TRANSPOWER

Operations Division

UG-OC-841 NZGB - Application and Calculation User Guide

This Userguide is part of the Outages and Constraints (OC) process within Transpower and forms part of the System Operator function. The document can be found in the Operational Documentation Library

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Prepared By: Alex Shin	Operations Planning Engineer	02/11/22
Reviewed By: Anjana Madurapperuma	Operations Planning Engineer	02/11/22
Approved By: Minura Vithanage	Planning and Project Support Manager	03/11/22

Ref	Related Artefact	Description	Location
1.			
2.			
3.			
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Contact Details

Address: Transpower New Zealand Ltd
22 Boulcott St
PO Box 1021
Wellington
New Zealand

Telephone: +64 4 495 7000

Email: system.operator@transpower.co.nz Website: https://www.transpower.co.nz

Contents

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1 Introduction

1.1. Document Purpose and Scope

This is the user guide for Asset Owners (AOs) using the NZGB application which is part of the Operations Customer Portal. This user guide document describes the features of NZGB, instructions on how to use the application and a definition of the generation balance calculation including the underlying assumptions.

1.2. Operations Customer Portal Overview

The Operations Customer Portal provides centralised access to the following System Operator applications:

- Planned Outage Co-ordination Process (POCP)
- Automated Under Frequency Load Shedding (AUFLS)
- Asset Capability Statement (ACS)
- New Zealand Generation Balance (NZGB)

In the future, it will be extended to include:

- Dispensations and Equivalence (D&E)

The URL to access the Operations Customer Portal is https://customerportal.transpower.co.nz/

1.3. NZGB overview

The New Zealand Generation Balance (NZGB) is an outage assessment tool utilised by Transpower's Operations Planning Group. The NZGB application takes scheduled equipment outages from the Planning and Outage Co-ordination (POCP) website and forecasts whether there will be enough generation capacity to securely meet demand (i.e. to also meet frequency keeping and reserve requirements). This can be used to:

- Communicate to industry participants any potential North Island generation balance shortfalls over the next 200 days.
- Provide industry participants with a means of assessing the potential impact of their planned outages on the North Island generation balance.
- Enable industry participants to select optimum outage periods with least impact to the North Island generation balance.

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2 Registering

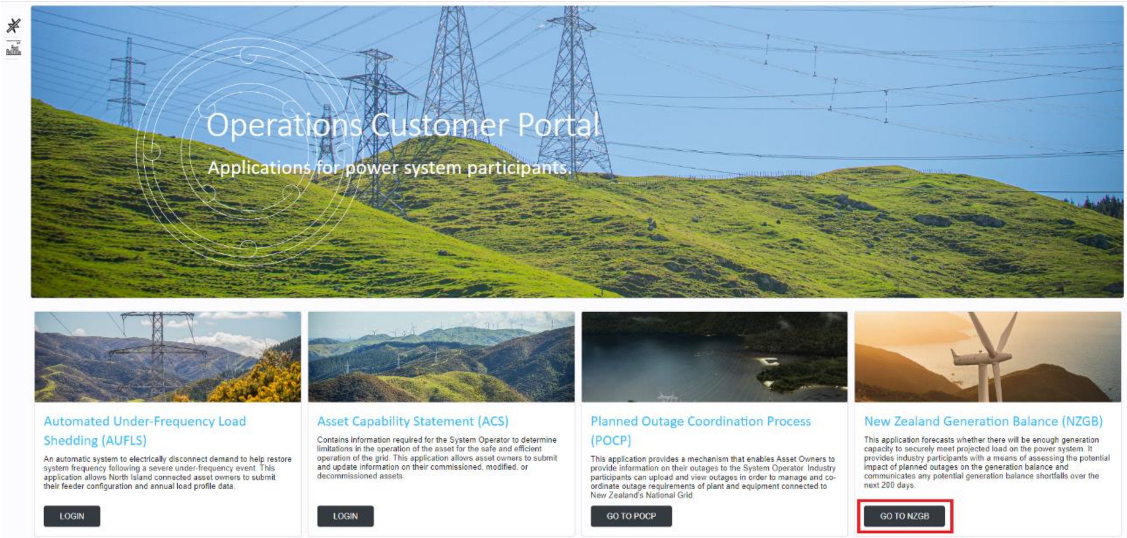
All accounts registered under any customer portal application will have access to NZGB. However, NZGB is open to registration for non-Asset Owner users through the NZGB application. This registration form is for users who do not belong to an electricity industry asset owner to request a login so they can view extended generation balance data and can be notified of new document uploads. This registration request will be sent to Transpower for fulfilment.

2.1 User types

Users have the following accesses:

User	Description
Guest	• View short term and long term N-1-G balance • View documents, including monthly reports and any assessments • Adjust timeframes to view generation balances
Registered	• View short term and long term N-1 balance • View generation, load, and HVDC transfer limits used in calculation • View outage Gantt chart • Select generation balance for a given day to get further details on calculation values used, outages considered, and available generation by station • Get email notifications when new documents (e.g. monthly report or assessment) are uploaded to the NZGB website • View comments made by NZGB admins

2.2 How to register

Step	Description
1.	Navigate to the customer portal landing page and click on New Zealand Generation Balance (NZGB). 
1.	Click on "Guest" to open the User menu.

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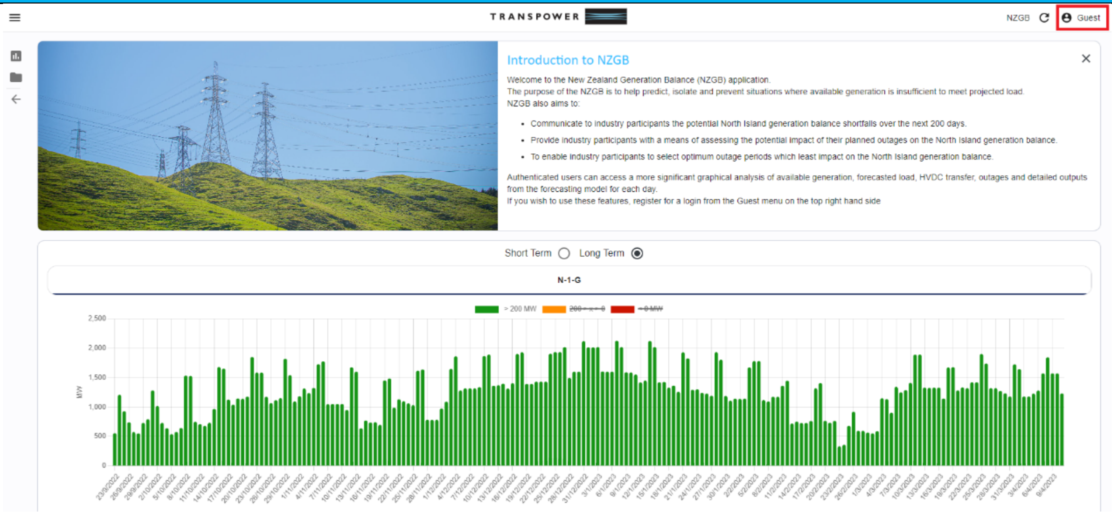
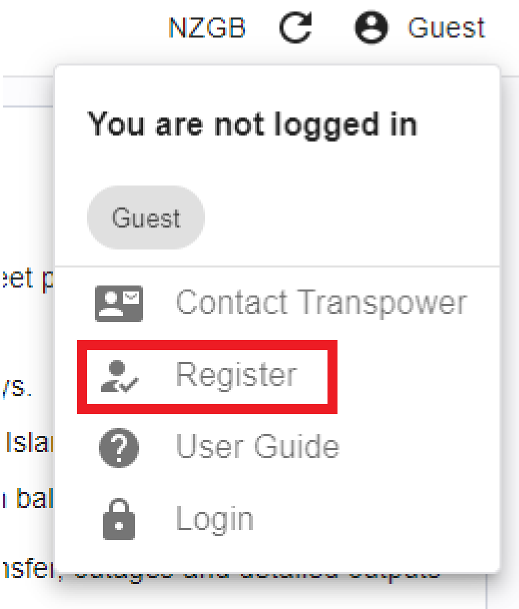
<table>
<tr><th>Step</th><th>Description</th></tr>
<tr><td></td><td>


</td></tr>
<tr><td>2.</td><td>Click on the “Register” button


</td></tr>
<tr><td>3.</td><td>Fill out the information</td></tr>
</table>

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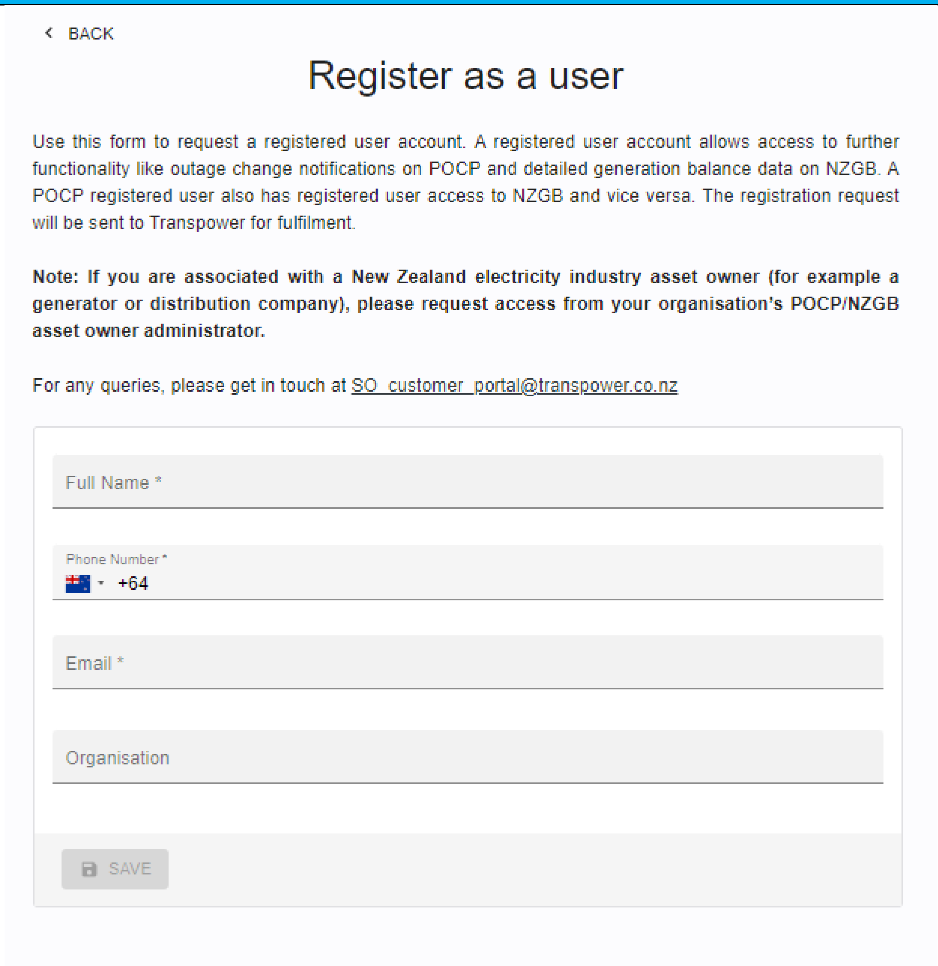
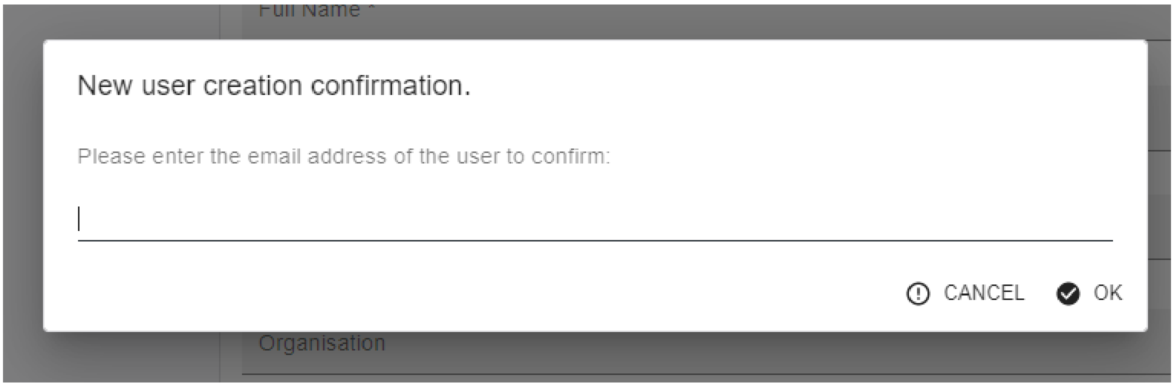
<table>
<tr><th>Step</th><th>Description</th></tr>
<tr><td></td><td>


</td></tr>
<tr><td>4.</td><td>You will be prompted to confirm your email address.


</td></tr>
<tr><td>5.</td><td>A prompt will appear confirming that you have registered and that your application has been sent to be reviewed.</td></tr>
</table>

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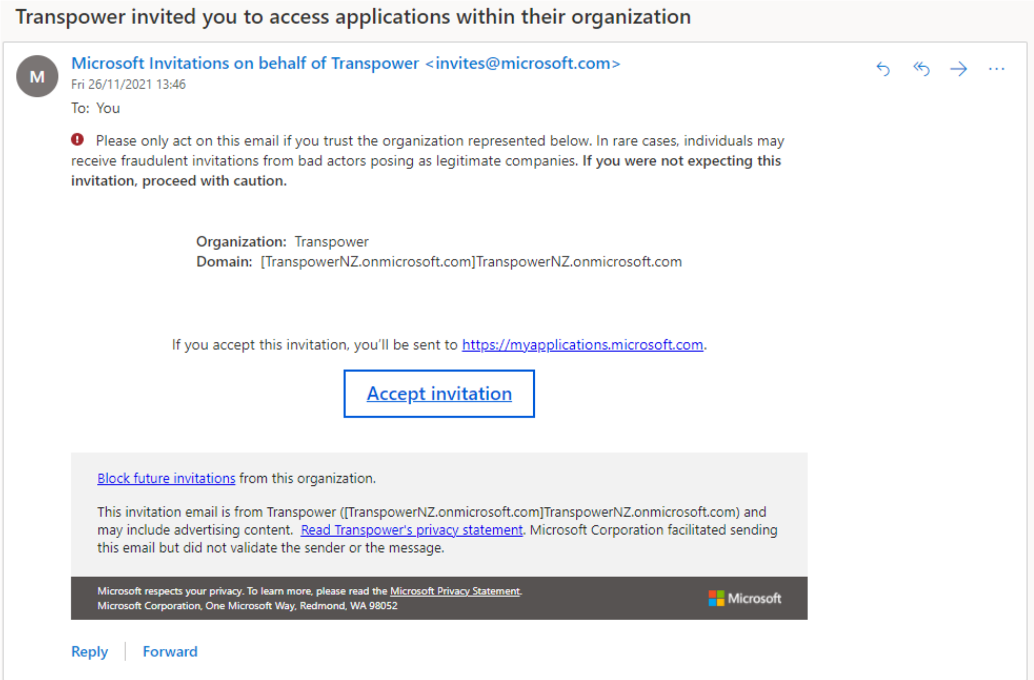
3 Logging In

3.1 Initial Log In

Once a user has been set up, they will receive an e-mail with a link to access the NZGB application.

The steps to log in initially which are outlined below may vary slightly depending on:

- whether the user's e-mail address is attached to an existing Microsoft account – if not, they will be prompted to create an account as a part of the sign in process.
- the verification settings on their Microsoft account (i.e. – whether they have opted for verification by text, e-mail, or phone call).

Step	Description
1.	The e-mail will look as below and is sent from 'invites@microsoft.com'. Click on the 'Accept Invitation' link. 
2.	If the e-mail is linked to an existing Microsoft account enter the password for that account and click on the '**Sign in**' button. 

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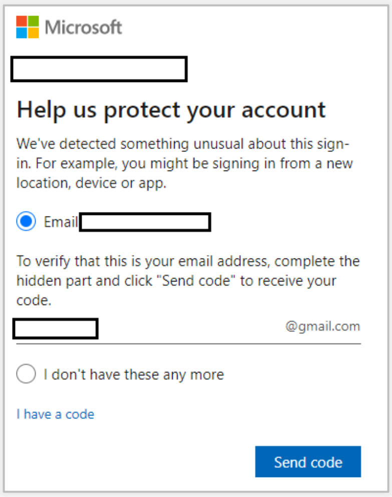
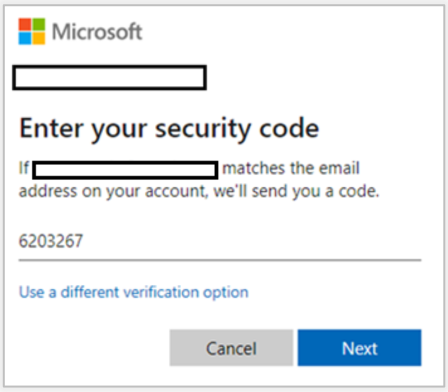
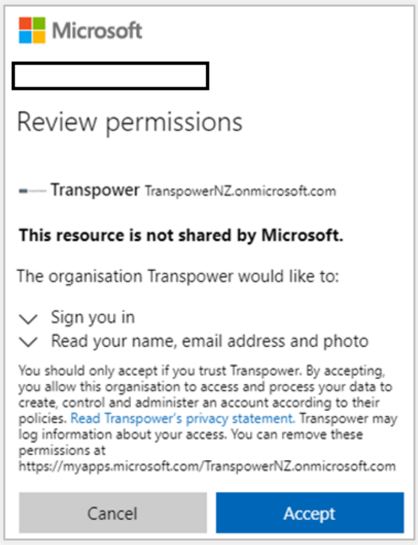
Step	Description
3.	The following message will also display asking you to verify your e-mail address. Click on the '**Send code**' button. **NOTE:** You may receive an e-mail to your e-mail address with the subject line 'Microsoft unusual sign-in activity'. 
4.	You will be sent an e-mail with a security code, enter it in the field provided and click on the '**Next**' button. 
5.	The following message will display. Click on the '**Accept**' button. 

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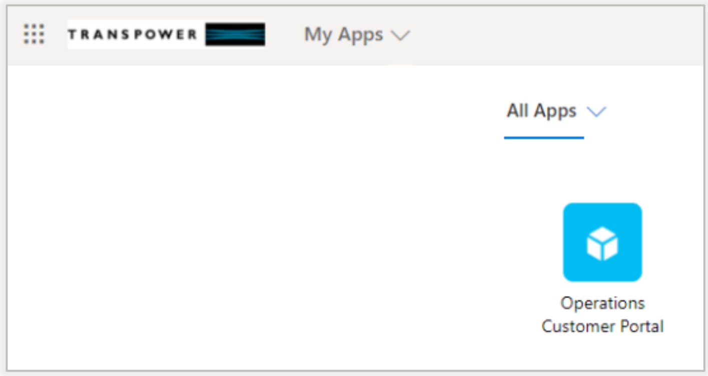
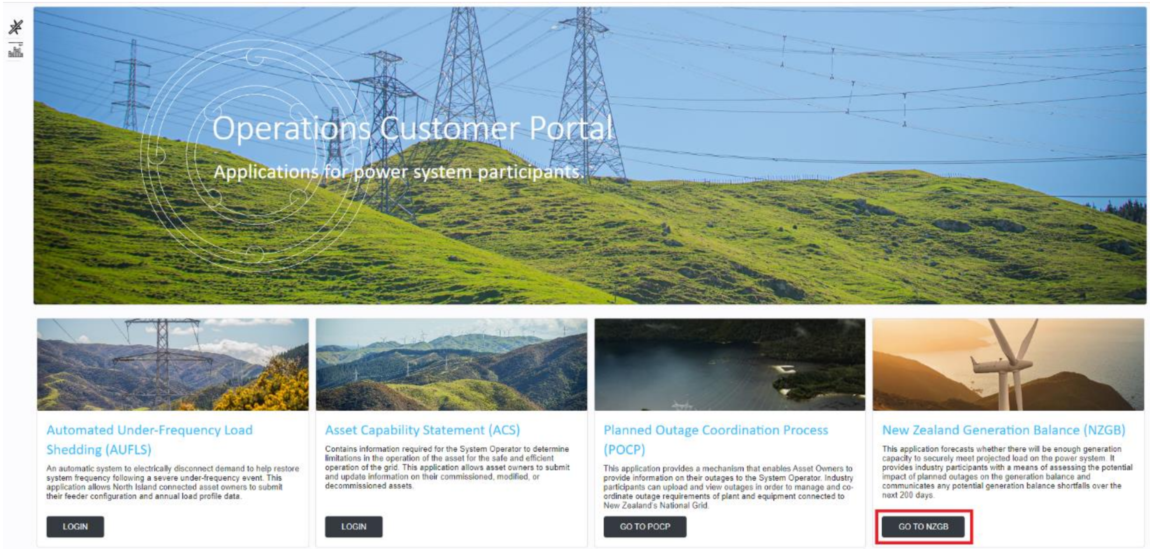
<table>
<tr><th>Step</th><th>Description</th></tr>
<tr><td>6.</td><td>You will be taken to this landing page – click on the' Operations Customer Portal' icon

</td></tr>
<tr><td>7.</td><td>You will be taken to the 'Operations Customer Portal' landing page – click on the 'Go to NZGB' button.

</td></tr>
</table>

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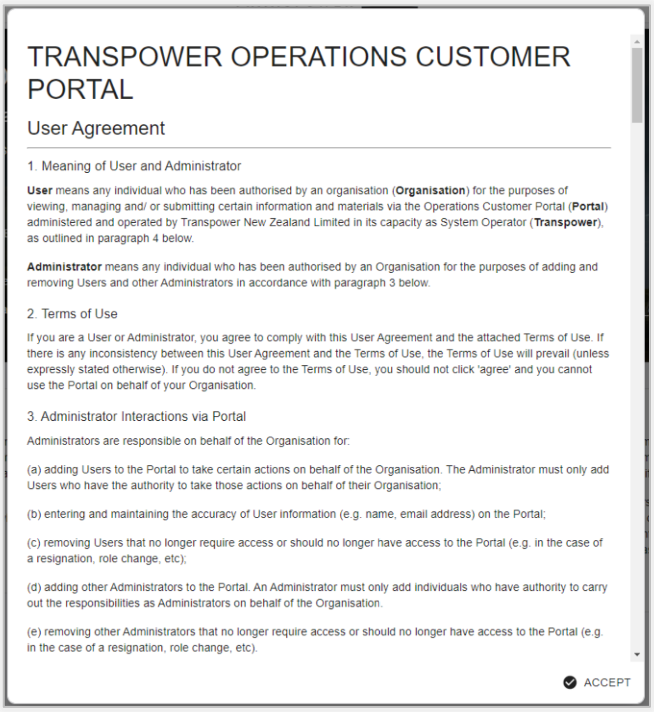
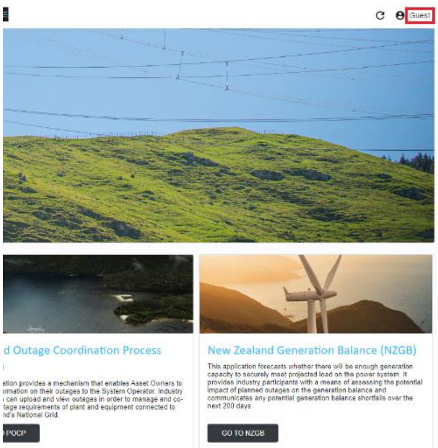
<table>
<tr><th>Step</th><th>Description</th></tr>
<tr><td>8.</td><td>You will see the 'User Agreement' pop-up screen – Read through the User Agreement and click on the 'ACCEPT' button if you wish to continue.

</td></tr>
</table>

3.2 Subsequent Log Ins

When a user logs in after the initial log in, they will only need to enter their email address and password – they will not be asked to enter a security code.

<table>
<tr><th>Step</th><th>Description</th></tr>
<tr><td>1.</td><td>Enter the following URL in a web browser – https://customerportal.transpower.co.nz/. You will be taken to the 'Operations Customer Portal' home page.</td></tr>
<tr><td>2.</td><td>

Click on the 'Guest'</td></tr>
</table>

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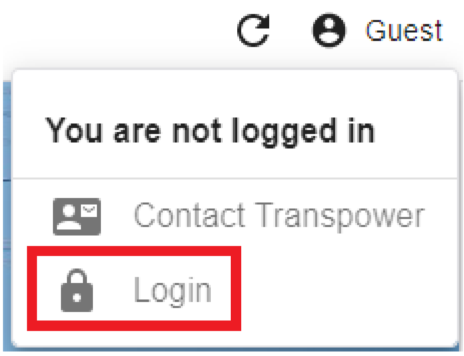
Step	Description	
		Click on the 'Login' button.

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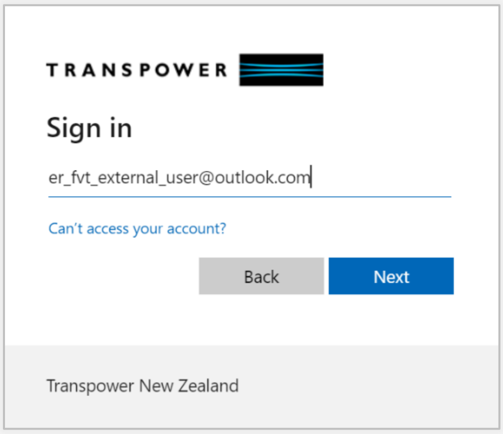
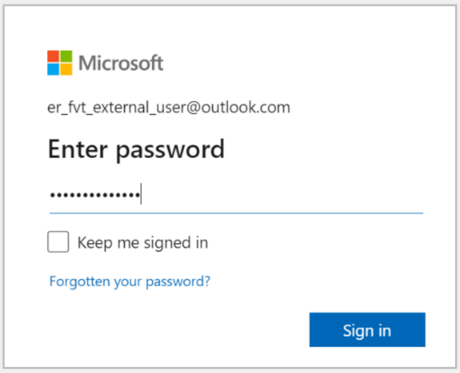
<table>
<tr><th>Step</th><th>Description</th></tr>
<tr><td>3.</td><td>


Enter your email address and press the 'Next' button.</td></tr>
<tr><td>4.</td><td>


You will be taken to an 'Enter password' pop-up screen – enter your password and press the 'Sign in' button.</td></tr>
<tr><td>5.</td><td>You will be logged into the portal and taken back to the Operations Customer Portal home page. From here, access the NZGB application as normal.</td></tr>
</table>

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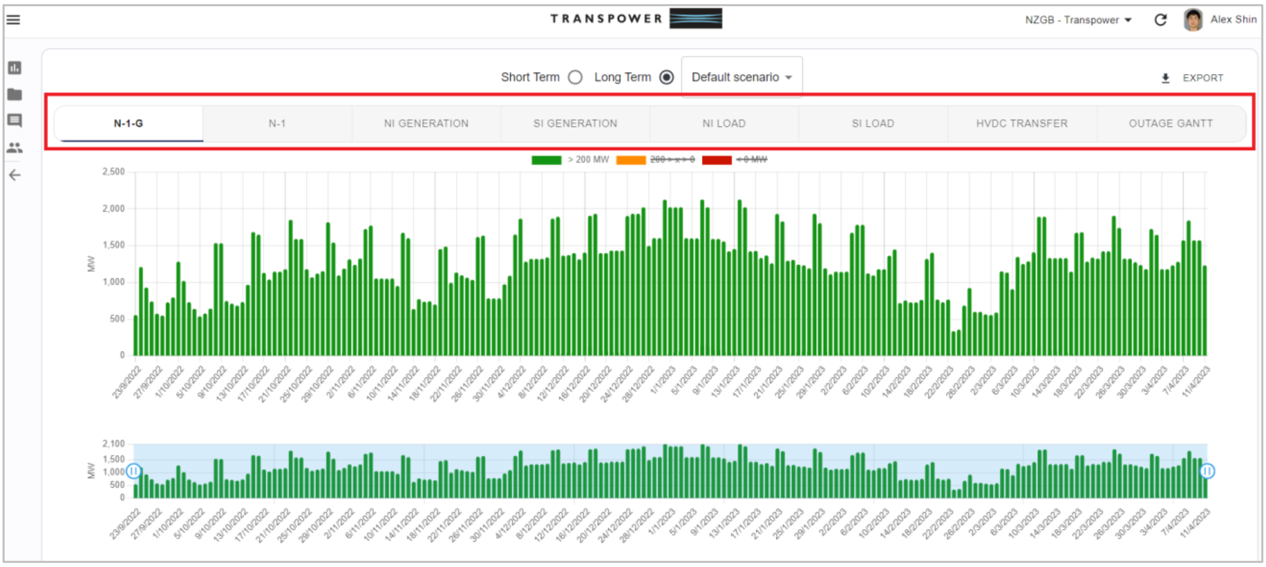
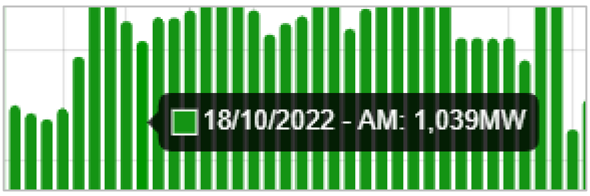
4 NZGB Dashboard

The 'NZGB Dashboard' is the landing page after logging into the NZGB application. It has several tabs to switch between different graphs. The user can move between graphs with the timeframe in the window fixed. To restore the configuration to default settlings, i.e. slider bar, zoom, etc, the user can refresh the page or press 'F5' button on their keyboard.



- **N-1-G:** Shows the available generation capacity to securely supply demand after the occurrence of the worst-case contingent event, with reserves considered to cover the next worst event.
- **N-1:** Shows the available generation capacity to securely supply demand with reserves considered to cover the next worst event.
- **NI/SI Generation:** The available generation after all outages are considered
- **NI/SI Load:** The worst-case load assumptions used in the calculation
- **HVDC Transfer:** The HVDC limit after all HVDC equipment outages are considered. The limits are based on Transpower's Bipole Operating Policy
- **Outage Gantt:** A high level overview of the outage impacts based on stations or transmission assets

For each segment of the graph, more information about each day can be seen by hovering over each bar. For example, N-1-G will show the date and worst-case value in MW, along with which period it was selected from (whether an AM or PM), and the colour of the bar will represent different MW values based on the margin thresholds (Red < 0MW, 0MW< Orange < 200MW, 200MW < Green):



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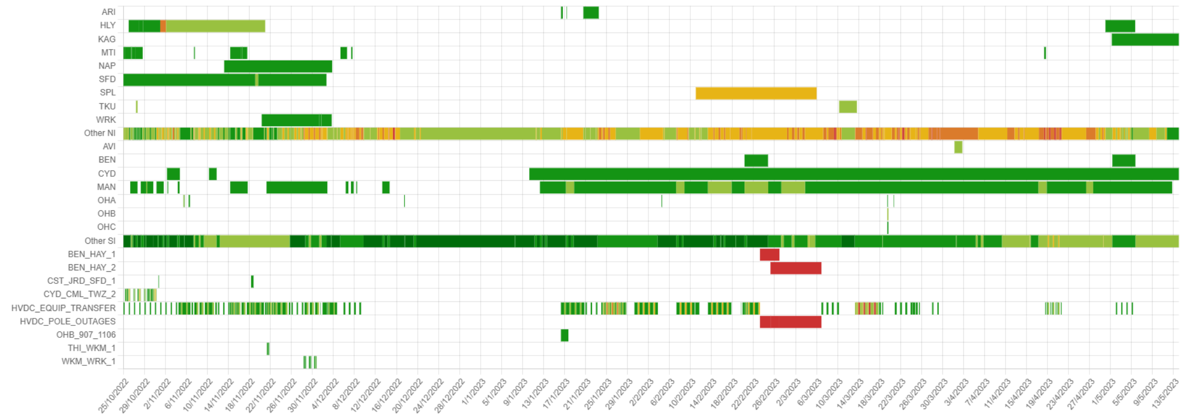
The Gantt chart is an exception to the other graphs as the time resolution shows up to 1 minute as opposed to 1 day (all other graphs). The Gantt chart values displayed are based on calculated values output by the NZGB model.



Note: 'other_si' , ' other_ni', and 'HVDC_EQUIP_TRANSFER' are aggregated values. The segments used for these are further categorised as 0- 99MW, 100-199MW, etc

At the top of the dashboard the user can select, using the radio button, the type of load forecast and timeframe they would like to use to generate the graphs. The short term looks 3 weeks ahead and uses the short-term load forecast, while the long term looks 200 days ahead and uses the long-term load forecast.

The slider bar on the bottom of the page can be adjusted to focus on a particular range of time in interest.

Adjusting the slider bar will change what is displayed on the graphs:

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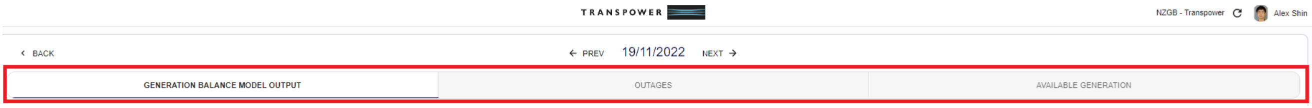
5 Navigating the New Zealand Generation Balance

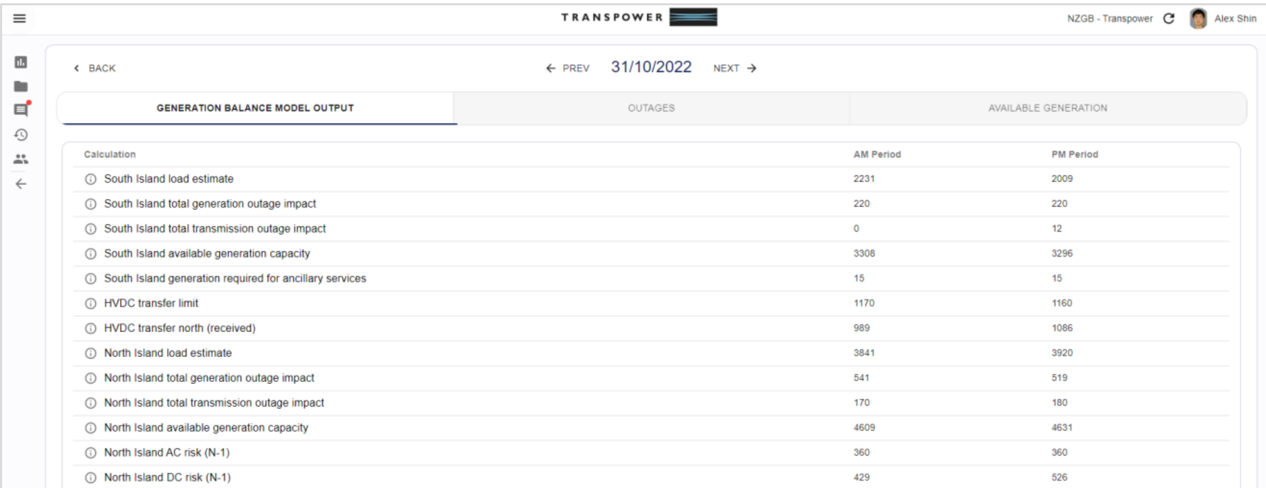
5.1 Daily Detail Page

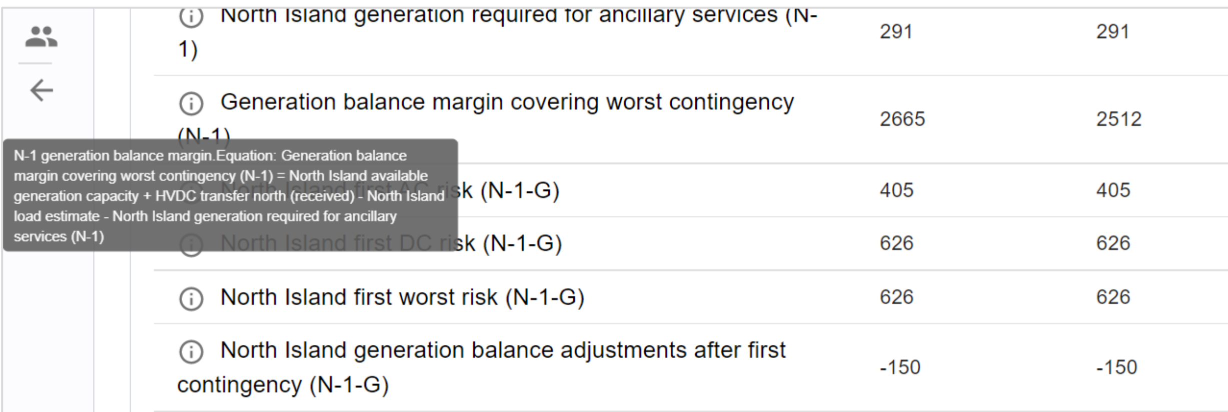
Once a segment on the dashboard graph is clicked, the user will be directed to a daily detail page where a break-down of Generation Balance Model Output, Outages, and Available Generation will be displayed under their corresponding tab.



5.1.1 *Generation Balance Model Output*

This contains the output produced by the NZGB model and can be used by the user to interpret the inputs and the intermediary steps taken during the calculation. Hovering over the help symbol on the right of the output name will display more information about the item and some will include equations that the value is derived from.





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Day Calculation Display Item	Description
South Island load estimate	Forecast South Island load and losses.
South Island total generation outage impact	Impact of South Island generation outages on the total available generation capacity.
South Island total transmission outage impact	Impact of South Island transmission outages on risk and available generation capacity.
South Island available generation capacity	South Island available generation capacity when transmission and generation outages are taken into account.
South Island generation required for ancillary services	South Island generation capacity required for reserve and frequency keeping.
HVDC transfer limit	The power transfer limit / capacity of the HVDC link (sent from Benmore).
HVDC transfer north (received)	The maximum power transferred north (received at Haywards) over the HVDC link. This value considers the excess generation in the South Island, the HVDC transfer capacity and losses inherent in the HVDC link.
North Island load estimate	Forecast North Island load and losses.
North Island total generation outage impact	Impact of North Island generation outages on the total available generation capacity.
North Island total transmission outage impact	Impact of North Island transmission outages on risk and available generation capacity.
North Island available generation capacity	North Island available generation capacity when transmission and generation outages are taken into account.
North Island AC risk (N-1)	Highest AC risk (generating unit) in the North Island.
North Island DC risk (N-1)	Highest DC risk (HVDC component) to be covered by reserves in the North Island.
North Island worst risk (N-1)	The highest of the AC and DC risks above.
North Island generation required for ancillary services (N-1)	North Island generation capacity required to provide reserves for the risk above and frequency keeping (i.e., risk and frequency keeping less interruptible load).
Generation balance margin covering worst contingency (N-1)	N-1 generation balance margin.

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Day Calculation Display Item	Description
North Island first AC risk (N-1-G)	Highest AC risk in the North Island before any contingencies are applied for the N-1-G generation balance calculation. This value will be identical to "North Island AC risk (N-1)".
North Island first DC risk (N-1-G)	Highest DC risk in the North Island before any contingencies are applied for the N-1-G generation balance calculation. For the loss of the first pole, this risk value uses the continuous rating risk subtractor of 500 MW. Therefore, this value could be different from the "North Island DC risk (N-1)"
North Island first worst risk (N-1-G)	The highest of the first AC and DC risk above, which could be different to "North Island worst risk (N-1)".
North Island generation balance adjustments after first contingency (N-1-G)	This is the adjustment that would need to be done to the N-1 generation balance margin due to the difference between "North Island first worst risk (N-1-G)" and "North Island worst risk (N-1)". Any difference is due to the different HVDC risk subtractors used for the N-1 and N-1-G generation balance calculations.
North Island second AC risk (N-1-G)	Highest AC risk in the North Island after the first worst case contingency has already occurred for the N-1-G generation balance calculation.
North Island second DC risk (N-1-G)	Highest DC risk in the North Island after the first worst case contingency has already occurred for the N-1-G generation balance calculation.
North Island second worst risk (N-1-G)	The highest of the second AC and DC risks above.
North Island generation required for ancillary services to cover second risk (N-1-G)	This is the quantity of generation that is required to cover reserves and frequency keeping for the next contingency.
Generation balance margin covering the next worst contingency (N-1-G)	N-1-G generation balance margin.
Selected minimum time	The precise time instance at which results are being displayed and when the lowest generation balance occurred.

5.1.2 Outages

In this section the user will be able to see the effects of various outages on the NZGB model. There will be a table containing a list of all the outages considered for a particular day and the POCP links on the left-hand column. Each outage will display its planning status, start time, end time, and amount of MW they reduce the generation balance by for the AM and PM peaks.

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POCP Outage ID	Generator/Circuit	Planning Status	Start Time	End Time	MW Loss	MW Reduced AM	MW Reduced PM
›	HVDC				-	90	90
1112532	CST_JRD_SFD_1	confirmed	31/10/2022 07:30	31/10/2022 18:30	-	50	50
1113659	CYD_CML_TWZ_2	confirmed	25/10/2022 07:30	31/10/2022 17:00	-	0	12
1121130	SFD_CB_552	confirmed	25/10/2022 15:00	03/11/2022 18:00	-	0	0
1117570	JRD_SFD_1	confirmed	31/10/2022 07:30	18/11/2022 18:30	-	-	-
76530	HLY_2	confirmed	15/10/2022 00:00	02/11/2022 03:00	240	250	250

The HVDC outage can be clicked, which will expand it to show the risk from filter outages (HVDC_FILTERS_RISK), the reduction in transfer limit due to equipment or circuit outages (HVDC_EQUIP_TRANSFER), and the loss from a pole or bipole outage (HVDC_POLE_OUTAGE). Each of these segments can also be expanded to view the individual components that contribute to the reduction. The HVDC number used in the NZGB calculation is the worst case of these three segments.

POCP Outage ID	Generator/Circuit	Planning Status	Start Time	End Time	MW Loss	MW Reduced AM	MW Reduced PM
1117570	JRD_SFD_1	confirmed	31/10/2022 07:30	18/11/2022 18:30	-	-	-
1112532	CST_JRD_SFD_1	confirmed	31/10/2022 07:30	31/10/2022 18:30	-	50	100
1113659	CYD_CML_TWZ_2	confirmed	25/10/2022 07:30	31/10/2022 17:00	-	0	12
⌄	HVDC				-	90	90
⌃ HVDC_FILTERS_RISK					-	90	90
POCP Outage ID	Generator/Circuit	Planning Status	Start Time	End Time	MW Loss	MW Reduced AM	MW Reduced PM
1113999	BEN_F_4	confirmed	31/10/2022 07:30	04/11/2022 18:30	-	-	-
1114015	HAY_F_6	confirmed	31/10/2022 07:00	04/11/2022 18:00	-	-	-
⌄ HVDC_EQUIP_TRANSFER					-	30	40
HVDC_POLE_OUTAGES					-	-	-

5.1.3 Available Generation

This screen shows the available generation at each generating site based on AM and PM timeframes. This considers generation and transmission outages, transmission constraints (they will be flagged 'Yes' in the Constrained column), and 20% Wind assumption for Wind generators. Rows are highlighted in red for the stations that have outages or are constrained, reducing their output below their maximum.

TAGES | AVAILABLE GENERATION

South Island Generators

Station	Form of Energy	Max Output	Constrained	AM Output	PM Output
AVI	Hydro	220	-	165	165
BBR	Hydro	11	-	11	11
BEN	Hydro	540	-	540	540
COB	Hydro	32	-	32	32
COL	Hydro	45	-	42	45
CYD	Hydro	432	Yes	432	420
HBK	Hydro	27	-	27	27
KUM	Hydro	7	-	7	7
MAH	Wind	36	-	7	7
MAN	Hydro	847	-	729	729
OHA	Hydro	248	-	248	248
OHB	Hydro	212	-	159	212
OHC	Hydro	212	-	212	212
PRU	Hydro	12	-	12	12
ROX	Hydro	320	-	280	280
TKA	Hydro	25	-	25	25
TKB	Hydro	146	-	146	146
WHL	Wind	56	-	7	7
WPI	Hydro	84	-	84	84
WTK	Hydro	90	-	75	90
		Wind Output: 92 Max Output: 3602		3240	3299

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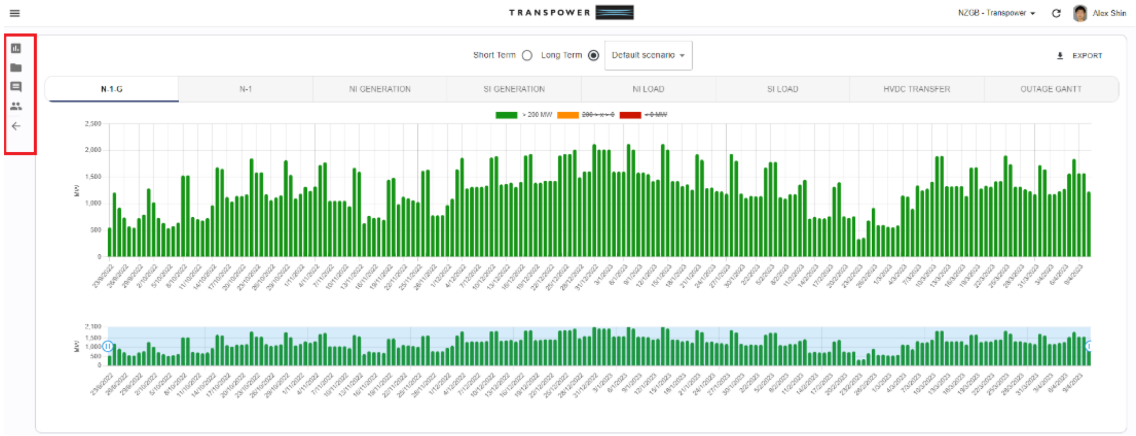
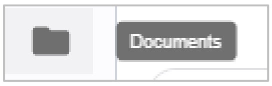
6 NZGB Menu

The NZGB Menu contains links to the various parts of the NZGB application – the generation balance outputs, the documents, and the comments made by the NZGB administrators.

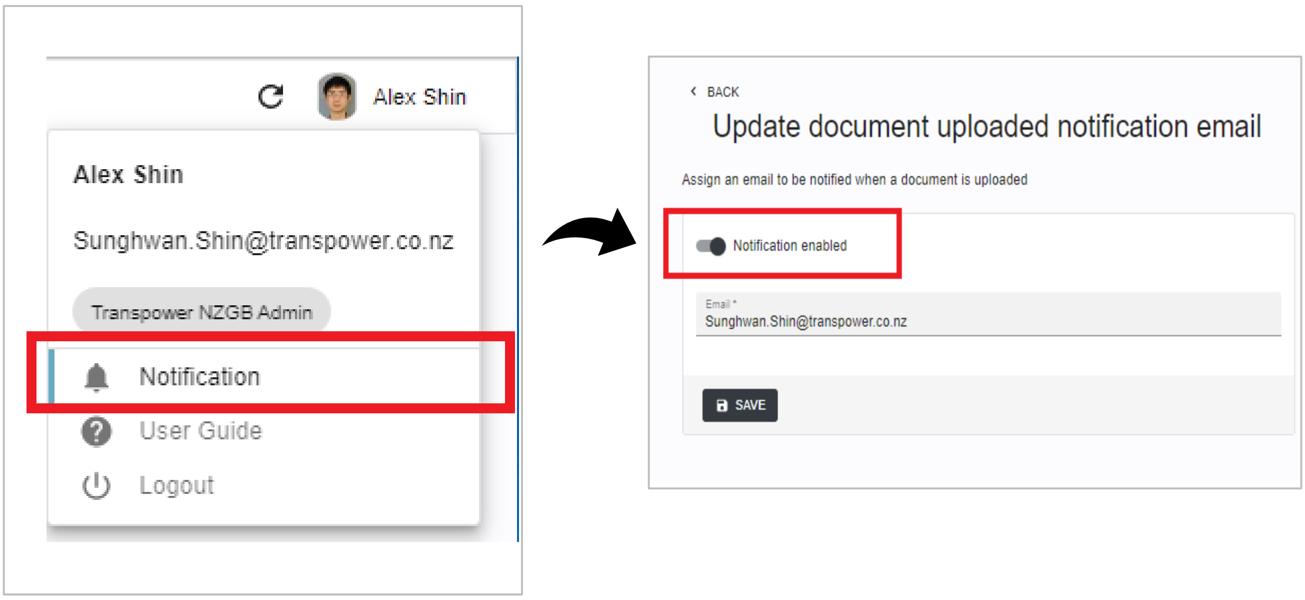


6.1 Documents



The documents page is where the monthly NZGB report is stored, as well as any assessments and supporting documentation. These can be filtered with the radio buttons shown below.

Users can subscribe to notifications that can alert them of any updates to the NZGB documents:



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6.2 Comments

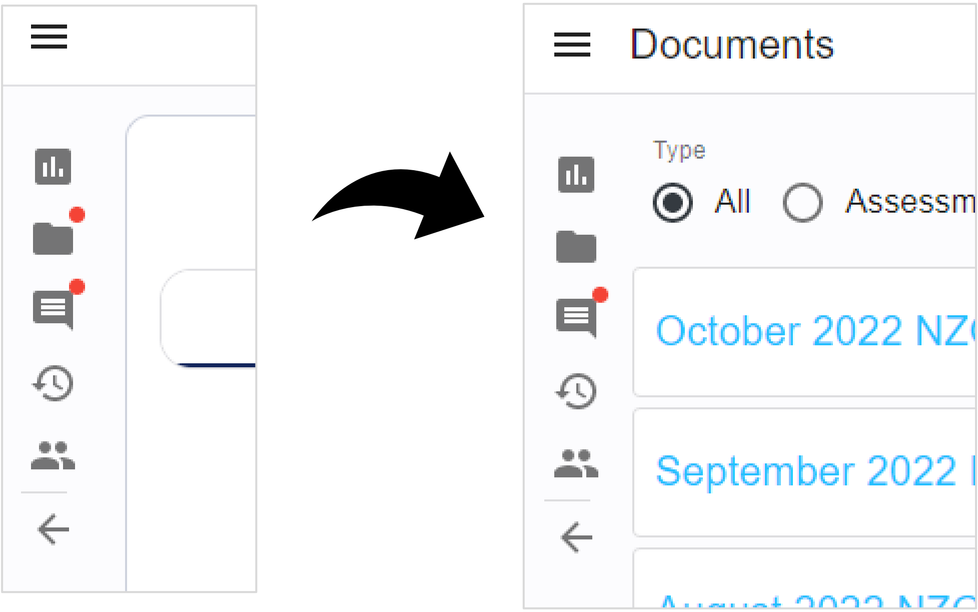
The comments page is where the NZGB administrators place information regarding any changes or industry information that may impact NZGB and its calculation

6.3 Change Log

The change log page contains a list of changes done to the NZGB calculation model. This will give an indication of the type of changes along with which area of the calculation it may impact.

6.4 New Update

There will be a red dot on top of menu icons, which will indicate a new update has been made in that section. Once a menu section has been opened, the notification will clear:



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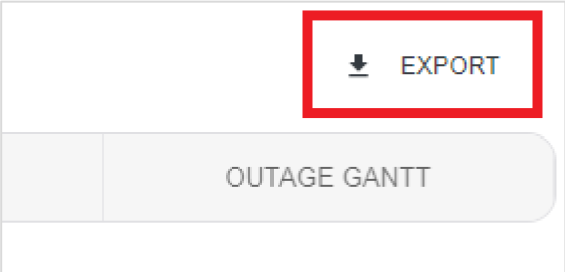
7 Export

It is possible to export the results of the generation balance calculation as a Microsoft Excel workbook. This is achieved by clicking on the "Export" link on the Navigation Panel.

The items that are displayed on the Day Calculation Page form the columns in the exported file and results for each morning and evening period for each day form the rows. A shortened name is used as the label for each column and the mapping between these labels and the full descriptions provided on the Day Calculation Page is provided in the table below.



Export Label	Day Calculation Page Item
si_load	South Island load estimate
si_gen_outages	South Island total generation outage impact
si_trans_outages	South Island total transmission outage impact
si_generation	South Island available generation capacity
si_ancillary_req	South Island generation required for ancillary services
hvdc_transfer_limit	HVDC transfer limit
hvdc_available	HVDC transfer north (received)
ni_load	North Island load estimate
ni_gen_outages	North Island total generation outage impact
ni_trans_outages	North Island total transmission outage impact
ni_generation	North Island available generation capacity
n1_ni_ac_risk	North Island AC risk (N-1)
n1_dc_risk	North Island DC risk (N-1)
n1_ni_risk	North Island worst risk (N-1)
n1_ni_ancillary_req	North Island generation required for ancillary services (N-1)
n1_contingency	Generation balance margin covering worst contingency (N-1)
n1g_ni_ac_risk_1st	North Island first AC risk (N-1-G)
n1g_dc_risk_1st	North Island first DC risk (N-1-G)

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Export Label	Day Calculation Page Item
n1g_ni_risk_1st	North Island first worst risk (N-1-G)
n1g_ni_adjustments_1st	North Island generation balance adjustments after first contingency (N-1-G)
n1g_ni_ac_risk_2nd	North Island second AC risk (N-1-G)
n1g_dc_risk_2nd	North Island second DC risk (N-1-G)
n1g_ni_risk_2nd	North Island second worst risk (N-1-G)
n1g_ni_ancillary_req	North Island generation required for ancillary services to cover second risk (N-1-G)
generation_balance	Generation balance margin covering the next worst contingency (N-1-G)

For further information on the meaning of Day Calculation Page items within this list, please refer to Section 5.1.

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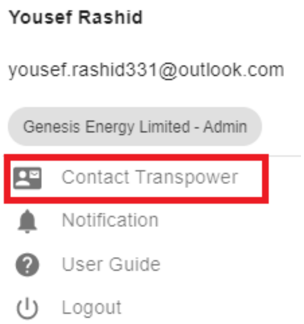
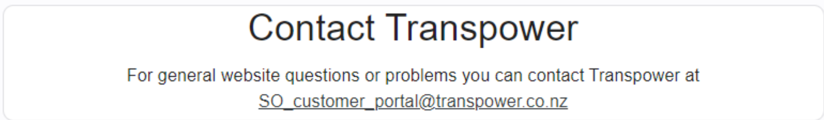
8 User Support

If you are unable to log into the Operations Customer Portal or have any queries, please contact the System Operator at the following e-mail address SO_customer_portal@transpower.co.nz Note that this e-mail will be staffed during business hours (Monday to Friday, 8am – 5pm).

This e-mail can also be accessed from the user menu.

Clicking on the e-mail address in the pop up will invoke your e-mail client so you can send an e-mail.





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9 The Generation Balance Calculation

The objective of the generation balance calculation is to forecast whether there will be enough generation capacity to securely meet demand (i.e. meet frequency keeping and reserve requirements) considering scheduled equipment outages. This calculation focuses on whether the instantaneous power balance can be met (i.e. MW) and hence differs from other security of supply assessments that are concerned with energy shortages (i.e. MWh).

The calculation within the NZGB application considers a scenario of peak demand in the North Island with HVDC power transfer north. A simplified model of the New Zealand power system is used for the generation balance calculation whereby the following aspects are estimated for each island:

- Demand and losses;
- Available generation;
- Generation required for ancillary services (reserves and frequency keeping); and
- HVDC transfer capacity.

The NZGB estimates the margin to a generation balance shortfall (or the severity of such a shortfall) by calculating the following metrics[1]:

Metric	Definition
N-1 Generation Balance Margin	The difference between the available generation capacity and the capacity required to securely supply demand before the occurrence of a contingent event (i.e. reserves need to be obtained to cover the worst case contingent event).
N-1-G Generation Balance Margin	The difference between the available generation capacity and the capacity required to securely supply demand after the occurrence of the worst case contingent event (i.e. reserves need to be restocked to cover the next worst case contingent event).

The following sections detail the assumptions built into the NZGB application as well as the way in which the application sources information for processing.

9.1 Daily Time Windows

The generation balance calculation is concerned with the morning and evening peak demand time periods for each day. The time windows (inclusive) that are associated with these peak periods are defined below:

- Morning peak (AM) period: 06:00 to 11:30, trading periods 13 to 23
- Evening peak (PM) period: 16:00 to 20:00, trading periods 32 to 40

These time windows limit the scheduled outages and historical data that is considered in the calculation

9.2 Demand Forecast

The NZGB estimates future demand based on historical telemetered data and incorporates network losses into the estimated figure. This is achieved by using North Island power supply (generation and HVDC transfer north) and total New Zealand generation as the source for the forecast. The island demand and losses are calculated from this data as detailed in the following table:

Estimated Values	Calculation from Source Data
North Island Demand and Losses	North Island Power Supply
Total System Demand and Losses	New Zealand Generation
South Island Demand and Losses	Total System Demand and Losses – North Island Demand and Losses

In some specific instances, individual GXP or Grid Zone demand data is also used by the NZGB application. The values for this data are calculated in the same fashion but using historical GXP or Grid Zone telemetered load data as the source.

All historical data used for demand estimation is provided to the NZGB application in the form of half-hourly time series data. Each half-hour data point is the average of the raw SCADA data over a trading period.

The NZGB can use either of two prediction methods to forecast demand. These are described in detail below.

9.2.1 *Short-term Forecast*

The short-term forecast uses historical data from the last three weeks to produce demand forecasts for the next three weeks. The application produces estimates for time periods that are unique combinations of the following:

- Week period, consisting of Weekday, Saturday, Sunday / public holiday; and
- Day period, consisting of morning or evening.

In order to estimate future island demand and losses, the NZGB application determines the maximum of the historical data for each unique week period and day period over the last three weeks (e.g. weekday mornings). For example, to determine weekday morning load values, the application will find the maximum value for weekday morning periods in the historical data. This method results in a conservatively high peak value when compared to the historical data. This is suitable for estimating island level demand and losses as larger values will result in worse generation margins.

For GXP or area level load which is used for security constraints and the HVDC limit however, the NZGB application first averages the values of load for each trading period across multiple days for each unique week period and day period combination (e.g. weekday mornings). Then, the application extracts the maximum value from the averaged data for the day period of interest. This method, in contrast to that of the island level method, results in a moderate peak value when compared to the historical data. This is suitable as lower estimated values will ultimately result in worse generation balance margins.

Lastly, a growth factor is not applied to any of these final calculated values for the short-term forecast.

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9.2.2 *Long term Forecast*

The long-term forecast uses historical data from the last year to produce demand forecasts for up to one year into the future. The application produces estimates for time periods that are unique combinations of the following:

- Period of the year.
- Week period, consisting of Weekday, Saturday, Sunday / public holiday; and
- Day period, consisting of morning or evening.

Similar to the short-term forecast, for the island level demand and losses the NZGB determines the maximum of the historical data for each unique time period. In estimating load values for weekday evenings, the application finds the maximum load value of weekday evenings of a 4-week period, two weeks either side of the same date in the previous year. Again, as per the short-term forecast, GXP and area level loads for determining the HVDC transfer limit and the impact of security constraints are estimated by first averaging across multiple days for each unique time period and then finding the maximum value for the day period in question.

A growth factor of **2%** is applied to all final calculated values for the long-term forecast.

9.3 Available Generation Capacity

The NZGB estimates the available generation based on two factors:

- The maximum capacity that is pre-configured in the tool; and
- The impact of transmission or generation outages which are entered into POCP.

Generation in the NZGB application is modelled in terms of generating stations which can then be (optionally) composed of individual generating units. Only dispatchable generation is considered by the calculation and the underlying assumption is that all generation will be offered unless outages are notified.

The sections below describe the various components of the generation availability estimate in more detail.

9.3.1 *Maximum Generation Capacity*

A full list of the maximum capacities of generating stations and units that are configured within the NZGB application can be found in found in Appendix 5.1.

Note that wind generation is assumed to only contribute 20% of its stated capacity toward the generation balance.

9.3.2 *Generation Outages*

Generation outages reduce the available capacity of individual generating units or generating stations. The NZGB application utilises the “MW Loss” field from POCP to determine the outage reduction amount.

The NZGB uses unit level outage entries to determine the generation capacity available from particular units and separately uses the station level entries to determine the generation capacity available from the entire station.

9.3.3 *Transmission Outages*

Certain transmission outages can constrain or disconnect generation thereby reducing the available generation capacity. The manner in which transmission outages influence available generation can be complex, hence transmission constraints are modelled on a case-by-case basis in the NZGB application.

The following table provides a list of transmission constraints that are applied as a result of transmission outages in the NZGB application. The export limit value is the maximum allowable generation export from an area of region under the outage condition and the constraint value represents an indicative generation reduction to meet the export limit:

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Outage	Description	Indicative Export Limits and Constraint
CYD_CML_TWZ_1 CYD_CML_TWZ_2 CYD_CML_1 CYD_CML_2	Generation export from the Southland region (CYD, ROX, MAN, MAH and WPI) limited to avoid overloading the NSY-ROX-1 circuit post-contingency.	Export Limit: Summer: 740 MW Shoulder: 790 MW Winter: 810 MW Constraint: Summer: 70 MW Shoulder: 0 MW Winter: 0 MW
NSY_ROX_1	Generation export from the Southland region (CYD, ROX, MAN, MAH and WPI) limited to avoid overloading the CYD-CML-TWZ circuits post-contingency.	Export Limit: Summer: 690 MW Shoulder: 710 MW Winter: 720 MW Constraint: Summer: 150 MW Shoulder: 60 MW Winter: 50 MW
LIV_NSY_1	Generation export from the Southland region (CYD, ROX, MAN, MAH and WPI) limited to avoid overloading the CYD-CML-TWZ circuits post-contingency.	Export Limit: Summer: 710 MW Shoulder: 720 MW Winter: 730 MW Constraint: Summer: 130 MW Shoulder: 50 MW Winter: 40 MW
CML_TWZ_1 CML_TWZ_2	Generation export from the Southland region (CYD, ROX, MAN, MAH and WPI) limited to avoid overloading the NSY-ROX-1 circuit post-contingency.	Export Limit: Summer: 790 MW Shoulder: 840 MW Winter: 840 MW Constraint: Summer: 20 MW Shoulder: 0 MW Winter: 0 MW
CYD_ROX_1 CYD_ROX_2	Generation export from the Southland region (CYD, ROX, MAN, MAH and WPI) limited to avoid overloading the NSY-ROX-1 circuit post-contingency.	Export Limit: Summer: 540 MW Shoulder: 620 MW Winter: 700 MW Constraint: Summer: 310 MW Shoulder: 150 MW

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Outage	Description	Indicative Export Limits and Constraint
		Winter: 70 MW
MTI_WKM_1 MTI_WKM_2	Generation export from MTI and WPA limited to avoid overloading of remaining MTI-WKM circuit pre-contingency.	Export Limit: Summer: 200 MW Shoulder: 225 MW Winter: 240 MW Constraint: Summer: 200 MW Shoulder: 175 MW Winter: 160 MW
THI_WKM_1 WKM_WRK_1	Generation export from the Central North Island region (THI, PPI, ATI, OHK, WRK, TAA, RKA, OKI, NAP, NTM, ARA, ARI_STH, KIN, KMI, WHE, KAG, MAT, ANI, WHI, KTW, PRI and TUI) limited to avoid overloading the OHK-WRK-1, ATI-OHK-1 and ATI-WKM-1 circuits post-contingency.	Export Limit: Summer: 420 MW Shoulder: 460 MW Winter: 470 MW Constraint: Summer: 650 MW Shoulder: 500 MW Winter: 470 MW
THI_WRK_1	Generation export from the Central North Island region (ATI, OHK, WRK, TAA, RKA, OKI, NAP, NTM, ARA, ARI_STH, KIN, KMI, WHE, KAG, MAT, ANI, WHI, KTW, PRI and TUI) limited to avoid overloading of the OHK-WRK-1, ATI-OHK-1 and ATI-WKM-1 circuits post-contingency.	Export Limit: Summer: 410 MW Shoulder: 460 MW Winter: 470 MW Constraint: Summer: 460 MW Shoulder: 370 MW Winter: 290 MW

The following table provides a list of transmission outages that result in the complete disconnection of generation from the grid in the NZGB application:

Outage	Generation Disconnected
ARA_WRK_1	ARA
MTI_WPA_1	WPA
PPI_ THI_1	PPI
OHB_806_1007	OHB_8 and OBH_9
OHB_907_1106	OHB_10 and OBH_11

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Outage	Generation Disconnected
OHC_1206_1407	OHC_12 and OHC_13
OHC_1307_1508	OHC_14 and OHC_15
SFD_CB_612	SPL
ARI_44_77_97	ARI_1, ARI_2, ARI_3 and ARI_4
MNI_MKE_SFD_1, MKE_CB_102	MKE
CST_JRD_SFD_1, JRD_CB_132	JRD
MTI_87_84_117, MTI_97_117_187, MTI_97_87_117_107	MTI_1, MTI_2, MTI_3, MTI_4, MTI_5
MTI_127_164_177, MTI_107_177_127, MTI_97_127_177	MTI_6, MTI_7, MTI_8, MTI_9, MTI_10
MTI_117_107_127	MTI
WRK_44_57_197	WRK_1, WRK_14, WRK_7, WRK_8, WRK_15, WRK_16
WRK_47_134_87	WRK_15, WRK_16, WRK_4, WRK_9, WRK_10, WRK_11, WRK_12, WRK_13
WRK_47_44_197	WRK_1, WRK_14, WRK_7, WRK_8
WRK_47_57	WRK_15, WRK_16
WRK_47_67	WRK_15, WRK_16, WRK_4, WRK_9, WRK_10, WRK_11
WRK_57_103_87	WRK_4, WRK_9, WRK_10, WRK_11, WRK_12, WRK_13
WRK_57_67	WRK_4, WRK_9, WRK_10, WRK_11
WRK_67_103_87, WRK_67_77	WRK_12, WRK_13
SFD_CB_522	SFD_21
SFD_CB_552	SFD_22
BPE_TWC_LTN_1	TWC, TRH
NAP_NTM_1	NTM_1, NTM_2, NTM_3, NTM_4

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9.3.4 Determining Generation Availability

The total generation availability is determined by examining the impact of outages on reducing generation capacity. The effect of transmission and generation outages are considered separately, and generation availability is calculated as the minimum of the two. Outages which impact an entire generating station or individual units are also considered separately.

The transmission and generation outages that reduce generation capacity are only considered for a particular peak demand period (the morning or evening period for a particular day), if their start or end times fall within that time window. Additionally, the NZGB takes into consideration actual concurrencies of outages within a given time window. This means that the application does not double count the effect of a series of staggered outages which do not overlap.

9.4 HVDC Transfer

For the purpose of calculating the generation balance, the NZGB application assumes that the full available capacity of the HVDC link will be utilized to transfer maximum power from the South Island to the North Island. The first aspect the NZGB uses to determine the HVDC transfer is the quantity of excess South Island generation, which is calculated using estimated values for South Island available generation capacity, demand and ancillary service requirements. The second aspect is the available HVDC transfer capacity which is estimated by utilising the formulae provided in Transpower's HVDC Bipole Operating Policy. This is achieved by estimating the Wellington load and taking into consideration the influence of outages of the following equipment:

- HVDC poles;
- Filter banks at Haywards and Benmore;
- Electrode circuits at Haywards;
- 220 kV circuits between Bunnythorpe and Haywards;
- 220 kV circuits north of Bunnythorpe;
- 220 kV / 110 kV interconnecting transformers at Haywards; and
- Dynamic reactive equipment at Haywards (synchronous condensers and STATCOM).

The NZGB application calculates the HVDC transfer to be the lower of the excess South Island generation and the HVDC transfer capacity. Lastly, losses inherent in the operation of the HVDC are also accounted for by subtracting a fixed loss value from the HVDC power sent to calculate the HVDC power received. The following table shows the assumed HVDC losses at various power transfer levels:

HVDC Sent [MW]	HVDC Loss [MW]
0 to 200	6
201 to 400	12
401 to 700	28
701 to 1000	52
1001 to 1200	74

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9.5 Generation Ancillary Service Requirements

The NZGB calculation dynamically estimates the generation that will be required for ancillary services, particularly frequency keeping and under-frequency reserves, for secure operation of the power system. This is important as the generation required for this purpose is not available to supply demand.

9.5.1 Reserve Estimation Methodology

The quantity of under-frequency reserve that is required to cover the worst case contingent event changes as a function of actual generation output or HVDC transfer. In reality, Transpower's Scheduling, Pricing and Dispatch application may find an optimum solution such that the generation output of the risk setting unit or HVDC transfer is limited thereby limiting the quantity of under-frequency reserves that are required. The exact optimum solution depends entirely on the actual energy and reserve offers that have been provided.

In the context of the generation balance calculation however, generation capacity utilised for supplying demand or providing reserves is equivalent. This means that the outcome of limiting generation output or HVDC transfer to reduce the quantity of reserves required would be equivalent to maximising generation output or HVDC transfer to supply demand and increasing the required reserves. Therefore, to simplify the generation balance calculation, the NZGB implements the latter methodology: assuming that the output of risk setting plant or the HVDC is at maximum capacity (taking outages into account) and then determining the reserves needed to cover this risk.

9.5.2 South Island Reserve and Frequency Keeping Requirements

South Island reserve and frequency keeping requirements indirectly impact generation balance margins by potentially limiting power transfer into the North Island (by reducing the available South Island generation capacity). For this purpose, the NZGB:

1. Assumes that 15 MW is required for South Island frequency keeping;
2. Assumes that 220 MW of reverse reserve sharing is available from the North Island as part of the National Market for Instantaneous Reserves; and
3. Dynamically determines the AC risk within the South Island.

The available capacity of the following generating units is used for dynamically determining the AC risk in the South Island:

1. An outage of MAN_BS_220_A causing the risk being equal to the sum of the available capacity of MAN_4, MAN_5, MAN_6 and MAN_7;
2. An outage of MAN_BS_220_C causing the risk being equal to the sum of the available capacity of MAN_1, MAN_2, MAN_3 and MAN_4; and
3. An outage of OHA_TWZ_1 or OHA_TWZ_2 causing the risk being equal to the available capacity of OHA.

Due to reserve sharing across the HVDC link, the AC risk in the South Island only has an influence on the reserves required when the AC Risk exceeds 220 MW.

Where none of these units are available, a minimum South Island AC risk of 125 MW is assumed.

9.5.3 HVDC Risks

The NZGB calculation considers the loss of a single piece of HVDC plant in determining the HVDC risk, which depends on the HVDC transfer and the risk subtractor. The HVDC transfer is determined as described in Section 3.5 and the risk subtractor is determined by taking into consideration outages of HVDC poles and filter banks at Haywards and Benmore. The risk subtractor values used within the NZGB are taken from the HVDC Operating Policy.

In the absence of pole or filter bank outages, the NZGB will utilise the risk subtractor of 650 MW to determine the reserve required to cover the loss of the first HVDC pole. However, this value relies upon the short-time rating of the remaining HVDC pole and is not suitable for the N-1-G generation balance calculation where the

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HVDC pole is the first worst case contingency. In this instance, a risk subtractor of 500 MW is used for the initial HVDC pole contingency, in accordance with the continuous rating of the remaining HVDC pole. Note that for such a situation, the second HVDC risk is assumed to be the remaining flow on the HVDC link as the loss of the second pole results in complete disconnection of the North and South Islands.

9.5.4 North Island Reserve and Frequency Keeping Requirements

The North Island reserve and frequency keeping requirements directly influence generation balance margins by reducing the available North Island generation capacity. For this purpose, the NZGB:

1. Assumes that 15 MW is required for North Island frequency keeping;
2. Assumes that 200 MW of North Island interruptible load is available, reducing the reserves that are required from generating plant;
3. Dynamically determines the AC risk within the North Island; and
4. Dynamically determines the North Island risk by taking the worst of the DC risk and the AC risk.
5. The available capacity of the following generating units is used for dynamically determining the AC risk in the North Island:
6. Huntly Units 1, 2, 4 and 5; and
7. Stratford / Taranaki Combined Cycle (SPL);
8. An outage of NAP_WRK_2 or OKI_WRK_1 causing the risk being equal to the sum of the available capacity of OKI, NTM and NAP;
9. An outage of NAP_OKI_2 causing the risk being equal to the sum of the available capacity of NTM and NAP;
10. An outage of MTI_WKM_1 or 2 causing the risk being equal to the sum of the available capacity of MTI and WPA;

Where none of these units are available, a minimum North Island AC risk of 220 MW is assumed.

9.6 Generation Balance Calculation Summary

The previous sections described how the various inputs to the generation balance calculation are obtained. The generation balance margin is defined by the following formula:

```
Generation Balance Margin = Available Generation and HVDC Transfer – Generation Required for Ancillary Services – Demand and Losses
```

The following sections provide a brief summary of the way in which the above formula is utilised for the N-1 and N-1-G generation balance calculations and the meanings of calculation values displayed on the Day Calculation Page.

9.6.1 N-1 Generation Balance Calculation

The N-1 generation balance margin is calculated by directly using the estimated generation, HVDC transfer, demand and risk values for the intact system in the generation balance formula above.

9.6.2 N-1-G Generation Balance Calculation

In order to calculate the N-1-G generation balance margin, the NZGB first re-calculates the impact of the worst case first contingency. This is required because as was described in Section 3.6 the DC risk considered in the N-1 generation balance calculation and the first DC risk in the N-1-G generation balance calculation may differ. The NZGB then simulates the impact of this contingency by reducing the available generation or HVDC transfer, depending on whether this contingency was the loss of a generating unit or HVDC equipment. Lastly, the second worst case contingency is determined based on the equipment that remains in service. Updated values of generation, HVDC transfer and risk are then used in the generation balance formula above to arrive at the N-1-G generation balance margin.

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9.6.3 *Definition of Calculation Components*

The Day Calculation Page displays the values of the major components of the generation balance calculation. These items are described in greater detail in the table below.

Day Calculation Display Item	Description
South Island load estimate	Forecast South Island load and losses.
South Island total generation outage impact	Impact of South Island generation outages on the total available generation capacity.
South Island total transmission outage impact	Impact of South Island transmission outages on risk and available generation capacity.
South Island available generation capacity	South Island available generation capacity when transmission and generation outages are taken into account.
South Island generation required for ancillary services	South Island generation capacity required for reserve and frequency keeping.
HVDC transfer limit	The power transfer limit / capacity of the HVDC link (sent from Benmore).
HVDC transfer north (received)	The maximum power transferred north (received at Haywards) over the HVDC link. This value considers the excess generation in the South Island, the HVDC transfer capacity and losses inherent in the HVDC link.
North Island load estimate	Forecast North Island load and losses.
North Island total generation outage impact	Impact of North Island generation outages on the total available generation capacity.
North Island total transmission outage impact	Impact of North Island transmission outages on risk and available generation capacity.
North Island available generation capacity	North Island available generation capacity when transmission and generation outages are taken into account.
North Island AC risk (N-1)	Highest AC risk (generating unit) in the North Island.
North Island DC risk (N-1)	Highest DC risk (HVDC component) to be covered by reserves in the North Island.
North Island worst risk (N-1)	The highest of the AC and DC risks above.
North Island generation required for ancillary services (N-1)	North Island generation capacity required to provide reserves for the risk above and frequency keeping (i.e. risk and frequency keeping less interruptible load).
Generation balance margin covering worst contingency (N-1)	N-1 generation balance margin.

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Day Calculation Display Item	Description
North Island first AC risk (N-1-G)	Highest AC risk in the North Island before any contingencies are applied for the N-1-G generation balance calculation. This value will be identical to "North Island AC risk (N-1)".
North Island first DC risk (N-1-G)	Highest DC risk in the North Island before any contingencies are applied for the N-1-G generation balance calculation. For the loss of the first pole, this risk value uses the continuous rating risk subtractor of 500 MW. Therefore, this value could be different from the "North Island DC risk (N-1)"
North Island first worst risk (N-1-G)	The highest of the first AC and DC risk above, which could be different to "North Island worst risk (N-1)".
North Island generation balance adjustments after first contingency (N-1-G)	This is the adjustment that would need to be done to the N-1 generation balance margin due to the difference between "North Island first worst risk (N-1-G)" and "North Island worst risk (N-1)". Any difference is due to the different HVDC risk subtractors used for the N-1 and N-1-G generation balance calculations.
North Island second AC risk (N-1-G)	Highest AC risk in the North Island after the first worst case contingency has already occurred for the N-1-G generation balance calculation.
North Island second DC risk (N-1-G)	Highest DC risk in the North Island after the first worst case contingency has already occurred for the N-1-G generation balance calculation.
North Island second worst risk (N-1-G)	The highest of the second AC and DC risks above.
North Island generation required for ancillary services to cover second risk (N-1-G)	This is the quantity of generation that is required to cover reserves and frequency keeping for the next contingency.
Generation balance margin covering the next worst contingency (N-1-G)	N-1-G generation balance margin.
Selected minimum time	The precise time instance at which results are being displayed and when the lowest generation balance occurred.

9.7 Application Aspects

9.7.1 Application Architecture

The NZGB application interfaces with multiple systems to calculate generation balance margins and display these to the user. The overall architecture of the NZGB application is outlined in the diagram below:

Outage information is obtained from POCP and generation and load data used for the demand forecast and transmission constraints is obtained from TPIX.

9.7.2 Manual Overrides

The bulk of the generation balance calculation is automated within the NZGB application as described before. However, NZGB administrators may from time to time apply manually overrides when the automated process cannot produce correct results. If manual overrides have been applied, a description will be provided on the Dashboard Page under the comments section.

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10 Appendix

10.1 NZGB Model Summary

The generating station and unit capacities which are configured into the NZGB model for North Island and South Island generators are tabulated in Table 1 and Table 2 respective.

Table 1 - North Island Generation Capacity

Station Name	Station Code	Station Capacity [MW]	Generating Units	Generating Unit Capacity [MW]
Aniwhenua	ANI	25	-	-
Aratiatia	ARA	78	ARA_1 ARA_2 ARA_3	26 26 26
Aripuni	ARI	192	ARI_1 ARI_2 ARI_3 ARI_4 ARI_5 ARI_6 ARI_7 ARI_8	22 22 22 22 26 26 26 26
Atiamuri	ATI	80	ATI_1 ATI_2 ATI_3 ATI_4	19 19 19 19
Glenbrook	GLN	74	-	-
Huntly	HLY	1047* *It is assumed that only 2 out of 3 Rankines will be offered so a station maximum of 965 MW is used in the calculation.	HLY_1 HLY_2 HLY5 HLY_6 HLY_4	250 250 405 50 250
Junction Road	JRD	100	JRD_071 JRD_072	50 50
Kawerau	KAG	106	-	-
Kinleith	KIN	39	-	-
Kaimai	KMI	42	-	-
Kapuni	KPI	24	KPI_1 KPI_2	12 12
Karapiro	KPO	96	KPO_1 KPO_2 KPO_3	32 32 32
Kaitawa – Waikaremoana	KTW	36	TUI_6 TUI_7	18 18

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Station Name	Station Code	Station Capacity [MW]	Generating Units	Generating Unit Capacity [MW]
Matahina	MAT	72	-	-
Mill Creek	MCK	60	-	-
Mangahao	MHO	38	-	-
McKee	MKE	100	-	-
Mokai	MOK	105	MOK_1 MOK_2 MOK_3 MOK_10 MOK_11 MOK_12 MOK_21 MOK_22 MOK_30 MOK_31 MOK_32 MOK_41	4 4 7 34 4 4 4 4 19 7 7 7
Maraetai	MTI	350	MTI_1 MTI_2 MTI_3 MTI_4 MTI_5 MTI_6 MTI_7 MTI_8 MTI_9 MTI_10	35 35 35 35 35 35 35 35 35 35
Nga Awa Purua	NAP	147	-	-
Ngawha A	NGA	25	-	-
Ngawha B	NGB	31	-	-
Nga Tamariki	NTM	82	NTM_1 NTM_2 NTM_3 NTM_4	20 20 20 20
Ohakuri	OHK	108	OHK_1 OHK_2 OHK_3 OHK_4	27 27 27 27
Ohaaki	OKI	56	-	-
Onepu	ONU	60	-	-
Pohipi	PPI	51	PPI_1	51
Piripaua – Waikaremoana	PRI	44	TUI_4	22

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Station Name	Station Code	Station Capacity [MW]	Generating Units	Generating Unit Capacity [MW]
			TUI_5	22
Patea	PTA	31	-	-
Rotokawa	RKA	31	RKA_1 RKA_10 RKA_11 RKA_12 RKA_21	3 16 3 3 5
Rangipo	RPO	120	RPO5 RPO6	60 60
Stratford (Peaking)	SFD	200	SFD_21 SFD_22	100 100
Stratford Power Limited (Taranaki Combined Cycle)	SPL	360	-	-
Te Huka Binary Plant	TAA	30	-	-
Te Apiti	TAP	90	-	-
Te Mihi	THI	166	THI_1 THI_2	83 83
Tokaanu	TKU	240	TKU1 TKU2 TKU3 TKU4	60 60 60 60
Te Rapa Cogen	TRC	45	TRC_1	45
Te Rere Hau	TRH	48	-	-
Tuai – Waikaremoana	TUI	52	TUI_1 TUI_2 TUI_3	19 19 20
Te Uku	TUK	63	-	-
Tararua Central	TWC	93	-	-
Tararua – Stage 1	TWF	65	-	-
Whareroa	WAA	64	-	-
Wheao / Flaxy	WHE	25	-	-
Whirinaki	WHI	157	WHI_1 WHI_2 WHI_3	52 52 52
Whakamaru	WKM	100	WKM_1 WKM_2 WKM_3	25 25 25

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Station Name	Station Code	Station Capacity [MW]	Generating Units	Generating Unit Capacity [MW]
			WKM_4	25
Waipapa	WPA	51	WPA_1 WPA_2 WPA_3	18 18 18
Waipipi	WPP	133	-	-
Wairakei	WRK	157	WRK_1 WRK_4 WRK_7 WRK_8 WRK_9 WRK_10 WRK_11 WRK_12 WRK_13 WRK_14 WRK_15 WRK_16	34 11 11 11 11 11 30 29 29 4 8 8
West Wind	WWD	140	WWD1 WWD2 WWD3 WWD4 WWD5 WWD6	23 23 23 25 25 23

Table 2 - South Island Generation Capacity

Station Name	Station Code	Station Capacity [MW]	Generating Units	Generating Unit Capacity [MW]
Aviemore	AVI	220	AVI1 AVI2 AVI3 AVI4	55 55 55 55
Brach River (Wairau / Argyle)	BBR	11	-	-
Benmore	BEN	540	BEN1 BEN2 BEN3 BEN4 BEN5 BEN6	90 90 90 90 90 90
Cobb	COB	32	-	-
Coleridge	COL	45	-	-
Clyde	CYD	432	CYD_1 CYD_2 CYD_3	108 108 108

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Station Name	Station Code	Station Capacity [MW]	Generating Units	Generating Unit Capacity [MW]
			CYD_4	108
Highback and Montalto	HBK	27	-	-
Kumara	KUM	7	-	-
Mahinerangi	MAH	36	-	-
Manapouri	MAN	847	MAN_1 MAN_2 MAN_3 MAN_4 MAN_5 MAN_6 MAN_7	121 121 121 121 121 121 121
Ohau A	OHA	264	OHA4 OHA5 OHA6 OHA7	66 66 66 66
Ohau B	OHB	212	OHB8 OHB9 OHB10 OHB11	53 53 53 53
Ohau C	OHC	212	OHC12 OHC13 OHC14 OHC15	53 53 53 53
Paerau / Pateraroa	PRU	12	-	-
Roxburgh	ROX	320	ROX_1 ROX_2 ROX_3 ROX_4 ROX_5 ROX_6 ROX_7 ROX_8	40 40 40 40 40 40 40 40
Tekapo A	TKA	25	TKA1	25
Tekapo B	TKB	146	TKB2 TKB3	80 80
White Hill	WHL	56	-	-
Waipori	WPI	84	-	-
Waitaki	WTK	90	WTK_1 WTK_2 WTK_3 WTK_4 WTK_5	15 15 15 15 15

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Station Name	Station Code	Station Capacity [MW]	Generating Units	Generating Unit Capacity [MW]
			WTK_6 WTK_7	15 15

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11 Document Information

11.1 Copyright Information

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11.2 Revision History

SharePoint Revision	Date	Change	Section
1.5	28/08/2019	Added electrodes to list of outages impacting HVDC transfer.	
1.6	18/10/2019	Added ROX_CML_TWZ_2 (CYD Bypass) to list of constraints.	
1.7	29/10/19	Added to list of disconnections ARI_44_77_97 and MNI_MKE_SFD_1	
2.0	16/12/19	Added to Operation Procedures management	
3.0	17/03/21	Major update to reflect changes to calculations, modelling etc.	
4.0		Major update to reflect the change migration to the Operations Customer Portal	

11.3 Metadata

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Prepared by (Writer/Reviewer):	Yousef Rashid
Peer Reviewer	[Peer Reviewer]
Approved by (Owner 1):	Minura Vithanage

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