sales-weighted fashion. By instead applying the assumed maximum tow capability regardless of application of the towing package needed to support this, EPA is basing the curve on outsized performance characteristics. Just as EPA did not factor in whether there might be sports cars or high-output luxury models in determining the passenger car attribute curve, EPA should limit its assessment of light truck characteristics to only those features which are actually deployed. While there may be a subset of the market that requires towing performance, which thus differentiates the light trucks from cars, that additional emissions offset should be applied on a sales-weighted basis solely to the respective segment of

[160] DRIA at 1-11.
[161] These towing capacities reflect the trim variant with the highest towing packages, both with and without the vehicle's tow package. Many of these vehicles have engine options that offer lower towing capability.

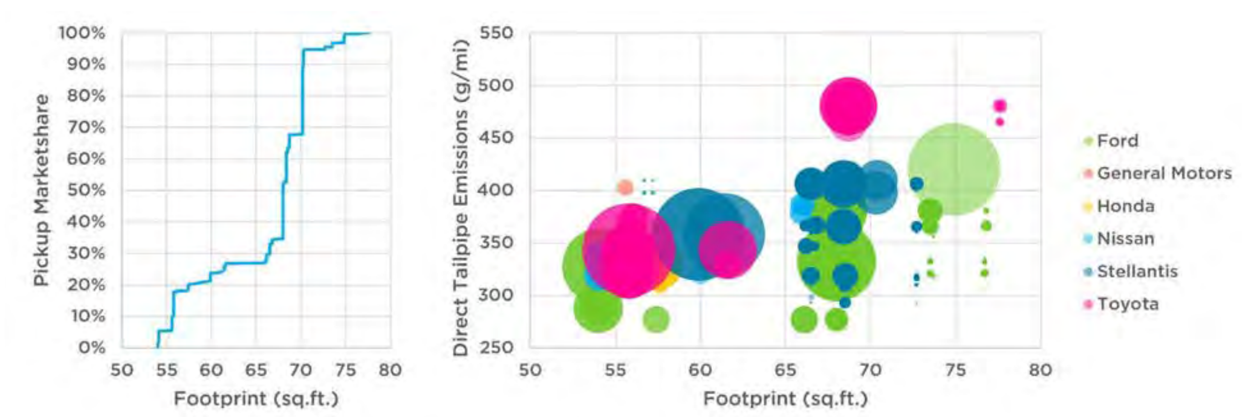
the fleet that is utilizing the maximum tow package. For the remainder of the fleet, only the base tow capability should be considered. This will necessarily reduce the slope of the attribute curve as currently defined.

3. EPA should further reduce the footprint of the cut point for light trucks based on pickup certification.

EPA has proposed phasing down the footprint of the cut point ("elbow") of the light truck attribute curve down to 70 sq. ft. The Agency should reduce it further, faster.

EPA has identified the need for the reduction in the cut point but has mistakenly focused on the average footprint of full-size pickups as the rationale.[162] While it is true that the average footprint has increased, and EPA is right to be concerned about incentives to upsize the pickup fleet, a large part of the reason for this increasing footprint is related to the growing share of four-door pickups. For example, the Ford F-150 has shifted from a mix of standard/extended/crew cab split of 17/50/33 in 2012 to 5/30/65 in 2022,[163] which increases the average wheelbase significantly for a standard bed and, thus, the vehicle's footprint. However, it is not the average footprint that is the relevant factor in setting the location of the cut point, but the relationship between the certified emissions from a full-size pickup truck and its footprint.

Figure VII.A-2. 2020 light-duty pickup market share and emissions, by footprint[164]



(left) While one-quarter of pickup sales are so-called "mid-size" pickups, the full-size pickup market in 2020 was highly concentrated around a footprint of 66 to 70 square feet, with 68% of all pickup sales falling in that narrow range. (right) While some larger pickups exist, those vehicles have virtually the same emissions because they have similar capability as the smaller

[162] DRIA at 1-14 - 1-15.
[163] Data from Wards Intelligence, "U.S. Light Vehicles by Body Style, '22 Model Year" and "'12 Model U.S. Domestic Car and Light Truck Output by Body Style."
[164] MY 2020 data taken from EPA's CCEMS modeling supporting the 2023-2026 final rulemaking. https://www3.epa.gov/otaq/ld/EPA-CCEMS-PostProcessingTool-Project-FRM.zip.

vehicle, even if they have a larger bed and/or cab. This is indicated by horizontal "lines" of dots (proportional to sales) for a given sub-model trim (e.g., the Stellantis pickups with 410 g/mi).

The effect of increasing the footprint at which the cut point occurs is to relax the standard for full-size pickup trucks, particularly those with longer beds and larger cabs, which have larger footprints. This cut point does not reflect the level of technical feasibility or actual certification of those larger pickups, however. As can be seen in Figure VII.A-2, pickups of a given powertrain and towing package configuration are certified to virtually identical fuel economy and emissions standards, as indicated by the flat rows of dots in Figure VII.A-2 spanning a range of footprints. This suggests that these larger pickup trucks should have standards consistent with the smallest full-size footprint vehicles, as was identified when the curves were first designed.

EPA should move swiftly to set the cut point of its standards at the average footprint of full-size pickups with a standard cab and bed because any vehicles with a larger footprint will be certified at virtually identical emissions levels, and it is precisely this flattening that the position of the cut point of the curve is meant to reflect. That footprint would correspond to 68.1 sq. ft. for MY 2022.

B. EPA should ensure that the final standards do not incentivize larger BEVs.

While we support EPA's incorporation of projected BEV penetration into the slopes of the footprint curves for the model years covered by the Proposal, we remain concerned that the Proposal retains the incentive for automakers to manufacture larger BEVs, a trend that has the potential to erode the environmental benefits of EPA's vehicle standards and that EPA anticipates will occur under the Proposed Standards. The final standards should incorporate a regulatory treatment of BEVs that discourages upsizing or selective manufacturing of larger BEVs.

As discussed previously, we support EPA's proposal to reflect projected BEV penetration in developing the slopes of the footprint curves. As EPA explains, the curves' flatter slope is "by design and reflects our projection of the likelihood that a future fleet will be characterized by a greatly increased penetration of BEVs, even in a no-action scenario." 88 Fed. Reg. at 29235. Inclusion of BEVs in establishing the curves has the effect of flattening their slope because BEVs have no tailpipe emissions and therefore factor into the curves at 0 g/mile.

While it is appropriate to reflect projected rates of BEV penetration in setting the slope of the footprint curves, it does not follow that it is appropriate to distinguish BEVs based on their vehicle footprint for purposes of regulatory compliance, effectively "rewarding" larger footprint BEVs. "From a physics perspective, a positive footprint slope for [combustion] vehicles makes sense because as a vehicle's size increases, its mass, road loads, and required power (and corresponding tailpipe CO2 emissions) will increase accordingly." 88 Fed. Reg. at 29235. The corollary, however, is that regulatory distinctions based on vehicle footprint lack a compelling basis for BEVs. As EPA notes, "a fleet of all BEVs would emit 0 g/mi, regardless of their respective footprints." *Id.* "[F]ootprint does not have any relationship with tailpipe emissions from BEVs." DRIA at 1-6.

Currently, manufacturers receive a considerable regulatory compliance benefit from producing larger-footprint BEVs: these BEVs increase the average footprint of the fleet and thus loosen the GHG emissions standard that the overall fleet will be required to meet. Because the GHG benefit of BEVs does not depend on their footprint and there is no practical need for crediting larger-footprint BEVs more robustly than smaller-footprint BEVs, the laxer standards applicable to fleets with larger-footprint BEVs come without any attendant climate benefit. At the same time, larger-footprint BEVs are likely to be heavier and less efficient, requiring more electricity to travel a given distance and typically requiring larger batteries and more of the materials that comprise those batteries, and carrying increased purchase costs. BEV footprint upsizing has adverse consumer, grid-related, and environmental consequences.

Concerns about incentivizing a shift to larger BEVs are well-founded. According to EPA's modeling, BEVs in MY 2032 are projected to increase in size relative to MY 2020. DRIA at 1-13–1-14, Fig. 1-12. The increase is 1.6 sq. feet for sedans, 1.9 square feet for CUVs/SUVs, and 3.3 square feet for pickups. DRIA at 1-13, Tbl. 1-2. Selective manufacturing of larger-footprint BEVs—which similarly raises the average footprint of the fleet—is already occurring. Automaker GM recently ceased production of its lone small-footprint BEV: the Chevy Bolt.[165] GM's remaining near-term BEV offerings are all larger vehicles: SUVs and pickup trucks.[166] A number of other automakers are also selectively manufacturing exclusively larger-footprint BEVs, including Ford, which currently produces only an SUV (the Mustang Mach-E) and a pickup truck (the F-150 Lightning); Rivian, which produces only an SUV (the R1S) and pickup truck (the R1T); and Volvo, which produces only a cross-over (the C40) and three SUVs (the XC40, EX30, and EX90).[167]

EPA's final regulations should include a regulatory mechanism that discourages the manufacture of larger BEVs.

C. EPA should not foreclose the possibility of including upstream emissions in compliance accounting.

The Agency's 2012 rule included net compliance accounting for PEVs' upstream emissions from electricity generation beginning with MYs 2022-2025. 88 Fed. Reg. at 29252; 77 Fed. Reg. at 62816. Under that rule, net upstream emissions were to be determined by "attribut[ing] a pro rata share of national CO_2 emissions from electricity generation to each mile

[165] Khristopher J. Brooks, *GM to stop making Chevrolet Bolt, its best-selling electric vehicle*, CBS News (Apr. 26, 2023), https://www.cbsnews.com/news/chevy-bolt-end-production-gm-vehicle/.
[166] *See* General Motors, Electrification, EV Spotlight, https://www.gm.com/commitments/electrification.
[167] *See* Ford, Explore Going Electric, https://www.ford.com/electric/; Rivian, Vehicles Made for the Planet, https://rivian.com/; Volvo, Our Cars, Our Full Range, https://www.volvocars.com/us/.

driven under electric power minus a pro rata share of upstream emissions" from gasoline production. 88 Fed. Reg. at 29252. EPA justified leaving these emissions unaccounted for through MY 2023 as a then-necessary incentive for EV technology adoption. However, EPA's 2020 rule, effective before MY 2023, removed net upstream accounting requirements through MY 2026. 85 Fed. Reg. at 25208. EPA now proposes to eliminate upstream emissions accounting permanently, reasoning that upstream CO_2 accounting has consistently been absent from the vehicle program since its inception; that Section 202 regulates only tailpipe emissions; and that power plant emissions, regulated under separate statutory programs, are on the decline. EPA also notes that it does account for upstream emissions in its separate analysis of overall estimated vehicle emissions impacts and the projected benefits of its rules, and that any EV upstream accounting for compliance purposes, were it to take place, would have to be accompanied by a calculation of upstream emission impacts of combustion vehicles from refineries. 88 Fed. Reg. at 29252.[168]

If EPA proceeds as proposed, it must undertake a full and comprehensive upstream emissions analysis for all vehicles as part of its cost-benefit analysis. However, as noted above, EPA itself previously (and reasonably) interpreted the statute as granting it discretion to include upstream emissions and has set standards that do so. 88 Fed. Reg. at 29252; 77 Fed. Reg. at 62816. We believe the better option is to include upstream emissions of all vehicles in compliance accounting, particularly as EVs are becoming a larger part of the new vehicle fleet and the proliferation of ever larger and heavier EVs increases their upstream emissions. In either case, as EPA states, any accounting of upstream emissions—whether for compliance purposes or cost-benefit analysis—must be consistent for all vehicles. If the Agency proceeds as proposed,

[168] On a "lifecycle" basis, ZEVs offer superior emissions reductions compared to combustion vehicles. *See generally* Adrian O'Connell et al., Int'l Council on Clean Transp. (ICCT), *A Comparison of the Life-Cycle Greenhouse Gas Emissions of European Heavy-Duty Vehicles and Fuels* (2023), https://theicct.org/wp-content/uploads/2023/02/lca-ghg-emissions-hdv-fuels-europe-feb23.pdf; Lu Xu, *Life Cycle Greenhouse Gas Emissions of Conventional and Alternative Heavy-duty Trucks: Literature Review and Harmonization* (Thesis), at chs. 3-4 (2021), https://hdl.handle.net/1807/108920; Dora Burul & David Algesten, Scania, *Life cycle assessment of distribution vehicles: Battery electric vs diesel driven* (undated), https://www.scania.com/content/dam/group/press-and-media/press-releases/documents/Scania-Life-cycle-assessment-of-distribution-vehicles.pdf; Georg Bieker, ICCT, *A Global Comparison of the Life-cycle Greenhouse Gas Emissions of Combustion Engine and Electric Passenger Cars* (2021), ttps://theicct.org/wp-content/uploads/2021/07/Global-Vehicle-LCA-White-Paper-A4-revised-v2.pdf; Jarod C. Kelly et al., Argonne National Laboratory, *Cradle-to-Grave Lifecycle Analysis of U.S. Light-Duty Vehicle-Fuel Pathways: A Greenhouse Gas Emissions and Economic Assessment of Current (2020) and Future (2030-2035) Technologies*, at ch. 8 & app. B, (2022), https://publications.anl.gov/anlpubs/2022/07/176270.pdf; Fuels Institute, *Life Cycle Analysis Comparison*, (2022), https://www.transportationenergy.org/wp-content/uploads/2022/10/FI_Report_Lifecycle_FINAL.pdf; Maxwell Woody et al., *Corrigendum: The role of pickup truck electrification in the decarbonization of light-duty vehicles*, Env't Rsch. Letters, July 15, 2022, https://iopscience.iop.org/article/10.1088/1748-9326/ac7cfc/pdf; David Reichmuth et al., Union of Concerned Scientists, *Driving Cleaner: Electric Cars and Pickups Beat Gasoline on Lifetime Global Warming Emissions* (2022), https://www.ucsusa.org/sites/default/files/2022-09/driving-cleaner-report.pdf; Florian Knobloch et al., *Net emission reductions from electric cars and heat pumps in 59 world regions over time* (Dec. 1, 2020), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7308170/pdf/EMS85812.pdf (author manuscript; published in final edited form at 3 Natural Sustainability 437 (2020)).

we strongly urge it *not* to characterize its decision as "permanent." Both the vehicle and power generation industries are currently undergoing rapid changes. Though power generation emissions have been declining, the need for electricity is increasing, and the reduction of EV energy use will become more important as the fleet becomes more electrified. Any decision now to permanently omit fleet upstream emissions compliance accounting would be premature.

VIII. Stronger GHG and Criteria Pollutant Standards for Medium-Duty Vehicles Are Feasible.

We now turn to EPA's proposed emission standards for medium-duty vehicles. Below, we examine the combustion vehicle and zero-emission technologies that can further reduce GHG emissions from the medium-duty fleet, comment on EPA's modeling, address economic considerations, and make suggestions on certain aspects of EPA's regulatory program. We also offer recommendations for the Tier 4 NMOG+NOx standards and PM requirements. As detailed below, strong GHG and criteria pollutant emission standards for MDVs are feasible and cost-reasonable.

A. EPA must strengthen its GHG standards for MDVs.

EPA's proposed GHG standards for MDVs significantly underestimate the potential for feasible emissions reductions from the Class 2b-3 fleet, particularly pickup trucks. EPA has primarily focused on the electrification of MDVs in setting its standards.[169] However, not only has it underestimated the share of MDVs that could be electrified, it has underestimated the technologies available to reduce GHG emissions from gasoline- and diesel-fueled vehicles. EPA should adopt more stringent final standards for MDVs that reflect greater application of both the zero-emission powertrain and conventional emission control technologies that are feasible and widely available.

1. The combustion vehicle technology pathways show the feasibility of stronger standards.

EPA proposes as its 2027 standard the current (Phase 2) standards for diesel pickups and vans, and then adjusts those standards in the future based on assumptions about the level of electrification within the fleet. In fact, in EPA's modeling, combustion MDVs actually increase average direct tailpipe emissions by 1.5% between 2022 and 2032, with the increase being even larger for the Phase 2 baseline. The modeling thus indicates that no technological improvements to combustion MDVs are needed to comply with even the existing Phase 2 standards through 2027.[170]

[169] DRIA at 1-21: "The feasibility of the 2027-2032 GHG standards is based primarily upon an assessment of the potential for a steady increase in MDV electrification, primarily within the van segment."

[170] This remains true for the "No IRA" sensitivity, though there is virtually no difference in the assumed production of electric MDVs between the default modeling run and this sensitivity case, indicating the degree to which electrification is expected to take off in the commercial van space due to improved TCO.

Subsequent to finalization of the Phase 2 standards in 2016, a number of technologies have been developed that EPA did not originally consider in establishing those standards; nor were the Phase 2 standards predicated on the full adoption of even those technologies that *were* identified at the time. As EPA noted in its Phase 3 heavy-duty vehicle proposal: "In developing the Phase 2 CO_2 emission standards, we developed technology packages that were premised on technology adoption rates of less than 100%. There may be an opportunity for further improvements and increased adoption through MY 2032 for many of these technologies included in the heavy-duty (HD) GHG Phase 2 technology package used to set the existing MY 2027 standards."[171]

By ignoring technologies for Class 2b-3 combustion vehicles that could achieve emissions reductions beyond the Phase 2 standards, EPA is setting its MDV standards below a level of readily achievable technology adoption (and, indeed, many of these technologies are already being deployed). Below, we walk through a number of the technologies that EPA should assume will be deployed by MDV manufacturers in the timeframe of the MDV Proposal.

a. EPA should consider additional compression-ignition (diesel) engine technologies.

Manufacturers of diesel engines for Class 2b-3 pickups and vans will deploy new engines in order to meet the 2027 NO_X standards that EPA finalized last year.[172] However, the Agency's modeling assumes that diesel vehicles will reduce GHG emissions by less than 1% from 2022 to 2032. This leaves a tremendous amount of technology on the table, not just from what the Agency identified in the Phase 2 rulemaking and assumed would be needed to meet the standards already on the books, but also from additional improvements that have been developed since then.

Diesel engine efficiency continues to increase, with HHD (Class 8) diesel engines demonstrating up to 55% brake-thermal efficiency (BTE) in response to the second phase of the SuperTruck program. The Navistar and Cummins/Peterbilt teams demonstrated 55% BTE, compared to the 50% target for the first phase, while Daimler, Volvo, and PACCAR all demonstrated over 50% BTE, with a clear pathway towards the 55% target. The PACCAR team's progress is particularly illuminating, as they undertook an additional challenge to meet "ultra low NO_X" targets consistent with EPA's recent regulation as part of their overall efficiency effort, indicating that these levels of thermal efficiency are not incompatible with achieving the 2027

[171] 88 Fed. Reg. at 25960.
[172] *See* 88 Fed. Reg. 4296.

NO_X standards.[173]

Significant improvements in efficiency are not limited to the largest engines and can also be feasibly deployed on Class 2b-3 vehicles. Ford's latest iteration of its 6.7L Power Stroke diesel engine cut GHG emissions by 3.5% over the previous generation when it was introduced in 2020, and 2023 saw an additional 3% improvement due to a revised injection system.[174] General Motors released its new 6.6L Duramax diesel engine in 2023 with improved cylinder heads, fuel injection, and other features in a design that is meant to increase both power and efficiency, particularly at higher output.[175] These engine improvements are already being deployed today but are not captured in the Agency's OMEGA2 modeling.

Mild electrification also offers increased emissions reduction capabilities. Eaton demonstrated that it is possible to outperform simultaneously the 2027 NO_x standards and the Phase 2 CO_2 standards through a number of different aftertreatment and powertrain combinations,[176] including those applicable to Class 2b-3 vehicles. A recent research paper by Eaton demonstrates various combinations of control technologies manufacturers can target CO_2 and NO_x emissions levels over different regulatory cycles to develop a technology package that

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[173] *See* Zukouski, Russ, *Navistar SuperTruck II: Development and demonstration of a fuel-efficient class 8 tractor & trailer*, DOE Annual Merit Review, (Jun. 21-23, 2022) https://www1.eere.energy.gov/vehiclesandfuels/downloads/2022_AMR/ace103_%20Zukouski_2022_o_4-29_1232pm_ML.pdf; Mielke, David, *2022 Annual Merit Review: Cummins/Peterbilt SuperTruck II*, DOE Annual Merit Review, (Jun. 21-23, 2022) https://www1.eere.energy.gov/vehiclesandfuels/downloads/2022_AMR/ace102_dickson_2022_o_rev2%20-%20TrailLife-GCCC%20IN0110%20REVISED.pdf; Bashir, Murad, et al., *Daimler: Improving transportation efficiency through integrated vehicle, engine, and powertrain research - SuperTruck 2*, DOE Annual Merit Review, (Jun. 21-23, 2022) https://www1.eere.energy.gov/vehiclesandfuels/downloads/2022_AMR/ace100_Villeneuve_2022_o_4-30_1116am_ML.pdf; Bond, Eric, et al, *Volvo SuperTruck 2: Pathway to cost-effective commercialized freight efficiency*, DOE Annual Merit Review, (Jun. 23, 2022) https://www1.eere.energy.gov/vehiclesandfuels/downloads/2022_AMR/ace101_bond_2022_o_5-1_129pm_ML.pdf; Meijer, Maarten, *Development and demonstration of advanced engine and vehicle technologies for class 8 heavy-duty vehicle ([PACCAR] SuperTruck II)*, DOE Annual Merit Review (Jun. 21-23, 2022), https://www1.eere.energy.gov/vehiclesandfuels/downloads/2022_AMR/ace124_Meijer_2022_o_4-29_1056pm_KF.pdf.

[174] To assess these improvements, we refer to the combined transient cycle certification results for the MHD Power Stroke family of diesel engines available in the chassis cab/F-650 and F-750 configurations. The engines available in the heavy-duty pickups are not required to certify to isolated engine tests, but are likely to see similar levels of improvement, even with the higher power output, since they also have the same underlying technology.

[175] GMC Pressroom, *The Ultimate Heavy Duty: GMC Introduces its Most Luxurious, Advanced and Capable Sierra HD Ever* (Oct. 6, 2022), https://media.gmc.com/media/us/en/gmc/home.detail.html/content/Pages/news/us/en/2022/oct/1006-sierra.html. It is difficult to compare apples-to-apples between the new and old Duramax engines due to limited certification data and because some of that efficiency improvement was used to reduce tailpipe NOx, since the new diesel-equipped Silverado/Sierra HD 2500 have a reduced NMOG+NOx bin of 200 vs. 250 mg/mile. Additionally, because the standards are set by "work factor," the increase in power used to raise towing capacity by 4000 pounds increases the allowable emissions for the engine, which means that despite an apparent increase in certified CO_2 emissions of 2.4%, there could be a net improvement in compliance of up to nearly 5% as the result of up to a 7% increase in the model year 2023 emissions target.

[176] *See generally* Dorobantu, Mihai, *Eaton considerations on MD/HD GHG Phase 3*, OIRA-Eaton meeting, (Mar. 23, 2023), https://www.reginfo.gov/public/do/eoDownloadDocument?pubId=&eodoc=true&documentID=215442.

is suitable for compliance, including packages that can achieve CO_2 reductions beyond Phase 2 while meeting EPA's future 2027 NO_x standards.[177]

One of the strategies deployed by Eaton is a 48V electric heater, which could be deployed easily with a 48V mild hybrid powertrain, again illustrating the complementary technology packages available to manufacturers to simultaneously meet GHG and NO_x standards. The 48V mild hybrid powertrain can power accessories, including those related to emissions control, and can also help reduce engine-out NO_x. This was also demonstrated through testing by FEV as a strategy particularly relevant to medium-heavy-duty vehicles that share chassis and power requirements with the Class 2b-3 pickups and vans covered by this proposal.[178] Such developments should be incorporated into the Agency's analysis of the level of emissions reductions achievable from diesel-powered Class 2b-3 vehicles.

In the Phase 2 rulemaking, EPA excluded cylinder deactivation from medium-duty diesel engines,[179] but its own analysis now shows that manufacturers are likely to deploy that technology to meet the heavy-duty NO_x standards.[180] Similarly, a recent report by Roush identified cylinder deactivation as a likely engine configuration for many Class 2b-3 vehicles.[181] The Agency should consider this technology in its OMEGA2 modeling, further increasing the available emissions reductions technologies for diesel-powered vehicles.

b. EPA should consider additional spark-ignition (gasoline) engine technologies.

Another significant opportunity for increased improvement to combustion vehicles lies in spark-ignition (SI) engines, for which Phase 2 required no engine improvements beyond the 2016 SI engine standard. While this is somewhat rectified in EPA's move to a fuel-neutral standard for Class 2b-3 pickups and vans—which effectively results in a 5-6% increase in stringency for MDVs—this still does not fully recognize the potential improvement available

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[177] McCarthy, J., et al. 2023. "Technology levers for meeting 2027 NOX and CO2 regulations." *SAE Technical Paper* 2023-01-0354. https://doi.org/10.4271/2023-01-0354.
[178] Fnu, D., *et al.* 2023. "Application of 48V mild-hybrid technology for meeting GHG and low NOX regulation for MHD vehicles." SAE Technical Paper 2023-01-0484. https://doi.org/10.4271/2023-01-0484.
[179] 81 Fed. Reg. at 73754, Table VI-4. Note, however, that the agencies did consider a "right-sizing" of diesel engines, based on a 4-cylinder vs. 6-cylinder engine, and cylinder deactivation could be seen as a control-based attempt to yield the equivalent improvement without altering the maximum output. *See* NHTSA, *Commercial medium- and heavy-duty truck fuel efficiency technology study – Report #2*, U.S. Dep. of Transportation, 52–53 (Feb. 2016), https://www.nhtsa.gov/sites/nhtsa.gov/files/812194_commercialmdhdtruckfuelefficiency.pdf.
[180] EPA, *Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards, Regulatory Impact Analysis*, at 108–131 (Dec. 2022), https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1016A9N.pdf.
[181] Himanshu Saxena et al., *Electrification Cost Evaluation of Class 2b and Class 3 Vehicles in 2027–2030*, Roush, at 24-25, 28-30 (May 2023), https://cdn.mediavalet.com/usva/roush/r0YBSBBv00edOiBP759yoA/3Hcv7F_W-0G9ek0ODPgNMg/Original/Electrification%20Cost%20Evaluation%20of%20Class%202b-3%20Vehicles%20in%202027-2030_ROUSH.pdf. [hereinafter Saxena et al., *Electrification Cost Evaluation*].

from gasoline engines. And in fact, in the Agency's modeling, gasoline vehicles see, on average, 5% *higher* emissions in 2032, compared to 2022.[182]

The weakness in EPA's Phase 2 targets for SI engines and vehicles is apparent in looking at manufacturers' growing bank of compliance credits to-date, particularly for Ford Motor Company, the largest SI engine supplier. Ford has run a credit surplus in every year of the vocational engine program, but this surplus exploded in MY 2020 with the release of its latest 7.3L V8 engine, codenamed "Godzilla."[183] Even though the engine platform is relatively low-tech (naturally aspirated, pushrod V8), by utilizing variable cam timing and a variable-displacement oil pump, Ford's engine achieved a significant improvement in efficiency. The engine was also designed with fuel economy at load in mind for applications like towing. A smaller engine built on the same platform replaced the older base engine in 2023, no doubt increasing Ford's overcompliance and increasing the efficiency of even more of the MDV fleet.

General Motors is not standing still, either—its fifth-generation small-block V8 platform is getting a next generation update to a 5% improvement over the current generation,[184] and the current generation is already a credit generator for GM's heavy-duty vehicles under the Phase 2 program.[185] No further details are available about the heir to the current iron-block direct-injection L8T variant found in GM's heavy-duty offerings.

Note that neither of these new improvements reflect technology adoption that was further anticipated for gasoline engines when the Phase 2 regulations were finalized. EPA assumed that cylinder deactivation (discrete or continuous), downsizing, and mild and strong hybridization would be used to meet those standards,[186] yet none have yet been deployed in Class 2b-3 pickups and vans. This further underscores the significant amount of emissions reductions that are still readily achievable for Class 2b-3 vehicles.

2. The electrification technology pathway shows the feasibility of stronger standards.

When it comes to electrification, EPA's OMEGA2 modeling applies electrification almost exclusively to commercial vans, with the model assuming just 236,000 Class 2b-3 electric pickups will be sold out of more than 5.2 million Class 2b-3 pickups sold between 2022-2032

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[182] Because the model preferentially selects vans for electrification, some of this decrease is related to a shift in the vehicles included in the remaining gasoline fleet. However, even when limited to gasoline pickups there is an apparent backsliding in emissions, with an increase of 3%. This is similar to the backsliding that appears in the modeling of light-duty vehicles (see Section VI.A.2).

[183] EPA, *Final Phase 1 EPA Heavy-Duty Vehicle and Engine Greenhouse Gas Emissions Compliance Report (Model Years 2014-2020)*, Appendix B, at 40-42 (Nov. 2022) https://nepis.epa.gov/Exe/ZyPDF.cgi/P1016962.PDF?Dockey=P1016962.pdf.

[184] Wren, Wesley, T*his is why GM is launching a new small block V8*, Autoweek, (Feb. 3, 2023) https://www.autoweek.com/news/industry-news/a42746723/why-gm-is-launching-a-new-small-block-v8/.

[185] EPA, *Final Phase 1 EPA Heavy-Duty Vehicle and Engine Greenhouse Gas Emissions Compliance Report (Model Years 2014-2020)*, Appendix B, at 43.

[186] 81 Fed Reg. at 73776, Table VI-13.

(4.5%). On the other end of the spectrum, the model shows sales of just over 1.2 million electric vans out of just under 2.8 million total sales over the same period (43.4%), with electric vans achieving a 98% market share by 2032. The reasons for such a broad disparity are entirely artificial—for example, the model's 25% cap on production of Class 2b-3 BEV pickups—and do not reflect the latest available data on technology or cost.[187]

a. EPA's modeling should better reflect the favorable economic case for electric pickup trucks.

A recent report by Roush examined the potential for electrification of MDVs under a range of scenarios, finding that electrification is cost-competitive in the great majority of them.[188] It is clear that some amount of the difference between the uptake of Class 2b-3 pickups and vans in the OMEGA2 modeling stems from the far lower range assumed for vans (150 miles) compared to that of pickups (300 miles). But as illustrated in Table VI.A-1 below,[189] Roush finds that by 2030, even when comparing a low-cost combustion powertrain to the most costly battery chemistry (NMC811) deployed in a 400-mile electric Class 3 pickup,[190] the electric pickup still achieves total cost of ownership (TCO) parity within the typical loan length for a new vehicle (7 years). And when comparing a Class 3 pickup with a low-cost battery (LFP) to a high-cost internal combustion engine powertrain, a 400-mile electric pickup would pay off within 1 year, well within the payback period assumed for consumers by manufacturers within EPA's OMEGA2 model.

Table VIII.A-1. Time to achieve TCO parity for Class 2b-3 BEVs with a 2027 and 2030 purchase timeframe

Vehicle Type	BEV Range	2027			2030		
		Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Class 2b Van	BEV150	< 1 year	< 1 year	2 years	< 1 year	< 1 year	< 1 year
	BEV250	< 1 year	4 years	End of life	< 1 year	1 year	4 years

[187] In its OMEGA2 modeling, EPA has set an artificial cap of 25% on the maximum production of Class 2b-3 BEV pickups, identified in the production_constraints-body_style_MD.csv input file. There is no sufficient justification for this cap in the DRIA or preamble, with the exclusive reference found on p. 1-21 of the DRIA, for which the Agency writes: "The primary assumptions within the work factor based GHG standards for MDV from 2028 to 2032 include an approximately 8 percent year over year improvement, to a large degree from electrification of MDV vans and to a lesser degree electrification of a small fraction (<25 percent) of MDV pickups and adoption of other technologies."

[188] Saxena et al., *Electrification Cost Evaluation* at 26.

[189] Table VI.A-1 is adapted from Saxena et al., *Electrification Cost Evaluation*, Tbl. 24, at 145. Scenario 1 represents the adoption of low-cost BEV and high-cost combustion vehicle technologies; Scenario 2, medium-cost BEV and combustion vehicle technologies; and Scenario 3, high-cost BEV and low-cost combustion vehicle technologies. *Id.* at 28-29.

[190] Roush used an LFP battery for its low-cost BEV, an NMC811 battery for its medium-cost BEV, and a "10% costlier" NMC811 battery for its high-bost BEV. *Id.* at 30-31.

Class 3 Pickup Truck	BEV150	< 1 year	< 1 year	1 year	< 1 year	< 1 year	< 1 year
	BEV250	< 1 year	2 years	6 years	< 1 year	< 1 year	2 years
	BEV300	< 1 year	4 years	9 years	< 1 year	1 year	4 years
	BEV400	1 year	6 years	End of life	< 1 year	3 years	7 years
Class 3 Van	BEV150	< 1 year	< 1 year	4 years	< 1 year	< 1 year	< 1 year
	BEV250	< 1 year	5 years	End of life	< 1 year	2 years	6 years

When accounting for the impacts of the IRA, the economic case for electrification of Class 2b-3 pickups is even clearer, as shown in Table VI.A-2. Here the impact of the full § 30D credit is shown, which is also the maximum allowable limit of the § 45W (commercial clean vehicle) credit for Class 2b-3 vehicles.[191] Roush's analysis finds that purchase price parity is achieved for virtually all BEV classes in the timeframe of the analysis, so the § 45W commercial vehicle credit is not applicable in the later years of their analysis.[192] In fact, Roush finds that, with the application of IRA credits, by MY 2027 all BEVs except the 400-mile pickup will be priced at or below a comparable combustion vehicle[193]; and that *all* MY 2027 BEVs will achieve TCO parity within the first two years of vehicle ownership.[194] Here it is worth noting that, despite the large share of MDVs that are purchased for commercial fleets, EPA did not directly include the § 45W credit in its analysis, instead applying the same combination of the § 30D and § 45W credit as it did for LDVs.[195] Because the § 45W credit is based on the lesser of $7500 or the difference in purchase price, this credit should act to hedge uncertainty in the Agency's analysis, though that is not how it was treated within the OMEGA2 modeling runs.

Table VIII.A-2. Time to achieve TCO parity with IRA § 30D credits for MYs 2023 and 2027[196]

	BEV Range	2023		2027	
		Original	with IRA credits	Original	with IRA credits
		Scenario 2	Scenario 2	Scenario 2	Scenario 2
Class 2b Van	BEV150	11 years	4 years	< 1 year	< 1 year
	BEV250	End of life	End of life	4 years	< 1 year

[191] *Id.* at 175-79. The § 45W credit is based on 30% of the basis of a vehicle not powered by a gasoline or diesel internal combustion engine, or the difference in purchase price between a qualified clean vehicle and a comparable combustion vehicle. In the case of vehicles that have a GVWR less than 14,000 pounds (which includes Class 2b-3 vehicles), the total credit is capped at $7500.
[192] *Id.* at 195.
[193] *Id.*
[194] *Id.* at 197-98.
[195] This is not immediately apparent in the text of the preamble or DRIA but can be assessed by comparing the contents of the vehicle_price_modifications_20230314b.csv input files from the LDV and MDV modeling runs, which are identical.
[196] This table is adapted from Saxena et al., *Electrification Cost Evaluation*, Tbl. 30, at 193.

Class 3 Pickup Truck	BEV150	7 years	3 years	< 1 year	< 1 year
	BEV250	End of life	10 years	2 years	< 1 year
	BEV300	End of life	End of life	4 years	< 1 year
	BEV400	End of life	End of life	6 years	2 years
Class 3 Van	BEV150	End of life	6 years	< 1 year	< 1 year
	BEV250	End of life	End of life	5 years	< 1 year

The Roush report is not the only analysis to find a strong economic rationale for the adoption of zero-emission MDVs. A recent report from the National Renewable Energy Laboratory (NREL) found that cost parity will be achieved before 2035 (even in the absence of the IRA) for medium- and heavy-duty vehicles, including Class 3 vans and Class 4-5 vehicles that share a platform with Class 2b-3 pickups (which were not part of that analysis).[197] Similarly, a recent International Council on Clean Transportation (ICCT) report on electric MDVs finds that purchase price parity with diesel MDVs will be achieved prior to 2032 for 300-mile and lower BEVs, even in the absence of IRA funding.[198] And when IRA funding is considered, even 400-mile BEV pickups would achieve purchase price parity in the timeframe of this rule.[199]

There is some difference in costs between EPA's assessment and other studies such as those described above: on average, according to EPA, Class 2b-3 combustion pickups will cost about $5,000 less (from a purchase price standpoint) than a comparable electric pickup. However, with the Agency's application of an average IRA credit of $6,000 in 2032, this would still yield cost parity, on average, so even EPA's higher cost assessment cannot fully explain the reason for Class 2b-3 pickups electrifying at such a reduced rate in the Agency's modeling. Even more than that, this disparity is almost entirely influenced by the relative price difference of gasoline and diesel pickups in EPA's modeling, with the Agency's BEV300 pickups just $1,100 more expensive than diesel pickups without the IRA incentives, not far off ICCT's conclusion that BEV300 pickups will achieve cost parity with diesel pickups by 2031.[200] Despite this, the model's conversion rate of combustion vehicle sales to electric vehicle sales is virtually indistinguishable between gasoline and diesel pickups, at roughly 20% for each, seemingly indicating that neither purchase price nor TCO parity have a significant impact on sales. Given that many Class 2b-3 vehicles are purchased for commercial use,[201] such modeling behavior is inconsistent with the economically-driven decisionmaking that would be expected to occur in the real world.[202]

[197] Catherine Ledna et al., NREL, *Decarbonizing medium- and heavy-duty on-road vehicles: Zero-emission vehicles cost analysis*, Mar. 2022, at 2, 46 https://www.nrel.gov/docs/fy22osti/82081.pdf.
[198] Eamonn Mulholland, ICCT, *Cost of electric commercial vans and pickup trucks in the United States through 2040* (Working Paper 2022-01), Jan. 2022, at 11 (Fig. 5), https://theicct.org/wp-content/uploads/2022/01/cost-ev-vans-pickups-us-2040-jan22.pdf.
[199] *See id.*
[200] *Id.*
[201] *See id.* at 1; Saxena et al., *Electrification Cost Evaluation*, at 49.
[202] For example, EPA's own analysis of the heavy-duty market assumed a conversion rate of 80% when cost parity is achieved. 88 Fed. Reg. at 25992, Tbl. II-23. And analysis from NREL finds this number to be nearly 100%; see

Based on EPA's own modeling, BEV variants for over 71% of the Class 2b-3 market achieve first cost parity with their combustion-powered equivalent by 2032 when including IRA incentives, including 57% of the Class 2b-3 pickup truck market.[203] This is a substantially higher share of vehicles than the model assumes will be deployed.

For all of these reasons, EPA's modeling does not accurately reflect the favorable economic case for commercial MDV electrification, particularly for pickups. While some of these modeling problems can be ascribed to differences in battery costs and EPA's unreasonable choice to include an artificial 25% production cap on BEV pickups, other problems are intrinsic to assumptions made within the model that do not reflect the Agency's own assessment of likely adoption of electrification for commercial vehicles, particularly considering the incentives available under the IRA.

b. EPA should more fully account for the impact of state regulations on the adoption of Class 2b-3 ZEV pickups and vans.

In addition to market forces, state regulatory requirements will have a significant impact on the adoption of Class 2b-3 ZEV pickups and vans, not just through ZEV sales requirements but through the corresponding industrial development and production that will occur to meet related demand. EPA does not appear to have considered the relative impact of such state regulations as part of its OMEGA2 modeling.[204]

Under the Advanced Clean Trucks (ACT) regulation, manufacturers must ensure that 40% of their sales of Class 2b-3 vehicles are ZEVs by 2032, en route to an eventual target of 55% ZEV sales in 2035.[205] ACT has already been adopted in eight states as of the date of this comment letter, and these states make up nearly 20% of the heavy-duty market (including Class 2b-3 vehicles) overall.[206] While there are no strict requirements on the mix of vehicles a manufacturer must sell in order to achieve these targets, the sheer size of the Class 2b-3 pickup market means that manufacturers cannot simply rely on the widespread deployment of ZEV commercial vans in order to meet the ACT-required level of ZEV adoption.

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comparison at pp. 59-60 of EDF, *Comment Letter on GHG Standards for HD Vehicles*, June 16, 2023, https://downloads.regulations.gov/EPA-HQ-OAR-2022-0985-1644/attachment_1.pdf (data from Ledna et al. 2022).

[203] This was established using the output files for the OMEGA2 MDV runs, using the vehicles file (2023_03_14_22_42_30_central_3alts_20230314_Proposal_vehicles.csv) to compare in a given model year BEV variants with their combustion equivalent, sharing a base-year vehicle ID.

[204] While the Agency has conducted a sensitivity analysis around the Advanced Clean Cars II program, for which California has not yet received a waiver, it has not similarly included any sensitivity or analysis incorporating into its compliance modeling the Advanced Clean Trucks regulation, for which California has already been granted a waiver.

[205] Table A-1, California Code of Regulations § 1963.1.

[206] Based on new vehicle registration data from Polk/IHS Markit for 2019-2021 Class 2b-8 trucks, by state, obtained from Atlas Public Policy.

These state regulations will yield a base level of Class 2b-3 ZEVs, even in the absence of EPA standards, that the Agency has not adequately considered in its No Action scenario or in its modeling. As a separate matter, these regulations (and the ZEV development and deployment efforts that manufacturers have already undertaken to achieve compliance with them) also validate the Agency's assessment that electrification will be a critical emissions control technology in the MDV space moving forward.[207]

3. EPA should finalize a fuel-neutral standard and a maximum cap on the work factor.

EPA has made two significant changes to its GHG program for Class 2b-3 pickups and vans: 1) setting a fuel-neutral standard; and 2) setting a maximum cap on the work factor.[208] As described below, both such changes are appropriate.

During the rulemaking process for the Phase 2 standards, numerous commenters opposed setting separate emissions standards for diesel and gasoline engines, with Cummins, Honeywell, Daimler, Bosch, and the Motor and Equipment Manufacturing Association all supporting a single fuel-neutral standard.[209] As noted in the sections above on gasoline- and diesel-powered MDVs, there is a significant overlap in the available technologies to reduce emissions from either powertrain (e.g., variable geometry turbocharging, cylinder deactivation, hybridization). And technological advancements since finalization of the Phase 2 standards, including the advancement of zero-emission technologies, supports setting a single standard for the fleet that well exceeds the Phase 2 requirements for either gasoline- or diesel-powered Class 2b-3 vehicles. For these reasons, we support EPA setting a fuel-neutral standard for MDVs.

We also support EPA setting a maximum cap on the work factor. As noted in Section VIII.A.1.a regarding GM's latest Duramax diesel engine, manufacturers continue to prioritize increases in power for new engines for Class 2b-3 pickups. Unfortunately, the existing work factor structure creates no disincentive to this path, and may actually encourage manufacturers to try to game the system by increasing tow capacity across their fleets in order to increase the allowable emissions of their fleet, particularly since tow capacity is not captured in the emissions certification tests. EPA's proposal to cap the work factor at least creates a limit to this behavior. While concerns may remain about the safety and emissions impacts from manufacturers' efforts to out-spec their competition, a cap on the work factor would limit regulatory incentives for such behavior.

[207] 88 Fed. Reg. at 29341-42; DRIA at 3-12–3-18.
[208] 88 Fed Reg. at 29242.
[209] 81 Fed. Reg. at 73738-39.

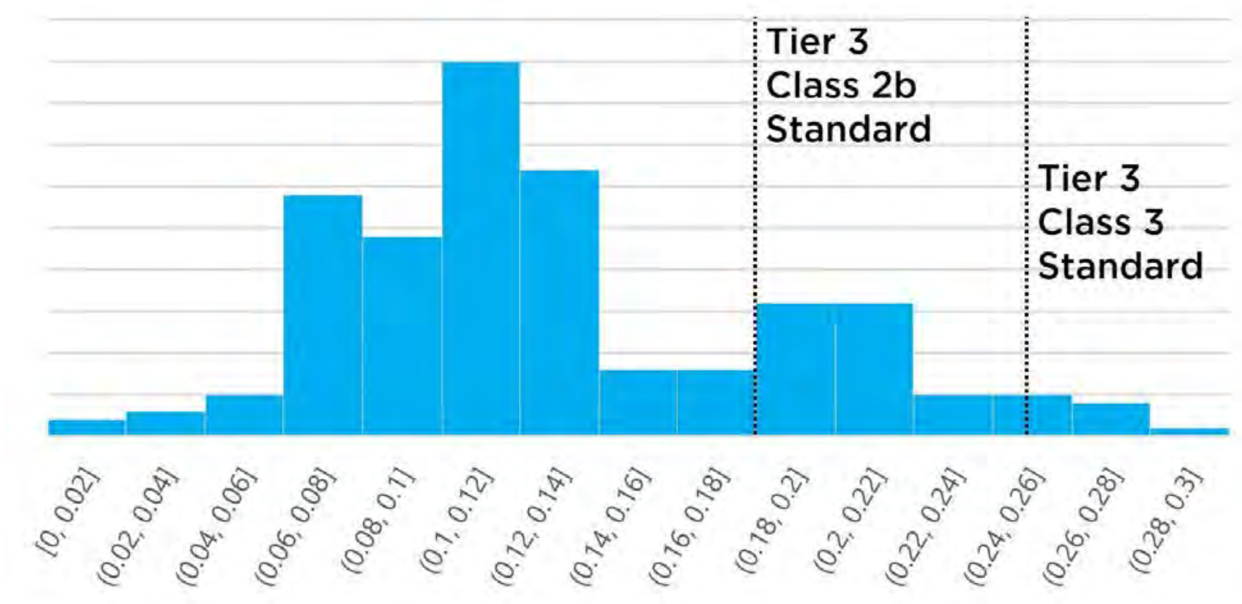
B. EPA should strengthen the Tier 4 $NMOG+NO_X$ standards, finalize the proposed PM requirements, and finalize the proposed change to criteria pollution requirements for MDVs with a GCWR above 22,000 pounds, subject to appropriate monitoring.

Consistent with the recently finalized criteria pollutant emission standards for heavy-duty engines (Classes 2b-8) and those that have been proposed for LDVs (Classes 1-2a plus medium-duty passenger vehicles) in this rulemaking, the Agency is proposing standards regulating tailpipe emissions of criteria pollutants from medium-duty vehicles. Under Clean Air Act Section 202(a)(3)(A), these standards must "reflect the *greatest degree of emission reduction achievable* through the application of technology which the Administrator determines will be available for the model year to which such standards apply, giving appropriate consideration to cost, energy, and safety factors associated with the application of such technology." 42 U.S.C. § 7521(a)(3)(A) (emphasis added). As described below, EPA should strengthen the Tier 4 $NMOG+NO_x$ standards and enact guardrails to ensure that windfall credits earned during a period of required lead time do not undercut the emissions gains possible in the 2027-2032 timeframe. We support the proposed $PM_{2.5}$ requirements and the proposed change to criteria pollution requirements for MDVs with a gross combined weight rating (GCWR) of more than 22,000 pounds, subject to appropriate monitoring to prevent manipulation.

1. EPA must improve the stringency of the Tier 4 $NMOG+NO_x$ standards for MDVs.

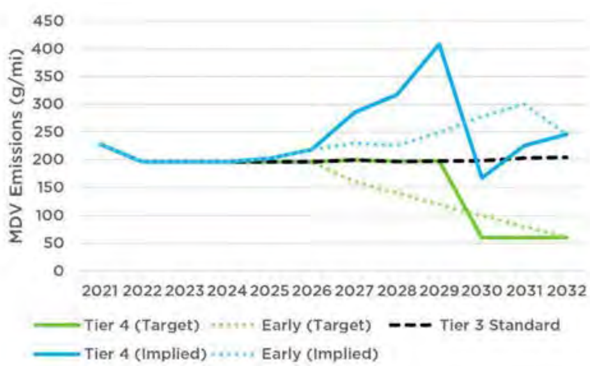
Because additional reductions in emissions of $NMOG+NO_x$ from MDVs are readily achievable, EPA must strengthen the Proposed Standards to meet its statutory mandate. Figure VIII.B-1 shows the distribution of certification data for MY 2022-2023 gasoline pickups, affirming EPA's observation that the MDV fleet is already capable of achieving levels of $NMOG+NO_x$ emissions far below the current standards. In fact, because these data are not sales-weighted and include some share of gasoline pickups that would now be required to certify to the heavy-duty engine standard under the Proposal, this table likely understates the capability of manufacturers to readily achieve reductions of $NMOG+NO_x$ emissions from their MDV combustion fleet.

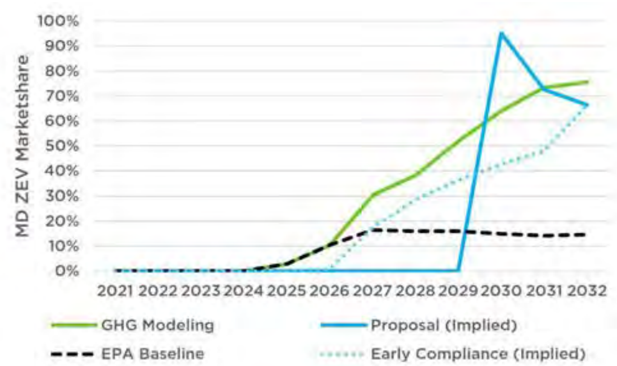
Figure VIII.B-1. Distribution of $NMOG+NO_x$ certification values for Class 2b-3 gasoline pickups and vans



As in the case of the proposed light-duty $NMOG+NO_x$ standards (Section VI.F, *supra*), EPA's Proposed Standards for MDVs are in tension with its modeling of GHG compliance (Figure VIII.B-2). Here too, the Proposed Standards are well above the average emissions value expected under the conditions that: (1) manufacturers' combustion vehicles achieve Tier 3 standards; and (2) ZEV sales consistent with EPA's GHG modeling are achieved. If EPA's compliance modeling of ZEV sales is accurate and materializes in real-world sales, the remaining combustion fleet would be able to backslide to as much as double the average $NMOG+NO_x$ emissions allowed under Tier 3 (Figure VIII.B-2 (left)). Given the danger that these pollutants cause to public health and welfare, including through localized effects, such backsliding would be wholly inappropriate under Section 202. If instead the combustion fleet achieves Tier 3 standards as expected, far fewer ZEVs would be needed to comply with the proposed Tier 4 program or the early compliance pathway.

Figure VIII.B-2. Emissions performance and ZEV market share implied by the combination of achieving the proposed MDV GHG standards and MDV Tier 3 / Proposed Tier 4 NMOG+NOx standards





If manufacturers deploy MD ZEVs consistent with EPA's projection of compliance with the GHG standards, tailpipe NMOG+NOx emissions performance from the remaining combustion vehicles will greatly exceed Tier 3 standards (left). If combustion vehicles instead achieve Tier 3 emissions standards, far fewer ZEVs will be required to meet the proposed Tier 4 fleet average standards than are modeled to comply with the GHG standards (right).[210]

The relationship between the GHG Proposal and the Tier 4 proposal means that a significant amount of NMOG+NO_x reductions are left on the table, in conflict with EPA's statutory mandate to achieve the "greatest degree of emission reduction achievable." 42 U.S.C. § 7521(a)(3)(A). As mentioned previously, combustion vehicles can readily reduce emissions below Tier 3 levels, but at a bare minimum, EPA's final standards should reflect the emissions levels that would be achieved by the combustion fleet achieving Tier 3 NMOG+NO_x standards with ZEVs deployed to the extent modeled to meet GHG standards. Under this more stringent standard, manufacturers would retain flexibility to invest in greater ZEV deployment or to instead apply existing, feasible, and cost-effective technologies within their combustion fleet. These modifications would better ensure that the Tier 4 MDV standards are consistent with the greatest degree of emissions reduction achievable.

EPA should also take action to prevent the problems caused by a growing bank of emissions credits. Even in the absence of a GHG rule, the expected market-driven deployment of ZEVs would result in a significant bank of credits prior to 2030 under the proposed Tier 4 standard for MDVs (Figure VIII.B-2, right). Those windfall credits would either be used to delay the achievement of Tier 3 standards or to offset required reductions in the MY 2030-2032 period. In an effort to mitigate the impact of the deployment of technology (electrification) that is not

[210] The ZEV market share here appears significantly higher than in the GHG modeling because it excludes combustion vehicles with a gross combined weight rating (GCWR) of more than 22,000 pounds. However, ZEVs with a GCWR greater than 22,000 pounds are included in the MDV fleet in our analysis. This proposed change is further discussed in Section VIII.B.3.

required to meet the current standards, EPA should limit the use of credits generated through overcompliance with Tier 3 standards. To encourage manufacturers to adopt the more stringent early compliance pathway, the Agency could (for example) restrict the use of Tier 3 credits in the 2027+ timeframe to only those manufacturers that have elected the early credit pathway. This would be appropriate, since the Tier 3 standards fixed under the proposal through MY 2029 were predicated on the deployment of a reduced suite of emissions reduction technologies.

2. The proposed $PM_{2.5}$ requirements are appropriate.

As discussed in Section VI.F.2, proven and cost-effective technology exists to reduce tailpipe $PM_{2.5}$ levels to the levels required by EPA's proposed standards. MDVs with GCWR over 22,000 pounds (see the section immediately below) will already be required to achieve similar levels of reductions under EPA's proposal to certify these vehicles under the heavy-duty engine requirements, and the data supporting the finalization of those standards include an assessment of technology improvements for both compression-ignition and spark-ignition engines supporting a technology neutral achievement of $PM_{2.5}$ reductions.[211] The test protocols and targets for EPA's proposed $PM_{2.5}$ standards are achievable, as discussed in Section VI.F.2, and will provide significant health benefits.

3. EPA's proposed change to criteria pollution requirements for MDVs with a gross combined weight rating of more than 22,000 pounds is likely appropriate, but should be monitored for manipulation and efficacy.

EPA is proposing to require that vehicles with a GCWR greater than 22,000 pounds be certified to the heavy-duty engine standards, rather than to the proposed MDV standards.[212] EPA's logic here is sound: these vehicles' powertrains are often more powerful than the Class 4 and Class 5 vehicles in which related engines may be deployed, and they have a GCWR comparable to vehicles currently covered by the heavy-duty engine rules.

Table VIII.B-1. Market share of MDVs above and below the 22,000-pound gross combined weight rating[213]

Vehicle type	Fuel	GCWR <= 22k lbs.	GCWR > 22k lbs.
2b-3 Pickups	Gasoline	12.5%	15.6%
	Diesel	0.0%	37.5%
2b-3 Vans	Gasoline	30.7%	0.0%
	Diesel	3.7%	0.0%

211 U.S. EPA, Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards: Regulatory Impact Analysis, Sections 3.1 & 3.2, EPA-420-R-22-035 (Dec. 2022).
212 88 Fed. Reg. at 29257.
213 Taken from EPA OMEGA2 modeling inputs: vehicles_mdv_20230208.csv (MY 2020 MDV fleet).

MY 2020 data indicates that this change could require more than half of the MDV fleet to certify to the heavy-duty engine standards (Table VIII.B-1).[214] Based on the emissions and warranty requirements for such engines, certifying the engines in these MDVs to such standards will likely yield emissions reductions at least as strong as if they were instead required to meet the proposed MDV standards. However, these standards apply solely to combustion engines and are not influenced by the share of deployed ZEVs.

In contrast, ZEV deployment affects the required emissions reductions for medium-duty combustion vehicles with a GCWR less than or equal to 22,000 pounds, as illustrated above in Section VIII.B.1. It is possible that manufacturers could try to shift more of their sales to vehicles with a GCWR over 22,000 pounds in order to reduce the required improvements to their remaining combustion fleet. If this change is finalized, the Agency should monitor future data from the MDV and heavy-duty engine in-use testing program to assess the nature of any difference between the emissions performance of MDVs above and below the 22,000-pound GCWR, and should commit to releasing a report on its findings.

IX. EPA Should Finalize the Proposed Changes to the Credit Program, but Should Not Renew Off-Cycle Menu Credits.

Below, we address EPA's proposal to renew the existing credit program with the following changes: (1) exclude all BEVs from eligibility for any off-cycle credits; (2) allow off-cycle credit eligibility for PHEVs based only on a ratio called the "utility factor"; (3) eliminate two of the three ways to obtain off-cycle menu credits (undergoing a 5-cycle testing procedure and documenting the efficacy of new technology via public notice and comment), while retaining only the third way (menu credits); and (4) renew but phase out the off-cycle menu credits for the remainder of the light- and medium-duty fleets over four years, in 10/8/6/3/0 gram/mile annual steps between MY 2028-2031. We support most of EPA's proposals but strongly urge EPA not to renew any off-cycle menu credits in this rulemaking.

We support EPA's continued use of an averaging, banking, and trading (ABT) compliance credit program for light- and medium-duty vehicle emissions, as it has for decades. We agree with EPA's determination that there is no reason to reopen those program provisions in this rulemaking.

We also note that the current compliance credit program includes multipliers for vehicles equipped with batteries, creating negative grams per mile values, and that EPA does not propose

[214] In the Proposal, EPA notes: "Based on an analysis of the MY 2022 and MY 2023 emissions certification data, most MDV complete and incomplete diesel pickup trucks would be required to switch to engine dynamometer certification; MY 2022 vans would not be required to use engine dynamometer certification; and only a small number of gasoline pickup trucks would be required to switch to engine certification." 88 Fed. Reg. at 29270. However, the data are not provided.

to renew those multipliers. We strongly support the sunsetting of all PEV multipliers and any other measures that create fictitious emission reductions.

A. Air conditioning credits

For light-duty vehicles,[215] EPA proposes to renew credits for manufacturers that install technology that improves the efficiency of air conditioning ("AC") systems, but to exclude BEVs from eligibility, while retaining current 5-cycle testing protocols that confirm the systems actually reduce emissions as anticipated. 88 Fed. Reg. at 29246. EPA also proposes not to renew light-duty vehicles' hydrofluorocarbon ("HFC") refrigerant leakage control credits and to sunset current refrigerant standards for medium-duty vehicles, because another rulemaking under a different statute is addressing HFCs. *Id.* We generally support EPA's proposals.

1. Background

AC systems create tailpipe emissions by using additional power generated through the combustion of gasoline. 88 Fed. Reg. at 29246. Since 2012 EPA has granted credits for AC systems that reduce this extra fuel usage by means of installing more efficient components and air recirculation settings, both measures that reduce engine loads. EPA states it has consistently increased the stringency of the light-duty CO_2 footprint curves in the amount of the anticipated AC credits by shifting the footprint curves downwards. Thus, according to EPA, manufacturers who opt not to install the more efficient systems must meet the increased stringency by means of other technology. AC efficiency credits are capped at 5.0 g/mile for passenger cars and 7.2 g/mile for light trucks, and all vehicles in these classes have been eligible for the credits. EPA deems the credits to be effective in reducing emissions and reports increased usage. In MY 2021, 17 of 20 manufacturers reported efficiency credits resulting in an average credit of 5.7 g/mile. 88 Fed. Reg. at 29246.

2. Proposal to renew AC efficiency credits for vehicles with combustion engines only

EPA now proposes to renew AC efficiency credit eligibility only for vehicles equipped with internal combustion engines. EPA reasons that such credits for BEVs are no longer required because BEVs running AC systems do not combust gasoline; AC efficiency credits are not representative of their emission reductions; and BEVs are already counted as 0 g/mile, so that adding AC efficiency credits to the calculation has led to reporting of BEV emissions at less than zero (in the case of Tesla, a fleet average of negative 126 g/mile, including 18.8 g/mile of AC credits). 88 Fed. Reg. at 29247. The credits, EPA explains, were adopted when BEV sales were low and incentivized BEVs, but are no longer needed. EPA next proposes to renew AC

[215] The medium-duty vehicle fleet does not include air conditioning efficiency-related credits or requirements, and EPA is not taking comments on that matter. 88 Fed. Reg. at 29246; 81 Fed. Reg. at 73742; 76 Fed. Reg. at 57196.

efficiency credits for combustion vehicles while increasing the standards' stringency to reflect use of those credits. EPA states it will continue to condition credit approval on mandatory 5-cycle testing[216] of certain grouped vehicles to confirm that the projected emission reductions are occurring in the real world (the "AC17" test).

We fully support EPA's proposal not to grant any AC credits to vehicles without a combustion engine. BEVs should no longer be credited with fictitious tailpipe emission reductions, in this case or otherwise. BEVs do not combust gasoline, regardless of whether they use AC systems. We also agree that the current credits are not representative of BEV upstream emissions and are no longer justified to incentivize BEVs, and that BEVs should not be accounted for as if they produce less than zero grams per mile.

We generally support the proposal to retain AC efficiency credits for vehicles with internal combustion engines, with some caveats. Historically, credits have allowed manufacturers to significantly delay compliance with EPA's standards, leading to near-term emission *increases*, as EPA has often acknowledged. *E.g.,* 86 Fed. Reg. at 43756; 77 Fed. Reg. 62812. That problem is exacerbated when vehicles do not have to undergo testing to confirm the technologies for which credits are awarded do in fact reduce emissions by an equivalent amount, and where the stringency of the standards has not been increased to reflect the anticipated credit use. Here, the latter concern is addressed if EPA does in fact increase stringency by lowering the footprint curve to reflect the available credits, and the AC17 test is vigorous. We would, however, oppose these AC efficiency credits should EPA relax any of the current AC17 test procedures, as their real-world effectiveness could no longer be assured. We also ask EPA to fully explain exactly how it ensures that the standards' stringency is in fact increased by an amount equivalent to the credits it grants.

We also support renewed AC efficiency system credits (for combustion vehicles only) for an additional reason. In light of the astonishingly rapid and dangerous temperature increases all across the country produced by the climate crisis, more frequent and more energy-intensive use of air conditioning is inevitable. Assuring that these systems are as efficient as possible is therefore of great importance. For that reason, we urge EPA to adopt an AC efficiency *standard* rather than a voluntary credit, as it has done for the medium-duty fleet in the case of refrigerant credits or, at a minimum, in its post-MY 2023 rulemaking.

B. Proposal not to renew air conditioning leakage credits

[216] The test includes a highway cycle, a high temperature condition cycle, a preconditioning cycle, and a cycle at solar peak periods of four hours. Where test results do not support full menu credits, proportional credits may be allowed. Tests are performed on one vehicle model for each platform, starting with the highest sales volume vehicles, and moving to the next-highest sales volume vehicle annually thereafter, until all vehicle models have been tested or the platform undergoes redesign. EPA is not taking comments on the testing procedures. 88 Fed. Reg. at 29247.

1. Background

When EPA established the current refrigerant leakage credits in 2012, the most common HFC refrigerant used in mobile air conditioners was HFC-134a, carrying a global warming potential ("GWP") of 1430 times that of CO_2. 88 Fed. Reg. at 29246. The most emission-reducing alternative at that time was HFO-1234yf, with a GWP of 4. To encourage the shift from HFC-134a, the 2012 standards allowed manufacturers to earn refrigerant credits for light duty vehicles and trucks, respectively, that are capped at 13.8 and 17.2 g/mile when an alternative refrigerant is used, and at 6.3 and 7.8 g/mile for employing leak-tight components. For the medium-duty fleet, EPA adopted a refrigerant leakage standard rather than a voluntary credit. *Id.* EPA describes the program as successful and reports that as of MY 2021, 95% of new vehicles use the refrigerant HFO-1234yf, 88 Fed. Reg. at 29247, which has a GWP of 4. 88 Fed. Reg. at 29246.

2. Proposal to eliminate refrigerant credits

EPA now proposes not to renew refrigerant credits beginning in MY 2027 for the light-duty fleet, and to sunset the refrigerant standards for medium-duty vehicles, largely because of the passage of the American Innovation and Manufacturing ("AIM") Act, 42 U.S.C. § 7675, in December 2020. Two years later, EPA issued a Notice of Proposed Rulemaking under the AIM Act (the "AIM Proposal") to restrict the HFCs used in light- and medium-vehicles to those not exceeding a GWP of 150, with effective dates, respectively, of MY 2025 for the light-duty fleet and MY 2026 for the heavy-duty fleet.[217] EPA states that there is no reason to believe manufacturers would use higher GWP refrigerants in the absence of EPA vehicle-based credits, and that not renewing the credits would avoid duplicative programs, simplify this rule, and reduce manufacturer credit reporting burdens.

EPA requests comments on whether there is any value in retaining the refrigerant credits. In our view, the answer is no. The AIM Proposal is expected to be finalized this summer or early fall, before EPA completes this rulemaking. If the current refrigerant credits are eliminated, there is no reason to believe manufacturers would use refrigerants other than HFC-1234yf (with its GWP of 4). Two possible alternative refrigerants with GWP values under 150 exist (HFC-152a and carbon dioxide), but adopting either would require a significant redesign of mobile air conditioners. We are not aware of any manufacturers currently planning to use HFC-152a, and while a few companies that import vehicles have investigated CO_2-based systems in northern Europe, it is our understanding that those systems would not work well in the temperature ranges experienced in the U.S. market. Thus, we concur with EPA's judgment that neither the majority of manufacturers already using HFO-1234yf nor the minority of manufacturers still using

[217] Phasedown of Hydrofluorocarbons: Restrictions on the Use of Certain Hydrofluorocarbons Under Subsection (i) of the American Innovation and Manufacturing Act of 2020, 87 Fed. Reg. 76738 (Dec. 15, 2022).

HFC-134a are likely to switch to either of the other two alternatives with GWPs under 150. Thus, while the AIM Proposal could be tightened to bar refrigerants with GWP greater than 4, the potential for backsliding under that proposal appears minimal. Thus, we agree that if the AIM Proposal is finalized as proposed, and considering that HFO-1234yf is already used in 95% of vehicles, there is no reason to renew a refrigerant credit program dating from 2012.

As a backstop, however, any remaining concerns can be resolved if either the AIM Proposal or this rule, once finalized, adopts a standard requiring refrigerants with no more than GWP values of 4, effective for MY 2026 and 2027, respectively.

C. Off-cycle credits

We strongly urge EPA not to renew any part of the off-cycle credit program after MY 2026. As explained below, EPA concedes that the program will cause significant fleet emissions *increases* even though it no longer achieves any of its purposes. There is no reasonable basis for carrying any part of the program forward beyond 2026, and doing so would be arbitrary and capricious.

1. Excluding BEVs from off-cycle credit eligibility

We concur with EPA's determination that off-cycle credits are inappropriate for BEVs for each of the reasons EPA states. 88 Fed. Reg. at 29251-52. Because EPA does not adjust the footprint curves downward to compensate for off-cycle credits, fleet emissions increase. Awarding credits is particularly inappropriate for BEVs because they have no tailpipe emissions and are already counted as emitting zero grams per mile, meaning that any credit awards tip their emission values into fictional negative territory. This in turn creates phantom benefits that further reduce the rule's average stringency. Because off-cycle credits are intended to stimulate the development of new combustion vehicle technologies, awarding them to BEVs also cannot, by definition, incentivize the development or application of new technology. Off-cycle credit values are also not representative of upstream emissions. These reasons for not awarding any off-cycle credits to BEVs become even more pertinent as the number of BEVs increases. *Id.* We urge EPA to finalize its proposal to exclude BEVs from off-cycle credit eligibility.

2. Renewing PHEV off-cycle credits based on the utility factor only.

We also concur with EPA that off-cycle credits for PHEVs exceeding their utility factor is inappropriate. 88 Fed. Reg. at 29251. Granting credits for any portion of time when PHEVs do not run on electricity is inappropriate for the reasons discussed in connection with BEVs. We agree with EPA that the current utility factor is inaccurate, as PHEVs run on electricity far less often than estimated. 88 Fed. Reg. at 29252, and *see* detailed discussion in Section XII, *infra*.[218] That is an additional reason why, as discussed below, off-cycle credits should not be renewed for PHEVs at all, regardless of whether they run on electricity or gasoline.

3. Eliminating the 5-cycle test procedures and the public notice and comment pathway

EPA justifies not renewing these two pathways for claiming off-cycle credits mainly because manufacturers have little or no interest in them. EPA points out that since 2021, the 5-cycle process has led to no new credits, and only one manufacturer has used it since 2012. As to the notice-and-comment pathway, EPA states that it has resulted in the award of only a few small credits since 2021. 88 Fed. Reg. at 20251. We agree that these programs should not be renewed, but we note that under EPA's Proposal, aside from air conditioning credits, the only off-cycle credits remaining would be menu credits, which require *neither* testing *nor* public comment, and as such are the least reliable and least defensible credits of all. Yet, as EPA reports, the use of menu credits has only grown over the years, and now constitutes a whopping *95% of credit use*. 88 Fed. Reg. at 29249. Eliminating pathways that automakers eschew because they impose the burden of demonstrating their effectiveness thus does very little indeed to address the fundamental flaws.

Because EPA's prior rules limited medium-duty fleet off-cycle credits to those approved under the 5-cycle test procedures or the notice-and-comment pathway and contained no menu credits, 88 Fed. Reg. at 29249, EPA's proposal not to renew those two pathways effectively terminates the credit program for that fleet, a decision we fully support.

4. Phasing out menu credits through MY 2030

EPA proffers numerous reasons for "phasing out" the menu credits program—for vehicles with internal combustion engines only—through 2030. But those reasons all demonstrate that retaining the program in any form has no verifiable benefits even as it significantly increases the fleet's emissions. Renewal of menu credits thus would be arbitrary and capricious, and we strongly urge EPA to abandon the proposal and not to renew the program at the end of MY 2026.

First, the Agency states that menu credits were designed "to provide an incentive for new and innovative technologies that reduce real world CO_2 emissions primarily outside of the 2-cycle test procedures." 88 Fed. Reg. at 29249. But EPA now concedes the program no longer accomplishes this purpose. It notes that industry is rapidly shifting its research and development resources and vehicle mix away from combustion vehicles to electrification, and is not likely to

[218] *See* also the numerous studies EPA cites at 88 Fed. Reg. 29252 n.274-475.

continue to "invest resources on off-cycle technology in the future for their ICE vehicle fleet." 88 Fed. Reg. at 29250. Moreover, industry has fewer and fewer opportunities of "recouping" its investments as "ICE vehicle production declines." *Id.* In other words, chances of menu credits stimulating any new technologies at all are slim to none.

Since 2012, EPA has also assured the public in its rulemakings that the increased emissions driven by credits are intended to be short-term and of a temporary nature only.[219] But EPA proposes to renew the program once again, even as it acknowledges the voluminous record evidence demonstrating its shortcomings and failures.[220] Reinstating the program through 2030 (for a total of 20 years) is in no way temporary and cannot be supported, as it is not delivering the hope for technical innovations that initially may have justified it.

EPA also concedes that menu credits meet neither of the guardrails that justify continuation of air conditioning credits. Menu credits undergo no or at most minimal testing to ascertain what, if any, emission reductions they may yield, and EPA once again is not proposing to increase the standards' stringency to account for the increased emissions. In 2021, EPA calculated the impact of the off-cycle credits it allowed under the MY 2023-2026 rulemaking as the loss of 42 g/mile. 88 Fed. Reg. at 29249 n.453, citing *Revised 2023 and Later Model Year Light-Duty Vehicle GHG Emissions Standards: Regulatory Impact Analysis*," EPA-420-R-21-028 (Dec. 2021). For MY 2016-2025, the impact of all off-cycle credits amounted to a stringency loss of 4-6%. 88 Fed. Reg. at 29249. EPA also notes that for this Proposal, emission increases caused by *all off-cycle credits* (i.e., under a full renewal of the program) would be even larger by 2032, when they would "become an outsized portion (*e.g.,* up to 12 percent) of the program." 88 Fed. Reg. at 29250. We note, however, that under EPA's proposal to *retain menu credits* through the proposed phase-out schedule, these compliance giveaways would still amount to some 3% reduction in stringency and a 3% increase in MY 2027-2055 cumulative CO_2e emissions.[221]

[219] *E.g.,* 88 Fed. Reg. at 29246, 29248; 86 Fed. Reg. at 74441; 75 Fed. Reg. at 25331.
[220] *See generally* EPA, *Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emission Standards: Response to Comments*, EPA-420-R-21-027, at 6-51 (Dec. 2021).
[221] The fleet average-modeled sum of off-cycle and air conditioning menu credits for MYs 2027-2032 represents about 3% of the MYs 2027-2032 Proposed Standards. We calculated this number by first sales-weighted averaging the direct off-cycle credits (i.e. air-conditioning plus off-cycle credits) in the modeled Proposal output file. We then compared these values to the Proposed Standards for the combined fleet. 88 Fed. Reg. at 29202, Table 10. Eliminating menu credits for MYs 2027-2055 improves the cumulative CO_2 emissions reductions of the Proposal by 275 million metric tons (roughly 3% of the total 8,000MMT shown in DRIA table 9-21). We calculated this number by first assuming manufacturers would achieve the same combustion vehicle emissions levels as they do in the modeled Proposal output file with only on-cycle technologies. We used this file because the on-cycle emissions values in a no-off-cycle scenario are equal to the currently-modeled certified emissions values (used for compliance calculations). These on-cycle values are then converted to on-road (i.e. real-world) emissions using conversion factors calculated from the output file. Finally, total fleetwide lifetime emissions are estimated by multiplying on-road CO_2e by lifetime vehicle-miles traveled and annual sales. For the detailed calculations, see the Excel Workbook attachment to this comment letter titled "No Off-Cycle Credits 2027-2055."

Next, EPA discusses that the synergistic effects and overlap among menu technologies—which reduce effectiveness—become more pronounced as credits represent a larger portion of emissions reductions and the standards become more stringent. Further, "the menu credits are based on MY 2008 vintage engine and vehicle baseline technologies . . . and therefore the credit levels are potentially becoming less representative of the emissions reductions." *Id.* And crucially, the Agency frankly admits that there is "*not currently a mechanism to check that off-cycle technologies provide emissions reductions in use commensurate with the level of the credits the menu provides*." 88 Fed. Reg. at 29250 (emphasis added). That the program simply cannot be fixed is all by itself sufficient reason not to carry it on.

The single reason proffered to justify a step-wise phase-out through MY 2030 as a "reasonable way to bring the program to an end" is the creation of "a transition period to help manufacturers who have made substantial use of the program in their product planning." 88 Fed. Reg. at 29250. But nothing backs up the need for a lead time of six or seven years (from the expected rule finalization in 2023 or 2024 through MY 2030). To the contrary, no lead time beyond MY 2026 is warranted, particularly in an industry racing toward zero-emission technologies. In any event, the menu program does not have to be "brought to an end" through this new rulemaking: it expires on its own after MY 2026. In its 2023-2026 rule (as before), EPA characterized the program as "temporary" and gave no indication that it would be extended, 86 Fed. Reg. at 74441, and commenters have implored EPA to jettison it for more than a decade. If a manufacturer has nonetheless made menu credits part of its post-MY 2026 product planning, it did so at its own risk. There is no need for a "transition period" for a program that ends in MY 2026.

D. The averaging, banking, and trading program continues to be an important way for manufacturers to maintain flexibility in meeting EPA's vehicle emission standards.

Like its previous GHG emission standards for light- and heavy-duty vehicles, and standards for certain vehicle criteria pollutant emissions dating back to 1983, EPA's Proposed Standards rely on an averaging, banking, and trading (ABT) approach allowing manufacturers to meet the standards by averaging emissions across vehicles. Given its longstanding use of this approach under Section 202, EPA's Proposal emphasizes that EPA is "not proposing any revisions to the [light-duty or medium-duty] GHG program ABT provisions or reopening them." 88 Fed. Reg. at 29246; *id*. at 29245; *see also id*. at 29277 (similar statement regarding ABT provisions for the proposed criteria pollutant program for NMOG+NOx standards).

We agree with EPA's determination that there is no reason to reopen the question whether it is permissible to use an ABT approach under Section 202. EPA has not only repeatedly used ABT in Section 202 standards but also repeatedly explained that ABT is consistent with and gives full effect to the requirements of Section 202 as well as the Clean Air Act's compliance and enforcement provisions applicable to standards issued under Section 202. Under such circumstances, it is eminently reasonable for EPA not to reconsider a question that has been settled for decades. *See Growth Energy v. EPA*, 5 F.4th 1, 13 (D.C. Cir. 2021). In promulgating its final standards, EPA should refrain from "substantive reconsideration," *id*. at 21, of whether ABT is a permissible approach under Section 202, which might inadvertently suggest, notwithstanding the statements in the Proposal, that EPA has reopened the issue. EPA may, of course, express its continued adherence to its previously settled view that Section 202 permits standards using ABT without reopening the issue, and it may respond to any unsolicited comments it may receive on the issue. *See Banner Health v. Price*, 867 F.3d 1323, 1341 (D.C. Cir. 2017) (quoting *Kennecott Utah Copper Corp. v. U.S. Dep't of Interior*, 88 F.3d 1191, 1213 (D.C. Cir. 1996)). But reexamination and reconsideration of whether ABT is consistent with the Clean Air Act is unnecessary and uncalled-for.

EPA first promulgated a Section 202 standard that used averaging when it issued its particulate standards for light-duty diesel vehicles in 1983. *See* 43 Fed. Reg. 33456 (July 21, 1983). EPA explained at that time that standards employing averaging fell within its "broad authority" under Section 202 and were "consistent with the [Clean Air Act's] certification scheme." *Id*. at 33458. Specifically, the 1983 standard required EPA to certify the conformity of a manufacturer's vehicles with a standard that was established based on a combination of testing of the families of vehicles making up their fleets and planned production volumes. This process would yield a fleet whose average emissions complied with the standard; the certificate would be conditioned on the manufacturer actually "maintain[ing] family production volumes such that the production-weighted average of the manufacturer's family limits indeed meets the standards at year's end." *Id*. at 33459. As EPA explained, averaging thus accords with the Act's prohibition on the sale of vehicles not covered by a certificate of conformity and allows imposition of appropriate penalties for any violations.

EPA's 1985 standard for NOx emissions from light-duty trucks, as well as for NOx and particulates from HD engines, similarly employed an averaging approach. *See* 50 Fed. Reg. 10606 (Mar. 15, 1985). EPA's final rulemaking notice again explained that its averaging approach was consistent with the statutory requirement that compliance be certified before vehicles were sold, and that certification was subject to the condition that the certificate would be voided if the manufacturer's production-weighted average emissions did not meet the standard at the end of the model year. *See id*. at 10633, 10636-37. EPA found that "the averaging concept" was "fully consistent with the technology-forcing mandate of the Act," *id*. at 10634, while at the same time "eas[ing] the compliance burden" for manufacturers, *id*. at 10635.

The D.C. Circuit rejected arguments that the 1985 standard's averaging approach was unauthorized under the Clean Air Act in *NRDC v. Thomas*, 805 F.2d 410 (D.C. Cir. 1986). The court observed that "EPA's agreement that averaging will allow manufacturers more flexibility in cost allocation while ensuring that a manufacturer's overall fleet still meets the emissions reduction standards makes sense." *Id*. at 425.

Thomas noted that there were potential arguments against averaging that it did not address because they had not been raised before the Agency, including an argument that an averaging approach might not be consistent with the Act's testing and certification provision, Section 206. *Id*. at 425 n.24. The court suggested that EPA consider this question in future proceedings and provide a further explanation of how averaging conformed to statutory requirements. *Id*.

EPA took the court up on that invitation in its subsequent 1990 rulemaking proceeding establishing certification programs for banking and trading of NOx and particulate emission credits for HD engines. That rulemaking resulted in an expanded averaging regime, with the addition of provisions for banking and trading of credits generated if manufacturers' production-weighted average emissions were below the requirements of the NOx and particulate standards. *See* 55 Fed. Reg. 30584, 30584-86 (July 26, 1990). Both in the final rulemaking notice and the proposal for those standards, EPA addressed the issues flagged in *Thomas* and explained at length how the ABT program conformed with the Clean Air Act's certification requirements. *See id*. at 30593-94 (final rule); 54 Fed. Reg. 22652, 22665-67 (May 25, 1989) (proposed rule). EPA articulated in detail how its ABT approach entails presale certification of the conformity of each engine or vehicle with the applicable standards based on testing of emissions generated by engine families and projected production estimates, with certification conditioned on a final end-of-model-year determination that a manufacturer's actual production-weighted average emissions comply with the standard. *See* 55 Fed. Reg. at 30585, 30594, 30600-04. These features of the ABT program, EPA explained, facilitate application of the Act's enforcement and penalty provisions. *See id*. at 30594, 30603-04. EPA similarly used ABT in its Tier 2 light-duty NOx standards promulgated in 2000. *See* 65 Fed. Reg. at 6744.

Having determined in these earlier rules that ABT standards are consistent with Section 202, EPA employed the ABT approach pioneered in the 1990 HD standards when it first adopted GHG standards for LDVs in 2010 and HD engines and vehicles in 2011. *See* 75 Fed. Reg. 25324, 25405 (May 7, 2010); 76 Fed. Reg. 57106, 57127-28 (Sept. 15, 2011). In each case, EPA explained at length how, in implementing ABT standards, it fulfills its statutory obligations to certify conformity of vehicles or engines with the standards before they are introduced into commerce, to require warranties of compliance, and to test for in-use compliance. *See* 75 Fed. Reg. at 25468-77; 76 Fed. Reg. at 57254-92. EPA also explained how, under an ABT approach, it would give full effect to the statute's provision for calculation of penalties for each nonconforming vehicle in the event of a violation of the standards. *See* 75 Fed. Reg. at 25482; 76 Fed. Reg. at 57257.

Subsequent iterations of GHG and other motor-vehicle emission standards under Section 202 for both LD and HD vehicles and engines have likewise used an ABT approach consistent with that used in the 2010 and 2011 GHG standards. *See* 77 Fed. Reg. 62624, 62788 (Oct. 15, 2012) (LD GHG standards); U.S. EPA, Control of Air Pollution From Motor Vehicles: Tier 3 Motor Vehicle Emission and Fuel Standards; Final rule, 79 Fed. Reg. 23414, 23419 (LD and HD Tier 3 NOx standards); 81 Fed. Reg. 73478, 73495 (Oct. 25, 2016) (HD Phase 2 GHG standards); 85 Fed. Reg. 24174, 25103-04, 25114 (Apr. 30, 2020) (LD GHG standards); 86 Fed. Reg. 74434, 74441 (Dec. 30, 2021) (LD GHG standards). In none of those rulemaking proceedings did EPA reopen the issue whether Section 202 permits use of ABT in standard-setting; the Agency treated the option to use ABT under Section 202 as a settled matter.

The Agency's settled practice of using ABT in Section 202 standards from 1990 onward did not generate further legal challenges until the most recent set of light-duty GHG standards. As to the latter standards, however, petitioners challenging the standards have argued in review proceedings pending in the U.S. Court of Appeals for the D.C. Circuit that Section 202 permits only the use of standards that specify emissions limits on an individual-vehicle basis, and that standards employing averaging render the Clean Air Act's compliance and enforcement provisions meaningless. *See* Final Br. for Priv. Petitioners, Texas v. EPA, Case No. 22-1031 (D.C. Cir. Apr. 27, 2023), ECF No. 1996915, at 36-50. EPA rejected those arguments when it considered them in the 1990 rulemaking, and they run counter to the settled construction of the statute on the basis of which EPA has issued standards since that time. EPA's brief in the D.C. Circuit and the brief of the state and nongovernmental organizations supporting EPA explain that challenges to ABT are untimely attempts to challenge determinations made decades ago, but also detail the reasons ABT is consistent with the language and structure of Section 202 and the applicable enforcement and compliance provisions of the Act. *See* EPA Br. 34-39, 62-75; State & Pub. Int. Br. at 3-6, 9-17.

In sum, the Proposal's statements that "EPA has included ABT in many programs across a wide range of mobile sources," 88 Fed. Reg. at 29245, and that the "ABT provisions are an integral part of the vehicle GHG program," *id*. at 29246, are unquestionably accurate. Given that EPA long ago addressed and resolved the lawfulness of ABT under Section 202, that EPA's use of ABT is consistent with the D.C. Circuit's precedent in *Thomas*, that EPA has repeatedly explained how the statute's certification, warranty, testing, and enforcement provisions function effectively in the context of ABT, and that the arguments against the use of ABT are essentially the same as those discussed in *Thomas* and revisited in the round of rulemaking that followed, there is no reason for the Agency to reopen these settled questions by reexamining them substantively in this rulemaking (or appearing to do so). The Agency should adhere to its statement in the Proposal that it is not reopening these issues.

To foster understanding of how the Act's testing, certification, warranty, in-use compliance, and penalty provisions operate in the context of a standard using ABT, it may be useful to include in the final rule's preamble a clear description of how EPA uses testing and manufacturers' production plans to issue certificates of conformity before vehicles or engines are marketed; how manufacturers warrant compliance; how EPA determines in-use compliance; how EPA determines whether a manufacturer's vehicles and engines have met the conditions imposed on their initial certification by ultimately complying with the production-weighted emission standards to which they are subject; and, in the event of noncompliance, how EPA would identify noncompliant vehicles and impose penalties or other remedies. If it does so, EPA should make clear that it is describing the operation of the statute and the ABT rules, not reexamining EPA's settled view that its ABT standards and their implementation conform to the Act's requirements.

Although the Agency need not, and should not, reconsider the lawfulness of ABT standards under Section 202, EPA's analysis more than adequately explains the benefits of continuing to use the ABT approach for this latest set of emission standards. EPA's analysis of the benefits ABT provides in this context, *see* 88 Fed. Reg. at 29342-43, amply justifies the Agency's choice of retaining the ABT approach for this set of standards. As EPA has indicated, the ABT structure allows EPA to require the reductions in vehicle pollutant emissions that are essential to addressing the endangerment of public health and welfare attributable to those emissions in a manner that best balances the need for significant cuts in emissions with the requirement that standards be feasible and achievable within the time allowed for compliance. The ABT approach "recognize[s] that automakers typically have compliance opportunities and strategies that differ across their fleet, as well a multi-year redesign cycle, so not every vehicle will be redesigned every year to add emissions-reducing technology;" ABT allows manufacturers to keep pace with required improvements by overcomplying with newly designed or redesigned vehicles while other vehicles whose designs are already locked in undercomply. 88 Fed. Reg. at 29342. Thus, "performance-based standards with ABT provisions give manufacturers a degree of flexibility in the design of specific vehicles and their fleet offerings, while allowing industry overall to meet the standards and thus achieve the health and environmental benefits projected for this rulemaking at a lower cost." *Id*. at 29343. These benefits of the ABT approach are recognized by regulators, environmental advocates, and industry alike. *See* Final Answering Br. for Intervenor Alliance for Automotive Innovation, Texas v. EPA, Case No. 22-1031 (D.C. Cir. Apr. 27, 2023), ECF No. 1996757, at 8-9 (stating that ABT has "been essential to the auto industry's efforts to meet EPA's increasingly ambitious goals for greenhouse gas reduction" and that "the automotive industry has relied for more than a generation" on ABT "to enable cost-effective emissions reductions"). These considerations more than justify EPA's continued use of this approach for purposes of these standards.

X. EPA Should Adopt the Proposed Durability and Warranty Requirements, But Should Also Require State-of-Certified Range Monitors.

We urge EPA to adopt the proposed PEV durability and warranty requirements. 88 Fed. Reg. at 29283-87. As EPA explains, the calculation of emission credits for PEVs is based on attributed mileage over their useful life. 88 Fed. Reg. at 29283. In addition to helping ensure that PEVs will in fact achieve the projected emission reductions throughout their useful lives, the warranty and durability requirements will enhance consumer confidence in PEVs and promote their faster adoption among purchasers, leading to greater air quality benefits.

EPA's authority to adopt the proposed durability requirements is grounded in Section 206 of the Clean Air Act, which (read in conjunction with Section 203) provides that before introducing a new motor vehicle into commerce, a manufacturer must obtain an EPA "certificate of conformity" indicating that the vehicle complies with applicable emission standards promulgated under Section 202. 42 U.S.C. § 7525(a)(1); 42 U.S.C. § 7522(a)(1). Section 202(a)(1), in turn, requires vehicles to achieve compliance with standards throughout their "useful life," "whether such vehicles and engines are designed as complete systems or incorporate devices to prevent or control such pollution." 42 U.S.C. § 7521(a)(1). Section 206 also provides that EPA may condition the certificate of conformity "upon such terms…as [it] may prescribe." 42 U.S.C. § 7525(a)(1). The statute thus confers broad authority on EPA to ensure that PEVs (like any other motor vehicle) in fact achieve the level of emission reductions attributed to them for purposes of compliance calculations throughout their useful lives.

Durability is also important for PEVs to ensure that vehicles in their second or third use cases maintain their durability and strong benefits to drivers. EPA points to several studies that highlight the importance of battery durability for PEVs, and notes that auto manufacturers are already required to "account for potential battery degradation that could result in an increase in CO2 emissions." 88 Fed. Reg. at 29283. Extending these requirements to PEVs is logical and well within EPA's authority.

Manufacturers are well-equipped to meet durability requirements, which are already in place in other jurisdictions. The United Nations Global Technical Regulation No. 22 (GTR No. 22) recommends durability standards for batteries in vehicles.[222] EPA notes that Agency staff chaired the informal working group that developed these standards. 88 Fed. Reg. at 29284 n.536. In the United States, the California Air Resources Board has established battery durability and warranty standards in the Advanced Clean Cars II regulations. *Id.* at 29284 nn.537-38. Pending approval of the ACC II waiver from EPA, at least seven states (representing approximately 25% of the United States vehicle sales market) will have enforceable battery durability and warranty

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[222] *See* United Nations, *Addendum 22: United Nations Global Technical Regulation No. 22* § 1.A, April 14, 2022.. https://unece.org/sites/default/files/2022-04/ECE_TRANS_180a22e.pdf

requirements. Therefore, EPA's consideration of battery durability and warranty standards is aligned with global trends and policies, and we support the proposed incorporation of GTR No. 22 into EPA's final rule.

However, while EPA has chosen to incorporate many parts of GTR No. 22, the Agency has chosen not to require a monitor for the vehicles' state of certified range (SOCR), without providing a sufficient justification. EPA recognizes that the state of certified energy (SOCE) is important to track minimum performance requirements, which we support. However, EPA notes that "monitoring the state of a vehicle's full-charge driving range capability… as an indicator of battery durability performance may be an attractive option because driving range is a metric that is more directly experienced and understood by the customer." 88 Fed. Reg. at 29286. The GTR No. 22 includes a requirement for SOCR, but it is not customer-facing, while California's ACC II program requires a range metric *instead* of a SOCE metric. *Id.* As EPA notes, drivers are accustomed to think about the range of their vehicles, not the energy levels of the battery. *Id.* Therefore, we request that EPA require both a SOCE monitor for compliance purposes as well as a SOCR monitor within the vehicle to provide confidence and transparency to drivers about the state of health of their vehicle battery. This is especially important as the vehicles transition into the secondary market, as SOCR monitors will enhance consumer confidence in used PEVs. We also request that EPA require the SCOR be readable by the customer, in addition to regulatory authorities.

We also support the proposed warranty provisions, which fall well within EPA's authority under the Clean Air Act. Section 207(a)(1) provides that manufacturers of motor vehicles must warrant that the vehicle is "free from defects in materials and workmanship which cause such vehicle . . . to fail to conform with applicable regulations" for the warranty period specified by EPA through regulation. 42 U.S.C. § 7541(a)(1). And Section 207(i)(2), which applies specifically to light-duty vehicles and light-duty trucks, establishes a warranty period for "specified major emission control components," including catalytic converters, electronic emissions control units, onboard diagnostic devices, and "any other pollution control device or component" EPA designates under that section. 42 U.S.C. § 7541(i)(2). PEV batteries and associated electric powertrain components are no different from the enumerated emission control technologies—they are "pollution control device[s] or component[s]" because they enable the control (in fact, the complete elimination) of tailpipe emissions from motor vehicles. We agree with EPA's rationale for applying warranty requirements to PEV batteries and associated electric powertrain components, 88 Fed. Reg. at 29286-87, and we recommend that EPA finalize this aspect of the Proposal.

XI. Revisions to Elements of the Compliance and Enforcement Program Are Warranted.

We also urge EPA to revise certain elements of its compliance and enforcement program, as detailed below.

A. Clarifications of EPA's existing enforcement authority are appropriate.

As noted in the Proposal, EPA has the authority to remedy non-compliance with its GHG emissions regulations by correcting credit balances.[223] Such action is appropriate under the Clean Air Act, and EPA has utilized such remedies on occasion in the past, including when manufacturers were found to be improperly certifying vehicles to lower emissions.[224]

EPA's in-use testing program is a critical part of ensuring that the regulatory program yields the reductions anticipated in the real world. Should a manufacturer's in-use testing illustrate deviations from the fleet level certification, particularly those of a systematic nature resulting in higher real-world emissions, it is appropriate for EPA to adjust the manufacturer's regulatory credit balance to reflect this real-world increase. We support EPA's clarification and believe EPA should act swiftly should a need for such enforcement arise.

Unlike other emissions programs, GHG certification is granted at the precise certified test, rather than as a bin, where there is some inherent compliance margin. While EPA has some allowance for in-use values that fall within 10% of the certified value, as discussed in the section immediately below, EPA is proposing to allow manufacturers to voluntarily certify to a higher emissions level to better reflect the range of anticipated in-use emissions from the full configurations of the certified fleet. We support this voluntary approach.

These two actions are complementary to each other, and we support EPA finalizing both together in the final rule. EPA is proposing to allow manufacturers to create their own compliance margin to reflect the full range of plausible in-use emissions from vehicle configurations covered under a given certification level. If, after in-use testing is completed, EPA still determines that the in-use test values do not reflect the emissions levels certified by the manufacturer, EPA is making clear that it has the authority to remedy the manufacturer's balance after the fact. This provides adequate opportunity in advance of the sale of vehicles to preemptively address any concerns about systematic deviation without relinquishing EPA's ultimate authority to ensure that credits for the regulatory program reflect in-use performance.

[223] 88 Fed. Reg. at 29288
[224] See "Correction of Greenhouse Gas Emission Credits" in Consent Decree, *United States & CARB v. Hyundai Motor Company et al.*, 14-cv-1837 (D.D.C. Jan. 9, 2015), ECF No. 8, at 9.

B. EPA should eliminate the 10-percent compliance factor adjustment.

While EPA's proposed clarifications will help ensure that its regulations better reflect in-use emissions performance, they also illustrate that the current in-use compliance margin is far too high. For EPA to detect systematic deviations in in-use emissions compared to certification, a manufacturer would have to be assured that variability is low enough that its vehicles would not emit above the 10% thresholds, despite certifying to an artificially low emissions level. This inherently means that the test-to-test variability and production variability within a subconfiguration or model type for which the 10% is supposed to account[225] is actually much less than 10%.

A 10% margin for error in in-use testing is quite high, particularly when considered in the context of the levels of improvement required under the standards: the average 2-cycle tailpipe certification value for a passenger car has decreased by just 19% from 2012-2021 and, for light trucks, just 18%. To put the 10% margin in perspective, take the example of the breadth of configurations of the Ford F-150: it is available in 3 body types, in rear- or four-wheel-drive, in trucks that vary in curb weight by 1600 pounds, with six different engines (including a hybrid), and additional high-payload and high-towing packages. And yet, the certified emissions levels from this vehicle span just 40%. The necessity of a 10% margin for a narrow slice of that spectrum (for one drivetrain, one engine, and one payload package) is implausibly high.

We support EPA eliminating the 10% in-use compliance allowance as part of this rule.[226] It is particularly relevant when considering EPA's clarifications around manufacturers' voluntary adjustments to certification, which would eliminate the need for such allowance. Shifting to a threshold for which additional testing is required supports the original intent of the allowance (to recognize testing variability) without undermining in-use emissions from vehicles regulated under the light-duty GHG program.

XII. EPA Should Improve Its Proposed Adjustment to the PHEV Fleet Utility Factor to More Accurately Capture the True Emissions from PHEVs.

Below, we offer comment on EPA's proposed adjustment to the PHEV Fleet Utility Factor (FUF). EPA is correct to adjust the FUF to reflect real-world driving and recharging behavior, but the modification proposed is not sufficient to reflect the true emissions from PHEVs. Prior to the availability of PHEV models (and therefore in the absence of data on their actual usage), it was rational to use the Fleet Utility Factor as formulated in SAE 2841 in 2010 as the basis for estimating the percentage of operation without internal combustion engine use occurring in charge-depleting (CD) mode. However, there is now a significant body of real-world data that can be used to develop utility factors that more accurately reflect the actual

[225] 88 Fed. Reg. at 29288-9.
[226] *Id.* at 29289.

tailpipe CO_2 emissions from PHEV operation.[227] Because EPA proposes to retain a zero gram per mile value for operation in CD mode, the choice of utility factor will play an important role in determining the compliance value for PHEVs.

EPA has obtained California Bureau of Automotive Repair (BAR) data from onboard diagnostics devices (OBD) that show the real-world utilization of PHEVs in CD mode. The data show that all PHEV models in the dataset have actual utility factors lower than the current (SAE 2841) FUF. In some cases, the BAR data show real-world utility factors that are nearly 50% lower than the current FUF values. For example, the BAR data show the Honda Clarity PHEV as having a real-world utility factor of 0.359 while the SAE 2841 method gives the Clarity a FUF of 0.676.[228] These results show that the SAE2841 method using travel survey data is a poor estimator of actual vehicle usage. The Agency proposes to reduce the FUF for compliance calculations by averaging the current FUF with a curve derived from the BAR real-world data. This averaging will lower the gap between actual emissions performance and the compliance value, but will still allow for compliance values for PHEVs that are higher than justified. Given that EPA now has clear real-world data showing that the current FUF is not reflective of actual emissions from PHEVs, it is inappropriate to use the original SAE J2841 FUF or to use it in an average with other data. EPA should instead use a FUF consistent with the actual in-use data from BAR and adopt the FUF labeled "ICCT-BAR" in the DRIA.

The decision to average real-world usage data with the SAE 2841 estimate is poorly justified. EPA states that "an overly low FUF curve could disincentivize manufacturers to apply this technology." 88 Fed. Reg. at 29254. However, both the current FUF curve and the proposed curve over-credit PHEVs. A curve that correctly credits PHEVs' reductions in emissions (such as the ICCT-BAR curve) will not disincentivize adoption of PHEVs, but instead will provide a lower incentive for the partial elimination of tailpipe emissions and a greater incentive for complete elimination via fully-electric powertrain options. Even with a lower FUF, the ability to reduce the compliance emissions values by use of zero grams per mile for the CD mode phase will provide a significant incentive for a manufacturer to choose a PHEV powertrain over a non-plug-in hybrid. Choice of a lower FUF curve will at the same time ensure that there is a sufficient incentive to encourage the continued development and deployment of zero-emission technologies.

EPA also cites future models with longer electric range and greater all-electric performance as leading to future real-world performance that meets the proposed FUF curve. This is not supported by the available data. The longest electric range PHEV currently available is the Toyota RAV4 Prime. The RAV4 Prime data from the BAR dataset show a real-world utility

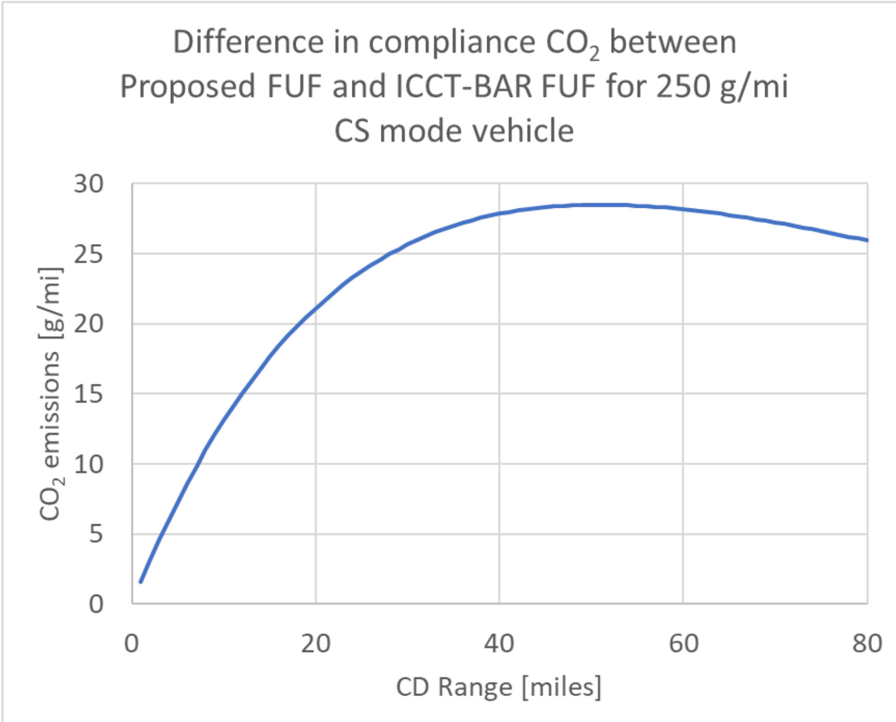
[227] Aaron Isenstadt et al., ICCT, *Real World Usage of Plug-in Hybrid Vehicles in the United States* (Dec. 2022), https://theicct.org/wp-content/uploads/2022/12/real-world-phev-us-dec22.pdf.
[228] The data is from EPA-HQ-OAR-2022-0829-0465_attachment_2.xlsx, and was processed using the method described in EPA-HQ-OAR-2022-0829-0465_attachment_1.pdf.

factor of 0.35, significantly lower than the proposed FUF for a 42-mile all-electric range (AER) vehicle (0.52) and even lower than the ICCT-BAR curve (0.41). EPA states that "increased consumer technology familiarity" will also make future PHEV usage approach the proposed FUF curve. 88 Fed. Reg. at 29254. Increased consumer knowledge may make purchasers able to shift more driving to electric-only mode. However, it is also possible that purchasers (especially in the secondary market) may buy a PHEV without the ability to plug in or may choose a PHEV because of incentives that make the purchase more attractive relative to a non-plug-in vehicle. Existing research on the use of PHEVs shows that the largest factor leading to lower real-world observed utility factors is lack of charging, with 20-30% of some PHEV models starting their travel day on a nearly empty battery.[229]

The proposed FUF could lead to PHEVs with a large difference between real-world emissions and the compliance values for CO_2 emissions. The use of PHEV powertrains in larger vehicles such as SUVs and pickups will cause this gap to grow, due to the gap between the zero grams per mile CD operation and the high gram per mile operation when the internal combustion engine is running. Over-crediting PHEVs' purported electric driving would create a new and unjustified loophole that would likely slow down the path to greater deployment of zero-emission technologies within the fleet. For example, for a PHEV that has compliance CO_2 charge sustaining (CS) mode emissions of 250 g/mile and an electric range of greater than 28 miles, the proposed FUF would artificially reduce the combined mode PHEV emissions by over 25 g/mile when compared to the ICCT-BAR FUF. (Figure XII.1). The gap between the proposed FUF and the real-world data (ICCT-BAR) is highest for vehicles with a CD range between 42 and 62 miles. California's ZEV regulations for model year 2029 and subsequent vehicles require a minimum certification electric range of 70 miles to be eligible for credit values, which is approximately a 50-mile label range. Therefore, PHEVs designed to meet the minimum range for ZEV credit value eligibility are likely to have the largest deviations between real-world emissions and the compliance emissions calculated using the proposed FUF.

[229] Seshadri Srinivasa Raghavan & Gil Tal, *Plug-in hybrid electric vehicle observed utility factor: Why the observed electrification performance differ from expectations*, 15 Int'l J. of Sustainable Transp. 105, 122 (2022), https://www.sciencedirect.com/org/science/article/pii/S1556831822004269.

Figure XII.1. Difference in Compliance CO_2 Between Proposed FUF and ICCT-BAR FUF for 250 g/mi CS Mode Vehicle



XIII. EPA Should Finalize the Proposed Test Fuel Change for GHG and Fuel Economy Certification But Not for Labeling Purposes, and It Should Require the Use of Adjustment Factors in Appropriate Circumstances.

We support EPA's proposal to require gasoline-powered vehicles to demonstrate compliance with the MY 2027-2032 GHG standards using Tier 3 test fuel, as well as its proposal to require the use of adjustment factors in certain situations. *See* 88 Fed. Reg. at 29240-42 & Tbl. 30. In addition to the points made below, we urge EPA to consider the comment letter that many of the undersigned organizations submitted to EPA in August 2020 regarding its related proposal on Tier 3 test fuel (which was never finalized).[230]

In the 2014 Tier 3 Rule, EPA appropriately decided to transition away from Indolene (also known as "Tier 2") test fuel, which no consumer can purchase, to a test fuel ("Tier 3," which contains 10% ethanol) that represents what consumers can actually purchase at the pump. 79 Fed. Reg. at 23525-26. As part of the Tier 3 rulemaking, EPA committed to assessing the impact of the test fuel change on the GHG emissions and fuel usage of the new vehicle fleet. *Id.* at 23531-32. The results of the Agency's subsequent research study were conclusive: switching from Indolene to Tier 3 test fuel reduces fuel economy and tailpipe emissions of carbon

[230] Comment Letter re: EPA-HQ-OAR-2016-0604, Vehicle Test Procedure Adjustments for Tier 3 Certification Test Fuel (Aug. 14, 2020), at https://www.regulations.gov/comment/EPA-HQ-OAR-2016-0604-0081.

dioxide.[231] As EPA rightly concludes, the "difference in GHG emissions between the two fuels is significant in the context of measuring compliance" with GHG standards. 88 Fed. Reg. at 29241.

Because EPA has based the proposed MY 2027-2032 GHG standards on the use of Tier 3 test fuel instead of Indolene, *id.* at 29240-41, requiring manufacturers to use Tier 3 test fuel to demonstrate compliance in MY 2027 and beyond is appropriate. We agree that compliance testing using Tier 3 fuel in MY 2027-2032 does not require an adjustment factor.

We also agree with EPA's proposal that any manufacturers that use Tier 3 test fuel to certify compliance with pre-MY 2027 GHG standards must apply an adjustment factor of 1.0166. 88 Fed. Reg. at 29241 & Tbl. 30. Since the existing (pre-MY 2027) GHG standards are based on Indolene test fuel, using this adjustment factor is necessary to avoid arbitrarily crediting vehicles tested with Indolene with artificial reductions in GHG emissions. As EPA has recognized, not applying an adjustment factor would effectively (and inappropriately) reduce the stringency of the existing GHG standards. U.S. EPA, Vehicle Test Procedure Adjustments for Tier 3 Certification Test Fuel, 85 Fed. Reg. 28564, 28566 (May 13, 2020) (proposed, never-finalized rule regarding Tier 3 test fuel change). Failing to require an adjustment factor would also impose unwarranted additional costs on consumers at the gas pump. To avoid unnecessary and harmful delays in manufacturers applying the adjustment factor to pre-MY 2027 vehicles tested on Indolene, EPA should also clarify that this provision takes effect 60 days after the rule becomes final.

EPA's approach to adjusting the fuel economy and GHG certification values based on the certified fuel as outlined in Table 30 of the Proposal is appropriate. However, the Agency should begin requiring Tier 3 fuel used for certification for all non-carryover vehicles beginning with the first complete model year following finalization of the rule, in order to avoid manufacturers trying to exploit relative Indolene vs. Tier 3 performance different than the average adjustment factor. Manufacturers already certify vehicles on Tier 3 fuel and are aware of any potential discrepancies that could be used to their advantage, so the Agency should eliminate any opportunity for manipulation of certification results as soon as possible, with no phase in period. Allowing carryover is a sufficient compromise to minimize testing burden.

We do not support EPA's proposal to adjust certification test fuel requirements for purposes of fuel economy and emissions labels. The use of Tier 3 fuel for certification was justified because this fuel more closely aligns with the fuel available to consumers at the pump.[232] Thus, Tier 3 fuel is more representative of the fuel a consumer would use to judge their own fuel economy. In contrast, the data collected to support the latest iteration of the fuel

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[231] *See* U.S. EPA, Tier 3 Certification Fuel Impacts Test Program, EPA-420-R-18-004 (Jan. 2018), at 2, available at https://www.regulations.gov/document/EPA-HQ-OAR-2016-0604-0003.

[232] "E10 most appropriately reflects in-use gasoline around the country today and into the foreseeable future, and thus we are finalizing E10 for the test fuel." 79 Fed. Reg. at 23450.

economy label was collected in 2004-2005,[233] prior to the Renewable Fuel Standard (RFS2) taking effect. Ethanol content in fuel in 2004-2005 was just 2%, on average; MTBE was the more popular oxygenate; and gasoline's oxygen content averaged just over 1%, as opposed to 2014, when Tier 3 (E10) fuel was defined to reflect the 10% ethanol content of the reformulated gasoline available to consumers and oxygen content nearly doubled.[234] While Indolene has never been available at the gas pump, many of the average properties for 2004 pump fuel are directionally more similar to Indolene than to Tier 3 fuel: lower gravity, lower ethanol content, lower oxygen, and higher aromatics.[235] Thus, the fuel economy labeling tests were, to first order, based on the pump fuel at the time, and now such tests should reflect the updated fuel more representative of today's current pump fuel. Therefore, rather than applying the adjustment factor to Tier 3-certified vehicles, as EPA proposes, it would be more appropriate to apply the inverse adjustment factor to Indolene-certified vehicles. While we appreciate the point made by EPA that "a comprehensive assessment of real world fuel economy is the best process to ensure that all real-world effects are reflected," 85 Fed. Reg. at 28579, such an assessment is a resource-intensive undertaking that has not been attempted in nearly 20 years, and EPA has sufficient data based on its Tier 2/Tier 3 program to account for a shift in the available pump fuel.

XIV. EPA Should Finalize Its Proposed Changes for Small Volume Manufacturers.

We support EPA's proposal to transition small volume manufacturers ("SVMs") into the primary program standards by MY 2032.[236] As illustrated in Table 37, the emissions standards presently applicable to SVMs are significantly less protective than those that apply to other manufacturers.[237] For MY 2021, SVM standards ranged from 308-376 g/mile.[238] By comparison, the revised footprint curve in SAFE 2 for passenger cars for MY 2021 was 161.8 to 220.9 g/mile.[239]

As EPA explains, there has been a significant shift in the vehicle market since EPA established the SVM alternative standards.[240] For example, "[v]ehicle electrification technologies are currently being implemented across many vehicle types including both luxury and high-performance vehicles by larger manufacturers and EPA expects this trend to continue."[241] In

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[233] U.S. EPA, Final Technical Support Document–Fuel Economy Labeling of Motor Vehicles: Revisions to Improve Calculation of Fuel Economy Estimates, EPA-420-R-06-017 (Dec. 2006), at Appendix A, available at http://nepis.epa.gov/Exe/ZyPDF.cgi/P1004F41.PDF?Dockey=P1004F41.PDF.
[234] U.S. EPA, Fuel Trends Report: 2006-2016, EPA-420-R-17-005 (2017), at 27, Tbl. 6, available at https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100T5J6.pdf.
[235] *Compare id.* Tbl. 6 *with* U.S. EPA, Tier 3 Certification Fuel Impacts Test Program, EPA-420-R-18-004 (Jan. 2018), at 5, Tbl. 3.1.
[236] 88 Fed. Reg. at 29197, 29255.
[237] *Id.* at 29256.
[238] *Id.*
[239] 84 Fed. Reg. 24174, 25268 (Apr. 30, 2020).
[240] 88 Fed. Reg. at 29256.
[241] *Id.*

addition, as EPA notes, the credit trading market has become more robust since the SVM alternative standards were initially developed, expanding compliance options for SVMs. EPA concluded that "meeting the CO_2 standards is becoming less a feasibility issue and more a lead time issue for SVMs."[242]

EPA's conclusions that a transition of SVMs to the primary program coheres with the recent announcements and developments in the business model of the SVMs who have previously pursued less stringent standards. There are only four SVMs currently subject to less stringent standards: Ferrari, Aston Martin, Lotus, and McLaren. All are moving toward greater hybridization and electrification, which will facilitate compliance with the primary LDV GHG standards.

Ferrari in 2022 announced plans to rapidly electrify its vehicle offerings, achieving 40% BEV sales by 2030 and 80% electrified (PHEV + BEV) vehicles.[243] Ferrari already sells two PHEVs, the SF90 Stradale[244] and the 296 GTB.[245] Likewise, Aston Martin has committed to electrification. It will offer its first BEV in 2025 and has committed to having every model available with an electrified powertrain by 2026.[246] It will begin delivering its first PHEV, the Valhalla, in 2024.[247] Lotus is offering the all-electric Evija[248] and Eletre SUV.[249] The Eletre will be available in the United States beginning in 2024.[250] And McLaren has recently developed its first hybrid vehicle, the Artura, and indicated that all its vehicles will eventually be gas-electric hybrids or electric-only.[251]

Based on the SVMs' active transition into hybrid and battery electric vehicles—with its attendant improvements in GHG emissions—the existence of a robust credit trading market, and the significant lead time proposed by EPA for transitioning the SVMs into the broader program, We support EPA's proposal.

[242] *Id.*
[243] Michael Taylor, *Ferrari to Go Electric in 2025, with 40% EV Sales by 2030*, Forbes (June 16, 2022), https://www.forbes.com/sites/michaeltaylor/2022/06/16/ferrari-to-go-electric-in-2025-with-40-ev-sales-by-2030/?sh=7fd8646d66a2.
[244] *SF90 Stradale*, Ferrari, https://www.ferrari.com/en-EN/auto/sf90-stradale (last visited June 29, 2023).
[245] *296 GTB*, Ferrari, https://www.ferrari.com/en-US/auto/296-gtb (last visited June 29, 2023).
[246] Eric Stafford, *Aston Martin Is Going Electric, Launching Its First EV in 2025*, Car and Driver (Apr. 22, 2022), https://www.caranddriver.com/news/a39798418/aston-martin-electric-lineup-reveal-first-ev-2025/.
[247] *Id.*; *see also Aston Martin Valhalla*, Aston Martin, https://www.astonmartin.com/en-us/models/special-projects/valhalla (last visited June 29, 2023).
[248] *Evija*, Lotus, https://www.lotuscars.com/en-US/evija (June 29, 2023).
[249] *Eletre*, Lotus, https://www.lotuscars.com/en-US/eletre (last visited June 29, 2023).
[250] Mike Duff, *Lotus Moves to Float Its EV Division*, Autoweek (Feb. 8, 2023), https://www.autoweek.com/news/green-cars/a42801104/lotus-moves-to-float-its-ev-division/.
[251] Josh Max, *McLaren Rolls Out the Hybrid 2023 Artura Supercar*, Forbes (Jan. 5, 2023), https://www.forbes.com/sites/joshmax/2023/01/05/mclaren-throws-its-hat-into-the-electrichybrid-ring-with-the-2023-artura/?sh=42c0eb057746.

XV. ZEV Penetration in the Absence of the Proposed Standards is Likely to Exceed EPA's Estimates, Supporting the Feasibility of More Stringent Standards.

To support the feasibility of Alternative 1 with a steeper increase in stringency after 2030, we now turn to the market growth of ZEVs and anticipated baseline (or "no action") levels of ZEV penetration. EPA's No Action scenario projected that BEVs will comprise 39% of the LDV fleet in 2032. To assess the reasonableness of this projection, EPA reviewed literature and other analytical projections, which clearly supported ZEV penetration at least as high as EPA's projections. While EPA's approach is reasonable, real-world "no action" levels of BEVs are likely to be even higher than EPA's No Action scenario. This supports making the finalized standards more stringent than proposed.

A. Other analyses predict high levels of ZEVs in the period of the Proposed Standards.

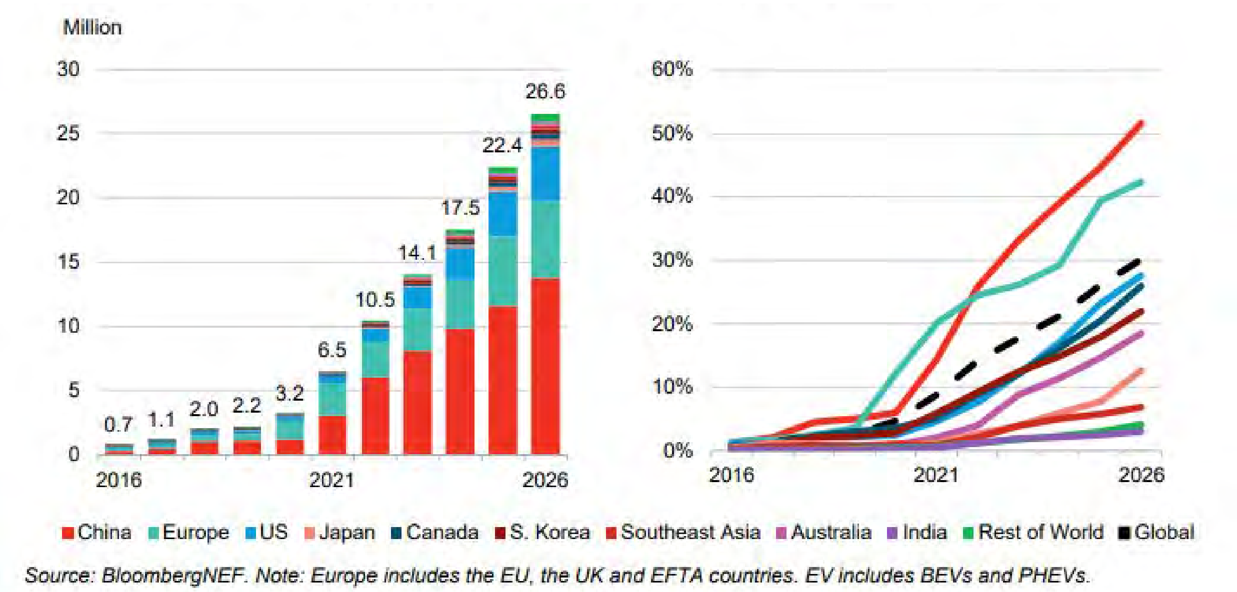
In the Proposal, EPA cites several sources that model the global and United States ZEV outlook over the next few decades. 88 Fed. Reg. at 29189, 29192-3.[252] These models vary in their assumptions (including whether IRA funding is considered in the projections), but all point to upward momentum of the PEV market globally and in the United States. EPA appears to have considered a variety of analyses available – looking at both aggressive projections and conservative models – to understand the global transition to PEVs. The most relevant of the analyses that EPA considered are those that account for the impact of the IRA in baseline ZEV penetration levels, and each of those supports baseline ZEV sales greater than the baseline levels projected in EPA's proposed No Action scenario. For example, the 2022 Bloomberg New Energy Finance (BNEF) analysis incorporating the IRA projects baseline ZEV sales of 52% in 2030, compared to EPA's projection of 39% in 2032. *Id.* at 29189. And the analysis by ICCT and Energy Innovation, which also incorporated the impacts of the IRA, projects 2032 baseline ZEV sales between 17% and 28% higher than EPA's projections. *Id.* An additional analysis by Boston Consulting Group not cited by EPA projects similar baseline ZEV sales, anticipating 53% U.S. market share for light-duty ZEVs in 2030.[253] The only analysis EPA considered that projected a baseline close to EPA's projection was IHS Markit—predicting nearly 40% ZEV sales in the U.S. by 2030—but this analysis was pre-IRA and therefore should be considered an underestimate. *See* 88 Fed. Reg. at 29189. These analyses justify and support strong EPA emission standards, and auto executives have signaled that their sales expectations align with baseline ZEV sales at least as high as—and most likely higher than—EPA's projections, even prior to the passage of

[252] IHS Markit (2021) predicted nearly 40% US PEV share by 2030 (pre-IRA); BNEF found the U.S. on pace to reach 40-50% PEVs by 2030, increasing to 52% when adjusted for IRA; ICCT/Energy Innovation found BEV share to be 56% to 67% by 2032 (including IRA); IEA found OEM announcements equal about 50% ZEVs in 2030.
[253] Nathan Niese et al., *Electric Cars Are Finding Their Next Gear*, BCG, Exhibit 1 (June 9, 2022), https://www.bcg.com/publications/2022/electric-cars-finding-next-gear. BCG's projections for 2030 include 47% market share for BEVs and 6% market share for PHEVs.

the IRA.[254] As discussed throughout these comments, we request that EPA adopt at least Alternative 1 based on strong projections of the growth of the PEV market, as well as consider additional new data that became available since the Proposal.

For example, in the Proposal, EPA cites 2022 BNEF data that states that global growth of EVs is projected to reach 21 million in 2025. However, the latest BNEF EV Outlook updates that modeling, and estimates that EV sales will reach approximately 22.4 million by 2025, growing to 26.6 million sales by 2026 and reaching 44% of global sales by 2030. In the United States, EVs are expected to reach 28% of sales by 2026, which equates to over 4 million new ZEV sales, a large growth from the 980,000 new ZEVs sold in 2022.[255]

Figure XV.A-1: **Global near-term passenger EV sales and share of new passenger vehicle sales by market**



B. State standards will lead to greater ZEV deployment.

In August 2022, CARB unanimously approved the ACC II standards, which, starting in model year 2026, require manufacturers to sell an increasing number of new ZEVs[256] annually,

[254] KPMG, 22nd Annual Global Automotive Executive Survey 2021 8 (Nov. 2021), https://assets.kpmg.com/content/dam/kpmg/xx/pdf/2021/11/global-automotive-executive-summary-2021.pdf (finding that, even before the passage of the IRA, auto executives on average expected 52% of new vehicle sales to be all-electric by 2030). *See also,* Michael Wayland, Auto Executives Say More Than Half of U.S. Car Sales Will Be EVs By 2030, KPMG Survey Shows, CNBC (Nov. 30, 2021), https://www.cnbc.com/2021/11/30/auto-executives-say-more-than-half-of-us-car-sales-will-be-evs-by-2030-kpmg-survey-shows.html.
[255] BloombergNEF, *Electric Vehicle Outlook 2023: Executive Summary* (2023).
[256] Defined as Battery Electric, Plug-in Hybrid, and Fuel Cell Electric Vehicles.

culminating in 100% new ZEV sales by model year 2035. CARB submitted a waiver request for the ACC II standards in late May 2023.

While the ACC II standards cannot be enforced until the waiver is granted by EPA, six additional states[257] have adopted the standards in anticipation of waiver approval. These seven states (including California) approximately 25% of the United States vehicle market.[258] Further, at least five other states and the District of Columbia have announced their intention to adopt ACC II.[259] Should those jurisdictions also adopt ACC II, nearly one-third of the United States vehicle market would be on a trajectory to have 100% new zero-emission vehicle sales by 2035.[260]

EPA included ACC II in a sensitivity analysis but did not include it in the central analysis, as CARB had not yet submitted the waiver request for ACC II as of the date of the Proposal. However, now that CARB has submitted the waiver request, we ask that ACC II be included in the central analysis if the waiver is granted before the Proposal is finalized. And while ACC II clearly supports the feasibility of stronger federal standards, including through changes to business-as-usual (BAU) PEV penetration, it is also clear that stronger federal standards are feasible and justified even without it. As a result, we encourage EPA to model a scenario in the final rule that does not include ACC II, which will demonstrate that the record supports the final standards even in the absence of ACC II.

The addition of the ACC II sensitivity makes a significant difference in the No Action scenario, as the BAU for PEVs increases from 39% to 54% and the incremental average cost of the standards decreases from $1,164 to $164. It appears that this sensitivity does not include all of the states that have adopted ACC II or intend to adopt ACC II—specifically Virginia—implying that the BAU will increase, and the average incremental costs of the standards will decrease even further when the full range of states are included. The inclusion of the full portfolio of states that have adopted ACC II by the time of the final regulation in the

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[257] The states that have adopted ACCII as of the date of this comment letter are Oregon, Washington, Virginia, Massachusetts, New York, and Vermont.

[258] CARB, *States that Have Adopted California's Vehicle Standards under Section 177 of the Federal Clean Air Act,* May 13, 2022, https://ww2.arb.ca.gov/sites/default/files/2022-05/%C2%A7177_states_05132022_NADA_sales_r2_ac.pdf

[259] These states are: Rhode Island (https://dem.ri.gov/environmental-protection-bureau/air-resources/advanced-clean-cars-ii-advanced-clean-trucks), Delaware (https://news.delaware.gov/2022/03/03/delaware-to-adopt-zero-emission-vehicle-regulation/), Maryland (https://governor.maryland.gov/news/press/pages/Governor-Moore-Announces-Maryland-Adoption-of-the-Advanced-Clean-Cars-II-Rule-to-Combat-the-Effects-of-Climate-Change.aspx), New Jersey (https://nj.gov/governor/news/news/562023/approved/20230215b.shtml), and Colorado (https://cdphe.colorado.gov/coloradocleancars). Earlier this year, Washington D.C completed the public comment period on its proposal to adopt the ACC II regulations (https://doee.dc.gov/release/notice-comment-period-proposed-rulemaking-adoption-california-vehicle-emission-standards).

[260] CARB, *States that Have Adopted California's Vehicle Standards under Section 177 of the Federal Clean Air Act.*

central analysis will provide a more accurate picture of the state of the U.S. PEV market as well as presumed costs of the regulation.

The inclusion of ACC II in the central analysis is also aligned with assumptions EPA has included throughout the Proposal with respect to ACC II adoption, such as the assumption that "anticipated longer all-electric range and greater all-electric performance, *partially driven by CARB's ACC II program*… should result in performance more closely matching [the] proposed curve," 88 Fed. Reg. at 29254, and the alignment of the NMOG + NOx provisions with ACC II 88 Fed. Reg. at 29275.

C. Private investments and commitments will lead to greater ZEV deployment.

EPA should also consider private investments and commitments that have been announced or implemented throughout the United States thus far that will further facilitate rapid growth of ZEVs.

EPA states in the proposed rule that automakers, based on their public commitments, will achieve approximately 50% ZEV sales by 2030. 88 Fed. Reg. at 29296. EPA also considered additional automaker announcements to accelerate the EV market in the United States, *see, e.g.*, 88 Fed. Reg. at 29193-94. EPA should update these estimates in the final rule, including by recognizing the $210 billion of investments in the United States to accelerate the transition to ZEVs and build up a robust, domestic supply chain – a higher investment than any other country.[261] These investments will help increase the availability of ZEVs in the United States and further accelerate the transition to ZEVs that is already well underway in the market.

D. Congressional support will increase ZEV deployment and cost-competitiveness.

In addition to highlighting the investments from the BIL (explored in further detail later in these comments), EPA rightly points to the historic funding from the IRA as building on and supporting EPA's efforts to regulate tailpipe emissions from vehicles:

> Congress passed the Bipartisan Infrastructure Law (BIL) in 2021, and the Inflation Reduction Act (IRA) in 2022, which together provide further support for a government-wide approach to reducing emissions by providing significant funding and support for air pollution and GHG reductions across the economy, including specifically, for the component technology and infrastructure for the manufacture, sales, and use of electric vehicles.[262]

[261] Noah Gabriel, *$210 Billion of Annouced Investments in Electric Vehicle Manufacturing Heading for the U.S.* (January 12, 2023), https://www.atlasevhub.com/data_story/210-billion-of-announced-investments-in-electric-vehicle-manufacturing-headed-for-the-u-s/.

[262] 88 Fed. Reg. at 29187.

Together, these legislative measures represent significant congressional support for accelerating the deployment of and market for ZEV technologies. First, the BIL and IRA provide an unprecedented level of investment (over $430 billion) in ZEV infrastructure, technology, and supply chains, through a variety of key tax provisions, manufacturing investments, grants, rebates, loans, and other investment mechanisms.[263] BIL and IRA programs will, among other things, provide both direct grants and tax credits to lower acquisition costs of vehicles and increase the range of cost-effective applications,[264] help entities conduct planning for fleet electrification,[265] enable deployment of charging and hydrogen fueling infrastructure,[266] and facilitate advances in technology that can lower future vehicle costs. These programs also invest in vehicle and battery manufacturing and recycling, driving cost reductions and increasing domestic supply. EPA should accordingly ensure that these important laws are reflected in its estimate of baseline LD ZEV market penetration.

These federal incentives are a key market enabler and will help drivers (and commercial L/MD fleets) adopt advanced clean transportation technologies (like ZEVs) that lower operating costs and reduce emissions. Manufacturers also stand to reap significant benefits, as several key tax credits are expected to add up to provide robust support of ZEV production. Passing those savings on to consumers could drive down the cost of new ZEVs and spur sales.[267] For example, Tesla alone could qualify for $1 billion in tax credits this year, while its Giga Nevada plant could gain up to $17.5 billion in credits for its projected annual production rate of 500 gigawatt hours.[268] Ford and General Motors also stated that they could reap significant benefits as a result of IRA investments. Ford expects $7 billion in tax credits over the next three years and GM could gain $300 million in 2023.[269]

Second, the congressional investments from the IRA and BIL further the public health goals of the Clean Air Act and of this rulemaking: the reduction of harmful pollution from light-

[263] U.S. DOE Office of Policy, *The IRA Drives Significant Emission Reductions and Positions America to Reach Our Climate Goals*, DOE/OP-0018 (August 2022), https://www.energy.gov/sites/default/files/2022-08/8.18%20InflationReductionAct_Factsheet_Final.pdf.

[264] *See, e.g.*, 42 U.S.C. § 7432 (appropriating $1 billion to EPA to create a program that awards grants and rebates for the costs of replacing existing class 6 and 7 HDVs with ZEVs, purchasing, installing, operating, and maintaining infrastructure needed for ZEVs, associated workforce development and training, and planning and technical activities needed to support the deployment of ZEV); 26 U.S.C. § 45W (providing up to $40,000 in tax credits to assist with vehicle replacements and reduce the effective cost of commercial ZEVs).

[265] *See, e.g.*, 42 U.S.C. § 7432.

[266] *See, e.g.*, 26 U.S.C. § 30C (providing tax credits to qualified alternative fuel vehicle property); 42 U.S.C. § 16161a (providing $8 billion to DOE to fund regional hydrogen hubs across the country); 23 U.S.C. § 151 (appropriating $2.5 billion to support the build-out of clean charging and fueling infrastructure projects along designated alternative fuel corridors of the National Highway System).

[267] Tom Taylor & Noah Gabriel, The EV Transition: Key Market and Supply Chain Enablers, Atlas Public Policy (Nov. 2022), https://atlaspolicy.com/wp-content/uploads/2022/12/2022-EV-Transition-Key-Market-and-Supply-Chain-Enablers.pdf.

[268] Joann Muller, *Biden's EV Surprise*, Axios (Feb. 1, 2023) https://www.axios.com/2023/02/01/electric-car-ev-tax-incentives-biden.

[269] Muller, *Biden's EV Surprise*.

and medium-duty vehicles. A preliminary assessment conducted by the U.S. Department of Energy (DOE) found that the IRA, in combination with other enacted policies and past actions, will help drive 2030 economy-wide GHG emissions down to 40% below 2005 levels and move the United States towards its overall 2030 target of achieving a 50 to 52% reduction in GHG emissions below 2005 levels.[270] DOE also noted that the impacts of these congressional investments can be further amplified and accelerated when paired with ambitious and consistent executive branch, state, local, and private sector actions to reduce transportation sector emissions and to make large-scale investments in PEV manufacturing and battery supply chains.[271] These investments are key factors driving industry developments in ZEVs and reducing manufacturing costs, in turn helping make compliance (with the stringency levels in Alternative 1) through enhanced ZEV deployment even more feasible and cost-effective for manufacturers.

Third, congressional funding will prompt and support private sector investment. An analysis by Atlas Public Policy explains that the combination of a strong regulatory environment (like EPA's vehicle standards help provide) along with congressional investments has and will continue to encourage substantial private sector investment in ZEVs, and finds that the U.S. is on track to reach $210 billion in economic commitments by automakers and battery manufacturers by 2030.[272] Clear regulatory signals – like EPA's vehicle emissions regulations – can create further confidence in the private sector to accelerate and expand investments and help ensure companies follow through on their ZEV commitments. In the Proposal, EPA highlights several IRA clean vehicles provisions that will help bolster ZEV deployment, drive down costs, and facilitate compliance with strong standards. These include the clean vehicles tax credit (§ 30D), the previously owned clean vehicle tax credit (§ 25E), the commercial clean vehicle tax credit (§ 45W), and the advanced manufacturing production credit (§ 45X). The § 45X credit is anticipated to be the most lucrative program for automakers, offering a tax credit of $35 per kilowatt-hour for each domestically made battery cell, which could slice manufacturer production costs by a third.

Fourth, a number of other congressional investments can be leveraged to address timelines for deploying ZEVs, human capital issues, potential supply chain constraints, consumer demand, and workforce development issues. For example, the IRA provided $500 million for the enhanced use of the Defense Production Act (DPA) – which President Biden recently invoked to support critical minerals production – on top of the funds made available for the DPA through the normal appropriations process.[273] This provision will support domestic mineral supply chains for large-capacity batteries, including those used in PEVs, and is intended to help increase

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[270] U.S. DOE Office of Policy, *The IRA Drives Significant Emission Reductions*.
[271] U.S. DOE Office of Policy, *The IRA Drives Significant Emission Reductions*.
[272] Gabriel, *$210 Billion of Annouced Investments*.
[273] The White House, *Building a Clean Energy Economy: A Guidebook to the Inflation Reduction Act's Investments in Clean Energy and Climate Action*. (2023). https://www.whitehouse.gov/wp-content/uploads/2022/12/Inflation-Reduction-Act-Guidebook.pdf

productivity, workforce safety, and sustainability in the various steps of the critical minerals lifecycle.

Additionally, the CHIPS and Science Act will strengthen American manufacturing, supply chains, and national security, and will invest in research and development, science and technology, and the workforce of the future to position the U.S. as a leader in clean transportation.[274] This law is further complemented by other congressional investments like the IRA's Advanced Energy Project Credit (§ 48C), which provides a $10 billion investment to expand clean manufacturing and recycling (including critical minerals refining, processing and recycling) and to address technology supply chain gaps. Manufacturers and other private parties are more likely to fully leverage these and other congressional investments if strong regulatory signals are in place, as would be the case under any policy scenarios that are at least as stringent as Alternative 1. This too helps bolster EPA's conclusion of feasibility for the standards outlined in Alternative 1 and in EPA's main Proposal.

Lastly, EPA's Proposal references a number of studies that look at the effect congressional investments (especially the IRA) have on ZEV penetration levels. These studies include reports from ICCT, BloombergNEF,[275] IHS Markit,[276] and others that suggest that even before the IRA, the U.S. was on track to reach as much as 50% new ZEV sales by 2030 due to a range of preexisting policies and market forces. When adjusted for the effects of the IRA, ZEV penetration levels are expected to increase to as much as 61% of sales in 2030, increasing to as much as 67% of new sales by 2032, per ICCT's analysis.[277] These studies further support the feasibility of a final rule at least as stringent as Alternative 1.

XVI. EPA Should Not Repeat Its Past Pattern of Underestimating ZEV Technology Advancements and ZEV Deployment Within the Fleet.

The regulatory history shows that EPA's projections of ZEV technology advancements and overall ZEV deployment within the fleet routinely prove too conservative. EPA should not repeat those same mistakes in this rulemaking. For example, EPA's light-duty GHG rule finalized in 2012 set standards for MYs 2017–2025 and projected "very small" numbers of electric

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[274] The White House. "CHIPS and Science Act Will Lower Costs, Create Jobs, Strengthen Supply Chains, and Counter China." press release, August 9, 2021. https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/.

[275] Bloomberg New Energy Finance (BNEF), Electric Vehicle Outlook 2022: Long term outlook economic transition scenario.

[276] IHS Markit, *US EPA Proposed Greenhouse Gas Emissions Standards for Model Years 2023-2026; What to Expect* (Aug. 9, 2021), https://www.spglobal.com/mobility/en/research-analysis/us-epa-proposed-greenhouse-gas-emissions-standards-my2023-26.html. The table indicates 32.3% BEVs and combined 39.7% BEV, PHEV, and range-extended electric vehicle (REX) in 2030.

[277] Peter Slowik et. al., Analyzing the Impact of the Inflation Reduction Act on Electric Vehicle Uptake in the U.S., ICCT (Jan. 2023), https://theicct.org/wp-content/uploads/2023/01/ira-impact-evs-us-jan23.pdf

vehicles in the light-duty fleet through MY 2025. 77 Fed. Reg. at 62917. In the 2012 rule, EPA projected combined PHEV and BEV penetration of only 1% for the MY 2021 car fleet. *Id.* at 62872. Yet BEV sales alone accounted for at least 3.2% of all vehicle sales in MY 2021.[278] In the 2012 rule, EPA did not even project combined BEV and PHEV sales that high *by MY 2025*. For the combined car and truck fleet, EPA projected BEV and PHEV penetration of only 2% by MY 2025, and for the car fleet alone, BEV and PHEV penetration of only 3% by MY 2025. *Id.* at 62874, 62875 Tbl. III-52. EPA re-evaluated those projections in 2016 and 2017, again projecting MY 2025 technology penetrations of around 3% or less for BEVs.[279] And EPA's 2020 rule still projected only 3.4% BEVs by MY 2025. 85 Fed. Reg. at 24936 Tbl. VII-29.

In the 2012 rulemaking, EPA also considered a more stringent alternative projecting a 5% combined BEV and PHEV penetration for MY 2025 for the car fleet, but it rejected this alternative based on "serious concerns about the ability and likelihood manufacturers can smoothly implement [that level of] increased technology penetration." 77 Fed. Reg. at 62877. Yet automakers ultimately surpassed that "serious[ly] concern[ing]" electrification penetration level in MY 2022 with BEVs alone. In MY 2022, BEV sales reached at least 5.8% of total light-duty vehicle sales,[280] and this growth has continued, with the United States on track to vastly outpace EPA's previous projections of MY 2025 light-duty vehicle electrification. In Q1 of 2023, for example, U.S. light-duty BEV sales alone reached 7.2% of total vehicle sales.[281]

EPA's projections of ZEV technology advancements and deployment have also proven too conservative in the heavy-duty sector. In the 2016 Phase 2 Final Rule, for example, EPA projected very small levels of HD ZEV penetration through MY 2027. In that rule, EPA projected "limited adoption of all-electric vehicles into the market," and stated that the Agency "do[es] not project fully electric vocational vehicles to be widely commercially available in the time frame of the final rules." 81 Fed. Reg. at 73500, 73704.[282] By the time EPA proposed a new rule in 2022, however, the Agency recognized that its 2016 projections were underestimates. *See,*

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[278] Cox Automotive, *In a Down Market, EV Sales Soar to New Record* (Jan. 13, 2023), https://www.coxautoinc.com/market-insights/in-a-down-market-ev-sales-soar-to-new-record/; EPA, *The 2022 Automotive Trends Report*, at 74. *See also* Ilma Fadhil et al., ICCT, *Electric Vehicles Market Monitor for Light-Duty Vehicles: China, Europe, United States, and India, 2020 and 2021*, at 6 (2023), https://theicct.org/publication/ev-ldv-major-markets-monitor-jan23/ (estimating nearly 5% total U.S. BEV and PHEV sales in MY 2021).

[279] *See* EPA, *Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022–2025*, at ES-10 (2016) https://www.nhtsa.gov/sites/nhtsa.gov/files/draft-tar-final.pdf; EPA, *Final Determination on the Appropriateness of the Model Year 2022–2025 Light-Duty Vehicle Greenhouse Gas Emissions Standards under the Midterm Evaluation*, at 4-5, 21 (2017), https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100QQ91.pdf.

[280] Cox Automotive, *In a Down Market, EV Sales Soar to New Record*. *See also* EPA, *The 2022 Automotive Trends Report*, at 74 (preliminary report that electric vehicle sales, including both BEVs and PHEVs, were 7.2% of total sales in 2022).

[281] Cox Automotive, *Another Record Broken: Q1 Electric Vehicle Sales Surpass 250,000, as EV Market Share in the U.S. Jumps to 7.2% of Total Sales* (Apr. 12, 2023), https://www.coxautoinc.com/market-insights/q1-2023-ev-sales/.

[282] *See also* 81 Fed. Reg. at 73818 ("As we look to the future, we are not projecting the adoption of electric HD pickups and vans into the heavy duty market…we believe there is no need to a cap for HD pickups and vans because of the infrequent projected use of EV technologies in the Phase 2 timeframe.").

e.g., 87 Fed. Reg. at 17595 ("Several factors have changed our outlook for heavy-duty electric vehicles since 2016. First, the heavy-duty market has evolved such that in 2021, there are a number of manufacturers producing fully electric heavy-duty vehicles in several applications."). Despite having predicted very limited HD ZEV penetration *through MY 2027* in 2016, EPA noted that by 2019, there were already approximately 60 makes and models of HD BEVs available for purchase, "with additional product lines in prototype or other early development stages." *Id.* EPA explained that "manufacturers and U.S. states have announced plans to shift the heavy-duty fleet toward zero-emissions technology beyond levels we accounted for in setting the existing HD GHG Phase 2 standards in 2016," and recognized the need "[t]o update the MY 2027 vehicle CO_2 standards from the HD GHG Phase 2 rulemaking to reflect the recent and projected trends in the electrification of the HD market." *Id.* at 17598. EPA acknowledged its 2016 under-projections again in the Phase 3 proposal, stating that the Agency has "considered new data and recent policy changes," and is "now projecting that ZEV technologies will be readily available and technologically feasible much sooner than we had projected." 88 Fed. Reg. at 25939. In both the light- and heavy-duty sectors, then, EPA's previous projections of ZEV deployment have proven far too conservative, and automakers have repeatedly shown they can deploy zero-emission technologies on a scale and at a pace far greater than EPA originally predicted.

XVII. Ongoing Investments in Charging Infrastructure and Efforts to Ready the Grid for Widespread EV Charging Justify Stronger Standards.

In this section, we explain in detail how charging infrastructure and the electric grid are well-positioned to support strong final standards—and in particular, Alternative 1 with a steeper increase in stringency after 2030.

A. Economic theory and historical precedent show that infrastructure buildout will occur at the pace and scale needed to support vehicle electrification.

EPA should reject arguments that the buildout of charging and grid infrastructure cannot occur at the pace and scale needed to support expanded vehicle electrification, which are unreasonably pessimistic and inconsistent with both economic theory and historical precedent. These arguments rely on the classic "chicken-and-egg" scenario said to be presented by ZEV sales and charging infrastructure, where each side of the market waits for the other. But EPA need not and should not wait for infrastructure to fully mature before finalizing strong standards. EPA's standards themselves will send a strong signal to the market to undertake the infrastructure investments needed to accommodate a gradual rise in vehicle electrification,[283] such that

[283] Environmental regulation itself, of course, can lead to technology innovation and market development. *See generally* Jaegul Lee et al., *Forcing Technological Change: A Case of Automobile Emissions Control Technology Development in the US*, 30 Technovation 249 (2010); Margaret R. Taylor, Edward S. Rubin, & David A. Hounshell, *Regulation as the Mother of Innovation: The Case of SO2 Control*, 27 Law & Policy 348 (2005); James Lents et al., *Chapter II: The regulation of automobile emission: A case study*, in *Environmental Regulation and Technology*

increased ZEV sales and infrastructure buildout will occur in relative tandem and reinforce each other. As one analyst sums it up: "The chicken-and-egg conundrum is being solved. Investments in the space and the adoption of EVs [a]re happening much faster than many analysts expected, and this is also accelerating the build-out of the charging network."[284]

The economic literature on indirect network effects and two-sided markets shows that an increase in BEV sales can be expected to stimulate associated infrastructure development. In a study on flex-fuel vehicles fueled by E85 (85% ethanol), Corts (2010) found that growth in sales of flex-fuel vehicles due to government fleet acquisition programs led to an increase in the number of retail E85 stations.[285] That relationship held true across all six Midwestern states analyzed, despite differences in those states' E85 subsidies and tax credits.[286] The author concluded that the results "confirm the basic validity" of the theory underlying government fleet purchase requirements: that increasing the "base of alternative fuel vehicles can spur the development of a retail alternative fuel distribution infrastructure."[287]

Recent economic research has confirmed this relationship in the context of ZEVs and charging infrastructure specifically. An influential study by Li et al. (2017) found that "EV demand and charging station deployment give rise to feedback loops" and that "subsidizing either side of the market will result in an increase in both EV sales and charging stations."[288] Similarly, Springel (2021) found "evidence of positive feedback effects on both sides of the market, suggesting that cumulative EV sales affect charging station entry and that public charging availability has an impact on consumers' vehicle choice."[289] The BIL and IRA subsidize *both* sides of the market, offering significant incentives for both ZEV purchases and the construction of charging infrastructure. Economic theory therefore supports the proposition that strong final standards, particularly in combination with the BIL and IRA's large financial incentives, will facilitate expansion of charging and grid infrastructure.[290]

Economic theory has in fact played out in Norway, where ZEV sales and infrastructure both expanded rapidly over the span of about a decade. There, the "path to charging point

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Innovation: Controlling Mercury Emissions from Coal-Fired Boilers (Marika Tatsutani & Praveen Amar eds., 2000) https://www.nescaum.org/documents/rpt000906mercury_innovative-technology.pdf.

[284] Gabriela Herculano, *Chicken-and-Egg Problem: EV Adoption and Buildout of Charging Networks*, Nasdaq (Apr. 18, 2022), https://www.nasdaq.com/articles/chicken-and-egg-problem%3A-ev-adoption-and-buildout-of-charging-networks.

[285] Kenneth S. Corts, *Building out alternative fuel retail infrastructure: Government fleet spillovers in E85*, 59 J. Env't Econ. & Mgmt. 219, 219-20 (2009).

[286] *Id.*

[287] *Id.* at 231.

[288] Shanjun Li et al., *The market for electric vehicles: indirect network effects and policy design*, 4 J. Ass'n Env't. & Resources Econ. 89, 128 (2017).

[289] Katalin Springel, *Network Externality and Subsidy Structure in Two-Sided Markets: Evidence from Electric Vehicle Incentives*, 13 Am. Econ. J.: Econ. Pol'y 393, 426 (2021).

[290] *See id.* at 394 (noting that "the presence of positive feedback amplifies the impact of both types of subsidies"), 415 ("positive feedback loops between the charging station network and total all-electric vehicle sales amplify the impact of both types of subsidy").

saturation *started by stimulating more demand for EVs*."[291] In other words, Norway did not wait for infrastructure to fully mature before beginning its transition to cleaner cars. Rather, rising ZEV sales themselves "helped trigger a spike in demand for charging stations."[292]

The concept that charging infrastructure will adequately scale up over time also finds support in an analogous historical example: the buildout of roads and gasoline refueling infrastructure in the early 20th century to serve the United States' growing fleet of automobiles. The country's exponential growth in automobile sales—first exceeding 1,000 in 1899 and growing to 1 million by 1916[293]—preceded the establishment of an extensive network of both suitable roads[294] and filling stations.[295] The buildout of road and refueling infrastructure unfolded over long time horizons and in a variety of ways, adapting to the needs of the automobile fleet as it changed and grew. Paving and other road improvement efforts began on a small scale in cities, where automobiles were initially concentrated; efforts to improve rural roads and construct highways happened a decade or more later, as motorists began to expand their driving beyond cities.[296] Similarly, in the case of refueling infrastructure, a network of modern filling stations did not spring up until well after automobiles had grown in popularity.[297] Before that, refueling needs were met through varied and dispersed "non-station" methods such as cans of gasoline sold at general stores, barrels at repair garages, mobile fuel carts, curb pumps, and home refueling pumps, which emerged at various times as the demand for gasoline increased.[298] Road and refueling infrastructure therefore exhibited a "long-term, adaptive and portfolio approach"[299] that, over the span of several decades, satisfied the shifting needs of the growing ranks of automobile owners.

That approach holds important lessons for this rulemaking. As detailed elsewhere in this comment letter, the introduction of ZEVs into the total on-road fleet will occur gradually. *See* Figure V.C-1 & Figure V.D-1, *supra*; Table XVII.G-1 (L/MD PEVs as a Share of Total On-Road

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[291] Whitney Bauck, *How Norway Became the World's Electric Car Capital*, Nexus Media News (Mar. 7, 2023), https://nexusmedianews.com/how-norway-became-the-worlds-electric-car-capital/.
[292] McKinsey & Co, *What Norway's Experience Reveals About the EV Charging Market* 3 (2023), https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/what-norways-experience-reveals-about-the-ev-charging-market#/.
[293] *Roads*, Encyclopedia.com (May 29, 2018), https://www.encyclopedia.com/science-and-technology/technology/technology-terms-and-concepts/roads.
[294] *See id.* (noting that around 1904, "[o]nly a few hundred miles of roads in the entire country were suitable for motor vehicles"); *see also* F.W. Geels, *The Dynamics of Transitions in Socio-technical Systems: A Multi-level Analysis of the Transition Pathway from Horse-drawn Carriages to Automobiles (1860–1930)*, 17 Tech. Analysis & Strategic Mgmt. 445, 460, 467-68 (2005) (discussing the gradual expansion and improvement of road infrastructure in the 1910s and 1920s to accommodate growth in and changes to automobile travel).
[295] Marc W. Melaina, *Turn of the century refueling: A review of innovations in early gasoline refueling methods and analogies for hydrogen*, 35 Energy Pol'y 4919, 4922 (2007) (noting that "the takeoff period for gasoline stations occurred between 1915 and 1925, but exponential growth in vehicles began around 1910, so the rise of gasoline filling stations followed rather than preceded the rise of gasoline vehicles").
[296] Geels, at 467-68.
[297] Melaina, at 4922.
[298] *Id.* at 4924-27.
[299] *Id.* at 4932 (discussing refueling infrastructure).

L/MD Fleet, 2026-2040), *infra.* Economic theory and historical precedent show that growth in ZEV sales and infrastructure buildout will occur in relative tandem, with infrastructure responding over time commensurate with the evolving needs of the ZEV fleet. And in finalizing these standards, EPA will send a strong market signal that will facilitate infrastructure development at the pace and scale needed to support compliance with the standards. EPA must reject unfounded chicken-and-egg arguments questioning whether infrastructure will respond to rising demand.

B. EPA neglects to account for other significant sources of federal funding for ZEVs and charging infrastructure.

The Proposed Rule states: "The Bipartisan Infrastructure Law (BIL) provides up to $7.5 billion over five years to build out a national PEV charging network."[300] However, as also noted in the Proposed Rule, there are many other programs funded by the BIL that could provide significant additional funding: "Other programs with funding authorizations under the BIL that could be used in part to support charging infrastructure installations include the Congestion Mitigation & Air Quality Improvement Program, National Highway Performance Program, and Surface Transportation Block Grant Program among others."[301] To illustrate the point, consider the two largest programs funded by the BIL, the National Highway Performance Program ($148 billion over five years) and the Surface Transportation Block Grant program ($72 billion over five years). A portion of those funds could be invested in EV charging infrastructure and other investments that reduce emissions by reducing the need to drive. The block grant program is explicitly designed to be versatile and is available for a wide range of uses. In fact, it was originally created in the 1991 transportation law to encourage states to move beyond the interstate highway-building era into investments in other improvements to our transportation system,[302] and Congress has added more uses since then. If, say, 20% of the funding provided by just those two programs were directed to EV charging infrastructure, it would provide $44 billion in additional federal funding.[303]

And even without accounting for a portion of the National Highway Performance Program and Surface Transportation Block Grant (the two largest funding allocations made by the BIL), Atlas Public Policy's inventory reveals there is a total of over $50 billion in BIL funding for which ZEVs and charging infrastructure are eligible expenses (see Figure XVII.B-1 below).

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[300] 88 Fed. Reg. at 29307.
[301] *Id.* at 29308.
[302] Ellen Schweppe, Legacy of A Landmark: ISTEA After 10 Years (2001), at https://highways.dot.gov/public-roads/novemberdecember-2001/legacy-landmark-istea-after-10-years (last accessed June 30, 2023).
[303] *See* Deron Lovaas & Max Baumhefner. What if States Turn Pavement Into Charging Stations? (May 16, 2022), at https://www.nrdc.org/bio/deron-lovaas/what-if-states-turn-pavement-charging-stations (last accessed June 30, 2023).

Figure XVII.B-1: ZEV Funding in the Bipartisan Infrastructure Law[304]

C. The Alternative Fuel Refueling Property Tax Credit extended by the IRA is not restricted to rural areas, but instead to areas that are not urban.

The Proposed Rule states that under the IRA, "residents in low-income or rural areas would be eligible for a 30% credit for the cost of installing residential charging equipment up to a $1,000 cap."[305] However, the word "rural" does not appear in IRA § 30C, which defines "eligible census tracts" for the Alternative Fuel Vehicle Refueling Property credit "as any census tract which (I) is described in § 45D(e), or (II) is not an urban area."[306] The distinction is important because there are many areas that have not been classified as rural that cannot rightly be classified as urban. For example, if the U.S. Department of the Treasury classifies a census tract as not urban if more than 10% of the blocks within the census tract are designated as rural census blocks (to ensure those who live in rural blocks are not unduly denied access just because they happen to live next to urban blocks), tens of millions more Americans and businesses would have access to these important tax credits. This approach has been recommended to Treasury by a diverse coalition of industry associations, individual companies, environmental, consumer, and environmental justice groups, and other stakeholders.[307] EPA should correct its characterization of § 30C and should convey to Treasury that adopting the broadly-supported approach described above would support strong vehicle standards.

304 Atlas Public Policy, Infrastructure Investment and Jobs Act (H.R. 3684), at https://www.atlasevhub.com/materials/invest-in-america-act-h-r-3684/ (last accessed June 30, 2023).
305 88 Fed. Reg. at 29308.
306 26 U.S.C. § 30C(c)(3)(B).
307 Ltr. from Max Baumhefner et al. to U.S. Dep't of the Treasury, June 2023 (attached to this comment letter; signatories include Natural Resources Defense Council, Alliance for Automotive Innovation, American Council on Renewable Energy, Ample, CALSTART, ChargePoint, Clean Energy Works, Earthjustice, Elders Climate Action, Electrification Coalition, Environmental Defense Fund, EV Charging for All, EVBox, Forth Mobility, Green Latinos, International Brotherhood of Electrical Workers, International Parking & Mobility Institute, Itselectric, League of Conservation Voters, National Association of Convenience Stores, National Consumer Law Center, NATSO, Navistar, Plug in America, Representing America's Travel Plazas and Truck Stops, Rivian, Sierra Club, SIGMA: America's Leading Fuel Marketers, TeraWatt, Transportation for America, Union of Concerned Scientists, and Volvo Group North America).

D. A more complete inventory reveals $67 billion in announced investments in charging infrastructure, including $33 billion dedicated to light-duty vehicles and $4 billion that could support light-duty vehicles.

EPA also correctly identifies that there has been "rapid growth in the broader market for charging infrastructure serving cars or other electric vehicles."[308] New charging infrastructure announcements are occurring every week, showing the public and private sectors' commitment to building out infrastructure to support vehicle electrification. The Proposed Rule's description of recently announced investments in charging infrastructure underscores the fact that significant progress is being made.[309] However, this narrative should be supplemented by a more comprehensive inventory of the public, private, and utility sectors. As of March 31, 2023, Atlas Public Policy (Atlas) estimates $67 billion dollars in charging infrastructure investments that have been announced by the public, private, and utility sectors but not yet installed as charging ports in the ground.[310] Table XVII.D-1 provides a summary of tallied investment amounts, which include:

- $33 billion in announced, unspent investments for LDV charging;
- $30 billion in announced, unspent investments for medium- and heavy-duty vehicle charging; and
- $4 billion in announced, unspent investments for use across any vehicle class.

Table XVII.D-1: Estimated U.S. Charging Infrastructure Investments Announced but Not Yet In the Ground, as of March 31, 2023

Investments Announced ($ millions)				
Funding Sector	**Funding available only for light-duty vehicle charging**	**Funding available for light-duty, medium-duty or heavy-duty vehicle charging**	**Funding available only for medium- and heavy-duty vehicle charging**	**Total**
Public	$22,263	$4,360	$20,562	$47,186

[308] U.S. EPA, Greenhouse Gas Emissions Standards for Heavy-Duty Vehicles—Phase 3, 88 Fed. Reg. 25926, 25934 (Apr. 27, 2023).
[309] 88 Fed. Reg. at 29308-09.
[310] Atlas Pub. Pol'y, *Announced EV Infrastructure Funding* (June 15, 2023).

Private (Non-Utility) [incomplete tally]	$6,254		$4,292	$10,546
Low Carbon Fuel Standard [2023 – 2032]	$2,941		$3,278	$6,219
Utility	$1,886		$1,402	$3,288
Grand Total	**$33,344**	**$4,360**	**$29,534**	**$67,239**

These totals include public sector (e.g., Charging and Fueling Infrastructure Discretionary Grant funding, state funding commitments, and modeled estimates of 26 U.S. Code § 30C tax credit payments), private sector (e.g., automaker and charging service provider), and utility program investments.[311]

Even Atlas's tally of private sector commitments is likely incomplete. Private sector actors often do not announce their investment plans, and are especially unlikely to do so if they are investing in home, depot, or workplace charging. Tallied private sector commitments *exclude* an estimated $3.0 billion in capital raised by charging companies (including ChargePoint, EVgo, Blink, and Volta), some percentage of which is expected still to be invested in charging hardware and installation.

The scale of these announced investments reflects a strong and growing deployment of public and private charging infrastructure that, even in advance of the finalization of the Proposed Standards, has begun to set the stage for a robust charging network. Additional analyses have emphasized the growing momentum in infrastructure deployment; for example, an International Energy Agency report noted that "there has been a substantial upswing in investment in EV charging infrastructure, which has doubled in 2022 compared to the previous year."[312]

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[311] Note that these figures do not include funding for hydrogen fuel cell vehicles. Regarding the § 30C tax credit, Atlas assumes that 1) all qualifying projects receive the tax credit, 2) on average, qualifying projects will receive tax credits worth 18% of covered costs, and 3) that Treasury will classify a census tract as not urban if more than 10% of the blocks within the census tract are designated as rural census blocks, as recommended by multiple stakeholders described in Section XVII.C. The estimated Low Carbon Fuel Standard value is based on modeling from Dean Taylor Consulting for California, Oregon, and Washington and does not include capacity credits. It uses a 2023 – 2032 EV adoption trajectory for those three states that meets President Biden's LDV goal of 50% ZEV sales share by 2030 (which is lower than the trajectory modeled in the EPA's proposed vehicle emission standards), an MDHD EV adoption curves modeled on the EPA's proposed emissions regulations for MD and HD vehicles, and modeling from Atlas's INSITE tool of MWh demanded by MDHD vehicles. Utility program investments include approved investor-owned utility programs with an EV charging element. Amounts are unspent program dollars as of the most recent program report available as of March 31, 2023. If no program report was available, Atlas used the percentage of time remaining in the approved program schedule to estimate the unspent proportion of program funding.

[312] IEA, *World Energy Investment 2023*, at 50 (2023), https://iea.blob.core.windows.net/assets/54a781e5-05ab-4d43-bb7f-752c27495680/WorldEnergyInvestment2023.pdf

E. Increased access to Tesla's large and growing supercharger network will accelerate PEV adoption.

Recent announcements from Tesla, Ford, GM, Rivian, and Volvo that will allow more drivers to access Tesla's SuperCharger network bolster the case for strong vehicle standards. As shown in Figure XVII.E-1 and Figure XVII.E-2, this effectively doubles the number of public fast charging locations and connectors available to a majority of the EV market.

Figure XVII.E-1: J1772Combo and Chademo DC Fast Charging Ports[313]

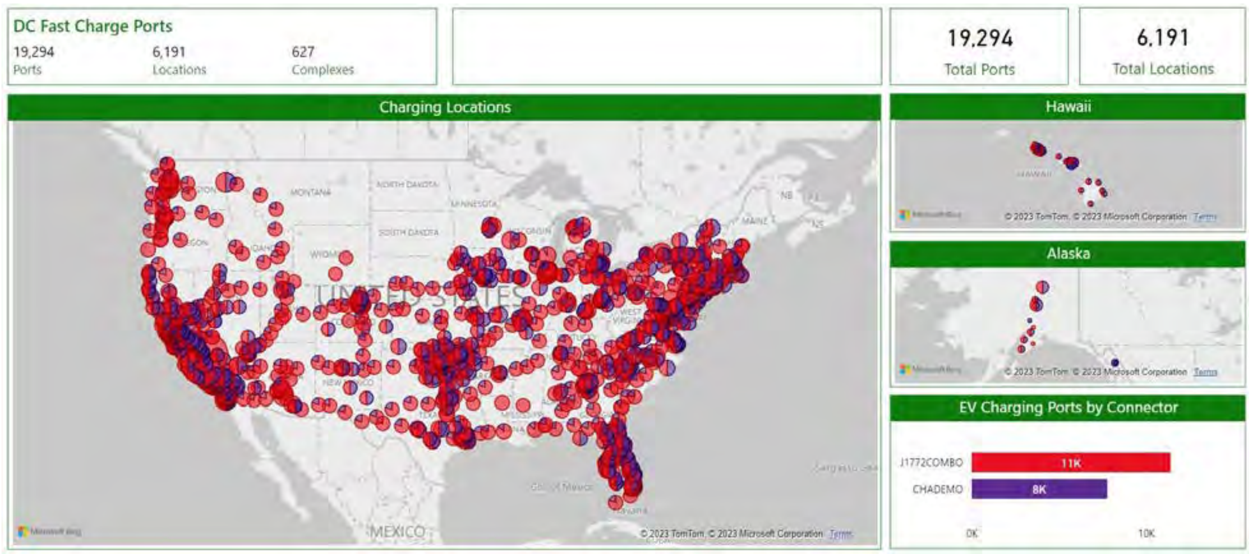
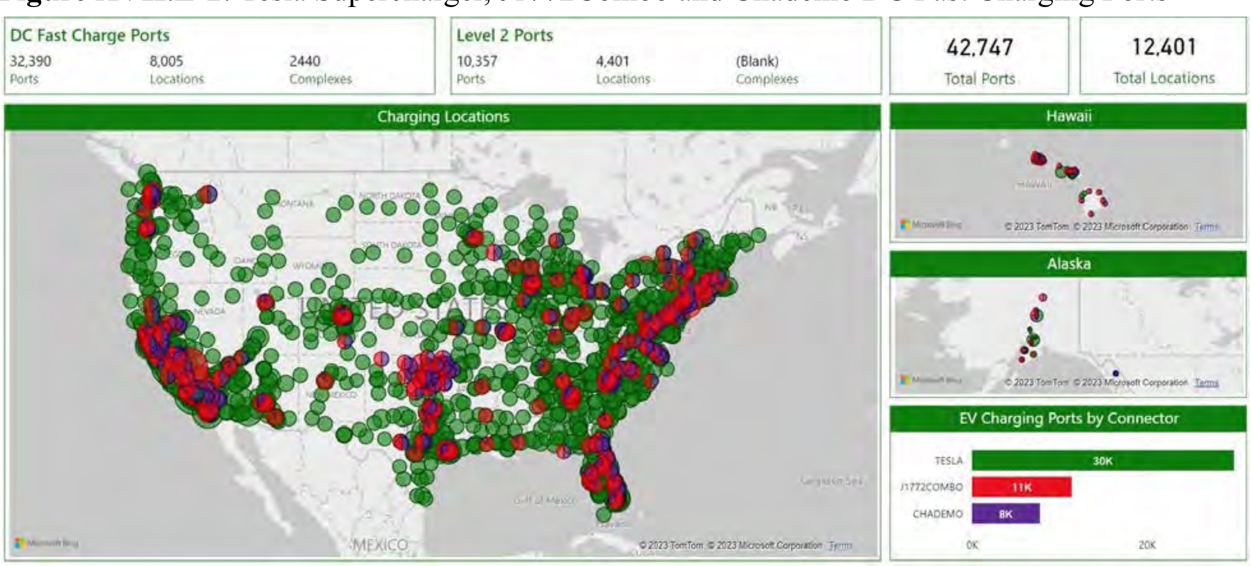


Figure XVII.E-2: Tesla Supercharger, J1772Combo and Chademo DC Fast Charging Ports[314]



[313] Atlas Public Policy, EV Hub (June 27, 2023) available at https://www.atlasevhub.com/materials/ev-charging-deployment/ (subscription required).
[314] *Id.*

F. Barriers to the installation of charging infrastructure identified in the Proposal are being removed.

Barriers to the timely installation of charging infrastructure are being removed, which will allow investments at an even greater pace and scale.

Most of the challenges associated with energizing charging infrastructure in a timely manner are being faced in California, which has to date the highest percentage of electric LDVs on the road. Thankfully, a state law enacted in 2022 provides California's investor- and publicly-owned utilities with data necessary to inform grid planning to accommodate high levels of EV charging, requires those utilities to propose proactive grid investments in their General Rate Cases to comply with ZEV regulations (as well as a long list of other laws, standards, and requirements), and directs the California Public Utilities Commission (CPUC) and local utility governing boards to ensure the proposed investments are consistent with achieving the state's goals and regulations.[315] In May 2023, Southern California Edison (SCE) filed its General Rate Case, which includes such proactive investments.[316]

In addition, the California Senate recently voted 32-to-8 to advance new legislation (Senate Bill 410, "Powering Up Californians Act") that builds upon existing law to accelerate short-term energization timelines for EV charging and to ensure timely grid investments needed to electrify "light-duty, medium-duty, and heavy-duty vehicles and off-road vehicles, vessels, trains, and equipment" consistent with state law requiring economy-wide carbon neutrality by 2045, and "federal, state, regional, and local air quality and decarbonization standards, plans, and regulations."[317] The legislation also establishes a balancing account to recover associated costs, which would ensure that Pacific Gas & Electric (PG&E) and San Diego Gas & Electric (SDG&E) do not have to wait several years for their next General Rate Cases to propose investments like those recently proposed by SCE (and it would also allow SCE to propose subsequent investments before its next rate case that could not be predicted when its current rate case was filed).

Utilities across the country are also already planning for and deploying solutions to address increased vehicle electrification as their customers adopt PEVs to improve fleet economics and performance. Utilities and their customers will benefit from the ability to plan ahead for any significant infrastructure requirements. The regulatory certainty provided by this rulemaking can aid this planning.

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[315] California Assembly Bill 2700 Transportation electrification: electrical distribution grid upgrades. (2021-2022). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB2700.

[316] Southern California Edison, What you should know about SCE's general rate case (May 2023), at https://energized.edison.com/stories/sce-details-investments-to-advance-electric-grid-reliability-resilience-and-readiness (last accessed June 30, 2023).

[317] California Senate Bill 410. (2023). https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202320240SB410.

Regulatory certainty can also help ensure that investments not only maintain strong electric service but improve it, while at the same time lowering costs. SCE President and CEO Steve Powell noted: "if we leverage the electric vehicle load and have that work for consumers as well, that whole idea of vehicle-to-grid, there can be real value in helping alleviate a lot of the infrastructure investments that need to happen," ultimately lowering overall energy bills for customers.[318] Similarly, Seattle City Light, in its Transportation Electrification Strategic Investment Plan, stated that "[w]hile there are system costs associated with increased transportation electrification (e.g., distribution and transmission infrastructure upgrades), with proactive utility planning and intervention, the system benefits (e.g., new revenue) are estimated to outweigh the costs, spreading the economic benefits of transportation electrification to all customers."[319] This will require action from regulators as well to help shape and approve these proactive and critical investments. As RMI recommended, "regulators can fulfil [sic] their responsibility for ensuring prudent and least-cost grid investments while proactively planning by using new information."[320]

In addition, the historic investments of the BIL and IRA are helping utilities build a stronger, cleaner grid and prepare for advanced electrification while minimizing customer costs. Duke Energy, for example, has stated that "[the BIL] provides an important down payment on the infrastructure and incentives that are needed to electrify transportation and secure the grid," and "[the IRA] can create significant cost savings for our customers."[321] New York utilities have indicated that they will be applying for $900 million in grants from the BIL and IRA to advance grid resilience.[322] National Grid in particular notes that "EV charging make-ready infrastructure is identical to electric infrastructure that serves other purposes, this is the kind of work electric utilities do every day,"[323] and that "areas of the [BIL] funding are enabling increased investment."[324]

Grid operators around the country are also beginning to incorporate EV planning into existing planning structures. For example, the Minnesota Public Utilities Commission has shifted investor-owned utility transportation electrification planning and reporting requirements to the integrated distribution planning process to account for increasing linkages between EV planning

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[318] Casey Wian, *Transportation Electrification Gains Momentum: Edison International and SCE outline plans to seize the "huge opportunity" of preparing the grid for exponential EV growth*, Energized, (Feb. 1, 2023), https://energized.edison.com/stories/transportation-electrification-gains-momentum.

[319] Seattle City Light, *Transportation Electrification Strategic Investment Plan* 6 (not dated), https://www.seattle.gov/documents/Departments/CityLight/TESIP.pdf.

[320] Ari Kahn et al., RMI, *Preventing Electric Truck Gridlock: Meeting the Urgent Need for a Stronger Grid* 16 (2023), https://rmi.org/insight/preventing-electric-truck-gridlock/.

[321] Jennifer Loraine, *Policy can have a crucial impact on our clean energy future*, Duke Energy News Center (Jan. 20, 2023), https://news.duke-energy.com/our-perspective/policy-can-have-a-crucial-impact-on-our-clean-energy-future.

[322] John Norris, *NY Utilities to Seek $900M from DOE*, RTO Insider, (Mar. 28, 2023), https://www.rtoinsider.com/articles/31898-ny-utilities-seek-900m-from-doe.

[323] Comments of National Grid to USDOT/FHWA on Docket No. FHWA-2021-0022, at 11 (Jan. 26, 2022), https://downloads.regulations.gov/FHWA-2021-0022-0150/attachment_1.pdf.

[324] *Id*. at 10.

and distribution system planning.[325] Incorporating robust EV planning in existing planning structures can help ensure those processes account for EV adoption, even where the utility business units responsible for those areas of planning may be distinct. Furthermore, combined planning processes can create administrative efficiencies that help expedite time-sensitive planning needs. On the transmission planning side, regional grid operators, such as the Midcontinent Independent System Operator, have already begun to think about how transportation electrification will affect total energy needs and the timing of annual peaks in electricity demand.[326] Strong vehicle standards give grid operators a reliable EV forecast against which to plan in processes that are already underway.

Finally, parties are working across sectors and industries to reduce barriers to charging deployment. Utilities, public utility commissions and other state regulators, grid operators, charging providers, and others can and have already begun to coordinate and plan for increased vehicle electrification. Examples include:

- The National Charging Experience Consortium (ChargeX) is a collaborative effort between Argonne National Laboratory, Idaho National Laboratory, NREL, BEV charging industry experts, consumer advocates, and other stakeholders whose mission is "to work together as BEV industry stakeholders to measure and significantly improve public charging reliability and usability by June 2025."[327]
- The National EV Charging Initiative brings together automakers, power providers, PEV and charging industry leaders, labor, and public interest groups to "develop a national charging network for light, medium, and heavy-duty vehicles and inspire deeper commitments from state leaders, the administration and each other."[328]
- The National Association of State Energy Officials and the American Association of State Highway and Transportation Officials partnered with the U.S. Joint Office of Energy and Transportation to hold a series of convenings to coordinate on a range of topics, including ZEV infrastructure and utility planning needs.[329]

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[325] Minn. Public Utilities Comm'n, Order (Dec. 8, 2022). In the Matter of a Commission Inquiry into Electric Vehicle Charging and Infrastructure (Docket No. E999/CI-17-879), In the Matter of Minnesota Power's 2021 Integrated Distribution System Plan (Docket No. M-21-390), In the matter of Distribution System Planning for Otter Tail Power Company (Docket No. 21-612), In the matter of Xcel Energy's 2021 Integrated Distribution System Plan (Docket No. (21-694).
https://www.edockets.state.mn.us/edockets/searchDocuments.do?method=showPoup&documentId={30E7F284-0000-C433-8FFA-298183EBEB26}&documentTitle=202212-191192-02.

[326] MISO Electrification Insights (April 2021), at 10, 14-15, available at https://cdn.misoenergy.org/Electrification%20Insights538860.pdf.

[327] Idaho Nat'l Lab'y, *National Charging Experience Consortium*, https://inl.gov/chargex/ (last visited June 13, 2023).

[328] EV Charging Initiative, https://www.evcharginginitiative.com/ (last visited June 13, 2023).

[329] Nat'l Ass'n State Energy Officials (NASEO) & the Am. Ass'n State Highway & Transp. Officials (AASHTO), *Building a National Electric Vehicle Charging Infrastructure Network: Regional EV Meetings Key Themes, Takeaways, and Recommendations from the States* (not dated),

These convenings brought together State Departments of Transportation officials, State Energy Offices, and other key partners.

- PG&E and BMW of North America are testing a "vehicle-to-everything technology that will improve grid reliability and help EV customers lower their electric bills by exporting power back to the grid during peak demand periods." PG&E notes that "[t]he utility and automotive industries are creating a transformative clean energy future together."[330]
- NREL and Volvo collaborated on a research paper regarding challenges and opportunities of commercial ZEVs, noting:

> Coordination between disparate and historically unconnected stakeholders, including state agencies, local governments, automotive manufacturers, fleets, energy infrastructure and utility companies, and research and academia will be required to ensure a smooth and timely transition to ZEVs. This paper, a joint research and industry perspective, is one such example of cross-sectoral collaboration.[331]

These examples show that the relevant stakeholders are already stepping up to plan for and accommodate the charging and grid needs associated with greater vehicle electrification.

Fundamentally, charging infrastructure challenges are being addressed, as evidenced by the progress described above. We are not starting from scratch and do not need to replicate the gasoline and diesel refueling network to electrify vehicles. The electric grid is already nearly ubiquitous; it only needs to be extended at the fringes. These actions benefit utility shareholders and customers alike by removing barriers to investment in charging infrastructure. As explored in more detail below, America's utilities have a long history of accommodating significant growth.

In sum, the private and federal infrastructure investments EPA has identified justify strong standards, and barriers to additional investment are actively being removed. Furthermore, as noted above, EPA's inventory of federal, public, and private investments that already justifies increasingly stringent vehicle standards is incomplete; and a more complete inventory justifies stronger standards.

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https://www.naseo.org/data/sites/1/documents/publications/NASEO_AASHTO_Regional%20EV%20Meetings%20Summary_%20Final.pdf.

[330] BMW Group, *More Power To You: BMW of North America and PG&E Start V2X Testing in California* (May 16, 2023), https://www.press.bmwgroup.com/usa/article/detail/T0417218EN_US/more-power-to-you:-bmw-of-north-america-and-pg-e-start-v2x-testing-in-california.

[331] Matteo Muratori, et al., *Road to zero: Research and industry perspectives on zero-emission commercial vehicles*, iScience, May 19, 2023, https://www.cell.com/action/showPdf?pii=S2589-0042%2823%2900828-3, at 7.

G. EPA's conclusion that LDV charging will not compromise the reliability of the electric grid is supported by empirical data.

EPA observes that LDV charging is not anticipated to adversely impact electric grid reliability:

> U.S. electric power utilities routinely upgrade the nation's electric power system to improve grid reliability and to meet new electric power demands. For example, when confronted with rapid adoption of air conditioners in the 1960s and 1970s, U.S. electric power utilities successfully met the new demand for electricity by planning and building upgrades to the electric power distribution system. Likewise, U.S. electric power utilities planned and built distribution system upgrades required to service the rapid growth of power-intensive data centers and server farms over the past two decades. U.S. electric power utilities have already successfully designed and built the distribution system infrastructure required for 1.4 million battery electric vehicles. Utilities have also successfully integrated 46.1 GW of new utility-scale electric generating capacity into the grid.[332]

These conclusions are supported by empirical evidence from California, which already has more than 1.3 million PEVs on the road.[333] While some pundits have claimed EV charging is already straining the grid, triggering service disruptions, those claims have been debunked.[334] And root cause analysis from the California Independent System Operator (California ISO) showed that PEVs are not what has strained the grid.[335] Indeed, empirical evidence shows that PEV charging has been accommodated with minimal required grid upgrades and that EV charging can be shifted to hours of the day when there is plenty of spare grid capacity. Since 2011, CPUC has required the utilities it regulates to report annually on costs associated with accommodating PEV charging and on the charging patterns of PEVs on different utility rates.[336] As summarized by Synapse Energy Economics, utility grid upgrades required to accommodate PEV charging to this point in those service territories are essentially rounding errors compared to the costs of maintaining the electrical grid:

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[332] 88 Fed. Reg. at 29311 (citations omitted).

[333] Alliance for Automotive Innovation, *Electric Vehicle Sales Dashboard*, https://www.autosinnovate.org/resources/electric-vehicle-sales-dashboard.

[334] Dustin Gardiner, *No, Newsom's Push for Electric Cars Isn't the Cause of Potential Blackouts in California*, San Francisco Chronicle (Sept. 7, 2022), https://www.sfchronicle.com/politics/article/No-Newsom-s-push-for-electric-cars-isn-t-the-17426102.php.

[335] California ISO, *Root Cause Analysis: Mid-August 2020 Extreme Heat Waive* (Jan. 13, 2021), http://www.caiso.com/Documents/Final-Root-Cause-Analysis-Mid-August-2020-Extreme-Heat-Wave.pdf.

[336] S. Cal. Edison Co., San Diego Gas & Elec. Co. & Pac. Gas & Elec. Co., *Joint IOU Electric Vehicle Load Research and Charging Infrastructure Cost Report 10th Report* (Mar. 31, 2022), https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/transportation-electrification/10th-joint-iou-ev-load-report-mar-2022.pdf.

> Even in the service territories with the most EVs, the observed costs have been minor. For instance, in California where EV adoption has been markedly higher than other states, EV-related distribution upgrade costs appear minor compared to total distribution costs. Despite the fact EVs are often more concentrated in many neighborhoods and distribution circuits, California utilities collectively spent less than 0.03% of their total distribution-related expenses on distribution system upgrades associated with residential EV adoption.[337]

Furthermore, as detailed below, the projected growth in electricity demand over the coming years is well within the range of past historical load growth. Additionally, the industry is already responding to and preparing for increased electrification as more fleets and individuals adopt PEVs, and it has a wide range of tools, practices, and partnerships in place to continue to maintain a strong and reliable grid.

1. Electric system impacts will be gradual and within the range of historical growth.

When considering infrastructure buildout, it is important to remember that L/MD PEVs will enter the total on-road L/MD fleet gradually and in volumes that will remain below in-use L/MD combustion vehicles for the foreseeable future. EPA's data show that the Proposed Standards, if finalized, would likely result in PEVs comprising just 5% of the total on-road L/MD fleet by 2027, gradually reaching 20% in 2032 and 43% in 2040. Similarly, under the more stringent standards we recommend in this comment letter, the transition of the on-road L/MD fleet to PEVs would be gradual, reaching 22% in 2032 and 49% in 2040 (Table XVII.G-1). In other words, a relatively small portion of the L/MD fleet will be tapping into charging and grid infrastructure over the next decade, and even by 2040, L/MD PEVs would comprise less than half of the on-road fleet under this rulemaking. Infrastructure needs for L/MD PEVs will accordingly grow gradually over time.

Table XVII.G-1: L/MD PEVs as a Share of Total On-Road L/MD Fleet, 2026-2040

Year	EPA No Action	EPA Main Proposal	Alt 1+
2026	3.1%	3.1%	3.1%
2027	4.6%	5.2%	5.2%
2028	6.3%	7.6%	7.7%

[337] Melissa Whited, Tyler Fitch, Jason Frost, Eric Borden, Courtney Lane, Ben Havumaki, Sarah Shenstone-Harris & Elijah Sinclair, *Electric Vehicles Are Driving Rates Down* (June 2023), https://www.synapse-energy.com/sites/default/files/Electric%20Vehicles%20Are%20Driving%20Rates%20Down%20Factsheet.pdf (citations omitted).

2029	8.3%	10.5%	10.6%
2030	10.3%	13.7%	14.0%
2031	12.3%	17.0%	17.7%
2032	14.2%	20.4%	21.6%
2033	16.0%	23.7%	25.5%
2034	17.8%	26.9%	29.3%
2035	19.5%	30.0%	32.9%
2036	21.1%	33.0%	36.4%
2037	22.7%	35.9%	39.8%
2038	24.1%	38.6%	43.0%
2039	25.4%	41.1%	46.0%
2040	26.6%	43.4%	48.8%

Additionally, projected growth in electricity demand over the coming years, including demand related to PEV deployment in line with strengthened L/MD standards as well as additional economy-wide load growth, is well within the range of past historical load growth. EPA provides estimates of system-wide demand, including L/MD PEVs, under both No Action (i.e., baseline) and the Proposed Standards. DRIA at 5-14. These values show that system-wide increases in demand, including both increased demand from the Proposed Standards (assuming EPA finalizes the stringency levels it has proposed) and projected economy-wide load growth, is projected to average 1.6% per year between 2028 and 2040. Furthermore, based on analysis conducted by ERM (see Section V above), it is expected that incremental annual average electricity demand growth associated with PEV penetration in line with Alternative 1+, as compared to EPA's Proposed Standards, would be minimal—i.e., around or less than one tenth of a percentage point.

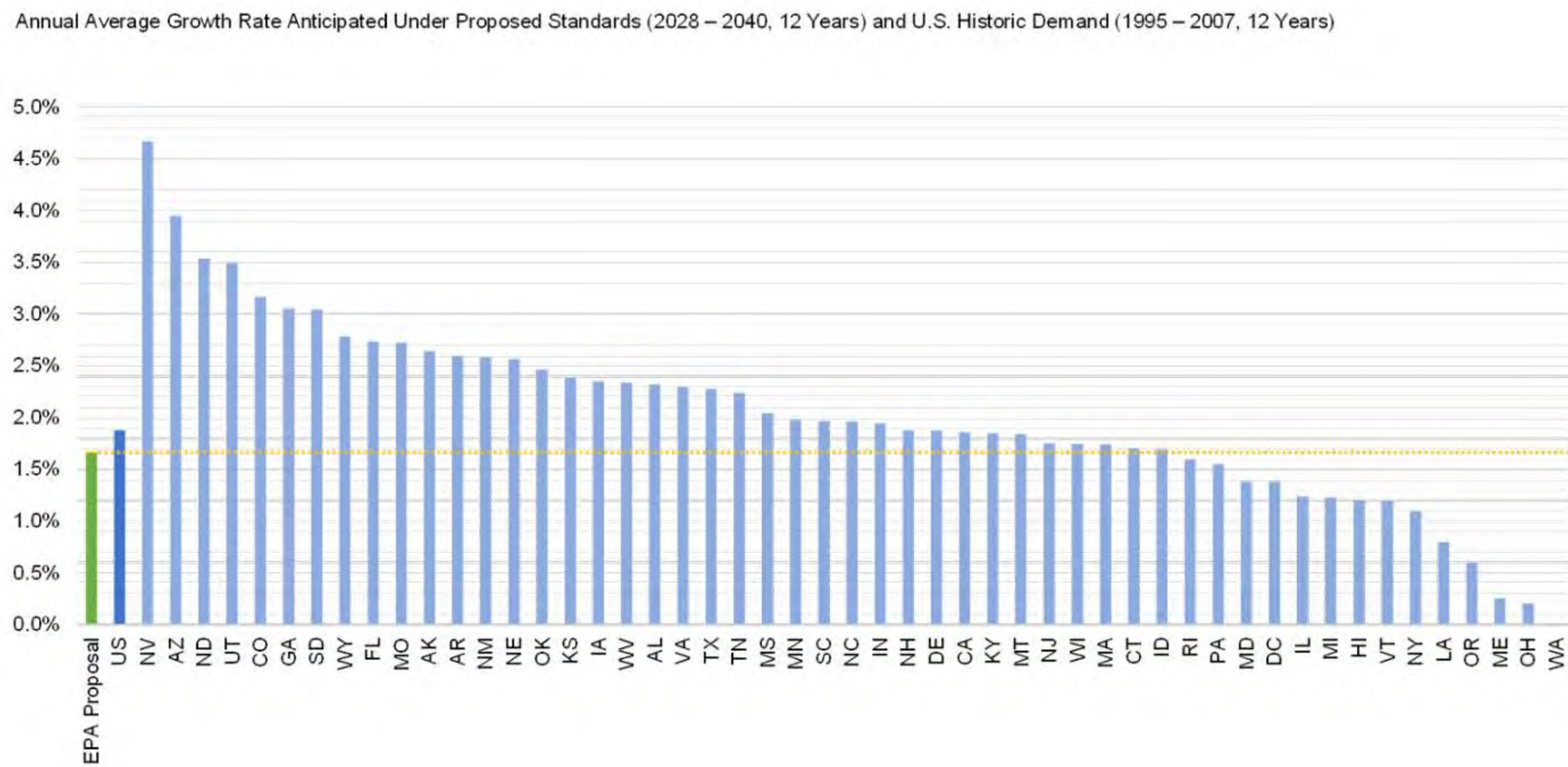
Maintaining reliable and safe electric power delivery through this level of demand growth, as well as higher levels of growth resulting from more stringent standards, is within electric utility standard practice as demonstrated through the electric power sector's strong track record of reliability and resiliency. These annual generation increases are well within the range of contemporary, normal operations for the U.S. electric sector (see Figure XVII.G-1 below). According to data reported to the Energy Information Administration in Form 861, in the 31 years from 1990 to 2021, average annual national growth in electricity sales was 1.1%. In 15 of those years, growth was 1.5% or higher, and in ten years it exceeded 2%. The U.S. has also seen previous periods of sustained high demand growth across most states; for example, 1995 to 2007 saw average nationwide growth of approximately 1.9% per year.

Many states saw much higher, sustained levels of growth. In the two decades from 1999 to 2018, North Dakota electric sales more than doubled. Year over year growth averaged nearly 5%, and in 2014 electric sales were 14% higher than the previous year alone. In Nevada between 1992 and 2007, annual electric sales growth averaged 4.9% and fell below 1.5% only once. More recently, Virginia has seen strong annual sales growth, with sales increasing 12.3% in the five years from 2016 to 2021, or 3% on average per year, even accounting for a pandemic dip.

This analysis draws similar conclusions to those of the researchers at the Electrification Futures Study, a multi-year research project to explore potential widespread electrification in the future energy system of the United States. In a report developing an integrated understanding of how the potential for electrification might impact the demand side in all major sectors of the U.S. energy system—transportation, residential and commercial buildings, and industry—this study concluded that "[e]lectrification has the potential to significantly increase overall demand for electricity, although even in the High scenario, compound annual electricity consumption growth rates are below long-term historical growth rates."[338] And costs associated with integrating PEV charging onto the grid can also be minimized with effective load management programs, as described immediately below.

[338] Trieu Mai et al., NREL, *Electrification Futures Study: Scenarios of Electric Technology Adoption and Power Consumption for the United States* (2018), https://www.nrel.gov/docs/fy18osti/71500.pdf.

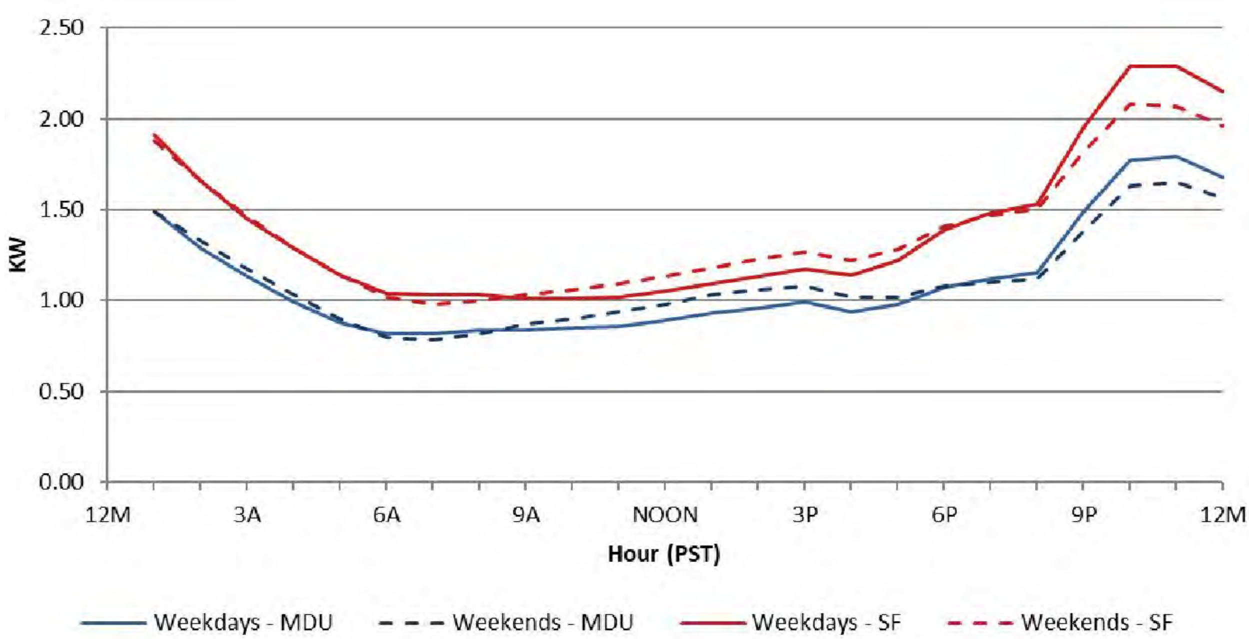
Figure XVII.G-1: Projected Demand Growth Rates Under Proposed Standards Compared to U.S. Historic Rates



2. Time-of-use electric rates are extremely effective at pushing PEV charging to hours of the day when there is plenty of spare grid capacity.

Real-world data from hundreds of thousands of PEVs reveals that time-of-use (TOU) electricity rates work. At the time the data described below was collected, SCE estimated there were 329,940 PEVs in its service territory (through December 31, 2021).[339] Figure XVII.G-2 shows the load profile of households in SCE territory with EVs, with a readily discernible uptick in electricity demand after 9PM (when the on-peak period ends on the time-of-use rates) as a result of PEV charging that increases until just before midnight and trails off in the early morning hours as those PEVs complete their charging.

Figure XVII.G-2. Load Profile of Households with PEVs on a TOU Rate in SCE Territory[340]

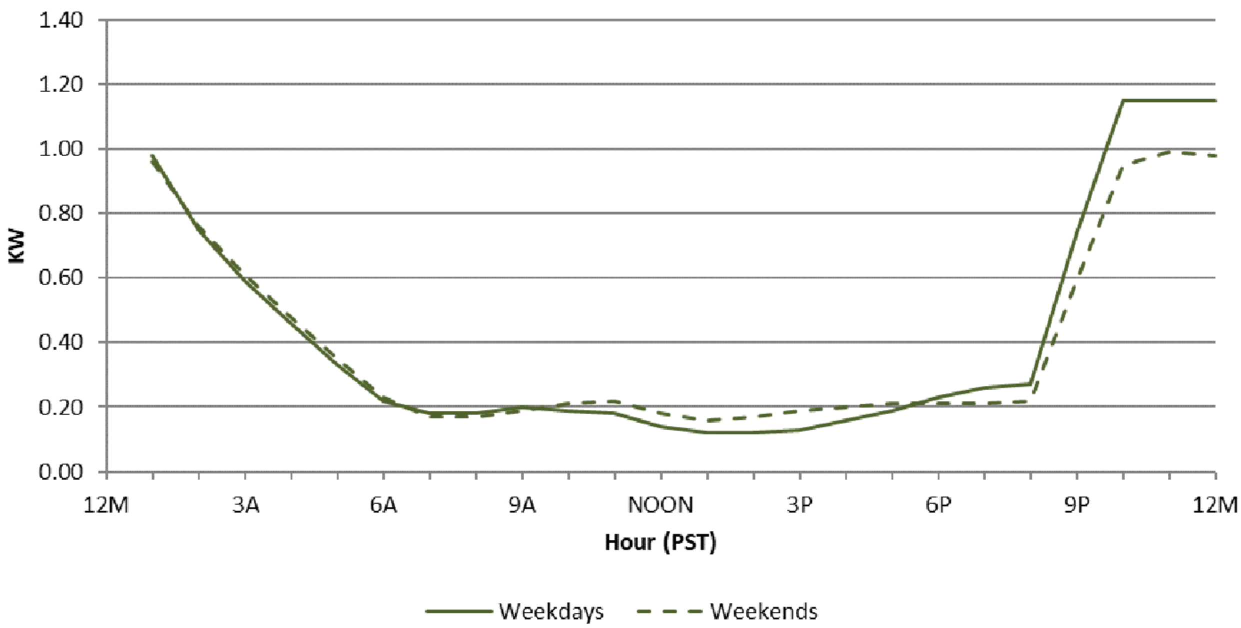


The impact of TOU rates is even more self-evident in Figure XVII.G-3, which isolates PEVs on separate meters, demonstrating that PEVs charge almost exclusively after 9 PM on that TOU rate.

[339] S. Cal. Edison Co., San Diego Gas & Elec. Co. & Pac. Gas & Elec. Co., *Joint IOU Electric Vehicle Load Research and Charging Infrastructure Cost Report 10th Report* Sec. VI Att. 2 - SCE (Mar. 31, 2022), https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/transportation-electrification/10th-joint-iou-ev-load-report-mar-2022.pdf.

[340] *Id.* at 59.

Figure XVII.G-3: Load Profile of PEVs on a Separately Metered TOU Rate in SCE Territory[341]



The figures above represent real-world data collected from hundreds of thousands of households with PEVs. There is no need to test the proposition that simple TOU rates designed for PEVs work.

The combination of TOU rates and more active means of managing PEV charging can yield even greater benefits. Researchers from NRDC, Lawrence Berkeley National Laboratory, and Pacific Gas & Electric found that well-designed TOU rates could allow the utility's system to accommodate universal light-duty BEV adoption with minimal associated costs.[342] This peer-reviewed study used real-world data on the distribution grid and BEVs to simulate what would happen if every household in a major metro area had a BEV, and found that more comprehensive load management could essentially prevent all otherwise necessary grid upgrades.[343]

3. EVs can lower the cost of managing an increasingly dynamic electric grid.

Third-party analyses have found that PEVs, if deployed strategically, can improve grid operations. For example, PEVs can "contribute significantly to grid stability" and provide value to the grid through "deferred or avoided capital expenditure on additional stationary storage,

[341] *Id.* at 60.
[342] Jonathan Coignard et al, *Will Electric Vehicles Drive Distribution Grid Upgrades?: The Case of California*, 7 IEEE Electrification Mag. 2, 55-56 (June 5, 2019).
[343] *Id.*

power electronic infrastructure, transmission build-out, and more."[344] Additionally, utilities can deploy proven and emerging rate designs that ensure utilities recover costs, reliably serve PEV charging load, improve PEV owner experience, and take advantage of grid strengthening services from these vehicles.[345]

Researchers from Lawrence Berkeley National Laboratory estimate that using smart charging of light-duty PEVs as a means to comply with California's energy storage procurement mandate (designed to facilitate the integration of renewable energy) would save utility customers approximately $1.5 billion because it is cheaper to use batteries customers have already purchased on four wheels than to pay private companies to deploy standalone battery storage.[346] The same study also found that enabling "vehicle-to-grid" (V2G) technology, allowing PEVs to supply power back to the grid during times of stress, could save $13-15 billion in stationary battery costs.[347] "By displacing the need for construction of new stationary grid storage, EVs can provide the dual benefit of decarbonizing transportation while lowering the capital costs for widespread renewables integration," the researchers concluded.[348]

Focusing on the Midwest to underscore the point, researchers concluded that very high levels of renewable energy penetration in the Midcontinent Independent System Operator region could result in "negative valleys" (requiring excess renewable energy to be exported or curtailed), but that "[c]ontrolled (EV) charging [both smart charging and smart discharging back onto the grid] is able to reduce these negative valleys, and with sufficient numbers of EVs can eliminate them altogether, obviating the need for either export of excess renewable generation or curtailment."[349] This would provide both increased environmental benefits by facilitating the

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[344] Chengjian Xu et al., *Electric vehicle batteries alone could satisfy short-term grid storage demand by as early as 2030*, Nature Commc'n, Jan. 17, 2023, at 1, https://doi.org/10.1038/s41467-022-35393-0.
[345] *See e.g.,* Brittany Blair et al., Smart Electric Power Alliance, *Managed Charging Programs: Maximizing Customer Satisfaction and Grid Benefits* (2023), https://sepapower.org/resource/managed-charging-programs-maximizing-customer-satisfaction-and-grid-benefits/; Enel-X, *Understanding Smart EV Load Management* (Apr. 8, 2022), https://info.evcharging.enelx.com/whitepaper-download-ev-load-management-utility-dive; Zachary Needell, Wei Wei & Jessika E. Trancik, *Strategies for beneficial electric vehicle charging to reduce peak electricity demand and store solar energy*, CELL REPS. PHYSICAL SCI., Mar. 15, 2023, https://www.cell.com/cell-reports-physical-science/fulltext/S2666-3864(23)00046-2; Lily Paul & Maureen Marshall, CALSTART, *Not Just Smart: The Importance of Managed Charging* (2021), https://calstart.org/wp-content/uploads/2022/01/Managed-Charging-Paper-Final.pdf; Karen Kirk, *Yes, the grid can handle EV charging, even when demand spikes,* Yale Climate Connections (Mar. 23, 2023), https://yaleclimateconnections.org/2023/03/yes-the-grid-can-handle-ev-charging-even-when-demand-spikes/.
[346] Jonathan Coignard, et al., Clean Vehicles as an Enabler for a Clean Electricity Grid. Environmental Research Letters. v. 13, No. 5. (May 2018), at 4, 5, http://iopscience.iop.org/article/10.1088/1748-9326/aabe97 (last accessed June 30, 2023).
[347] *Id*. at 5, 6.
[348] *Id*. at 1.
[349] Jeffery Greenblatt, et al., Quantifying the Potential of Electric Vehicles to Provide Electric Grid Benefits in the MISO Area: Final report to the Midcontinent Independent System Operators. Lawrence Berkeley National Laboratory, at 6, 56, at https://cdn.misoenergy.org/Quantifying%20the%20Potential%20of%20Electric%20Vehicles%20to%20Provide%20Electric%20Grid%20Benefits%20in%20the%20MISO%20Area354192.pdf. (last accessed June 30, 2023).

integration of high levels of renewable generation and significant customer benefits. Put simply, it is cheaper to pay individual utility customers to use batteries on wheels they have already bought and paid for than it is to pay corporations to buy big batteries and park them on the grid.

4. PEV charging is already putting downward pressure on electric rates, to the benefit of all utility customers.

Because much PEV charging can be accomplished when there is spare capacity on the grid, charging can spread the costs of maintaining the system over a greater volume of electricity sales, reducing the per-kilowatt-hour price of electricity to the benefit of all customers. This has already been demonstrated in the real world.

In fact, empirical data compiled by Synapse Energy Economics shows that PEV drivers are not being subsidized by other utility customers and, in fact, they are putting downward pressure on rates. Between 2011 and 2020, PEV customers across the United States contributed more than $1.7 billion in net revenue to the body of utility customers.[350]

The results shown in Figure XVII.G-4 compare the new revenue the utilities collected from PEV drivers to the cost of the energy, capacity, transmission, and distribution system upgrades required to charge those vehicles, plus the costs of utility PEV infrastructure programs that are deploying charging stations for PEVs. In total, PEV drivers contributed an estimated $1.7 billion more than associated costs. That net revenue is returned to the body of utility customers in the form of electric bills that are lower than they would otherwise be.

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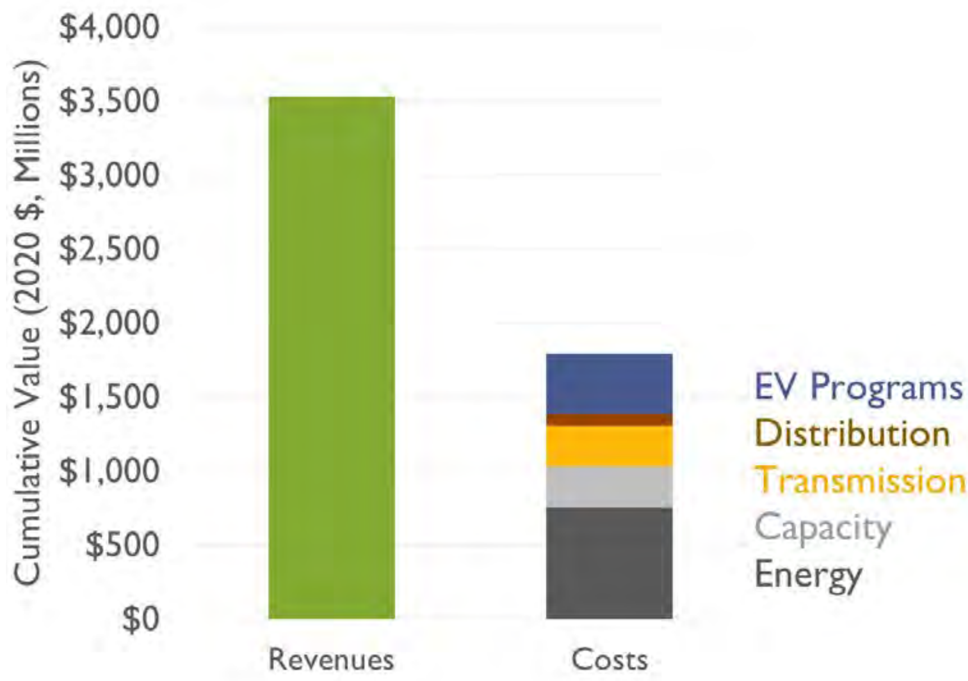
[350] Melissa Whited, Tyler Fitch, Jason Frost, Eric Borden, Courtney Lane, Ben Havumaki, Sarah Shenstone-Harris & Elijah Sinclair, *Electric Vehicles Are Driving Rates Down* 1 (June 2023), https://www.synapse-energy.com/sites/default/files/Electric%20Vehicles%20Are%20Driving%20Rates%20Down%20Factsheet.pdf.

Figure XVII.G-4: Total Utility Revenues vs. Total Costs Associated with PEVs (2011-2020)[351]



5. New utility rates designed for PEV charging increase the fuel cost savings PEVs can provide.

Gasoline and electricity prices vary across the country, and electricity prices vary depending upon the particular characteristics of the utility rate on which a customer takes service. And many existing commercial and industrial utility rates have "demand charges" that can reduce fuel cost savings for high-powered/low-utilization PEV charging use cases, such as public charging along highways in remote areas. Thankfully, the challenge such demand charges can pose for PEV charging has long been recognized, and across the nation, many utilities and regulators have already implemented solutions or are in the process of doing so.

In fact, the BIL amended the Public Utility Regulatory Policies Act (PURPA) Section 111(d) to require regulators and non-regulated utilities to consider new rates that:

> promote affordable and equitable electric vehicle charging options for residential, commercial, and public electric vehicle charging infrastructure; improve the customer experience associated with electric vehicle charging; accelerate third-party investment in electric vehicle charging for light-, medium-, and

[351] *Id.* at 3.

> heavy-duty vehicles; and appropriately recover the marginal costs of delivering electricity to electric vehicles and electric vehicle charging infrastructure.[352]

This has spurred new regulatory proceedings across the country. But many utilities, regulators, and state legislatures were already acting to address this issue before the BIL became law.

As detailed in a publication of the National Association of Regulatory Utility Commissioners (NARUC) entitled "Best Practices for Sustainable Commercial EV Rates and PURPA 111(d) Implementation," rates designed for EV charging can deliver significant fuel cost savings without relying on cross-subsidies from other utility customers.[353] For example, on a new Pacific Gas & Electric rate designed for commercial EV charging that still recovers all associated marginal costs, the San Joaquin Regional Transit District reduced its overall fuel cost per mile from $2.31 to $0.68 (in a utility service territory that has some of the higher underlying marginal costs in the nation).[354] The paper also details rates that take a similar approach that were approved for Southern California Edison, San Diego Gas & Electric, and Alabama Power.

Since the publication of that NARUC paper, many other utilities and regulators have either proposed or secured approval of new rates designed for EV charging. And by the time the standards in this rulemaking take effect in 2027, many more will have followed suit, increasing the fuel cost savings EVs can provide.

H. EPA should expect significant employment opportunities associated with the installation and maintenance of charging infrastructure and related grid infrastructure.

Research conducted on behalf of *EV Infrastructure Strike Force* suggests that, if the Biden Administration's goal of deploying 500,000 EV charging stations is met with public fast charging stations, it will support about 30,000 job-years.[355]

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[352] H.R.3684. Infrastructure Investment and Jobs Act. 117th Congress. (2021-2022). Section 40431 www.congress.gov/bill/117th-congress/house-bill/3684/text.

[353] Nancy Ryan, Alissa Burger, Jenifer Bosco, John Howat, and Miles Muller, Best Practices for Sustainable Commercial EV Rates and PURPA 111(d) Implementation (2022), https://pubs.naruc.org/pub/55C47758-1866-DAAC-99FB-FFA9E6574C2B.

[354] *Id.*

[355] Edward W. Carr, James J. Winebrake, and Samuel G. Winebrake, *Workforce Projections to Support Battery Electric Vehicle Charging Infrastructure Installation*, Energy and Environmental Research Associates, LLC (2021), https://etcommunity.org/assets/files/Workforce-ProjectionstoSupportBatteryElectricVehicleChargingInfrastructureInstallation-Final202106082.pdf.

XVIII. EPA Appropriately Concludes that Critical Minerals and the Battery Supply Chain Will Be Sufficient for the Levels of BEVs Projected in the Proposal, and More Reasonable Battery-Related Modeling Assumptions Would Demonstrate the Feasibility of Even Higher Levels of BEVs.

In this section, we explore how critical mineral and battery supply chain issues should not act as constraints on strong final standards, including Alternative 1 with a steeper increase in stringency after 2030. As EPA's analysis demonstrates, there will be sufficient materials and battery supply chain production to electrify light- and medium-duty vehicles consistent with the levels EPA projects for the Proposal, and for more stringent alternatives. In this section, we provide additional analysis that supports this conclusion.

In addition, alternative battery-related modeling inputs would increase the feasibility and benefits of PEVs. Below, we highlight modeling inputs that we believe led EPA to overestimate battery capacity requirements for electric vehicles. We provide support for alternative input values including new technologies, specific energy, and battery design, all of which will have direct implications for cost modeling and mineral demand (underscoring EPA's conclusion that there is sufficient mineral supply to meet electric vehicle demand).

As EPA notes, "with any emerging technology, a transition period must take place in which a robust supply chain develops to support production." 88 Fed. Reg. at 29313. Indeed, this is not the first time that the automotive industry has confronted critical mineral supply chain issues, and the industry has proven that it can rise to such challenges. For example, metal supply chain concerns arose during the move toward catalytic converters, and equipping all new vehicles with catalytic converters was seen at the time as a challenging "awesome prospect."[356] At the time, "[c]atalyst companies were concerned about their ability to obtain adequate supplies of noble metals if they would be used extensively in automotive catalytic converters."[357] Contemporaneous considerations of the "primary technical barriers" to catalytic converter adoption included "reducing the amount of precious metals used in each converter to a point where aggregate demand can be supplied without exhausting world reserves in the near future."[358] The only significant reserves of the necessary platinum group metals were located in the Republic of South Africa and the former USSR, "neither of which [could] be considered secure sources of supply."[359] Despite these concerns—which sound very similar to some of the rhetoric surrounding the battery minerals conversation—the automotive industry succeeded in

[356] J.R. Mondt, *Cleaner Cars: The History and Technology of Emission Control Since the 1960s*, at 105 (2000). *See also* EPA, *Tier 2 Report to Congress*, at E-13 to E-15 (1998), https://nepis.epa.gov/Exe/ZyPDF.cgi/940054QY.PDF?Dockey=940054QY.PDF (noting that in the late 1990s there were concerns regarding increasing concentrations of palladium in automotive catalyst applications, and resulting future supply and price concerns).
[357] Mondt, at 99.
[358] Daniel Dexter, *Case Study of the Innovation Process Characterizing the Development of the Three-Way Catalytic Converter System*, at S-3 to S-4 (1979) https://rosap.ntl.bts.gov/view/dot/10766.
[359] *Id.* at S-4, 20.

incorporating catalytic converters in all U.S. vehicles. As detailed below, the industry can rise to the challenge again today.

A. There will be enough materials and battery supply chain production to electrify transportation.

We agree with EPA's conclusion that vehicle electrification, including the electrification of the heavy-, medium-, and light-duty fleets, will not lead to energy security risks but will instead provide the potential for a low-impact and domestic energy supply.[360] This section provides comments on the assessment of battery critical materials and battery production.

The lithium-ion batteries used to power PEVs include the following materials deemed critical by the United States Geological Survey: lithium, nickel, manganese, cobalt, graphite, and aluminum.[361] Of these materials, lithium is the only one that does not have a substitute currently on the market. Nickel and cobalt are in the cathodes nickel-manganese-cobalt (NMC) and nickel-cobalt-aluminum (NCA). These are not the constraining materials because they are now substituted in a growing portion of PEVs with the lithium-iron-phosphate (LFP) cathode.[362] Graphite can also be substituted; synthetic graphite is a direct substitution for mined graphite,[363] and research has also demonstrated the use of silicon mixed with or to replace graphite as the anode.[364]

Lithium is vital to manufacturing lithium-ion batteries, which are currently the only type of PEV battery used in all PEVs purchased in the U.S. Therefore, the analysis correctly points to lithium as the constraining material for lithium-ion batteries. Yet, this is a slightly conservative estimation for future constraints because alternative battery types are beginning to be marketed globally. For example, sodium-ion batteries have recently been recognized as a potential lithium-ion battery substitute[365] as Chinese automakers unveil their new technology.[366] This type of innovation is likely to reduce lithium demand globally and is further discussed in the next section.

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[360] 88 Fed. Reg. at 29313.
[361] U.S. Geological Survey, *United States Geological Survey Releases List of 2022 Critical Minerals* (2022), https://www.usgs.gov/news/national-news-release/us-geological-survey-releases-2022-list-critical-minerals.
[362] International Energy Agency, *Global EV Outlook 2023* at 11 (2023), https://www.iea.org/reports/global-ev-outlook-2023/trends-in-batteries.
[363] Jinrui Zhang, Chao Liang, and Jennifer B. Dunn, *Graphite Flows in the U.S.: Insights into a Key Ingredient of Energy Transition,* See 3402–3414, Environ. Sci. and Tech. (2023), https://pubs.acs.org/doi/10.1021/acs.est.2c08655.
[364] Xiuxia Zuo, Jin Zhu, Peter Müller-Buschbaum, Ya-Jun Cheng, *Silicon based lithium-ion battery anodes: A chronicle perspective review,* See 2211–2855, Nano Energy, (2017), http://dx.doi.org/10.1016/j.nanoen.2016.11.013.
[365] Petrova, *Here's why sodium-ion batteries are shaping up to be a big technology breakthrough* (2023), https://www.cnbc.com/2023/05/10/sodium-ion-batteries-shaping-up-to-be-big-technology-breakthrough.html.
[366] Jiri Opletal, *CATL's sodium-ion batteries will debut in Chery Auto EVs*, Car News China (2023), https://carnewschina.com/2023/04/16/catls-sodium-ion-batteries-will-debut-in-chery-auto-evs/.

Furthermore, we know that advocating for increased deployment of ZEVs within the light- and medium-duty fleet, which is an essential step to reducing fossil fuel emissions and addressing the climate crisis, will potentially include mining projects that impact environmental justice communities and, in particular, indigenous communities. PEVs also eliminate tailpipe emissions of harmful air pollutants that cause asthma and respiratory diseases, especially among Black, Indigenous, and other communities of color. However, without adequate protections for workers, communities, and environments near mining and processing sites, we risk replicating the harms of fossil fuel extraction. Besides the details below that discuss opportunities for PEV batteries that will not rely on lithium, there are measures that EPA can and should take to address the potential mining impacts. For example, EPA and the Administration can take action to build a robust circular economy to reduce the need for virgin material extraction and increase the supply of more responsibly sourced materials.

EPA points to findings by several sources that concur with its assessment that material and production will be sufficient to meet electric vehicle uptake in the LDV, MDV, and HDV sectors. *See* 88 Fed. Reg. at 29312-23; DRIA Chs. 3.1.3.2., 3.1.3.3. Increased demand for minerals, as well as government investments, will continue to spur these developments. The 2023 BNEF Electric Vehicle Outlook demonstrates these effects on the continued expansion of the supply chain.[367] In addition, academic sources have demonstrated that there are enough reserves and recycled content such that demand for lithium will barely exceed a quarter of the available reserve by 2050 and about half by 2100.[368]

1. Federal investments have spurred private investments in domestic supply.

Actions taken by the federal government have increased private investment in U.S. battery production. The impact of the BIL and the IRA on U.S.-based PEV manufacturing, repurposing, and recycling growth demonstrates the influence U.S. policy has on rapidly growing a domestically-produced supply. Within six months of the IRA's passage, automakers and battery manufacturers had announced a total of roughly $52 billion of planned investment in North America's PEV supply chain, with over 70% of those investments going toward battery supply chains and recycling.[369]

2. Recycled content can provide additional domestic mineral supply.

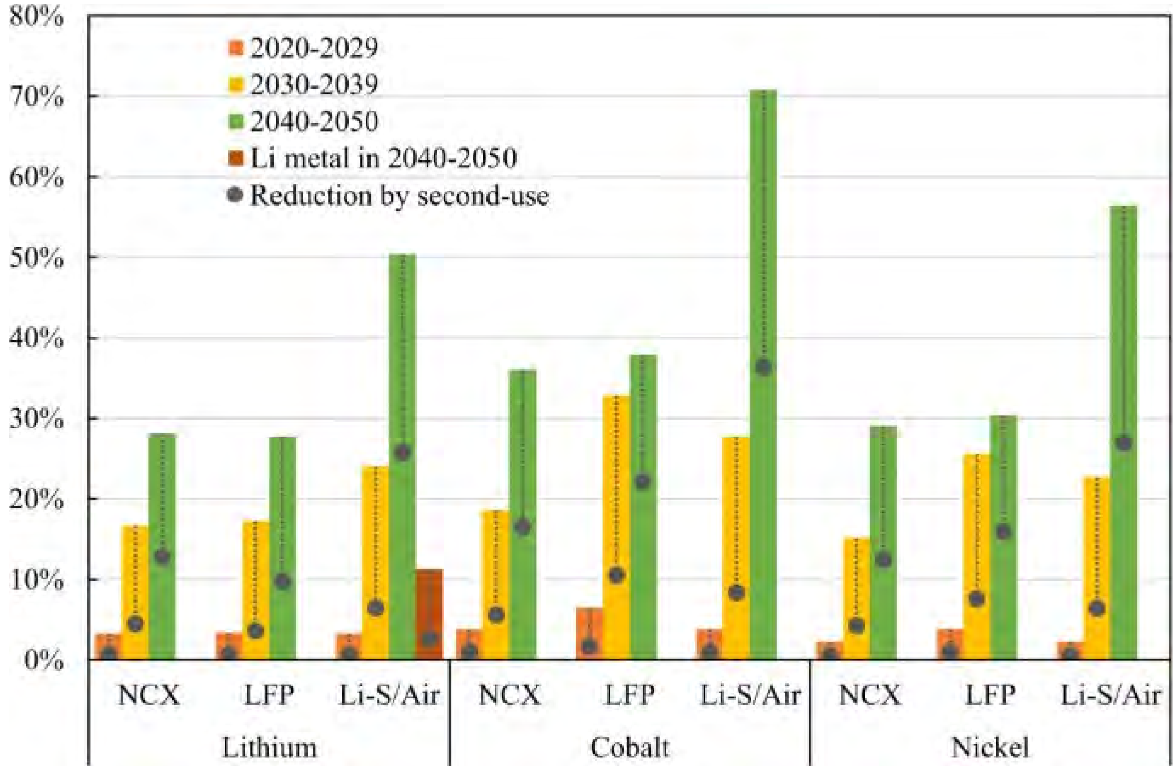
The current oil-dependent transportation system not only impacts the climate and the health of the U.S. population, it also requires continual drilling, production, and importing of

[367] Bloomberg New Energy Finance, *Electric Vehicle Outlook 2023* (2023), https://about.bnef.com/electric-vehicle-outlook/#download.
[368] Klimenko, Ratner, & Tereshin, *Constraints imposed by key-material resources on renewable energy development*, Renewable and Sustainable Energy Reviews, 2021, 144, 111011, 1364-0321. https://www.sciencedirect.com/science/article/pii/S1364032121003014.
[369] Cory Cantor, US Climate Law Fuels $52 Billion in New EV Investments, p 1, BloombergNEF, Mar. 13, 2023. Subscription required.

fuel. This is in stark contrast to the use of materials needed for electrified transportation, which can be continually recycled to produce the next generation of more efficient vehicles. This results in the continued growth of U.S. material stock even when initially relying on imported minerals. As the Proposal states, in 2050, 25 to 50% of lithium demand from electric vehicles can be met with recycled content. 88 Fed. Reg. at 29323-24.[370] Recycled content availability has been highly studied and documented in academic studies beyond the two listed in the Proposal (Sun et al., 2022; Ziemann et al., 2018), including in findings by Xu et al.[371] and Dunn et al.[372] Xu et al. demonstrates that the material demand that could be met by retiring and recycled supply is highly impacted by innovation and advancing energy density. As batteries become more advanced and energy-dense, either through innovation of chemistries used (e.g., the progress made in NMC) or through different chemistries (e.g., lithium-sulfur or lithium-air batteries), the mineral demand decreases to meet the same energy storage needs. This means that a high percentage of material demand can be met with the retiring supply of less material-efficient and lower density batteries. This is demonstrated in Figure XVIII.A-1 below; the more energy dense batteries (Li-S/Air) have higher recycled content for lithium, cobalt, and nickel in 2040-2050 (green bar).[373]

[370] The Proposal cites Sun et al., *Surging lithium price will not impede the electric vehicle boom*, Joule, doi:10.1016/j.joule.2022.06.028, https://dx.doi.org/10.1016/j.joule.2022.06.028, and. Ziemann et al., *Modeling the potential impact of lithium recycling from EV batteries on lithium demand: a dynamic MFA approach*, Resour. Conserv. Recycl. 133, 76–85. https://doi.org/10.1016/j.resconrec.
[371] Xu, C., Dai, Q., Gaines, L. et al. *Future material demand for automotive lithium-based batteries*, *Commun Materials,* 2020, 1, 99, 5–8, https://doi.org/10.1038/s43246-020-00095-x [hereinafter Xu, *Future material demand*].
[372]Jessica Dunn, Margaret Slattery, Alissa Kendall, Hanjiro Ambrose, and Shuhan Shen, *Circularity of Lithium-Ion Battery Materials in Electric Vehicles*, Environmental Science & Technology, 2021, 55, 5189–5198. DOI: 10.1021/acs.est.0c07030 [hereinafter Dunn, *Circulatity*].
[373] Xu, *Future material demand* at 6.

Figure XVIII.A-1: Closed-loop recycling potential of battery materials in a STEP scenario.

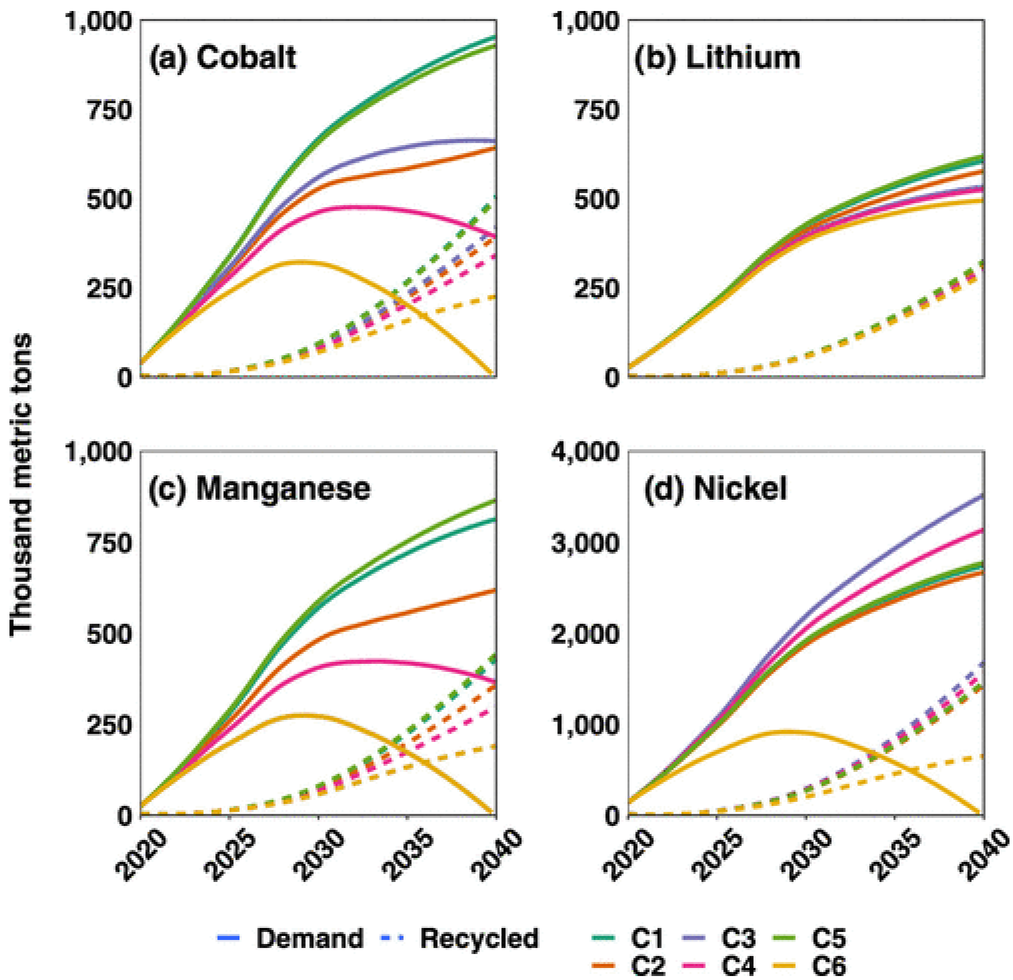


(Source: Xu et al.)

Dunn et al.[374] demonstrate that the choice of cathode materials can also highly increase potential circularity. Figure XVIII.A-2 below shows that a future with high lithium-iron-phosphate (LFP) market concentration, labeled as C6 in the legend, can significantly increase the amount of lithium, cobalt, manganese, and nickel demand met with recycled content, compared to a business-as-usual cathode market share, labeled as C1 in the legend.

[374]Dunn, *Circulatity* at 5194.

Figure XVIII.A-2: Circularity potential of materials as additional years are added to battery lifespan.



Source: Dunn et al.

The recycled content also varies based on the collection rate and the material recovery rate. There is potential for high material recovery due to the 95% recovery rate of lithium, nickel, cobalt, and manganese by commercial-scale hydrometallurgical recyclers in the U.S., such as Lithion, Redwood Materials, Licycle, and Cirba Solutions. In addition, direct cathode recycling, which can recover a cathode without breaking it down into separate materials, is under development by several startups as well as the National Lab research group, ReCell. As shown in Table XVIII.A-1 below, direct recycling currently has a recovery rate of 40% for lithium. But increasing the lithium recovery rate is a priority area for ongoing research.[375] The Argonne

[375] *See generally* Kendall, A., Slattery, M., Dunn, J., *Lithium-ion car battery recycling advisory group report*, (Mar. 16, 2022), https://calepa.ca.gov/lithium-ion-car-battery-recycling-advisory-group/.

National Laboratory model, BattPac, lists the following recovery rates shown in Table XVIII.A-1.[376]

Table XVIII.A-1: Recovery rates of battery materials from different recycling processes.

	Pyrometallurgical	Hydrometallurgical	Direct Physical
Copper	90%	90%	90%
Steel	90%	90%	90%
Aluminum		90%	90%
Graphite		90%	90%
Plastics		50%	50%
Li+ in product		90%	40%
LCO			90%
NMC(111)			90%
NMC(532)			90%
NMC(622)			90%
NMC(811)			90%
NCA			90%
LMO			90%
LFP			90%
Co2+ in product	98%	98%	
Ni2+ in product	98%	98%	
Mn2+ in product		98%	
Electrolyte Organics		50%	50%

Source: Argonne National Lab BatPac

Recycling facilities are also operational and under development in the United States. Table XVIII.A-2 from Atlas Public Policy attempts to capture all these developments.[377]

[376] Argonne National Laboratory, "BatPaC: battery manufacturing cost estimation," (2022). https://www.anl.gov/partnerships/batpac-battery-manufacturing-cost-estimation.
[377] Atlas Public Policy, *The EV Transition: Key Market and Supply Chain Enablers*, at 42 (Nov. 2022). https://atlaspolicy.com/the-ev-transition-key-market-and-supply-chain-enablers/.

XVIII.A-2: EV battery recycling facilities in the U.S.

Site Name	State	Target Capacity (tons/year)	Facility Product	Year Operational	Company
St Louis Facility	IL	24,000	Battery Grade Materials	Operational	Interco
Spoke Facility	NY	5,000	Black Mass	Operational	Li-Cycle
Worcester, Pilot Plant	MA	15	Cathode materials	Operational	Ascend Elements
Fairfield County Facility	OH	NA	NA	Operational	Cirba Solutions
Wistron Greentech facility	TX	500	Direct Recycling	Operational	Princeton NuEnergy
Spoke Facility	AL	10,000	Black Mass	Operational	Li-Cycle
Spoke Facility	AZ	10,000	Black Mass	Operational	Li-Cycle
Recycling Facility	GA	30,000	Cathode materials	2022	Ascend Elements
Spoke Facility	OH	15,000	Black Mass	2023	Li-Cycle
Hub Facility	NY	35,000	Battery Grade Materials	2023	Li-Cycle
Apex 1	KY	NA	Battery Grade Materials	2023	Ascend Elements
SungEel Recycling Park	GA	50,000	NA	2024	SungEel Materials
Carson City facility	NV	20,000	Battery Grade Materials	NA	Redwood Materials
Lithium-Ion Battery Recycling Pilot Plant	NV	20,000	Battery Grade Materials	NA	American Battery

Source: T. Taylor and N. Gabriel for Atlas Public Policy

3. EPA appropriately concludes that there will be sufficient lithium for the Proposed Standards, and supporting analysis also indicates likelihood of IRA-qualifying sources.

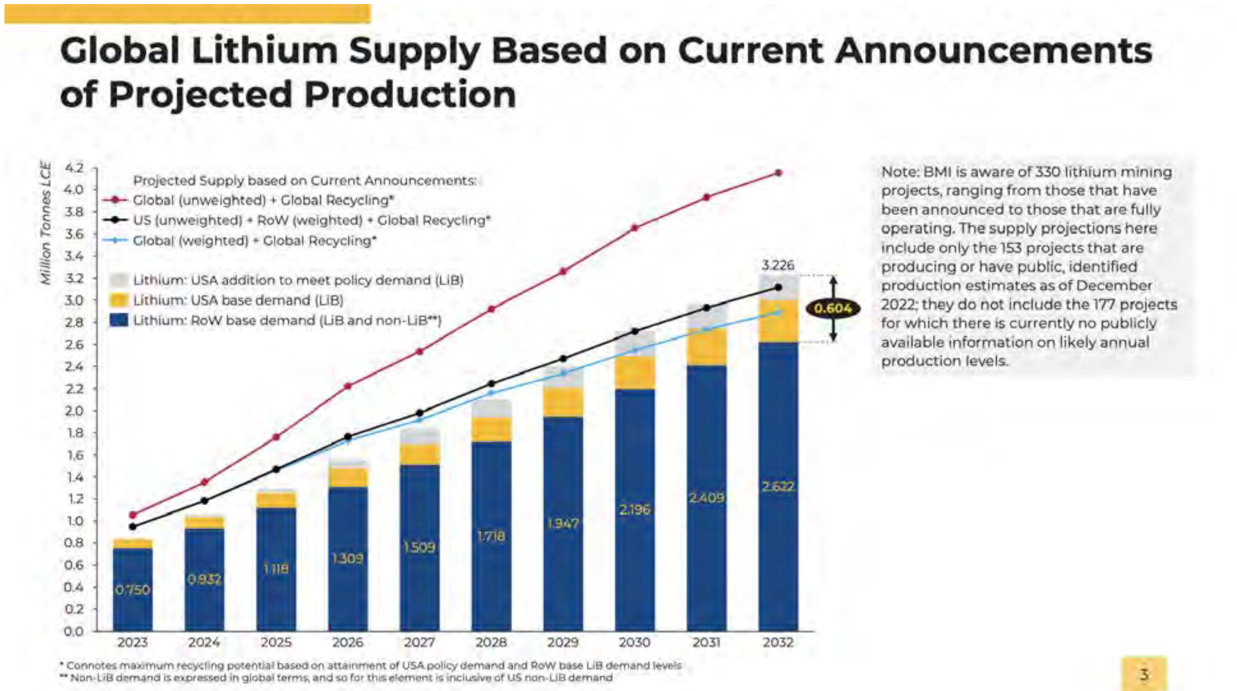
As discussed above, the current primary constraining material for PEVs is lithium. EPA points to a variety of sources to support its assumptions regarding lithium availability for U.S. PEV demand. *See* 88 Fed. Reg. at 29312-23; DRIA Chs. 3.1.3.2, 3.1.3.3.

Recent analysis by Benchmark Mineral Intelligence (BMI) on future lithium supply supports EPA's findings.[378] BMI compiled a list of all currently known lithium mining projects, including those already in operation as well as those in development, totaling 330 projects globally as of December 2022. Of those, 153 are already producing lithium or have public, identified supply projections. BMI took those supply projections and assigned them probabilities—e.g., currently producing mines were weighted at 100%, while projects that have secured a significant proportion of their funding and completed certain feasibility milestones necessary for production within the next 5 years were considered "probable" and weighted at 50%. Supply from the other 177 lithium mining projects (which do not yet have supply projections) were all counted as 0.

BMI then compared these projections to the projected lithium demand through 2032, using forecast global demand (including for non-battery applications), as well as demand based on EPA's proposed light-, medium-, and heavy-duty vehicle emission standards. Based just on the 153 included projects, BMI's weighted projections show sufficient lithium for the EPA's Proposed Standards (on top of forecast demand for the rest of the world) through 2028 as shown below in Figure XVIII.A-3. When the 18 U.S. projects with supply projections (out of 48 total U.S. projects) are weighted at 100%, lithium supply is sufficient for the Proposed Standards through 2030. And when the 153 included projects are weighted at 100%, global supply greatly exceeds demand through 2032.

[378] BMI, *Lithium Mining Projects – Supply Projections*, June 2023 (slide deck); BMI, *Lithium Mine Projects (06.30.2023)* (Excel spreadsheet), both attached to this comment letter.

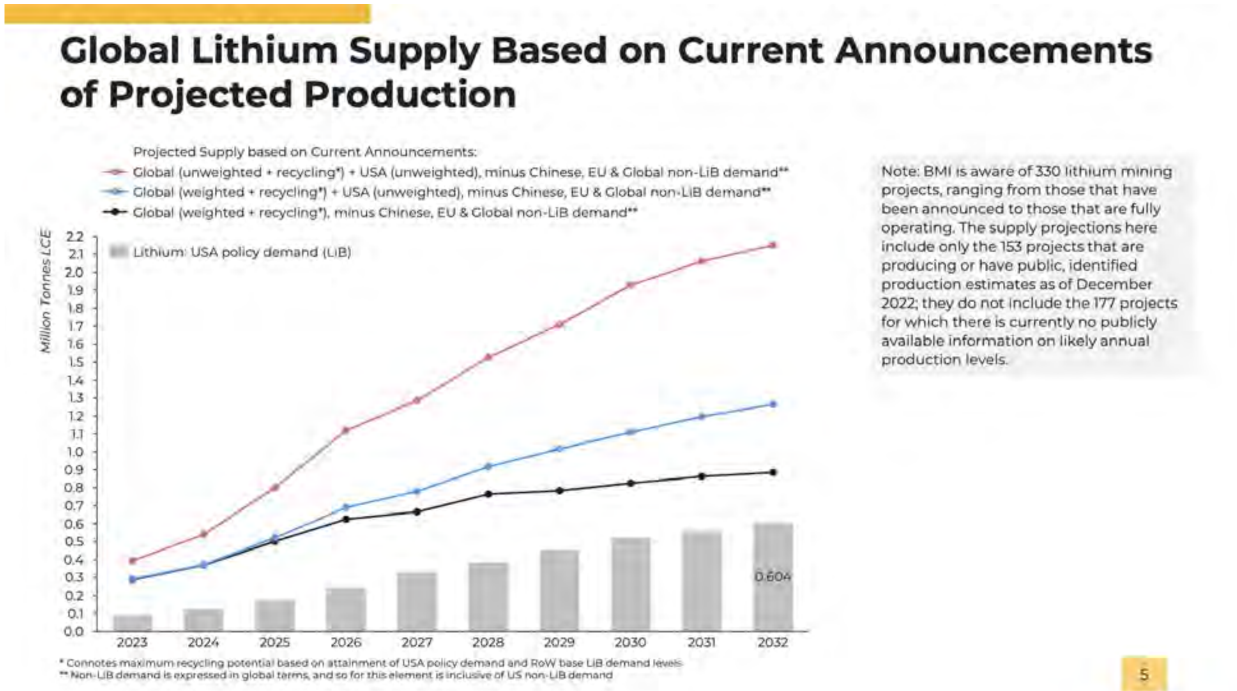
Figure XVIII.A-3: Global Lithium Supply Based with U.S. and Global Demand



Given that BMI's projections exclude 177 projects that have been announced but do not yet have supply projections, even a 100% weighting for the 153 projects that are operating or have supply projections is a conservative approach. It does not include any supply growth outside of the 153 projects identified as of December 2022, not even from the other 177 identified projects, despite increasing global demand and strong U.S. tax incentives. Moreover, it would be reasonable and expected that even BMI's supply projections would continue to increase as the identified projects get further along in the development process and market forces continue to act.

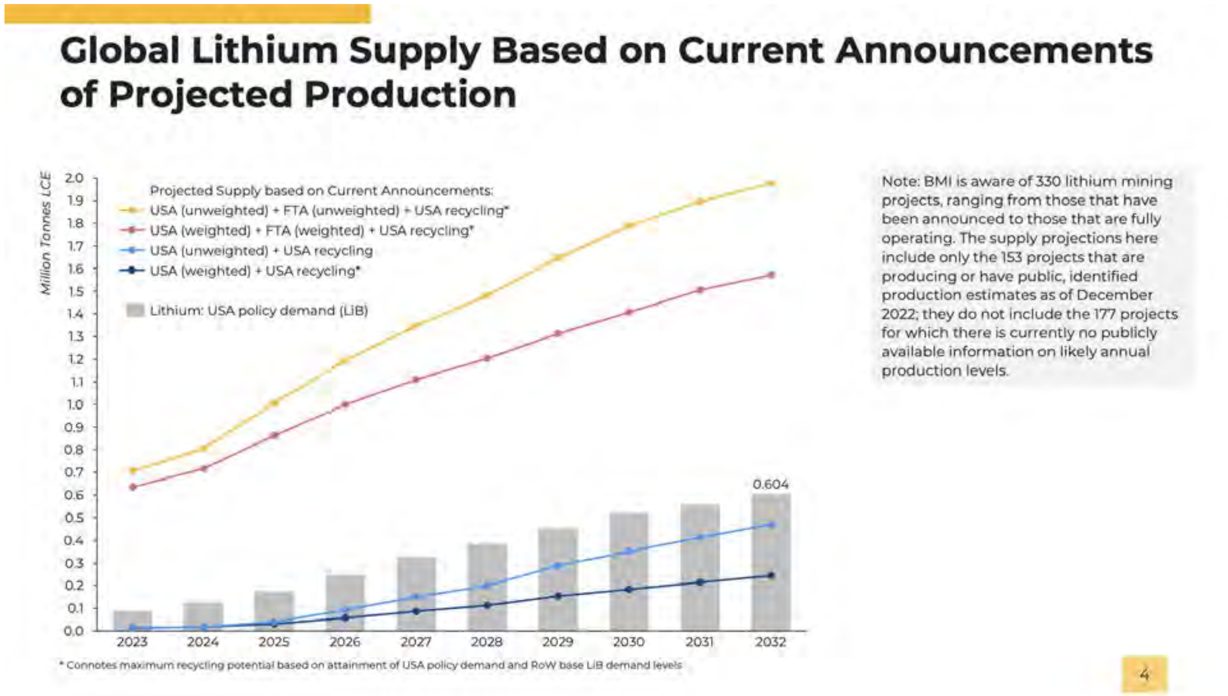
In addition, BMI's analysis indicates that there will be sufficient supply for U.S. demand even after considering competing lithium battery demand from China and Europe and global non-lithium battery demand as shown below in Figure XVIII.A-4.

Figure XVIII.A-4: Remaining Global Lithium Supply with U.S. Demand



BMI also broke down the supply from the 153 included projects by country, and then grouped those countries into categories based on U.S. trade-agreement status, consistent with the terms in the IRA. This projection shown in Figure XVIII.A-5 below makes clear that there is ample lithium supply from sources that satisfy the IRA § 30D Clean Vehicles Tax Credit requirements—specifically, domestic sources, as well as countries that have free trade agreements with the U.S. ("FTA countries"). This supports EPA's modeling assumption of an average tax credit of $6,000 per electric vehicle (out of a maximum allowable credit of $7,500), as lithium from these sources would qualify a vehicle for the tax credit, provided other conditions are met (e.g., vehicle assembly in North America, purchaser income limits).

Figure XVIII.A-5: U.S. Lithium Supply and Free Trade Agreement Country Supply with U.S. Demand



Slides of BMI's analysis, as well as their full list of lithium supply projects, are attached to these comments.

Finally, as has been noted elsewhere in these comments, there are alternative battery chemistries that do not use lithium (including sodium-ion batteries), and thus may end up lowering lithium demand in the future. In addition, in light of the points made in Section XVIII.B, below, we believe EPA's analysis of future lithium demand—and thus future lithium supply sufficiency—is conservative.

B. Alternative battery-related modeling inputs increase the feasibility and benefits of PEVs.

EPA's OMEGA modeling likely overestimates the battery cost and material demand per passenger PEV due to conservative technical assumptions made about advancements in lithium-ion batteries that would replace materials, increase specific energy, or allow for the longer use of batteries through refurbishment or reuse. Additionally, the variables discussed below can also cause mineral demand forecasts to be higher than actual future material demand.

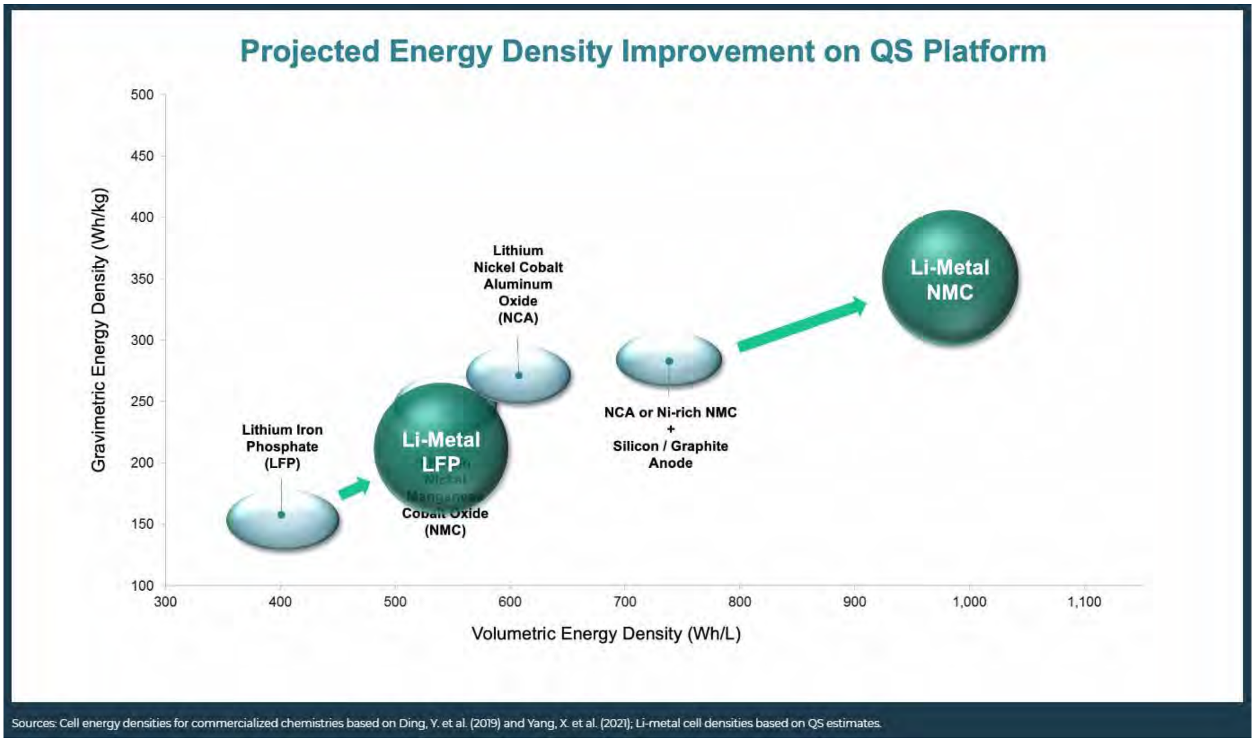
1. Technological advancements resulting in decreased mineral demand can also further decrease battery costs.

In addition to the substitution of lithium discussed above, advanced lithium-ion batteries such as solid-state batteries could decrease the amount of lithium required to provide the same kWh and miles traveled. Innovation will increase battery specific energy and energy density, therefore reducing the amount of materials needed per kWh as well as battery cost.

Solid-state battery startups, such as QuantumScape,[379] are already partnering with automakers to ensure the technology is suitable for PEVs. Solid Power has partnered with Ford and BMW and has provided BMW with a research and development license to its all-solid-state cell design and manufacturing knowledge, and QuantumScape in December 2022 shipped its first lithium metal battery cells for trial.[380] Solid-state batteries have increased specific energy, with QuantumScape reporting their Li-Metal NMC batteries having up to 400 Wh/kg or 1,100 Wh/L depending on the anode. This increase is graphically represented in Figure XVIII.B-1 below, which was produced by QuantumScape.

[379] QuantumScape, Delivering on the promise of solid-state technology, https://www.quantumscape.com/technology/ (last accessed, June 29, 2023).
[380] Steve Hanley, Solid Power & QuantumScape Begin Shipping Solid-State Batteries For Trials, CleanTechnica (Dec. 22, 2022), at https://cleantechnica.com/2022/12/22/solid-power-quantumscape-begin-shipping-solid-state-batteries-for-trials/ (last accessed June 29, 2023).

Figure XVIII.B-1: Energy Density Improvements as Projected by QuantumScape



Sources: Cell energy densities for commercialized chemistries based on Ding, et al.[381] *and Yang et al.*[382]*; Li-metal cell densities based on QuantumScape estimates*

Sodium-ion batteries are also making their way to the market, providing an alternative to lithium minerals and potentially reducing future lithium demand. CATL (the world's largest PEV battery maker) invested in the technology in 2021,[383] and the Chery iCar will be the first EV to use the technology.[384] There are already 20 sodium-ion battery factories under construction or planned around the world, demonstrating the uptake of this technology.[385]

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381 Yuanli Ding, et al., Automotive Li-Ion Batteries: Current Status and Future Perspectives. Electrochem. Energy Rev. 2:1–28 (2019), available at https://doi.org/10.1007/s41918-018-0022-z (last accessed June 29, 2023).

382 Xiaofei Yang, et al., Recent advances and perspectives on thin electrolytes for high-energy-density solid-state lithium batteries, Royal Society of Chem. (2020) DOI: 10.1039/d0ee02714f, available at https://www.eng.uwo.ca/nanoenergy/publications/2020/pdf/xiaofei-ees-thin-SSE-2020.pdf (last accessed June 29, 2023).

383 Magdalena Petrova, Here's why sodium-ion batteries are shaping up to be a big technology breakthrough, CNBC (May 10, 2023), at https://www.cnbc.com/2023/05/10/sodium-ion-batteries-shaping-up-to-be-big-technology-breakthrough.html (last accessed June 29, 2023).

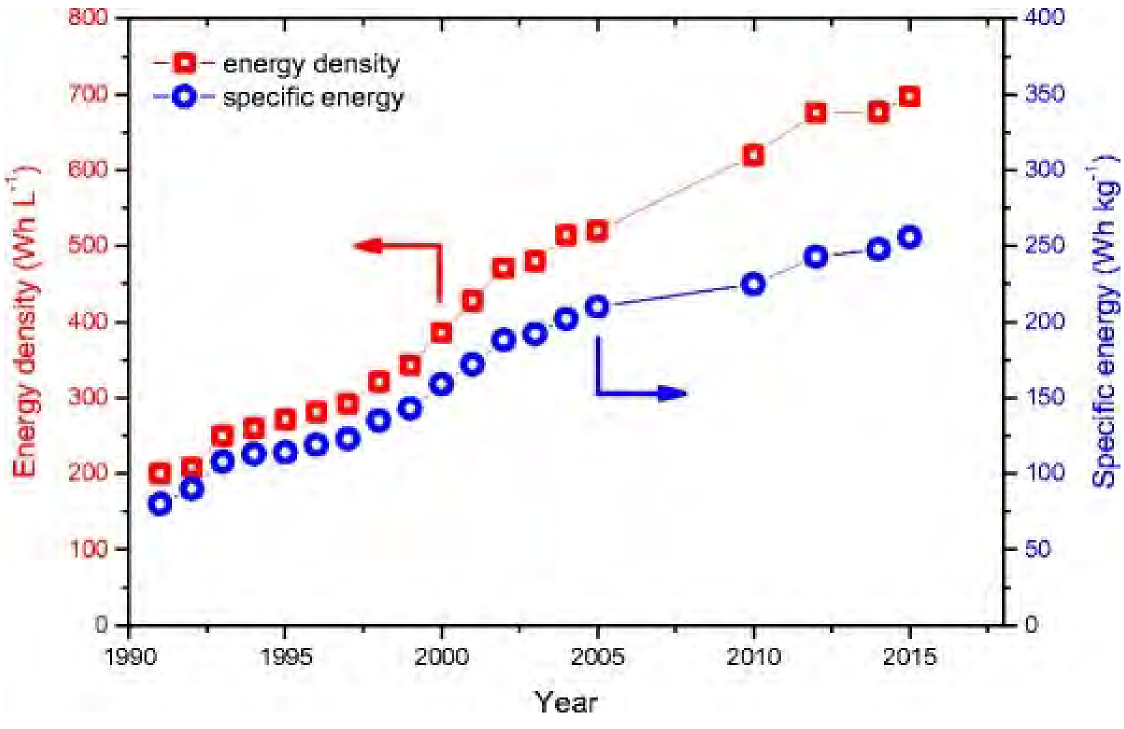
384 Jiri Opletal, CATL's sodium-ion batteries will debut in Chery Auto EVs, Car News China (Apr. 16, 2023), at https://carnewschina.com/2023/04/16/catls-sodium-ion-batteries-will-debut-in-chery-auto-evs/ (last accessed June 29, 2023).

385 Steve Hanley, The Sodium-Ion Battery Is Coming To Production Cars This Year, CleanTechnica (Apr. 22, 2023), at https://cleantechnica.com/2023/04/22/the-sodium-ion-battery-is-coming-to-production-cars-this-year/ (last accessed June 29, 2023).

2. Specific energy assumed in the model is lower than expected for LDVs.

"Specific energy" is the amount of energy a battery can store per unit of its weight, and "energy density" is the amount of energy a battery can store per unit of its volume. As shown in Figures XVIII.B-2 and XVIII.B-3 below, both of these metrics have increased dramatically over time for lithium-ion batteries. Improving battery specific energy and energy density increases the amount of energy that can be stored using the same amount of materials. This is important not only for reducing demand for battery minerals but also for improving the range of PEVs. These increases are the result of various factors, including battery chemistry and design improvements. Battery chemistries have different specific energies; nickel- and cobalt-containing chemistries have higher specific energy than LFP. For example, the Tesla Model Y uses an NCA battery with a reported 276-333 Wh/kg, while the Model S and Model X use a battery with slightly less at 250 Wh/kg.[386] While lower, this 250 Wh/kg is still a dramatic increase from Sony's commercialization in 1991 when it was 80 Wh/kg.[387]

Figure XVIII.B-2: Specific energy and energy density of nickel-based lithium-ion batteries continue to increase

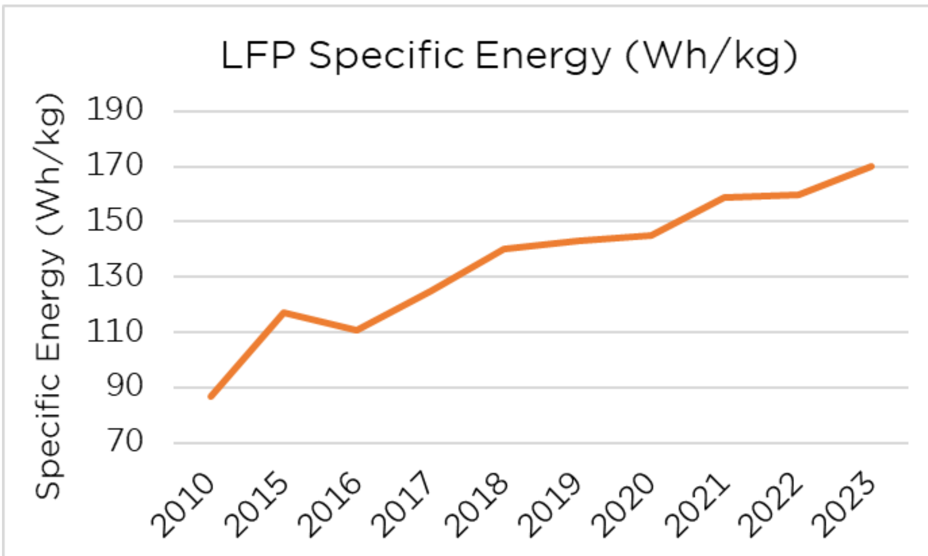


Source: Placke et al.

[386] Aditya Dhage, Cylindrical Cell Comparison 4680 vs 21700 vs 18650 (Jan. 8, 2023), at https://www.batterydesign.net/cylindrical-cell-comparison-4680-vs-21700-vs-18650/ (last accessed June 29, 2023).
[387] Tobias Placke, et al., Lithium ion, lithium metal, and alternative rechargeable battery technologies: the odyssey for high energy density, J Solid State Electrochem, 21:1939–1964 (2017) (hereinafter Placke et al. - Odyssey).

LFP batteries have similarly seen advancements in their specific energy, from below 90 Wh/kg in 2010[388] (shown in the figure below) to current reports from Proterra of 170 Wh/kg[389] and BYD of 166 Wh/kg.[390] BYD has recently announced the blade LFP battery, which is estimated to reach 180 Wh/kg[391] due to the use of "cell to pack" design, therefore not using the "cell to module to pack" design that has been historically seen.[392]

Figure XVIII.B-3: Specific energy of LFP lithium-ion batteries continues to increase



Data Source: BloombergNEF Electric Vehicle Outlook 2022 (subscription required)

a. Specific energy forecasts

U.S. PEV sales are currently dominated by nickel- and cobalt-containing cathode chemistries, representing 100% of sales in 2019.[393] The NCA cathode, used by Tesla, represents

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[388] Dr. Andy Leach, Lithium-Ion Batteries: State of the Industry 2022, *Historic and estimated changes to battery-pack energy density*, BloombergNEF, Sept. 9, 2022. Subscription required
[389] Proterra, Proterra battery pack features and specifications (2020), at https://www.proterra.com/wp-content/uploads/2020/08/Proterra-EV-Battery-Pack-Specs-2020.pdf (last accessed June 29, 2023).
[390] Nigel, Battery Design from Chemistry to Pack: BYD Blade (July 4, 2022), at https://www.batterydesign.net/byd-blade/ (last accessed June 29, 2023).
[391] Yiwen Shi, Feasibility of BYD blade batteries in electric vehicles, Highlights in Sci., Engineering and Tech., Vol. 32 (2023), at https://drpress.org/ojs/index.php/HSET/article/view/5087/4928#:~:text=The%20ratio%20of%20energy%20density,to%2030%25%20%5B2%5D (last accessed June 29, 2023).
[392] International Energy Agency, Global EV Outlook 2022, at 140, available at https://iea.blob.core.windows.net/assets/ad8fb04c-4f75-42fc-973a-6e54c8a4449a/GlobalElectricVehicleOutlook2022.pdf (last accessed June 29, 2023).
[393] Jessica Dunn, et al., Circularity of Lithium-Ion Battery Materials in Electric Vehicles, Envtl. Sci. & Tech., 55 (8), 5189, 5192, Fig. 4 (2021), DOI: 10.1021/acs.est.0c07030 (hereinafter Dunn - Circularity).

the most sold PEV batteries in the United States over the last couple of years.[394] More recently, Tesla began selling PEVs in the United States that use LFP,[395] a trend that is being followed by Ford and Rivian.

If reviewed globally, NMC of different ratios (particularly 622 and 811) is the most prevalent chemistry today,[396] and LFP is more frequently used globally than in the U.S., with around 40% of global passenger PEV sales expected to contain LFP batteries in 2023.[397] While LFP batteries have lower specific energy, and therefore less range than nickel- and cobalt-based chemistries, they are cheaper to manufacture due to the lack of cobalt and nickel, and technological advances are closing the gap between LFP and nickel- and cobalt-based specific energies.[398]

Although the prevalence of different ratios of nickel- and cobalt-based chemistries (NMC and NCA) vary with time, those chemistries are currently predicted to hold nearly half the global passenger PEV market into the early 2030s, with NMC811 and NMC955 being the most popular chemistries in that category in 2027.[399] U.S.-based forecasts similarly assume nickel- and cobalt-based chemistries to be dominant over the next decade, despite the increasing use of LFP.[400]

The OMEGA model uses the NMC811 cathode for a base technology and 180-200 Wh/kg as the base specific energy. There are a few issues with these assumptions: 1) while NMC811 is representative of a technology sold today, NMC611 is currently more common, and NMC955 along with other chemistries like NCA and LFP are expected to be more common than NMC811 in 2027-2032; and 2) the specific energy used in OMEGA does not align with real-world NMC811 specific energy.[401] NMC811 has one of the highest specific energies, behind only NCA.[402] When paired with a graphite anode, the specific energy of the battery should be at least 250 Wh/kg, as shown in Figure XVIII.B-4 below, compared to the 180-200 Wh/kg used by EPA.[403]

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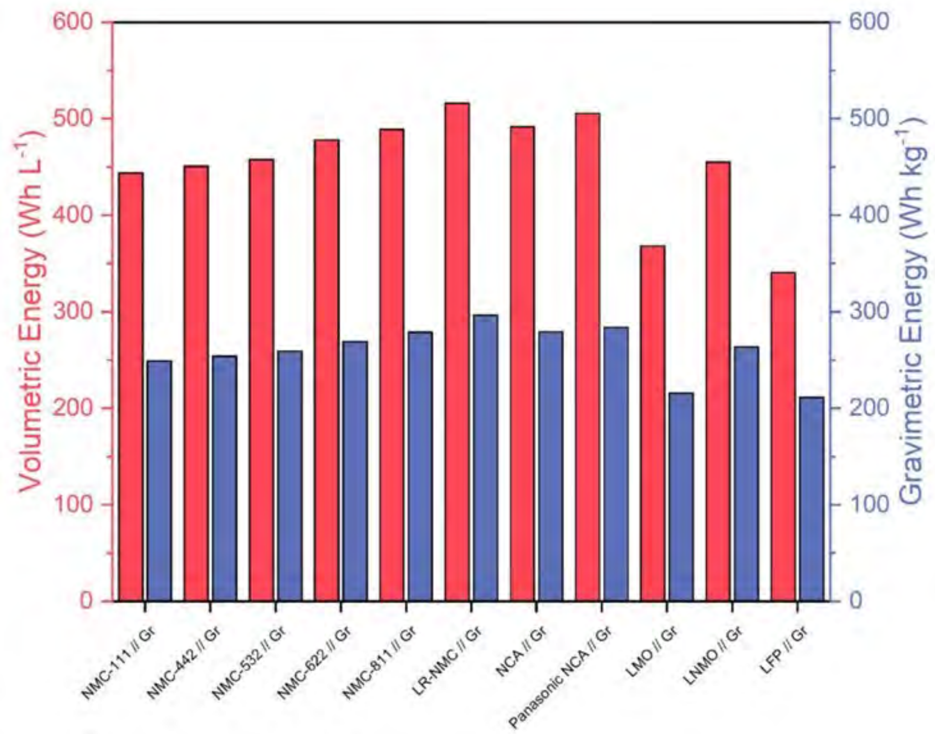
[394] *Id.* at 5192, Fig. 4.
[395] Michael Wayland, Tesla will change the type of battery cells it uses in all its standard-range cars, CNBC (Oct. 20, 2021), at https://www.cnbc.com/2021/10/20/tesla-switching-to-lfp-batteries-in-all-standard-range-cars.html (last accessed June 29, 2023).
[396] Colin McKerracher et al. Electric Vehicle Outlook 2023, Figure 202, BloombergNEF. June 8, 2023. Subscription required
[397] *Id.*
[398] *Id.* at 157-158
[399] *Id.* at Figure 202
[400] Dr. Andy Leach, Lithium-Ion Batteries: State of the Industry 2022, *US demand, chemistry mix, and recycling Capacity*, BloombergNEF, Sept. 9, 2022. Subscription required.
[401] *Id.*
[402] *Id.* at Historic and estimated changes to battery-pack energy density
[403] Marc Wentker, A Bottom-Up Approach to Lithium-Ion Battery Cost Modeling with a Focus on Cathode Active Materials, Energies 12(3):504, at 6, Fig. 2 (2019), available at https://doi.org/10.3390/en12030504

Figure XVIII.B-4: Specific energy of lithium-ion batteries with various cathodes and anodes



Source: Wentker et al., 2019

BloombergNEF's specific energy forecast used linear interpolation to demonstrate that in 2030, the 95% confidence lower limit of specific energy is 210 Wh/kg, with a higher limit of 275 Wh/kg, as shown in Figure XVIII.B-5 below.[404] This linear interpretation includes both LFP and NMC, but does not account for the high amount of nickel- and cobalt-containing cathodes used in the U.S. The forecast also does not account for material substitution and large specific energy gains expected from quickly-advancing technology. For example, the use of silicon in the anode can increase specific energy,[405] and while it is not yet used widely, startups are progressing this technology and constructing commercial-scale manufacturing facilities.[406]

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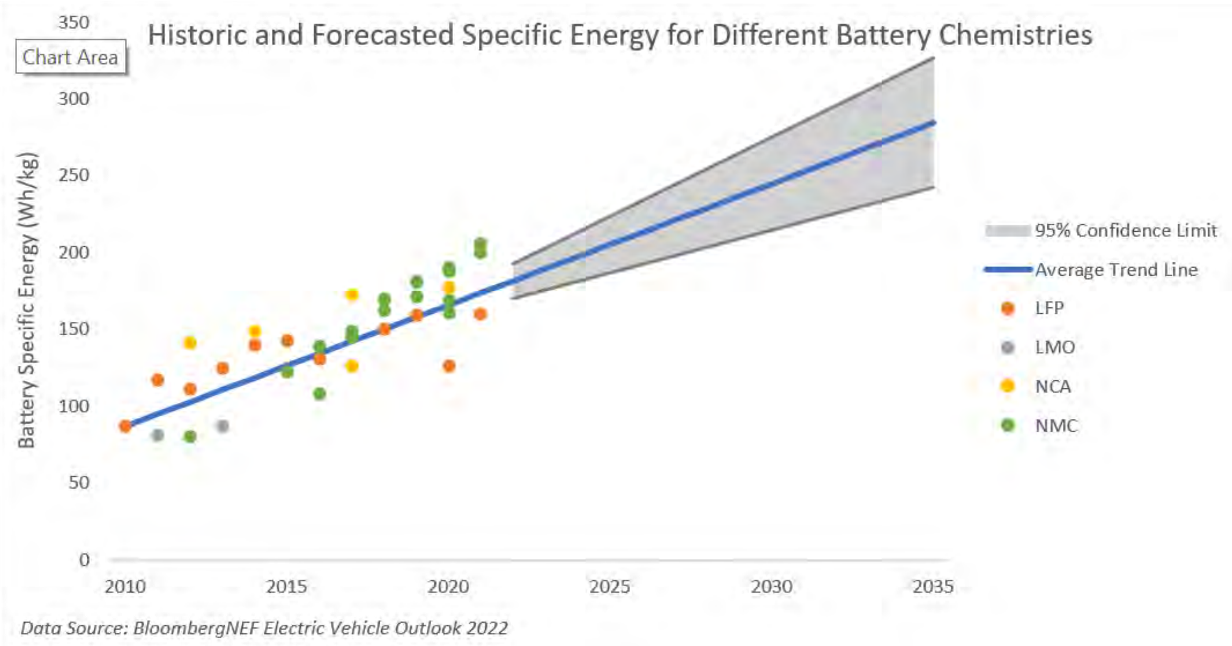
[404] Dr. Andy Leach, Lithium-Ion Batteries: State of the Industry 2022, *Historic and estimated changes to battery-pack energy density*, BloombergNEF, Sept. 9, 2022. Subscription required

[405] Placke et al. - Odyssey, *supra*.

[406] Matt Blois, Silicon anode battery companies get a major boost, Chemical and Engineering News (2022), at https://cen.acs.org/energy/energy-storage-/Silicon-anode-battery-companies-major/100/web/2022/12; *see also* Group14 Begins Construction of World's Largest Commercial Factory for Advanced Silicon Battery Materials (Apr. 4, 2023), at https://group14.technology/en/news/group14-technologies-begins-construction-of-the-worlds-largest-commercial-factory-for-advanced-silicon-battery-materials-.

Figure XVIII.B-5: Historic and forecasted battery-pack specific energy for different battery chemistries



Data Source: BloombergNEF Electric Vehicle Outlook 2022 (subscription required)

b. An updated specific energy forecast

The relatively low pack-level specific energy described in section 2.5.2.1.1 (Battery sizing) of the DRIA (180-200 Wh/kg) appears to only account for the use of LFP, even though the following section, 2.5.2.1.2 (Base year battery cost estimation), states that vehicles were assumed to contain batteries with the more efficient NMC811 chemistry in the cost analysis. Therefore, EPA's inputs for specific energy are conservative considering that nickel- and cobalt-containing cathodes are used in the vast majority of passenger PEVs sold in the US, and recent advancements, such as the Blade Battery (10 Wh/kg increase), demonstrate specific energy gains faster than historically seen. The EPA forecasts generally align with the lowest limit of specific energy forecasts by BloombergNEF in Figure XVIII.B-5 in the prior section, although it would be more accurate to align with a high forecast scenario considering the share of NMC chemistries in use.

Updating the specific energy forecast would likely lead to lower costs and mineral demand for passenger PEVs, and therefore increased feasibility and cost benefits of PEV technologies compared to EPA's current analytical approach. EPA's assumptions must be revised to reflect what is actually occurring in the market and what the currently predicted trends are for the future.

Table XVIII.B-1 Estimated Specific Energy for Passenger PEVs[407]

	Specific Energy (Wh/kg)	
Year	BNEF range	Our estimate (30% LFP & 70% NCX)
2024	180-212	214
2025	185-222	224
2026	190-233	234
2027	195-243	244
2028	200-254	254
2029	205-264	264
2030	210-275	274
2031	215-285	283
2032	220-296	293
2033	224-306	303
2034	229-317	313
2035	234-327	323

Table XVIII.B-1 is calculated based on historical energy densities for LFP and cobalt-containing cathodes (NCX) provided by BloombergNEF.[408] When specific energy for LFP and cobalt-containing cathodes are individually calculated based on linear interpolation, Table XVIII.B-2 shows the results. If the ratio of 30% LFP and 70% nickel-based is kept, we get the average specific energy in Table XVIII.B-1.

Table XVIII.B-2: Estimated Specific Energy for LFP and Nickel-Based Battery Chemistries

	Specific Energy (Wh/kg)	
Year	LFP	Nickel-based
2027	179	272
2028	184	284
2029	190	295
2030	195	307
2031	201	319
2032	206	331

Data Source: BloombergNEF Electric Vehicle Outlook 2023 (subscription required)

[407] Colin McKerracher et al. Electric Vehicle Outlook 2023, Figure 201, BloombergNEF. June 8, 2023. Subscription required
[408] *Id.*

Appropriately representing higher specific energies that align with today's technologies and forecasts also has implications for vehicle range, weight, and mineral demand. Batteries with higher specific energies can provide the same amount of power while using fewer minerals, therefore weighing less than batteries with lower specific energies. This means that vehicles with more efficient batteries can travel further with the same amount of energy because the battery significantly impacts the weight, and therefore, the efficiency of PEVs.

3. Design for disassembly holds promise for battery recycling.

The battery design parameters listed in the Proposal, which EPA used to develop battery cost estimates, *see* 88 Fed. Reg. at 29299, do not include design for disassembly (Dfd), also referred to as design for recycling or design for reuse. Dfd involves factoring end-of-life into the design of the vehicle, meaning that the battery is designed to be taken apart so that cells and modules can be refurbished, reused, or replaced, or so that the battery can be more efficiently and safely disassembled for recycling. This disassembly is typically a difficult, lengthy, and therefore expensive process because Dfd is not included in the design phase.[409]

As reuse and recycling becomes more prevalent and policies begin to require it, we expect that Dfd will also be more common. If Dfd occurs, more reuse, refurbishment and replacement will occur and batteries will have a longer lifespan, therefore reducing the amount of new batteries necessary for electrification.[410] The disassembly of a battery from a vehicle and down to the cell level currently represents approximately a third of light-duty vehicle recycling costs in the United States.[411] If Dfd occurs, this recycling cost will also decline, therefore leading to more prevalent recycling and greater availability of recycled supply.

XIX. Consumer Acceptance of PEVs Is Not a Barrier to Feasibility of EPA's Proposed Standards or More Stringent Standards.

In this section and in Sections XX and XXI, we explain how consumer acceptance considerations support strong final standards. As detailed below, PEVs offer significant economic and performance benefits to consumers, and consumer interest in PEVs continues to grow.

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[409] CalEPA, Lithium-ion car battery recycling advisory group report (2022), https://calepa.ca.gov/lithium-ion-car-battery-recycling-advisory-group/ (last accessed June 29, 2023).
[410] Michael S. Koroma, et al., Life cycle assessment of battery electric vehicles: Implications of future electricity mix and different battery end-of-life management, Sci Total Env. 20;831:154859 (2022), available at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9171403/ (last accessed June 29, 2023).
[411] *See* Jessica Dunn, et al., Electric vehicle lithium-ion battery recycled content standards for the US – targets, costs, and environmental impacts, Resources, Conservation and Recycling, 185, 106488, 0921-3449 (2022), at 6, Fig. 3, available at https://doi.org/10.1016/j.resconrec.2022.106488

A. EPA has broad discretion in considering consumer preferences when promulgating emission standards but should not give undue weight to that factor.

As explained in EPA's Proposal and Section II of these comments, when promulgating new emissions standards under Clean Air Act § 202(a), EPA must consider the statutory criteria of technological feasibility, cost of compliance, and lead time.[412] EPA may consider other factors, and in the past has considered a rule's various impacts on vehicle purchasers.[413]

While EPA has often considered consumer acceptance in its Section 202 rulemakings, the Agency may not let the unique preferences of each and every consumer dictate its consideration of the appropriateness or feasibility of emission standards. In *International Harvester Company v. Ruckelshaus*, 478 F.2d 615, 640 (D.C. Cir. 1973), the D.C. Circuit Court of Appeals concluded:

> We are inclined to agree with the Administrator that as long as feasible technology permits the demand for new passenger automobiles to be generally met, the basic requirements of the Act would be satisfied, even though this might occasion fewer models and a more limited choice of engine types. The driver preferences of hot rodders are not to outweigh the goal of a clean environment.

While *International Harvester* involved emission requirements for light-duty vehicles under a provision of the 1970 Amendments, the principles the court expressed apply just as well to standards under Section 202(a)(1). As detailed in Section II, Congress intended EPA's standards to push the industry toward greater emission reductions and did not expect them to preserve the market dominance of any particular type of powertrain or power source. EPA should not give oversized weight to arguments questioning consumer preferences, which is not a factor Congress identified in Section 202(a)(1).

While EPA has discretion whether to consider and how much weight to give purchaser acceptance in setting emission standards, that discretion is limited by EPA's primary statutory duty to set standards that adequately protect public health and welfare. An understanding of consumers' willingness to purchase and drive PEVs could inform the feasibility and effectiveness of EPA's regulations. EPA's attention to consumer preferences, however, cannot compromise its overall Clean Air Act mandate to mitigate the automobile's "devastating impact on the American environment," *International Harvester*, 478 F.2d at 622, or the Agency's primary duty to protect public health and welfare by minimizing harmful air pollution. Most importantly here, however, is that consumer acceptance of PEVs is widespread and growing, and PEVs provide the vehicle features and characteristics that drivers want and need. Thus, as this

[412] 42 U.S.C. § 7521(a); 88 Fed. Reg. at 29186.
[413] 88 Fed. Reg. at 29186.

section will explain, consumer acceptance is not a barrier to PEV penetration at the levels projected by EPA's Proposal or at levels consistent with Alternative 1 with increasing stringency after 2030.

B. Consumer acceptance of PEVs is not a barrier to feasibility because consumer acceptance is widespread and growing.

Under EPA's Proposed Standards and under Alternative 1 with a faster ramp-up after 2030, consumer preferences generally align with the most economically advantageous and cost-effective compliance pathway (increasing the deployment of PEVs within the light-duty fleet) toward meeting strong emission standards that fulfill EPA's statutory mandate. American drivers have shifted and are continuing to shift toward acceptance of—and, increasingly, preference for—PEVs. As several original equipment manufacturers (OEMs) have themselves explained, "[r]educed interest in legacy products due to technology advancements and consumer preference shifts are an inevitable reality of the market and occur in all sectors of the economy." *See* Initial Brief for Industry Respondent-Intervenors at 13-14, *Ohio v. EPA*, No. 22-1081 (D.C. Cir. Feb. 13, 2023).[414] Here, as PEV technology advances and both the public health and driver-experienced benefits of PEVs become apparent, consumer's preferences are naturally shifting away from combustion vehicles and toward PEVs.

EPA's Proposal accurately highlights the already "greatly increased acceptance [of PEVs] by consumers," 88 Fed. Reg. at 29187, and that "consumer affinity for PEVs is strong." *Id.* at 29189. This market-based consumer acceptance is evidenced at least in part by recent rapid growth in PEV market share—growth that has outpaced historical estimates considered ambitious just a decade ago. EPA's 2012 Rule, for example, assumed electric vehicles would account for only 3% of the car market and 2% of the combined car and light-duty truck market by 2025. 77 Fed. Reg. at 62874, 62875 Tbl.III-52. By 2021, however, combined car BEV and PHEV market share had already outpaced that estimate for 2025, reaching about 4.2% of LDV sales and double the 2020 market share.[415] By 2022, electric vehicle market share had again reached a new high, with combined LDV BEV and PHEV market share totaling 7.6% for 2022[416]—already more than double EPA's 2012 Rule projection *for 2025*. As of the first quarter

[414] Automaker industry respondent-intervenors on this brief include Ford Motor Company, BMW of North America, LLC, Volkswagen Group of America, Volvo Car USA LLC, American Honda Motor Co., Inc., and the National Coalition for Advanced Transportation (whose members include Rivian and Tesla). The Initial Brief for Industry Respondent-Intervenors is available at https://blogs.edf.org/climate411/files/2023/02/Industry-Respondent-Intervenors-Initial-Brief-Feb.-13-2023_.pdf.

[415] Plug In America, *The Expanding EV Market: Observations in a Year of Growth* 4 (Feb. 2022), https://pluginamerica.org/wp-content/uploads/2022/03/2022-PIA-Survey-Report.pdf; David Gohlke et al., *Assessment of Light-Duty Plug-In Electric Vehicles in the United States, 2010–2021*, Argonne National Laboratory 4 (Nov. 2022), https://publications.anl.gov/anlpubs/2022/11/178584.pdf; Argonne National Laboratory, *Light Duty Electric Drive Vehicles Monthly Sales Updates*, https://www.anl.gov/esia/light-duty-electric-drive-vehicles-monthly-sales-updates); EPA, *The 2022 EPA Automotive Trends Report* 57 (Dec. 2022), https://www.epa.gov/system/files/documents/2022-12/420r22029.pdf.

[416] Colin McKerracher et al., *Electric Vehicle Outlook 2023*, BloombergNEF (June 8, 2023). Subscription required.

of 2023, U.S. light-duty PEV sales were up again, to 8.3%,[417] an increase of 60% compared to the same period in 2022.[418] As discussed in the Proposal, forecasts based on consumer demand now suggest U.S. passenger car PEV sales percentages of 40% to more than 50% by 2030, 88 Fed. Reg. at 29192, and public announcements by major automobile manufacturers support baseline PEV sales at this level or higher. *Id.* at 29190-2; DRIA at 3-16..

Data regarding PEV registrations and preorders also shows strong and growing consumer demand for these vehicles and signals widening consumer acceptance. In the first three months of 2022, registrations for new PEVs increased 60% in the United States, even though overall new car registrations were down 18%.[419] Looking at consumer sales shares, however, is likely an inadequate proxy for actual consumer interest in PEVs, given the fact that many consumers do not yet have access to these vehicles. A recent analysis by Sierra Club found that 66% of car dealerships nationwide did not yet have a single EV available for sale.[420] When new PEV models enter the market, consumers race to place orders. In late 2022, for example, GMC's new Sierra model electric pickup truck averaged more than 500 reservations per day and reached roughly 20,000 reservations after a little over a month, on top of over 170,000 reservations for GMC's Silverado EV pickup.[421] Similarly, the Dodge Ram 1500 REV pickup reached its maximum number of preorders in just 5 days earlier this year.[422]

This consumer purchase data shows Americans' increasing desire for PEVs, and is backed up by other data and research. Specifically, as this section will explain, peer-reviewed research and analyses, customer-based surveys, and comparisons with international sales trends provide further evidence of broad and expanding consumer preference for PEVs.

1. Recent peer-reviewed academic literature supports broad and growing consumer acceptance of PEVs.

Several recent peer-reviewed papers have shown that consumers are in fact ready and willing to adopt electric vehicles. EPA references some of these papers in the Proposal, and

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[417] Argonne National Laboratory, *Light Duty Electric Drive Vehicles Monthly Sales Updates*, https://www.anl.gov/esia/light-duty-electric-drive-vehicles-monthly-sales-updates (showing, as of May 2023, PEV car sales over 10% of total car sales, and combined PEV car and light-duty truck sales of 8.36% of total light-duty sales).

[418] International Energy Agency, *Global EV Outlook 2023*, at 22 (April 2023), https://iea.blob.core.windows.net/assets/dacf14d2-eabc-498a-8263-9f97fd5dc327/GEVO2023.pdf.

[419] Jayme Deerwester, *Registrations for Electric Vehicles Soar, Signaling Increasing Mainstream Acceptance*, USA Today (May 16, 2022), https://www.usatoday.com/story/money/cars/2022/05/16/electric-vehicle-registration-soars/9798645002/.

[420] Sierra Club, *Rev Up Electric Vehicles: A Nationwide Study of the Electric Vehicle Shopping Experience* (May 2023), https://www.sierraclub.org/sites/www.sierraclub.org/files/2023-05/SierraClubRevUpReport2023.pdf.

[421] Peter Holderith, *2024 GMC Sierra EV Waitlist Proves People Want All the Electric Pickups*, thedrive.com (Nov. 29, 2022), https://www.thedrive.com/news/2024-gmc-sierra-ev-waitlist-proves-people-want-all-the-electric-pickups.

[422] Peter Johnson, *Ram Closes Reservations for Its First Electric Truck, the 1500 REV, After 5 Days*, electrek (Feb. 17, 2023), https://electrek.co/2023/02/17/ram-closes-reservations-for-its-first-electric-truck-the-1500-rev/.

should also consider additional research on PEV consumer acceptance, including research that is recently published. For example, a recent study by leading academics in this field, and not discussed in EPA's Proposal, examined consumer choices of plug-in electric vehicles (including BEVs and PHEVs) relative to conventional gasoline vehicles.[423] The study, Forsythe et al. (2023), found that when consumers' basic demands for vehicle attributes are met, they accept or prefer BEVs to combustion vehicles.[424] The analysis was conducted through a nationwide survey-based consumer discrete choice experiment from December 2020 to September 2021, in which new vehicle consumers—weighted to be representative of the U.S. population—chose among potential vehicle options in a manner that mimicked the process of comparing vehicles on an automaker's website.[425] In order to examine how consumer preferences might be changing over time, the experiment was designed to be compared to an earlier discrete choice experiment conducted in 2012–2013.[426] The Forsythe et al. (2023) experiment was well-designed in that it (1) mitigated typical concerns of stated-preference experiments by "incorporat[ing] multiple features into the survey design that tend to improve the ability for survey responses to reveal comparable preferences as when making true purchase decisions";[427] (2) included a substantial number of participants (734 car-buyers and 862 SUV-buyers) recruited using both Amazon's Mechanical Turk (to mirror the earlier comparative study) and Dynata (which includes older and higher-income respondents), and weighted to ensure representativeness of the U.S. new vehicle buying population;[428] and (3) evaluated expected technology for a near-future hypothetical vehicle based on extensive research conducted by the National Academies of Sciences, Engineering, and Medicine, thus reflecting what PEV models could realistically be available to consumers in the short term.[429]

Forsythe et al. (2023) was the first to examine "the degree to which consumer willingness to trade off relevant vehicle attributes associated with electrification (e.g., range, operating cost, price, etc.) may have changed over time due to technology improvements or other factors and

[423] Connor R. Forsythe, Kenneth T. Gillingham, Jeremy J. Michalek & Kate S. Whitefoot, *Technology Advancement is Driving Electric Vehicle Adoption*, PNAS (May 2023), https://www.pnas.org/doi/epdf/10.1073/pnas.2219396120.
[424] *Id.*
[425] *Id.* at 1, 3.
[426] *Id.* at 1*; see also* J.P. Helveston, et al., *Will Subsidies Drive Electric Vehicle Adoption? Measuring Consumer Preferences in the U.S. and China*, 73 Transp. Res. Part A: Policy Pract. 96-112 (2015), https://reader.elsevier.com/reader/sd/pii/S0965856415000038?token=029105616ECD043F67531E36FA6FBC42FD0801DE87C8B7FB2771B0B4E37E79E91CA7AE0CBC4CC7EFA61DCFC6A671DDFC&originRegion=us-east-1&originCreation=20230518185020.
[427] Forsythe et al. (2023) at 3 (listing features incorporated to mitigate any limitations of stated-preference surveys). *See also* C.A. Vossler, M. Doyon & D. Rondeau, *Truth in Consequentiality: Theory and Field Evidence on Discrete Choice Experiments*, 4 Am. Econ. Journal: Microeconomics 145-171 (2012), https://www.aeaweb.org/articles?id=10.1257/mic.4.4.145.
[428] Forsythe et al. (2023) at 3.
[429] *Id.* at 2–3; *see also* National Academies of Sciences, Engineering, and Medicine, *Assessment of Technologies for Improving Light-Duty Vehicle Fuel Economy—2025-2035* (2021), https://nap.nationalacademies.org/catalog/26092/assessment-of-technologies-for-improving-light-duty-vehicle-fuel-economy-2025-2035.

what this could imply for the sales of new vehicles in upcoming years."[430] The results indicated that "any perceived disadvantages of BEVs relative to gasoline vehicles are often compensated by the BEV's improved operating cost, acceleration, and fast-charging capabilities, particularly for BEVs with a longer range."[431]

In short, the study reveals that the attributes consumers look for in their vehicles have most likely stayed consistent between the 2012 stated-preference experiment and Forsythe et al. (2023)'s most recent. As BEVs are able to provide more of those attributes, consumers choose BEVs more often. The authors ultimately concluded that reasonable forecasted improvements of BEV range and price—based on extensive research on technology development by the National Academies of Sciences—show that "consumer valuation of many BEVs is expected to equal or exceed their gasoline counterparts by 2030," resulting in 40% to nearing 60% of consumers choosing BEV powertrain options over combustion powertrain options for the same vehicle.[432] Moreover, "[a] suggestive market-wide simulation extrapolation indicates that if every gasoline vehicle had a BEV option in 2030, the majority of new car and near-majority of new sport-utility vehicle choice shares could be electric in that year due to projected technology improvements alone."[433] Finally, Forsythe et al. (2023) suggested that, with the assumed technological projections, even if all BEV purchase incentives were entirely phased out, BEVs could still have a market share of about 50% relative to combustion vehicles by 2030, based on consumer choice alone.[434]

As discussed in EPA's Proposal and the Agency's January 2023 literature review of consumer acceptance research,[435] other recent studies show a similar trend of increasing consumer preference for PEVs. For example, Carley et al. (2019) found that American consumers were more intent on purchasing PEVs in 2017 than in 2011.[436] Gillingham et al. (2023), cited briefly in EPA's Proposal, is especially illustrative of the increasing consumer demand for PEVs. That study used data on all new light-duty vehicles sold in the United States between 2014 and 2020 (a dataset of over 106 million observations), and found that in the

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[430] Forsythe et al. (2023) at 2.
[431] *Id.* at 2.
[432] *Id.* at 1, 5 Fig.3 (showing U.S. BEV car market shares in MY 2030 over 50% and U.S. BEV SUV market shares in MY 2030 over 40%).
[433] *Id.* at 1. These projected technology improvements follow the projections from National Academies of Sciences, Engineering, and Medicine, *Assessment of Technologies for Improving Light-Duty Vehicle Fuel Economy—2025-2035* (2021), https://nap.nationalacademies.org/catalog/26092/assessment-of-technologies-for-improving-light-duty-vehicle-fuel-economy-2025-2035.
[434] Forsythe et al. (2023) at 6.
[435] EPA & Lawrence Berkeley National Laboratory, *Literature Review of U.S. Consumer Acceptance of New Personally Owned Light Duty Plug-In Electric Vehicles* (Jan. 2023), https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=OTAQ&dirEntryId=353465.
[436] Sanya Carley, Saba Siddiki & Sean Nicholson-Crotty, *Evolution of Plug-In Electric Vehicle Demand: Assessing Consumer Perceptions and Intent to Purchase Over Time*, 70 Transp. Res. Part D: Transp. Environ. 94-111 (2019), https://www.sciencedirect.com/science/article/abs/pii/S1361920918311635.

vehicle segments and classes where EVs were available, they were competing very successfully with comparable combustion vehicles, with relative market shares "exceeding 30% in recent years."[437] The results of this investigation could imply that fleet-wide LDV PEV market share in 2020 was around 2% not because only 2% of buyers wanted PEVs, but at least in part due to "the (near-)absence of EV offerings in many segments of the vehicle market"[438] where purchasers are interested in purchasing vehicles. If consumers want to purchase a particular vehicle type and there are no PEVs available within that market segment, they will buy a combustion vehicle. Gillingham et al. (2023) shows that when PEVs are available in those market segments, consumers already often choose the PEV over the combustion vehicle.

A number of studies in addition to those cited in EPA's literature review of consumer acceptance have considered the impacts of various factors on consumer acceptance of PEVs, and these—coupled with the current rapid pace of technological development and vast investment in PEV infrastructure—provide additional evidence that consumer acceptance is not a barrier to PEV penetration at levels consistent with EPA's Proposal or with Alternative 1 with increasing stringency after 2030. One body of research, for example, reveals that consumer demand is responsive to the availability of public charging infrastructure. When this infrastructure is available—as it increasingly is and will be, *see* Section XVII—consumer acceptance of and demand for PEVs increases. Cole et al. (2023) concluded that for encouraging PEV sales, "[s]pending on charging stations is more effective than spending on rebates," with shifting spending from rebates to charging station programs increasing projected EV penetration share in 2030 from 48% to 68%.[439] Similarly, Li (2017) found that, between 2011 to 2013, the federal income tax credit of up to $7,500 for EV buyers contributed to about 40% of EV sales, but "[a] policy of equal-sized spending but subsidizing charging station deployment could have been more than twice as effective in promoting EV adoption."[440] Using data from Norway, Springel (2021) found that spending on charging station subsidies, at least initially, resulted in more EV purchases than spending on consumer price subsidies.[441] Given the extensive investments in PEV infrastructure, detailed in Section XVII, PEV demand would be expected to be responsive to these investments, and increasing. Additionally, Herberz et al. (2022) studied BEV adoption and found that "car owners systematically underestimate the compatibility of available battery ranges with their annual mobility needs and that this underestimation is associated with increased

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[437] Kenneth T. Gillingham, Arthur A. van Benthem, Stephanie Weber, Mohamed Ali Saafi & Xin He, *Has Consumer Acceptance of Electric Vehicles Been Increasing? Evidence from Microdata on Every New Vehicle Sale in the United States*, American Economic Association: Papers & Proceedings 333–334 (May 2023).
[438] *Id.* at 334.
[439] Cassandra Cole, Michael Droste, Christopher Knittel, Shanjun Li & James Stock, *Policies for Electrifying the Light-Duty Fleet in the United States*, American Economic Association: Papers & Proceedings 320 (May 2023).
[440] Shanjun Li, Lang Tong, Jianwei Xing & Yiyi Zhou, *The Market for Electric Vehicles: Indirect Network Effects and Policy Design*, 4 Journal of the Association of Environmental and Resource Economists 89 (Jan. 2017).
[441] Katalin Springel, *Network Externality and Subsidy Structure in Two-Sided Markets: Evidence from Electric Vehicle Incentives*, American Economic Journal: Economic Policy 393, 425–426 (Nov. 2021).

demand for long battery ranges and reduced willingness to adopt electric vehicles."[442] Researchers found that simply providing tailored compatibility information increased consumer willingness to pay for BEVs, even more than information about easy access to charging infrastructure.

2. Consumer surveys also support broad and growing consumer acceptance of PEVs.

Many well-designed, real-world consumer surveys also confirm significant and growing consumer interest in purchasing PEVs. A report on a recent, nationally representative survey of 8,027 Americans conducted by Consumer Reports with input from the Union of Concerned Scientists, GreenLatinos, and EVNoire, conducted between January 27 and February 18, 2022, found that "[o]verall interest in EVs is high" across all racial demographics.[443] Between 33% and 52% of respondents (depending on racial demographics) would "definitely" or "seriously consider" purchasing or leasing an EV as their next vehicle.[444] Only 28% of Americans would not consider getting an electric-only vehicle if they were to buy or lease a vehicle today.[445] Even in rural areas, the survey showed that current interest in EV purchases is high, with up to 29% of rural drivers at least seriously considering buying or leasing an EV.[446] Between 2020 and 2022, Consumer Reports surveys have shown a 350% increase in consumer demand for BEVs.[447]

Survey responses in the 2022 Capital One Car Buying Outlook also overwhelmingly show that Americans envision a future in which they will be driving PEVs. Over 60% of American car buyers and 84% of American car dealers surveyed agreed that electric vehicles are

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[442] Mario Herberz, Ulf J. J. Hahnel & Tobias Brosch, *Counteracting Electric Vehicle Range Concern with a Scalable Behavioural Intervention*, Nature Energy 503 (2022).
[443] Consumer Reports, et al., *Survey Says: Considerable Interest in Electric Vehicles Across Racial, Ethnic Demographics: Smarter Policies Can Help Overcome Barriers* 2 (Sept. 2022), https://www.ucsusa.org/sites/default/files/2022-09/ev-demographic-survey_0.pdf.
[444] *Id.*
[445] Consumer Reports, *Battery Electric Vehicles & Low Carbon Fuel Survey: A Nationally Representative Multi-Mode Survey* 3 (Apr. 2022), https://article.images.consumerreports.org/image/upload/v1657127210/prod/content/dam/CRO-Images-2022/Cars/07July/2022_Consumer_Reports_BEV_and_LCF_Survey_Report.pdf. *See also* Lydia Saad, *Gallup Vault: Misjudging Cellphone Adoption* (Feb. 16, 2018), https://news.gallup.com/vault/227810/gallup-vault-misjudging-cellphone-adoption.aspx (noting that Americans have not always accurately judged their acceptance of future behavior and have underestimated their acceptance of newer technologies, with almost a quarter of Americans saying in 2000 that they had no intention of ever having a mobile phone).
[446] Maria Cecilia Pinto de Moura, *Survey Shows Pathway to Speeding Up EV Adoption in Rural Areas*, Union of Concerned Scientists (March 14, 2023), https://blog.ucsusa.org/cecilia-moura/survey-shows-pathway-to-speeding-up-ev-adoption-in-rural-areas/.
[447] Chris Harto, *Excess Demand: The Looming EV Shortage*, Consumer Reports 2, 4 (Mar. 2023), https://advocacy.consumerreports.org/wp-content/uploads/2023/03/Excess-Demand-The-Looming-EV-Shortage.pdf.

the future.[448] Additionally, 46% of car buyers already believe they will be driving an electric vehicle within the next 10 years.[449] The annual global EY Mobility Consumer Index found a similar level of consumer demand for and interest in PEVs, and also emphasized that this is a global trend with which the United States must keep pace in order to remain globally competitive. The investigation, conducted in March 2022, surveyed approximately 13,000 respondents from 18 countries including the United States on themes including EVs, mobility and travel behavior, and car buying. It found that preference for fully electric cars for those surveyed tripled between 2020 and 2022,[450] and 52% of global car buyers currently prefer their next car purchase to be an EV, PHEV, or hybrid vehicle.[451]

Very recent surveys from this year also show strong consumer interest in PEVs. KPMG's Consumer Pulse Summer 2023 survey of 1,000 Americans showed that nearly half of U.S. combustion vehicle owners are considering switching to PEVs or hybrid electric vehicles, prompted in large part by increasing gas prices and environmental concerns.[452] A 2023 online poll of 4,410 Americans by Reuters/Ipsos found that already just over a third of Americans would consider buying an EV for their next car purchase.[453] J.D. Power's most recent U.S. Electric Vehicle Consideration Study, released in June 2023, also found high interest in EVs. The study found the number of car buyers "very likely" and "overall likely" to consider purchasing an EV increased over 2002, with 26% of shoppers "very likely" and 61% "overall likely" to consider purchasing an EV.[454]

3. A "tipping point" in PEV adoption can signify rapid mass consumer acceptance, and the United States has reached this milestone.

Analysis from other countries shows that once 5% of a country's new car sales are electric—a threshold the United States has crossed—the country has reached an "electric-car

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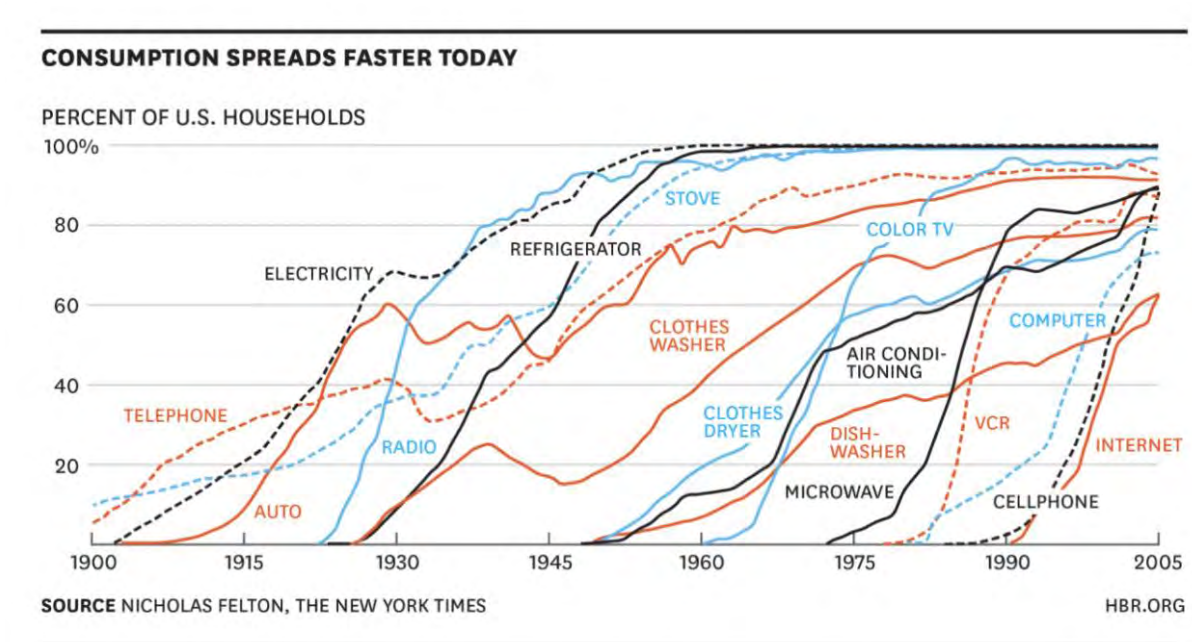
[448] Capital One, *19 Percent of Consumers Find Car Buying Process Transparent* (July 26, 2022), https://www.capitalone.com/about/newsroom/car-buying-outlook-deep-dive/ (summarizing findings of Capital One's 2022 Car Buying Outlook).
[449] *Id.*
[450] Gaurav Batra, Ankit Khatri, Akshi Goel & Menaka Samant, *EY Mobility Consumer Index 2022 Study* 4 (May 2022), https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/automotive-and-transportation/automotive-transportation-pdfs/ey-mobility-consumer-index-2022-study.pdf.
[451] *Id.*
[452] KPMG, *Consumer Pulse Summer 2023 Report, Consumer & Retail* 3, 45–46 (Apr. 2023), https://advisory.kpmg.us/content/dam/advisory/en/pdfs/2023/consumer-pulse-summer-2023-report-april.pdf.
[453] David Shepardson, *One-Third of Americans Would Consider EV Purchase - Reuters/Ipsos Poll*, Reuters (Mar. 21, 2023), https://www.reuters.com/technology/one-third-americans-would-consider-ev-purchase-reutersipsos-poll-2023-03-21/; Ipsos, *Reuters/Ipsos Issues Survey March 2023* (March 24, 2023), https://www.ipsos.com/en-us/reutersipsos-issues-survey-march-2023.
[454] J.D. Power, *Action Needed to Keep Charging from Short Circuiting EV Purchase Consideration, J.D. Power Finds* (June 15, 2023), https://www.jdpower.com/business/press-releases/2023-us-electric-vehicle-consideration-evc-study.

tipping point" which "signals the start of mass EV adoption, the period when technological preferences rapidly flip."[455] So far, 18 countries have reached this "tipping point," and assuming the United States follows their trend, "a quarter of new car sales could be electric by the end of 2025. That would be a year or two ahead of most major forecasts."[456] This "tipping point" occurs because technologies generally follow an S-shaped adoption curve. "Sales move at a crawl in the early-adopter phase, then surprisingly quickly once things go mainstream….In the case of electric vehicles, 5% seems to be the point when early adopters are overtaken by mainstream demand. Before then, sales tend to be slow and unpredictable. Afterward, rapidly accelerating demand ensues."[457] This S-shaped pace of technology adoption has been observed for numerous emerging technologies since the early 1900s, including the telephone, the automobile, electricity, refrigeration, clothes washers and dryers, air conditioning, microwaves, computers, cellphones, and the internet, as Figure XIX.B-1 shows.[458]

Figure XIX.B-1. Consumption Spreads Faster Today[459]



455 Tom Randall, *U.S. Crosses the Electric-Car Tipping Point for Mass Adoption* at 1, Bloomberg (July 9, 2022), https://www.bloomberg.com/news/articles/2022-07-09/us-electric-car-sales-reach-key-milestone; *See also* McKinsey & Company, *Why the Automotive Future is Electric* at 7 (Sept. 2021), https://www.mckinsey.com/~/media/mckinsey/industries/automotive%20and%20assembly/our%20insights/why%20the%20automotive%20future%20is%20electric/why-the-automotive-future-is-electric-f.pdf (noting that the global "tipping point in passenger EV adoption occurred in the second half of 2020, when EV sales and penetration accelerated in major markets despite the economic crisis caused by the COVID-19 pandemic").
456 Tom Randall, *U.S. Crosses the Electric-Car Tipping Point for Mass Adoption* at 1, Bloomberg (July 9, 2022), https://www.bloomberg.com/news/articles/2022-07-09/us-electric-car-sales-reach-key-milestone.
457 *Id.* at 3.
458 Rita McGrath, *The Pace of Technology Adoption is Speeding Up*, Harvard Business Review (Nov. 25, 2013), https://hbr.org/2013/11/the-pace-of-technology-adoption-is-speeding-up.
459 This figure is reproduced from *id.*

Moreover, the pace of adoption has been speeding up consistently across new technologies, as Figure XIX.B-1 also shows. For example, "[i]t took decades for the telephone to reach 50% of households, beginning before 1900. It took five years or less for cellphones to accomplish the same penetration in 1990."[460] The automotive industry has not been left out of this increasing speed of technological adoption, with automotive design cycles decreasing from 60 months to 24 or 36 months over a period of five years.[461]

Between 2021 and 2022, the United States reached this "tipping point" level of PEV penetration, jumping from 4% to over 7.6% PEV sales share.[462] As this tipping point is reached, it is likely that Americans' exposure to PEVs increases. Importantly, "studies show that increasing knowledge and exposure to these [electric] vehicles results in lasting, positive impressions."[463] A comprehensive literature review regarding consumer adoption of BEVs found that social interactions can influence BEV adoption.[464] Some consumers have no interest in purchasing a PEV simply because they lack information about the characteristics of PEVs, but when consumers learn about PEVs, they are more likely to be interested in purchasing one. For example, a study considering hybrid electric vehicle ("HEV") adoption—which "can be used as a proxy for future PEV adoption"—found that there is a strong "direct neighbor effect" by which each consumer's HEV-adoption decision can be influenced by the HEV-adoption decisions of geographic neighbors.[465] Another study, using a survey of vehicle customers in California and a spatial and statistical analysis, found that having more neighbors and work colleagues who have EVs increases EV adoption.[466] Yet another study using very rich data from Sweden found the same result: having more neighbors and work colleagues who drive EVs increases EV adoption. This study also explored reasons for the effect, finding that information transmission is likely very important.[467]

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[460] *Id.* See also Michael DeGusta, *Are Smart Phones Spreading Faster than Any Technology in Human History*, MIT Technology Review (May 9, 2012), https://www.technologyreview.com/2012/05/09/186160/are-smart-phones-spreading-faster-than-any-technology-in-human-history/ (showing that it took 25 years for telephones to reach a 10% adoption rate and an additional 39 years for telephones to reach a 40% penetration rate, but smart phones reached 40% penetration in just 10 years).
[461] Rita McGrath, *The Pace of Technology Adoption is Speeding Up*, Harvard Business Review (Nov. 25, 2013), https://hbr.org/2013/11/the-pace-of-technology-adoption-is-speeding-up.
[462] Colin McKerracher et al., *Electric Vehicle Outlook 2023*, BloombergNEF (June 8, 2023). Subscription required.
[463] CARB, *California's Advanced Clean Cars Midterm Review, Appendix B: Consumer Acceptance of Zero Emission Vehicles and Plug-In Hybrid Electric Vehicles* B-2 (Jan. 18, 2017), https://ww2.arb.ca.gov/sites/default/files/2020-01/appendix_b_consumer_acceptance_ac.pdf.
[464] M. Coffman et al., *Electric Vehicles Revisited: A Review of Factors that Affect Adoption*, Transp. Rev. 37, 79–93 (2017).
[465] X. Liu, M. Roberts & R. Sioshani, *Spatial Effects on Hybrid Electric Vehicle Adoption*, Transportation Research Part D: Transport and Environment 52A, at 86 (2017), https://www.osti.gov/pages/biblio/1346139.
[466] Debapriya Chakraborty, David S. Bunch, David Brownstone, Bingzheng Xu & Gil Tal, *Plug-In Electric Vehicle Diffusion in California: Role of Exposure to New Technology at Home and Work*, Transportation Research Part A: Policy and Practice 156, pp. 133-151 (2022).
[467] Sebastian Tebbe, *Peer Effects in (Hybrid) Electric Vehicle Adoption*, working paper, *see* https://sebastiantebbe.github.io/files/YST_Slides.pdf.

Survey data again corroborates this research. The 2022 Consumer Reports survey found that for all groups of consumers, "experience with EVs strongly correlated to interest in purchasing or leasing an EV."[468] The survey found, for example, that "Americans who are more likely to say that they will buy/lease an electric-only vehicle if they were to get a vehicle today have had more exposure to them. They see them where they live and have friends, relatives, or co-workers who own one."[469] In fact, 71% of those who said they would definitely buy or lease an EV if they were getting a vehicle today had seen EVs in their neighborhood, compared to 44% of all survey respondents.[470] "There is … a strong relationship between having some personal experience with an electric-only vehicle and the likelihood of buying or leasing one."[471] Seventeen percent of all survey respondents had been a passenger in an electric-only vehicle in the past 12 months, compared to 39% of people who said they would definitely buy or lease an electric-only vehicle if they were to buy or lease a vehicle today. Only 7% of survey respondents had driven an EV in the past 12 months, but 20% of those who would definitely buy or lease one have driven one.[472] Two surveys commissioned by the Consumer Federation of America to study consumer attitudes towards PEVs similarly found that "the more consumers know about PEVs, the more positive their attitudes towards them and the more likely they are to consider acquiring one."[473] And J.D. Power's 2023 U.S. Electric Vehicle Consideration Study found that the number of consumers reporting they are "very likely" to consider purchasing an EV was more than double for consumers who had ridden as a passenger in an EV compared to those with no personal experience with EVs.[474]

This exposure effect is also evident when reviewing the outcome of events specifically aimed at exposing potential buyers to PEVs. For example, research by CARB has found that "exposure to PEVs through ride and drive events or car-sharing programs seem to result in lasting, positive impressions and serve to be one of the most influential information sources for helping consumers decide on a PEV. Second to a vehicle test drive, another PEV driver is the

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[468] Consumer Reports, et al., *Survey Says: Considerable Interest in Electric Vehicles Across Racial, Ethnic Demographics: Smarter Policies Can Help Overcome Barriers* 2 (Sept. 2022), https://www.ucsusa.org/sites/default/files/2022-09/ev-demographic-survey_0.pdf.
[469] Consumer Reports, *Battery Electric Vehicles & Low Carbon Fuel Survey: A Nationally Representative Multi-Mode Survey* 7 (Apr. 2022), https://article.images.consumerreports.org/image/upload/v1657127210/prod/content/dam/CRO-Images-2022/Cars/07July/2022_Consumer_Reports_BEV_and_LCF_Survey_Report.pdf.
[470] *Id.*
[471] *Id.* at 8.
[472] *Id.*
[473] Consumer Federation of America, *New Data Shows Consumer Interest in Electric Vehicles Is Growing* (Sept. 19, 2016), https://consumerfed.org/press_release/new-data-shows-consumer-interest-electric-vehicles-growing/; Consumer Federation of America, *Knowledge Affects Consumer Interest in EVs, New EVs Guide to Address Info Gap* (Oct. 29, 2015), https://consumerfed.org/press_release/knowledge-affects-consumer-interest-in-evs-new-evs-guide-to-address-info-gap/.
[474] J.D. Power, *Action Needed to Keep Charging from Short Circuiting EV Purchase Consideration, J.D. Power Finds* (June 15, 2023), https://www.jdpower.com/business/press-releases/2023-us-electric-vehicle-consideration-evc-study.

other most influential information source for new buyers to choose a PHEV or BEV."[475] CARB explained that "[t]he impact of exposure to PEVs through participation in ride and drive events and carsharing programs has been shown to have a positive effect on attitudes towards PEVs and increase interest in PEV adoption."[476] Furthermore, "simply giving consumers more information on PEVs also increases their interest in acquiring one. A study analyzed the effect of providing information on fuel costs of different vehicle technologies for specific commuting patterns on attitudes regarding PEVs," and found that after utilizing an online tool that allowed users to compare fuel costs for different vehicles based on their own commuting patterns, local fuel prices, and charging opportunities, "[p]articipants reported a significantly greater intention to acquire a PEV."[477]

This "tipping point" concept, and the resulting wider PEV exposure when a location reaches the tipping point, is possibly already playing out in microcosms of high PEV sales within the nation. In California, for example—a state even further past this "tipping point" than the United States as a whole—sales of EVs reached more than 21% of all new vehicles sold in early 2023,[478] and at least one survey shows almost three-quarters of California vehicle shoppers say they are "overall likely" to consider an EV.[479] The phase of rapid PEV adoption also has already been underway in several individual cities. For example, 32.9% of monthly new vehicle registrations in the San Francisco metro area were EVs in January 2023, up from 26.7% in January 2022, and 17.2% of new vehicle registrations in Seattle were EVs in January 2023, up from 8.4% in January 2022.[480] Passenger EV sales shares for the first quarter of 2023 were 29.1% of sales in San Francisco and 20.7% of sales in Los Angeles.[481] In the New York City metro area in 2020, there were about three EVs per 1,000 people; today there are about seven EVs per 1,000 people—growth that has been "propelled by more varied models, more charging stations and lower prices."[482]

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475 CARB, *California's Advanced Clean Cars Midterm Review, Appendix B: Consumer Acceptance of Zero Emission Vehicles and Plug-In Hybrid Electric Vehicles* B-39 (Jan. 18, 2017), https://ww2.arb.ca.gov/sites/default/files/2020-01/appendix_b_consumer_acceptance_ac.pdf.
476 *Id*. at B-50 to B-51.
477 *Id.* at B-52.
478 Amy Chen, Yuri Avila & Dustin Gardiner, *EV Sales are Booming in California. Charts Show How Tesla is Quickly Losing Market Share*, San Francisco Chronicle (Apr. 26, 2023), https://www.sfchronicle.com/projects/2023/ev-tracker-california/.
479 J.D. Power, *Action Needed to Keep Charging from Short Circuiting EV Purchase Consideration, J.D. Power Finds* (June 15, 2023), https://www.jdpower.com/business/press-releases/2023-us-electric-vehicle-consideration-evc-study.
480 Emily Harris, *EVs Dominate San Francisco Market as Choices Expand*, Axios (Apr. 7, 2023), https://www.axios.com/local/san-francisco/2023/04/07/evs-tesla-dominate-san-francisco-market-brand-choices-expand; Melissa Santos & Joann Muller, *Electric Vehicle Adoption Doubles in Seattle*, Axios (Apr. 20, 2023), https://www.axios.com/local/seattle/2023/04/20/electric-vehicles-seattle-registrations.
481 California Energy Commission, *New ZEV Sales in California*, https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/new-zev-sales (filtered to show ZEV sales in San Francisco and Los Angeles counties).
482 Robin Shulman Agueros, *Why the New York Area Is Seeing an Explosive Growth in Electric Cars*, New York Times (Mar. 7, 2023), https://www.nytimes.com/2023/03/05/nyregion/electric-vehicles-cars-nyc.html.

This concept could also shed light on one possible reason that PEV sales percentages have been unevenly distributed across the nation, with more sales in cities than rural areas, in a way that minimizes any concerns that rural consumers could have insufficient demand for PEVs. A 2023 survey conducted by the Union of Concerned Scientists and Consumer Reports "uncover[ed] that there isn't sufficient familiarity with EVs in rural areas. The overwhelming majority of respondents—96%—has never owned or leased an EV."[483] The survey found that only 6% of rural respondents said they were very familiar with the fundamentals of buying and owning an EV, while 30% said they were somewhat familiar, and concluded that "[o]ne of the reasons for this lack of familiarity could be the scarcity of EVs in rural areas: only 27% of rural dwellers have seen an EV in their neighborhood in the past month compared to more than half of urban dwellers, and even fewer have a friend, relative or co-worker who owns an EV. A whopping 90% of rural dwellers have never been a passenger in an EV, and almost nobody has ever driven one."[484] As efforts are made to increase familiarity with PEVs in rural areas, more Americans will learn about the very real benefits and advantages of PEVs, especially for rural drivers, *see* Section XIX.C.6 below, and this "neighbor effect" will begin to take hold in more places.

C. When considering the attributes consumers care about most, EVs are a great fit.

One of the reasons this "neighbor effect" may occur is because when consumers learn about PEVs, they often realize that PEVs offer a superior fit for the attributes they care about most in their driving and vehicle-owning experience. Forsythe et al. (2023) found that key factors Americans consider when purchasing vehicles and considering PEV options are operating cost, range, fast-charging capabilities, and performance characteristics such as acceleration.[485] Consumer surveys and other studies have found the same attributes, along with fuel economy, as key to purchase decisions.[486] As explained briefly in this section and in more detail in Sections

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483 Maria Cecilia Pinto de Moura, *Survey Shows Pathway to Speeding Up EV Adoption in Rural Areas*, Union of Concerned Scientists (Mar. 14, 2023), https://blog.ucsusa.org/cecilia-moura/survey-shows-pathway-to-speeding-up-ev-adoption-in-rural-areas/.

484 *Id.*

485 Forsythe et al. (2023) at 1–2.

486 *See, e.g.*, Consumer Reports, *Consumer Attitudes Towards Fuel Economy: 2020 Survey Results* 3-4, 6 (Feb. 2021), https://advocacy.consumerreports.org/wp-content/uploads/2021/02/National-Fuel-Economy-Survey-Report-Feb-2021-FINAL.pdf (showing high value placed on fuel economy in purchase decisions); Alexey Sinyashin, *Optimal Policies for Differentiated Green Products: Characteristics and Usage of Electric*, U.C. Berkeley Haas School of Business (Nov. 8, 2021) https://drive.google.com/file/d/1KEYJWa25DjH_g89ukSRW3PymjsTkUq4c/view (finding range and charging station availability as key elements in purchase decisions); J.D. Power, *EV Price Pressure Grows as Government Incentives and Lease Deals Wield Outsized Influence on Consumer Demand* (Mar. 29, 2023), https://www.jdpower.com/business/resources/ev-price-pressure-grows-as-government-incentives-and-lease-deals-wield-outsized-influence-on-consumer-demand#:~:text=At%20the%20current%20trajectory%2C%20J.D..is%20expected%20to%20surpass%2075%25 ("Consumer interest in EVs is increasingly being heavily swayed by price"); Consumer Reports, *Consumer Attitudes Towards Fuel Economy: 2020 Survey Results* 6 (Feb. 2021), https://advocacy.consumerreports.org/wp-content/uploads/2021/02/National-Fuel-Economy-Survey-Report-Feb-2021-FINAL.pdf (finding that 94% of potential vehicle purchasers considered fuel economy to be "extremely important," "very important," or "somewhat important" when purchasing a vehicle).

XIX.C and XX, PEVs offer superior satisfaction of these consumer preferences. Any existing or perceived barriers to PEV adoption based on consumer acceptance are either minimal or surmountable, policies are already in place to support rapid elimination of any remaining barriers, and the pace of PEV incorporation into the fleet will allow for consumer preferences to be fulfilled.

1. PEVs are increasingly favorable from a total cost of ownership perspective and save drivers money over the life of the vehicle. As more models become available, this benefit will be accessible to more consumers.

First, PEVs are increasingly favorable from an operating cost and total cost of ownership (TCO) perspective—a factor that is very important to U.S. consumers when deciding which vehicles they want to buy. A 2020 nationally representative survey of potential vehicle purchasers found that 94% of potential purchasers considered fuel economy to be important when purchasing a vehicle.[487] PEVs excel in the area of fuel cost savings. As EPA's Proposal shows, the incremental costs of PEVs over combustion vehicles are increasingly insignificant or nonexistent—especially in light of various state and federal incentives—resulting in PEVs saving drivers money in very short periods of time. And as operating costs are reduced, consumers are willing to pay more for their vehicles. Forsythe et al. (2023) found car buyers willing to pay upfront an additional $1,960 per 1 cent/mile reduction in operating cost, and SUV buyers willing to pay an additional $1,490.[488] The paper also found that any perceived PEV disadvantages were made up for by favorable operating costs (along with fast-charging capability), and that lower operating costs "can help increase consumer adoption."[489] Forsythe et al. (2023) further found that reductions in the BEV price-premium, which are projected to occur, "have driven substantial increases in consumer choices of BEV cars and SUVs over their conventional gasoline vehicle counterparts."[490] A March 2023 J.D. Power survey reflected one example of this consumer responsiveness to price, finding that consumer interest in the Ford Mustang Mach-E and Tesla Model Y measurably increased when both manufacturers announced price drops and both models were made eligible for the IRA's $7,500 federal tax credit.[491] A June 2023 J.D. Power survey also indicated that consumers are recognizing these savings, finding that "[t]he more miles that vehicle owners drive, the more likely they are to consider an EV. As in

[487] Consumer Reports, *Consumer Attitudes Towards Fuel Economy* at 3-4, 6.
[488] Forsythe et al. (2023) at 5.
[489] Forsythe et al. (2023) at 1–2, 6 (assuming sufficiently long range).
[490] Forsythe et al. (2023) at 2.
[491] J.D. Power, *EV Price Pressure Grows as Government Incentives and Lease Deals Wield Outsized Influence on Consumer Demand* (Mar. 29, 2023), https://www.jdpower.com/business/resources/ev-price-pressure-grows-as-government-incentives-and-lease-deals-wield-outsized-influence-on-consumer-demand#:~:text=At%20the%20current%20trajectory%2C%20J.D.,is%20expected%20to%20surpass%2075%25.

prior-year studies, daily commuters faced with higher fuel expenses are trading in their gas-powered vehicles for EVs."[492]

Up until recently, nearly all PEV models on the market were sedans or hatchbacks, or vehicles in the luxury car segment of the market,[493] leaving vehicle purchasers looking for other types of vehicles without many options. But dozens of new models are entering the market in the next year, in all vehicle segments.[494] Additional PEV model availability will provide a wider range of price points and greater diversity of vehicle types and features for potential PEV purchasers, further driving down average PEV costs and resulting in a PEV "fit" superior to a comparable combustion vehicle for more consumers. Research by ICCT has shown that "[g]reater availability of models in more vehicle segments and in higher volumes that meet consumers' wide range of needs and preferences is critical to market growth," and "states with greater model availability tend to have higher electric vehicle uptake."[495] In recent years, average PEV costs have appeared higher than average combustion vehicle costs because many PEVs have been offered only in the luxury vehicle market. Gillingham et al. (2023)'s review of its dataset containing every new LDV sale in the United States between 2014 and 2020 revealed that, during that time period, "the market share of EVs and PHEVs is quite high in several price brackets at the high end, but the number of vehicles sold in these high price brackets is relatively small," and that "EVs *can* make up a large market share in the U.S. new car market," and "there is a great deal of untapped product space for EVs in the lower price brackets."[496] Drivers of non-luxury vehicles want PEVs—and their benefits—as well. Automakers understand this demand and are expanding their PEV options, and an appropriately stringent rule by EPA will go further to accelerate this trend by offering automakers regulatory certainty.

Already, the number of light-duty PEV options has grown dramatically. The Alliance for Automotive Innovation states that at the end of 2022, there were 95 PEV models available in the United States.[497] More models are forthcoming, including additional truck and SUV models

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492 J.D. Power, *Action Needed to Keep Charging from Short Circuiting EV Purchase Consideration, J.D. Power Finds* (June 15, 2023), https://www.jdpower.com/business/press-releases/2023-us-electric-vehicle-consideration-evc-study.

493 *See, e.g.*, Gillingham et al. (2023) at 329, 332–333 (noting that EVs are overrepresented in the luxury market segments and that in the hatchback category—"a small market segment with a relatively large number of EV offerings"—sales of PEVs have been "close to 15% of the market in some years").

494 Jeff S. Bartlett & Ben Preston, *Automakers are Adding Electric Vehicles to Their Lineups. Here's What's Coming*, Consumer Reports (Mar. 10, 2023), https://www.consumerreports.org/hybrids-evs/why-electric-cars-may-soon-flood-the-us-market-a9006292675/.

495 Anh Bui, Peter Slowik & Nic Lutsey, *Briefing: Evaluating Electric Vehicle Market Growth Across U.S. Cities*, ICCT 13-14 (Sept. 2021), https://theicct.org/wp-content/uploads/2021/12/ev-us-market-growth-cities-sept21_0.pdf.

496 Gillingham et al. (2023) at 331–332.

497 Alliance for Automotive Innovation, *Get Connected: Electric Vehicle Quarterly Report, First Quarter, 2023* 2 (2023), https://www.autosinnovate.org/posts/papers-reports/Get%20Connected%20EV%20Quarterly%20Report%202023%20Q1.pdf.

along with the expansion of a wider range of EV sedans.[498] EPA's Proposal notes research by EDF and ERM projecting that there will be over 180 PEV models available by the end of 2025, 88 Fed. Reg. at 29190 n.59, but EDF and ERM have since updated their analysis and now project that there will be 197 PEV models available by the end of 2025.[499] Many of the world's largest automakers have committed to significantly expanding PEV production in the next few years, even absent additional standards,[500] which will naturally lead to a larger array of model choices. For example, BMW, Volkswagen, and Stellantis have each committed to fleets half comprised of zero-emission vehicles by 2030.[501] Mercedes-Benz, Ford, and GM have committed to an entirely zero-emission fleet by 2035.[502] Volvo announced its fleet will be all electric by the end of the decade.[503] J.D. Power's EV Index and EV Consideration Pulse Survey found that half of all new car shoppers will have a viable EV option by the end of 2023, and three out of four shoppers will have a viable EV option by the end of 2026.[504]

2. PEVs offer meaningful refueling (charging) benefits to consumers.

Americans are interested in how quickly they can refuel their vehicles. Again, PEVs have real advantages that should not be underestimated. While opponents to PEVs frequently assert what they believe will be fundamental changes to how Americans get to work, school, and run errands, a closer look at the issue reveals that PEVs can offer meaningful benefits. Most trips are well below the average PEV range, and charging for these trips can often be done when vehicles are parked at home, work, or in public in between trips. In fact, recent research has shown that 90% of trips could be completed in vehicles with 124 miles of range—well below the capabilities of the current average EV range in the United States (almost 300 miles).[505] Even as of 2016, researchers at MIT found that electric vehicles at the time could handle almost 90% of all car travel in the U.S.[506]

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498 Consumer Reports, *Hot, New Electric Cars That Are Coming Soon* (June 9, 2023), https://www.consumerreports.org/cars/hybrids-evs/hot-new-electric-cars-are-coming-soon-a1000197429/.
499 Rachel MacIntosh et al., *Electric Vehicle Market Update*, Environmental Defense Fund and ERM 7 (Apr. 2023), https://www.edf.org/sites/default/files/2023-05/Electric%20Vehicle%20Market%20Update%20April%202023.pdf.
500 Zifei Yang, *Beyond Europe: Are There Ambitious Electrification Targets Across Major Markets?*, Int'l Council on Clean Transp. Staff Blog (Nov. 15, 2022), https://theicct.org/global-oem-targets-cars-ldvs-nov22/.
501 *Id.*
502 *Id.*
503 *Id.*
504 J.D. Power, *EV Price Pressure Grows as Government Incentives and Lease Deals Wield Outsized Influence on Consumer Demand* (Mar. 29, 2023), https://www.jdpower.com/business/resources/ev-price-pressure-grows-as-government-incentives-and-lease-deals-wield-outsized-influence-on-consumer-demand#:~:text=At%20the%20current%20trajectory%2C%20J.D.,is%20expected%20to%20surpass%2075%25.
505 Mario Herberz, Ulf J. J. Hahnel & Tobias Brosch, *Counteracting Electric Vehicle Range Concern with a Scalable Behavioural Intervention*, Nature Energy 503 (2022) (finding that 90% of trips could be completed in vehicles with 124 miles of range); Tom Randall, *Americans Insist on 300 Miles of EV Range. They're Right*, Bloomberg (May 4, 2023), (noting that U.S. EVs have almost reached 300 mile average range).
506 Catherine Caruso, *Why Range Anxiety for Electric Cars is Overblown*, MIT Technology Review (Aug. 15, 2016), https://www.technologyreview.com/2016/08/15/158319/why-range-anxiety-for-electric-cars-is-overblown/.

Drivers with access to a garage or dedicated overnight parking spot may simply charge at home while they sleep, and most do. EY's Mobility Consumer Index 2022 survey found that 80% of EV owners use home charging,[507] and other research has found that more than half of all reported EV charging takes place at home.[508] Once a home charger is installed, "the home then has its own permanent home refueling station that can likely be used with all future PEVs."[509] Substantial investments in infrastructure incentives will help to reduce any consumer concerns over range or charging availability. About half of Americans (49%) say "discounts to install a home charger" are the incentives that would most encourage them to get an EV.[510] The Inflation Reduction Act extended the EV charger credit, which covers 30% (up to $1,000 per unit) of the cost of charging equipment for individual/residential uses. *See* 26 U.S.C. § 30C. Many states and local jurisdictions offer additional installation incentives that can further reduce costs.

Furthermore, "[e]lectric vehicles have the meaningful advantage of refueling at a far wider array of locations than gasoline stations."[511] Gas stations "must be carefully located to achieve scale economies to pay for expensive sturdy buried fuel storage tanks, environmental and safety protection methods, and gas pumps. In contrast, PEVs can charge at millions of potential home, work, or public locations."[512] And, with increasing numbers of chargers available in places where drivers otherwise spend their time, "drivers can simply plug in and charge at a variety of locations where they would naturally park their vehicle for long periods of time."[513] Recently, Walmart announced plans to install new BEV fast-charging stations at thousands of Walmart and Sam's Club locations across the country, in addition to the 1,300 BEV fast-charging stations the retailer has already made available.[514] Other retailers already offering significant levels of BEV charging include 7-Eleven, Cinemark, Ikea, Kohl's, Kroger, Macy's, Starbucks,

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[507] Gaurav Batra, Ankit Khatri, Akshi Goel & Menaka Samant, *EY Mobility Consumer Index 2022 Study* 5 (May 2022), https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/automotive-and-transportation/automotive-transportation-pdfs/ey-mobility-consumer-index-2022-study.pdf.

[508] Rob Stumpf, *Americans Cite Range Anxiety, Cost as Largest Barriers for New EV Purchases: Study* (Feb. 26, 2019), https://www.thedrive.com/news/26637/americans-cite-range-anxiety-cost-as-largest-barriers-for-new-ev-purchases-study.

[509] David P. Tuttle & Ross Baldick, *Technological, Market and Policy Drivers of Emerging Trends in the Diffusion of Plug-In Electric Vehicles in the U.S.*, Electr. J. 7 (Aug./Sept. 2015), https://users.ece.utexas.edu/~baldick/papers/plugindiffusion.pdf.

[510] Consumer Reports, *Battery Electric Vehicles & Low Carbon Fuel Survey: A Nationally Representative Multi-Mode Survey* 4 (Apr. 2022), https://article.images.consumerreports.org/image/upload/v1657127210/prod/content/dam/CRO-Images-2022/Cars/07July/2022_Consumer_Reports_BEV_and_LCF_Survey_Report.pdf.

[511] Tuttle & Baldick (2015) at 7.

[512] *Id.*

[513] *Id.*

[514] Vishal Kapadia, *Leading the Charge: Walmart Announces Plan to Expand Electric Vehicle Charging Network*, Walmart (Apr. 6, 2023), https://corporate.walmart.com/newsroom/2023/04/06/leading-the-charge-walmart-announces-plan-to-expand-electric-vehicle-charging-network (noting that this will offer customers and members the convenience of "being able to pick up essentials for their families or grab a bite to eat while they charge").

Subway, Taco Bell, Walgreens, and Whole Foods.[515] PlugShare's charger locator can be searched based on various types of charging locations, revealing chargers at hiking, dining, shopping, camping, park, and grocery locations throughout the country.[516] As far back as 2015, drivers who parked on the street could access street lights for charging in some dense urban areas,[517] and this cost-effective technology[518] is expanding in Europe and the United States, with U.S. pilot programs in New York, Charlotte, and Kansas City,[519] and a large number of BEV charging stations on streetlight poles in Los Angeles.[520] In addition, experts anticipate that charging equipment will increasingly be distributed widely throughout apartment building and multi-family garages.[521] Research on parking has found that the average car is parked for 95% of its useful life,[522] leaving plenty of time to charge in a large variety of locations. As these public chargers increase, PEVs become a viable and attractive option for more drivers, including those without access to easy home-charging.[523]

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[515] Dan Avery, *12 Places That Offer EV Charging While You Shop*, CNET (Apr. 19, 2023), https://www.cnet.com/roadshow/news/12-places-that-offer-ev-charging-while-you-shop/.

[516] PlugShare, Map of EV Charging Locations, https://www.plugshare.com/.

[517] *See* Tuttle & Baldick (2015) at 8 ("Charging cords with wireless revenue-grade meters that plug into street lights are now offered for drivers who park on the street in dense urban areas.").

[518] Research by WRI found that compared to ground-mounted chargers, pole-mounted chargers result in installation cost savings of up to 55% and overall cost reductions of 30% because they use existing electrical connections and have minimal costs associated with construction, materials, and labor. *See* Emmett Werthmann & Vishant Kothari, *Pole-Mounted Electric Vehicle Charging: Preliminary Guidance for a Low-Cost and More Accessible Public Charging Solution for U.S. Cities*, World Resources Institute 12 (Nov. 2021), https://files.wri.org/d8/s3fs-public/2021-11/pole-mounted-electric-vehicle-charging-preliminary-guidance.pdf?VersionId=xNjP5je_Ohc5WnFVVCbxWGmmk_vMIqpu.

[519] Jay Ramey, *Are Lamppost EV Chargers Ideal for City Dwellers?*, Autoweek (Jan. 23, 2023), https://www.autoweek.com/news/green-cars/a42618155/ubitricity-lamppost-ev-chargers-curbside/; EVANNEX, *Study Finds On-Street Lampost EV Chargers Are Lowest-Carbon Solution*, Inside EVs (Nov. 5, 2022), https://insideevs.com/news/619989/using-lamposts-for-ev-charging-reduces-carbon-footprint/.

[520] Bradley Berman, *LA Adds Hundreds of EV Chargers to Streetlights, Giving Renters a Place to Plug In*, Electrek (Nov. 13, 2019), https://electrek.co/2019/11/13/la-adds-hundreds-of-ev-chargers-to-streetlights-giving-renters-a-place-to-plug-in/ (noting over 130 EV chargers on streetlights as of 2019); LA Lights, *EV Charging Stations*, https://lalights.lacity.org/connected-infrastructure/ev_stations.html (map showing streetlight chargers across Los Angeles); Emmett Werthmann & Vishant Kothari, *How Utility Poles and Streetlights Can Improve Equitable Access to EV Charging in U.S. Cities*, The City Fix, World Resources Institute (Nov. 30, 2021), https://thecityfix.com/blog/how-utility-poles-and-streetlights-can-improve-equitable-access-to-ev-charging-in-u-s-cities/ (noting 431 streetlight chargers and 44 utility pole chargers in Los Angeles and a pilot project in Charlotte, North Carolina).

[521] Joshua Stein, *How Electric Cars Might Affect Multifamily And Other Real Estate*, Forbes (May 25, 2023), https://www.forbes.com/sites/joshuastein/2023/05/25/how-electric-cars-will-affect-multifamily-and-other-real-estate/?sh=59d16f66317c.

[522] Ruth Eckdish Knack, *Pay As You Park*, Planning Magazine (May 2005), http://shoup.bol.ucla.edu/PayAsYouPark.htm#:~:text=%22Most%20people%20in%20transportation%20focus,learn%20from%20that%2095%20percent.

[523] Cassandra Cole, Michael Droste, Christopher Knittel, Shanjun Li & James Stock, *Policies for Electrifying the Light-Duty Fleet in the United States*, American Economic Association: Papers & Proceedings 321 (May 2023) (noting that "providing additional [public] charging stations enables EV ownership" for more drivers).

PEV charging is increasingly taking less time, further enhancing the convenience benefits of PEV ownership. Hyper-fast Level 3 DC fast chargers can charge a BEV in as little as 30 minutes or less, adding up to 10 miles of range for each minute of charging time,[524] and consumers have expressed strong willingness-to-pay for this capability.[525] Research has shown that availability of more fast-chargers "reduce[s] range anxiety and make[s] it possible to use EVs in the way that drivers now use ICEs."[526]

PEV charging has additional benefits on top of saving drivers money and eliminating weekly trips to the gas pump. First, PEVs with bi-directional charging capability have potential to serve as back-up home generators in temporary power outages, with a typical BEV storing about 67 kWh in its battery—more than three days' worth of electricity.[527] In fact, when a 2021 ice storm in Texas left millions of residents without electricity, Ford "lent out their hybrid F-150s as home generators."[528] More makes and models are expected to offer bi-directional charging,[529] with the potential that this capability becomes the norm. Additionally, vehicle-to-grid (V2G) charging offers potential benefits for both the grid and PEV owners. RMI found that by 2030, "virtual power plants" including parked vehicles supplying energy to the grid could reduce peak loads in the United States by 60 gigawatts.[530] As this capability continues to develop, there could be additional "revenue opportunities for PEV owners for providing these grid services."[531] Research in Germany has shown that bidirectional EV charging can generate significant revenue for the typical German household: between 310 and 530 euros per year.[532] A recent successful vehicle-to-grid demonstration in North Carolina, taking place over two years, reveals the potential for V2G not only to improve grid optimization and resilience, but also to save

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[524] Electrify America, *Charging with Electrify America*, https://www.electrifyamerica.com/what-to-expect/ (noting full charging in 30 minutes); Jessica Shea Choksey, *What is DC Fast Charging?*, J.D. Power (May 10, 2021), https://www.jdpower.com/cars/shopping-guides/what-is-dc-fast-charging (noting ability to charge to 80% "in anywhere from 15 minutes to 45 minutes"); DriveClean, *Electric Car Charging Overview*, CARB https://driveclean.ca.gov/electric-car-charging (noting that DC fast charging can add "up to 10 miles of range per minute of charging time"); ICCT, *Five Things You Know About Electric Vehicles That Aren't Exactly True* (July 19, 2021), https://theicct.org/stack/explaining-evs/ (high-powered DC fast chargers can charge a long-range EV in 20–36 minutes).
[525] Forsythe et al. (2023) at 5 (noting additional willingness to pay $4,140 for BEV fast charging capability).
[526] Cassandra Cole, Michael Droste, Christopher Knittel, Shanjun Li & James Stock, *Policies for Electrifying the Light-Duty Fleet in the United States*, American Economic Association: Papers & Proceedings 321 (May 2023).
[527] Michael J. Coren, *Electric Vehicles Can Now Power Your Home for Three Days*, Washington Post (Feb. 17, 2023), https://www.washingtonpost.com/climate-environment/2023/02/07/ev-battery-power-your-home/.
[528] *Id.*
[529] *Id.* (noting that makers of the Hyundai Ioniq 5, Lucid Air, Kia EV6, VW ID.4, Mitsubishi Outlander, and Chevy Silverado EV, in addition to Ford's F-150, have announced plans for offering electricity services in the next year or so).
[530] *Id.*; Kevin Brehm, Avery McEvoy, Connor Usry & Mark Dyson, *Virtual Power Plants, Real Benefits*, Rocky Mountain Institute (2023), https://rmi.org/insight/virtual-power-plants-real-benefits/.
[531] Tuttle & Baldick (2015) at 11 (citing Quinn, C. et al., *The Effect of Communication Architecture on the Availability, Reliability and Economics of Plug In Hybrid Vehicle-to-Grid Charging*, 195 J. Power Sources 1500-1509 (Mar. 5, 2010)).
[532] Timo Kern, Patrick Dossow & Elena Morlock, *Revenue Opportunities by Integrating Combined Vehicle-to-Home and Vehicle-to-Grid Applications in Smart Homes*, 307 Applied Energy 1 (Feb. 2022), https://www.sciencedirect.com/science/article/pii/S0306261921014586.

consumers money. The North Carolina Clean Energy Technology Center explained that "[q]uantifying the potential value streams from bidirectional charging allows utilities to begin considering incentive payments and other EV program options for customers and members. By demonstrating significant positive value, this study encourages utilities in similar market conditions to help customers overcome the financial barriers to purchasing an EV, particularly in low- and moderate-income areas where these costs may restrict EV adoption."[533] The University of Delaware has partnered with local electric utilities and a regional transmission organization to have their vehicles plugged in and available when called upon for grid support, with the transmission organization paying the university the market rate, or roughly $1,200 per year per BEV.[534] Research by NREL has also considered net revenue generation from V2G services, including from private LDVs, and found significant potential.[535]

3. PEV range has increased enough to meet the demands of nearly all American car trips.

American consumers are interested in how far their cars can travel, as Americans currently drive an above average number of vehicle miles per day (compared to the rest of the world),[536] and demand "roughly a third more [range] than the global average."[537] While range was therefore once a key challenge for PEV adoption, it is no longer. In fact, "many EVs are approaching the range of an average gasoline vehicle," and "the combined electric and gasoline range for PHEVs often exceeds gasoline-only vehicles."[538]

The average BEV range has skyrocketed in recent years, making range issues no longer a real concern. Average BEV range reached 298 miles in MY 2021, "or about four times the range of an average EV in 2011,"[539] when range was in fact a real concern. Longer-range BEVs are available for consumers with more substantial driving needs,[540] PEVs are becoming more

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[533] North Carolina Clean Energy Technology Center, *NC Cooperative Demonstration of Vehicle-to-Grid Smart Charger Concludes with Positive Results* (May 8, 2023), https://nccleantech.ncsu.edu/2023/05/08/nc-cooperative-demonstration-of-vehicle-to-grid-smart-charger-concludes/.
[534] U.S. Department of Energy, Federal Energy Management Program, *Bidirectional Charging and Electric Vehicles for Mobile Storage*, https://www.energy.gov/femp/bidirectional-charging-and-electric-vehicles-mobile-storage.
[535] Darlene Steward, *Critical Elements of Vehicle-to-Grid (V2G) Economics*, NREL (Sept. 2017), https://www.nrel.gov/docs/fy17osti/69017.pdf.
[536] Bryn Huxley-Reicher, *Fact File: Americans Drive the Most*, Frontier Group (Feb. 14, 2022), https://frontiergroup.org/resources/fact-file-americans-drive-most/.
[537] Tom Randall, *Americans Insist on 300 Miles of EV Range. They're Right*, Bloomberg (May 4, 2023).
[538] EPA, *The 2022 EPA Automotive Trends Report: Greenhouse Gas Emissions, Fuel Economy, and Technology Since 1975* E-2, 60 (Dec. 2022), https://www.epa.gov/system/files/documents/2022-12/420r22029.pdf (finding that the efficiency of EVs has increased by about 18% in the last ten years).
[539] *Id.* at 60.
[540] *See, e.g.*, Nicholas Wallace et al., *Longest Range Electric Cars for 2023, Ranked*, Car and Driver (Mar. 23, 2023), https://www.caranddriver.com/features/g32634624/ev-longest-driving-range/ (listing U.S. PEVs with longest driving range).

efficient,[541] and several PHEVs exceed 500 miles of total range.[542] The well-designed stated-preference experiment conducted by Forsythe et al. (2023) found that "[m]ost vehicles with a range of at least 300 miles were valued by consumers equivalently or more than their conventional gasoline vehicle counterparts."[543] BEV range is "on the cusp of exceeding 300 miles, a key psychological barrier."[544] This level of range handily fulfills the needs and preferences of almost every American driver. The average U.S. one-way commute is about 27.6 minutes,[545] and the average single-car American household drives about 30 miles per day[546]—both well within the range of all PEVs in today's vehicle market. ICCT has explained that "87% of American car drivers drive on average less than 100 kilometers (60 miles) a day—that is, only half the range capacity of the e-Golf, one third of the Leaf's, and less than a quarter of the Tesla's range on a single charge."[547] Chakraborty et al. (2021) examined how much PEVs were used within households, and concluded that "BEVs and PHEVs appear to be viable as alternatives to conventional vehicles in terms of meeting the travel needs of households," and that "[s]ince most new and upcoming BEVs are longer-range vehicles, we expect this to mean BEVs will largely be suitable replacements for conventional vehicles in household fleets."[548]

As consumer understanding of the capabilities inherent in this amount of range increases, range anxiety would be expected to decline and consumer acceptance of PEVs to match the vehicles' other benefits. Forsythe et al. (2023) explained that range increase is a key advancement in BEV technology that has "driven substantial increases in consumer choices of BEV cars and SUVs over their conventional gasoline vehicle counterparts."[549] And Herberz et al. (2022) found that 90% of trips could be completed in cars with less than half of the current U.S. average range, but that most drivers do not understand this.[550] Surveys by automakers have also found that range anxiety is the largest factor in consumers refraining from purchasing PEVs, explaining that drivers can be fearful they will run out of power before being able to recharge

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[541] EPA, *The 2022 EPA Automotive Trends Report*, at 60.
[542] *Id.* at E-2.
[543] Forsythe et al. (2023) at 6.
[544] Tom Randall, *Americans Insist on 300 Miles of EV Range. They're Right*, Bloomberg (May 4, 2023).
[545] Charlynn Burd et al., *Travel Time to Work in the United States:2019*, U.S. Census Bureau 1 (2019), https://www.census.gov/content/dam/Census/library/publications/2021/acs/acs-47.pdf.
[546] U.S. Department of Energy, *Daily Vehicle Miles Traveled Varies with the Number of Household Vehicles* (Sept. 17, 2018), https://www.energy.gov/eere/vehicles/articles/fotw-1047-september-17-2018-daily-vehicle-miles-traveled-varies-number.
[547] ICCT, *Five Things You Know About Electric Vehicles That Aren't Exactly True* (July 19, 2021) https://theicct.org/stack/explaining-evs/.
[548] Debapriya Chakraborty, Scott Hardman & Gil Tal, *Integrating Plug-In Electric Vehicles (PEVs) into Household Fleets – Factors Influencing Miles Traveled by PEV Owners in California*, U.C. Davis 2, 33 (Aug. 2021), https://escholarship.org/content/qt2214q937/qt2214q937.pdf.
[549] Forsythe et al. (2023) at 1-2.
[550] Herberz et al. (2022) at 503, 506–507. *See also* Jennifer Sensiba, *Putting Two Ford Announcements Together Shows Us How It Thinks About EV Range* (May 29, 2023), https://cleantechnica.com/2023/05/29/putting-two-ford-announcements-together-shows-us-how-it-thinks-about-ev-range/ (noting that 90% of all drives are within range of home).

their vehicles, though some of these surveys were conducted in 2019 or earlier, when average PEV ranges were lower.[551] Simply providing tailored compatibility information regarding the ability of BEVs to fulfill drivers' range needs increased willingness to pay for BEVs even more than information about easy access to charging infrastructure.[552]

Even for longer travel and trips in excess of the average daily drive—which make up a very small percentage of U.S. driving—PEVs provide a good fit for most consumers' needs and wants. U.S. Bureau of Transportation Statistics data shows that trips longer than 250 miles make up a miniscule fraction of U.S. daily driving. In 2022, U.S. drivers took between 1.3 billion and 1.5 billion vehicle trips per day, with fewer than 2 million trips per day 500 miles or longer and between about 1.5 million and 2.5 million trips per day between 250 and 500 miles.[553] Charging infrastructure is rapidly developing to support this small percentage of longer drives. As Section XVII explains, the number of public PEV charging stations is growing rapidly,[554] and the BIL and IRA are funding new PEV charging corridors. Alternative Fuels Data Center's map of nationwide PEV charging stations shows that already—with 8.3% PEV sales penetration in the first quarter of 2023[555]—charging stations are widespread.[556] In May, U.S. and Canadian officials announced the first Binational EV Corridor, covering a nearly 900-mile stretch between the United States and Canada, with PEV chargers every 50 miles.[557] Similarly, last year four states announced plans to build a 1,100-mile PEV charging circuit along Lake Michigan.[558] In Washington, Oregon, and California, the West Coast Electric Highway provides DC fast charging stations every 25 to 50 miles along Interstate 5, Highway 99, and other major roadways.[559] Electrify America's DC fast-charging network includes two cross-country routes (one from Los Angeles to Washington, DC, and another from San Diego to Jacksonville), along with a route covering much of the East Coast on Interstate 95 (from Portland, Maine to Miami,

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[551] Rob Stumpf, *Americans Cite Range Anxiety, Cost as Largest Barriers for New EV Purchases: Study*, The Drive (Feb. 26, 2019), https://www.thedrive.com/news/26637/americans-cite-range-anxiety-cost-as-largest-barriers-for-new-ev-purchases-study.
[552] Herberz et al. (2022) at 503.
[553] *See* U.S. Bureau of Labor Statistics, *Trips by Distance Band*, https://www.bts.gov/browse-statistical-products-and-data/covid-related/trips-distance-groupings-national-or-state.
[554] Alternative Fuels Data Center, *Alternative Fueling Station Locator*, https://afdc.energy.gov/stations/#/analyze?country=US&fuel=ELEC&ev_levels=all&access=public&access=private (noting 57,882 station locations and 155,449 EVSE ports available) (last accessed June 30, 2023); *see also* EPA, *The 2022 EPA Automotive Trends Report*, at E-2.
[555] Argonne National Laboratory, *Light Duty Electric Drive Vehicles Monthly Sales Updates*, https://www.anl.gov/esia/light-duty-electric-drive-vehicles-monthly-sales-updates.
[556] Alternative Fuels Data Center, *Electric Vehicle Charging Station Locations*, https://afdc.energy.gov/fuels/electricity_locations.html#/find/nearest?fuel=ELEC.
[557] Kalea Hall, *EV Corridor to Run Nearly 900 Miles from Kalamazoo to Quebec, US and Canada Officials Say*, The Detroit News (May 16, 2023), https://www.detroitnews.com/story/business/autos/2023/05/16/binational-ev-corridor-to-run-860-miles-from-kalamazoo-to-quebec/70224111007/.
[558] *Id*.
[559] West Coast Green Highway, *West Coast Electric Highway*, http://www.westcoastgreenhighway.com/electrichighway.htm.

Florida), and most of the West Coast along Interstate 5 (from Seattle, Washington to San Diego, California).[560] GM and Pilot Company just announced plans to collaborate on a national DC fast charging network of 2,000 charging stalls at up to 500 travel centers across the country, to "help enable long-distance electric travel of people and vehicles across the U.S."[561] These chargers will be capable of the fastest 350 kW charging speeds.[562]

Infrastructure will continue to build out rapidly on highways with increasing PEV penetration, fulfilling the needs for even these comparatively less frequent longer drives. Survey data from Europe shows that as PEV penetration rates increase and drivers become more experienced with PEV operation, they become comfortable taking longer trips in their vehicles and are "more relaxed" about traveling long distances and when they charge their vehicles.[563] In addition, other developing technologies could make both short and longer drives even more seamless, such as possible "electrified" roadways that contain wireless charging infrastructure under the asphalt and wirelessly charge PEVs while driving.[564] Such projects are already in development or testing in the United States and Europe.[565]

4. PEVs have additional attributes that are superior to combustion vehicles.

PEVs have additional superior attributes related to the driving and ownership experience that are widely attractive to drivers. These include faster acceleration; improved performance; better noise, vibration, and harshness characteristics; and reduced maintenance. Sections XIX.C, XX, and XXI detail these additional superior attributes and the benefits that they provide for drivers and vehicle owners. These attributes will continue to further increase consumer preference for PEVs.

5. American consumers also place high importance on environmental sustainability, and EPA should not ignore these preferences.

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[560] Stephen Edelstein, *Electrify America Finishes First Cross-Country Fast-Charging Route for EVs*, Green Car Reports (June 24, 2020), https://www.greencarreports.com/news/1128610_electrify-america-finishes-first-cross-country-fast-charging-route-for-evs. *See also* Electrify America, *Locate A Charger*, https://www.electrifyamerica.com/locate-charger/ (showing map of fast-charging network across the United States).
[561] Anne LeZotte, *GM and Pilot Company to Build Out Coast-to-Coast EV Fast Charging Network*, Pilot Flying J, https://pilotflyingj.com/press-release/19335.
[562] *Id.*
[563] Shell Global, *Shell Recharge Research Suggests Increasing EV Adoption is Driving Range Confidence* (June 23, 2023), https://www.shell.com/energy-and-innovation/mobility/mobility-news/shell-recharge-research-suggests-increasing-ev-adoption-is-driving-range-confidence.html.
[564] Joann Muller, *A Roadway Will Charge Your EV While You're Driving*, Axios (Feb. 6, 2022), https://www.axios.com/2022/02/02/a-roadway-will-charge-your-ev-while-youre-driving.
[565] *Id.*

When considering consumer preferences, EPA cannot overlook the importance that American consumers place on sustainability. U.S. consumers increasingly place high priority on protecting the environment, and PEVs are well positioned to satisfy this aspect of consumer preference. Numerous consumer surveys, including by YouGov, CarMax, and others have found that protecting the environment is a top consideration in purchasing a vehicle.[566] In CarMax's survey, over 60% of people said a car's "fuel emissions are moderately or extremely important to them, while only 7.3% of people found fuel emissions not at all important."[567]

6. PEVs are a great fit for the needs and demands of rural drivers.

PEVs are a great fit even for rural drivers. Although rural Americans are currently adopting PEVs at slower rates than urban Americans,[568] PEVs actually excel at meeting the demands of rural drivers. "Fuel savings for rural households are larger than for urban households, because trips in rural areas are longer than in urban areas, and vehicles tend to be older and less efficient, requiring more fuel per mile, [P]EVs require fewer trips to a mechanic for repairs and maintenance. Because of the high torque and low center of gravity, they have excellent performance, which is important on rough, curvy and steep roads."[569] A survey by the Union of Concerned Scientists and Consumer Reports found that "there is plenty of interest [in PEVs] in rural areas, but there is a huge knowledge gap about what it is like to own an EV."[570] Correcting for this knowledge gap and educating rural consumers on PEVs' real benefits will undoubtedly significantly increase PEV adoption in rural areas, allowing all Americans to reap their benefits.

7. Most PEV drivers purchase or plan to purchase another PEV, indicating high satisfaction.

The appeal of these beneficial PEV attributes is made clear from the fact that most PEV buyers purchase another PEV for their next vehicle and through the ample available information

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[566] Bill Howard, *Survey: 23% of Americans Would Consider EV as Next Car*, Forbes (Oct. 8, 2021), https://www.forbes.com/wheels/features/ev-survey/ (YouGov poll for Forbes Wheels); CarMax, *Green-Conscious: Exploring Americans' Views on Hybrid and Electric Vehicles* (Aug. 23, 2021), https://www.carmax.com/articles/green-cars-trend.

[567] CarMax, *Green-Conscious: Exploring Americans' Views on Hybrid and Electric Vehicles* (Aug. 23, 2021), https://www.carmax.com/articles/green-cars-trend.

[568] U.S. Department of Transportation, *Individual Benefits of Rural Vehicle Electrification* (May 4, 2023), https://www.transportation.gov/rural/ev/toolkit/ev-benefits-and-challenges/individual-benefits (noting that rural EV adoption is currently roughly 40% lower than urban EV adoption, but explaining that EVs can have significant benefits for rural drivers); Maria Cecilia Pinto de Moura, *Survey Shows Pathway to Speeding Up EV Adoption in Rural Areas*, Union of Concerned Scientists (March 14, 2023), https://blog.ucsusa.org/cecilia-moura/survey-shows-pathway-to-speeding-up-ev-adoption-in-rural-areas/.

[569] Maria Cecilia Pinto de Moura, *Survey Shows Pathway to Speeding Up EV Adoption in Rural Areas*, Union of Concerned Scientists (March 14, 2023), https://blog.ucsusa.org/cecilia-moura/survey-shows-pathway-to-speeding-up-ev-adoption-in-rural-areas/.

[570] *Id.*

pointing to satisfied PEV drivers. As far back as almost a decade ago, Tesla's Model S had the highest owner satisfaction of any vehicle in the U.S. market.[571] A recent analysis of S&P Global Mobility vehicle registration data found that roughly two-thirds of EV-owning households that bought a new car in 2022 purchased another EV.[572] Other surveys and analyses have found the same. In 2021, Plug In America surveyed over 5,500 EV owners and more than 1,400 potential EV purchasers and found that 90% of EV owners said that it was "likely" (13%) or "very likely" (77%) that their next vehicle purchase would be an EV.[573] In Plug In America's most recent survey (conducted between December 2022 and February 2023), again 90% of EV owners said it is "likely" or "very likely" that their next purchase will be another EV.[574] Even as of January 2017, CARB found that over 10% of recent PEV buyers were already driving their second or subsequent PEV.[575]

As Forsythe et al. (2023) explain, "technology progress projections are key for future BEV adoption projections used in policy planning and cost–benefit analyses."[576] Here, it is clear that technological progress is sufficient to support significant consumer acceptance of (and satisfaction with) PEVs. Even considering consumer acceptance as a relevant and permissible factor in EPA's analysis, EPA should enact standards consistent with Alternative 1 with increasing stringency after MY 2030. Consumer acceptance is not a barrier to PEV sales at a pace consistent with this level of stringency, when desirable vehicles are available—as they are expected to be—and purchasers have information about their benefits.[577]

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[571] Consumer Reports, *Tesla Model S Takes the Top Spot in Consumer Reports Car Owner-Satisfaction Ratings* (Nov. 21, 2013).
[572] Joann Muller, *Most Electric Car Buyers Don't Switch Back to Gas*, Axios (Oct. 5, 2022), https://www.axios.com/2022/10/05/ev-adoption-loyalty-electric-cars.
[573] Plug In America, *The Expanding EV Market: Observations in a Year of Growth* 1, 11 (Feb. 2022), https://pluginamerica.org/wp-content/uploads/2022/03/2022-PIA-Survey-Report.pdf.
[574] Plug In America, *2023 EV Driver Survey* 1 (May 2023), https://pluginamerica.org/wp-content/uploads/2023/05/2023-EV-Survey-Final.pdf.
[575] CARB, *California's Advanced Clean Cars Midterm Review, Appendix B: Consumer Acceptance of Zero Emission Vehicles and Plug-in Hybrid Electric Vehicles* B-2 (Jan. 18, 2017), https://ww2.arb.ca.gov/sites/default/files/2020-01/appendix_b_consumer_acceptance_ac.pdf.
[576] Forsythe et al. (2023) at 6.
[577] EPA's approach to modeling consumer acceptance through the Global Change Analysis Model ("GCAM"), utilizing an S curve, while by no means the only approach to modeling consumer acceptance, is a reasonable one. Specifically, as recent analyses show, GCAM is a random utility discrete choice model equivalent to a logit model with a particular utility function form. Eric G. O'Rear et al., *Projecting Vehicle Sales: A Review of Light-Duty Vehicle Adoption Models*, Rhodium Group 15-16 (Mar. 24, 2023), https://rhg.com/wp-content/uploads/2023/03/Projecting-Vehicle-Sales-A-Review-of-Light-Duty-Vehicle-Adoption-Models.pdf.

XX. BEVs Provide Additional Economic and Performance Benefits to Consumers.

A. Slightly higher upfront costs are offset by lower operating and fuel costs, saving drivers money.

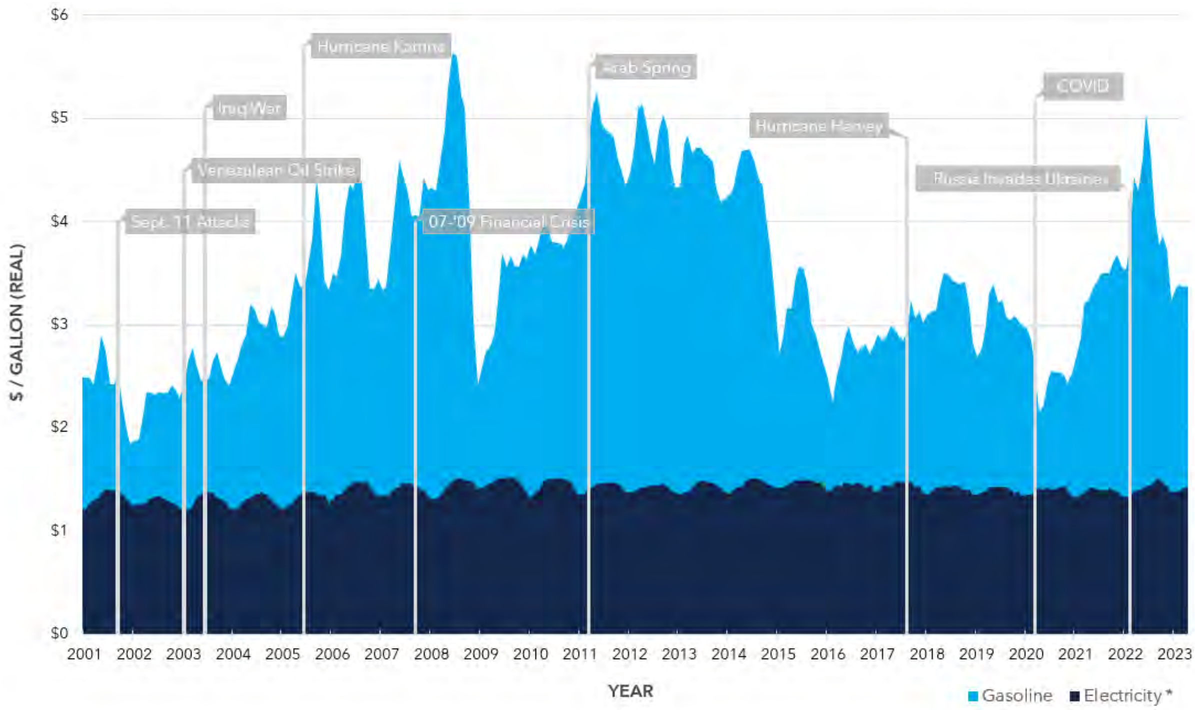
EPA is correct to conclude that consumers experience net economic benefits when purchasing electric vehicles because lower operating costs offset increases in vehicle technology costs, irrespective of purchase incentives. 88 Fed. Reg. at 29344. EPA projects that aggregate vehicle technology costs through 2055 will range from $260 billion to $380 billion (7 and 3% discount rates). *Id*. Yet EPA estimates that total fuel savings over the same period will range from $560 billion to $1.1 trillion, while reduced maintenance and repair costs will range from $280 billion to $580 billion. *Id*. On net, consumers benefit from the Proposed Standards.

These savings also filter down to the individual buyer. Even under the "high battery costs" sensitivity analysis, EPA found that the average incremental vehicle cost for the Proposed Standards was $1,632, and $2,066 for Alternative 1 (6-year average). Table 117, 88 Fed. Reg. at 29337. (Under the "low battery costs" analysis, incremental cost increases are far lower: $441 for the Proposed Standards, and $1,360 for Alternative 1 (6-year average). *Id*. at 29336.) These upfront costs are quickly eclipsed as the broader picture of overall costs emerges. First, some BEV models would be eligible for the full $7,500 purchase incentive in the Inflation Reduction Act, while others would be eligible for a partial credit. As EPA notes, this means that net purchase expenses are lowest across all body styles for BEVs (assuming the maximum incentive applies). DRIA at 4-20. Moreover, in operating expenses over 8 years (the average length of time a new owner keeps a vehicle), BEV owners save between $9,040 for sedans to $12,880 for pickups. *Id*. These operating expenses, which include lower maintenance and repair costs, are highly significant, and only grow larger the longer the owner retains the vehicle.

B. Consumers and businesses will appreciate the stability of electricity prices relative to the volatility of gasoline prices.

In addition to providing significant absolute fuel cost savings relative to gasoline or diesel, driving on electricity also provides a significant price-stability advantage. As shown in Figure XX.B-1, for more than the last two decades, driving a passenger BEV on residential electricity prices has been the cost equivalent of driving on dollar-a-gallon gasoline, whereas the price of gasoline itself jumps up and down in response to world events.

Figure XX.B-1: Equivalent Electricity and Gasoline Prices: January 2001-April 2023[578]



While gasoline prices fluctuate wildly due to uncontrollable events, electricity prices are inherently more stable because electricity is produced from a diverse mix of largely domestic energy sources. Electricity prices also are more stable because the power industry is regulated, while the world oil market and petro-dictatorships are not.

Households and businesses both stand to benefit from the predictable savings that driving on electricity can provide. And low-income households that spend a disproportionate share of their disposable income at the gas pump will benefit financially from getting off the rollercoaster of the world oil market.

C. BEVs provide additional performance and handling improvements for consumers, improving their overall driving experience.

In addition to the clear economic benefits of BEV purchase and ownership described in the previous section, there are other "intangible" factors that make the overall BEV experience better for consumers. EPA cites several of these factors, including responsive acceleration,

[578] Source data: EIA, *Short Term Energy Outlook*. Electricity prices shown in "eGallons" a Department of Energy metric that "represents the cost of driving an electric vehicle (EV) the same distance a gasoline powered vehicle could travel on one (1) gallon of gasoline." Methodology available at: https://www.energy.gov/articles/egallon-methodology.

improved performance and handling, and quiet operation. DRIA at 3-15. Many examples confirm these advantages.

As Consumer Reports notes, "most electric cars deliver instant power from a stop, and they are both smooth and quiet when underway. The driving experience is quite different from a traditional gasoline-fueled car because EVs feel like they glide effortlessly."[579] Other reviewers have found that the lower center of gravity in BEVs improves their handling by allowing turning and cornering more quickly and smoothly than gas-powered cars.[580] In addition, BEVs' regenerative braking capabilities, which captures energy normally lost during braking, may also improve the driving experience by extending the vehicle's range and provide a "smoother and more controlled" braking experience.[581]

Car and Driver tested dozens of EVs and compared the data with gasoline-powered cars, finding that EVs are quieter at "max-attack acceleration" as well as at 70 miles per hour, have a more even weight distribution due to battery packs positioned low and in the vehicle's center, and accelerate almost as quickly as their combustion counterparts.[582] Several other analysts have concluded that EVs accelerate faster than gas-powered vehicles because they provide instant torque to the wheels.[583] For example, a Tesla Model S Plaid (with a starting price of around $108,000) accelerates from 0 to 60 miles per hour in just under two seconds, a full second faster than a supercar like the Ferrari Daytona SP3 that starts at $2,226,935 (about 20 times the cost of the Tesla).[584] And the same holds for more affordable vehicles. For example, the Volvo EX30 promises to be a full second faster to 60 miles per hour than a comparably priced Chevy Camaro.[585] While EPA did not place undue emphasis on these factors when making its assumptions about BEV adoption rates, these benefits are nonetheless significant and support EPA's finding that BEV performance and handling factors will contribute to high rates of adoption in coming years.

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[579] Consumer Reports, *Electric Cars 101: The Answers to All Your EV Questions* (March 2, 2023), https://www.consumerreports.org/cars/hybrids-evs/electric-cars-101-the-answers-to-all-your-ev-questions-a7130554728/.
[580] Steer EV, *8 Reasons Why Electric Vehicles Are Safer Than Traditional Cars* (Apr. 27, 2023), https://steerev.com/steer-vs-other/8-reasons-why-electric-vehicles-are-safer-than-traditional-cars/.
[581] *Id.*
[582] Dave Vanderwerp, *How EVs Compare to Gas-Powered Vehicles in Seven Performance Metrics*, Car and Driver (May 15, 2021), https://www.caranddriver.com/features/g36420161/evs-compared-gas-powered-vehicles-performance/.
[583] *See, e.g.*, Jeremy Laukkonen, Lifewire, *Want a High-Performance Car? Think EV* (Sept. 29, 2021), https://www.lifewire.c/want-a-high-performance-car-think-ev-5203444; Electric Driver, *Electric Vehicle Performance*, https://electricdriver.co/articles/electric-vehicle-performance/.
[584] *See* Christian Seabaugh, *2022 Tesla Model S Plaid First Test: 0–60 MPH in 1.98 Seconds*, Motortrend (Jun. 17, 2021), https://www.motortrend.com/reviews/2022-tesla-model-s-plaid-first-test-review/; Angus MacKenzie, *Driven! The Ferrari Daytona SP3 Isn't Rational—and That's the Point*, Motortrend (Jul. 31, 2022), https://www.motortrend.com/reviews/2023-ferrari-daytona-sp3-supercar-first-drive-review/
[585] *See* Viknesh Vijayenthiran, *2025 Volvo EX30 hits 0-60 in 3.4 seconds, starts at $36,145*, Motor Authority, https://www.motorauthority.com/news/1139801_2025-volvo-ex30-price.

XXI. Consumers Will Experience Significant Savings Due to Reduced Repair and Maintenance Costs for BEVs.

EPA's Proposal accurately projects significant consumer savings due to reduced repair and maintenance costs for BEVs. EPA relies on comprehensive repair and maintenance cost estimates developed by Argonne National Laboratory (ANL) in 2021 to project per vehicle maintenance and repair savings per year of between $430 (BEV sedan/wagons) and $470 (BEV pickups) in 2032. DRIA at 4–20; *see also* DRIA at 4–32 to 4–37. Other analyses—both those that have relied on the same underlying ANL cost estimates and those that have relied on other data—have found similarly significant maintenance and repair savings.

A 2022 ICCT study considering LDV costs and benefits in the United States between 2022 and 2035 also relied on the ANL cost estimates and found almost identical reductions in per vehicle maintenance costs.[586] The ICCT analysis concluded that maintenance costs for BEVs are expected to be about $2,650 lower than for gasoline vehicles over a six-year period,[587] which averages to about $442 savings per year. A survey conducted by Consumer Reports in 2019 and 2020 also found very significant self-reported consumer savings on repair and maintenance. The data from surveys of thousands of Consumer Reports members revealed that "BEV and PHEV owners are paying half as much as ICE owners are paying to repair and maintain their vehicles," with lifetime savings of BEVs and PHEVs over combustion vehicles being approximately $4,600.[588] Similarly, a study by UBS estimated that the Chevy Bolt (BEV) has total annual maintenance costs of $255 and the VW Golf (combustion vehicle) has repair and maintenance costs of $610.[589] An analysis using U.S. Office of Energy Efficiency and Renewable Energy data regarding maintenance and repair costs and U.S. General Services Administration data regarding federal vehicle use calculated that "a hypothetical full-electric government fleet would have saved just over $78 million in maintenance costs" in one year.[590] An analysis of repair and maintenance costs in Canada, which found 47% repair and maintenance cost savings for BEVs over combustion vehicles, noted that U.S. studies have found cost savings in similar ranges, and explained that when looking at the top 10 most common U.S. car repair items, none of the repairs in the list apply to a BEV.[591] These significant repair and maintenance savings are expected to

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[586] Peter Slowik et al., *Assessment of Light-Duty Electric Vehicle Costs and Consumer Benefits in the United States in the 2022–2035 Time Frame*, ICCT (Oct. 2022), https://theicct.org/wp-content/uploads/2022/10/ev-cost-benefits-2035-oct22.pdf.

[587] *Id.* at 24.

[588] Chris Harto, *Electric Vehicle Ownership Costs: Today's Electric Vehicles Offer Big Savings for Consumers*, Consumer Reports at 9, 11 (Oct. 2020), https://advocacy.consumerreports.org/wp-content/uploads/2020/10/EV-Ownership-Cost-Final-Report-1.pdf.

[589] UBS, *UBS Evidence Lab Electric Car Teardown — Disruption Ahead?* 7 (May 18, 2017), https://neo.ubs.com/shared/d1ZTxnvF2k/.

[590] Nick Yekikian, *The Government Confirms Obvious: Electric Cars Cheaper to Maintain Than Internal Combustion Vehicles*, Motortrend (June 21, 2021), https://www.motortrend.com/news/government-ev-ice-maintenance-cost-comparison/.

[591] Ryan Logtenberg, James Pawley & Barry Saxifrage, *Comparing Fuel and Maintenance Costs of Electric and Gas Powered Vehicles in Canada*, 2 Degrees Institute at 5 (Sept. 2018),

occur because "[t]ypical BEV drivetrains have 90% fewer moving parts, require no maintenance such as oil changes or timing belts and their ability to use regenerative braking saves energy and makes their brake pads last longer."[592] Thus, U.S. drivers and vehicle purchasers stand to gain significant benefits from reduced automotive repair and maintenance needs for BEV.

XXII. BEV Ownership, Combined with Supportive Policies, Will Benefit Lower-Income Consumers.

EPA describes several expected outcomes of the Proposed Standards on lower-income households: first, that increased upfront purchase costs may impact highly price-sensitive consumers; and second, that decreased fuel and maintenance costs from BEV ownership may benefit these consumers disproportionately. 88 Fed. Reg. at 29368. While upfront BEV cost concerns may serve as an initial barrier to lower-income consumers, a suite of targeted policies can mitigate this concern.

First, several policies may help with the upfront cost concerns, including the (maximum) $7,500 new vehicle purchase incentive and the first-of-its-kind (maximum) $4,000 incentive for used vehicles in the Inflation Reduction Act. These policies may also be supplemented by state-level initiatives that further reduce the purchase cost for buyers falling under defined income thresholds, such as California's Clean Vehicle Rebate Project.[593] Also, as EPA notes, for used BEVs, there is evidence that the original purchase incentive is passed on to the next buyer, which reduces the effective price of BEVs. Taken together, these savings bring the initial cost of several BEV models–and undoubtedly more to come in future years–below the purchase price of a comparable combustion vehicle. *See* DRIA Ch. 4.2.2.

Moreover, because lower-income households spend a disproportionate amount on vehicle repair and fuel costs,[594] they should benefit from these savings that come with BEVs, which continue to accrue year after year. This is especially true because fuel economy, and therefore fuel savings, tends not to degrade much as a vehicle ages, even when the vehicle is sold and resold for a lower price over time. 88 Fed. Reg. at 29368. Separately, from an overall ownership perspective, modifications to the Alternative Fuel Refueling Property Tax Credit in the IRA limit applicability to charging infrastructure in low-income areas and areas that are not urban. DRIA at

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https://www.2degreesinstitute.org/reports/comparing_fuel_and_maintenance_costs_of_electric_and_gas_powered_vehicles_in_canada.pdf.

[592] *Id*.

[593] California Clean Vehicle Rebate Project, Eligibility & Requirements, https://cleanvehiclerebate.org/en/eligibility-guidelines.

[594] *See, e.g.*, Hardman, Fleming et al., A Perspective on Equity in The Transition to Electric Vehicles, MIT Science Policy Review (Aug. 30, 2021), https://sciencepolicyreview.org/wp-content/uploads/securepdfs/2021/08/A_perspective_on_equity_in_the_transition_to_electric_vehicles.pdf.

5-26. This change may help residents in those communities afford home charging or incentivize businesses to install public chargers, which would improve the BEV ownership experience.

For these reasons, EPA was correct to consider the effects of BEV purchase and ownership on lower-income consumers. Inclusive policies that ease the burden of any potential higher costs on these consumers merit further study, and it is essential that the benefits of BEV ownership are accessible to all and shared equitably. EPA has shown that the cost savings over time make BEV ownership worthwhile for lower-income households, and that additional policies like the IRA purchase incentives can lessen any upfront cost disparities.

XXIII. BEV Charging Times Are Constantly Improving and Are Not a Constraint on Strong Standards.

Taking refueling considerations into account, BEV charging times are consistent with setting strong final standards. Charging technologies have come a long way in recent years, increasing in their capability to deliver more energy to a vehicle in the same unit of time. EPA notes that its assumptions for BEV refueling times are outdated, 88 Fed. Reg. at 29200, and that is indeed the case. EPA's analysis assumes 100 miles of driving added for each hour of charging as the "charge rate" across all BEVs. DRIA at 4-29. That equates to an average power delivery of just over 30 kilowatts, using the current on-road fleet average BEV efficiency.[595] While power delivery during a charging session does taper off as the vehicle battery approaches a full charge, the average power delivery for mid-trip charging events will be much higher than 30 kW. Those events are likely to be done with fast charging, where available, and the availability of high-powered, fast charging will expand greatly leading up to and through the lifetimes of vehicles sold during the period of the Proposed Standards.

Not only is consumer demand for fast charging for mid-trip fueling pushing the market in the direction of higher-powered ports, the minimum power requirements for federal programs, as well as some state programs, ensure the market will meet those consumer needs in a timely manner. For example, the minimum standards and requirements for the National EV Charging Formula Program specify that each charging location must have at least four charging ports that can deliver 150 kW (or higher) simultaneously. 88 Fed. Reg. at 12754. A 150 kW port would deliver closer to 450 miles of range in an hour, greatly reducing the disbenefit of refueling time associated with BEVs. That number of miles per hour of charging is really a theoretical construct, as the hourly output is more energy than light- and medium-duty vehicle batteries can hold. A vehicle would not spend a full hour fueling at a 150 kW charging station, even if the battery is fully depleted.

[595] David Reichmuth, Jessica Dunn, & Don Anair, *Driving Cleaner*, Union of Concerned Scientists (July 2022) at 20, https://www.ucsusa.org/sites/default/files/2022-07/driving-cleaner-report_0.pdf.

The hourly charging speed of a 150 kW station is, however, a useful apples-to-apples comparison to the 100 miles/hour figure used in EPA's analysis. It suggests that many vehicles will charge nearly four and a half times faster than the speed assumed in the analysis. Still other vehicles may use even faster charging for their mid-trip events, with chargers on the market approaching 350 kW, for vehicles that can accept that output.[596] Thus, EPA's charging rate assumption could be quadrupled (and the refueling time disbenefit for BEVs greatly reduced) and still result in a conservative assumption that leaves room for vehicles that may do some mid-trip charging at more moderate DC charging power levels.

XXIV. EPA's Consideration of Sales Impacts Is Reasonable, but the Agency Should Consider Using a Sales Elasticity of Demand Lower in Magnitude for LDVs.

In this section, we turn to EPA's consideration of sales impacts. While we support EPA's proposal to use a sales elasticity of demand of zero for MDVs, we recommend that it use a sales elasticity of demand lower than –0.4 for LDVs.

A. EPA should consider using a sales elasticity of demand lower in magnitude than –0.4 for LDVs.

EPA continues to use the new vehicle demand elasticity of –0.4 for its modeling of LDV sales impacts, based on the Agency's final 2021 rule and a 2021 EPA peer reviewed report on this topic. 88 Fed. Reg. at 29,370.[597] Recent research supports a sales elasticity value of –0.4, or one even lower in absolute value, as EPA suggests. *See* 88 Fed. Reg. at 29370 (noting that " –0.4 appears to be the largest estimate (in absolute value) for a long-run new vehicle demand elasticity in recent studies," and that "EPA's report examining the relationship between new and used vehicle markets shows that, for plausible values reflecting that interaction, the new vehicle demand elasticity varies from –0.15 to –0.4"); *see also* 83 Fed. Reg. at 43075 (based on the available research, the 2020 Rule NPRM conducted a data analysis and projected an elasticity in the range of –0.2 to –0.3.)[598]

Using a price elasticity of demand that is lower in absolute value could provide a more realistic picture of the sales impacts of LDV GHG regulations, and EPA should consider whether

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[596] Andrei Nedelea, *800V EV Charging Will Drastically Reduce Waiting Times At The Charger*, Inside EVs (June 5, 2020), https://insideevs.com/features/427039/800-volt-charging-to-change-industry/.

[597] Citing EPA, *The Effects of New-Vehicle Price Changes on New- and Used-Vehicle Markets and Scrappage*, EPA–420–R–21–019 (2021), https://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=352754&Lab=OTAQ.

[598] This number was actually incorrectly calculated and too high due to a spreadsheet error identified in a Comment to the 2018 NPRM. It should be -0.07. *See* J.H. Stock et al., Comments on Notice of Proposed Rulemaking for The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, EPA-HQ-OAR-2018-0283-6220, at 6–8 (Oct. 26, 2018). *See also* Brief of Amici Curiae Economists in Support of Coordinating Petitioners, Competitive Enterprise Institute v. NHTSA, D.C. Cir. No. 20-1145, at 26 (filed Jan. 21, 2021) (hereinafter "Amicus Brief of Economists").

a value lower in magnitude than –0.4 is appropriate here. The price elasticity of demand for new vehicles is a critical factor to consider in setting LDV regulations because without this input EPA could not quantify the rule's effect on vehicle purchases. Changes in demand for new vehicles can have an impact on jobs, emissions, safety, and other factors relevant to the net benefits of revised standards.

Vehicles have different price elasticities depending on the timeframe considered, and sales of automobiles tend to be less sensitive to price fluctuations, especially in the long run.[599] This is because in most areas of the United States vehicles are essential goods.[600] EPA's Science Advisory Board explained that while "a consumer can easily hold on to their existing vehicle a bit longer[,] . . . an old vehicle will not be functional forever, and thus the long-run price elasticity for new vehicles is likely to be smaller [in magnitude] than the short-run elasticity."[601] Therefore, it is common to distinguish between short-run elasticity values (sales effects that take place within one year of a price change)[602] and long-run elasticity values (sales effects beginning approximately five years into the future).[603] Thus, the 2012 Final Rule explained, while short-run elasticity may apply very briefly at the start of a program, "over time, a long-run elasticity may better reflect behavior." 77 Fed. Reg. at 63102 n.1300. Similarly, in the 2016 Midterm Evaluation Proposed Determination, EPA explained that "short run elasticity estimate[s] . . . may not be appropriate for standards that apply several years into the future."[604]

Because analyses of LDV GHG emissions standards project sales many years into the future, the long-run price elasticity is the relevant value to apply to the analysis. And because

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599 Howard, P. & M. Sarinksy, *Turbocharged: How One Revision in the SAFE Rule Economic Analysis Obscures Billions of Dollars in Social Harms*, N.Y.U. Inst. for Policy Integrity, at 3 (Nov. 2020), https://policyintegrity.org/files/publications/Turbocharged_How_One_Revision_in_the_SAFE_Rule_Economic_Analysis_Obscures.pdf ("Because automobiles are essential goods in most areas of the United States (and lack any comparable substitute), both economic theory and observed behavior finds that vehicle sales are relatively inelastic—meaning that price fluctuations produce just modest changes in vehicle sales").

600 *See, e.g.*, Anderson P.L. et al., *Price Elasticity of Demand* (1997), https://scholar.harvard.edu/files/alada/files/price_elasticity_of_demand_handout.pdf.

601 EPA, Science Advisory Board (SAB) Consideration of the Scientific and Technical Basis of the EPA's Proposed Rule titled The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks, EPA-HQ-OAR-2018-0283-7659, at 22 (Feb. 27, 2020).

602 *See* Pindyck, R.S. & D.L. Rubinfeld, *Microeconomics* (8th ed.), at 39 (1989) (describing short-run elasticity as measuring "one year or less").

603 *See* Klier, T. & J. Linn, *The Effect of Vehicle Fuel Economy Standards on Technology Adoption*, Resources for the Future Discussion Paper, at 3, 6 (Rev'd 2015), https://media.rff.org/archive/files/document/file/RFF-DP-13-40-REV2.pdf (noting that long-run impacts measure across engine design cycles, and that "models contain redesigned engines about once every five years in the United States"); *see also* Amicus Brief of Economists at 20 (noting that "long-run" concerns sales effects that begin approximately five to ten years into the future).

604 EPA, Proposed Determination on the Appropriateness of the Model Year 2022-2025 Light-Duty Vehicle Greenhouse Gas Emissions Standards under the Midterm Evaluation, EPA-HQ-OAR-2018-0283-7640, at A-40 (Nov. 2016). *See also* NHTSA CAFE Model Peer Review, at B-35 (rev. July 2019) (advising EPA and NHTSA that the long-run price elasticity of demand provides the "proper focus" for analyzing the 2020 Final Rule's impacts).

vehicle sales are less elastic in the long run, the price elasticity of demand for vehicles is substantively lower in magnitude in the long run than in the short run.

The chart below provides a comprehensive review of current and historical long-run and short-run elasticity estimates.[605] The median elasticity of the studies published since 2000 (including an outlier estimate) is approximately –0.35, with a mean of –0.4, and those numbers decrease when looking only at studies published since 2010.[606] The most recent reliable studies, such as Leard (2021) and Stock et al. (2018), would support values even lower in magnitude than –0.4.

Sales Elasticity Estimates

Author(s)	**Year**	**Time Period**	**Short-Run**	**Long-Run**
McAlinden et al. (2016) CAR Report[607]				
Atkinson	1952	1925–1940	-1.33	–
Nerlove	1957	1922-1941; 1948-1953	-0.9	-1.2
Suits	1958	1929-1941; 1949-1956	–	-0.57
Chow	1960	1921-1953	–	-0.7
Suits	1961	1929-1941; 1949-1956	–	-0.675
Hymans, Ackley, and Juster	1970	1954-1968	-1.14	-0.46
Hess	1977	1952-1972	-1.63	–
Trandel	1991	1983-1985	-1.43	–

[605] This review included the sources cited by the agencies in the 2020 Final Rule, 85 Fed. Reg. 24174 (June 29, 2020), as well as other relevant sources (in particular those in National Research Council, *Cost, Effectiveness, and Deployment of Fuel Economy Technologies for Light-Duty Vehicles* (June 2015), and previous EPA rules) and more recent studies.

[606] These values are consistent with a review done by several economists and detailed in an amicus brief filed in the litigation over the 2020 Final Rule. That review considered what the economists viewed as the four most relevant, distinct estimates of long-run elasticity based on original data analysis since 2000, and found a long-run price elasticity of demand for vehicles subject to the Proposal of between -0.03 and -0.61. *See* Amicus Brief of Economists at 25-26.

[607] Sean P. McAlinden et al., *The Potential Effects of the 2017–2025 EPA/NHTSA GHG/Fuel Economy Mandates on the U.S. Economy*, Center for Automotive Research (Sept. 2016), https://www.cargroup.org/wp-content/uploads/2017/02/The-Potential-Effects-of-the-2017_2025-EPANHTSA-GHG Fuel-Economy-Mandates-on-the-US-Economy.pdf.

Levinsohn	1988	1983-1985	-0.82	–
McCarthy	1996	1989	-0.87	–
Bordley	1993	Assumed	-1	–
Fischer, Harrington, and Parry	2007	Not indicated	-1	-0.36
Irvine (1983)[608] (basis for Kleit (1990)[609])				
Dyckman	1975	1929-1962	-1.45	–
Hamburger	1967	1954-1964	-1.17	–
Evans	1969	1948-1964	-3.1	-1.5
Hymans	1970	1954-1968	-1.07	-0.36
Rippe and Feldman	1976	1958-1973	-1.14	-0.6
Carlson	1978	1965-1975	-1.1	–
Additional estimates				
Goldberg	1998	1984-1990	-0.9	–
Juster and Wachtel	1972	1949-1967	-0.7	–
Lave and Train	1979	1976	-0.8	–
McAlinden et al.*	2016	1953-2013	-0.79	-0.61
Berry et al.	2004	1993	–	-1
Stock et al.	2018	1967-2016	-0.27	-0.03 to -0.09
Leard	2021	2013	–	-0.34
Bento et al.	2020	Not indicated	–	-0.13
Dou and Linn	2020	1996 to 2016	-1.5	–
Averages				
Mean			-1.15	-0.6

[608] F. Owen Irvine, Jr., *Demand Equations for Individual New Car Models Estimated Using Transaction Prices with Implications for Regulatory Issues*, 49 Southern Economic Journal 764–782 (Jan. 1983).
[609] Andrew N. Kleit, *The Effect of Annual Changes in Automobile Fuel Economy Standards*, 2 Journal of Regulatory Economics 151–172 (1990).

Median			-1.07	-0.6
Averages of Recent Estimates				
Mean published since 2000			-0.9	-0.4
Median published since 2000			-0.9	-0.35
Mean published since 2010			-0.85	-0.3
Median published since 2010			-0.79	-0.24
*Averages Without Inconsistent Estimates***				
Mean			-1.1	-0.4
Median			-1.07	-0.46
Mean: Published since 2000			-0.9	-0.3
Median: Published since 2000			-0.9	-0.34

* McAlinden et al. (2016) conducted both a literature review, represented at the top of this table, and separately produced its own elasticity estimates, shown here.
** Inconsistent estimates: Nerlove (1957) as long-run elasticity is higher than short-run elasticity; Evans (1969) as elasticities are extreme outliers with long-run elasticity that is elastic contrary to intuition in the literature; and Berry et al. (2004) as estimate was suggested by General Motors staff despite "impl[ying] a large (in absolute value) own-price semi-elasticity of demand equal to −10.56" and conducted sensitivity analysis using –0.2 and –0.4 (the latter producing more realistic own-price semi-elasticity) (Leard (2021)).[610]

B. EPA is correct to use a sales elasticity of zero for MDVs.

For MDV sales impacts, EPA's Proposal assumes an elasticity of zero, reasoning that MDVs largely serve commercial applications and that business owners are less sensitive to changes in vehicle price. 88 Fed. Reg. at 29372. As EPA explains, "as long as the characteristics of the vehicle do not change, commercial buyers will still purchase the vehicle that fits their needs," even with a change in price. *Id.* We agree with EPA that, for this reason, the literature examining LDV sales elasticity does not directly translate to MDV sales elasticity, and that factors such as the importance of fuel efficiency, warranty considerations, maintenance cost, and replacement parts could be more relevant to commercial vehicle purchasers than changes in vehicle price. DRIA at 4-43.

[610] Benjamin Leard, *Estimating Consumer Substitution Between New and Used Passenger Vehicles*, Resources for the Future 12 (rev. Aug. 2021), https://media.rff.org/documents/WP_19-01_rev_2021.pdf.

Attributes of MD ZEVs also could help to mitigate vehicle sales impacts, particularly for commercial applications. For example, as with commercial HDVs, educating commercial MDV purchasers regarding the benefits of ZEV ownership such as reduced operating and maintenance costs can be especially effective in mitigating possible sales impacts, 88 Fed. Reg. at 26068,[611] as TCO has long been a key consideration for commercial vehicle owners and operators.[612] The availability of data analytics tools for commercial fleets also makes it easier for commercial purchasers to understand and evaluate the TCO.[613] Medium-duty ZEVs largely have reached TCO parity with their conventional counterparts, or will in the very near future and by the time period covered by the Proposed Rule.[614] For commercial HDVs, EPA has projected little to no sales impacts as a result of its newly proposed GHG standards, which are likely to be complied with through increased ZEV penetration,[615] and EPA is correct to do the same for MDVs.

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[611] *See also,* EPA, Greenhouse Gas Emissions Standards for Heavy-Duty Vehicles: Phase 3, Draft Regulatory Impact Analysis (Apr. 2023), at 411–412.

[612] *See, e.g.*, Seth Skydel, *Determining ROI to Lower TCO*, Fleet Equipment (Nov. 5, 2014), https://www.fleetequipmentmag.com/truck-investment-cost-ownership/ (explaining the importance of TCO to commercial fleets); David A. Kolman, *The True Costs of a Truck Purchase*, Fleet Maintenance (June 9, 2015), https://www.fleetmaintenance.com/home/article/12072830/the-true-costs-of-a-truck-purchase ("TCO is far more important than initial price when acquiring a vehicle"); Patrick Gaskins, *Despite Initial Cost, Purchase Decision is Always About TCO*, Fleet Owner (Jan. 13, 2022), https://www.fleetowner.com/operations/article/21213521/despite-initial-cost-purchase-decision-is-always-about-tco ("Don't base your decision on whether to buy a new piece of equipment on the upfront cost alone. Take the time to do a TCO calculation that includes both hard and soft costs. That will tell you whether the time is right to buy."); ICCT & Ricardo Strategic Consulting, *E-Truck Virtual Teardown Study* 6 (June 11, 2021), https://theicct.org/wp-content/uploads/2022/01/Final-Report-eTruck-Virtual-Teardown-Public-Version.pdf; ("Zero emission truck price should be viewed in the wider context of overall TCO."); McKinsey Center for Future Mobility, *Preparing the World for Zero-Emission Trucks* 6 (Sept. 2022), https://www.mckinsey.com/~/media/mckinsey/industries/automotive%20and%20assembly/our%20insights/preparing%20the%20world%20for%20zero%20emission%20trucks/preparing-the-world-for-zero-emission-trucks.pdf (explaining that TCO is a "key factor" in deployment of zero-emission trucks).

[613] *See, e.g.*, Seth Skydel, *Determining ROI to Lower TCO*, Fleet Equipment (Nov. 5, 2014) (detailing data analytics tools that aid fleets in making equipment purchase decisions based on TCO); David A. Kolman, *The True Costs of a Truck Purchase*, Fleet Maintenance (June 9, 2015) (explaining the use of telematics software in analyzing TCO, and noting that "OEM dealer sales representatives are trained on effectively calculating TCO costs and on assisting truck buyers [to] evaluate and assess planned operation of their trucks.").

[614] Saxena et al., *Electrification Cost Evaluation*, at 26 ("While the economics vary based on several factors, the TCO of most MY 2027 and MY 2030 class 2b–3 BEV types is lower than the TCO of comparable ICEVs, largely due to BEVs' lower maintenance and energy costs. Across the vehicle types and three scenarios of electrification considered in this report, the TCO of BEVs averages $0.334 per mile (ranging from $0.291 per mile to $0.39 per mile), while the TCO of ICEVs averages $0.428 per mile (ranging from $0.336 per mile to $0.574 per mile)."); Ari Kahn, et al., *The Inflation Reduction Act Will Help Electrify Heavy-Duty Trucking*, RMI (Aug. 25, 2022), https://rmi.org/inflation-reduction-act-will-help-electrify-heavy-duty-trucking/ (finding that the IRA will result in the TCO of electric trucks falling below the TCO of comparable diesel trucks about five years faster than without the IRA).

[615] EPA, Greenhouse Gas Emissions Standards for Heavy-Duty Vehicles: Phase 3, Draft Regulatory Impact Analysis (Apr. 2023), at 414.

XXV. EPA's Use of a 10% Rebound Effect for Combustion Vehicles, While Reasonable, Is Clearly at the High End of Estimates, Leading to a Possible Overestimation of Costs and Underestimation of Benefits.

This section explores EPA's consideration of rebound effects. As detailed below, while the Agency has justified a 10% rebound effect in its prior rulemakings, it should consider using a lower value here. It is also reasonable for EPA to assume no rebound driving for BEVs.

A. EPA has provided a thorough and sufficient justification for a 10% rebound effect in several prior rulemakings.

EPA's Proposal estimates the vehicle miles traveled (VMT) rebound effect for combustion vehicles to be 10%. DRIA at 4-16. The quantitative estimate of the rebound effect—which indicates the amount of additional driving that will occur as the cost of driving decreases due to fuel economy improvements—significantly influences multiple factors considered in promulgating new GHG regulations for light-duty vehicles. Additional driving leads to more accidents, road congestion, and noise, while also reducing the fuel savings and emission reductions associated with more stringent standards. Therefore, without a reasonable estimate of the rebound effect, the magnitude of a new rule's costs and benefits cannot be properly understood.

The use of a 10% rebound effect is not new. EPA also estimated the rebound effect to be 10% in the 2010 and 2012 Final Rules and the Revised 2023 and Later Model Year Light-Duty Vehicle GHG Emissions Standards finalized in 2021. *See* 75 Fed. Reg. 25324, 25517 (May 7, 2010); 77 Fed. Reg. 62624, 62716 (Oct. 15, 2012); 86 Fed. Reg. 74434, 74476 (Dec. 30, 2021). During each of these previous rulemakings, EPA considered a large body of both historical and recent literature that reported a very broad range of rebound estimates arrived at through a variety of research methods. EPA understood that simply averaging all of the rebound estimates from all of the studies was an unreasonable and inadequate method for reaching an accurate estimate of rebound for the vehicles subject to the relevant standards.[616] For example, many of the studies considered old research, data from other countries with vastly different driving habits, or estimates that were not forward-looking to the years when the covered vehicles would be driven. 77 Fed. Reg. at 62924. Historically, EPA has correctly acknowledged that rebound research should be weighted based on its relevance to GHG emissions regulations in the United States.[617]

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[616] 77 Fed. Reg. at 62924; EPA & NHTSA, *Joint Technical Support Document, Final Rulemaking for 2017-2025 Light Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards*, EPA-HQ-OAR-2018-0283-0654, at 4-22 to 4-26 (Aug. 2012) (2012 TSD); EPA & NHTSA, *Joint Technical Support Document, Final Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards*, at 4-15 to 4-22 (Apr. 2010).

[617] *See* 77 Fed. Reg. at 62924 (noting a focus on U.S. estimates and declining to use estimates of elasticity of demand for gasoline to measure the VMT rebound effect); 2012 TSD at 4-25 (noting that historical estimates may overstate

In the 2010 Final Rule, EPA concluded that while the historical research dating back to the 1950s suggested higher rebound values, the most recent literature supported a 10% "or lower" rebound effect. 75 Fed. Reg. at 25517. In the 2012 Final Rule, EPA again assumed a 10% rebound effect, and in 2016, EPA confirmed three times that a 10% rebound effect was appropriate. In both the 2016 Draft Technical Assessment Report and the 2016 Final Technical Support Document under the Midterm Evaluation, EPA cited multiple studies demonstrating that the rebound effect shrinks as incomes rise, and again explained that older studies were likely to be less reliable than more recent research.[618] Also in 2016, EPA used a 10% rebound effect in adopting standards for heavy-duty pickups and vans.[619]

The 2020 Rule was the only recent rule to depart from this 10% rebound rate, and the revised MY 2023 and later standards, finalized in 2021, returned to the 10% rebound rate after EPA conducted a rigorous review of the rebound literature in order to prioritize the most relevant rebound studies. EPA's current Proposal refers to the 2021 rule as support for its proposed 10% rebound rate for combustion vehicles. In the 2021 rule, EPA built on well-established precedent, citing much of the same support provided in the 2010 and 2012 rulemakings, along with additional more recent research. EPA also provided even more clarity into the Agency's approach to the broad body of rebound literature spanning many decades. EPA is correct in its belief that "it is important to critically evaluate which studies are most likely to be reflective of the rebound effect that is relevant to the final standards," and that "one cannot just take the 'average' rebound estimates from literature to use for the VMT rebound effect." *See* EPA, Revised 2023 and Later Model Year Light Duty Vehicle GHG Emissions Standards: Regulatory Impact Analysis (Dec. 2021) ("2021 RIA"), at 3-13. When agencies consider a range of studies, they should focus on those that are similar to the relevant policy context.[620]

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the rebound effect because the magnitude of the rebound effect declines over time, so more recent studies were entitled to increased weight). *See also* EPA, T*echnical Support Document, Proposed Determination on the Appropriateness of the Model Year 2022-2025 Light-Duty Vehicle Greenhouse Gas Emissions Standards under the Midterm Evaluation*, at 3-20 to 3-21 (Nov. 2016), available at https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100Q3L4.pdf (2016 TSD) (finding some rebound estimates in the literature to be more applicable to the standards than others and according those more weight).

[618] EPA & NHTSA, *Draft Technical Assessment Report, Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025*, EPA-HQ-OAR-2015-0827-0926, at 10-10, 10-13 & 10-20 (July 2016), available at https://nepis.epa.gov/Exe/ZyPDF.cgi/P100OXEO.PDF?Dockey=P100OXEO.PDF (2016 Draft TAR); 2016 TSD at 3-10 to 3-13, 3-16 & 3-20.

[619] *Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2, Proposed Rule*, 80 Fed. Reg. 40138, 40453 (July 13, 2015) ("Since [HD pickups and trucks] are . . . more similar in use to large light-duty vehicles, we have chosen the light-duty rebound effect of 10 percent . . ."); *Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2, Final Rule*, 80 Fed. Reg. 73478, 73746 (Oct. 25, 2016) (finalizing use of 10%).

[620] *See, e.g.*, U.S. Office of Management and Budget, Circular A-4 (Sept. 17, 2003) at 25. https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/circulars/A4/a-4.pdf; *see also* EPA, Science Advisory Board (SAB) Consideration of the Scientific and Technical Basis of the EPA's Proposed Rule titled The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks, EPA-HQ-OAR-2018-0283-7659, at 27 (Feb. 27, 2020) (SAB Report) (stating that "the rebound estimate [should] be

Specifically, in the 2021 rule reasoning on which EPA continues to rely for its 10% combustion vehicle rebound estimate, EPA appropriately identified factors for weighting rebound studies that reflect their relevance to the proposed rulemaking: (1) geography/timespan relevance (priority given to U.S. studies as opposed to international estimates); (2) time period of study (priority given to recent studies); (3) reliability/replicability of studies (priority given to studies using odometer readings vs. household surveys such as the 2009 National Household Travel Survey); and (4) statistical/methodological basis (priority given to studies employing a strong statistical/methodological basis). 2021 RIA at 3-13. EPA further explained why these factors are important and why they lead to more accurate estimates of the rebound effect. As a result, the Agency provided a clear and well-reasoned basis for its decision to give more weight to studies based on these four key criteria, and thus to conclude that the seven papers listed in Table 3-4 of the 2021 RIA should be given the most significant weight in developing the rebound estimate used in the Proposal. *See* 2021 RIA at 3-14 to 3-15.

B. Even the 10% rebound effect is too high, and EPA should consider using a rebound effect of a lesser magnitude.

The two most reliable rebound estimates based on U.S. national data from EPA's preferred studies are 10% (Greene (2012)) and around 4% (Hymel and Small (2015)).[621] Hymel and Small (2015) noted that their data indicated that fuel economy rebound could be lower than fuel price rebound, meaning that even the 4.0% and 4.2% values could be too high.[622] Moreover, another paper in the list of EPA's seven preferred studies, Gillingham et al. (2015), estimates the rebound effect at 10%. But the study also found that "a high percentage of vehicles are almost entirely inelastic in response to gasoline price changes" and that "the lowest fuel economy vehicles in the fleet drive the responsiveness, with higher fuel economy vehicles highly inelastic with respect to gasoline price changes."[623] While Gillingham et al. (2015) does not offer an alternative best rebound estimate for higher fuel economy vehicles, it is fair to assume that the 10% estimate is at the high end of reasonable estimates for the vehicles impacted by this rulemaking.

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reconsidered to account for the broader literature, and that it be determined through a full assessment of the quality and relevance of the individual studies rather than a simple average of results," and "recent papers using strong methodology and U.S. data should be weighted more heavily than older papers, or those from outside the U.S., or those with weaker methodology.").

[621] *See* Kenneth A. Small, Comment Letter on Proposed MY 2021-2026 Standards, NHTSA-2018-0067-7789, at 1 (Sept. 14, 2018) ("A better characterization of the most recent study would be that it finds a long-run rebound effect of 4.0 percent or 4.2 percent under two more realistic models that are supported by the data.").

[622] Hymel K. & K. Small, *The Rebound Effect for Automobile Travel: Asymmetric Response to Price Changes and Novel Features of the 2000s*, 49 Energy Econ. 93, 97 (2015); *see also* Greene, D., *Rebound 2007: Analysis of U.S. Light-Duty Vehicle Travel Statistics*, 41 Energy Pol'y 14 (2012) (although fuel prices "had a statistically significant impact on VMT, . . . fuel efficiency did not.").

[623] Kenneth Gillingham et al., *Heterogeneity in the Response to Gasoline Prices: Evidence from Pennsylvania and Implications for the Rebound Effect*, 52 Energy Economics S41–S52 (2015).

Other factors would also suggest that even the best and most relevant existing studies could lead to a rebound estimate that is too large. For example, the rebound effect's magnitude diminishes over time, largely due to increasing income and decreasing driving costs, a fact that EPA has historically understood.[624] As incomes rise over time, any fuel efficiency improvement will have less of an effect on the total vehicle miles traveled, and thus the rebound effect will decline. In both 2010 and 2012, EPA chose to use a 10% rebound effect as "a reasonable compromise between historical estimates and projected future estimates."[625] The 2012 Final Rule noted, however, that several high-quality studies indicated that the rebound effect's magnitude is significantly diminishing over time as incomes rise.[626] This income effect on rebound makes clear that the projected future estimates are in fact much more accurate than historical estimates. Moreover, more than 15 years will have passed since the 2010 Final Rule found a 10% rebound effect to be a good compromise and the implementation of the Proposed Standards, and income has continued to grow since that time, supporting a substantially diminished rebound effect.

EPA should give more weight to the fact that the rebound effect varies with income over time. In the 2021 rule, the agency cited Gillingham (2014) to assert that the evidence of how the rebound effect varies with income is "mixed," but then also correctly excluded that study from its list of preferred studies. Gillingham (2014) specifically considers the response to the 2008 gasoline price shock in California. EPA is correct to conclude that this was "an unusual period when gasoline prices were particularly salient to consumers." 2021 RIA at 3-6 to 3-7. As EPA noted, Gillingham explained in a follow-up paper in 2020 that the Gillingham (2014) results should not be used for developing an estimate of the VMT rebound effect for fuel economy or GHG standards. 2021 RIA at 3-7. The Gillingham (2014) paper is equally irrelevant to the question of the income effect on rebound. Various papers have confirmed that the rebound effect is declining over time and one study certainly should not be used as the basis for giving this factor "less weight," especially a study whose own author acknowledges its irrelevance to this rulemaking context and to which EPA gives little to no weight otherwise. Because of this, EPA should more fully consider the impacts of the income effect on rebound, and in doing so, could support a rebound effect of a magnitude lower than 10%.

In fact, the income effect on rebound is particularly important in the context of setting LDV GHG emissions regulations for two reasons. First, even the most recent relevant studies on which rebound estimates are based consider data only from 2013 and earlier. The historical

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[624] *See, e.g.*, 2016 Draft TAR at 10-14 and 10-20; 77 Fed. Reg. at 62924, 62995; *accord* Small K. & K. Van Dender, *Fuel Efficiency and Motor Vehicle Travel: The Declining Rebound Effect*, 28 Energy J. 25 (2007); Hymel, K. et al., *Induced Demand and Rebound Effects in Road Transport*, 44 Transp. Rsch. Part B 1220 (2010).
[625] 77 Fed. Reg. at 62924.
[626] NHTSA, Corporate Average Fuel Economy for MY 2017-MY 2025 Passenger Cars and Light Trucks: Final Regulatory Impact Analysis, at 851-52 (2012) (citing Small & Van Dender (2007) (finding average rebound to be 22% for 1966-2001, but declining to 11% when looking at only 1997-2001); Hymel et al. (2010) (finding that average rebound for 1966 through 2004 was 24%, but rebound by 2004 was only 13%); Greene, D., *Rebound 2007: Analysis of Light-Duty Vehicle Travel Statistics* (Mar. 2010) (internal EPA research) (estimating the rebound effect would be 10% in 2010 and 8% in 2030, using 1966-2007 data); *see also* Greene (2012) (same)).

growth rate of per capita personal income was 1.4% between 2001 and 2019,[627] and thus income growth since 2013 would indicate a declining rebound effect even in the time since the most recent data utilized were collected. Second, EPA's final standards will affect the fuel efficiency—and therefore the rebound effect—for vehicles for the next 30 years or more. Private forecasts have estimated approximately 1.6% growth in real personal income per year over the next 30 years, *see* 85 Fed. Reg. at 24675 n.1763, meaning that when most vehicles subject to the regulations are retired, incomes will be at least 61% higher than they are today (which are already higher than during the time periods in which the available rebound studies were conducted).[628] More recent projections in AEO 2023 anticipate incomes rising even more than prior estimates—an average of 2.4% per year through 2050.[629] This income growth would be expected to cause a large reduction in the magnitude of the rebound effect, supporting a rebound effect for the vehicles subject to EPA's final standards of a magnitude well below 10%.

C. It is reasonable for EPA to assume no rebound driving for BEVs.

Based on several recent studies looking at VMT for BEVs, and two studies specifically considering BEV rebound, EPA's Proposed Rule assumes that the rebound effect for BEVs is 0% rather than the 10% value the Agency uses for combustion vehicles. It is reasonable for EPA to assume no rebound driving for BEVs for the reasons stated in the DRIA, *see* DRIA at 4-14 to 4-17, and because longstanding rebound research indicates that rebound is likely more a response to fuel prices than to fuel efficiency.

The rebound effect relevant to these standards—for all vehicles, but especially with respect to BEVs—is fuel efficiency rebound. A substantial body of research indicates that fuel price or fuel cost rebound effects are higher than fuel economy rebound effects, meaning that rebound may be more responsive to fuel prices than fuel efficiency. Both Greene (2012) and Hymel and Small (2015)—two of EPA's seven most preferred studies—came to this conclusion. Other studies cited by EPA—Gillingham (2012), Small and Van Dender (2007), West et al. (2015), and Wang and Chen (2014)—also concluded the same. Kenneth A. Small has explained that his studies indicate that the fuel economy rebound effect "is statistically indistinguishable from zero," and that "[t]his is also true of the vast majority of other studies that have tried to measure separately these two responses."[630] He further explained that "the most defensible result empirically is that people do respond to fuel prices as expected, but that they do not respond to fuel economy at all," and that "Small and Van Dender (2007) make this point explicitly, and point out that we are therefore assuming a positive [fuel economy] rebound effect when actually

[627] *See* Amicus Brief of Economists at 16 for calculation of 1.4% growth rate.
[628] Amicus Brief of Economists at 16.
[629] U.S. Energy Information Administration, Annual Energy Outlook 2023, Table 20: Macroeconomic Indicators, https://www.eia.gov/outlooks/aeo/data/browser/#/?id=18-AEO2023&cases=ref2023&sourcekey=0.
[630] Kenneth A. Small, Comment Letter at 2.

we cannot prove that it's greater than zero."[631] Greene (2012) also found that the impact of fuel efficiency on VMT was not statistically significant, a point EPA referred to in the 2016 Draft TAR to suggest that the relevant rebound effect for policymaking purposes "could be zero." 2016 Draft TAR at 10-14.[632] And Wenzel & Fujita (2018) found that vehicles with the highest fuel economy—but still vehicles significantly less efficient than BEVs—had notably lower rebound rates than vehicles with lower fuel economy, with an average rebound effect well below 10%.[633]

Additional very recent research that has been presented but is not yet published provides further support for EPA's 0% BEV rebound effect. Spiller et al. (2023) investigated the existence of rebound effects in annual miles driven for BEV owners.[634] The study "compile[d] household level fleet data in Massachusetts to perform an event-study and difference-in-difference analysis, comparing miles driven after new vehicle purchases" across BEVs and combustion vehicles.[635] The analysis distinguished between BEVs purchased as additions to the household fleet versus replacement vehicles, and used propensity score matching to find an appropriate control group. Spiller et al. (2023) "estimate[d] the elasticity of VMT to changes in gasoline prices for households with and without BEVs, using a fixed effect model and instrumenting for the price of gasoline with the price of crude oil in the international markets," and found that "EV households shift VMT to EVs when gasoline prices increase, although the increase in driving after the purchase of a new vehicle does not differ across fuel type, suggesting the absence of a rebound effect."[636] EPA should include discussion of Spiller et al. (2023) in its final rule if the research is published or available in a working paper form prior to promulgation of the final rule.

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[631] *Id.* In the 2020 Final Rule, EPA relied on Linn (2016) to support an argument that fuel economy rebound is greater than fuel price rebound. Linn (2016), however, described the separate coefficients for fuel price and fuel economy changes as statistically insignificant. Linn, J., *The Rebound Effect of Passenger Vehicles*, 37 Energy J. at 277 (2016). Moreover, Linn also explained that self-reported VMT data (as was used for his research) "may be noisy when compared to VMT calculated from multiple odometer readings," and that therefore studies that use VMT based on multiple odometer readings—such as all of those enumerated above—"should have lower measurement error, and yield preferable estimates from a statistical point of view." Joshua Linn, Comment on Proposed MY 2021-2026 Standards, NHTSA-2018-0067-7188, at 2 (Oct. 11, 2018).

[632] Additionally, this point is relevant to the discussion above regarding 10% rebound being a maximum estimate for combustion vehicles. Because some of EPA's seven most preferred studies consider fuel prices rather than fuel efficiency, the most accurate rebound estimate would be no higher than—and likely lower than—the average of those studies' best estimates.

[633] Tom Wenzel & K. Sydney Fujita, *Elasticity of Vehicle Miles of Travel to Changes in the Price of Gasoline and the Cost of Driving in Texas*, Lawrence Berkeley National Laboratory (Mar. 2018) at iv (explaining that rebound for "high MPG" vehicles—which are still less efficient than BEVs—is estimated to be 5.2%).

[634] *See* American Economic Association, AASA Annual Meeting 2023 Program, Abstract for Beia Spiller, Kenneth Gillingham & Mart Talevi, *The Electric Vehicle Rebound Effect* (Jan. 6, 2023), https://www.aeaweb.org/conference/2023/program/1610?q=eNqrVipOLS7OzM8LqSxIVbKqhnGVrAxrawGlCArI.

[635] *Id.*

[636] *Id.*

XXVI. BEV Safety Should Not Be a Constraining Factor in This Rulemaking.

We agree with EPA's conclusion that, taking safety into consideration, the standards are appropriate under Section 202(a). 88 Fed. Reg. at 29347. While some have put forward misguided arguments about the safety of BEVs as a reason for EPA to set weak standards in this rulemaking, those claims miss the mark for many reasons. BEVs have been on the road in appreciable numbers for more than a decade already, and BEV sales will continue to grow due to market forces alone. OEMs, trade and professional associations, and safety authorities at all levels have long been studying, planning for, and responding to BEV safety matters.[637] With or without this rulemaking, the number of BEVs will continue to grow, and safety research, planning, and design efforts will continue apace. Thus, safety should not act as a constraining factor in this rulemaking.

In the Proposal, EPA considered the impact of projected changes in vehicle weight on safety, including heavier BEV vehicles. *See* 88 Fed. Reg. at 29387-88; DRIA Ch. 9.4. EPA relied on analysis developed by the National Highway Traffic Safety Administration (NHTSA), which found no statistically significant impact on safety due to vehicle weight changes, holding vehicle footprint constant. 88 Fed. Reg. at 29387 n.796.[638] EPA also considered the possible safety effects of changes in fleet composition due to changes in new vehicle sales and fleet turnover, also relying on underlying analysis by NHTSA. *See* DRIA Ch. 9.4. Based on these analyses, EPA concluded that "there are no changes to the vehicles themselves, nor the combined effects of fleet composition and vehicle design, that will have a statistically significant impact on safety." 88 Fed. Reg. at 29387.

While EPA did not find any statistically significant impacts on safety from changes in vehicle weight and fleet turnover, EPA nonetheless quantified those impacts, based on NHTSA's

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[637] Indeed, these efforts began more than a decade ago. For example, in 2010, the National Fire Protection Association and SAE International hosted a summit on EV safety standards. Am. Nat'l Standards Inst. (ANSI), U.S. *National Electric Vehicle Safety Standards Summit Report Released* (Jan. 5, 2011), https://www.ansi.org/news/standards-news/all-news/2011/01/us-national-electric-vehicle-safety-standards-summit-report-released-05. And in 2011, ANSI convened a workshop on behalf of the U.S. DOE "to consider current and future U.S. domestic, regional, and international standards, codes, and conformity assessment activities needed to facilitate the introduction and widespread deployment of grid-connected electric vehicles." ANSI, *ANSI Workshop: Standards and Codes for Electric Drive Vehicles* (Apr. 5-6, 2011), https://share.ansi.org/Shared%20Documents/Meetings%20and%20Events/EDV%20Workshop/EDVSponsorship.pdf

[638] In addition, the weight of future BEVs will be influenced by a variety of factors, including developments in battery chemistries and other technologies that could reduce weight. *See generally* Sebastian Blanco, *The Future of Solid-State Batteries*, J.D. Power (Apr. 3, 2023), https://www.jdpower.com/cars/shopping-guides/the-future-of-solid-state-batteries; Chris Teague, *What You Need To Know About Solid-State Batteries*, Autoweek, https://www.autoweek.com/news/technology/a36189339/solid-state-batteries/ (last visited June 15, 2023); Michael Bull, *Mass Reduction and Performance of PEV and PHEV Vehicles* (undated), https://www-esv.nhtsa.dot.gov/Proceedings/22/files/22ESV-000346.pdf; Stanley, *How Electric Vehicle Light-weighting is Changing the Automotive Industry*, https://www.stanleyengineeredfastening.com/en/News%20and%20Stories/How%20Electric%20Vehicle%20Light-weighting%20is%20Changing%20the%20Automotive%20Industry (last visited June 15, 2023).

underlying analysis, as well as the impacts of rebound driving (*i.e.*, increased driving due to lower fueling costs). *Id.* at 29387. EPA's modeling projected that over the full period of 2027-2055, the Proposal would lead to an increase of 1,595 vehicle fatalities from all three sources (weight changes, fleet turnover changes, and rebound driving). *Id.* As EPA notes, this is of a similar scale to the expected *reductions* in premature deaths from air pollution in just a single year (2055) that would result from the Proposed Standards. *Id.* at 29388.

As EPA explained in its proposal for the Phase 3 Heavy-Duty GHG standards, numerous standards and codes govern BEV safety. 88 Fed. Reg. at 25962; Phase 3 DRIA Ch. 1.5.2. BEVs must meet the same federal safety requirements and undergo the same safety testing as combustion vehicles.[639] Evidence shows that BEVs "are at least as safe" as combustion vehicles in terms of crashworthiness test performance, while "injury claims are substantially less frequent" for BEVs than for combustion vehicles.[640] And on some safety metrics, BEVs perform substantially *better* than combustion vehicles. Due to their battery architecture, for example, BEVs typically have a lower center of gravity than combustion vehicles, which increases stability and reduces the risk of rollovers[641] (the cause of up to 35% of accident deaths[642]).

Fire risk and emergency response can also be managed effectively. BEVs are significantly less likely to catch fire than combustion vehicles in the first place.[643] While BEVs can behave differently in fires than combustion vehicles, emergency responders have been gaining experience in BEV fire response as the number of BEVs on the road has grown. Numerous agencies and associations, including the National Transportation Safety Board,[644] National Highway Traffic Safety Administration,[645] and National Fire Protection Association,[646] have established fire safety and emergency response recommendations for BEVs. The National Fire Protection Association and other organizations offer BEV fire response trainings,[647] as do

[639] DOE, *Maintenance and Safety of Electric Vehicles*, Alternative Fuels Data Center, https://afdc.energy.gov/vehicles/electric_maintenance.html (last visited June 15, 2023).
[640] Insurance Inst. for Highway Safety, *With More Electric Vehicles Comes More Proof of Safety* (Apr. 22, 2021), https://www.iihs.org/news/detail/with-more-electric-vehicles-comes-more-proof-of-safety.
[641] DOE, *Maintenance and Safety of Electric Vehicles*.
[642] CleanTechnica, *The EV Safety Advantage* 4 (2018), https://cleantechnica.com/files/2018/07/CleanTechnica-EV-Safety-Advantage-Report.pdf.
[643] *See* Rachel Bodine, *Gas vs. Electric Car Fires [2023 Findings]*, AutoinsuranceEZ (Nov. 11, 2022), https://www.autoinsuranceez.com/gas-vs-electric-car-fires/ (calculating rate of car fires using National Transportation Safety Board data).
[644] *See, e.g.*, NTSB, *Risks to Emergency Responders from High-Voltage, Lithium-Ion Battery Fires Addressed in Safety Report* (Jan. 13, 2021), https://www.ntsb.gov/news/press-releases/Pages/NR20210113.aspx.
[645] *See, e.g.*, NHTSA, *Interim Guidance for Electric and Hybrid-Electric Vehicles Equipped With High Voltage Batteries* (2012), https://www.nhtsa.gov/sites/nhtsa.gov/files/interimguide_emergencyresponse_012012_v3.pdf.
[646] *See, e.g.*, R. Thomas Long Jr., et al., *Best Practices for Emergency Response to Incidents Involving Electric Vehicles Battery Hazards: A Report on Full-Scale Testing Results* (2013), https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Electrical/EV-BatteriesPart-1.ashx.
[647] *See generally* Nat'l Fire Protection Ass'n, *Training that Helps Keep You Protected*, https://www.nfpa.org/EV (last visited June 15, 2023).

OEMs, which also produce emergency response guides for their vehicles.[648] The National Institute for Automotive Service has also developed safety-related standards and a testing and certification program for automotive technicians who service BEVs.[649] Expected future use of solid state batteries will further reduce BEV fire risk.[650] Other research efforts have identified battery designs that can improve thermal management,[651] as well as improved methods of extinguishing battery fires.[652]

In sum, EPA properly considered the impact of the Proposal on safety, including by placing vehicle safety impacts "in the context of all projected health impacts from the rule including public health benefits from the projected reductions in air pollution." 88 Fed. Reg. at 29345. In addition, the public and private sectors have been working diligently to address BEV safety considerations; those efforts will continue as the number of BEVs on the road grows, regardless of EPA's regulatory actions. EPA is correct in not treating safety as a constraining factor in this rulemaking.

XXVII. Stronger Standards Will Improve U.S. Energy Security.

Energy security considerations also support strong final standards. Reducing U.S. reliance on oil enhances U.S. energy security, and—with energy security in mind—Congress has specifically directed the U.S. to conserve energy. Energy Policy and Conservation Act of 1975, 42 U.S.C. § 32902(f). EPA defines energy security as "the uninterrupted availability of energy sources at affordable prices," 88 Fed. Reg. at 29388; DRIA at 11-1, and states that "[t]he goal of U.S. energy independence is the elimination of all U.S. imports of petroleum and other foreign sources of energy, but more broadly, it is the elimination of U.S. sensitivity to variations in the price and supply of foreign sources of energy." 88 Fed. Reg. at 29388. Despite increases in domestic oil production that have made the United States an energy exporter, EPA should continue to consider the energy security impacts of GHG standards. EPA notes that combustion vehicles continue to present an energy security risk because the United States remains vulnerable to "episodic oil supply shocks and price spikes." *Id.* U.S. refineries continue to import heavy crude oil from potentially unstable regions of the world, and sudden disruptions in supply pose a threat to U.S. financial and strategic interests. DRIA at 11-1. Moreover, EPA is correct that "oil exporters with a large share of global production have the ability to raise or lower the price of oil by exerting the market power associated with the Organization of Petroleum Exporting Countries

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[648] DOE, *Maintenance and Safety of Electric Vehicles*.
[649] FleetMaintenance, *ASE unveils new EV standards, testing, and certification* (May 4, 2023), https://www.fleetmaintenance.com/equipment/safety-and-technology/article/53059346/national-institute-for-automotive-service-excellence-ase-ase-unveils-new-ev-standards-testing-and-certification.
[650] Blanco, at 3; Teague, at 5.
[651] *See generally* Chuanbo Yang et al., *Compressible battery foams to prevent cascading thermal runaway in Li-ion pouch batteries*, J. Power Sources, Sept. 1, 2022, https://doi.org/10.1016/j.jpowsour.2022.231666.
[652] *See, e.g.*, Int'l Ass'n Fire & Rescue Services, *New revolutionary method tested extinguishes lithium-Ion EV fires in ten minutes with minimal water use* (Mar. 22, 2023), https://www.ctif.org/news/new-revolutionary-method-extinguishes-lithium-ion-ev-fires-ten-minutes-minimal-water.

(OPEC) to alter oil supply relative to demand," *id.*, which would cause oil price shocks that have greater impacts when nations are heavily reliant on oil. Because the Proposed Standards will significantly reduce U.S. reliance on foreign oil, *see* 88 Fed. Reg. at 29388, Tbl.198 (showing decrease of 42,000 barrels of imported oil per day in 2027 and decrease of 2.3 million barrels of imported oil per day by 2055, and even greater import reductions under Alternative 1), EPA's Proposal and Alternative 1 both enhance U.S. energy security and make progress toward the goal of energy independence.

For the Proposal, EPA has quantified the energy security risks using a macroeconomic oil security premium. 88 Fed. Reg. at 29389. Oil security premiums measure the extra cost of importing oil beyond the price paid for the oil itself (or, in the case of a reduction in demand, the extra benefit of reducing oil imports beyond the actual expenditures saved). The main input to calculating the oil security premium is the macroeconomic benefit, which measures the potential macroeconomic disruptions and increased oil import costs to the economy resulting from oil price spikes or "shocks," or the value of avoiding these costs due to less domestic reliance on oil. In estimating the macroeconomic benefit used to calculate oil security premiums, EPA has historically relied on research conducted by Oak Ridge National Laboratory (ORNL), and EPA again takes this approach in the Proposal.[653] *Id.* EPA has estimated macroeconomic oil security premiums based on ORNL's methodology developed in 1997 and updated in 2008[654] for a series of past rulemakings including the 2010, 2012, and 2021 Final Rules and the heavy-duty vehicle GHG and fuel economy Phase I and Phase II standards and Phase III proposal.[655] In this Proposal, EPA reasonably utilizes the long-used ORNL methodology and applies the same values for the price elasticity of demand for oil and elasticity of GDP to oil price shocks as for the 2021 Rule. DRIA at 11-28 to 11-29. Similarly, EPA reasonably calculates the oil import reduction factor by the same method used for the most recent rulemaking. *Id.* at 11-25.

[653] In this Proposal, EPA reasonably calculates the macroeconomic oil security premiums using the same price elasticity of demand for oil and the same elasticity of GDP to an oil price shock as for the 2021 Rule. DRIA at 11-28 to 11-29.

[654] Leiby, P.N., *Estimating the Energy Security Benefits of Reduced U.S. Oil Imports, Final Report*, ORNL/TM-2007/028, Oak Ridge National Laboratory (Rev. Mar. 14, 2008); Leiby, P.N. et al., *Oil Imports: An Assessment of Benefits and Costs*, ORNL-6851, Oak Ridge National Laboratory (Nov. 1997); *see also* R. Uria-Martinez, et al., *Using Meta-Analysis to Estimate World Oil Demand Elasticity*, ORNL Working Paper (2018).

[655] The 2020 LDV GHG standards proposal also relied on the ORNL literature and methodologies for estimating oil security premiums, and only the 2020 Final Rule abandoned this research and methodology, instead relying on a single paper (Brown (2018)) to drastically reduce oil security premiums. Stephen A. Brown, *New Estimates of the Security Costs of U.S. Oil Consumption*, 13 Energy Policy 171-92 (2018). Reliance on Brown was inappropriate for two reasons: (1) EPA failed to provide adequate justification for departing from the established ORNL methodologies and research that had been used for over 20 years to instead rely on a single study; and (2) the 2020 Final Rule did not appear to have used Brown's best or most accurate estimates in setting oil security premiums, but rather used estimates that even Brown (2018) suspected to be inaccurate. *Id.* at 181 (noting that Brown's estimate of the "combined" value for oil security premiums "might best reflect the uncertainty in what we know about oil security premiums," and that the values derived from only the most recent research—which EPA used in the 2020 Final Rule—may not be the most reliable).

In addition to the macroeconomic oil security premium, military and monopsony benefits are considered energy security benefits of reduced U.S. oil demand. DRIA at 11-2, 11-30 to 11-32. While EPA has historically refrained from applying these values in any quantified way, it is important to recognize that energy security benefits that take into account only the macroeconomic oil security premiums could be low estimates. EPA's Proposal correctly explains that one cost of oil use is "maintaining a military presence to help secure a stable oil supply from potentially vulnerable regions of the world," *id.* at 11-30, and therefore, reducing domestic reliance on oil has the potential to result in some form of military benefit. EPA states that the Agency does not include these benefits because they are hard to quantify. *Id.* at 11-31 to 11-32. EPA is encouraged to consider methodologies for quantifying these benefits in the future, and to acknowledge that their existence makes EPA's current estimations of energy security benefits conservative.

Finally, EPA is correct that electricity used in PEVs will "improve the U.S.'s overall energy security position," 88 Fed. Reg. at 29389, because electricity is more affordable and less price volatile than oil, a point that numerous sources support.[656] Even more importantly, the electricity will be almost exclusively produced in the United States, "mov[ing] the U.S. towards the goal of energy independence." *Id.* Additionally, PEVs offer significant energy security benefits in that "[e]lectric vehicles can be powered by any energy source because all energy sources can be converted to electricity."[657] Unlike combustion vehicles—which can be powered only by oil—PEVs can utilize solar, wind, hydroelectric, geothermal, or any other electricity resources available to the grid.[658]

Critical minerals needed for EV batteries do not raise the same energy security concerns because these minerals are not the source of energy for U.S. vehicles, but a component of their manufacture. We agree with EPA that increased electrification does not constitute a vulnerability

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[656] *See, e.g.*, Talor Gruenwald, *Reality Check: The Myth of Stable and Affordable Natural Gas Prices*, Rocky Mountain Institute (Nov. 17, 2021), https://rmi.org/the-myth-of-stable-and-affordable-natural-gas-prices/ ("Electricity prices, which are driven by the costs of a variety of fuels including renewables, are much less susceptible to individual commodity price shocks."); Jeremy Martin, *Why Are Gasoline Prices So Volatile?*, Union of Concerned Scientists (Mar. 29, 2022), https://blog.ucsusa.org/jeremy-martin/why-are-gasoline-prices-so-volatile/ (explaining the price volatility of the oil market and noting that its global nature "means that U.S. consumers remain vulnerable to changes in oil prices across the globe" and that "electricity prices are far less volatile than gasoline."); U.S. Department of Energy, *Saving Money with Electric Vehicles* (Sept. 28, 2022), https://www.energy.gov/energysaver/articles/saving-money-electric-vehicles (noting that "electricity is less expensive than gasoline," and that "[p]etroleum prices are historically very volatile and change substantially over time," while "electricity prices are much more stable.").

[657] Nicholas Brown, *EVs Provide Energy Security, Aid Energy Transitions During Conflicts*, Clean Technica (July 12, 2022), https://cleantechnica.com/2022/07/12/evs-provide-energy-security-aid-energy-transitions-during-conflicts/.

[658] *Id.*; *see also* Lee F. Gunn, *Electric Vehicles Improve Our National Security*, Orlando Sentinel (June 9, 2023), https://www.orlandosentinel.com/2023/06/09/electric-vehicles-national-security-opinion/ ("Diversified energy resources and EVs are already beginning to reduce our dependence on unpredictable oil-exporting partners. Accordingly, EVs can reduce our exposure to energy supply shocks and, importantly, limit the risk of supply disruptions for military operations.").

to national security because the utilization of critical minerals is fundamentally different from the utilization of foreign oil. As EPA explains, oil is consumed as a fuel and is a continuous input necessary for vehicle operation, while minerals are used only in the vehicle production phase and become a constituent of manufactured vehicles, with the potential to be recovered and recycled. 88 Fed. Reg. at 29323.

Minerals are "an input to the construction" of vehicles and their infrastructure rather than "a fuel that is combusted on an ongoing basis," meaning that "the near term risk is not one of 'traditional' energy security (short-term supply constraints or high prices)."[659] Critical minerals do not pose energy security concerns because, "unlike reliance on oil (where the resource is consumed with each trip) EVs consume locally produced electricity with each trip and additional lithium is only required when the battery is replaced or a new vehicle is purchased."[660] An event squeezing or shutting off the supply of oil would have "an almost immediate deleterious effect on transportation," but a squeeze in critical mineral supply would allow "batteries in existence [to] continue to function," and "there [would] not be a fundamental disruption of the transportation sector."[661] Increases in oil prices and decreases in supply impact all drivers, and easing this dependence through electrification would shield drivers from daily price volatility. Moreover, whereas "fuel is burnt once," EV battery materials "can be reused and recovered in a circular loop to produce new batteries."[662] Recyclers such as Redwood Materials and Li-Cycle can recover up to 95% of the minerals from old batteries at commercial scale today.[663]

Finally, combustion vehicles will remain in production and operation for many years, diversifying the one-time and ongoing inputs needed for vehicles and allowing the U.S. battery supply chain time to stabilize through increased domestic mining and production, advances in battery design and recycling, and cooperation with allies over the next decade.

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[659] Sara Hastings-Simon & Morgan Bazilian, *Critical Minerals Don't Burn Up – Why the Energy Security Playbook Needs a Re-Write*, Global Policy (July 23, 2020), https://www.globalpolicyjournal.com/blog/23/07/2020/critical-minerals-dont-burn-why-energy-security-playbook-needs-re-write.
[660] Fred Stein, *Ending America's Energy Insecurity: Why Electric Vehicles Should Drive the United States to Energy Independence*, 9 Homeland Security Affairs (Feb. 2013), https://www.hsaj.org/articles/236.
[661] *Id.*
[662] Transport & Environment, *From Dirty Oil to Clean Batteries* 6–7, 41 (2021), https://www.transportenvironment.org/wp-content/uploads/2021/07/2021_02_Battery_raw_materials_report_final.pdf.
[663] Redwood Materials, *Recycling, Refining, and Remanufacturing Battery Materials for a Clean Energy Future*, Redwood Materials, https://www.redwoodmaterials.com/solutions/.
Li-Cycle, Full-Service Solution for Recycling Lithium-ion Batteries, https://li-cycle.com/services/#closed-loop-battery-resource-recovery.

XXVIII. U.S. Employment in the Auto Sector is Likely to Increase as Electrification of the Vehicle Fleet Grows.

Finally, we turn to employment considerations. EPA is correct that the employment effects of environmental regulation "are difficult to disentangle from other economic changes (especially the state of the macroeconomy) and business decisions that affect employment, both over time and across regions and industries," 88 Fed. Reg. at 29390, and that there is some uncertainty in the data regarding specific job impacts of increased electrification, *id*. EPA notes that although BEVs have fewer parts than combustion vehicles, initial results of a vehicle tear-down study commissioned by the Agency and performed by FEV Consulting suggest that the labor hours needed to assemble BEVs and combustion vehicles are "very similar." 88 Fed. Reg. at 29392; DRIA at 2-57 to 2-58. The teardown study performed a side-by-side analysis of significant systems and subsystems to develop a projected cost model comparing a "relatively equivalent" BEV (2021 Volkswagen ID.4) and a combustion vehicle (2021 Volkswagen Tiguan). DRIA at 2-57.[664] Although the full final results of EPA's commissioned study are not yet publicly available, the information provided in the docket indicates a well-designed peer-reviewed analysis that considered platform optimization, used an absolute costing approach, considered potential differences in incremental costs, and involved a detailed labor assessment for each component. *Id*. The docket includes detailed slides from FEV Consulting summarizing the preliminary cost results of the study, and EPA should further incorporate these and other relevant results from the FEV Consulting research into the Agency's support for the final rule.[665]

EPA's DRIA notes two additional older teardown studies that the Agency considered in its analysis—a 2017 UBS teardown of the Chevy Bolt EV, and a 2017–2018 teardown study of several EV components performed for CARB—neither of which was as comprehensive or comparative as EPA's project with FEV Consulting, and neither of which specifically looked at total labor hours.[666] *See* DRIA at 2–58. At least one other recent teardown study has considered labor hours and come to a conclusion similar to FEV Consulting's analysis—that "very similar" labor hours are needed between BEVs and combustion vehicles—finding that BEVs require 99% of the total labor hours per vehicle compared to combustion vehicles, primarily due to battery cell manufacturing, and PHEVs require *more* labor than combustion vehicles.[667] As automakers have already begun taking significant steps toward on-shoring battery manufacturing and the rest

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[664] *See also* Michael Safoutin, *Cost and Technology Evaluation, Conventional Powertrain Vehicle Compared to an Electrified Powertrain Vehicle, Same Vehicle Class and OEM*, Memo to EPA Docket # EPA-HQ-OAR-2022-0829-0422 (Apr. 18, 2023).
[665] *See* FEV Consulting, *EPA FEV Cost and Technology Evaluation VW Tiguan and VW ID4*, Attachment to Safoutin, *Cost and Technology Evaluation*, Memo to EPA Docket # EPA-HQ-OAR-2022-0829-0422 (Apr. 18, 2023).
[666] The UBS project was an EV teardown only, and UBS did not conduct a side-by-side comparison with a similar combustion vehicle, and the CARB project involved only specific components from strong hybrids and plug-in hybrids, which have cost profiles very different from BEVs.
[667] Daniel Kupper et al., *Shifting Gears in Auto Manufacturing*, Boston Consulting Group (Sept. 28, 2020), https://www.bcg.com/publications/2020/transformative-impact-of-electric-vehicles-on-auto-manufacturing.

of the PEV supply chain, supported by the significant funding incentives for domestic manufacturing in the BIL and IRA, the United States is well-positioned to capture battery-related and other PEV manufacturing jobs as the PEV sector grows. The positive impact on employment from this increase in vertical integration is illustrated in preliminary results from the Agency's FEV Consulting study, which finds nearly a 50% increase in labor hours in BEV compared to combustion engine manufacturing for a highly vertically integrated manufacturer.[668]

EPA cites reports by the Economic Policy Institute, Seattle Jobs Initiative, and Climate Nexus, all of which found that total U.S. employment in the auto sector could increase with electrification, in particular if the share of vehicles sold in the United States that are produced in the United States increases. 88 Fed. Reg. at 29390–92. In fact, Congress has recognized the benefits of ensuring that large shares of vehicles sold in the United States are produced in the United States. Through the on-shoring incentives in recent legislation, particularly the IRA, Congress has encouraged substantial growth in the domestic ZEV manufacturing and supply chain and has indicated congressional support for increasing numbers of ZEVs in the light-duty fleet in order to meet the nation's climate goals. These IRA incentives are having their intended effects of encouraging development of the domestic ZEV supply chain. As EPA notes, reports by the BlueGreen Alliance and the Political Economy Research Institute estimate that the IRA will create over 9 million jobs over the next decade, with about 400,000 attributed directly to the battery and fuel cell provisions. 88 Fed. Reg. at 29390–91.

Other analyses have found similar positive employment impacts. A University of Massachusetts study of job creation resulting from the IRA found that the IRA's programs, including the law's transportation-sector funding programs that encourage ZEV development, could lead to overall job creation.[669] The analysis estimated significant job increases in the transportation, electricity, and manufacturing sectors, both annually and in total job-years.[670] Analysis of the IRA and BIL by the Boston Consulting Group found that the two laws would increase new U.S. ZEV industry jobs through 2030 from about 455,000 to about 680,000, "primarily due to domestic manufacturing incentives."[671] And, supporting this post-IRA upward trend, EDF recently found that "46,400 announced jobs, representing approximately 32% of all EV job announcements, have occurred in the last 6 months since the passage of the IRA."[672]

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[668] FEV Consulting, *Assembly Times Comparison Draft Report*, EPA-HQ-OAR-2022-0829-0460, Slide 28 (May 9, 2023).
[669] Robert Pollin et al., *Job Creation Estimates Through Proposed Inflation Reduction Act*, University of Massachusetts Amherst Political Economy Research Institute 10-13 (Aug. 4, 2022), https://peri.umass.edu/publication/item/1633-job-creation-estimates-through-proposed-inflation-reduction-act.
[670] *Id.* at 3, 13 (estimating 447,472 additional job-years in relevant transportation jobs due to IRA, along with 31,510 additional job-years due to IRA's EV manufacturing grants under Section 50143 and 114,592 additional job-years due to IRA's clean manufacturing investment tax credit under Section 13501).
[671] Boston Consulting Group, *Impact of IRA, IIJA, CHIPS, and Energy Act of 2020 on Clean Technologies* 3 (April 2023), https://breakthroughenergy.org/wp-content/uploads/2023/04/EV-Cleantech-Policy-Impact-Assessment.pdf.
[672] EDF, *U.S. Electric Vehicle Manufacturing Investments and Jobs: Characterizing the Impacts of the Inflation Reduction Act after 6 Months* 5 (March 2023),

Other analyses in addition to those cited by EPA also have concluded that more stringent GHG standards can lead to positive job impacts. For example, several state-level analyses conducted by ERM using the Impact Analysis for Planning (IMPLAN) model found that state adoption of clean car standards would result in net job increases, assuming that incremental spending on PEV batteries and electric drivetrain components would be in the United States.[673] Moreover, each of these analyses found that the jobs created would be high-quality, high-paying jobs, with average wages for the new jobs between 33% and 100% higher than average wages for the jobs being replaced.[674] Similarly, a state-level analysis conducted by the World Resources Institute (WRI) on increased PEV penetration in Michigan found that the state "stands to gain tens of thousands of high-quality jobs," if it "seize[s] the opportunities" of the PEV sector.[675] Because PEVs are cheaper to drive, the analysis found that "[s]witching to EVs will allow drivers to save money on vehicle purchases, maintenance, and gasoline, which will improve household finances and have positive employment impacts" as consumers spend their extra money throughout the rest of the economy.[676] Analysis on the nationwide impacts of California's clean car policies also projects significant overall job gains resulting from increased production of ZEVs—with over 7.3 million full-time equivalent job-years of employment created through 2045.[677] Another nationwide study found that, compared to a "no new policy" scenario, a scenario with high levels of ZEVs would result in a peak of over 2 million jobs created in 2035, even without accounting for the impact of any additional on-shoring incentives such as those in the IRA.[678]

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https://blogs.edf.org/climate411/files/2023/03/State-Electric-Vehicle-Policy-Landscape.pdf?_gl=1*1uxcnl5*_ga*MTk3NDc4MzQ3NS4xNjMyODU4NDY0*_ga_2B3856Y9QW*MTY3ODgwMjg0Ny4xNTQuMC4xNjc4ODAyODQ5LjU4LjAuMA..*_ga_Q5CTTQBJD8*MTY3ODgwMjg0Ny4xNTMuMC4xNjc4ODAyODQ5LjU4LjAuMA.

[673] Dave Seamonds et al., *New York Advanced Clean Cars II Program*, ERM 20 (Feb. 2023), https://www.erm.com/globalassets/documents/global-policies/new-york-advanced-clean-cars-program-report_2023.pdf (evaluating impacts of Advanced Clean Cars II adoption in New York); Sophie Tolomiczenko et al., *The Benefits of the Colorado Clean Car Standard*, ERM 19–20 (May 2023), https://www.erm.com/globalassets/foundation-annual-report-2023/co_acc_ii_final_report_15may2023.pdf (evaluating Colorado's Clean Car Standards); Sophie Tolomiczenko et al., *New Jersey Advanced Clean Cars II Program*, ERM 21 (April 2023), https://www.erm.com/contentassets/0ea3b193115448cd9dd5c7e3622373a0/new-jersey-advanced-clean-cars-ii-program.pdf (evaluating impacts of Advanced Clean Cars II adoption in New Jersey).

[674] *Id.*

[675] Devashree Saha et al., *A Roadmap for Michigan's Electric Vehicle Future*, World Resources Institute 3 (May 2023), https://files.wri.org/d8/s3fs-public/2023-05/roadmap-michigan-ev-future.pdf?VersionId=v0C1QYM5LrUtDymSBYzR_PGHpKMUmRju.

[676] *Id.* at 10–11.

[677] Austin L. Brown et al., *Driving California's Transportation Emissions to Zero*, University of California Institute of Transportation Studies 327 (April 2021), https://escholarship.org/uc/item/3np3p2t0.

[678] University of California Berkeley Goldman School of Public Policy, *The 2035 Report: Transportation* ES-4 & 22–24 (April 2023), http://www.2035report.com/transportation/wp-content/uploads/2020/05/2035Report2.0-1.pdf?hsCtaTracking=544e8e73-752a-40ee-b3a5-90e28d5f2e18%7C81c0077a-d01d-45b9-a338-fcaef78a20e7.

These new clean vehicle jobs are also poised to have positive environmental justice impacts as they bring significant new jobs to communities of color. Research by Climate Power has found that "[a] majority of new clean energy jobs and projects [resulting from IRA investments] are located in communities of color across America," with Arizona, Georgia, South Carolina, Nevada, and Michigan home to the largest number.[679] Climate Power's report details numerous gigafactories, cathode manufacturing facilities, and ZEV factories that will bring jobs to communities of color nationwide. For example, Kore Power Gigafactory will bring 6,400 jobs to Arizona, in two counties that are 46.6% and 32% Hispanic/Latino, and Scout Motors will open an EV plant in South Carolina, bringing 4,000 jobs to two counties that are between 40% and 50% Black/African American.[680] Climate Power's Clean Energy Jobs Tracker provides detailed data on new clean energy jobs since the passage of the IRA, showing large job growth in numerous states related to battery and ZEV manufacturing.[681]

While certain employment sectors may be impacted over time by increased electrification, as EPA notes, 88 Fed. Reg. at 29392, we agree that this will "happen over a longer time span due to the nature of fleet turnover," *see* Table XVII.G-1 (L/MD PEVs as a Share of Total On-Road L/MD Fleet, 2020–2040), *supra*, with time to retrain workers for better, higher paying jobs, 88 Fed. Reg. at 29392. A World Resources Institute study considering Michigan's automotive industry noted that many new ZEV-sector jobs will require skill development, with opportunities to "re-skill, upskill, or shift to jobs of equal or greater quality," and that much of this "could be addressed as part of normal rates of retirement, given that 52% of all current auto manufacturing workers in Michigan will reach age 65 by 2040."[682] Moreover, programs have already been implemented to train workers with the skills they will need for jobs within ZEV manufacturing. California's Energy Commission, for example, created the state's Clean Transportation Program to "invest[] in manufacturing and workforce training and development, working with a variety of public and private partners."[683] Electric bus company Proterra and community colleges in California joined together to provide a nine-week training program to become electric bus manufacturing technicians, which workers have already used to transition from lower-paying restaurant jobs, for example, to higher-paying union jobs at Proterra.[684] General Motors launched the Automotive Manufacturing Electrical College (AMEC)

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[679] Climate Power, *The Clean Energy Boom in Communities of Color* 1, 4, https://climatepower.us/wp-content/uploads/sites/23/2023/05/Clean-Energy-Boom-Communities-of-Color-Report.pdf (noting plans for 51 new battery manufacturing sites in places like Augusta, Georgia; Tucson, Arizona; and St. Louis, Missouri; and plans for 26 new or expanded EV manufacturing facilities in Pryor, Oklahoma; Montgomery, Alabama; and Detroit, Michigan).
[680] *Id.* at 4–5.
[681] Climate Power, *The Clean Energy Plan*, https://thecleanenergyplan.com/.
[682] Devashree Saha et al., *A Roadmap for Michigan's Electric Vehicle Future* at 8, 10.
[683] California Energy Commission, Workforce Development, https://www.energy.ca.gov/programs-and-topics/programs/clean-transportation-program/clean-transportation-funding-areas-4.
[684] Jill Replogle, *Training a New Workforce for California's Move to Electric Vehicles*, Marketplace (June 28, 2021), https://www.marketplace.org/2021/06/28/training-a-new-workforce-for-californias-move-to-electric-vehicles/.

"to train current and future employees to work on evolving electrical systems in future GM vehicles."[685] States are also funding training for ZEV-related jobs.[686]

XXIX. Conclusion

EPA should finalize emission standards for light- and medium-duty vehicles that are at least as stringent as Alternative 1 but with increasing stringency from 2030 to 2032 to put the country on track for 100% new ZEV sales by 2035. EPA can and must go further than it has proposed. Adopting the recommendations set forth in this comment letter would result in feasible, cost-beneficial emission standards that would better serve EPA's statutory mandate to protect public health and welfare.

Respectfully submitted,

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[685] General Motors, *Training Manufacturers for the Vehicles of Tomorrow*, https://www.gm.com/stories/amec-electric-manufacturing-workforce.
[686] *See, e.g.*, State of Illinois, *Illinois Drives Electric: Training and Degree Programs*, https://ev.illinois.gov/grow-your-business/training-and-degree-programs.html (noting various job programs with state funding); State of Michigan, *Gov. Whitmer Announces New EV Jobs Academy Website to Connect Michiganders to Careers in Electric Vehicle Industry* (March 1, 2023), https://www.michigan.gov/leo/news/2023/03/01/gov-whitmer-announces-new-ev-jobs-academy-website-to-connect-michiganders-to-careers-in-ev-industry ("The EV Jobs Academy is designed to provide Michiganders with tuition assistance and supportive services, including "earn while you learn" opportunities through a Registered Apprenticeship, to support and streamline onramps to high-wage, in-demand careers. With more than 100 partners including employers, industry stakeholders and education institutions, the EV Jobs Academy is driving the state's advanced mobility talent development for the future.").

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Attachment 80

Comments of Environmental and Public Health Organizations on:

EPA, California State Motor Vehicle Pollution Control Standards; Advanced Clean Cars II Regulations; Request for Waiver of Preemption; Opportunity for Public Hearing and Public Comment, 88 Fed. Reg. 88908 (December 26, 2023); Docket ID No. EPA–HQ–OAR–2023–0292

Submitted February 27, 2024

Electricity Laws and Incentives in California

The list below contains summaries of all California laws and incentives related to electricity.

California

More Laws and Incentives
To find laws and incentives for other alternative fuels and advanced vehicles, search all laws and incentives (/laws/).

Laws and Regulations

Establishment of Zero Emission Vehicle (ZEV) and Near-ZEV Component Rebates
The California Air Resources Board (CARB) will establish the Zero Emission Assurance Project (ZAP) to offer rebates for the replacement of a battery, fuel cell, or other related vehicle component for eligible used ZEVs and near-ZEVs. Rebates will be limited to one per vehicle. By January 1, 2024, CARB must publish a report to the legislature detailing the number of rebates awarded, the emissions benefits of the ZAP, and the impacts of the ZAP on low-income consumer decisions to purchase zero and near-zero emissions vehicles. A ZEV is defined as a vehicle that produces no criteria pollutant, toxic air contaminant, or greenhouse gas emissions when stationary or operating. A near-ZEV is a vehicle that uses zero emission technologies, uses technologies that provide a pathway to zero emission operations, or incorporates other technologies that significantly reduce vehicle emissions. Rebates will be available through July 31, 2025.

(Reference California Health and Safety Code 44274.9 (http://leginfo.legislature.ca.gov/faces/home.xhtml))

Access to Electric Vehicle (EV) Registration Records
The California Department of Motor Vehicles may disclose to an electrical corporation or local publicly owned utility an EV owner’s address and vehicle type if the information is used exclusively to identify where the EV is registered.

(Reference California Vehicle Code 1808.23 (http://www.oal.ca.gov/))

Alternative Fuel Vehicle (AFV) Parking Incentive Programs
The California Department of General Services (DGS) and California Department of Transportation (Caltrans) must develop and implement AFV parking incentive programs in public parking facilities operated by DGS with 50 or more parking spaces and park-and-ride lots owned and operated by Caltrans. The incentives must provide meaningful and tangible benefits to drivers, such as preferential spaces, reduced fees, and fueling infrastructure.

(Reference California Public Resources Code 25722.9 (http://www.oal.ca.gov/))

Alternative Fuel Vehicle (AFV) and Fueling Infrastructure Grants
The Motor Vehicle Registration Fee Program (Program) provides funding for projects that reduce air pollution from on- and off-road vehicles. Eligible projects include purchasing AFVs and developing alternative fueling infrastructure. For more information, including grant funding and distribution, contact local air districts (https://ww2.arb.ca.gov/air-pollution-control-districts) and see the Program (https://ww2.arb.ca.gov/resources/fact-sheets/motor-vehicle-registration-fee-program) website for more information about available grant funding and distribution from the Program.

(Reference California Health and Safety Code 44220 (b) (http://www.oal.ca.gov/))

Alternative Fuel and Hybrid Electric Vehicle Retrofit Regulations
Converting a vehicle to operate on an alternative fuel in lieu of the original gasoline or diesel fuel is prohibited unless the California Air Resources Board (CARB) has evaluated and certified the retrofit system. CARB will issue certification to the manufacturer of the system in the form of an Executive Order once the manufacturer demonstrates compliance with the emissions, warranty, and durability requirements. A manufacturer is defined as a person or company who manufactures or assembles an alternative fuel retrofit system for sale in California; this definition does not include individuals wishing to convert vehicles for personal use. Individuals interested in converting their vehicles to operate on an alternative fuel must ensure that the alternative fuel retrofit systems used for their vehicles have been CARB certified. For more information, see the CARB Alternative Fuel Retrofit Systems (https://ww3.arb.ca.gov/msprog/aftermkt/altfuel/altfuel.htm) website.

A hybrid electric vehicle that is Model Year 2000 or newer and is a passenger car, light-duty truck, or medium-duty vehicle may be converted to incorporate off-vehicle charging capability if the manufacturer demonstrates compliance with emissions, warranty, and durability requirements. CARB issues certification to the manufacturer and the vehicle must meet California emissions standards for the model year of the original vehicle.

(Reference California Code of Regulations Title 13, Section 2030-2032 (http://www.oal.ca.gov/) and California Vehicle Code 27156 (https://leginfo.legislature.ca.gov/faces/home.xhtml))

Alternative Fuel and Infrastructure Assessment
Every three years, the California Council on Science and Technology must assess clean energy projects, including the deployment of, or upgrades to, alternative fueling infrastructure and low carbon fuels.

(Reference Assembly Bill 585, 2023 (https://leginfo.legislature.ca.gov/faces/home.xhtml))

Alternative Fuel and Vehicle Policy Development
The California Energy Commission (CEC) must prepare and submit an Integrated Energy Policy Report (IEPR) to the governor on a biannual basis. The IEPR provides an overview of major energy trends and issues facing the state, including those related to transportation fuels, technologies, and infrastructure. The IEPR also examines potential effects of alternative fuels use, vehicle efficiency improvements, and shifts in transportation modes on public health and safety, the economy, resources, the environment, and energy security. The IEPR’s primary purpose is to develop energy policies that conserve resources, protect the environment, ensure energy reliability, enhance the state’s economy, and protect public health and safety.

As of November 1, 2015, and every four years thereafter, the CEC must also include in the IEPR strategies to maximize the benefits of natural gas in various sectors. This includes the use of natural gas as a transportation fuel. For more information, see the 2020 Integrated Energy Policy Report (https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2020-integrated-energy-policy-report-update).

(Reference California Public Resources Code 25302 and 25303.5 (http://www.oal.ca.gov/))

Electric Vehicle (EV) Charging Access
Municipalities may not restrict the types of EVs, such as plug-in hybrid electric vehicles, that may access an EV charging station that is public, intended for passenger vehicle use, and funded in any part by the state or utility ratepayers.

(Reference California Government Code 65850.9 (http://www.oal.ca.gov/))

Electric Vehicle (EV) Charging Electricity Exemption
Electricity used to charge EVs at a state-owned parking facility is exempt from California law prohibiting gifting public money or items of value.

(Reference California Government Code 14678 (http://www.oal.ca.gov/))

Electric Vehicle (EV) Charging Requirements
New EVs must be equipped with a conductive charger inlet port that meets the specifications contained in Society of Automotive Engineers (SAE) standard J1772. EVs must be equipped with an on-board charger with a minimum output of 3.3 kilowatts (kW). These requirements do not apply to EVs that are only capable of Level 1 charging, which has a maximum power of 12 amperes (amps), a branch circuit rating of 15 amps, and continuous power of 1.44 kW.

(Reference California Code of Regulations Title 13, Section 1962.2 (http://www.oal.ca.gov/))

Electric Vehicle (EV) Charging Station Assessment
The California State Energy Resources Conservation and Development Commission (Commission), in partnership with the California Air Resources Board and the California Public Utility Commission, must publish a statewide assessment of the EV charging station infrastructure needed to support the levels of plug-in electric vehicle adoption required for at least five million zero emission vehicles to operate on California roads by 2030. The Commission must consider the EV charging station infrastructure needs for all vehicle categories, including on-road, off-road, port, and airport vehicles. In addition, the assessment must analyze the existing and future infrastructure needs across California, including in low-income communities. The assessment must be updated at least once every two years.

(Reference California Public Resources Code 25229 (http://leginfo.legislature.ca.gov/))

Electric Vehicle (EV) Charging Station Billing Requirements
EV charging station charging rates must be based on a price per megajoule or kilowatt-hour. All EV charging stations must be able to indicate the billing rate at any point during a transaction. Existing Level 2 EV charging stations installed before January 1, 2021, must be updated by January 1, 2031, and Level 2 EV charging stations installed after January 1, 2021, must comply upon installation. Existing direct current fast charging (DCFC) stations installed before January 1, 2023, must be updated by January 1, 2033, and DCFC installed after January 1, 2023, must comply upon installation.

(Reference California Code of Regulations Title 4, Sections 4001 and 4002.11 (https://oal.ca.gov/publications/ccr/))

Electric Vehicle (EV) Charging Station Certification and Training Requirements
All EV charging stations funded or authorized by the California Public Utilities Commission (CPUC), the California Energy Commission (CEC), or the state board, must be installed by a licensed contractor. At least one electrician on each installation must hold an Electric Vehicle Infrastructure Training Program (https://evitp.org/) (EVITP) certification.

The CEC and CPUC must conduct joint public workshops (https://www.energy.ca.gov/event/workshop/2021-04/joint-workshop-california-energy-commission-and-california-public-utilities) to determine if the EVITP curriculum and testing should be supplemented to ensure safe EV charging station installation. The EVITP must offer courses in an online format that would remain available through December 31, 2024.

(Reference California Public Utilities Code Section 740.20 (http://leginfo.legislature.ca.gov/faces/home.xhtml))

Electric Vehicle (EV) Charging Station Location Assessment
The State Energy Resources Conservation and Development Commission (Commission), in partnership with the California Air Resources Board (CARB), must assess whether EV charging stations in California is located disproportionately by population density, geographical area, or population income level. If the Commission and CARB determine that EV charging stations have been disproportionately installed, the Commission must use funding from the Clean Transportation Program, as well as other funding sources, to proportionately install new EV charging stations, unless it is determined that the current locations of EV charging stations are reasonable and further California's energy or environmental policy goals.

(Reference California Public Resources Code 25231 (http://www.oal.ca.gov/))

Electric Vehicle (EV) Charging Station Open Access Requirements
EV charging station service providers may not charge a subscription fee or require membership for use of their public charging stations. In addition, providers must disclose the actual charges for using public EV charging stations at the point of sale; allow contactless payment and pay-by-phone payment methods; install the Open Charge Point interoperability billing standard on each EV charging station; and disclose the EV charging station geographic location, schedule of fees, accepted methods of payment, and network roaming charges to the National Renewable Energy Laboratory. Beginning July 10, 2024, direct current fast charging (DCFC) stations must also include Plug-and-Charge payment capabilities. Additional terms and conditions apply. For more information, see the California Air Resources Board EV Charging Station Standards (https://ww2.arb.ca.gov/our-work/programs/electric-vehicle-supply-equipment-evse-standards) website.

(Reference California Health and Safety Code 44268 and 44268.2 (http://www.oal.ca.gov/) and Senate Bill 123, 2023 (https://leginfo.legislature.ca.gov/faces/home.xhtml))

Electric Vehicle (EV) Charging Station Policies for Multi-Unit Dwellings

A common interest development, including a community apartment, condominium, and cooperative development, may not prohibit or restrict the installation or use of EV charging stations or EV-dedicated time-of-use (TOU) meter in a homeowner's designated parking space or unit. These entities may put reasonable restrictions on EV charging stations, but the policies may not significantly increase the cost of the EV charging stations or significantly decrease its efficiency or performance. Restrictions may be placed on TOU meter installations if they are based on the structure of or available space in the building. If installation in the homeowner's designated parking space or unit is not possible, with authorization, the homeowner may add EV charging stations or a EV-dedicated TOU meter in a common area. The homeowner must obtain appropriate approvals from the common interest development association and agree in writing to comply with applicable architectural standards, engage a licensed installation contractor, provide a certificate of insurance, and pay for the electricity usage, maintenance, and other costs associated with the EV charging stations or TOU meter. Any application for approval should be processed by the common interest development association without willful avoidance or delay. The homeowner and each successive homeowner of the parking space or unit equipped with EV charging stations or a TOU meter is responsible for the cost of the installation, maintenance, repair, removal, or replacement of the equipment, as well as any resulting damage to the EV charging stations, TOU meter, or surrounding area. The homeowner must also maintain a $1 million umbrella liability coverage policy and name the common interest development as an additional insured entity under the policy. If EV charging stations or an EV-dedicated TOU meter is installed in a common area for use by all members of the association, the common interest development must develop terms for use of the EV charging stations or TOU meter.

(Reference California Civil Code 4745 and 6713 (http://www.oal.ca.gov/))

Electric Vehicle (EV) Charging Station Policies for Residential and Commercial Renters
The lessor of a dwelling or commercial property must approve written requests from a lessee to install EV charging station at a parking space allotted for the lessee on qualified properties. Certain exclusions apply to residential dwellings and commercial properties. All modifications and improvements must comply with federal, state, and local laws and all applicable zoning and land use requirements, covenants, conditions, and restrictions. The lessee of the parking space equipped with EV charging station is responsible for the cost of the installation, maintenance, repair, removal, or replacement of the equipment, electricity consumption, as well as any resulting damage to the EV charging station or surrounding area. Unless the EV charging station is certified by a Nationally Recognized Testing Laboratory and electrical upgrades are performed by a licensed electrician, the lessee must also maintain a personal liability coverage policy.

Electric Vehicle (EV) Charging Station Signage Authorization on Highways
EV charging station facilities located at roadside businesses are eligible to be included on state highway exit information signs. Signage must be consistent with California's Manual on Uniform Traffic Control Devices (https://dot.ca.gov/programs/safety-programs/camutcd/camutcd-files).

(Reference California Streets and Highway Code 101.7 (http://leginfo.legislature.ca.gov))

Electric Vehicle (EV) Charging Station Uptime Reporting Standards
By January 1, 2024, the California Energy Commission (CEC) in collaboration with the California Public Utilities Commission (CPUC) must develop uptime recordkeeping and reporting standards for EV charging stations purchased through a state incentive program or rate payer charges. The CEC must hold a public workshop to identify best practices for supporting EV charging station reliability and incorporate them into the uptime recordkeeping and reporting standards. Standards may vary by technology type, power level, number of chargers per site, and site ownership model. EV charging station uptime data must be reported for a minimum of six years. These standards only apply to EV charging stations installed on or after January 1, 2024, and do not apply to residential dwellings with less than five units.

CEC and CPUC must adopt tools to increase charging station uptime, including uptime requirements, operation and maintenance requirements, or operation and maintenance incentives. By January 1, 2025, CEC must set standards for how station operators notify customers about availability and accessibility of public EV charging infrastructure.

Beginning January 1, 2025, the CEC must assess the uptime of EV charging stations. The assessment must include considerations for equitable access to EV charging stations in low-, moderate-, and high-income communities. The assessment must be updated every two years.

(Reference Assembly Bill 126, 2023 (https://leginfo.legislature.ca.gov/faces/home.xhtml))

Electric Vehicle (EV) Grid Integration Requirements
In June 2020, the California Public Utilities Commission (PUC) published a plan establishing strategies to maximize EV grid integration. The PUC must also consider how to limit cost increases for all ratepayers. EV grid integration refers to any action that optimizes when or how an EV is charged. Additional terms and conditions apply.

(Reference California Public Utilities Code 740.16 (https://leginfo.legislature.ca.gov/faces/home.xhtml))

Electric Vehicle (EV) Infrastructure Information Resource
The California Energy Commission, in consultation with the Public Utilities Commission, must develop and maintain a website containing specific links to electrical corporations, local publicly owned electric utilities, and other websites that contain information specific to EVs, including the following:

- Resources to help consumers determine if their residences will require utility service upgrades to accommodate EVs;
- Basic charging circuit requirements;
- Utility rate options; and
- Load management techniques.

(Reference California Public Resources Code 25227 (http://www.oal.ca.gov/))

Electric Vehicle (EV) Parking Space Regulation

An individual may not park a motor vehicle within any on- or off-street parking space specifically designated by a local authority for parking and charging EVs unless the vehicle is an EV fueled by electricity. Eligible EVs must be in the process of charging to park in the space. A person found responsible for a violation is subject to traffic violation penalties.

(Reference California Vehicle Code 22511 (http://leginfo.legislature.ca.gov/faces/home.xhtml))

Electric Vehicle (EV) Pilot Programs
The California Public Utilities Commission (CPUC) may provide funding for pilot utility programs to install EV charging stations at school facilities, other educational institutions, and state parks or beaches. Priority must be given to locations in disadvantaged communities, as defined by the California Environmental Protection Agency. For more information, see the CPUC project guidance (http://docs.cpuc.ca.gov/SearchRes.aspx?docformat=ALL&docid=206663987) and the CPUC Zero Emission Vehicles (http://www.cpuc.ca.gov/zev/) website.

(Reference Public Utilities Code 740.13-740.14 (http://leginfo.legislature.ca.gov/faces/home.xhtml))

Electric Vehicle (EV) Support
The Public Utilities Commission must consider the following to support EVs in California:

- Strategies to facilitate the development of technologies that promote grid integration, including technologies with submetering capabilities for residential EV chargers, if implementing these technologies is in the interest of ratepayers;
- Policies that support the development of technologies and rate strategies that reduce the impact of demand charges of EV drivers and fleets and to accelerate the adoption of EVs; and
- A tariff specific to heavy-duty EV fleets that encourages EV charging when there is excess grid capacity.

(Reference California Public Utilities Code 740.15 (http://www.oal.ca.gov/))

Establishment of a Zero Emission Medium- and Heavy-Duty Vehicle Program
The California Clean Truck, Bus, and Off-Road Vehicle and Equipment Technology Program (Program) will provide funding for development, demonstration, pre-commercial pilot, and early commercial implementation projects for zero and near-zero emission trucks, buses, and off-road vehicles and equipment. Eligible projects include, but are not limited to, the following:

- Technology development, demonstration, pre-commercial pilots, and early commercial implementation projects for zero and near-zero emission truck technology;
- Zero and near-zero emission bus technology development, demonstration, pre-commercial pilots, and early commercial deployments, including pilots of multiple vehicles at one site or region;
- Purchase incentives for commercially available zero and near-zero emission truck, bus, and off-road vehicle and equipment technologies and fueling infrastructure; and
- Projects that support greater commercial motor vehicle and equipment freight efficiency and greenhouse gas emissions reductions, including autonomous vehicles, grid integration technology, and charge management solutions.

Remanufactured and retrofitted vehicles meeting warranty and emissions requirements may also qualify for funding. At least 20% of allocated funds must go towards early commercial deployment of eligible vehicles and equipment. The California Air Resources Board and the State Energy Resources Conservation and Development Commission will develop and administer the Program.

(Reference California Health and Safety Code 39719.2 (http://www.oal.ca.gov/))

Fleet Vehicle Procurement Requirements
When awarding a vehicle procurement contract, every city, county, and special district, including school and community college districts, may require that 75% of the passenger cars and/or light-duty trucks acquired be energy-efficient vehicles. This includes hybrid electric vehicles and alternative fuel vehicles that meet California's advanced technology partial zero emission vehicle standards. Vehicle procurement contract evaluations may consider fuel economy and life cycle factors for scoring purposes.

(Reference California Public Resources Code 25725-25726 (http://www.oal.ca.gov/))

Hydrogen and Electric Vehicle (EV) Charging Station Local Permitting Policies
All cities and counties, including charter cities, must adopt an ordinance that creates an expedited and streamlined permitting process for EV charging stations. Cities and counties must approve applications to install EV charging stations within five to ten business days, depending on the number of stations proposed in the application. Applications will be approved after 20 to 40 business days, if the county or city does not approve the application, the building official does not deny the application, or the city or county does not submit an appeal. Each city or county must consult with the local fire department or district and the utility director to develop the ordinance, which must include a checklist of all requirements for EV charging stations to be eligible for expedited review. A complete application that is consistent with the city or county ordinance must be approved, and entities submitting incomplete applications must be notified of the necessary required information to be granted expedited permit issuance. Beginning January 1, 2022, these provisions apply to cities and counties with populations above 200,000 residents. Beginning January 1, 2022, these provisions apply to cities and counties with populations less than 200,000 residents.

(Reference California Government Code 65850.7 (http://www.oal.ca.gov/) and Assembly Bill 970, 2021 (https://leginfo.legislature.ca.gov/faces/home.xhtml))

Light-Duty Zero Emission Vehicle (ZEV) Sales Requirement
All sales of new light-duty passenger vehicles in California must be ZEVs by 2035. ZEVs include battery-electric and fuel cell electric vehicles. The California Air Resources Board (CARB) will develop regulations related to in-state sales of new light-duty cars and trucks. CARB developed a ZEV Market Development Strategy (https://static.business.ca.gov/wp-content/uploads/2021/02/ZEV_Strategy_Feb2021.pdf) to support these regulations and assess statewide ZEV infrastructure. The Strategy will be updated triennially.

(Reference Executive Order N-79-20 (https://www.gov.ca.gov/category/executive-orders/))

Low Emission Vehicle (LEV) Standards

California's LEV II exhaust emissions standards apply to Model Year (MY) 2004 and subsequent model year passenger cars, light-duty trucks, and medium-duty passenger vehicles meeting specified exhaust standards. The LEV II standards represent the maximum exhaust emissions for LEVs, Ultra LEVs, and Super Ultra LEVs, including flexible fuel, bi-fuel, and dual-fuel vehicles when operating on an alternative fuel. MY 2009 and subsequent model year passenger cars, light-duty trucks, and medium-duty passenger vehicles must meet specified fleet average greenhouse gas (GHG) exhaust emissions requirements. Each manufacturer must comply with these fleet average GHG requirements, which are based on California Air Resources Board (CARB) calculations. Bi-fuel, flexible fuel, dual-fuel, and grid-connected hybrid electric vehicles may be eligible for an alternative compliance method.

In December 2012, CARB finalized regulatory requirements, referred to as LEV III, which allow vehicle manufacturer compliance with the U.S. Environmental Protection Agency's GHG requirements for MY 2017-2025 to serve as compliance with California's adopted GHG emissions requirements for those same model years.

In November 2022, CARB approved LEV IV standards, which updates regulations for light- and medium-duty internal combustion engine vehicles by reducing allowable exhaust emissions and emissions caused by evaporation. LEV IV also changes the calculation procedure for new vehicle fleet-average emissions and prohibits zero emissions vehicles from being considered in fleet-average emissions calculations by MY 2029.

For more information, see the CARB LEV (https://ww2.arb.ca.gov/our-work/programs/low-emission-vehicle-program) website for more information.

(Reference California Code of Regulations Title 13, Section 1961-1961.3 (http://www.oal.ca.gov/))

Mandatory Electric Vehicle (EV) Charging Station Building Standards
The California Building Standards Commission (CBSC) published mandatory building standards requiring pre-wiring for EV charging station installation in parking spaces at one- and two-family dwellings with attached private garages, multi-family dwellings, commercial facilities, and public buildings in the California Green Building Standards Code within the California Building Standards Code.

New one- and two-unit single family dwellings or townhouses with attached private garages must have electrical conduit installed that is capable of supporting a Level 2 EV charging station. For new multifamily dwellings and hotels, 10% of parking spaces must be EV-capable and 25% of parking spaces must be EV-ready. New multifamily dwellings and hotels with more than 20 units must install Level 2 EV charging stations at 5% of all parking spaces.

For public parking facilities, minimum EV charging station prewiring installation requirements are based on the number of parking spaces, per parking facility, as follows:

Total Actual Parking Spaces	Required EV-Capable Parking Spaces
0 to 9	2
10 to 25	5
26 to 50	11
51 to 75	19
76 to 100	26
101 to 151	38
151 to 200	53
201 and over	30% of total parking spaces

Public facilities must also install handicap-accessible EV charging stations when installing new or additional EV charging stations. Minimum accessible EV charging station installation requirements, per parking facility, are as follows:

Total EV Charging Stations	Van Accessible EV Charging Stations	Standard Accessible EV Charging Stations	Ambulatory Accessible EV Charging Stations
1 to 4	1	0	0
5 to 25	1	1	0
26 to 50	1	1	1
51 to 75	1	2	2
76 to 100	1	3	3
101 and over	1, plus 1 for each 300, or fraction thereof, over 100	3, plus 1 for each 60, or fraction thereof, over 100	3, plus 1 for each 50, or fraction thereof, over 100

In cases in which EV charging stations can simultaneously charge more than one vehicle, the number of EV charging stations provided shall be considered equivalent to the number of EVs that can be simultaneously charged.

Beginning January 1, 2023, CBSC must convene a workshop to evaluate demand for EV charging infrastructure, electric load forecasts, and statewide transportation electrification goals and use the workshop's findings to recommend updates to EV charging station building standards. The workshop must convene and propose recommendations on a triennial basis. CBSC must also publish guidance and best practices for installing EV charging stations.

Additional requirements may apply. For more information, including exemptions and additional regulations, see the CBSC (http://www.bsc.ca.gov/Codes.aspx) website.

(Reference California Health and Safety Code 18941.10 and 18941.11 (http://www.oal.ca.gov/), California Building Code Chapter 2 (http://www.oal.ca.gov/), and California Green Building Standards Title 24, Part 11 (http://www.oal.ca.gov/))

Medium- and Heavy-Duty (MHD) Fleet Vehicle Data Collection and Planning
The California Energy Commission (CEC) in collaboration with the California Air Resources Board (CARB) and the California Public Utilities Commission (CPUC) must collect state agency fleet data for MHD on- and off-road vehicles. Fleet data must include vehicle fuel types, fleet address, and current and future vehicle charging needs. The CEC must share this data with the PUC and electric utilities to inform electrical grid planning efforts.

(Reference Assembly Bill 2700, 2022 (https://leginfo.legislature.ca.gov/faces/home.xhtml))

Medium- and Heavy-Duty (MHD) Zero Emission Vehicle (ZEV) Deployment Support
California, Colorado, Connecticut, District of Columbia, Hawaii, Maine, Maryland, Massachusetts, Nevada, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Rhode Island, Vermont, Virginia, and Washington (signatory states) signed a memorandum of understanding (https://www.nescaum.org/documents/mhdv-zev-mou-20220329.pdf/) (MOU) to support the deployment of medium- and heavy-duty (MHD) ZEVs through involvement in a Multi-State ZEV Task Force (Task Force).

In July 2022, the Task Force published a multi-state action plan (https://www.nescaum.org/documents/multi-state-medium-and-heavy-duty-zev-action-plan.pdf) to support electrification of MHD vehicles. The action plan includes strategies and recommendations to accomplish the goals of the MOU, including limiting all new MHD vehicle sales in the signatory states to ZEVs by 2050, accelerating the deployment of MHD ZEVs, and ensuring MHD ZEV deployment also benefits disadvantaged communities.

For more information, see the Medium- and Heavy-Duty ZEVs: Action Plan Development Process (https://www-f.nescaum.org/documents/multi-state-medium-and-heavy-duty-zero-emission-vehicle-action-plan/) website.

Medium- and Heavy-Duty Zero Emission Vehicle (ZEV) Requirement
The California Air Resources Board's (ARB) Advanced Clean Truck Program requires all new medium- and heavy-duty vehicles sold in California to be a ZEV by 2045. Zero-emission technologies include all-electric and fuel cell electric vehicles. Beginning in 2024, manufacturers seeking ARB certification for Class 2b through Class 8 chassis or complete vehicles with combustion engines will be required to sell zero-emission trucks as an increasing percentage of their annual California sales. Manufacturers must achieve the following annual sales percentages for medium- and heavy-duty ZEVs sold in California:

	ZEV Sales Percentages		
Vehicle Model Year (MY)	Class 2b-3	Class 4-8	Class 7-8 Tractors
2024	5%	9%	5%
2025	7%	11%	7%
2026	10%	13%	10%
2027	15%	20%	15%
2028	20%	30%	20%
2029	25%	40%	25%
2030	30%	50%	30%
2031	35%	55%	35%
2032	40%	60%	40%
2033	45%	65%	40%
2034	50%	70%	40%
2035 and future years	55%	75%	40%

*Excludes pickup trucks for 2024-2026 MYs

Additionally, entities with annual gross revenues greater than $50 million, fleet owners with 50 or more medium- and heavy-duty vehicles, and any California government or federal agency with one or more vehicles over 8,500 pounds must report their existing fleet operations to ensure fleets are purchasing and placing zero-emission trucks in the correct service locations.

For more information, including additional requirements and exemptions, see the ARB Advanced Clean Trucks Program (https://ww2.arb.ca.gov/our-work/programs/advanced-clean-trucks) website.

(Reference California Code of Regulations Title 13, Sections 1963-1963.5 and 2012-2012.2 (https://oal.ca.gov/))

Mobile Source Emissions Reduction Requirements
Through its Mobile Sources Program, the California Air Resources Board (CARB) has developed programs and policies to reduce emissions from on-road heavy-duty diesel vehicles through the installation of verified diesel emission control strategies (VDECS) and vehicle replacements.

The on-road heavy-duty diesel vehicle rule (http://www.arb.ca.gov/msprog/onrdiesel/onrdiesel.htm) (i.e., truck and bus regulation) requires the retrofit and replacement of nearly all privately owned vehicles operated in California with a gross vehicle weight rating (GVWR) greater than 14,000 pounds (lbs.). School buses owned by private and public entities and federal government owned vehicles are also included in the scope of the rule. By January 1, 2023, nearly all vehicles must have engines certified to the 2010 engine standard or equivalent. The drayage truck rule (http://www.arb.ca.gov/msprog/onroad/porttruck/porttruck.htm) regulates heavy-duty diesel-fueled vehicles that transport cargo to and from California's ports and intermodal rail facilities. The rule requires that certain drayage trucks be equipped with VDECS and that all applicable vehicles have engines certified to the 2007 emissions standards. By January 1, 2023, all applicable vehicles must have engines certified to 2010 standards. The solid waste collection vehicle rule (http://www.arb.ca.gov/msprog/swcv/swcv.htm) regulates solid waste collection vehicles with a gross vehicle weight rating of 14,000 lbs. or more that operate on diesel fuel, have 1960 through 2006 engine models, and collect waste for a fee. The fleet rule for public agencies and utilities (https://ww3.arb.ca.gov/msprog/publicfleets/publicfleets.htm) requires fleets to install VDECS on vehicles or purchase vehicles that run on alternative fuels or use advanced technologies to achieve emissions requirements by specified implementation dates.

(Reference California Code of Regulations Title 13, 2021-2027 (http://www.oal.ca.gov/))

Point of Contact
Moyer Help
California Air Resources Board
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Public Utility Definition
A corporation or individual that owns, controls, operates, or manages a facility that supplies electricity to the public exclusively to charge light-, medium-, and heavy-duty all-electric and plug-in hybrid electric vehicles, compressed natural gas to fuel natural gas vehicles, or hydrogen as a motor vehicle fuel is not defined as a public utility.

(Reference California Public Utilities Code 216 (http://www.oal.ca.gov/) and California Public Utilities Decision 20-09-025, 2020 (https://leginfo.legislature.ca.gov/faces/home.xhtml))

State Agency Low Carbon Fuel Use Requirement
At least 3% of the aggregate amount of bulk transportation fuel purchased by the state government must be from very low carbon transportation fuel sources. The required amount of very low carbon transportation fuel purchased will increase by 1% annually until January 1, 2024. Some exemptions may apply, as determined by the California Department of General Services (DGS). Very low carbon fuel is defined as a transportation fuel having no greater than 40% of the carbon intensity of the closest comparable petroleum fuel for that year, as measured by the methodology in California Code of Regulations (http://www.oal.ca.gov/) Title 17, Sections 95480-95486. DGS will submit an annual progress report to the California Legislature.

(Reference California Code of Regulations Title 17, Section 95480-95486 (http://www.oal.ca.gov/))

State Transportation Plan
The California Department of Transportation (Caltrans) must publish a California Transportation Plan (Plan) every five years, beginning December 31, 2015. The Plan must address how the state will achieve maximum feasible emissions reductions, taking into consideration the use of alternative fuels, new vehicle technology, and tailpipe emissions reductions. Caltrans must consult and coordinate with related state agencies, air quality management districts, public transit operators, and regional transportation planning agencies. Caltrans must also provide an opportunity for public input. Caltrans must submit a final draft of the Plan to the legislature and governor. A copy of the 2020 report is available on the Caltrans (https://dot.ca.gov/programs/transportation-planning/division-of-transportation-planning/state-planning-equity-and-engagement/california-transportation-plan) website. Caltrans must also review the Plan and prepare a report for the legislature and governor that includes actionable, programmatic transportation system improvement recommendations every five years.

(Reference California Government Code 65070-65073 (http://www.oal.ca.gov/))

Utility Transportation Electrification Cost Recovery Regulations
The California Public Utilities Commission must approve or modify utility transportation electrification programs, including those that deploy electric vehicle (EV) charging stations, through a reasonable cost recovery mechanism that does not unfairly compete with nonutility enterprises. At least 35% of the investments must be in underserved communities.

Utilities must file a new tariff to design and deploy all electrical distribution infrastructure on the utility side of the customer meter, for all customers installing a separately metered, to be recovered as other distribution infrastructure authorized on an ongoing basis in the utility's general rate case of EV charging station.

(Reference California Public Utilities Code 740.19 (https://leginfo.legislature.ca.gov/faces/home.xhtml))

Vehicle Acquisition and Petroleum Reduction Requirements
The California Department of General Services (DGS) is responsible for maintaining specifications and standards for passenger cars and light-duty trucks that are purchased or leased for state office, agency, and department use. These specifications include minimum vehicle emissions standards and encourage the purchase or lease of fuel-efficient and alternative fuel vehicles (AFVs). Specifically, DGS must reduce or displace the fleet's consumption of petroleum products by 20% by January 1, 2020, as compared to the 2003 consumption level. DGS must also ensure that at least 50% of the light-duty vehicles purchased by the state are zero emission vehicles (ZEVs). Further, at least 15% of DGS' fleet of new vehicles with a gross vehicle weight rating of 19,000 pounds or more must be ZEVs by 2025, and at least 30% by 2030.

On an annual basis, DGS must compile information including, but not limited to, the number of AFVs and hybrid electric vehicles acquired, the locations of the alternative fuel pumps available for those vehicles, and the total amount of alternative fuels used. Vehicles the state owns or leases that are capable of operating on alternative fuel must operate on that fuel unless the alternative fuel is not available. DGS is also required to:

- Take steps to transfer vehicles between agencies and departments to ensure that the most fuel-efficient vehicles are used and to eliminate the least fuel-efficient vehicles from the state's motor vehicle fleet;

- Submit annual progress reports to the California Department of Finance, related legislative committees, and the general public via the DGS (https://www.dgs.ca.gov/OFAM/Services/Page-Content/Office-of-Fleet-and-Asset-Management-Services-List-Folder/Report-your-Vehicle-Data?search=alternative%20fuel%20vehicles) website;
- Encourage other agencies to operate AFVs on the alternative fuel for which they are designed, to the extent feasible;
- Encourage the development of commercial fueling infrastructure at or near state vehicle fueling or parking sites;
- Work with other agencies to incentivize and promote state employee use of AFVs through preferential or reduced-cost parking, access to electric vehicle charging, or other means, to the extent feasible; and
- Establish a more stringent fuel economy standard than the 2007 standard.

Beginning January 1, 2024, DGS must develop criteria to evaluate commercial car rental service contracts based on the number of ZEVs or PHEVs available in the service's fleet.

(Reference California Public Resources Code 25722.5-25722.11, and 25724 (http://www.oal.ca.gov/))

Volkswagen (VW) Zero Emission Vehicle (ZEV) Investment Plan
The California Air Resources Board (CARB) approved the VW California ZEV Investment Plan. As required by the October 2016 2.0-Liter Partial Consent Decree, VW must invest $800 million over ten years to support the increased adoption of ZEV technology in California. VW will submit a series of four 30-month cycle ZEV investment plans to CARB for approval. CARB has approved the Cycle 2 plan, covering July 2019 through December 2021. The Cycle 2 plan includes building a basic charging network, public outreach, education, and marketing, and ZEV access projects. ZEV infrastructure rollouts will be focused in nine metropolitan areas. VW will continue access efforts in Sacramento, with the goal of offering residents a better quality of life through enhanced mobility and improved air quality.

For more information, see the Electrify America Investment Plan (https://www.electrifyamerica.com/our-plan) website and CARB's VW Settlement (https://www.arb.ca.gov/msprog/vw_info/vsi/vw-zevinvest/vw-zevinvest.htm) website.

Zero Electric Vehicle (ZEV) Office Authorization and Equity Assessment
The California legislature established the ZEV Market Development Office (Office) is established within the Governor's Office of Business and Economic Development to serve as a point of contact for stakeholders to provide feedback on California's ZEV goals and to direct the equitable deployment of light-, medium-, and heavy-duty ZEVs, supporting infrastructure, and ZEV workforce development. The Office must also create an equity action plan as part of the ZEV Market Development Strategy (https://static.business.ca.gov/wp-content/uploads/2021/02/ZEV_Strategy_Feb2021.pdf). The action plan must include recommendations to:

- Improve access to ZEVs, supporting infrastructure, and ZEV transportation options in low-income, disadvantaged, and underserved communities; and,
- Reduce pollution from transportation in low-income, disadvantaged, and underserved communities; and,
- Support the ZEV industry and workforce in California.

The Office must track state progress toward achieving recommendations included in the equity action plan.

(Reference California Government Code 12100.150) (http://www.oal.ca.gov/))

Zero Emission School Bus Acquisition Requirements
Beginning January 1, 2035, school districts may only purchase or lease zero emission school buses. Exemptions may apply if zero emission school bus use is not feasible due to terrain or route constraints.

(Reference Assembly Bill 579, 2023 (https://leginfo.legislature.ca.gov/faces/home.xhtml))

Zero Emission Transit Bus Incentive Assessment
The California Legislative Analyst's Office must submit a report to the legislature on the effectiveness of the Zero Emission Transit Bus Tax Exemption (https://afdc.energy.gov/laws/12309) by May 1, 2024. The report must consider the annual number of zero emission transit bus purchases by transit authorities and agencies and the number of zero emission transit bus purchases made in advance of the Innovative Clean Transit (https://afdc.energy.gov/laws/12257) regulation deadlines.

(Reference California Revenue and taxation Code 6377 (http://www.oal.ca.gov/))

Zero Emission Transit Incentive Program Authorization
The California State Transportation Agency (CalSTA) is authorized to establish the Zero-Emission Transit Capital Program to provide funding for zero-emission transit equipment, including zero emission vehicles and infrastructure. By October 31, 2025, and annually thereafter, funding recipients must submit a report to CalSTA on how funds were utilized. For more information, see the CalSTA SB 125 Transit Program (https://calsta.ca.gov/subject-areas/sb125-transit-program) website.

(Reference Senate Bill 775, 2023 (https://leginfo.legislature.ca.gov/faces/home.xhtml))

Zero Emission Transportation System Support
Private, nonprofit entities that provide services to zero emission transportation may enter into a joint power agreement with a public agency to facilitate the development of a zero-emission transportation system. The system must reduce greenhouse gas emissions, reduce vehicle congestion and vehicle miles traveled, and improve public transit options.

(Reference Senate Bill 1226, 2022 (http://leginfo.legislature.ca.gov/faces/home.xhtml) and California Government Code 6538 (https://leginfo.legislature.ca.gov/faces/codes.xhtml))

Zero Emission Vehicle (ZEV) Deployment Support
California joined Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont in signing a memorandum of understanding (https://www.nescaum.org/documents/zev-mou-10-governors-signed-20191120.pdf/) (MOU) to support the deployment of ZEVs through involvement in a ZEV Program Implementation Task Force (Task Force). In May 2014, the Task Force published a ZEV Action Plan (https://www.nescaum.org/documents/multi-state-zev-action-plan.pdf) (Plan) identifying 11 priority actions to

accomplish the goals of the MOU, including deploying at least 3.3 million ZEVs and adequate fueling infrastructure within the signatory states by 2025. The Plan also includes a research agenda to inform future actions. On an annual basis, each state must report on the number of registered ZEVs, the number of public electric vehicle (EV) charging stations and hydrogen fueling stations, and available information regarding workplace fueling for ZEVs.

In June 2018, the Task Force published a new ZEV Action Plan (https://www.nescaum.org/documents/2018-zev-action-plan.pdf) for 2018-2021. Building on the 2014 Action Plan, the 2018 Action Plan makes recommendations for states and other key partners in five priority areas:

- Raising consumer awareness and interest in electric vehicle technology;
- Building out a reliable and convenient residential, workplace and public charging/fueling infrastructure network;
- Continuing and improving access to consumer purchase and non-financial incentives;
- Expanding public and private sector fleet adoption; and
- Supporting dealership efforts to increase ZEV sales.

For more information, see the Multi-State ZEV Task Force (https://www-f.nescaum.org/documents/multi-state-medium-and-heavy-duty-zero-emission-vehicle-action-plan) website.

Zero Emission Vehicle (ZEV) Fee
ZEV owners must pay an annual road improvement fee of $100 upon vehicle registration or registration renewal for ZEVs model year 2020 and later. The California Department of Motor Vehicles will increase the fee annually to account for inflation, equal to the increase in the California Consumer Price Index for the prior year.

(Reference California Vehicle Code 9250.6 (https://leginfo.legislature.ca.gov/faces/home.xhtml))

Zero Emission Vehicle (ZEV) Infrastructure Fee Structure Assessment
By January 1, 2026, California Energy Commission, California Air Resources Board, and California Department of Motor Vehicles must assess the economic equity of fee structures for ZEV and propose to the Legislature alternative fee structures for funding ZEV infrastructure.

(Reference Assembly Bill 126, 2023 (https://leginfo.legislature.ca.gov/faces/home.xhtml))

Zero Emission Vehicle (ZEV) Initiative
The California Air Resources Board's (CARB) Charge Ahead California Initiative was established to help place into service at least 1 million ZEVs and near-zero emission vehicles in California by January 1, 2023. In consultation with the State Energy Resources Conservation and Development Commission, CARB prepared a funding plan (https://ww2.arb.ca.gov/sites/default/files/2019-09/fy1920fundingplan.pdf) that includes a market and technology assessment, assessments of existing zero and near-zero emission funding programs, and programs that increase access to disadvantaged, low-income, and moderate-income communities and consumers. Potential programs under the initiative include those involving innovative financing, car sharing, charging infrastructure in multi-unit dwellings located in disadvantaged communities, public transit, and agricultural vanpool programs. The funding plan must be updated at least every three years through January 1, 2023.

(Reference California Health and Safety Code 44258.4 (http://www.oal.ca.gov/))

Zero Emission Vehicle (ZEV) Production Requirements
The California Air Resources Board (CARB) certifies new passenger cars, light-duty trucks, and medium-duty passenger vehicles as ZEVs if the vehicles produce zero exhaust emissions of any criteria pollutant (or precursor pollutant) under all possible operational modes and conditions. Manufacturers with annual sales between 4,501 and 60,000 vehicles may comply with the ZEV requirements through multiple alternative compliance options that include producing low emission vehicles and obtaining ZEV credits. Manufacturers with annual sales of 4,500 vehicles or less are not subject to this regulation.

CARB's emissions control program for model year (MY) 2017 through 2025 combines the control of smog, soot, and greenhouse gases (GHGs) and requirements for ZEVs into a single package of standards called Advanced Clean Cars (ACC). In December 2012, CARB finalized new regulatory requirements that allow vehicle manufacturer compliance with the U.S. Environmental Protection Agency's (EPA) GHG requirements for MY 2017 through 2025 to serve as compliance with California's adopted GHG emissions requirements for those same model years.

The accounting procedures for MY 2018 through 2025 are based on a credit system as shown in the table below. The minimum ZEV requirement for each manufacturer includes the percentage of passenger cars and light-duty trucks produced by the manufacturer and delivered for sale in California. The regulation also includes opportunities for compliance with transitional ZEVs, which must demonstrate certain exhaust emissions standards, evaporative emissions standards, on-board diagnostic requirements, and extended warranties.

MY	ZEV Requirement
2021	12%
2022	14.5%
2023	17%
2024	19.5%
2025 and later	22%

In November 2022, CARB finalized another rule in addition to the ACC emissions control program for MY 2026 through 2035 called Advanced Clean Cars II (ACCII), requiring an increasing percentage of ZEVs in new vehicle sales beyond MY 2025. ZEV sales requirements under ACCII are shown in the table below.

MY	ZEV Requirement
2026	35%
2027	43%
2028	51%
2029	59%
2030	68%
20231	76%
2032	82%
2033	88%
2034	94%
2035 and later	100%

For more information, see the CARB ZEV Program (http://www.arb.ca.gov/msprog/zevprog/zevprog.htm) website.

(Reference California Code of Regulations Title 13, Section 1962 -1962.2 and 1962.4 (http://www.oal.ca.gov/))

Zero Emission Vehicle (ZEV) Promotion Plan
All California state agencies must support and facilitate the rapid commercialization of ZEVs in California. In particular, the Air Resources Board, Energy Commission (CEC), Public Utilities Commission, and other relevant state agencies must work with the private sector to establish benchmarks to achieve targets for ZEV commercialization and deployment. These targets include:

- By 2020, the state will have established adequate infrastructure to support one million ZEVs;
- By 2025, there will be 1.5 million ZEVs on the road in California and clean, efficient vehicles will displace 1.5 billion gallons of petroleum fuels annually;
- By 2025, there will be 200 hydrogen fueling stations and 250,000 electric vehicle (EV) chargers, including 10,000 direct current fast chargers, in California;
- By 2030, there will be 5 million ZEVs on the road in California; and
- By 2050, greenhouse gas emissions from the transportation sector will be 80% less than 1990 levels.

State agencies must also work with their stakeholders to accomplish the following:
- Develop new criteria for clean vehicle incentive programs to encourage manufacturers to produce clean, affordable cars;
- Update the 2016 ZEV Action plan, with a focus on low income and disadvantaged communities;
- Recommend actions to increase the deployment of ZEV infrastructure through the Low Carbon Fuel Standard;
- Support and recommend policies that will facilitate the installation of EV infrastructure in homes and businesses; and
- Ensure EV charging and hydrogen fueling are affordable and accessible to all drivers.

The ZEV promotion plan additionally directs the state fleet to increase the number of ZEVs in the fleet through gradual vehicle replacement. By 2020, ZEVs should make up at least 25% of the fleet's light-duty vehicles. Vehicles with special performance requirements necessary for public safety and welfare are exempt from this requirement. For more information about the plan, see CEC's ZEVs and Infrastructure Update (https://www.energy.ca.gov/data-reports/energy-insights/zero-emission-vehicle-and-charger-statistics).

(Reference Executive Order B-16, 2012 (https://www.gov.ca.gov/category/executive-orders/), Executive Order B-48, 2018 (https://www.gov.ca.gov/category/executive-orders/), and Executive Orders N-19-19, 2019 (https://www.gov.ca.gov/category/executive-orders/))

Zero Emission Vehicle (ZEV) and Infrastructure Support
The California Energy Resources Conservation and Development Commission must provide technical assistance and support for the development of zero-emission fuels, fueling infrastructure, and fuel transportation technologies. Technical assistance and support may include the creation of research, development, and demonstration programs.

(Reference California Public Resources Code 25617 (https://leginfo.legislature.ca.gov/faces/home.xhtml))

Zero-Emission Airport Shuttle Requirement
By 2035, all airport fixed-route shuttle fleets must transition to 100% zero-emission vehicles (ZEVs). Zero-emission shuttle technologies include battery-electric or fuel cell electric technologies. Starting in 2022, shuttle fleets must report the details of their vehicles to the California Air Resources Board (CARB). Starting in 2023, if fleets replace a ZEV shuttle, the replacement must be a ZEV. For additional terms and conditions, see CARB's Zero-Emission Airport Shuttle (https://ww2.arb.ca.gov/our-work/programs/zero-emission-airport-shuttle) website.

(Reference Resolution Number 19-8, 2019 (http://www.oal.ca.gov/))

Zero-Emission Freight Assessment
The California Transportation Commission (CTC), along with other state agencies, must develop a Clean Freight Corridor Efficiency Assessment. As part of the assessment, the CTC must establish an advisory committee, made up of industry representatives and public and private freight stakeholders. The assessment must:

- Identify and designate priority freight corridors for the deployment of zero emission medium- and heavy-duty (MHD) vehicles and associated infrastructure;
- Identify projects to further state goals for zero emission freight and potential sponsors of projects;
- Identify barriers and potential solutions to deploying zero emission MHD vehicles; and,
- Assess impacts on existing infrastructure, potential funding opportunities, and benefits from deploying zero emission MHD vehicles.

By December 1, 2023, the CTC must submit a report containing the assessment's findings and recommendations to the Legislature. Findings from the assessment must be incorporated into the California Transportation Plan (https://dot.ca.gov/programs/transportation-planning/division-of-transportation-planning/state-planning-equity-and-engagement/california-transportation-plan).

(Reference California Government Code 14517 and 65072.5 (http://www.oal.ca.gov/))

Zero-Emission Transit Bus Requirement
By 2040, all public transit agencies must transition to 100% zero-emission bus fleets. Zero-emission bus technologies include battery-electric or fuel cell electric. Transit agencies must purchase or operate a minimum number of zero-emission buses according to the following schedules:

	Large Transit Agency	Small Transit Agency
January 1, 2023	25% of the total number of new bus purchases in each calendar year must be zero-emission buses	No requirement
January 1, 2026	50% of the total number of new bus purchases in each calendar year must be zero-emission buses	25% of the total number of new bus purchases in each calendar year must be zero-emission buses
January 1, 2029	All new bus purchases must be zero-emission buses	All new bus purchases must be zero-emission buses

Each transit agency will submit a plan demonstrating how it will purchase clean buses, develop infrastructure, train personnel, and other required details. Large transit agencies must submit a plan in 2020 and small agencies must submit a plan in 2023. Additional rules and requirements apply.

For more information, including definitions of large and small transit agencies and additional terms and conditions, see the California Air Resources Board's Innovative Clean Transit (https://ww3.arb.ca.gov/msprog/ict/ict.htm) website.

(Reference California Code of Regulations Title 13, Section 2023.1 (http://www.oal.ca.gov/))

Zero-Emission Vehicle (ZEV) Requirements for Transportation Network Companies (TNC)
The California Air Resource Board (CARB) and the California Public Utilities Commission must develop and implement new requirements for reducing the greenhouse gas emissions (GHGs) from TNCs. By January 1, 2021, CARB must adopt annual goals requiring TNCs to phase in ZEVs by 2023 and achieving at least 90% of the miles driven by TNCs by ZEVs by 2030. By January 1, 2022, each TNC must develop a GHG emission reduction plan. For more information, see the California Clean Miles Standard (https://ww2.arb.ca.gov/our-work/programs/clean-miles-standard/about) website.

(Reference California Health and Safety Code 44274.4 (http://www.oal.ca.gov/) and California Public Utilities Code Section 5431 and 5450 (http://leginfo.legislature.ca.gov/faces/home.xhtml))

Zero-Emission and Autonomous Vehicle Infrastructure Support
Cities and counties that receive funding from the Road Maintenance and Rehabilitation Program are encouraged to use funds towards advanced transportation technologies and communication systems, including, but not limited to, zero-emission vehicle fueling infrastructure and infrastructure-to-vehicle communications for autonomous vehicles.

(Reference California Streets and Highways Code 2030 (http://leginfo.legislature.ca.gov/faces/home.xhtml))

Utility / Private Incentives

Pre-Owned Electric Vehicle (EV) Rebates – Pacific Gas and Electric (PG&E)
PG&E offers residential customers a rebate of $1,000 for the purchase of a pre-owned EV. Low-income residents are eligible for a rebate of up to $4,000. Additional terms and conditions apply. For more information, see the PG&E Drive Forward Electric (https://evrebates.pge.com/program-requirements) website.

Agricultural Equipment Electrification Grant - Central Coast Community Energy (CCCE)
CCCE offers grants to replace heavy-duty agricultural vehicles with all-electric equipment. Costumers are eligible for incentives up to 50 to 70% of the total project cost, up to $75,000. Funding is available on a first-come, first-served basis. For more information, see the CCCE Ag Electrification Program (https://3cenergy.org/ag-electrification-program/) website.

Commercial Electric Vehicle (EV) Charging Station Rebate - Pasadena Water and Power (PWP)
PWP offers rebates of $3,000 per port for commercial, workplace, multi-unit dwelling (MUD), and fleet customers for the installation of networked Level 2 EV charging stations, or rebates of $1,500 per port for non-networked Level 2 EV charging stations. PWP also offers rebates of $6,000 for the installation of direct current fast charging (DCFC) stations or Level 2 EV charging stations installed at select sites, including disadvantaged communities. Additional terms and conditions apply. For more information, including how to apply, see the PWP Commercial EV and Charger Incentive Program (https://ww5.cityofpasadena.net/water-and-power/commercialchargerrebate/) website.

Commercial Electric Vehicle (EV) and EV Charging Station Rebates - TID
Turlock Irrigation District (TID) offers commercial customers a rebate for the purchase or lease of a qualifying new or pre-owned EV. Rebates are available in the following amounts:

Vehicle Category	Maximum Rebate Amount
Light-Duty	$500
Medium-Duty	$1,500
Heavy-Duty	$5,000

School Bus	$5,000

TID also offers commercial customers rebates of up to $1,000 for the purchase of Level 2 EV charging stations and $20,000 for the purchase of direct current fast charging (DCFC) stations. Customers installing Level 2 EV charging stations may also be eligible for a rebate of up to $6,000 for qualifying installation costs. Up to ten rebates may be claimed for EVs and EV charging stations per commercial account, respectively. For more information, including vehicle category details and eligibility requirements, see the TID Commercial EV Rebates (https://www.tid.org/customer-service/save-energy-money/rebates/commercial-ev/) website.

Electric School Bus Grant - Central Coast Community Energy (CCCE)
CCCE offers grants to school districts for the purchase of an electric school bus. Grants may cover up to 50% of the cost of an electric school bus, up to $200,000. For more information, see the CCCE Electric School Bus Program (https://3cenergy.org/rebates/electric-bus-program/) website.

Electric Vehicle (EV) Charging Rate Incentive – Glendale Water and Power (GWP)
GWP offers a monthly incentive of $12 for customers who charge their EV during off-peak hours. Incentives are distributed annually. For more information, see the GWP Off-Peak EV Charging Rebate (https://www.bringyourowncharger.com/gwp-home) website.

Electric Vehicle (EV) Charging Rate Reduction - Azusa Light & Water
Azusa Light & Water offers a $0.05 per kilowatt-hour (kWh) discount for electricity used to charge EVs during off peak times. Customers must use a minimum of 50 kWh to receive the discount. For more information, see the Azusa Light & Water Schedule EV (https://www.ci.azusa.ca.us/1191/Schedule-EV) website.

Electric Vehicle (EV) Charging Rate Reduction - SCE
Southern California Edison (SCE) offers a discounted electricity rate to customers that own or lease an EV. Two rate schedules are available for EV charging during on- and off-peak hours. For more information, see the SCE EV Plans (https://www.sce.com/residential/rates/electric-vehicle-plans) website.

Electric Vehicle (EV) Charging Rate Reduction - SMUD
The Sacramento Municipal Utility District (SMUD) offers a discounted rate to residential customers for electricity used to charge EVs. For more information, see the SMUD Rate Details (https://www.smud.org/en/Rate-Information/Time-of-Day-rates/Time-of-Day-5-8pm-Rate/Rate-details#EVdiscount) website.

Electric Vehicle (EV) Charging Station Incentive – SDG&E
The San Diego Gas & Electric (SDG&E) Power Your Drive for Fleets program installs or incentivizes medium- and heavy-duty EV charging stations for commercial customers. Customers may apply for a no-cost installation by SDG&E, with SDG&E owning the infrastructure up to the charging station, or customers may apply for rebate of up to 80% the cost of installing the infrastructure from the meter to the charging station. Additionally, transit agencies, school districts, and some private fleets in disadvantaged communities are eligible for a rebate up to 50% the cost of the charger purchase. For more information, including eligibility and additional program details, see the SDG&E Power Your Drive for Fleets (https://www.sdge.com/business/electric-vehicles/power-your-drive-for-fleets#overview) website.

Electric Vehicle (EV) Charging Station Incentives for Medium- and Heavy-Duty Fleets - PG&E
Pacific Gas & Electric's (PG&E) EV Fleet Program offers competitive incentives to facilitate the installation of EV charging stations for medium- and heavy-duty vehicle fleets. PG&E offers dedicated electrical infrastructure design and construction services and reduced costs for electrical infrastructure work. Eligible entities include schools, transit agencies, and disadvantaged communities. Rebates are available in the following amounts:

EV Charging Station Power Output	Maximum Rebate Amount
Up to 50 kilowatt (kW)	50% of the purchase price, up to $15,000
50.1 kW to 150 kW	50% of the purchase price, up to $25,000
150.1 kW and above	50% of the purchase price, up to $42,000

Additional terms and conditions apply. For more information, see the PG&E EV Fleet Program (https://www.pge.com/en_US/large-business/solar-and-vehicles/clean-vehicles/ev-fleet-program/ev-fleet-program.page?WT.mc_id=Vanity_evfleet) website.

Electric Vehicle (EV) Charging Station Rebate - Alameda Municipal Power (AMP)
AMP provides rebates to residential, commercial, and multifamily customers for the purchase of Level 2 EV charging stations. Rebates are available in the following amounts:

Applicant Type	Rebate Amount	Maximum Number of Rebates per Applicant
Residential	$500	1
Commercial	$6,000	6
Multifamily	$8,000	6

Commercial customers are also eligible for a $500 rebate for every additional port, up to $3,000. Customers may apply for multiple rebates at a time. Additional terms and conditions apply. For more information, see the AMP EVs (https://www.alamedamp.com/349/Electric-Vehicles) website.

Electric Vehicle (EV) Charging Station Rebate - Azusa Light & Water
Azusa Light & Water offers a $150 rebate to customers for the purchase of an ENERGY STAR certified Level 2 EV charging station. For more information, see Azusa's EVs (https://www.ci.azusa.ca.us/1625/Plug-In-Electric-Vehicles) website.

Electric Vehicle (EV) Charging Station Rebate - Burbank Water and Power (BWP)

BWP provides rebates to commercial and residential customers toward the purchase of Level 2 EV charging stations. Residential customers may receive a rebate of up to $500 to purchase and install a Level 2 charging station. Commercial or multi-unit dwelling customers may receive up to $15,000 for the purchase and installation of Level 2 or direct current fast charging (DCFC) stations.

Residential customers who install a charger can receive up to $500 and will be placed on BWP's time-of-use rate. Applications must be submitted no later than six months from the date of purchase for commercial customers, and no later than four months for residential customers. Residential customers may receive an additional $750 rebate for an electric panel upgrade.

Rebates are available on a first-come, first-served basis. Customers in disadvantaged communities are eligible for higher rebate amounts. For program guidelines and application materials, see the BWP Residential Electric Vehicle Charger Rebate (https://www.burbankwaterandpower.com/rebates-and-incentives) and Lead the Charge (https://www.burbankwaterandpower.com/leadthecharge) websites.

Electric Vehicle (EV) Charging Station Rebate - Glendale Water and Power (GWP)
GWP provides rebates to commercial and residential customers toward the purchase of Level 2 EV charging stations. Commercial or multi-unit dwelling customers who purchase and install EV charging stations can receive up to $6,000 for each charger and up to four rebates. Residential customers who install a charger can receive up to $599. Applications must be submitted no later than four months from the date of purchase. Rebates are available on a first-come, first-served basis until funds are exhausted. For program guidelines and application materials, see the GWP Electric Vehicles (https://www.glendaleca.gov/government/departments/glendale-water-and-power/electric-vehicles) website.

Electric Vehicle (EV) Charging Station Rebate - SCE
Southern California Edison's (SCE) Charge Ready Program offers customer rebates for businesses, government organizations, and multifamily properties to install EV charging stations at business, public sector, or multifamily dwelling locations. Rebate amounts vary, and sites located in disadvantaged communities are eligible for additional rebates. For more information, including eligibility requirements and funding availability, see the SCE Charge Ready Program (https://www.sce.com/business/electric-cars/Charge-Ready) website.

Electric Vehicle (EV) Charging Station Rebate – Liberty Utilities
Liberty Utilities offers residential customers a rebate of $1,500 and commercial customers a rebate of $2,500 for the purchase and installation of Level 2 EV charging stations at their home or small business. For more information, see the Liberty Utilities EV Program (https://california.libertyutilities.com/portola/residential/drive-electric/electric-vehicle-program.html#navbar-hp-menu-el-res) website.

Electric Vehicle (EV) Charging Station Rebates - Anaheim Public Utilities (APU)
APU provides rebates for residential, commercial, industrial, and municipal customers for the purchase and installation of Level 2 or direct current fast charging (DCFC) stations. Rebates are available in the following amounts:

Customer Type	Charger Type	Access	Maximum Rebate Amount per EV charging station
Residential and commercial	Level 2	Private	$1,500
Residential and commercial participating in a time-of-use rate	DCFC	Public	$3,000
Commercial, municipal, and multiunit dwelling	Level 2 or DCFC	Public	$5,000
School, affordable housing, and publicly accessible DCFC locations	Level 2 or DCFC	Public	$10,000

Applicants installing DCFC stations may receive a maximum of 10 rebates. Applicants may also receive up to $5,000 for sub-meter installation fees and up to $1,500 for city permit fees. Additional terms and conditions apply. For more information, including how to apply, see the APU Personal EV Charger Rebate (http://www.anaheim.net/593/Personal-EV-Charger-Rebate) and Public EV Charger Rebate (http://www.anaheim.net/3312/Public-EV-Charger-Rebate) websites.

Electric Vehicle (EV) Charging Station Rebates for Businesses - SMUD
Sacramento Municipal Utility District (SMUD) offers rebates to commercial customers for the purchase and installation of Level 2 EV charging stations and direct current fast charging (DCFC) stations at a workplace or multi-unit dwelling. DCFC stations may receive rebates of up to $30,000 per station and Level 2 charging stations may receive up to $4,500 per port. For more information, including eligibility requirements and how to apply, see the SMUD Business EV (https://www.smud.org/en/Going-Green/Electric-Vehicles/Business) and Sacramento County Incentive Project (https://calevip.org/incentive-project/sacramento-county-incentive-project) websites.

Electric Vehicle (EV) Charging Station Rebates – PG&E
Pacific Gas and Electric (PG&E) offers residential customers rebates of up to $500 for a Level 2 EV charging station and $2,000 for electric panel upgrades necessary to support the EV charging station. Eligible participants must meet household income requirements. For more information, including income thresholds, see the PG&E Empower EV Program (https://www.pge.com/en_US/residential/solar-and-vehicles/options/clean-vehicles/electric/empower-ev-program.page) website.

Electric Vehicle (EV) Charging Station Rebates – Silicon Valley Power (SVP)
SVP offers rebates for the purchase and installation of Level 2 EV charging stations to residential, multifamily, school, and nonprofit customers. Rebates are available in the following amounts:

Applicant Type	Maximum Rebate Amount
Residential	$550 per station

Multifamily, commercial, government, nonprofit, and fleet	$8,000 per port

Charging stations must have Wi-Fi capabilities. Residential customers may also receive a rebate of up to $2,000 to upgrade their electric panel to accommodate a Level 2 EV charger. Low-income residents and applicants located in equity areas may receive increased rebate amounts. Additional terms and conditions apply. For more information, see the SVP Rebates (https://www.siliconvalleypower.com/residents/rebates-6214) website.

Electric Vehicle (EV) Charging Station and Charging Incentive - Sonoma Clean Power (SCP)
Qualified SCP customers are eligible to receive a free Level 2 EV charging station with Wi-Fi capabilities. Customers are responsible for shipping and installation costs. Customers may also receive $5 per month for connecting the EV charging station to the GridSavvy Rewards program. Other terms and conditions may apply. For more information, see the SCP GridSavvy (https://sonomacleanpower.org/programs/gridsavvy) website.

Electric Vehicle (EV) Incentives for Medium- and Heavy-Duty Fleets - PG&E
Pacific Gas & Electric (PG&E) offers rebates for the purchase of electric fleet vehicles. EV rebates are available in the following amounts:

Technology	Rebate Amount
Transit buses and class 8 vehicles	Up to $9,000 per vehicle
Transportation refrigeration units, truck stop electrification, airport ground support equipment, and forklifts	Up to $3,000 per vehicle
School buses, local delivery trucks, and other vehicles	Up to $4,000 per vehicle

Applicants are limited to 25 vehicle rebates per site. Additional terms and conditions apply. For more information, including eligibility requirements, see the PG&E EV Fleet Program (https://www.pge.com/en_US/large-business/solar-and-vehicles/clean-vehicles/ev-fleet-program/ev-fleet-program.page?WT.mc_id=Vanity_evfleet) website.

Electric Vehicle (EV) Infrastructure Support
California utilities joined the National Electric Highway Coalition (NEHC), committing to create a network of direct current fast charging (DCFC) stations connecting major highway systems from the Atlantic Coast to the Pacific of the United States. NEHC utility members agree to ensure efficient and effective fast charging deployment plans that enable long distance EV travel, avoiding duplication among coalition utilities, and complement existing corridor DCFC sites. For more information, including a list of participating utilities and states, see the NEHC (https://www.eei.org/issuesandpolicy/Pages/NEHC.aspx) website.

Electric Vehicle (EV) Rebate - Pasadena Water and Power (PWP)
PWP provides rebates of $250 to residential customers who purchase or lease an eligible new or pre-owned EV. An additional $250 is available for eligible EVs purchased or leased from a Pasadena dealership. Customers participating in PWP's income-qualifying programs may also qualify for an additional $1,000 rebate, for a total of $1,500. Customers may receive rebates for up to 2 EVs per address every 3 years. Additional terms and conditions apply. For more information, see the PWP Residential EV and Charger Incentive Program (https://ww5.cityofpasadena.net/water-and-power/residentialevrebate/) website.

Electric Vehicle (EV) Rebates for Fleet Vehicles - SMUD
Sacramento Municipal Utility District (SMUD) offers rebates to businesses for the purchase of new commercial light-, medium-, and heavy-duty EVs. Rebates are available in the following amounts:

Vehicle Class	Rebate Amount
Class 1-2b and passenger vehicles	$750 per vehicle
Class 3-5	$5,000 per vehicle
Class 6-7	$7,000 per vehicle
Class 8	$15,000 per vehicle

Additional terms and conditions apply. For more information, including how to apply, see the SMUD Business EV (https://www.smud.org/en/Going-Green/Electric-Vehicles/Business#d516cde3-45a5-42f2-9d6e-0235da3ca8fe-9f57022f-fa9c-4c0f-b346-f35b01afec56) website.

Electric Vehicle (EV) Time-Of-Use (TOU) Rate - Burbank Water and Power (BWP)
BWP offers a TOU rate to residential or multi-family customers for electricity used to charge EVs. Customers must remain on the EV TOU rate for a minimum of one year. For more information, see the BWP EVs (https://www.burbankwaterandpower.com/electric/rates-and-charges) website.

Electric Vehicle (EV) Time-Of-Use (TOU) Rate - SDG&E
San Diego Gas & Electric (SDG&E) offers three EV TOU rates to residential customers. For more information, including eligibility requirements and rate details, see the SDG&E EV Plans (https://www.sdge.com/residential/pricing-plans/about-our-pricing-plans/electric-vehicle-plans) website.

Electric Vehicle (EV) Time-of-Use (TOU) Rate - Azusa Light & Water
Azusa Light & Water offers a TOU rate to residential customers that own or lease an EV. For more information, see Azusa's EVs (https://www.ci.azusa.ca.us/1625/Plug-In-Electric-Vehicles) website.

Electric Vehicle (EV) Time-of-Use (TOU) Rate – Liberty Utilities

Liberty Utilities offers residential and commercial customers TOU rates for charging EVs. For more information, see the Liberty Utilities EV Program (https://california.libertyutilities.com/portola/residential/drive-electric/electric-vehicle-program.html#navbar-hp-menu-el-res) website.

Electric Vehicle (EV) Time-of-Use (TOU) Rate – MCE
MCE offers residential, multi-unit dwelling, and workplace customers TOU rates for charging EVs. Additional terms and conditions apply. For more information, see the MCE EV Rate Plans (https://www.mcecleanenergy.org/mce-news/electric-vehicles/how-to-charge-your-ev-for-less/) website.

Electric Vehicle (EV) and Compressed Natural Gas (CNG) Rate Reduction - PG&E
Pacific Gas & Electric (PG&E) offers discounted residential time-of-use rates for electricity used to charge EVs during off-peak hours. Discounted rates are also available for CNG or uncompressed natural gas used in vehicle home fueling appliances. For more information, see the PG&E EV Rate Plans (https://www.pge.com/en_US/residential/rate-plans/rate-plan-options/electric-vehicle-base-plan/electric-vehicle-base-plan.page?) and CNG for Vehicles (https://www.pge.com/en/clean-energy/natural-gas-vehicles.html) websites.

Electric Vehicle (EV) and EV Charging Station Rebates - Central Coast Community Energy (CCCE)
CCCE offers rebates of up to $4,000 to residential, commercial, and public agency customers for the purchase of new or pre-owned EVs or electric motorcycles. CCCE also offers a rebate of up to $10,000 for Level 2 EV charging stations installed at homes or workplaces. For more information, see the CCCE Electrify Your Ride (https://3cenergy.org/rebates/electrify-your-ride-residential/) website.

Electric Vehicle (EV) and EV Charging Station Rebates - TID
Turlock Irrigation District (TID) offers residential customers a $500 rebate for the purchase or lease of a qualifying new or pre-owned EV. TID also offers residential customers a rebate of $300 for the purchase and installation of a qualifying Level 2 EV charging station. Low-income customers enrolled in the TID CARES Program are eligible for an additional rebate of $700 per EV and $100 per EV charging station. Up to two rebates may be claimed for EVs and EV charging stations per residential account. For more information, including eligibility requirements, see the TID Residential EV Rebates (https://www.tid.org/customer-service/save-energy-money/rebates/residential-ev/) and CARES Program (https://www.tid.org/customer-service/save-energy-money/rebates/residential-ev/) website.

Electric Vehicle (EV) and Plug-In Hybrid Electric Vehicle (PHEV) Rebate - MCE
MCE offers a $3,500 rebate for the purchase or lease of a new EV or PHEV and a $2,000 rebate for the purchase or lease of a pre-owned EV or PHEV for residential customers. To be eligible for the rebate, applicants must live in MCE's service area, be an MCE customer, and meet at least one of the qualifying income requirements. For more information, including eligibility requirements and how to apply, see the MCE EV Rebates (https://www.mcecleanenergy.org/ev-drivers/) website.

Electric Vehicle (EV) and Plug-In Hybrid Electric Vehicle (PHEV) Rebate – Silicon Valley Power (SVP)
SVP offers income-qualifying residential customers a $1,000 rebate for the purchase of a PHEV and $1,500 rebate for the purchase of an EV. For more information, including income requirements, see the SVP Rebates (https://www.siliconvalleypower.com/residents/rebates-6214) website.

Multi-Unit Dwelling (MUD) and Workplace Electric Vehicle (EV) Charging Station Incentive - SDG&E
San Diego Gas & Electric's (SDG&E) Power Your Drive program provides EV charging stations, installation, and maintenance support for MUDs and workplaces in the SDG&E territory. Site hosts must make a one-time participation payment and be able to dedicate at least five parking spaces at residential locations or at least ten parking spaces at workplaces for EV charging stations. MUDs and workplaces located in disadvantaged communities may qualify for the program at no cost to the site host. Additional terms and conditions apply. For more information, including funding availability, see the Power Your Drive (https://www.sdge.com/residential/electric-vehicles/power-your-drive) website.

Multi-Unit Dwelling (MUD) and Workplace Electric Vehicle (EV) Charging Station Rebate - MCE
MCE provides rebates of up to $3,000 for the purchase and installation of qualifying Level 2 EV charging stations at MUDs and workplaces in MCE territory, up to $60,000 per site. Customers that are enrolled in the MCE Deep Green program may be eligible for an additional $500 rebate per port, up to $10,000 per site. For more information, including how to apply and eligible EV charging stations, see the MCE EV Rebates (https://www.mcecleanenergy.org/ev-charging/) website.

Pre-Owned Electric Vehicle (EV) Incentives - Peninsula Clean Energy (PCE)
PCE and Peninsula Family Service (PFS) offer up to $1,000 for the purchase of a pre-owned plug-in hybrid electric vehicle or all-electric EV to San Mateo County residents. Low-income residents may receive an additional $3,000 rebate. Additional terms and conditions apply. For more information, see the PCE DriveForward Electric (https://www.peninsulacleanenergy.com/driveforwardelectric/) website.

Pre-Owned Electric Vehicle (EV) Rebate - Alameda Municipal Power (AMP)
AMP provides rebates of up to $4,000 for the purchase of a pre-owned EV with a purchase price below $40,000. Income-qualifying customers may receive an additional $2,000 rebate. For more information, see the AMP EVs (https://www.alamedamp.com/349/Electric-Vehicles) website.

Pre-Owned Electric Vehicle (EV) Rebate – Burbank Water and Power (BWP)
BWP offers residential customers a rebate of up to $1,000 for the purchase of a pre-owned EV. For more information, see the BWP Used EV Rebate (https://www.burbankwaterandpower.com/conservation/used-ev-rebate) website.

Residential Electric Vehicle (EV) Charging Rate Incentive – MCE
MCE offers residential customers an incentive of $50 for enrolling in MCE's managed charging program. Participants in this program may receive a monthly rebate of up to $10. For more information, including participation and eligibility requirements, see the MCE EV Smart Charging App (https://www.mcecleanenergy.org/mce-sync/?gclid=CjwKCAjw6eWnBhAKEiwADpnw9oSmUxi2btoyNP50dBpHEmn50-eYIg-jgSIMMrRnn7QesBrfMLCfEBoCNWQQAvD_BwE) website.

Residential Electric Vehicle (EV) Charging Station Rebate - LADWP

The Los Angeles Department of Water and Power (LADWP) offers a rebate of up to $1,000 for the purchase and installation of qualified Level 2 EV charging stations, and a $250 rebate for the installation of a dedicated EV charging station meter. Customers participating in LADWP Lifeline or EZ-SAVE Low-Income Customer Assistance programs are eligible for an additional $500 rebate. For more information, including program guidelines and application materials, see the LADWP Charge Up L.A.! (https://www.ladwp.com/ladwp/faces/ladwp/residential/r-gogreen/r-gg-driveelectric?_adf.ctrl-state=1d4357epvd_4&_afrLoop=472125629767806) website.

Residential Electric Vehicle (EV) Charging Station Rebate - Pasadena Water and Power (PWP)
PWP provides rebates of $600 for residential customers toward the installation of a WiFi enabled EV charging station, or $200 toward the installation of a non-WiFi enabled EV charging stations. Additional terms and conditions apply. For more information, including how to apply, see the PWP Residential EV and Charger Incentive Program (https://ww5.cityofpasadena.net/water-and-power/residentialevrebate/) website.

Residential Electric Vehicle (EV) Charging Station Rebate – SMUD
The Sacramento Municipal Utility District (SMUD) offers a rebate of up to $1,000 for the purchase and installation of a new Level 2 EV charging station and associated electrical upgrades. For more information, see the SMUD Residential EVs (https://www.smud.org/en/Going-Green/Electric-Vehicles/Residential) website.

School Electric Vehicle (EV) Charging Station Rebate – PG&E
Pacific Gas and Electric (PG&E) offers EV charging station rebates for school facilities. Participating schools may own, operate, and maintain EV charging stations, or have PG&E-owned EV charging stations installed. Rebates may be up to $11,500 for single port Level 2 EV charging stations or up to $15,500 for dual port Level 2 EV charging stations. A minimum of 40% of funds must be allocated to disadvantaged communities. For more information, including eligibility requirements and funding availability, see the PG&E EV program (https://www.pge.com/en_US/small-medium-business/energy-alternatives/clean-vehicles/ev-charge-network/electric-vehicle-charging/electric-vehicle-programs-and-resources.page) website.

State Parks Electric Vehicle (EV) Charging Station Program – PG&E
Pacific Gas and Electric's (PG&E) EV Charge Parks program provides EV charging stations at state parks and beaches for fleet and public usage. PG&E will own, operate, and maintain EV charging stations and pay for associated network fees for a period up to eight years. A minimum of 25% of funds must be allocated to disadvantaged communities. For more information, including funding availability, see the PG&E EV program (https://www.pge.com/en_US/small-medium-business/energy-alternatives/clean-vehicles/ev-charge-network/electric-vehicle-charging/electric-vehicle-programs-and-resources.page) website.

Used Electric Vehicle (EV) Rebate Program - LADWP
The Los Angeles Department of Water and Power (LADWP) offers rebates up to $1,500 to residential electric customers for the purchase of eligible pre-owned EVs. Customers participating in the LADWP Lifeline or EZ-SAVE Low-Income Customer Assistance programs are eligible for an additional $1,000 rebate. Additional terms and conditions apply. For more information, including program guidelines and application materials, see the LADWP Charge Up L.A.! (https://www.ladwp.com/ladwp/faces/ladwp/residential/r-gogreen/r-gg-driveelectric?_adf.ctrl-state=1d4357epvd_4&_afrLoop=472125629767806) website.

State Incentives

Advanced Transportation Tax Exclusion
The California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA) provides a sales and use tax exclusion for qualified manufacturers of advanced transportation products, components, or systems that reduce pollution and energy use and promote economic development. Incentives are available until December 31, 2025. For more information, including application materials, see the CAEATFA Sales and Use Tax Exclusion Program (http://www.treasurer.ca.gov/caeatfa/ste/index.asp) website.

(Reference California Public Resources Code 26000-26017 (http://www.oal.ca.gov/))

Alternative Fuel Mechanic Technical Training - San Joaquin Valley
The San Joaquin Valley Air Pollution Control District (SJVAPCD) administers the Alternative Fuel Mechanic Training Program, which provides incentives of up to $15,000 per fiscal year to educate personnel on the mechanics, operation safety, and maintenance of alternative fuel vehicles, fueling stations, and tools involved in the implementation of alternative fuel technologies. For more information, see the SJVAPCD Alternative Fuel Mechanic Training Component (http://valleyair.org/grants/mechanictraining.htm) website.

Alternative Fuel Vehicle (AFV) Incentives - San Joaquin Valley
The San Joaquin Valley Air Pollution Control District administers the Public Benefit Grant Program, which provides funding to cities, counties, special districts (such as water districts and irrigation districts), and public educational institutions for the purchase of new AFVs, including electric, hybrid electric, natural gas, and propane vehicles. The maximum grant amount allowed per vehicle is $20,000, with a limit of $100,000 per agency per year. Projects are considered on a first-come, first-serve basis. For more information, see the Public Benefit Grant Program (http://valleyair.org/grants/content/publicbenefit.html) website.

Alternative Fuel and Advanced Vehicle Rebate - San Joaquin Valley
The San Joaquin Valley Air Pollution Control District (SJVAPCD) administers the Drive Clean! Rebate Program, which provides rebates for the purchase or lease of eligible new vehicles, including qualified natural gas, hydrogen fuel cell, all-electric, plug-in electric vehicles, and zero emission motorcycles. The program offers rebates of up to $3,000, which are available on a first-come, first-served basis for residents and businesses located in the SJVAPCD. For more information, including a list of eligible vehicles and other requirements, see the SJVAPCD Drive Clean! Rebate Program (http://valleyair.org/drivecleaninthesanjoaquin/rebate/) website.

Alternative Fuel and Vehicle Incentives
The California Energy Commission (CEC) administers the Clean Transportation Program (Program) to provide financial incentives for businesses, vehicle and technology manufacturers, workforce training partners, fleet owners, consumers, and academic institutions with the goal of developing and deploying alternative and renewable fuels and advanced transportation technologies. Funding areas include:

- Electric vehicles and charging infrastructure;
- Hydrogen vehicles and refueling infrastructure;

- Medium- and heavy-duty zero emission vehicles;
- Natural gas vehicles and refueling infrastructure;
- Biofuels; and,
- Workforce development.

The CEC must prepare and adopt an annual Investment Plan (https://www.energy.ca.gov/transportation/arfvtp/investmentplans.html) for the Program to establish funding priorities and opportunities that reflect program goals and to describe how program funding will complement other public and private investments. For more information, see the Program (https://www.energy.ca.gov/programs-and-topics/programs/clean-transportation-program) website.

(Reference California Health and Safety Code 44272 - 44273 (https://leginfo.legislature.ca.gov/faces/home.xhtml) and California Code of Regulations, Title 13, Chapter 8.1 (http://www.oal.ca.gov/))

Bus Replacement Grant
The California Air Resources Board (CARB) offers grants for the purchase of new zero-emission buses to replace old gasoline, diesel, compressed natural gas, or propane buses. Grants awards vary based on vehicle type and are available in the following amounts:

Vehicle	Maximum Grant Amount
Electric Transit Bus	$216,000
Fuel Cell Transit Bus	$480,000
Electric School Bus	$400,000
Electric School Bus (CARB non-compliant)	$380,000
Electric Shuttle Bus	$192,000

Non-compliant school buses are vehicles that are not compliant with the CARB Truck and Bus Regulation. Eligible applicants include owners of transit, school, and shuttle buses. Grants are awarded on a first-come, first-served basis. The program is funded by California's portion of the Volkswagen Environmental Mitigation Trust (https://www.epa.gov/enforcement/volkswagen-clean-air-act-civil-settlement). For more information, including funding availability, see the CARB's Volkswagen Settlement (https://ww2.arb.ca.gov/our-work/programs/volkswagen-environmental-mitigation-trust-california) website.

California's National Electric Vehicle Infrastructure (NEVI) Planning
The U.S. Department of Transportation's (DOT) NEVI Formula Program (https://afdc.energy.gov/laws/12744) requires the California Department of Transportation to submit an annual EV Infrastructure Deployment Plan (Plan) to the DOT and U.S. Department of Energy (DOE) Joint Office of Energy and Transportation (https://driveelectric.gov) (Joint Office), describing how the state intends to distribute NEVI funds. The submitted plans must be established according to NEVI guidance (https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/nominations/90d_nevi_formula_program_guidance.pdf).

For more information about California's NEVI planning process, see the California Energy Commission NEVI (https://www.energy.ca.gov/programs-and-topics/programs/national-electric-vehicle-infrastructure-program-nevi#:~:text=Caltrans%20and%20the%20CEC%20have%20partnered%20to%20create,chargers%20along%20Interstates%20and%20National%20Highways%20throughout%20Cali website. To review California's NEVI plan, see the Joint Office State Plans for EV Charging (https://driveelectric.gov/state-plans/) website.

Clean Vehicle Rebate - El Dorado County
The El Dorado County Air Quality Management District (EDC AQMD) offers rebates of up to $599 to residents toward the purchase or lease of a new zero emission vehicle (ZEV) or partial-ZEV, as defined by the California Air Resources Board. To qualify, vehicles must be owned or leased for at least three years within El Dorado County. For more information, including eligibility requirements, see the EDC AQMD Grants and Incentives (https://www.edcgov.us/Government/AirQualityManagement/Pages/grants_and_incentive_refunds.aspx) website.

Electric Vehicle (EV) Charging Station Grant – Antelope Valley
Antelope Valley Air Quality Management District (AVAQMD) offers grants for the installation of public EV charging stations, up to 70% of the total costs of infrastructure, equipment, and installation of eligible projects. Preferred project sites include retail centers, multi-unit dwellings, workplaces, hospitals, public transit stations, and park & rides. For more information, including application criteria and eligibility requirements, visit the AVAQMD Electric Vehicle Charging Stations Program (https://avaqmd.ca.gov/electric-vehicle-charging-stations-program) website.

Electric Vehicle (EV) Charging Station Incentive Program Support
The California Electric Vehicle Infrastructure Project (CALeVIP), funded by the California Energy Commission, provides guidance and funding for property owners to develop and implement EV charging station incentive programs that help meet regional needs for Level 2 and direct current fast charging (DCFC) stations. Level 2 EV charging stations must be ENERGY STAR certified. CALeVIP evaluates proposed EV charging station incentive programs and solicits input from stakeholders to guide the development and implementation of the programs. CALeVIP also provides the incentive funding for each program. For more information, see the CALeVIP (https://calevip.org/) website.

Electric Vehicle (EV) Charging Station Incentives - San Joaquin Valley
The San Joaquin Valley Air Pollution Control District (SJVAPCD) administers the Charge Up! Program, which provides funding for public agencies, businesses, and property owners of multi-unit dwellings for the purchase and installation of new EV charging stations. Rebates are available in the following amounts:

EV Charging Station Type	Maximum Rebate Amount per EV Charging Station	Minimum Cost Share
Single Port Level 2	$5,000	None

Dual Port Level 2	$6,000	None
Direct Current Fast Charging (DCFC) Station	$25,000	30% of Total Cost

Annual funding is capped at $50,000 per applicant. For more information, including application requirements and restrictions, see the SJVAPCD Charge Up! Program (http://valleyair.org/grants/chargeup.htm) website.

Electric Vehicle (EV) Charging Station Rebate - South Coast and MSRC
The South Coast Air Quality Management District (SCAQMD) and the Mobile Source Air Pollution Reduction Review Committee's (MSRC) Residential EV Charging Incentive Pilot Program offers rebates of up to $500 towards the purchase of a qualified residential Level 2 EV charging station. Funding is available on a first-come, first-served basis to residents within the SCAQMD jurisdiction. Additional terms and conditions apply. For more information, including application guidelines, see the Residential EV Charging Incentive Pilot Program (http://www.aqmd.gov/home/programs/community/community-detail?title=ev-charging-incentive) website.

Electric Vehicle (EV) Grants
The California Air Resources Board (CARB) offers grants to income-qualifying individuals for the purchase or lease of a new or pre-owned EV, plug-in hybrid electric vehicle (PHEV), or fuel cell electric vehicle (FCEV). EVs and FCEVs are eligible for grants of up to $7,500 and PHEVs are eligible for grants of up to $7,000. Applicants may also be eligible to receive a grant of up to $2,000 for the purchase and installation of a Level 2 EV charging station. For more information, including income requirements, see the Clean Vehicle Assistance Program (https://cleanvehiclegrants.org/vehicles/) website.

Electric Vehicle (EV) Rebate - Antelope Valley
The Antelope Valley Air Quality Management District (AVAQMD) offers residents rebates of up to $500 for the purchase or lease of an EV from a dealership within the Antelope Valley jurisdiction. For more information, including how to apply, see the AVAQMD (https://avaqmd.ca.gov/alternative-fuel-vehicle-program) website.

Electric Vehicle (EV) and Fuel Cell Electric Vehicle (FCEV) Grant - Bay Area
The Bay Area Air Quality Management District's (BAAQMD) Clean Cars for All program offers grants up to $9,500 to income-eligible residents to replace a vehicle eligible for retirement with an EV, hybrid electric vehicle (HEV), plug-in hybrid electric vehicle (PHEV), or FCEV. Eligible vehicles for replacement should be model year 2005 or older. Recipients may buy or lease a new or used EV, HEV, PHEV, or FCEV. Grants vary depending on the household income and vehicle technology. Vehicles that are replaced must be turned in at an authorized dismantler.

Individuals that purchase a PHEV or EV are eligible to receive up to $2,000 for the purchase and installation of Level 2 electric vehicle supply equipment.

For more information, including additional eligibility requirements and how to apply, see the BAAQMD Clean Cars for All (http://www.baaqmd.gov/funding-and-incentives/residents/clean-cars-for-all) website.

Electric Vehicle Charging Station Rebate – Northern and Southern California
The Golden State Priority Project, funded by the California Energy Commission as part of the California Electric Vehicle Infrastructure Project (CALeVIP), offers rebates for the purchase and installation of direct current fast charging (DCFC) stations. Rebates will fund 50% of project costs, up to the following amounts:

Power Output Rating	**Maximum Rebate per Connector**
150 kilowatts (kW) to 274 kW	$55,000
Greater than 274 kW	$100,000

Eligible applicants include businesses, non-profit organizations, tribal governments, or government entities. Applicants may receive rebates for a maximum of 20 DCFC connectors. Qualifying installation sites must be accessible to the public 24 hours a day in underserved and low-income census tracts located in Central or Eastern California. For more information, including additional eligibility requirements, see the CALeVIP Golden State Priority Project (https://calevip.org/incentive-project/gspp-incentive-north-south) website.

Employer Invested Emissions Reduction Funding - South Coast
The South Coast Air Quality Management District (SCAQMD) administers the Air Quality Investment Program (AQIP). AQIP provides funding to allow employers within SCAQMD's jurisdiction to make annual investments into an administered fund to meet employers' emissions reduction targets. The revenues collected are used to fund alternative mobile source emissions and trip reduction programs, including alternative fuel vehicle projects, on an on-going basis. Programs such as low emission, alternative fuel, or zero emission vehicle procurement and old vehicle scrapping may be considered for funding. For more information, including current requests for proposals and funding opportunities, see the AQIP (http://www.aqmd.gov/home/programs/business/business-detail?title=air-quality-investment-program) website.

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http://www.aqmd.gov/home/programs/business/business-detail?title=air-quality-investment-program (http://www.aqmd.gov/home/programs/business/business-detail?title=air-quality-investment-program)

Heavy-Duty Low Emission Vehicle Replacement and Repower Grants
The South Coast Air Quality Management District (SCAQMD) offers grants for the replacement or repower of eligible class 7 and 8 heavy-duty vehicles with low oxide of nitrogen (NOx) vehicles. Grants may cover up to 50% of non-government project costs and up to 100% of government project costs; up to $3 million per entity. Eligible applicants include Class 7 and 8 freight trucks, drayage trucks, dump trucks, waste haulers, and concrete mixers,

freight switcher locomotives. Grants are awarded on a first-come, first-served basis. The program is funded by California's portion of the Volkswagen Environmental Mitigation Trust (https://www.epa.gov/enforcement/volkswagen-clean-air-act-civil-settlement). For more information, including program guidance and application, see the California Air Resources Board's Volkswagen Settlement (https://xappprod.aqmd.gov/vw/) website.

Heavy-Duty Truck Emission Reduction Grants - San Joaquin Valley
The San Joaquin Valley Air Pollution Control District (SJVAPCD) administers the Truck Replacement Program, which provides funding for fleets to replace old vehicles with lower emitting vehicles or to purchase new zero emission, hybrid, or low oxides of nitrogen (NOx) vehicles. Funding is available for the following projects:

- Replacement of model year (MY) 2009 or older diesel trucks with new trucks that meet or exceed the 2010 NOx emissions standard; and,
- Replacement of MY 2010 – MY 2016 trucks with new zero emission, hybrid, or low-NOx trucks.

Incentive amounts vary by weight class and fuel type. Fleets may receive up to 80% of the vehicle cost for new diesel trucks. To qualify, eligible trucks for replacement must be garaged in the SJVAPCD and have operated at least 75% of the time in California and 50% of the time in the SJVAPCD for the previous two years. For more information, including application requirements, see the SJVAPCD Truck Replacement Program (http://valleyair.org/grants/truck-replacement.htm) website.

Heavy-Duty Zero Emission Vehicle (ZEV) Grant – Santa Barbara County
The Santa Barbara County Air Pollution Control District (SBCAPCD) provides grants to offset the costs of zero-emission heavy-duty vehicles that reduce on-road emissions within Santa Barbara County. Eligible projects include the replacement of commercial trucks and buses, transit buses, authorized emergency vehicle, transportation refrigeration units, and more. Eligible technology includes the purchase of battery-electric, hydrogen fuel cell, and natural gas vehicles. Priority will be given to projects located in multi-unit dwellings or low-income communities. For more information, including current funding opportunities, see the SBCAPCD Clean Air Grants (https://www.ourair.org/grants-for-on-road-vehicles/) website.

High Occupancy Vehicle (HOV) and High Occupancy Toll (HOT) Lane Exemption
Compressed natural gas, hydrogen, electric, and plug-in hybrid electric vehicles meeting specified California and federal emissions standards and affixed with a California Department of Motor Vehicles (DMV) Clean Air Vehicle sticker may use HOV lanes regardless of the number of occupants in the vehicle. Orange stickers expire January 1, 2024; blue stickers expire January 1, 2025; and yellow and green stickers expire September 30, 2025.

Residents with an annual income at or below 80% of California's median income level may participate in the Income-Based CAV (IB-CAV) Decal Program, which allows used vehicles with previously issued CAV decals to retain eligibility for a CAV decal. IB-CAV decals are valid through January 1, 2024. Additional requirements apply.

Vehicles originally issued white, green, purple, or red decals are no longer eligible to participate in this program. Vehicles with stickers are also eligible for reduced rates on or exemptions from toll charges imposed on HOT lanes. For more information and restrictions, including a list of qualifying vehicles and additional eligibility requirements, see the California Air Resources Board Carpool Stickers (http://www.arb.ca.gov/msprog/carpool/carpool.htm) website.

(Reference California Vehicle Code 5205.5 and 21655.9 (http://www.oal.ca.gov/))

Low Emission Truck and Bus Purchase Vouchers
Through the Hybrid and Zero Emission Truck and Bus Voucher Incentive Project (HVIP) and Low Oxide of Nitrogen (NOx) Engine Incentives, the California Air Resources Board provides vouchers to eligible fleets to reduce the incremental cost of qualified electric, hybrid, or natural gas trucks and buses at the time of purchase. Vouchers are available on a first-come, first-served basis. Only fleets that operate vehicles in California are eligible. Voucher amounts vary depending on whether the vehicles are located in a disadvantaged community. For more information, including a list of qualified vehicles and other requirements, see the HVIP (http://www.californiahvip.org/) website.

Medium- and Heavy-Duty (MHD) Zero Emission Vehicle (ZEV) Financing Program
The California Pollution Control Financing Authority (CPCFA) must develop and implement a purchasing assistance program for MHD ZEV fleets. CPCFA must consult with stakeholders to design a program that provides financial support and technical assistance to fleet managers deploying MHD ZEVs. CPCFA must designate high-priority fleets, considering implications for climate change, pollution, environmental justice, and post-COVID economy recovery. A minimum of 75% of financing products must be directed towards operators of MHD ZEV fleets whose fleets directly impact, or operate in, underserved communities. CPCFA must establish the program by January 1, 2023, and provide annual reports on program outcomes to the California Air Resources Board.

(Reference California Health and Safety Code 44272 (https://leginfo.legislature.ca.gov/faces/home.xhtml))

Medium- and Heavy-Duty (MHD) Zero Emission Vehicle (ZEV) and Infrastructure Grants
The Energy Infrastructure Incentives for Zero-Emission Commercial Vehicles (EnergIIZE), funded by the California Energy Commission, offers grants for the purchase and installation of ZEV infrastructure for MHD electric vehicles and hydrogen fuel cell electric vehicles. Eligible applicants include commercial fleets and station owners. Incentive amounts vary based on project type. Increased incentive amounts are available for commercial fleets that operate in low-income and underserved communities. For more information, including eligible project types and funding amounts, see the EnergIIZE (https://www.energiize.org/) website.

Plug-In Hybrid and Zero Emission Light-Duty Public Fleet Vehicle Fleet Rebates
The Clean Vehicle Rebate Project (CVRP) offers rebates to eligible state and local public entities for the purchase of qualified light-duty fleet vehicles. Public fleets located in disadvantaged communities are eligible for increased incentives. Rebates are available in the following amounts:

Technology	Standard Rebate	Increased Rebate
Fuel Cell Electric Vehicle	$4,500	$7,000

All-Electric Vehicle	$2,000	$7,500
Plug-In Hybrid Electric Vehicle	$1,000	$6,500

Eligible vehicles must be certified by the California Air Resources Board (ARB). Rebates are available on a first-come, first-served basis. Manufacturers must apply to ARB to have their vehicles considered for rebate eligibility. Each entity may receive up to 30 rebates annually and may not receive CVRP incentives for the same vehicle. For more information, including a list of eligible vehicles, locations, and entities, see the CVRP (https://cleanvehiclerebate.org/en) website.

(Reference California Health and Safety Code 44274 and 44258 (http://www.oal.ca.gov/))

Plug-In Hybrid and Zero Emission Light-Duty Vehicle Rebates
The Clean Vehicle Rebate Project (CVRP) offers rebates for the purchase or lease of qualified vehicles. Qualified vehicles include light-duty electric vehicles (EVs), fuel cell electric vehicles (FCEVs), and plug-in hybrid electric vehicles (PHEVs) the California Air Resources Board (CARB) has approved or certified. The rebate amounts are up to $4,500 for FCEVs, $2,000 for EVs, $1,000 for PHEVs, and $750 for zero emission motorcycles. Rebates are available on a first-come, first-served basis to California residents who purchase or lease new eligible vehicles. Residents of San Diego County may be eligible for a preapproved rebate through the CVRP Rebate Now (https://cleanvehiclerebate.org/en/dealer/rebate-now) pilot. Manufacturers must apply to CARB to have their vehicles included in the CVRP.

Individuals are eligible for the rebate based on gross annual income, as stated on the individual's federal tax return. Individuals with a gross annual income below the following thresholds are eligible for all rebates except those that apply to FCEVs:

- $135,000 for single filers
- $175,000 for head-of-household filers
- $200,000 for joint filers

Increased rebate amounts are available for individuals with low and moderate household incomes of less than or equal to 400% of the federal poverty level. CARB must provide outreach to low-income households and communities to raise awareness about CVRP.

For more information, including information on income verification, a list of eligible vehicles, and instructions on how to apply, see the CVRP (https://cleanvehiclerebate.org/eng) website.

(Reference California Health and Safety Code 44274 and 44258 (http://www.oal.ca.gov/))

Residential Electric Vehicle (EV) Charging Station Financing Program
Property Assessed Clean Energy (PACE) Loss Reserve Program financing allows property owners to borrow funds to pay for energy improvements, including purchasing and installing EV charging stations. The borrower repays the financing over a defined period of time through a special assessment on the property. Local governments in California are authorized to establish PACE programs. Property owners must agree to a contractual assessment on the property tax bill, have a clean property title, and be current on property taxes and mortgages. Financing limits are 15% of the first $700,000 of the property value and 10% of the remaining property value. For more information, see the California Alternative Energy and Advanced Transportation Financing Authority PACE Loss Reserve Program (https://www.treasurer.ca.gov/caeatfa/pace/index.asp) website.
(Reference California Public Resources Code (https://leginfo.legislature.ca.gov/faces/home.xhtml) 26050-26082)

Zero Emission School Bus Grants
The Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) Public Bus Set-Aside Program, funded by the California Air Resources Board and the California Energy Commission, offers grants for the purchase of new zero emission school buses to replace fossil fuel-powered buses. Grants awards vary based on vehicle type and are available in the following amounts:

School Bus Type	Maximum Grant Amount Without a Wheelchair Lift	Maximum Grant Amount With a Wheelchair Lift
Type A	$285,000	$310,000
Type C	$350,000	$375,000
Type D	$370,000	$395,000

Eligible applicants include public school districts, public charter schools, joint power authorities, county offices of education, and the Division of State Special Schools of the California Department of Education. For more information, including funding priorities and availability, see the HVIP Program Public School Bus Set-Aside (https://californiahvip.org/purchasers/#schoolbus) website.

Zero Emission Transit Bus Tax Exemption
Zero-emission transit buses are exempt from state sales and use taxes when sold to public agencies eligible for the Low Emission Truck and Bus Purchase Vouchers (https://afdc.energy.gov/laws/8160). This exemption expires January 1, 2024.

(Reference California Revenue and Taxation Code 6377 (https://leginfo.legislature.ca.gov/faces/home.xhtml))

Zero Emission Transit Funding
The California Clean Mobility Options Voucher Pilot Program offers vouchers of up to $1,000,000 per project for the purchase of zero-emission vehicles, infrastructure, planning, outreach, and operations projects in low-income communities, disadvantaged communities, and tribal areas. For more information, see the Clean Mobility Options (https://www.cleanmobilityoptions.org/) website.

Zero Emission Vehicle (ZEV) and Near-ZEV Weight Exemption

ZEVs and near-ZEVs may exceed the state's gross vehicle weight limits by an amount equal to the difference of the weight of the near-zero emission or zero emission powertrain and the weight of a comparable diesel tank and fueling system, up to 2,000 pounds. A ZEV is defined as a vehicle that produces no criteria pollutant, toxic air contaminant, or greenhouse gas emissions when stationary or operating. A near-ZEV is a vehicle that uses zero emission technologies, uses technologies that provide a pathway to zero emission operations, or incorporates other technologies that significantly reduce vehicle emissions.

(Reference California Business and Professions Code 12725 and California Vehicle Code 35551 (http://leginfo.legislature.ca.gov/faces/home.xhtml))

Attachment 81

Comments of Environmental and Public Health Organizations on:

EPA, California State Motor Vehicle Pollution Control Standards; Advanced Clean Cars II Regulations; Request for Waiver of Preemption; Opportunity for Public Hearing and Public Comment, 88 Fed. Reg. 88908 (December 26, 2023); Docket ID No. EPA–HQ–OAR–2023–0292

Submitted February 27, 2024

SOUTHERN CALIFORNIA EDISON

WHAT YOU SHOULD KNOW ABOUT SCE'S GENERAL RATE CASE

Every four years, SCE requests funding for its day-to-day operations to safely deliver reliable, affordable and clean energy to our customers through a public process called the General Rate Case (GRC). On May 12, SCE filed its GRC request with the California Public Utilities Commission for the years 2025-2028.

SCE'S GRC INVESTMENTS WILL STRENGTHEN THE ELECTRIC GRID

RELIABILITY

UPGRADING THE GRID WITH ADVANCED TECHNOLOGY TO HELP PREVENT UNPLANNED OUTAGES AND RESTORE POWER FASTER WHEN OUTAGES HAPPEN.

ACCELERATING REPLACEMENT OF AGING INFRASTRUCTURE TO ENSURE GRID HEALTH.

RESILIENCE

MORE PROTECTION AGAINST RISING THREATS LIKE WILDFIRES, PROLONGED HEAT, WIND EVENTS OR CYBERATTACKS.

REPLACING 1,250 MILES OF OVERHEAD POWER LINES WITH COATED WIRE.

READINESS

DELIVERING MORE CLEAN, RENEWABLE ENERGY FROM WIND AND SOLAR SOURCES, AND 100% CARBON-FREE ELECTRICITY BY 2045.

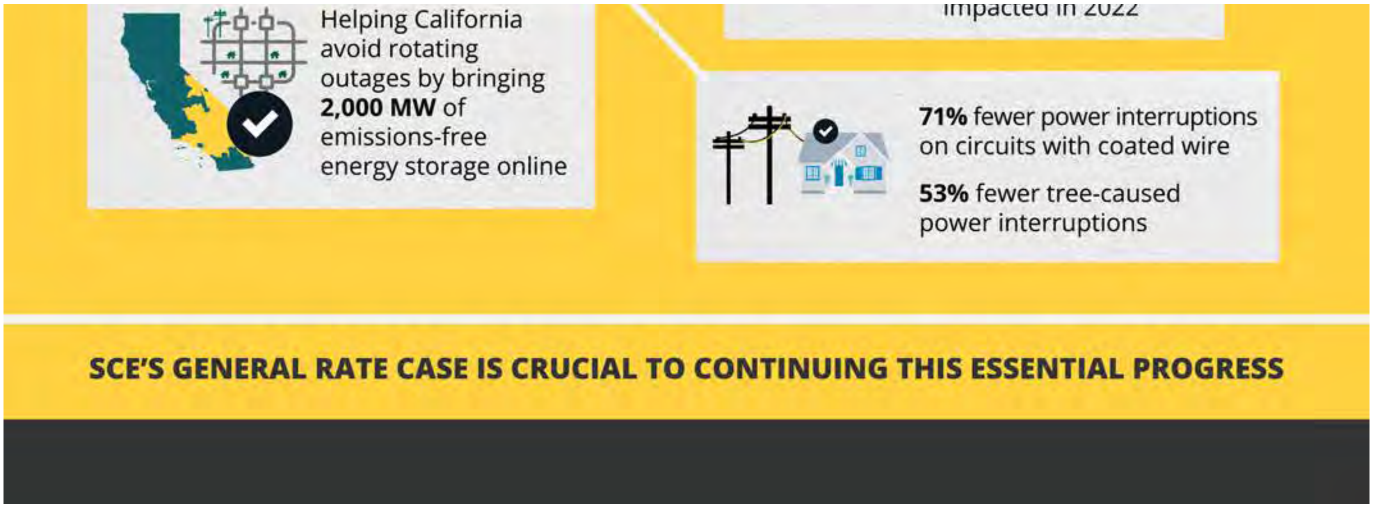
PREPARING FOR RAPIDLY GROWING CUSTOMER DEMAND FOR ELECTRIC VEHICLES AND CLEAN ENERGY TECHNOLOGY.

CUSTOMER DOLLARS MADE THESE RECENT SCE ACHIEVEMENTS POSSIBLE

Reducing wildfire risk associated with our utility equipment by **75%-80%** since 2018

Significantly reducing Public Safety Power Shutoff (PSPS) events

89% fewer customers



SCE Details Investments to Advance Electric Grid Reliability, Resilience and Readiness

Grid upgrades aim to meet growing customer needs, guard against rising threats and continue progress toward California's clean energy transition.

Ron Gales
ENERGIZED by Edison Writer
Contributors
Infographic: **Lawrence Tsuei**
Video Credit: **Joseph Foulk, Ernesto Sanchez and Roberto Lazarte**

Story Images

Published on May 12, 2023

General Rate Case FAQs / Fact Sheet / Infographic

Customers experiencing fewer outages, faster power restoration and continued improvements to the safe delivery of reliable electric service – these are a few of the priorities addressed in Southern California Edison's 2025 General Rate Case, which was filed today with the California Public Utilities Commission.

Other priorities include:

- Building on achievements in wildfire risk reduction;
- Boosting electric grid resilience to withstand rising threats from extreme weather and cyberattacks; and

Ensuring the grid's readiness for rapid growth in customer demand for energy.

SCE's request continues its urgent wildfire prevention program, including the addition of 1,250 miles of coated wire between 2025-2028. At the same time, SCE plans to ramp up the traditional "nuts-and-bolts" work of replacing aging grid equipment across its service area to preserve grid health and reliability.

VIDEO: Southern California Edison's 2025-2028 General Rate Case filing seeks to build on wildfire risk reduction, boost electric grid resilience and ensure the grid's readiness for rapidly growing energy demands.

With customers adding more electric vehicles and clean energy technologies, SCE also expects to continue modernizing and upgrading the grid to prepare for the largest expected increase in electricity demand in decades.

"SCE's emphasis on foundational investments will further strengthen the electric grid," said Colin Lavin, business manager and financial secretary for the International Brotherhood of Electrical Workers Local 47, whose members are on the front lines of keeping power flowing to 15 million residents in SCE's service area.

"These investments foster worker and public safety, protect the electric grid against the impacts of extreme weather and support IBEW members in their work to keep service reliable and the lights on for customers," he said.

Strengthening the electric grid is also a major concern for Dustin Gardner, fire chief of the Ventura County Fire Department.

"SCE is a critical partner to California's firefighting community, and in recent years they've made significant progress in reducing wildfire risk," said Gardner. "There's more work ahead, and with public safety at stake, we must continue this partnership and invest in hardening the electric grid against the rising threats of extreme weather events."

SCE owns more than 126,000 miles of transmission and distribution lines serving more than 5 million customer accounts.

“This request comes at a crucial turning point in California’s clean energy transformation,” said Russell Archer, director of SCE’s General Rate Case. “In the near future, the electric grid will support vastly more renewable energy. Many more customers are adding electric vehicles, battery storage and electric heat pumps in their home and work lives, a trend that’s only increasing. That’s one reason why this GRC request is vital for SCE to continue meeting customers’ needs today while also preparing for that future.”

If the commission approves SCE’s full request, the average monthly bill for residential customers would increase by about $17 in 2025, and about $5 each year thereafter through 2028. The impacts will be less for lower-income customers enrolled in SCE’s Bill Assistance Programs — about $12 in 2025, $3 in 2026 and 2027 and $4 in 2028.

"SCE understands that rate increases are difficult for customers," said Archer. “This GRC request balances the need to keep customer bills manageable with the necessary work to strengthen reliability, resilience and readiness to meet rapidly growing customer needs.”

The General Rate Case is a regulatory process conducted by the CPUC that determines how much investor-owned utilities like SCE can charge customers for electric service. Utilities submit a rate case to request funding of day-to-day operations for an established four-year spending cycle. This SCE request covers the years 2025-2028. ***(See this Fact Sheet.)***

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Reducing wildfire risk associated with our utility equipment by **75%-80%** since 2018

Significantly reducing Public Safety Power Shutoff (PSPS) events

89% fewer customers impacted in 2022

Helping California avoid rotating

outages by bringing **2,000 MW** of emissions-free energy storage online

71% fewer power interruptions on circuits with coated wire

53% fewer tree-caused power interruptions

SCE'S GENERAL RATE CASE IS CRUCIAL TO CONTINUING THIS ESSENTIAL PROGRESS

Attachment 82

Comments of Environmental and Public Health Organizations on:

EPA, California State Motor Vehicle Pollution Control Standards; Advanced Clean Cars II Regulations; Request for Waiver of Preemption; Opportunity for Public Hearing and Public Comment, 88 Fed. Reg. 88908 (December 26, 2023); Docket ID No. EPA–HQ–OAR–2023–0292

Submitted February 27, 2024

Who We are

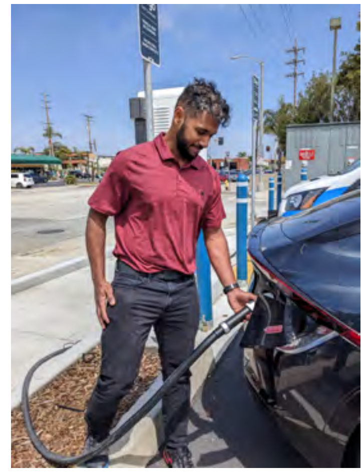
The National Charging Experience Consortium, or ChargeX Consortium, is a collaborative effort between Argonne National Laboratory, Idaho National Laboratory, National Renewable Energy Laboratory, electric vehicle (EV) charging industry experts, consumer advocates, and other stakeholders.

Our Mission

Our mission is to work together as EV industry stakeholders to measure and significantly improve public charging reliability and usability by June 2025.

The Process

To achieve our mission, the Consortium will divide into three working groups to exchange information that helps the national labs complete the following objectives:



Define the Charging Experience: With the help of data and insights from Consortium participants, the national labs will define and publish key performance indicators that measure the customer charging experience, set targets for each performance indicator, measure performance of charging networks in the U.S., and provide a blueprint for recognizing excellence in industry**.**

Triage Charging Reliability and Usability: The national labs will work with Consortium participants to understand the root causes and quickly identify solutions to problems that prevent customers from successfully charging on public chargers, with emphasis on issues related to payment, user interface, and communication between EVs, chargers, and cloud services.

Develop Solutions for Scaling Reliability: With input from Consortium participants, the national labs will design new diagnostics and testing tools to ensure successful charging and scalable interoperability testing as the number of EVs and EV chargers continue to grow.

Participating Organizations

The following EV industry stakeholders are participating with the national labs in the consortium:

Current Consortium Participants:

- **ABB E-mobility (https://e-mobility.abb.com/)**
- **AeonCharge (https://www.aeoncharge.com/)**
- American Honda
- Ampcontrol
- **AMPECO (https://www.ampeco.com/)**
- Amphenol
- **ampUp (https://ampup.io/)**
- Autel
- **Blink Charging (https://blinkcharging.com/)**
- **Bluedot (https://thebluedot.co/)**
- **BMW of North America (https://www.bmwusa.com/)**
- **Bosch (http://www.bosch-mobility.com/en/solutions/charging/convenience-charging/)**
- **bp pulse (https://bppulsefleet.com/)**
- **BTC Power (https://btcpower.com/)**
- **ChargeHub (https://chargehub.com/en/)**
- **ChargePoint (https://www.chargepoint.com/)**
- **ChargerHelp! (https://www.chargerhelp.com/)**
- **CharIN (https://www.charin.global/contact/north-america/)** (Charging Interface Initiative North America)
- **Consumer Reports (https://www.consumerreports.org/)**
- **Cool the Earth (https://cooltheearth.org/)**
- **COVESA (http://www.covesa.global)**
- **Discover Global Network (https://www.discoverglobalnetwork.com/)**
- Dover Fueling Solutions
- **Eaton (https://www.eaton.com/us/en-us.html)**
- **Electrify America (https://www.electrifyamerica.com/)**
- **Enel X Way (https://www.enelxway.com/us/en)**

- **Energetics (https://www.energetics.com/)**
- **EPRI (http://www.epri.com/)**
- **EV Connect (https://www.evconnect.com/)**
- **EVBox (https://evbox.com/us-en/)**
- **EVgo (http://www.evgo.com/)**
- **EVSession (https://www.evsession.com/components)**
- **Field Advantage (http://www.fieldadv.com)**
- **FLO (http://www.flo.com/)**
- **Ford Motor Company (http://www.ford.com/)**
- **FreeWire Technologies (https://freewiretech.com/)**
- **Francis Energy (https://francisenergy.com/)**
- **General Motors (http://www.gm.com/)**
- **Hertz (http://www.Hertz.com)**
- **Hubject (https://www.hubject.com/)**
- **IoTecha (https://www.iotecha.com/)**
- **J.D. Power (https://www.jdpower.com/)**
- **KIGT (https://www.kigtinc.com/)**
- **Koulomb Fast Charging (http://www.koulomb.com)**
- **Lucid (https://lucidmotors.com/)**
- Mercedes Benz
- **Nayax (http://www.nayax.com)**
- **New York Power Authority (https://www.nypa.gov/)**
- **Noodoe (https://www.noodoe.com/)**
- **NovaCHARGE (https://www.novacharge.net/)**
- **Open Charge Alliance (http://www.openchargealliance.org/)**
- **Payter (https://www.payter.com/)**
- **PIONIX (http://www.pionix.com)**
- **Plug In America (https://pluginamerica.org/)**
- **Rivian Automotive (http://www.rivian.com/)**
- **SAE Sustainable Mobility Solutions (https://sms.sae.org/)**
- **Siemens (https://www.siemens.com/)**
- **SK signet (https://sksignet.us/)**
- **Stellantis (https://www.stellantis.com/en)**
- **Subaru of America Inc. (https://www.subaru.com/index.html)**
- **Switch (https://www.switch-ev.com/)**
- **SWTCH Energy (https://swtchenergy.com/)**
- **Tesla (http://www.tesla.com/)**
- **Toyota Motor North America (www.toyota.com)**
- **Transportation Energy Institute (https://www.transportationenergy.org/)**
- **Tritium (https://tritiumcharging.com/)**
- **University of California, Davis (https://www.ucdavis.edu/)**
- **University of Washington (https://www.washington.edu/)**
- **Uptime Charger (https://www.uptimecharger.com/)**
- **VinFast Auto (https://vinfastauto.us/)**
- **Volvo Car USA (https://www.volvocars.com/us/)**
- **Wallbox (http://www.wallbox.com)**
- **Xeal Energy (https://xealenergy.com/)**

Attachment 83

Comments of Environmental and Public Health Organizations on:

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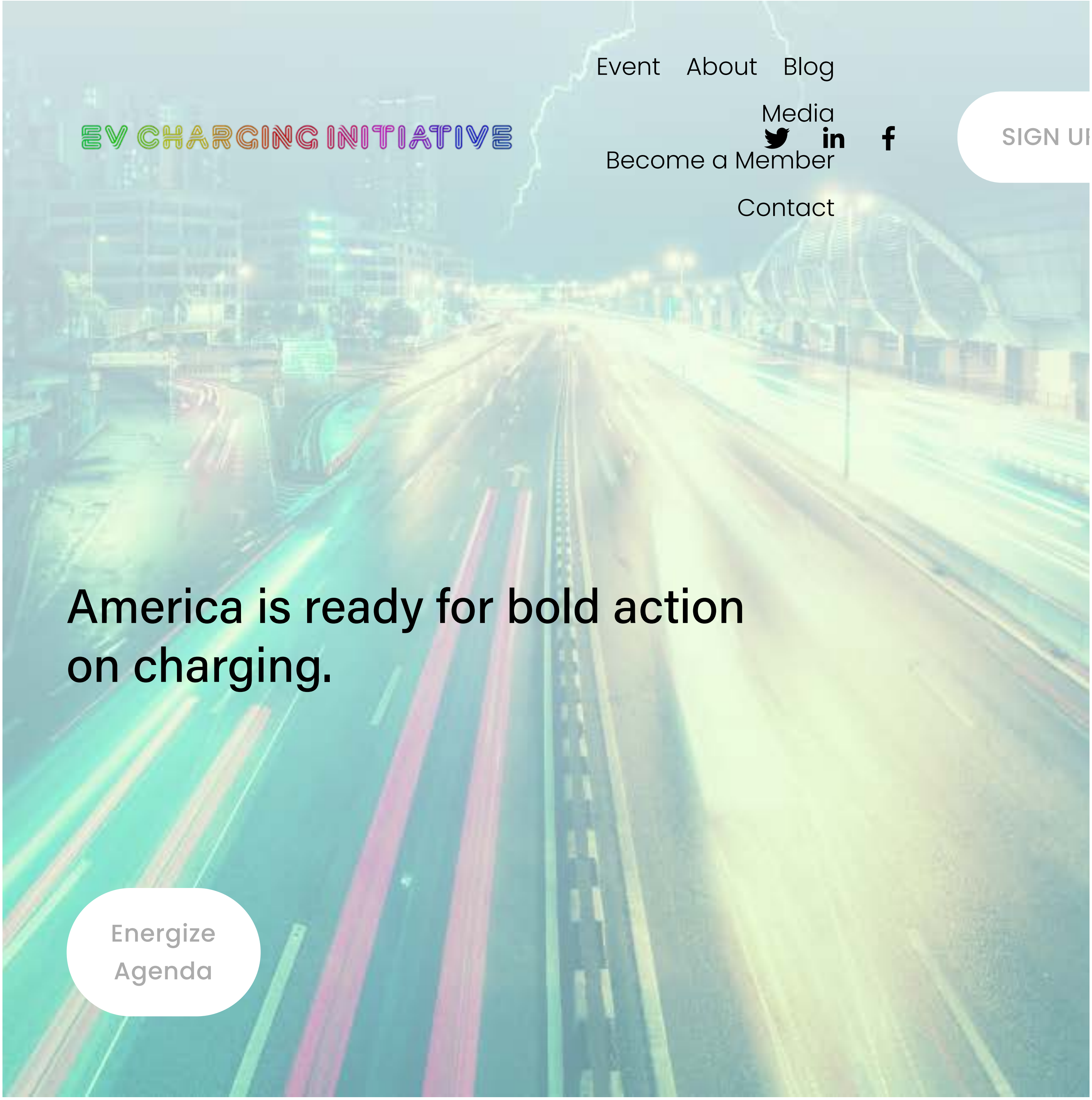

EV CHARGING INITIATIVE

America is ready for bold action on charging.

Energize Agenda

Partnering for a national charging network that delivers cleaner air, climate action and good-paying jobs.

Our Commitments

The **National EV Charging Initiative** brings together automakers, power providers, electric vehicle and charging industry leaders, labor, and public interest groups to signal they are ready, willing and able to support federal action on a national charging network for light, medium and heavy-duty vehicles. Members collaborate to accelerate shovel-ready charging infrastructure projects that will put people to work, infuse the economy with billions of dollars of investment, and increase access to clean transportation.

It’s time to fuel the zero-emission transportation future.

Advancing the latest technology

Creating good jobs that support families

Catalyzing private investments

Improving equitable access for all

The Biden Administration is moving aggressively to address climate change and understands the urgency and challenges of cutting climate pollution from cars and trucks. The **National EV Charging Initiative** is meeting the moment and setting a new pace for electric vehicle adoption that will reap benefits for communities from coast to coast.