# 2024 EMI POWERFACTORY CASE

NORTH and SOUTH ISLANDS

Transpower New Zealand Limited

December 2024

*Keeping the energy flowing*




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# CONTENTS



# 1 Overview

The System Operator releases the latest PowerFactory case files for the Electricity Market Information (EMI) website for December 2024.

This year's North Island update has seen a few updates affecting both steady state load flow and dynamic (rms) simulations.

**Power Flow simulations:** The study cases provided converge easily. Peak load cases should have voltages above 0.95 p.u and less than 1.05 p.u for 66kV and above. Light load cases may have nodes with voltages slightly above 1.05 p.u.

**Dynamic simulations (rms):** The study cases were tested for initialisation and balanced RMS solves with 3 phase fault conditions on various 220kV busbars, typically cleared in 120ms. The faults were studied separately and found to be stable. Generator and load trip events were done separately and confirm that machine governor controls (where modelled) respond accordingly.

**Eigenvalue analysis**: The case is created with controller models that will linearise (where possible). Small signal analysis can therefore be carried out on the case. Such studies are subject to the internal limitations of PowerFactory regarding in built components of the software that will not linearise – this is detailed in the Technical Reference documents provided within the help menu of the application.

**Harmonic Analysis:** The case as provided is not suitable for harmonic analysis due to the use of lumped parameter line models. The case library includes a script to modify the line data modelling from lumped parameters to the distributed parameter modelling required for harmonic analysis. The resulting case is not verified for harmonic studies but can provide an initial frequency scan.

**Protection Analysis:** The EMI case is not suitable for detailed protection analysis and a case should be requested from Transpower's Protection team.

# 2 Known Issues

## 2.1 PowerFactory versions

It is advised to run the case files in PowerFactory 2024 SP4 as they were tested for both steady state and dynamic solutions in this version and found to be stable.

## 2.2 Modelling Issues

These are often quite technical issues but are noted here to assist users not familiar with the selected modelling.

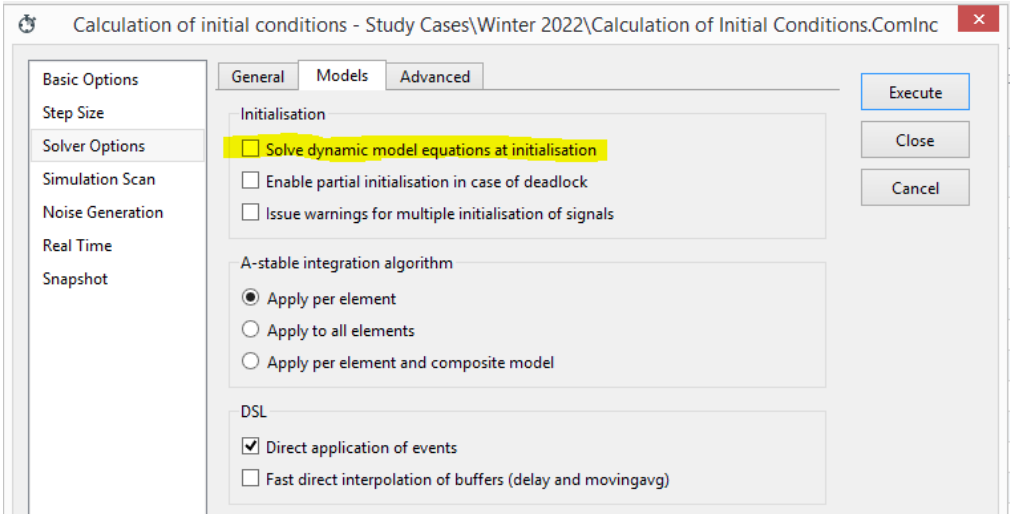
### 2.2.1 Dynamic Model Initialisations

Every effort is made to ensure that dynamic (i.e. RMS) models initialise in steady state with zero-value derivatives and remain stable when run with no disturbance.

However, some models may not be able to initialise with zero derivatives, this includes for example:

- Phase locked loop controls where voltage angle is used as a state variable, the derivative of this can only be 0 if the system initialises at a perfectly stable 50 Hz which is very unlikely given the mathematical differences between the power flow and rms models.
- Some Limiter models where a non-limited signal creates a non-zero input to an integrator deliberately to keep the limiter inactive

By default, the initialisation of dynamics does not have the PowerFactory option to 'solve dynamic model equations' selected:

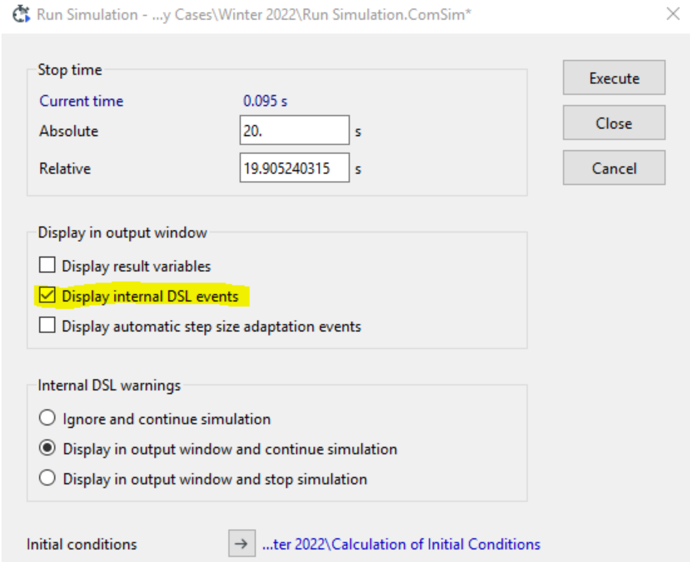


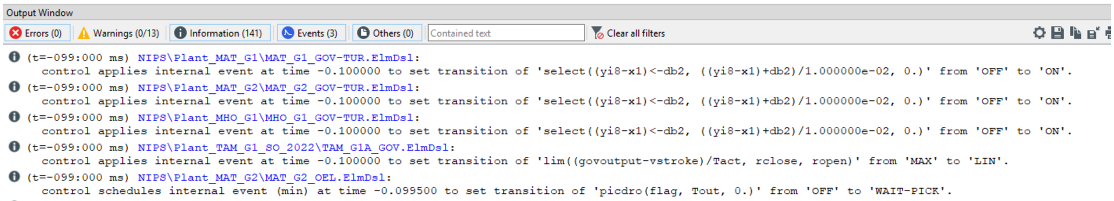

In version 2021 of PowerFactory some initialisation errors have been observed in previously acceptable models because the relevant initialising equations for the state variables (i.e. inc() statements) within the model are reliant on calculations that are either within the dynamic model equations or embedded in the DSL block diagram (such as signal additions, multipliers etc). In some cases even if this is a simple algebraic calculation it is not carried out if this option is not selected, resulting in an apparently incorrect initialisation and an error message.

Future releases may have the highlighted option enabled – but there are other changes required within the existing models to allow for this without creating many warning messages during the initialisation. From version 2022 there is new functionality allowing inc() statements to also initialise state variable derivatives, which may be a better solution.

### 2.2.2 Internal DSL Events

Because the ‘solve dynamic model equations’ option is not selected as described above, several models have internal DSL events at the beginning of the simulation. These will appear in the output window if the option to “Display internal DSL events” is selected:




In future releases models might be modified to remove these events, or the ‘solve dynamic model equations’ option in the installation might be enabled which removes most of these events.

### 2.2.3 KPO Governor and ANI AVR Models

The System Operator is aware that the existing models for the KPO governors and ANI AVRs cause unstable modes in Eigenvalue analysis and case issues in some RMS studies. We will endeavour to resolve these issues in a future release.

## 2.3 Reporting Issues

To report any issues, please contact Power_Systems_Engineering@transpower.co.nz in the first instance. We cannot guarantee we will resolve issues immediately, but we will endeavour to resolve them in the next release.

# 3 Major Updates in NIPS 2024 case

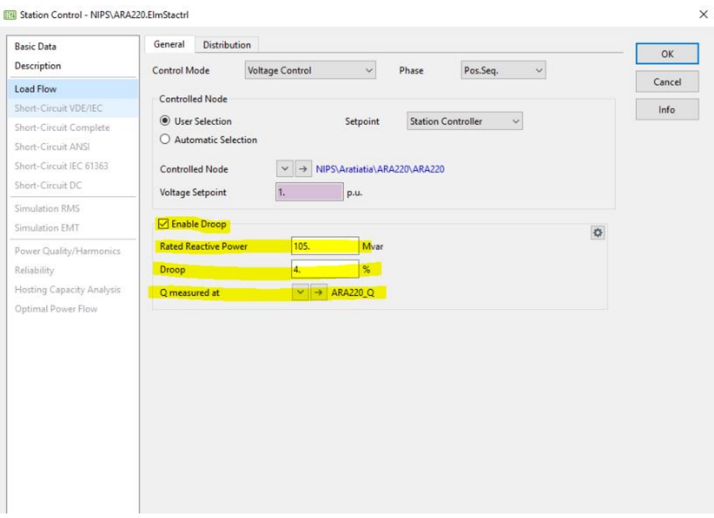
 

## 3.1 Changes affecting Steady state/Short circuit calculations

1. The 2024 expected load forecasts have been uploaded. These provide external users the ability to move through years or seasonal load conditions the same way Transpower would. Selection of the load profile is by a trigger in the study case.

2. Study cases have been set up for Winter and Summer out to 2027. This allows users to set up their own studies more easily and provides an example of how Transpower set up study cases.

3. Most Station Controllers (ElmStactrl) have been changed to add a droop setting. This makes it easier to redispatch generation and makes it less likely for generators to reach reactive power limits. The actual droop setting at the station is used where this is known, and where this is not known 4% is used because this is a reasonable estimate in most cases. If the in-service generation units in a case are changed then the droop setting of the relevant station controller needs to be updated to reflect the new MVA total. A script (Droop_MVA_Set) is provided in the library which runs through all station controllers and sets the Rated MVA to the sum of the rated MVA of all online generators participating in that station control. The reactive power is measured at a boundary which includes all generators in the station control. For more detailed information on droop settings, refer to PowerFactory's Station Controller technical reference.




An additional script (Droop_MVA_report) is provided which will simply report what is set up in the case without modifying any values – this is useful for checking purposes. Compared to the 2023 EMI case, the controllers have been modified so that the reactive power is measured at the HV side of the relevant transformers.

4. Based on feedback from industry, bus voltage triggers have been removed. Voltage setpoints are now set in the generation scenario variations

5. TAB, RGT, TAC, KTS, and HRP generation moved from committed project variations to base case, because this generation is now commissioned.

6. Boundaries that were used to create the Grid Zone EMT models have been added to the case. Refer to the documentation included with the EMT models for more details.

7. Reactive capability curves have been added for most generators. The curves are the same as the curves used in the System Operator's real-time tools, therefore they are not voltage dependent because this functionality is not available in real-time.

## 3.2 Future Grid changes/ reinforcements (variations)

Where major project work on the grid is financially committed, these projects have been included as Variations which can be enabled to study future periods. Note that all dates are best estimates at the time of publication and are subject to change.  The details of these are as follows:

### 3.2.1 Brownhill – Pakuranga Bypass

This variation reflects Transpower's major project to inspect and replace joints on the BHL-PAK cables and the temporary bypass which connects one circuit from WKM to OHW. More information on this project can be found on the Transpower Website: Brownhill Pakuranga Cable Remediation.

### 3.2.2 Hautapu GXP

A new 220/33kV GXP is commissioned, tee-ed from the OTA-WKM circuits. Operational January 2025

### 3.2.3 Solar Farms

Several solar farms were added:

- Te Herenga o Te Ra Solar Farm (HTR), 8x4.3MVA inverters, connecting at Waiotahe December 2024
- Genesis Solar, 115MW, connecting at Edgcumbe June 2025. Note that this generation was identified as Helios Solar in the 2023 EMI Case
- Far North Solar Farm at Waiotahe, 58MW connecting March 2025
- Far North Solar Farm at Edgcumbe, 29MW connecting June 2025
- Pukenui Solar Farm, 20MW, connecting at Kaitaia January 2025

All solar farms are modelled as static generators, set to use a constant impedance model for RMS simulations. None of these stations have fully commissioned or completed testing so detailed dynamic models are not yet available. In future releases these models may be added. For embedded solar farms, an equivalent impedance to the relevant GXP is modelled where this information is available.

### 3.2.4 Transformer Replacements

A third 250MVA Interconnecting Transformer is added at RDF in January 2024 (RDF-TF-T5). Kawerau T13 is replaced with a new 250MVA transformer in March 2025. Te Matai T1 is replaced in April 2025.

### 3.2.5 Otahuhu STATCOM

A new 165 MVA STATCOM is added at the OTA 220kV bus in May 2026. A preliminary dynamic model is provided however parameters are subject to change.

### 3.2.6 Ruakaka BESS

The 100MW Rukaka BESS, commissioning December 2024, is included. No models are available to publish so it is modelled as constant impedance.

### 3.2.7 Net Zero Grid Pathways Stage 1

Several variations for the NZGP Stage 1 project are included. For further details of the project and up to date commissioning dates please refer to https://www.transpower.co.nz/about-us/our-strategy/net-zero-grid-pathways/nzgp-phase-one/nzgp-latest-updates

## 3.3 Changes affecting Dynamic simulations

1. Version Control information has been added in the description field of all common models. This information is primarily intended for System Operator internal use however it does provide users with an indication of the date models were added.
2. Several models have been updated. These have been identified in the description field of the relevant common models. Updated models include: MTI, TUI, TAB, TAC, HAY Condensers, MOK, RPO, and MAT
3. Unencrypted models are included in these windfarm grids for TWN, TWS and TWC, an encrypted model for TAP is included
4. It should be noted that dynamic models are not included for the windfarms at TRH, MCK, WWD, TUK and TUR. Where these windfarms will be a significant factor in study results a model should be used, please consult with the SO if required.
5. Generic dynamic models for voltage controllers have been added at sites JRD, MKE where a specific controller model is not yet available. Some voltage control action is required for credible transient study results when these generators are in service; however study results for rms studies in the Taranaki region should confirm the basic generic model has performed acceptably.
6. The base case is suitable for small signal stability studies. However, the windfarm dynamic models have not been verified for small signal analysis.

# 4 Dynamic Models Used in NIPS 2024 case

The tables below show the current models used in the NIPS case file:

Note that Voltage Droop is determined by Xc > 0, not by the presence of the droop slot.

Limiters may be internal to exciter/AVR models or may be separate models. Similarly, Turbine modelling may be included within a Governor model or as a separate model.

If generic models are being used this is identified in the site name

| CONTACT | | | | | | |
|---|---|---|---|---|---|---|
| Generators | V Droop | Exciter/AVR | PSS | Limiters | Governor | Turbine |
| OKI | Yes | Yes | No | No | Yes | No |
| PPI | No | Yes | Yes | OEL/UEL | Yes | No |
| SFD | No | Yes | Yes | OEL/UEL | Yes | Yes |
| SPL | No | Yes | Yes | No | Yes | Yes |
| TAA | No | Yes | No | OEL/UEL | No | No |
| TAB | Yes | Yes | No | OEL/UEL | Yes | Yes |
| TAC | Yes | Yes | No | OEL/UEL/SCL/VHz | Yes | No |
| THI | No | Yes | Yes | OEL/UEL/VHz | Yes | No |
| TRC | No | Yes | No | No | Yes | No |
| WHI | Yes | Yes | No | OEL/UEL | Yes | No |
| WRK (G1,7,8) | Yes | Yes | No | No | Yes | No |
| WRK (rest) | No | Yes | No | No | No | No |
| EASTLAND | | | | | | |
| Generators | V Droop | Exciter/AVR | PSS | Limiters | Governor | Turbine |
| TAM | No | Yes | No | OEL/UEL | Yes | No |
| GENESIS | | | | | | |
| Generators | V Droop | Exciter/AVR | PSS | Limiters | Governor | Turbine |
| HLY (Rankine) | No | Yes | No | No | Yes | Yes |
| HLY U5 | No | Yes | Yes | OEL/UEL | Yes | Yes |
| HLY U6 | Yes | Yes | No | No | Yes | No |

| | | | | | | |
|---|---|---|---|---|---|---|
| KTW_generic | No | Yes | No | No | Yes | Yes |
| PRI | No | Yes | Yes | PQ | Yes | Yes |
| RPO | No | Yes | No | OEL/UEL | Yes | Yes |
| TKU | No | Yes | No | OEL/UEL | Yes | Yes |
| TUI | No | Yes | No | No | Yes | Yes |
| KING COUNTRY | | | | | | |
| Generators | V Droop | Exciter/AVR | PSS | Limiters | Governor | Turbine |
| MHO | No | Yes | No | OEL/UEL | Yes | Yes |
| MANAWA | | | | | | |
| Generators | V Droop | Exciter/AVR | PSS | Limiters | Governor | Turbine |
| LMD_generic | No | Yes | No | No | No | No |
| MAT | No | Yes | No | OEL/UEL | Yes | Yes |
| MPA_generic | No | Yes | No | No | No | No |
| PTA_generic | No | Yes | No | No | No | No |
| RHI_generic | No | Yes | No | No | No | No |
| WHE_generic | No | Yes | No | No | No | No |
| MERCURY | | | | | | |
| Generators | V Droop | Exciter/AVR | PSS | Limiters | Governor | Turbine |
| ARA | Yes | Yes | Yes | OEL/UEL/SCL | Yes | Yes |
| ARI | No | Yes | Yes | OEL/UEL | Yes | Yes |
| ATI | No | Yes | No | No | Yes | Yes |
| KAG | No | Yes | No | OEL/UEL | No | No |
| KPO | No | Yes | No | No | Yes | Yes |
| MOK (G2, 11,12,21,22) | Yes | Yes | No | OEL/UEL | Yes | No |
| MOK (G10) | Yes | Yes | No | OEL/UEL | YNo | No |
| MOK_generic (G1) | No | Yes | No | No | No | No |

| | | | | | | |
|---|---|---|---|---|---|---|
| MOK_generic (G3,30,31,32, 41) | No | Yes | No | No | Yes | No |
| MTI G1-G5 | Yes | Yes | No | OEL/UEL/SCL | Yes | Yes |
| MTI G6-G10 | No | Yes | No | OEL/UEL/Vhz | Yes | Yes |
| NAP | No | Yes | No | OEL/UEL | Yes | No |
| NTM | Yes | Yes | No | OEL/UEL | No | No |
| OHK | No | Yes | No | No | Yes | Yes |
| RKA_generic (G1-4) | No | Yes | No | No | No | No |
| RKA (G21) | Yes | Yes | No | OEL/UEL | Yes | No |
| WKM | Yes | Yes | No | No | Yes | Yes |
| WPA | Yes | Yes | No | OEL/UEL/SCL | Yes | Yes |
| PIONEER | | | | | | |
| ANI | No | Yes | No | No | Yes | Yes |
| TODD | | | | | | |
| Generators | V Droop | Exciter/AVR | PSS | Limiters | Governor | Turbine |
| EDG_generic | No | Yes | No | No | No | No |
| JRD_generic | No | Yes | No | No | No | No |
| KPI | Yes | Yes | No | No | Yes | No |
| MKE_generic | No | Yes | No | No | No | No |
| WAA | Yes | Yes | No | No | Yes | Yes |
| TOP | | | | | | |
| Generators | V Droop | Exciter/AVR | PSS | Limiters | Governor | Turbine |
| NGA_generic | No | Yes | No | No | No | No |
| OTHERS | | | | | | |
| Generators | V Droop | Exciter/AVR | PSS | Limiters | Governor | Turbine |
| GLN_generic | No | Yes | No | No | No | No |
| KIN | No | Yes | No | No | No | No |

# 5 Major updates in SIPS 2024 case

## 5.1 Changes affecting Steady State/Short Circuit simulations

1. As with NIPS, the 2024 Load forecasts have been left in the case. These provide external users the ability to move through years or seasonal load conditions the same way Transpower would. Selection of the load profile is by a trigger in the study case.
2. As with NIPS, study cases have been provided out to 2027.
3. As with NIPS, most Station Controllers (ElmStactrl) have been changed to add a droop setting.
4. Timaru T8 replacement included in base case
5. Motor Load – details of motor load that were included in the 2023 case have not been added, because of issues adding it to PowerFactory 2024. The motor load will be included in a future release. Where this is likely to have a significant impact on study results, please contact the System Operator for advice.

## 5.2 Future Grid changes/ reinforcements

### 5.2.1 Frankton Supply Transformer Replacement

Frankton T2 and T4 are replaced with new 120MVA transformers in May 2025

### 5.2.2 Kaiwera Downs Windfarm Stage 2

Kaiwera Downs Stage 2 (KWE) is included as a variation, commissioning December 2025. Dynamic Models are not currently available, so the wind farm is modelled as a single constant impedance static generator.

## 5.3 Changes affecting Dynamic simulations

1. As for NIPS, version control information has been added to common models. This information is primarily intended for System Operator internal use however it does provide users with an indication of the date models were added
2. Clyde AVR models updated
3. The Manapouri Governor and Turbine models were modified to allow each unit to initialize and operate correctly up to 135MW
4. Models have been added for:
   - White Hill (WHL) wind farm at North Makarewa (using CIGRE based DFIG generation with standard parameters).
   - Mahinerangi (MAH) wind farm at Waipori (using CIGRE based DFIG generation with standard paramaters)
   - Kaweria Downs Stage 1 (KWD) wind farm at Gore (using WECC generic model, with sit specific parameters)
   - The wind farm dynamic models are out of service by default and can be enabled with a variation, the same as the NIPS case

# 6 Dynamic Models used in SIPS 2024 case

| CONTACT | | | | | | |
|---|---|---|---|---|---|---|
| Generators | V Droop | Exciter/AVR | PSS | Limiters | Governor | Turbine |
| CYD | No | Yes | No | OEL/UEL | Yes | Yes |
| ROX | No | Yes | No | No | Yes | Yes |
| GENESIS | | | | | | |
| Generators | V Droop | Exciter/AVR | PSS | Limiters | Governor | Turbine |
| TKA | No | Yes | Yes | OEL/PQ | Yes | Yes |
| TKB | No | Yes | Yes | OEL/PQ | Yes | Yes |
| MANAWA | | | | | | |
| Generators | V Droop | Exciter/AVR | PSS | Limiters | Governor | Turbine |
| ALD | No | Yes | No | No | No | No |
| ARG | No | Yes | No | No | No | No |
| COB | No | Yes | No | No | Yes | Yes |
| COL | No | Yes | No | No | Yes | Yes |
| HBK | No | Yes | No | No | No | No |
| KUM | No | Yes | No | No | No | No |
| WAU | No | Yes | No | No | No | No |
| WPI | No | Yes | No | No | No | No |
| MERIDIAN | | | | | | |
| Generators | V Droop | Exciter/AVR | PSS | Limiters | Governor | Turbine |
| AVI | Yes | Yes | No | No | Yes | Yes |
| BEN | No | Yes | Not in service | UEL/OEL | Yes | Yes |
| MAN | No | Yes | Yes | UEL/OEL/ SCL/PQ | Yes | Yes |
| OHA | No | Yes | No | No | Yes | Yes |
| OHB | Yes | Yes | No | UEL/OEL | Yes | Yes |
| OHC | Yes | Yes | No | UEL/OEL | Yes | Yes |
| WTK | Yes | Yes | No | UEL/OEL | Yes | Yes |

| OTHERS | | | | | | |
|---|---|---|---|---|---|---|
| Generators | V Droop | Exciter/AVR | PSS | Limiters | Governor | Turbine |
| AMS | No | Yes | No | No | No | No |
| KWT | No | Yes | No | No | No | No |
| OPU | No | Yes | No | No | Yes | Yes |

# 7 User Guide

This section provides a brief user guide for the provided study cases.

## 7.1 Triggers

This section provides a brief overview of the triggers in the EMI case and how they should be used. More detailed explanations of triggers and characteristics can be found in Chapter 18 of the PowerFactory User Manual.

### 7.1.1 Load Forecast Triggers

Two triggers are provided to change the load forecast – LoadSeason (which selects the forecast to use) and LoadYear (which selects the year to use). Most loads in the case have two Matrix characteristics (ElmChaMat), one for P and one for Q, which contains the load values for each forecast and year. A few loads which are not seasonal, i.e. generator auxiliary load or traction loads, do not have characteristics. Note that peak forecasts are provided by Grid Zone, but due to a limitation in the forecasting, the trough forecasts use the Transmission Planning Report (TPR) Regions. There is not a significant difference between the Grid Zones and TPR regions and it is acceptable to use the region forecasts in place of the Grid Zones for connection studies. Forecasts are available for the following Scenarios:

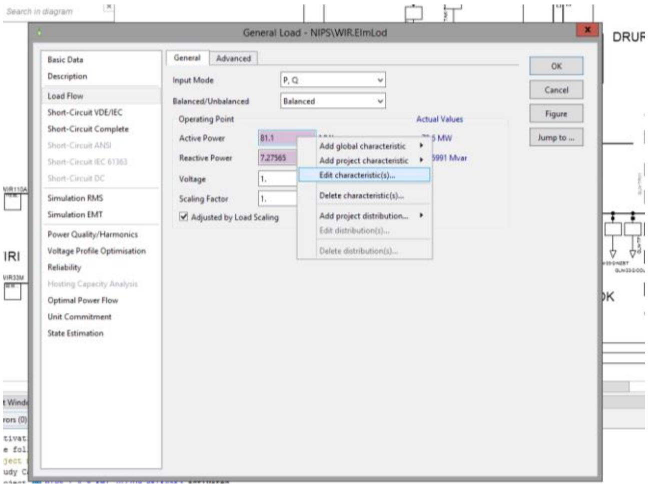
| **Name** | **Description** |
|---|---|
| At_regional_peak_*season*_EXP | The peak load for each Grid Zone in that season, based on expected (50% probability of exceedance) forecast. Note that the trigger applies to all Grid Zone simultaneously, so the total Island load is higher than the expected peak. This can cause convergence issues in later years. Forecasts are provided for summer, winter, and shoulder seasons. |
| At_regional_trough_*season*_day_EXP | The load for daytime trough for that TPR region. This will generally be higher than the nighttime trough. This forecast is useful when considering peak solar output. |
| At_regional_trough_*season*_night_EXP | The load for nighttime trough for that region. |
| At_island_peak_*season*_EXP | The peak load for the whole island in that season, based on expected (50% probability of exceedance) forecast. Forecasts are provided for summer, winter, and shoulder seasons. |

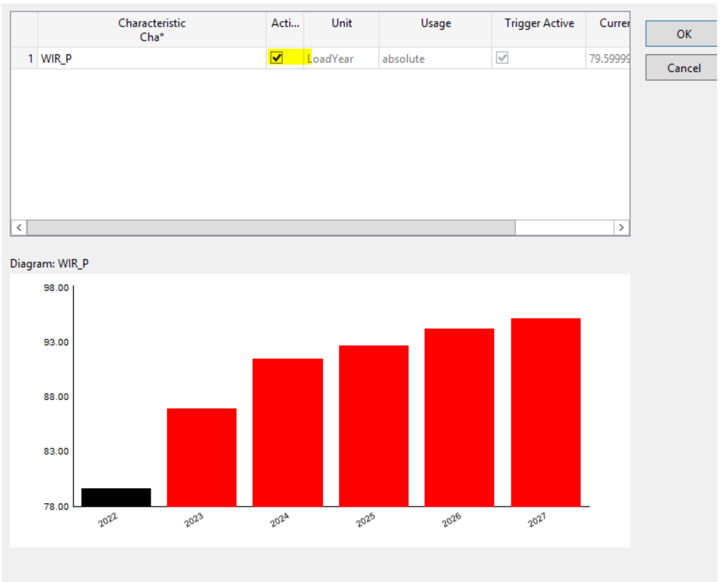
 

| | |
|---|---|
| At_island_trough_*season*_day_EXP | The load for daytime trough for the whole island. This will generally be higher than the nighttime trough. This forecast is useful when considering peak solar output |
| At_island_trough_*season*_night_EXP | The load for nighttime trough for the whole island. |

The provided study cases have the triggers set up to suit each case. When running studies, users should be careful to choose the correct triggers. The choice of island or regional load depends on the nature of the studies being conducted. By default, the provided study cases use island peak, however users should follow the relevant guidelines and use engineering judgement. Note that these triggers are not time sensitive – that is changing the study time will not change the load. The load can only be changed using the triggers.

If the user wants to set the value of a specific load / loads, the triggers can be disabled by opening the relevant load/s, going to the “load flow” page, right clicking in the Active Power box and selecting “Edit Characteristic”, and then unchecking the active box:




Alternatively, a script (DeleteLoadTrigger.ComDPL) is provided which disables all of the active load triggers.

Note that in the provided cases, generation is set in the relevant variation in the “Generation Scenarios” folder. Only small, embedded generators are linked to the load triggers. Therefore, if the user changes the load triggers, they will likely need to redispatch generation to match their specific case.

### 7.1.2 Wind, Solar, and BESS Contribution

Three triggers are provided which scale the wind, solar, and BESS generation by the specified percentage. In the base case, the generator output is set to the unit’s MCO, then the trigger applies to the scaling factor, so if the Wind contribution trigger is set to 0.5, each windfarm will output 50% of it’s rated MCO. By default, the wind trigger is set to 0.3 in all cases, and the solar trigger is set to 0.5 in summer peak, 0.1 in winter peak, and 0 in the nighttime trough cases. The BESS trigger is currently set to 0 as there is not sufficient data available to provide a typical value. The System Operator believes these are reasonable values, however users should set these triggers to the appropriate value for their specific study, i.e. if studying peak solar output, it might be more appropriate to set the solar trigger to 1.0.

## 7.2 Provided Cases

The EMI case is provided with study cases set up for peak winter and summer load from 2024 to 2027, and a Summer Trough 2024 case. The provided cases have all triggers set to appropriate values and generation set based on historical data. Users can use these cases as is or modify them to suit their specific study.

## 7.3 Slack Buses

The NIPS case has three variations for selecting a slack bus – one for the HVDC, one for HLY5, and one for “future slack.” Future slack adds 1000 MW static generators at BPE, WKM, and WRK (for a total of 3000 MW) to use as slack buses. These do not represent specific generation but rather locations where the Grid Owner assess that significant new generation is likely to connect in the future. The SIPS case only has an HVDC slack – there is sufficient generation in the South Island that a future slack is deemed unnecessary.

By default, the provided cases use the HVDC slack. With either the HVDC or HLY5 slack, when using the Island Peak forecast all cases will converge and the slack will be within its operational limits. When using the Region peak forecast, all cases will converge however the slack might be slightly outside of its operational limits. The choice of slack bus depends on the specifics of the study – region of interest, purpose of the study, etc. Users should follow relevant guidelines and use engineering judgement.

For System Operator connection studies as described in GL-EA-953, we recommend not using the “Future Slack” variation. This variation is intended for longer term planning studies, to represent generation projects that are not sufficiently advanced to include individually. Within the timeframe of SO connection studies (approx. 3-4 years from EMI case publication), the case generally should converge with the HVDC slack. If your case doesn’t converge, we recommend adding more thermal generation (i.e. an extra Rankine or Gas Peaker) and/or increasing wind contribution instead of using the future slack. Users should exercise engineering judgement.