2022 EMI POWERFACTORY CASE

NORTH and SOUTH ISLANDS

Transpower New Zealand Limited

October 2022

Keeping the energy flowing




TRANSPOWER

Transpower New Zealand Limited The National Grid

CONTENTS

1 Overview

The System Operator releases, as per obligations of the Code, the latest PowerFactory case files for the Electricity Market Information (EMI) website for September 2022.

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 Software Version Issues

2.1 PowerFactory versions

It is advised to run the case files in PowerFactory 2021 SP7 as they were tested for both steady state and dynamic solutions in this version and found to be stable.

In PowerFactory 2022 a new version of DSL has been introduced. A number of changes have occurred to the DSL model initialisation tests and checks within the software. One particular issue for our older SIPS models is that some connections within frames (i.e. connectors between slot inputs and outputs) which work in the 2021 software now throw up error messages that inhibit a solution. The 2022 SIPS case has been modified (specifically the OHB, OHC and WTK frames) to avoid this problem but further validation in PowerFactory 2022 has not been done.

2.2 Known issues

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

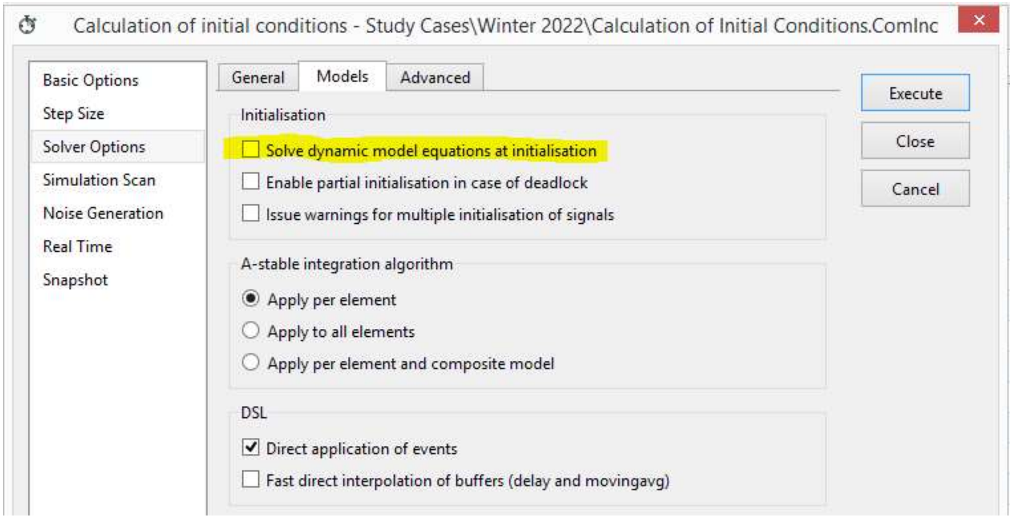
2.2.1 Dynamic Model Initialisations

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.

For this release of the EMI NIPS and SIPS cases, models have been modified to correct this where it happens. KAG UEL and KIK Stacom Control are examples.

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. In version 2022 there is new functionality allowing inc() statements to also initialise state variable derivatives, which may be a better solution.

3 Major Updates in NIPS 2022 case

3.1 Changes affecting Steady state/Short circuit calculations

1. The Load forecasts used for the System Security Forecast (SSF Dec 2022) 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. Most Station Controllers (ElmStactrl) have been changed to make the Controlled Node selection automatic. This change is to make it easier for most users to get convergence in their load flow calculations when reconfiguring bus sections or removing bus sections from service. Figure 1 shows the settings change where the “Automatic Selection” option is selected under the Controlled Node area. With this setting, the station controller will control the voltage of the nearest bus that satisfies the “busbar search criteria” and the setpoint will be the nominal voltage of the busbar.

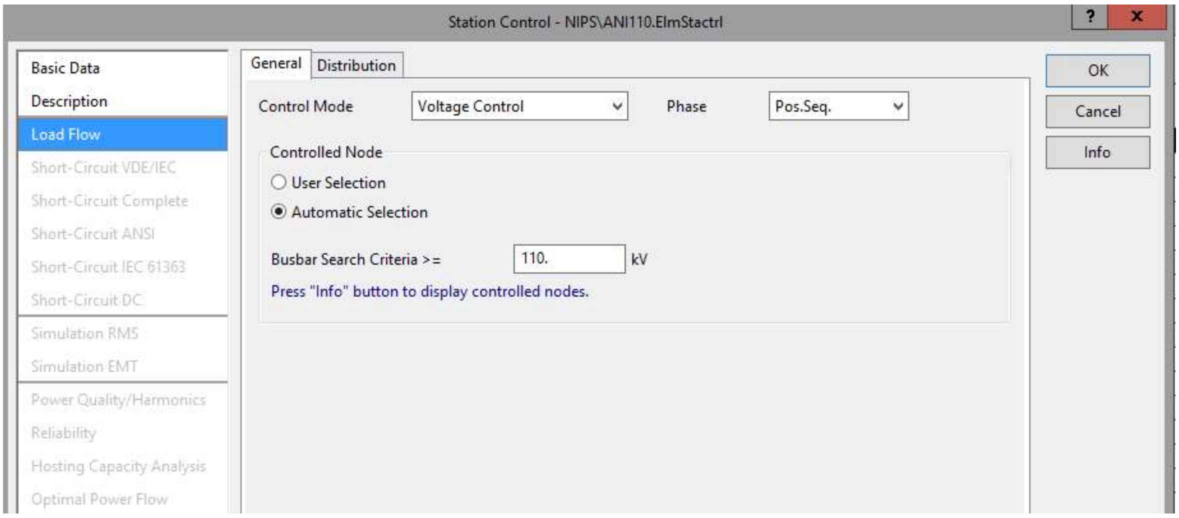


Figure 1: Station Controller with Controlled Node set to automatic selection

3. To enable users to easily set the voltage setpoint at each substation, all the relevant bus section nominal voltages are linked to a scale and a trigger. The triggers are stored in the study case – this is a new approach (rather than say using Operational Scenarios). The triggers make it easier to configure an appropriate network voltage profile for a particular load scenario.

4. WKM-MOK line resistance and WKM T8 and T9 updated

5. OTA tie lines modelled as lines

6. PEN and SWN traction loads added. Currently modelled as 3ph loads for balanced load limit studies.

7. KPI11 and MOK110 loads added. CPK33 loads merged.

8. Earthing Transformers at TRK and KMO added.

9. MNG-TF-T1, MNG-TF-T2, WKO-T1, WHU-T1 NERs corrected.

10. CBG-KPO line resistances corrected

11. MTI generator transformer data corrected.

12. WHI-11-1 and WHI-11-3 loads swapped to correct buses.

13. Norske Skog load removed from service (closed industrial plant)

14. Wind generation modelled at Turitea and Waipipi

15. Substation Indoor conversions modelled at ALB, FHL, HEN, HWA, LTN, MHO, MNG, PEN, ROS, WHU, WIR, and WKO (may be configuration and/or rating changes)

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. The details of these are as follows :

3.2.1 Bombay regional Major Capex Project

As part of the Bombay regional reinforcement, new 220kV transformers are added to Bombay and teed into the HLY/DRY/TAT lines.

- Two new 220/110/11 kV transformers are added to Bombay and teed into the 220 kV HLY/DRY/TAT lines
- Otahuhu–Wiri 110 kV circuits reconductored using Goat ACSR conductor
- Bombay–Wiri Tee 110 kV circuits dismantled
- Arapuni–Bombay 110 kV circuit bused at the Hamilton 110 kV bus and the Bombay–Hamilton section dismantled
- Both Bombay–Hamilton 110 kV circuits dismantled.

The Bombay 220/110 kV transformers and Otahuhu–Wiri reconductoring are estimated to be commissioned in 2023 followed by the remaining 110 kV changes.

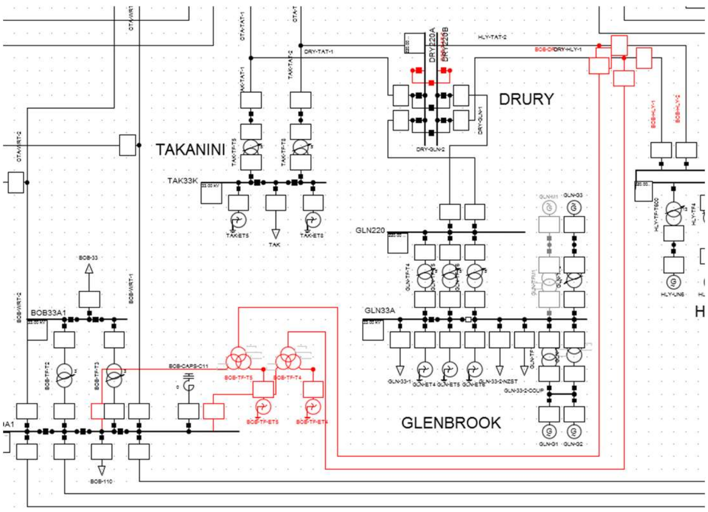


Figure 2: Bombay 220kV transformer variation

3.2.2 Harapaki and Tauhara generation

New generation at Harapaki and Tauhara are added to the existing RDF-WRK-1 line.

Harapaki: 41 x 4.3MW wind turbines, 176MW, estimated operational 2024

Tauhara: Geothermal single 152MW generator, estimated operational mid 2023

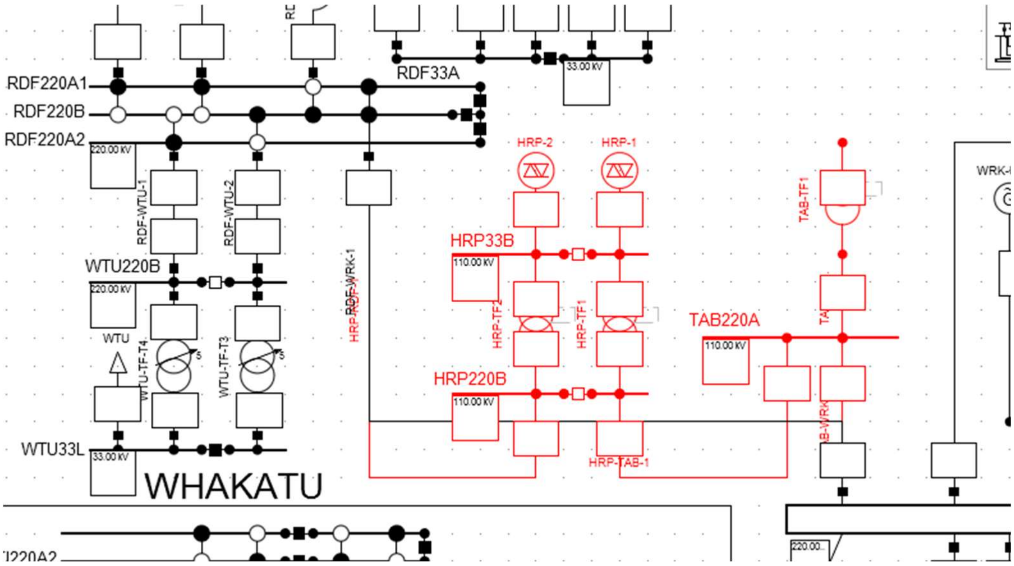


Figure 3: Harapaki and Tauhara generation variation

3.2.3 Atiamuri series reactor

New series reactor on Atiamuri-Ohakuri-1 circuit, impedance set to 14.5 Ohm. Estimated operational towards the end of 2022.

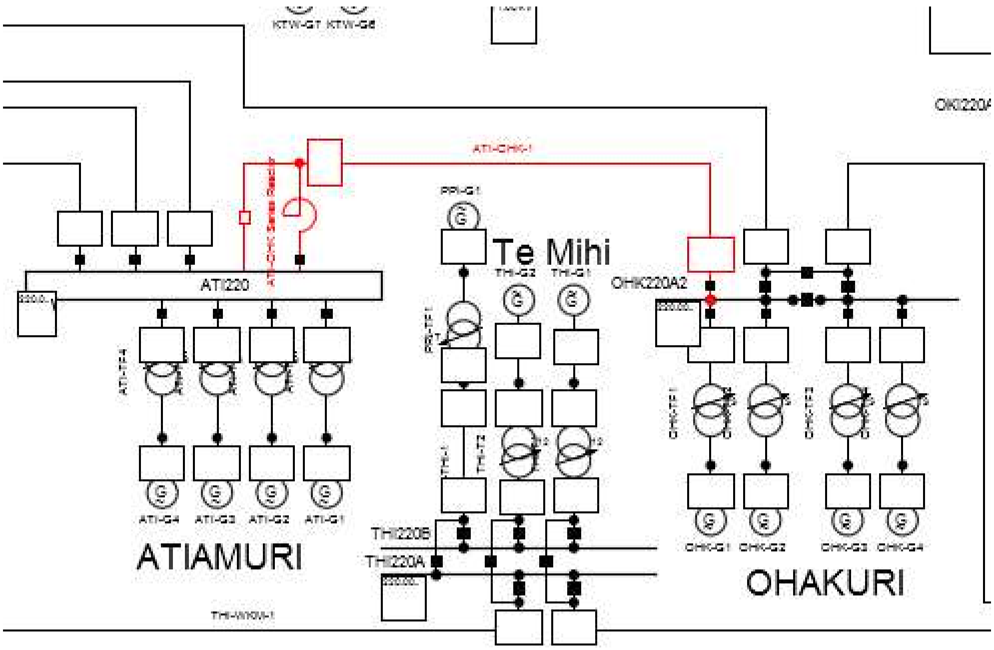


Figure 4: Atiamuri series reactor variation

3.3 Changes affecting Dynamic simulations

1. The library for dynamic models for generation assets has been re-organised to provide a tree structure for each asset owner with each site as a separate sub-tree below the owner. This involves some duplication of model types within the case (e.g. for frames and commonly used standard models) but provides significant benefits when updating or correcting issues at specific sites and also enables much greater traceability and auditability.
2. Many central North Island models have been updated. These have been identified in the libraries with a date suffix (2022) and include controllers at the following sites : ARA, ARI, HLY, KPI, KAG, NAP, NGA, MOK, RKA, TAM and WAA
3. Windfarm grids are included for TWN, TWS, TWC, TRH, WWD, TAP – by default these are not activated and windfarms are modelled in base case simulations as static generators
4. Unencrypted models are included in these windfarm grids for TWN, TWS and TWC, an encrypted model for TAP is included
5. Library\Templates have been included for :
    - TAP wind farm (using an encrypted model with site specific parameters)
    - WPP wind farm (using a generic IEC 4B model with site specific parameters)
    - HRP wind farm (using a generic WECC 4B control with conservative control performance parameters – this is not based on site specific parameters which are not available yet)
6. 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.
7. Dynamic models specific to the new Tauhara generation are not available yet. A copy of the Te Mihi Geothermal control system has been modelled at Tauhara B to provide a credible dynamic behaviour of the plant when it is included in studies.
8. 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.
9. The base case is suitable for small signal stability studies. However, the windfarm dynamic models have not been verified for small signal analysis.
10. The HLY U1 and U2 AVRs have been set up to use the model and data for the U4 AVR due to some issues observed in studies using the original data. The models for the HLY Rankine units will be investigated further and any update will appear in a future release.

4 Dynamic Models Used in NIPS 2022 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 (as THI)						
THI	No	Yes	Yes	OEL/UEL/V Hz	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	No

RPO	No	Yes	No	OEL/UEL	Yes	Yes
TKU	No	Yes	No	OEL/UEL	Yes	Yes
TUI_generic	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_generic (G1,10)	No	Yes	No	No	No	No
MOK_generic (G3,30,31,32, 41)	No	Yes	No	No	Yes	No
MTI	No	Yes	No	No	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	No	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 2022 case

5.1 Changes affecting Steady State/Short Circuit simulations

1. As with NIPS, the Load forecasts used for the System Security Forecast (SSF Dec 2022) 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, most Station Controllers (ElmStactrl) have been changed to make the Controlled Node selection automatic. This change is to make it easier for most users to get convergence in their load flow calculations when reconfiguring bus sections or removing bus sections from service. With this setting, the station controller will control the voltage of the nearest bus that satisfies the "busbar search criteria" and the setpoint will be the nominal voltage of the busbar. Note that the modelling for KIK220 does not allow for this option presently, so the KIK220 station control needs to be adjusted directly.

3. As with NIPS, the voltage setpoint at each substation with the new control option is linked to a scale and a trigger. The triggers are stored in the study case and create a network voltage profile for that study case.

4. Deep Stream generation connected to HWB33 bus.

5. STK ET6 and ET10 resistances fixed

6. WPI T1, T2, T93 and T94 transformers solidly earthed.

7. Added Roaring Meg embedded generation on the Cromwell 33 kV bus.

8. Naseby embedded generation modelled in more detail.

5.2 Future Grid changes/ reinforcements

5.2.1 LIV-NSY-ROX duplexing

As part of the Clutha and Upper Waitaki capital works, the LIV-NSY-1 circuit and the NSY-ROX-1 circuit were duplexed. This work is already complete, but the updates had not been completed in ACI when the system data snapshot was taken for updating the SIPS model.

These Variations should be left enabled for all existing grid or future grid analysis.

5.2.2 Norwood Grid Exit Point

A new grid exit point called Norwood is committed. The GXP will be connected to the existing Islington–Livingstone–1 circuit and is expected to be commissioned in late 2023.

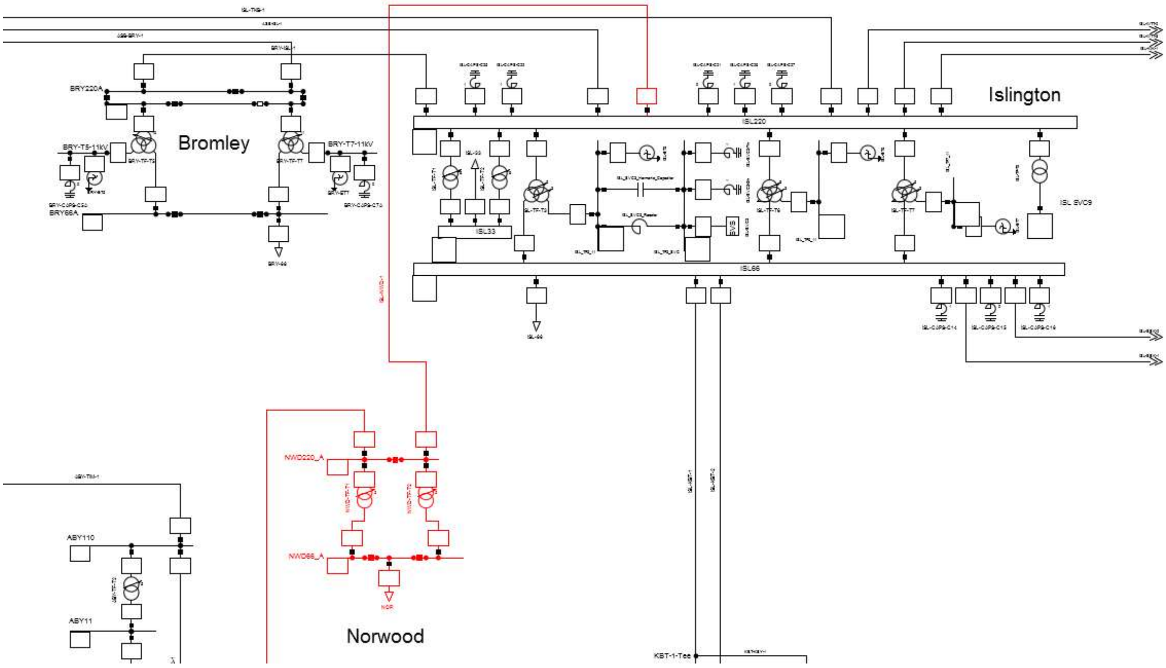


Figure 5: Norwood GXP variation

5.3 Changes affecting Dynamic simulations

1. As for NIPS, the library for dynamic models for generation assets has been re-organised to provide a tree structure for each asset owner with each site as a separate sub-tree below the owner. This involves some duplication of model types within the case (e.g. for frames and commonly used standard models) but provides significant benefits when updating or correcting issues at specific sites and also enables much greater traceability and auditability.

2. KIK STC controller model has been corrected to remove initialization errors

6 Dynamic Models used in SIPS 2022 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
AVIic	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