AEMO RIT-T on Western Victoria Renewable Integration – Network options study

Network Planning Group

This issue	Revision 0
Pages this issue	66
Author	Joseph Leung, Senior Electrical Engineer
Reviewed	Jahan Peiris, Network Modelling and Performance Manager
Approved	Andrew Kingsmill, Manager/Network Planning
Revision History	Revision 0 issued in July 2017

Executive Summary

AEMO NTNDP 2016 [1] and Victorian APR 2016 [2] indicate that up to 1,500 MW of new large-scale renewable energy generation would be developed by 2020 and up to 5,400 MW by 2025 in Victoria primarily as a result of the Victorian Renewable Energy Targets. AEMO has identified a shortage of transmission capacity in the North West Victorian subsystem to connect this additional generation. In April 2017, AEMO published a RIT-T Project Specification Consultation Report (PSCR) [3] for the Western Victoria Renewable Integration project, considering minor network augmentations, major network augmentations, and non-network options to address the identified need.

TransGrid is exploring opportunities available for connecting these renewable generations by extending the NSW transmission network. This report aims to examine the capacities of a range of network augmentation options.

The studies have not taken into account the proposed expansion of Snowy Hydro to add pumped storage. This is expected to deliver additional benefits to those identified in these studies and will be considered in an assessment of the feasibility and benefits of the proposed expansion of Snowy Hydro.

Study Options

These options include:

- Scenario 1 – Base case
- Scenario 2 – New 330 kV double circuit from Darlington Point to Kerang initially strung one side
- Scenario 3 – New 330 kV double circuit line from Darlington Point to Kerang with a second 330 kV line from Darlington Point to Wagga
- Scenario 4 – AEMO VIC RIT-T line reinforcements: 220 kV line reinforcements in western Victoria and Ballarat – Sydenham/Moorabool 500 kV (a variant on 220kV and 500kV options in the PSCR)
- Scenario 5 – Darlington Point to Kerang loop to Ballarat double circuit 330kV, and Ballarat to Sydenham/Moorabool single circuit 500kV, double circuit 220kV from Ararat to Ballarat
- Scenario 6 – Snowy to South Morang 330 kV double circuit and Victorian system option 2 (Partial, i.e. Scenario 9)
- Scenario 7 – Scenario 5 + new medium capacity NSW-SA interconnector
- Scenario 8 – Scenario 5 + new medium capacity SA-VIC interconnector
- Scenario 9 – Victorian system option 2 (Partial RIT-T augmentation)

Renewable connections considered

Renewable generation connections to the following six nodes in the regional VIC network are considered:

- Kerang (600 MW)
- Ararat (300 MW)
- Mortlake (400 MW)
- Ballarat (534 MW)
- Horsham (386 MW)
- Moorabool (321 MW)

In addition, for Scenario 5, new renewable generation (300 MW) connecting to a new 330 kV mid-point substation between Kerang and Ballarat is also considered.

For the Kerang node, a sensitivity study was performed to examine the loading on the new 330 kV lines (from Kerang to Darlington point) for renewable connections either on the 220 kV or the 330 kV buses.

Key results

Renewable generation capacity in western Victoria

The table below summarises the maximum renewable generation capacity that can be accommodated while ensuring system security[1] under system normal (N) and contingency (N-1) conditions for each scenario.

Scenario	Maximum VIC renewables (MW)			
	N capacity[2]	Increase above base case	N-1 capacity[3]	Increase above base case
1	1,621	-	1,381	-
2[4]	1,841	220	1,523	142
3	1,941	320	1,661	280
4	2,564	943	2,464	1,083
5	2,444	823	2,284	903
6	2,324	703	2,004	623
7	1,864	243	1,684	303
8	2,043	422	1,944	563
9	2,324	703	1,904	523

Summary on VIC-NSW transfer capacity

Scenario	Additional VIC export to NSW (MW)	Additional VIC import from NSW (MW)	Comment
1	No change	No change	VIC renewables displace existing thermal generators. No interconnector augmentation
2	420	310	Single circuit 330 kV KER-DLP increases the transfer limit. This scenario assumes transfer trip of new renewable generation for trip of Kerang – Darlington Point line.
2B	570	155	Connecting additional 300 MW renewables at Kerang 330 kV bus will increase VIC export by approx. 150 MW and reduce VIC import by approx. 150 MW, compared to scenario 2. This scenario assumes transfer trip of new renewable generation for trip of Kerang – Darlington Point line.

[1] Avoiding thermal overloads and maintain voltage profile

[2] This capacity can be accommodated if generation runback/transfer tripping can be implemented to manage line overloads in the event of a contingency

[3] This is the maximum allowed if AEMO generation dispatch is utilised to manage line loading in the event of contingencies

[4] This scenario assumes inter-tripping Kerang generation for trip of Kerang-Darlington Point line

Scenario	Additional VIC export to NSW (MW)	Additional VIC import from NSW (MW)	Comment
3	540	420	Double circuit 330 kV KER-DLP increases the transfer limit. Note that the additional flow path encourages extra power flow from Ballarat to Kerang via Bendigo, therefore creating higher line overload. Remedial action (e.g. phase-shifting transformer or series reactor limiting the flow, or increase the line thermal capacity) will facilitate higher transfers.
3B	740	220	Connecting additional 300 MW renewables at Kerang 330 kV bus will increase VIC export by approx. 200 MW and reduce VIC import by approx. 200 MW, compared to Scenario 3.
4	No change	No change	VIC renewables displace existing thermal generators. No interconnector augmentation. Regional VIC transmission network augmentation has no thermal impact to VIC-NSW interconnectors.
5	670	465	Double circuit 330 kV DLP-KER-MPT-BAL increases the transfer limit.
6	480	500	Additional double 330kV circuit from South Morang to Murray via Dederang increases the generation from Snowy (e.g. Snowy 2.0) to VIC. VIC export is limited due to the thermal constraints north of Murray/Snowy.
7	670	465	Inter-connector flow increases due to the Scenario 5 augmentation. However, it cannot increase further as some VIC 220 kV lines will be overloaded. NSI and the corresponding upgrade from Buronga to Wagga via Darlington Point can increase the flow to/from VIC via OX1. However, the flow cannot be increase from current level unless OX1 is upgraded.
8	670	465	Inter-connector flow increases due to the Scenario 5 augmentation. However, it cannot increase further as some VIC 220 kV lines will be overloaded. Horshamlink can increase the transfer between VIC and SA but not with NSW.
9	No change	No change	VIC renewables displace existing thermal generators. No interconnector augmentation. Regional VIC transmission network augmentation has no thermal impact to VIC-NSW interconnectors.

Contents

1. Introduction

1.1. Integration of renewables in Victoria

AEMO NTNDP 2016 [1] and Victorian APR 2016 [2] indicate that up to 1,500 MW of new large-scale renewable energy generation would be developed by 2020 and up to 5,400 MW by 2025 in Victoria primarily as a result of the Victorian Renewable Energy Targets.

Victorian APR [2] lists the following potential renewable generation connections in the North West Victorian network.

Table 1: Potential renewable connections in the regional Victorian network [2]

Project	Capacity (MW)	Location	Service date
Ararat Wind Farm	241	Approximately 9–17 km northeast of Ararat in Western Victoria	July 2016
Bulgana Wind Farm	189	Within the Joel Joel, Joel South, Bulgana and Great Western districts of south-west Victoria	Not available
Crowlands Wind Farm	82	Approximately 20–25 km northeast of Ararat in Western Victoria	Not available
Dundonnell Wind Farm	312	Approximately 25 km northeast of Mortlake in the Western District of Victoria	Not available
Gannawarra Solar Farm	300	Near Kerang	Not available
Kiata Wind Farm	39	10 km south east of Nhill	Not available
Moorabool Wind Farm	321	South of Ballan and 25–30 km southeast of Ballarat	Not available
Mortlake South Wind Farm	76.5	5 kilometres south of Mortlake in the Moyne Shire of south-west Victoria	Not available
Mount Gellibrand Wind Farm	132	25 km east of Colac and 17 km west of Winchelsea in the Colac Otway Shire on Victoria's Western Plains	Not available
Murra Warra Wind Farm	386	About 25 km north of Horsham	Not available
Salt Creek Wind Farm	30	2.5 km south of Woorndoo, Victoria	April 2018
Stockyard Hill Wind Farm	534	Approximately 35 km west of Ballarat	Not available

* Information provided in this table has been sourced from publicly available information. Where information is not available publicly this has been noted as 'not available'.

The above includes a total of about 2,640 MW renewable generators. About 1,500 MW of this generation is in the Ballarat – Horsham corridor (refer to the geographical representation in Figure 1).

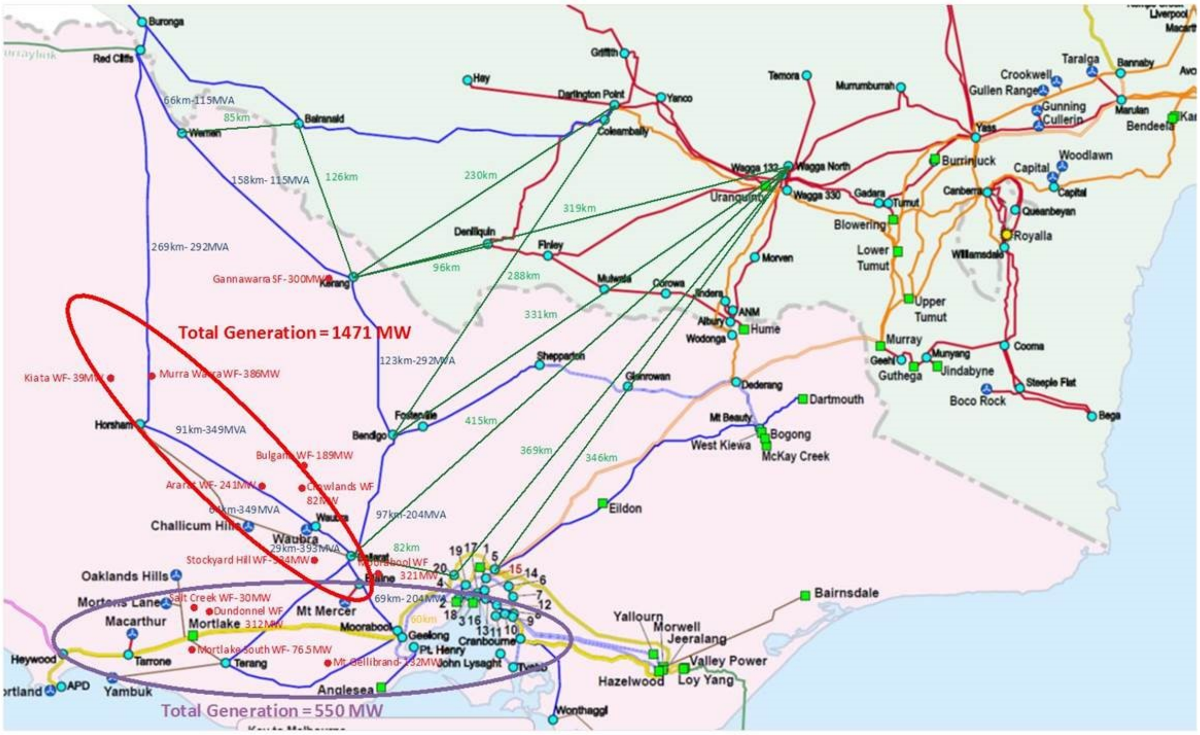

Figure 1: Geographic diagram of the regional Victorian network and the proposed renewable connections

1.2. AEMO's network augmentation options

AEMO has identified a shortage of transmission capacity in the North West Victorian subsystem to connect this additional generation and is undertaking a RIT-T to identify the most suitable options (network and/or non-network) for avoiding constraints on these new renewable generations.

AEMO published a RIT-T Project Specification Consultation Report (PSCR) [3] for the Western Victoria Renewable Integration project in April 2017. AEMO is considering minor network augmentations, major network augmentations, and non-network options to address the identified need. Key network options include:

- **Minor network augmentations options**: These involve transmission line upgrades that can be carried out at the terminal station, rather than along the transmission line. It involves replacing primary plant that is currently limiting transmission line ratings, and installing dynamic wind monitoring.
- **220kV network augmentations options**: This option involves progressively adding new 220 kV transmission line capacity to congested parts of the Western Victorian network. Figure 2 shows the proposed transmission augmentations.
- **275 kV or 330 kV network augmentations**: This option as presented in the PSCR is contingent on a new interconnector from Robertstown in South Australia to Buronga in New South Wales (i.e. NSI), with a voltage of either 275 kV or 330 kV.
- **500 kV network augmentations**: This option involves building a new 500 kV transmission backbone at the most congested parts of the Western Victoria network, most likely between Horsham, Ballarat, and Moorabool, or between Horsham, Ballarat, and Sydenham.

TransGrid is considering further options to extend the NSW transmission network to enable the connection of renewable generation.

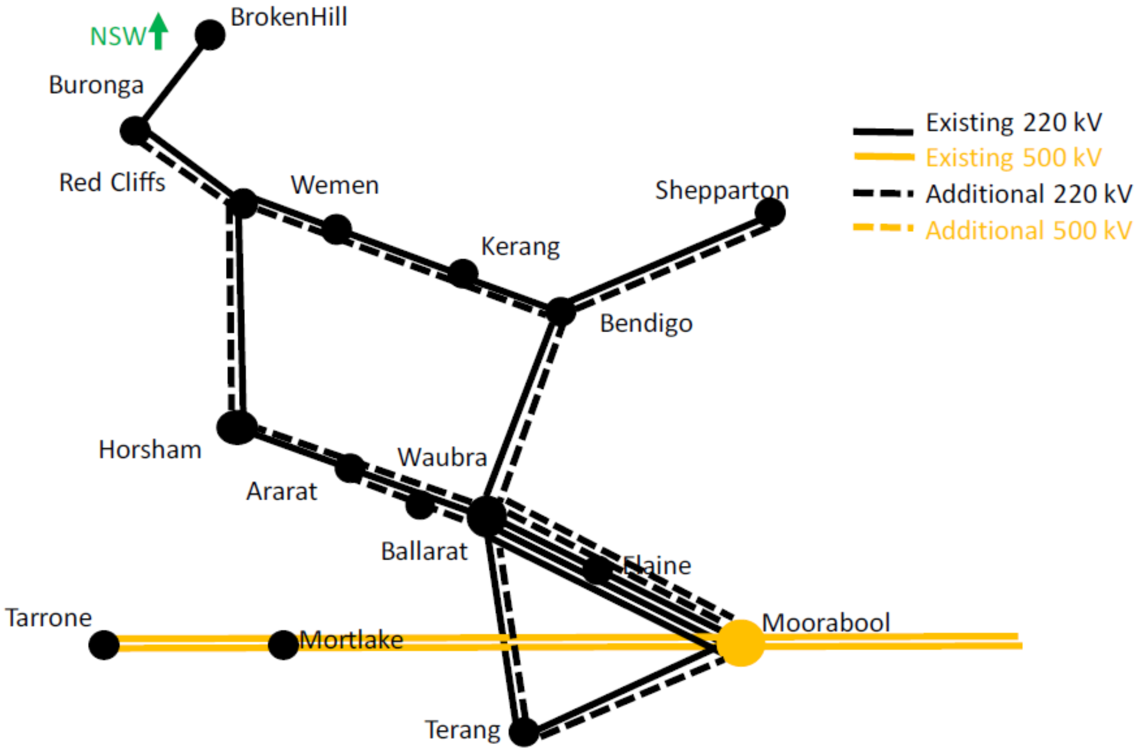

Figure 2: Potential 220 kV network augmentations in Western Victoria [3]

2. Study objectives

The focus of this study is to investigate options for extending the NSW network to connect Victorian renewables. The studies will:

1. identify optimal high level staging of network developments
2. identify appropriate circuit configurations (voltage levels, conductors, etc.) and capacity levels
3. determine maximum western Victorian renewable generation that can be accommodated by different options
4. determine potential impacts on the interconnector transfer capacity (NSW – VIC) and factors affecting the transfer limits
5. identify deep network limitations and remedial measures
6. identify the sensitivity of other factors such as new interconnectors (Riverlink or Horshamlink) and existing interconnector reinforcements on the developments.

3. TransGrid's network augmentation scenarios

TransGrid carried out independent technical and economic analyses in response to AEMO's RIT-T report [3]. TransGrid's proposed network augmentations are summarised in Table 2.

Table 2: Study scenarios

Scenario	Description	Commission Date	Augmentation Details
1	Base case	Present	No change.
2	New 330 kV double circuit from Darlington Point to Kerang initially strung one side	2021	Augmentation from Darlington Point to Kerang (stage 1) – single circuit 330kV (e.g. strung one side of double circuit towers) directly from Darlington Point to Kerang (bypassing Deniliquin). Assumed transfer trip of new generation to cover contingencies (to avoid any overloads on Victorian 220 kV network).
3	New 330 kV double circuit line from Darlington Point to Kerang with a second 330 kV line from Darlington Point to Wagga	2021	Augmentation from Darlington Point to Kerang (stage 2) – double circuit 330kV direct from Darlington Point to Kerang (bypassing Deniliquin) • Add a new 330 kV line from Darlington Point to Wagga
4	AEMO VIC RIT-T 220 kV line reinforcement: Ballarat – Sydenham/Moorabool 500 kV and Western Victoria upgrades only (a variant on 220 kV and 500 kV options in the PSCR)	2021	Augmentation from Ballarat to Sydenham – single circuit 500kV. Ballarat to Moorabool single circuit 500kV • Red Cliffs – Horsham new 220kV single circuit • Red Cliffs – Wemen – Kerang – Bendigo – Shepparton/Ballarat new 220kV single circuits • Horsham – Ararat new 220kV single circuit • Ararat – Waubra – Ballarat new double circuit 220kV • Terang – Ballarat new single circuit 220kV • Terang – Moorabool new single circuit 220kV
5	Complete Darlington Point to Kerang loop to Ballarat double circuit 330kV (via a new substation near Mid Point), and Ballarat to Sydenham/Moorabool 500kV single circuits	2023	Complete Darlington Point to Kerang loop to Ballarat double circuit 330kV (via Mid Point), and Ballarat to Sydenham single circuit 500kV • Ballarat to Moorabool single circuit 500kV • Double circuit 220kV from Ararat to Ballarat
6	Snowy to South Morang upgrade	2023	Scenario 9 plus augmentation from Snowy to South Morang double circuit

Scenario	Description	Commission Date	Augmentation Details
			330kV. New double circuit 330 kV line from Murray via Dederang to South Morang.
7	Scenario 5 + new medium capacity NSW-SA interconnector	2023	Scenario 5 + NSI (275 kV double circuit between Robertstown and Buronga) New 275 kV line from Buronga to Darlington Point This is to compare differences with NSI (Sensitivity study)
8	Scenario 5 + new medium capacity SA-VIC interconnector	2023	Scenario 5 + double circuit 275 kV Horshamlink circuit. This is to compare differences with Horshamlink. Extend scenario 5 network from Mid-Point to Horsham as well. (Sensitivity study) Horsham – Ararat new 220kV single circuit
9	Victorian system option 2 (Partial) - Ballarat – Sydenham/Moorabool 500 kV and limited Western Victoria upgrades only	2021	Ballarat – Sydenham single circuit 500kV Ballarat – Moorabool single circuit 500kV Ararat – Waubra – Ballarat new double circuit 220kV

3.1. Scenario 2 — New 330 kV double circuit from Darlington Point to Kerang strung on one side

This scenario involves:

Transmission Lines, Transformers and Substation Work

- Build 262 km, 330 kV transmission line between Darlington Point 330 kV substation in NSW and Kerang terminal station in VIC with double-circuit towers.
- String above transmission line only on one side (single-circuit) with 900 MVA (at 330 kV) normal (continuous) rating with twin ACSR Mango 373 mm^2 conductor designed for 90 Deg C temperature.
- Installation of a new 330 kV busbar at Kerang terminal station. The existing 220 kV switchyard remains.
- Installation of a new 2 x 330/220 kV interconnecting transformers with 500 MVA capacity at Kerang terminal station to interface with the existing 220 kV connections to VIC Wemen and Bendigo terminal stations.

SPS

- A transfer trip / run-back of new generation connecting at Kerang to cover the contingency of this line (to avoid any overloads on Victorian 220 kV network).

3.2. Scenario 3 — 330 kV double circuit from Darlington Point to Kerang

This scenario involves:

Transmission Lines, Transformers and Substation Work

- Double circuit transmission line with 900 MVA (at 330 kV) normal (continuous) rating with twin ACSR Mango 373 mm^2 conductor designed for 90 Deg C temperature.
- Second transmission line from Darlington Point to Wagga with 900 MVA (at 330 kV) normal (continuous) rating with twin ACSR Mango 373 mm^2 conductor designed for 90 Deg C temperature.
- Installation of a new 330 kV busbar at Kerang terminal station. The existing 220 kV switchyard remains.
- Installation of a new 2 x 330/220 kV interconnecting transformers with 500 MVA capacity at Kerang terminal station to interface with the existing 220 kV connections to VIC Wemen and Bendigo terminal stations.

SPS

- Not required

3.3. Scenario 4 — AEMO RIT-T regional Victorian network reinforcement

This scenario involves:

Transmission Lines, Transformers and Substation Work

- Installation of a new 500 kV busbar at Ballarat substation. The existing 220 kV switchyard remains (Cost to be estimated)
- Two new 500 MVA 220/500 kV transformers at Ballarat 220 kV terminal station (Cost to be estimated)
- Ballarat to Moorabool single circuit 500kV ($57M)
- Ballarat to Sydenham single circuit 500kV (Cost to be estimated)
- Red Cliffs – Horsham new 220kV single circuit ($144M)
- Red Cliffs – Wemen – Kerang – Bendigo – Shepparton/Ballarat new 220kV single circuit ($127M)
- Horsham – Ararat new 220kV single circuit ($54M)
- Ararat – Waubra – Ballarat new double circuit 220kV ($75M)
- Terang – Ballarat new single circuit 220kV ($63M)
- Terang – Moorabool new single circuit 220kV ($72M)

SPS

- Not required

3.4. Scenario 5 — New 330 kV double circuit from Darlington Point to Ballarat with 500 kV single circuits to Sydenham and Moorabool

This scenario involves:

Transmission Lines, Transformers and Substation Work

- Developments under Scenario 3 above
- Installation of a new 330 kV mid-point terminal station which is in the mid-point of Kerang, Horsham, Red Cliffs and Ballarat
- Installation of a new 330 busbar at Ballarat 220 kV terminal station
- Build 265 km, 330 kV transmission line between Kerang terminal station to Ballarat terminal station via the above new mid point terminal station with double-circuit towers. Provide separate cost estimate for:
  - Kerang – Mid point section of the line, which is approx. 95 km;
  - Mid point – Ballarat section of the line, which is approx. 170 km.

- String above transmission line on both sides with 900 MVA (at 330 kV) normal (continuous) rating with twin ACSR Mango 373 mm^2 conductor designed for 90 Deg C temperature
- Installation of two new 330/500 kV transformers with 500 MVA capacity at Ballarat terminal station
- Build 91 km, single circuit transmission line (from Ballarat to Sydenham) with 2400 MVA (at 500 kV) normal (continuous) rating with 4 x Orange 438 mm^2 conductor designed for 90 Deg C temperature
- Build 77 km, single circuit transmission line (from Ballarat to Moorabool) with 2400 MVA (at 500 kV) normal (continuous) rating with 4 x Orange 438 mm^2 conductor designed for 90 Deg C temperature
- Installation of a new 500 kV busbar at Ballarat substation. The existing 220 kV switchyard remains
- Two new 500 MVA 220/500 kV transformers at Ballarat 220 kV terminal station

SPS

- Not required

3.5. Scenario 6 — Snowy to South Morang variation

This scenario involves:

Transmission Lines, Transformers and Substation Work

- Build new 330 kV double-circuit transmission line between Murray 330 kV substation in NSW and Dederang terminal station in VIC with double-circuit towers.
- String above transmission line on both side (double-circuit) with 900 MVA (at 330 kV) normal (continuous) rating with twin ACSR Mango 373 mm^2 conductor designed for 90 Deg C temperature.
- Build new 330 kV double-circuit transmission line between Dederang 330 kV substation in VIC and South Morang terminal station in VIC with double-circuit towers.
- String above transmission line on both side (double-circuit) with 900 MVA (at 330 kV) normal (continuous) rating with twin ACSR Mango 373 mm^2 conductor designed for 90 Deg C temperature.
- One new 1000 MVA 330/500 kV transformer at South Morang 330 kV terminal station

SPS

- Not required

3.6. Scenario 7 — NSI variation

This scenario involves:

Transmission Lines, Transformers and Substation Work

- Developments under Scenario 5 above

- NSI Option G (Buronga 275 kV double circuit medium – high capacity connection):
    - Two 275 kV lines from Buronga to Robertstown
    - Three 400 MVA PST's at Buronga 275 kV substation
    - One 400 MVA 275/220 kV transformer at Buronga substation
    - New single circuit 275 kV line from Buronga to Darlington Point (X5 to remain 220 kV)
    - New 330 kV single circuit from Wagga to Darlington Point

SPS

- Not required

3.7. Scenario 8 — Horshamlink variation

This scenario involves:

Transmission Lines, Transformers and Substation Work

- Developments under Scenario 5 above
- Installation of a new 220 kV busbar at Mid-point substation. The existing 330 kV switchyard remains
- Two new 400 MVA 220/330 kV transformers at Mid-point 330 kV terminal station
- Build 95 km, double circuit transmission line between Mid-point terminal station to Horsham terminal station with 400 MVA (at 220 kV) normal (continuous) rating with twin lemon 207 mm^2 conductor designed for 90 degrees Celsius temperature
- Horshamlink (two 220 kV transmission lines from Horsham terminal station in VIC to Tungkillo substation in SA)

SPS

- Not required

3.8. Scenario 9 — Partial VIC RIT-T option

This scenario involves:

Transmission Lines, Transformers and Substation Work

- Installation of a new 500 kV busbar at Ballarat substation. The existing 220 kV switchyard remains (Cost to be estimated)
- Two new 500 MVA 220/500 kV transformers at Ballarat 220 kV terminal station (Cost to be estimated)
- Ballarat to Moorabool single circuit 500kV ($57M)
- Ballarat to Sydenham single circuit 500kV (Cost to be estimated)
- Horsham – Ararat new 220kV single circuit ($54M)

- Ararat – Waubra – Ballarat new double circuit 220kV ($75M)
- Terang – Ballarat new single circuit 220kV ($63M)
- Terang – Moorabool new single circuit 220kV ($72M)

SPS

- Not required

4. Future VIC renewable connections to be considered

The following VIC renewable generation connections were considered in this report. It should be noted that while these projects are publicly announced, most of their in-service dates are not yet known.

Table 3: VIC Renewables considered in this study

Item	Renewable nodes	Project	Assumed Capacity[5] (MW)
1	Kerang	Gannawarra SF: 300 MW Iraak Solar Farm: 112 MW Wemen Solar Farm: 109 MW Yatpool Solar Farm: 112 MW Bannerton Solar Park: 51 MW Mildura Solar Farm: 100 MW	600
2	Ararat	Ararat WF	300
3	Mortlake	Mortlake South WF: 76.5 MW Dundonnell WF: 312 MW	400
4	Ballarat	Stockyard Hill WF	534
5	Horsham	Murra Warra WF	386
6	Moorabool	Moorabool WF	321
7[6]	Mid point	Crowlands WF: 82 Bulgana WF: 189 MW	300

The total assumed power generated from the above renewable connections is 2,541 MW (items 1 to 6 of last column). In addition to the above projects, the following variations are also considered:

1. For Scenarios 2, 3 and 5, apart from having 600 MW renewables connecting to Kerang 220 kV bus, an additional 300 MW of renewables are connected directly to the 330 kV Kerang bus (scenarios 2b, 3b, 5b). This is to test the sensitivity of renewable connection to the 220 kV and 330 kV Kerang buses.
2. For Scenario 5, an additional 300 MW (5c) is connected to the newly created mid-point 330 kV bus to capture the additional renewables available in the new transmission corridor.

Note:

[5] Assumed capacities are sometimes different to the total available to allow for uncertainties with future renewables

[6] This renewable connection is only applicable for Scenario 5c when the new mid point 330 kV substation is developed.

1. Renewable projects at each connection point are assumed to be independent from those at the other connection points. Therefore, the regional VIC network will be extremely overloaded when projects at all seven connection points are committed to the full assumed capacity. With seven connection points considered in this project, the total number of renewable connection patterns = 2^6 = 64 cases.
2. Some other renewables listed in Table 1 are not considered because either of their relative smaller capacity (e.g. Kiata wind farm) or their close proximities to the VIC 500 kV network (e.g. Mortlake).

5. Study snapshots

The studies were performed using PSS/E Power System Analysis software (version 32). Ten system snapshots, covering different operating conditions including demand and interconnector flows, were developed using OPDMS snapshots and future network augmentation information provided by the TNSPs. Information about these study cases are provided in Table 4. Detailed information about demand and generation for each state is provided in Appendix B.

Table 4: PSS/E Study case information

Case	SA demand	NSW demand	VIC demand	QLD Demand	NSW – VIC
1	Low	Low	Low	Average	Max VIC to NSW
2	Average	Average	Average	Average	Max VIC to NSW
3	Average	Low	Average	Average	Average VIC to NSW
4	High	Average (peak SW connection point demands)	High (peak NW connection point demands)	Average	Average NSW to VIC
5	High	Average-High	High (peak NW connection point demands)	Average	Average NSW to VIC
6	High	High	High (peak NW connection point demands)	Average	Average NSW to VIC
7	Low	Average	Low	Average	Max VIC to NSW
8	Average	Average	Average	Average	Low VIC to NSW
9	Average	Average	Average	Average	Low VIC to NSW
10	High	Average (peak SW connection point demands)	High (peak NW connection point demands)	Average	Average NSW to VIC

5.1. Line ratings

The thermal ratings of the VIC 220 kV transmission lines considered in this study are extracted from "AEMO Transmission Equipment Ratings" spreadsheet on the AEMO website. 40 degrees Celsius is used as the reference temperature. Note that the normal ratings and emergency ratings of these lines are the same.

Table 5: Regional VIC transmission line ratings

Line	Description	Voltage (kV)	Reference	Rating (MVA)
1	Wemen - Kerang	220	WET-KER	205
2	Bendigo - Kerang	220	BEN-KER	302
3	Ballarat - Bendigo	220	BAL-BEN	240
4	Horsham - Red Cliffs	220	HOR-RED	302
5	Horsham - Ararat	220	HOR-ART	301
6	Ararat - Waubra	220	ART-WBT	301
7	Waubra - Ballarat	220	WBT-BAL	376
8	Ballarat - Moorabool	220	BAL-MOO	240

6. Methodology

This study report is based on the following methodologies.

Stage 1 – Creation of loadflow cases

Given:

- 9 scenarios
- 64 combination of generation patterns (2 to the power of 6 locations)
- 10 system snapshots

More than 5,760 loadflow cases[7] were created. These cases were set up based on the following methodology:

1. The slack bus was transferred to Bayswater generator 1 in NSW.
2. The increase in VIC renewable generation will be balanced by the corresponding decrease in VIC synchronous generation, such that the VIC-NSW and Snowy to Canberra/Yass cut-set will not be substantially overloaded by the additional VIC renewable power.
3. The new renewable generations are all modelled as PV buses in PSS/E with terminal voltage controlled to 1.0 pu.
4. Additional switched shunt (reactor or capacitor) will be added to the load flow case to ensure the 220 kV bus voltages are within 0.9 pu to 1.1 pu.

[7] The additional cases are the case variations (2b, 3b, 5b and 5c) for sensitivity testing.

Stage 2 – Reactive power compensation assessment

As described from Note No. 3 above, all the additional VIC renewable generations are modelled as PV buses in PSS/E, with the terminal voltage controlled to 1.0 pu. Reactive power compensation requirements for different scenarios were identified, based on the reactive power generated or absorbed at the PV buses, in order to ensure appropriate voltage range (0.9 – 1.1 pu) during system normal and following contingencies.

Stage 3 – Thermal assessment

This includes calculation of the 220 kV regional Victoria transmission line loadings for both system normal and N-1 contingency, for all the scenarios considered.

Probability[8] of thermal overloading of Scenarios 1 (base case), 4 (AEMO RIT-T case) and 5 (TransGrid complete case) were also calculated for the same set of sampled cases. This will provide a fairer comparison among different scenarios not just for the overloading magnitude, but also probability of occurrence.

Calculation of the sensitivities of line loading to different renewable connections is performed for Scenarios 1, 4 and 5. The results are used to better understand how to maximise the transfer of renewable power from the regional Victoria network without causing thermal constraints.

Stage 4 – Contingency analysis

AEMO is required to ensure secure operation of the power system after a credible N-1 contingency. It is therefore important to re-evaluate the transfer limits based on N-1 contingency criteria.

As for the regional Victoria network, two important flow paths are:

- Upper flow path: from Red Cliffs to Wemen, Kerang, Bendigo, Ballarat to Moorabool;
- Lower flow path: from Red Cliffs to Horsham, Ararat, Waubra, Ballarat to Moorabool.

The loss of one of the BEN-BAL, WBT-BAL or BAL-MOO lines are therefore considered as the more critical cases and will be used for determining the N-1 contingency limit.

Stage 5 – VIC-NSW transfer limit evaluation

Additional interconnection to the NSW network exists for Scenarios 2, 3, 5, 6, 7 and 8. The benefits of these Scenarios in terms of the additional transfer were calculated and reported.

[8] This is not a probability based on historic loading data but rather on the line loading distributions in the sampled cases.

7. Study results

This section presents the results for the nine main scenarios described in Table 2.

7.1. Reactive power compensation requirement at System Normal

Table 6 and Table 7 show the shunt reactor and shunt capacitor requirements for each scenario under system normal situation. Key observations are:

- For all scenarios, only 200 MVAr Shunt capacitor at Ballarat 220 kV, or 150 MVAr at Ballarat 500 kV bus is required for voltage support as this is the key intersection point for the regional VIC renewable generation to the VIC 500 kV main grid.
- Shunt reactors will be required for most of the regional VIC 220 kV buses where augmentation (new line) is built. This is because these new lines introduce additional charging capacitance and will create over-voltage in light load operating conditions.
- Scenarios 4 and 5 have similar reactive power compensation requirements.

Table 6: Shunt reactor requirement (MVAr) for each scenario

Scenario	Darlington Point 330	Kerang 330	Kerang 220	Ballarat 220	Ballarat 500	Horsham 220	Midpoint 330	Moorabool 500	Ararat 220
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
2B	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
3B	0	0	0	0	0	0	0	0	0
4	0	0	100	300	400	0	0	300	0
5	100	0	100	200	400	0	0	300	0
5B	200	250	0	200	300	0	0	300	0
5C	0	0	0	200	300	0	0	300	0
5B_5C	50	50	0	200	300	0	0	300	0
6	0	0	0	300	350	0	0	400	0
7	0	0	100	300	400	0	0	400	0
8	0	0	100	300	400	200	0	400	0
9	0	0	0	300	350	0	0	400	0

Table 7: Shunt capacitor requirement (MVAr) for each scenario

Scenario	Darlington Point 330	Kerang 330	Kerang 220	Ballarat 220	Ballarat 500	Horsham 220	Midpoint 330	Moorabool 500	Ararat 220
1	0	0	0	200	0	0	0	0	0
2	0	0	0	200	0	0	0	0	0
2B	0	0	0	200	0	0	0	0	0
3	0	0	0	200	0	0	0	0	0
3B	0	0	0	200	0	0	0	0	0
4	0	0	0	0	150	0	0	0	0
5	0	0	0	0	150	0	0	0	0
5B	0	0	0	0	150	0	0	0	0
5C	0	0	0	0	150	0	0	0	0
5B_5C	0	0	0	0	150	0	0	0	0
6	0	0	0	0	150	0	0	0	0
7	0	0	0	0	150	0	0	0	0
8	0	0	0	0	150	0	0	0	0
9	0	0	0	0	150	0	0	0	0

7.2. Thermal loading during System Normal

Table 8 and Table 9 summarise the maximum loadings for each transmission lines of interest in both forward (VIC export) and reverse (VIC import) directions respectively. Key observations are as follows:

Scenario 1 (Base case):

- If 600 MW of renewable generations are injecting at the Kerang 220 kV terminal, on top of its existing flow, both KER-WET and KER-BEN lines will be overloaded (139% and 152% respectively).
- In presence of other renewable connections, further renewable generations connecting at Ballarat will lead to congestions at BAL-BEN (133%), BAL-MOO1 (141%) and BAL-MOO2 (182%).
- Murra Warra wind farm at Horsham is likely to consume most of the HOR-ART transfer capacity (98%).
- On top of power generated from Murra Warra wind farm, Ararat wind farm output will overload the ART-WBT line (209%), and Waubra wind farm output will overload the WBT-BAL line (201%).

Scenario 2 (Single 330 kV circuit from Kerang to Darlington Point):

- Compared with Scenario 1, this scenario does not significantly relieve the VIC 220 line overloads.
- A maximum of 420 MW flows from Kerang to Darlington Pont, and 310 MW from Darlington Pont to Kerang. Less than 50% capacity of the 330 kV line can be utilised.

Scenario 2B [Sensitivity study] (Single 330 kV circuit from Kerang to Darlington Point, additional 300 MW injection at Kerang 330 kV bus):

- Compared with Scenario 2, this scenario reduces the power flow from Horsham and Ballarat towards Red Cliffs/Kerang, thus reducing the thermal overloads of the related lines.
- A maximum of 570 MW flows from Kerang to Darlington Pont, and 150 MW from Darlington Pont to Kerang. About 50% capacity of the 330 kV line can be utilised.

Scenario 3 (Double 330 kV circuit from Kerang to Darlington Point):

- Compared with Scenario 1, overloads at HOR-RED, ART-WBT, WBT-BAL, BAL-MOO1 and BAL-MOO2 are slightly reduced. However, overloads at BAL-BEN is further increased (from 133% to 179%).
-

Scenario 3B [Sensitivity study] (Double 330 kV circuit from Kerang to Darlington Point, additional 300 MW injection at Kerang 330 kV bus):

- Compared with Scenario 3, the 300 MW Kerang renewable injection at 330 kV bus increases the Kerang to Darlington Point line flow from 540 MW to 740 MW, but reduces the Darlington Point to Kerang line flow from 420 MW to 220 MW.

Scenario 4 (AEMO VRET RIT-T augmentation):

- No VIC 220 kV line is overloaded in both directions under system normal condition.

- The highly loaded lines are BAL-BEN (88%) and BEN-KER (85%).

Scenario 5: Complete Darlington Point to Kerang loop to Ballarat double circuit 330kV (via Mid Point), and Ballarat to Sydenham single circuit 500kV and Ballarat to Moorabool single circuit 500 kV):

- This option can relieve the thermal overloading for most of the VIC 220kV lines except BAL-BEN (115%) and KER-WET (135%).
- A maximum of 680 MW flows from Kerang to Darlington Pont, and 460 MW from Darlington Pont to Kerang. More than 50% capacity of the 330 kV line can be utilized.

Scenario 5B [Sensitivity study] (Scenario 5, additional 300 MW injection at Kerang 330 kV bus):

- Compared with Scenario 5, the additional 300 MW Kerang renewable generation connecting to Kerang 330 kV bus reduces the BAL-BEN overload from 115% to 111%, but increases the KER-WET overloads from 135% to 141%.
- A maximum of 820 MW flows from Kerang to Darlington Pont (in case when VIC demand is low), and 300 MW from Darlington Pont to Kerang (in case when VIC demand is high). More than 80% capacity of the 330 kV line can be utilized for the flow from Kerang to Darlington Point.

Scenario 5C [Sensitivity study] (Scenario 5, additional 300 MW injection at Mid Point 330 kV bus):

- Compared with Scenario 5, the additional 300 MW Mid Point renewable generation marginally increases the BAL-BEN overloads from 115% to 116%, and KER-WET overloads from 135% to 140%.
- A maximum of 800 MW flows from Kerang to Darlington Pont, and 340 MW from Darlington Pont to Kerang. (Note this is less than 820 MW as reported in Scenario 5B because the mid point is further away from Kerang.) More than 80% capacity of the 330 kV line can be utilized for the flow from Kerang to Darlington Point.

Scenario 5B_5C [Sensitivity study] (Scenario 5, additional 300 MW injection at Kerang 330 kV bus, additional 300 MW injection at Mid Point 330 kV bus):

- Compared with Scenario 5, the additional 600 MW of combined renewable generations reduce the BAL-BEN overloads from 115% to 103%, and increase KER-WET overloads from 135% to 146%
- A maximum of 880 MW flows from Kerang to Darlington Point, and 180 MW from Darlington Pont to Kerang. Close to 90% capacity of the 330 kV line can be utilized for the flow from Kerang to Darlington Point.

Scenario 6 (Victorian system option 2 (Partial, i.e. Scenario 9) and Snowy to South Morang upgrade):

- Results of this scenario are similar to those for Scenario 9 (refer to comments for Scenario 9 below.) The Murray-Dederang-South Morang line augmentation does not significantly relieve the VIC constraints. The partial VIC network augmentation relieves the constraints from Ararat to Moorabool only.

Scenario 7 (Scenario 5 + new medium capacity NSW-SA interconnector):

- Compared with Scenario 5, the NSW-SA interconnector increases the thermal overloading at HOR-RED (from 82% to 119%), the WET-KER overloading also increases from 135% to 189%.

Scenario 8 (Scenario 5 + new medium capacity SA-VIC interconnector):

- Compared with Scenario 5, the VIC-SA interconnector decreases the thermal overloading at BAL-BEN (from 115% to 101%), the WET-KER overloading also decreases from 135% to 127%.
- A maximum of 760 MW flows from Kerang to Darlington Point, and 500 MW from Darlington Point to Kerang. More than 50% capacity of the 330 kV line can be utilized for the flow from Kerang to Darlington Point.

Scenario 9 (Victorian system option 2 (Partial RIT-T augmentation)):

- Compared with Scenario 1, this partial VIC augmentation option can relieve the thermal overloads for ART-WBT, WBT-BAL, BAL-MOO1, BAL-MOO2 lines.
- This option cannot relieve the overload at WET-KER (139%), BEN-BAL (128%), BEN-KER (146%) and HOR-ART (117%) lines.

Table 8: Thermal loadings of the transmission lines with VIC renewables connected (forward direction)

Scenario From: To:	OX1: NSW VIC	X5: BRG BRD	X5: BRD DLP	63: DLP WAG	KER DLP1	KER DLP2	WET KER	BEN KER	BAL BEN	FOS BEN	HOR RED	HOR ART	ART WBT	WBT BAL	BAL MOO1	BAL MOO2	DED SM1	DED SM2
Rating (MVA)	417	417	417	915	1000	1000	205	302	240	556	302	301	301	376	240	240	1145	1145
1	51%	72%	66%	17%	-	-	58%	68%	133%	53%	106%	98%	209%	201%	141%	182%	75%	74%
2	34%	40%	39%	44%	42%	-	73%	48%	148%	36%	105%	93%	203%	195%	129%	166%	74%	74%
2B	32%	44%	42%	56%	57%	-	54%	12%	126%	27%	97%	101%	211%	201%	137%	176%	72%	72%
3	32%	36%	35%	29%	27%	27%	84%	59%	179%	29%	105%	90%	200%	192%	124%	159%	74%	74%
3B	31%	39%	37%	39%	37%	37%	73%	34%	163%	23%	99%	96%	206%	197%	130%	168%	73%	72%
4	41%	66%	62%	16%	-	-	31%	36%	88%	29%	53%	58%	77%	74%	60%	76%	71%	70%
5	30%	35%	34%	35%	34%	34%	52%	13%	115%	27%	82%	98%	70%	70%	62%	79%	62%	62%
5B	29%	38%	36%	42%	41%	41%	44%	1%	111%	22%	80%	101%	71%	70%	63%	81%	59%	58%
5C	29%	38%	37%	41%	40%	40%	47%	6%	116%	23%	82%	99%	71%	70%	63%	81%	58%	57%
5B_5C	27%	38%	37%	45%	44%	44%	39%	-8%	103%	18%	80%	102%	72%	71%	65%	84%	54%	54%
6	48%	67%	63%	16%	-	-	45%	68%	123%	50%	92%	118%	76%	74%	63%	81%	73%	72%
7	-12%	23%	22%	36%	31%	31%	35%	36%	114%	29%	119%	88%	66%	67%	58%	75%	54%	54%
8	29%	33%	32%	39%	38%	38%	52%	18%	101%	28%	57%	98%	74%	70%	60%	76%	58%	58%
9	49%	68%	63%	16%	-	-	45%	65%	128%	47%	93%	117%	76%	74%	63%	81%	73%	73%

Table 9: Thermal loadings of the transmission lines with VIC renewables connected (reversed direction)

Scenario From: To:	OX1: NSW VIC	X5: BRG BRD	X5: BRD DLP	63: DLP WAG	KER DLP1	KER DLP2	WET KER	BEN KER	BAL BEN	FOS BEN	HOR RED	HOR ART	ART WBT	WBT BAL	BAL MOO1	BAL MOO2	DED SM1	DED SM2
Rating (MVA)	417	417	417	915	1000	1000	205	302	240	556	302	301	301	376	240	240	1145	1145
1	-80%	-64%	-69%	-38%	-	-	-139%	-152%	-85%	-72%	-26%	-85%	-61%	-42%	-51%	-64%	-66%	-65%
2	-49%	-46%	-49%	-58%	-31%	-	-153%	-116%	-86%	-50%	-21%	-80%	-59%	-36%	-45%	-57%	-52%	-52%
2B	-52%	-45%	-48%	-42%	-15%	-	-168%	-145%	-100%	-57%	-30%	-73%	-52%	-30%	-37%	-46%	-55%	-55%
3	-45%	-44%	-47%	-37%	-21%	-21%	-157%	-121%	-88%	-44%	-19%	-79%	-57%	-31%	-46%	-58%	-59%	-59%
3B	-47%	-43%	-46%	-25%	-11%	-11%	-167%	-139%	-97%	-50%	-25%	-74%	-52%	-27%	-40%	-50%	-61%	-60%
4	-75%	-54%	-57%	-33%	-	-	-75%	-85%	-61%	-47%	-16%	-44%	-24%	-16%	-14%	-15%	-64%	-63%
5	-44%	-42%	-44%	-38%	-23%	-23%	-135%	-71%	-40%	-43%	-15%	-66%	-17%	-12%	-12%	-13%	-54%	-54%
5B	-46%	-41%	-43%	-29%	-15%	-15%	-141%	-85%	-44%	-47%	-18%	-65%	-17%	-11%	-10%	-11%	-58%	-58%
5C	-47%	-41%	-43%	-31%	-17%	-17%	-140%	-80%	-40%	-47%	-17%	-66%	-17%	-12%	-10%	-12%	-59%	-59%
5B_5C	-47%	-40%	-42%	-23%	-9%	-9%	-146%	-93%	-44%	-49%	-19%	-65%	-16%	-11%	-8%	-9%	-58%	-58%
6	-75%	-60%	-65%	-36%	-	-	-141%	-146%	-84%	-67%	-32%	-81%	-22%	-16%	-12%	-13%	-68%	-68%
7	-71%	-51%	-55%	-48%	-14%	-14%	-189%	-65%	-10%	-41%	-5%	-100%	-29%	-21%	-20%	-24%	-53%	-53%
8	-42%	-41%	-43%	-39%	-25%	-25%	-127%	-79%	-30%	-46%	-11%	-64%	-34%	-20%	-18%	-21%	-53%	-53%
9	-77%	-62%	-66%	-37%	-	-	-139%	-146%	-84%	-65%	-31%	-79%	-22%	-15%	-12%	-14%	-68%	-68%

7.3. Detailed congestion analyses – Scenario 1, 4 and 5

Section 7.2 summarises the worst case loading at each relevant VIC 220 kV transmission line. It does not, however, provides sufficient insights into the contribution factors to each overloading conditions, or the probability of overloading in general. It is the aim of this section to further explore the line loading sensitivity to the renewable connections at different 220 kV buses, and to provide an overview of the relative probability of thermal congestion.

The methodology of congestion study is as follows:

1. For each scenario, connect the renewable generation (with all combinations) to the study case and observe the loadings of the VIC transmission line of interests
2. Plot the "load duration curve" of each transmission line based on all the load flow cases studied. Note that this is not a true representation of the real load duration curve (based on historical loading), but the possibility of overloading under all sampled cases which contain different possible combinations of network demand and renewable generation dispatch scenarios.
3. Compare the load duration curve for Scenario 4 (AEMO RIT-T) and Scenario 5 (TransGrid complete augmentation) against Scenario 1 (Base case, no augmentation) and report findings.
4. Carry out regression analysis to identify correlation of the loading of selected VIC transmission line to the VIC renewable injection. Report the coefficients to each renewable injection.

The results are presented in the following sub-sections.

7.3.1. Probability of overloading

The probability of overloading for the respective regional VIC 220 kV transmission lines, based on the sampled test cases, are shown in Table 10. Key observations are:

- Most of the regional VIC 220 kV lines of interest will experience up to 38% of probability being thermally overloaded in Scenario 1 (Base case, no augmentation).
- The AEMO RIT-T full augmentation option (Scenario 4) can resolve the thermal overloads with the amount of renewable generations (2,541 MW) are connected.
- There is a 30% probability for the WET-KER line to experience up to 135% (see Table 9) thermal overloading under TransGrid's complete option (Scenario 5). It is however not much different from the existing (Scenario 1) situation. Additional augmentations can be introduced to scenario 5 to address these overloads which will result in higher economic benefits compared to what is calculated with the presently identified scenario 5 augmentations.

Figure 3 to Figure 10 show the line loading for each of the regional VIC 220 kV lines considered in this study.

Table 10: Percentage of occurrence of overloading for selected VIC 220 kV line under Scenarios 1, 4 and 5

Scenario	VIC 220 kV lines							
	WET-KER	BEN-KER	BAL-BEN	HOR-RED	HOR-ART	ART-WBT	WBT-BAL	BAL-MOO
1	27%	26%	8%	1%	0%	38%	35%	18%
4	-	-	-	-	-	-	-	-
5	30%	-	3%	-	-	-	-	-

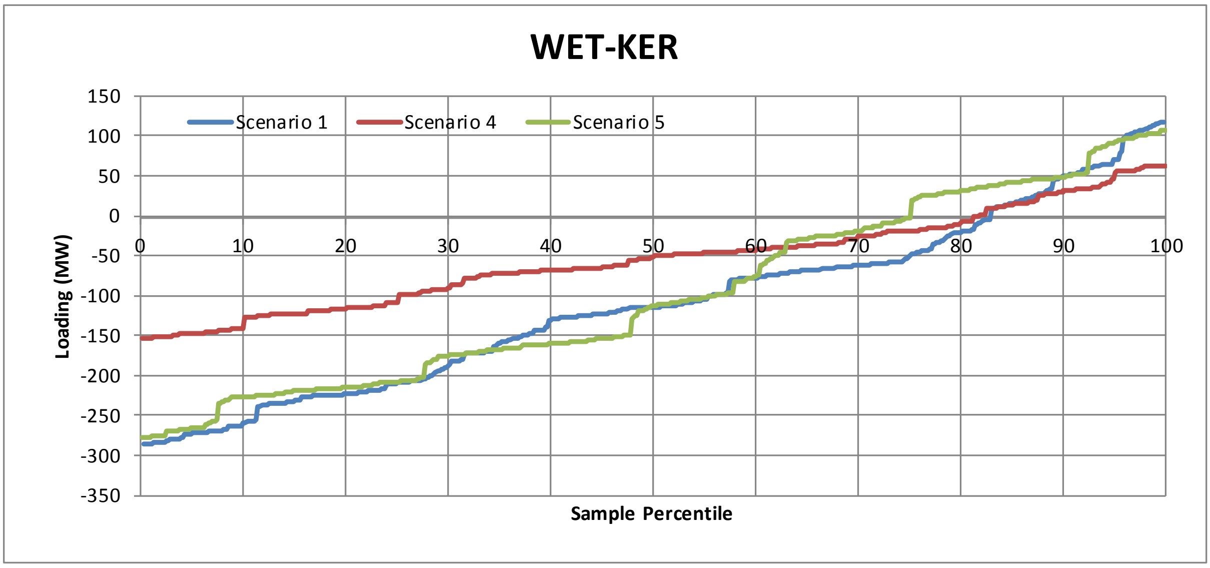

Figure 3: Comparison of load duration of WET-KER line for Scenarios 1, 4 and 5

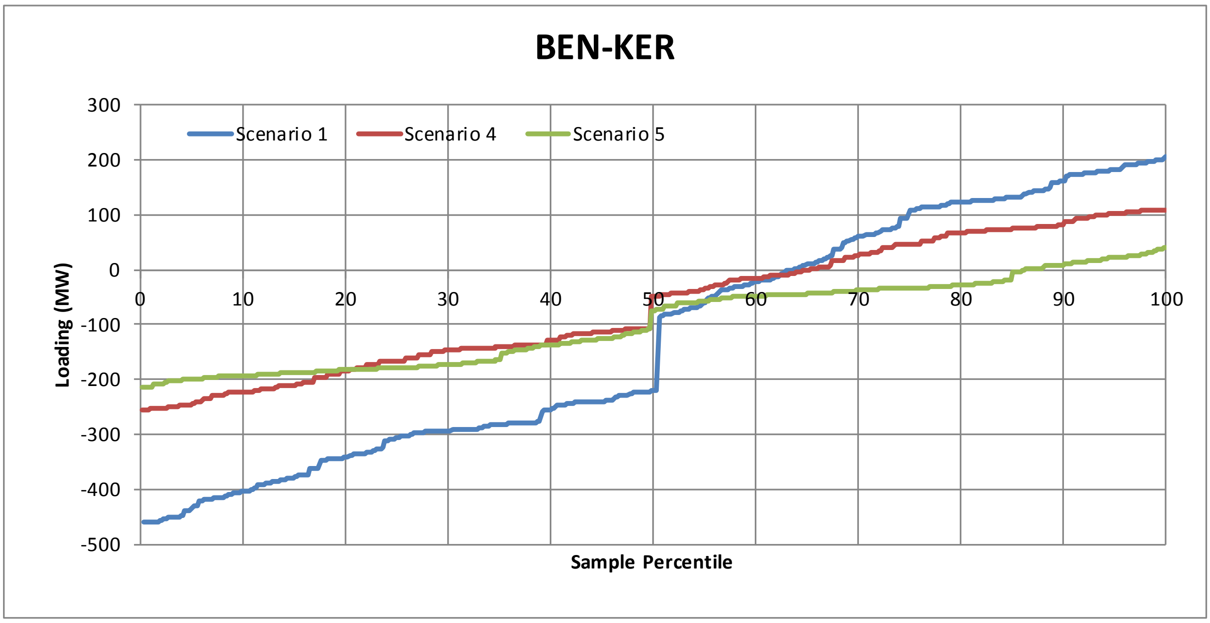

Figure 4: Comparison of load duration of BEN-KER line for Scenarios 1, 4 and 5

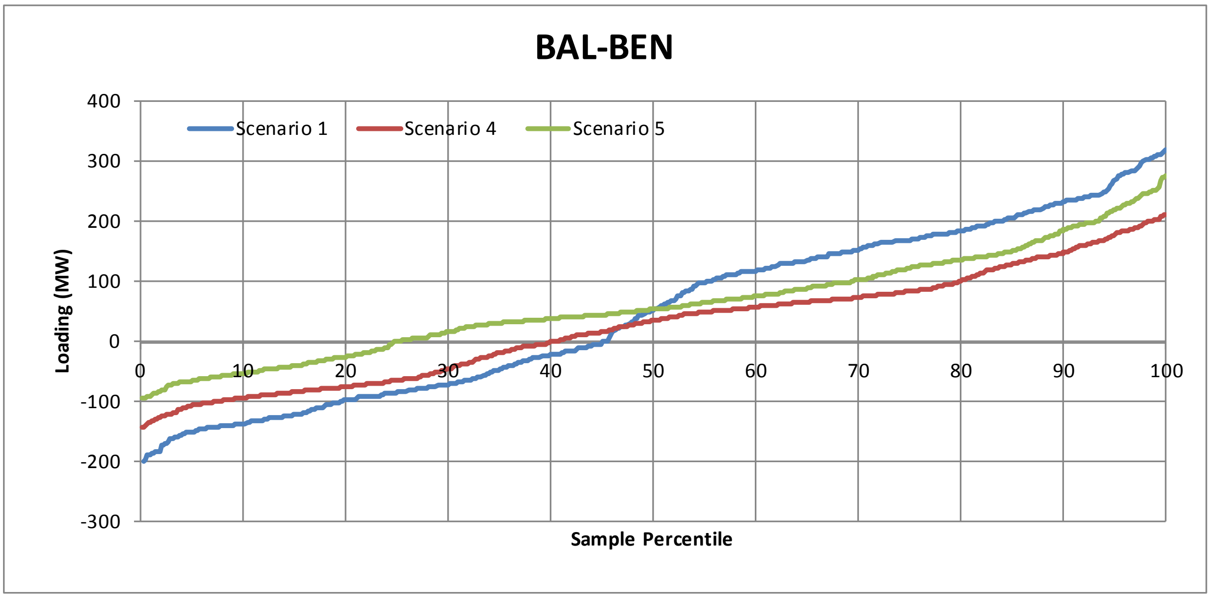

Figure 5: Comparison of load duration of BAL-BEN line for Scenarios 1, 4 and 5

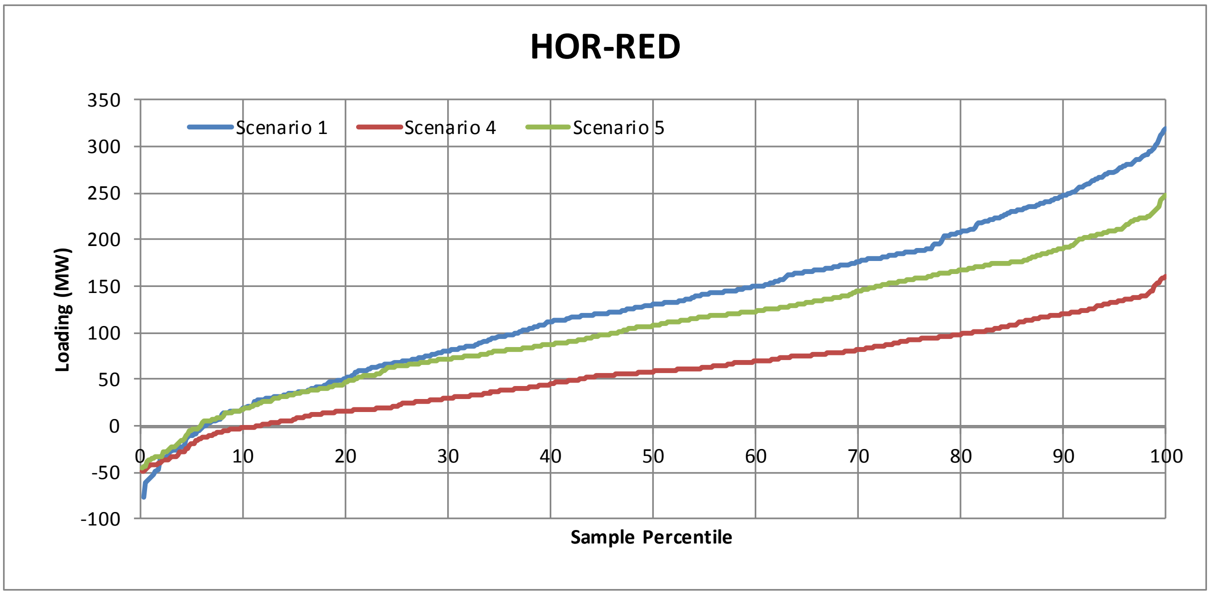

Figure 6: Comparison of load duration of HOR-RED line for Scenarios 1, 4 and 5

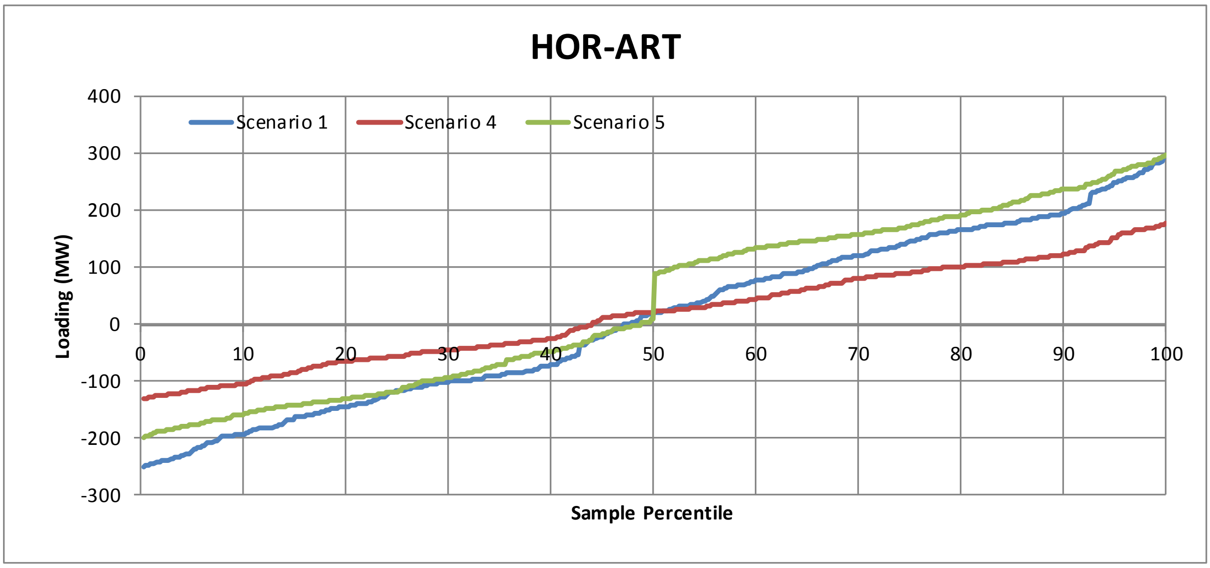

Figure 7: Comparison of load duration of HOR-ART line for Scenarios 1, 4 and 5

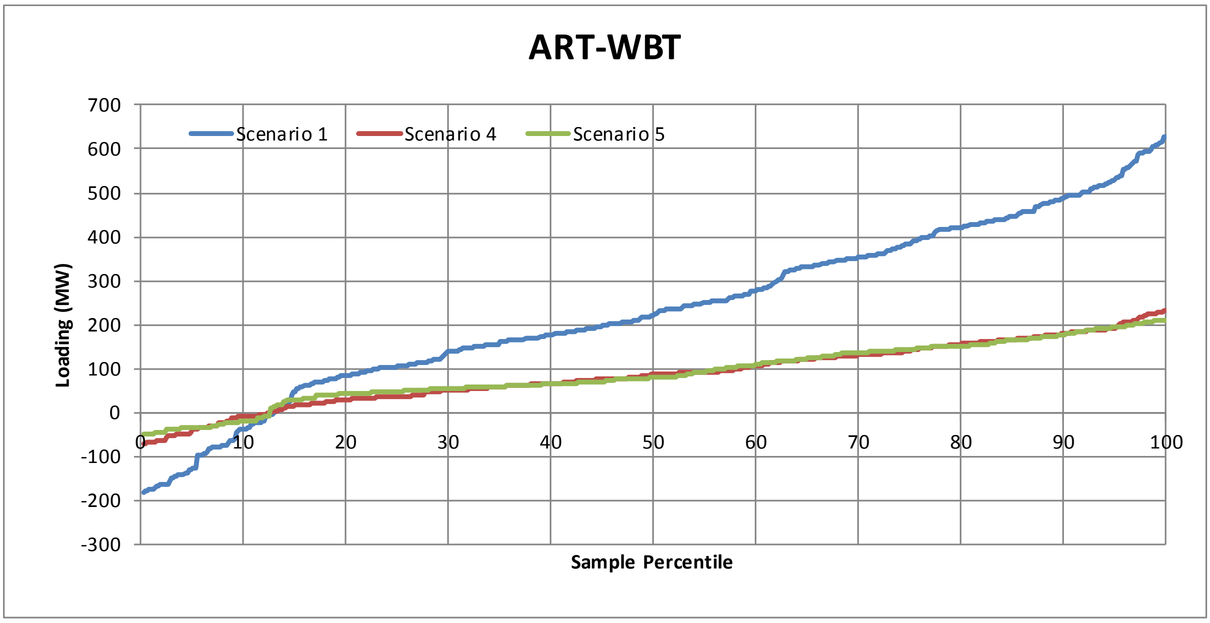

Figure 8: Comparison of load duration of ART-WBT line for Scenarios 1, 4 and 5

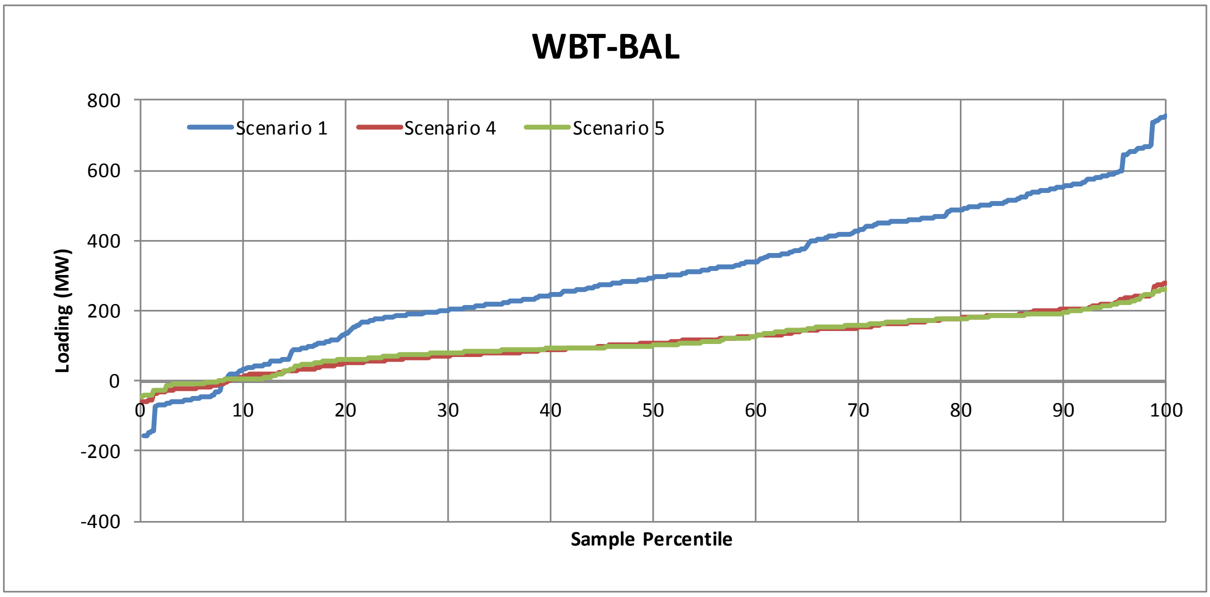

Figure 9: Comparison of load duration of WBT-BAL line for Scenarios 1, 4 and 5

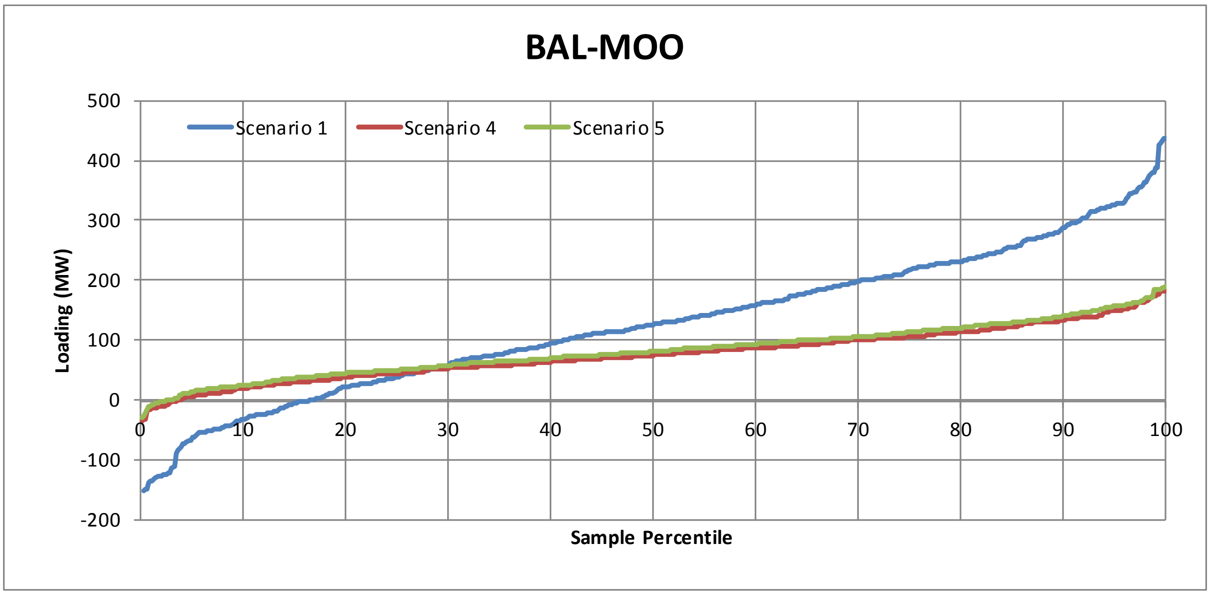

Figure 10: Comparison of load duration of BAL-MOO line for Scenarios 1, 4 and 5

7.3.2. Analysis of other operating conditions leading to overloading the selected regional VIC transmission lines

While additional renewable generation is the primary cause for overloading some of the regional VIC 220 kV lines, it is also important to understand the influence from other factors, such as region demand, other generation in the regions and interconnector transfers.

From the sampled cases in Scenario 1 (base case), Table 11 shows the cases in which selected line overloading occurs. Key observations are:

- The three regional VIC lines, ART-WBT, WBT-BAL and BAL-MOO are always overloaded irrespective of network operating conditions.
- HOR-RED line will be overloaded when local demand is low and Horsham renewable generation is high.

- BAL-BEN line will be overloaded when local demand is low and Ballarat (e.g. Stockyard Hills WF) renewable generation is high.
- WET-KER and BEN-KER lines will be overloaded when Kerang renewable generation is high.

Table 11: Case distribution of overloaded lines

Case	WET-KER	BEN-KER	BAL-BEN	HOR-RED	ART-WBT	WBT-BAL	BAL-MOO
1	-	Y	Y	-	Y	Y	Y
2	-	Y	Y	-	Y	Y	Y
3	Y	Y	Y	Y	Y	Y	Y
4	Y	-	-	-	Y	Y	Y
5	Y	-	-	-	Y	Y	Y
6	Y	-	-	-	Y	Y	Y
7	-	Y	Y	-	Y	Y	Y
8	-	Y	-	-	Y	Y	Y
9	Y	Y	-	-	Y	Y	Y
10	Y	Y	-	-	Y	Y	Y

7.3.3. Contribution factor of each renewable generation location to the line loading

Regression analysis over a number of variables was performed to identify the relative contribution of each variable to the loading of the selected line. The general formula is shown in equation 1 below:

$$y = \sum_1^n a_i x_i \qquad (1)$$

where:

y = output variable (i.e. line loading),

x = input variable (e.g. renewable generation, region demand, interconnector flows), and

a = coefficient of the corresponding variable

n = No. of variables

The coefficient factor of each renewable generator to the corresponding line loading is shown in Table 12, Table 13, and Table 14 for Scenarios 1, 4 and 5 respectively. The multiplication of the renewable generation (in MW) with the corresponding coefficient will be the MW change in the selected line. For example, in Scenario 1, for every 100 MW change in Kerang generation, approximately 41.6 MW will flow to the Kerang-Wemen line. Note that high correlation (R-squared from 97% to 99%) is obtained for all cases suggesting good correlation between the inputs and output variables. Detailed statistics are included in Appendices D to F.

Table 12: Sensitivity of renewable generation to the VIC 220 kV lines (Scenario 1)

Generation Variable	VIC 220 kV lines							
	WET-KER	BEN-KER	BAL-BEN	HOR-RED	HOR-ART	ART-WBT	WBT-BAL	BAL-MOO
Kerang	-0.416	-0.488	-0.181	0.053	-0.043	-0.023	0.286	0.184
Ararat	0.057	-0.060	0.001	0.072	-0.087	0.679	0.628	0.201
Mortlake	-0.148	0.198	0.257	0.230	-0.210	-0.200	0.140	-0.008
Stockyard	-0.141	0.190	0.325	0.240	-0.219	-0.215	0.116	0.294
Horsham	0.000	0.039	0.193	0.475	0.501	0.529	0.810	0.236
Moorabool	-0.146	0.200	0.281	0.234	-0.213	-0.216	0.151	-0.008

Table 13: Sensitivity of renewable generation to the VIC 220 kV lines (Scenario 4)

Generation Variable	VIC 220 kV lines							
	WET-KER	BEN-KER	BAL-BEN	HOR-RED	HOR-ART	ART-WBT	WBT-BAL	BAL-MOO
Kerang	-0.225	-0.237	-0.065	0.045	-0.037	-0.050	0.079	0.058
Ararat	0.028	-0.029	-0.010	0.017	-0.020	0.232	0.215	0.065
Mortlake	-0.094	0.119	0.196	0.152	-0.142	-0.123	0.009	-0.023
Stockyard	-0.088	0.113	0.213	0.151	-0.140	-0.131	-0.002	0.074
Horsham	-0.015	0.038	0.148	0.253	0.247	0.143	0.268	0.073
Moorabool	-0.089	0.114	0.201	0.148	-0.137	-0.130	-0.001	-0.092

Table 14: Sensitivity of renewable generation to the VIC 220 kV lines (Scenario 5)

Generation Variable	VIC 220 kV lines							
	WET-KER	BEN-KER	BAL-BEN	HOR-RED	HOR-ART	ART-WBT	WBT-BAL	BAL-MOO
Kerang	-0.392	-0.154	-0.008	0.203	-0.176	-0.125	0.117	0.092
Ararat	0.033	-0.005	0.008	0.030	-0.034	0.248	0.252	0.087
Mortlake	-0.270	0.088	0.206	0.278	-0.249	-0.128	0.069	0.016
Stockyard	-0.261	0.097	0.238	0.288	-0.258	-0.133	0.077	0.135
Horsham	-0.119	0.048	0.190	0.485	0.511	0.125	0.311	0.114
Moorabool	-0.266	0.087	0.216	0.280	-0.250	-0.130	0.081	-0.043

7.4. Amount of VIC renewable integration without overloading the network during system normal

The coefficient factors obtained in Section 7.3.3 do not only show the relative loading sensitivity to each renewable generation, but also provide a mechanism to prioritise the reducing renewable generation in order to avoid thermal overloading, i.e. the generation that causes the largest increase in line loading will be reduced first[9]. Using a set of load flow cases where all 6 renewable sites initially generate maximum active power, the renewable generators that are more responsible for line overloading are gradually reduced until all VIC 220 kV lines no longer overloaded. Table 15 shows the maximum regional VIC renewable generations that can be integrated into the network without causing congestion. Note that the actual renewable generation will be dependent on other variables such as local demand and interconnector flows. The values calculated in this study provide a comparison among the nine scenarios based on the same set of load flow cases.

Key observations are:

- The maximum of 1,621 MW of renewable generation permissible in regional VIC area without being constrained for Scenario 1 (base case). The result shows that without augmentation, Ararat has to be constrained to 0 (if Horsham is to be dispatched more), Stockyard Hill will also be constrained. Similarly, Kerang generation will be limited to 320 MW.
- The interconnection to NSW (Scenarios 2 and 3) can increase the VIC renewable generation by permitting more power generated in Kerang. However, the renewable generation in the Horsham-Ararat-Waubra-Ballarat-Moorabool path is still restricted due to no network augmentations in the area.
- With no transmission line being overloaded, Scenario 4 can achieve a maximum of 2,564 MW of renewable generation. This is followed by Scenario 5 (2,444 MW)[10].
- Scenarios 6 and 9 enable similar amount of renewable generation. The additional Snowy upgrade does not have any direct influence on the western VIC renewable generation.
- The development of NSI (Scenario 7) will enable more power flow from VIC through Kerang, Wemen, Red Cliffs to Buronga and Robertstown. Therefore, the Kerang generation has to be reduced (from case 1) to avoid overloading, resulting in a reduction in total VIC renewable generation allowable without being constrained.
- Similarly, the development of Horshamlink (Scenario 8) will encourage VIC renewable power flow from Ballarat to Tungkillo via Horsham. Reduction in the VIC renewable generation is needed to make room for the additional power flow to/from South Australia. Alternatively, further reinforcement is needed to accommodate the additional renewable generation from the two states.

[9] This is similar to the effect of coefficients in constraint equations used in NEMDE. However, actual generation dispatch process involves marginal loss factor (MLF) which is not modelled in this report

[10] Additional augmentations in the Victorian 220 kV network will increase this

Table 15: Maximum allowable VIC renewable generation without causing thermal overloading

Scenario	Estimated maximum regional VIC renewable generation (MW)						
	Kerang	Ararat	Mortlake	Stockyard	Horsham	Moorabool	Total
1	320	0	400	234	346	321	**1,621**
2	560	0	400	214	346	321	**1,841**
3	600	0	400	274	346	321	**1,941**
4	600	323	400	534	386	321	**2,564**
5	480	323	400	534	386	321	**2,444**
6	360	323	400	534	386	321	**2,324**
7	0	323	400	534	286	321	**1,864**
8	80	323	400	534	386	321	**2,043**
9	360	323	400	534	386	321	**2,324**

7.5. Maximum VIC renewable generation based on N-1 contingency consideration

Three critical line contingencies are used to determine the maximum VIC renewable generation allowable before overloading any of the regional VIC 220 kV transmission lines. These lines are:

- Contingency 1: Ballarat – Waubra (BAL-WBT)
- Contingency 2: Ballarat – Bendigo (BAL-BEN)
- Contingency 3: Ballarat – Moorabool (BAL-MOO)

The same set of load flow cases used for determining the maximum VIC renewable generation under system intact condition were used. The renewable generations were progressively scaled back until no line is overloaded after the corresponding contingency. The results are summarized in Table 16 below:

Table 16: Maximum allowable VIC renewable generation under N-1 contingency

Scenario	*Maximum RE generation N (MW)*	*Contingency 1 BAL-WBT (MW)*	*Contingency 2 BAL-BEN (MW)*	*Contingency 3 BAL-MOO (MW)*	*Maximum RE generation N-1 (MW)*
1	**1,621**	**1,585**	**1,601**	**1,381**	**1,381**
2	**1,841**	**1,661**	**1,800**	**1,523**	**1,523**
3	**1,941**	**1,701**	**1,921**	**1,661**	**1,661**
4	**2,564**	**2,464**	**2,464**	**2,464**	**2,464**
5	**2,444**	**2,344**	**2,284**	**2,324**	**2,284**
6	**2,324**	**2,004**	**2,204**	**2,204**	**2,004**
7	**1,864**	**1,764**	**1,684**	**1,784**	**1,684**
8	**2,043**	**1,944**	**1,964**	**1,944**	**1,944**
9	**2,324**	**2,003**	**1,904**	**2,204**	**1,904**

Key observations are:

- All scenarios enable higher renewable integration to the regional VIC network under both system intact and N-1 contingencies.
- While Scenario 4 can export all VIC renewables studied in this report at system intact condition, there is a 200 MW reduction for N-1 contingency due to the trip of one of the three WBT-BAL lines. The N-1 contingency capacities between Scenarios 4 and 5 are similar.

The limiting factors for each scenario are explained in Table 17 as follows:

Table 17: Limiting factor of each scenario under N-1 contingency

Scenario	*Critical contingency*	*Constraint mechanism*
1	BAL-MOO	The trip of one of the two BAL-MOO lines will reduce the VIC generation by the amount similar to the line rating (240 MVA).
2	BAL-MOO	The trip of one of the two BAL-MOO lines will reduce the VIC generation by the amount similar to the line rating (240 MVA).
3	BAL-MOO	The trip of one of the two BAL-MOO lines will reduce the VIC generation by the amount similar to the line rating (240 MVA).
4	BAL-WBT	The remaining two BAL-WBT lines can only carry a maximum of 752 MVA (376 MVA each). The sum of Horsham (386 MW) and Ararat (300 MW) and the existing Waubra WF will exceed this limit.
5	BAL-BEN	The trip of the only one BAL-BEN line will divert all power flow north of Bendigo (e.g. Kerang plus power from DLP) to KER-WET line which has a capacity of 205 MVA only.
6	BAL-WBT	This is the partial AEMO RIT-T option plus Snowy upgrade and the constraint mechanism is similar to that for Scenario 4.
7	BAL-BEN	Similar to Scenario 5.
8	BAL-BEN	HOR-RED is the limiting element as Horshamlink will increase flow into Horsham.
9	BAL-BEN	This partial AEMO-RIT-T relieves the thermal constraint in the ART-WAU-BAL corridor and therefore the trip of BAL-BEN which causes the KER-WET line to become the limiting factor.

Note that the maximum renewable generation is dependent on the local demand near the renewable generation sources, i.e. consumption of generation locally will reduce the network export to VIC load centre via the 220 kV network.

7.6. Augmentation impact on VIC-NSW transfer capacity

The impact of VIC renewable integration under the various scenarios on the VIC-NSW transfer capacity is discussed in Table 18[11].

Table 18: Summary on VIC-NSW transfer capacity

Scenario	Additional VIC export to NSW (MW)	Additional VIC import from NSW	(MW)Comment
1	No change	No change	VIC renewables displace existing thermal generators. No interconnector augmentation
2	420	310	Single circuit 330 kV KER-DLP increases the transfer limit. This scenario assumes transfer trip of new renewable generation for trip of Kerang – Darlington Point line.
2B	570	155	Connecting additional 300 MW renewables at Kerang 330 kV bus will increase VIC export by approx. 150 MW and reduce VIC import by approx. 150 MW, compared to scenario 2. This scenario assumes transfer trip of new renewable generation for trip of Kerang – Darlington Point line.
3	540	420	Double circuit 330 kV KER-DLP increases the transfer limit. Note that the additional flow path encourages extra power flow from Ballarat to Kerang via Bendigo, therefore creating higher line overload. Remedial action (e.g. phase-shifting transformer or series reactor limiting the flow, or increase the line thermal capacity) will facilitate higher transfers.
3B	740	220	Connecting additional 300 MW renewables at Kerang 330 kV bus will increase VIC export by approx. 200 MW and reduce VIC import by approx. 200 MW, compared to Scenario 3.
4	No change	No change	VIC renewables displace existing thermal generators. No interconnector augmentation. Regional VIC transmission network augmentation has no thermal impact to VIC-NSW interconnectors.
5	670	465	Double circuit 330 kV DLP-KER-MPT-BAL increases the transfer limit.
6	480	500	Additional double 330kV circuit from South Morang to Murray via Dederang increases the generation from Snowy (e.g. Snowy 2.0) to VIC. VIC export is limited due to the thermal constraints north of Murray/Snowy.
7	670	465	Inter-connector flow increases due to the Scenario 5 augmentation. However, it cannot increase further as some VIC 220 kV lines will be overloaded. NSI and the corresponding upgrade from Buronga to Wagga via Darlington Point can increase the flow to/from VIC via OX1. However, the flow cannot be increase from current level unless OX1 is upgraded.
8	670	465	Inter-connector flow increases due to the Scenario 5 augmentation. However, it cannot increase further as some VIC 220 kV lines will be overloaded. Horshamlink can increase the transfer between VIC and SA but not with NSW.

[11] Note that the transfer limit is based on thermal loading and voltage stability after N-1 contingency, and no transient stability is considered in this report.

Scenario	Additional VIC export to NSW (MW)	Additional VIC import from NSW	(MW)Comment
9	No change	No change	VIC renewables displace existing thermal generators. No interconnector augmentation. Regional VIC transmission network augmentation has no thermal impact to VIC-NSW interconnectors.

Note that the above transfer limits were derived using a limited number of system snapshots. Although effort is made to cover a wide range of operating conditions, the above transfer limits may vary under extreme operating conditions due to deep network limitations.

8. Additional sensitivity studies

Section 7 identified the capability of each scenario for accommodating renewable generations in the regional VIC network and the limiting factors. This section aims to refine the configurations of some of these options in order to optimize the performance. Table 19 shows the modifications made to selected scenarios.

Table 19: List of modifications of the scenarios selected for additional studies

Scenario	Modifications
2	Convert the originally proposed 330 kV KER-DLP single circuit to 220 kV single circuit of 417 MVA rating
3	Convert the originally proposed 330 kV KER-DLP double circuit to 220 kV double circuit of 417 MVA rating each circuit
5	Double circuit WET-KER and BEN-BAL lines to relieve the thermal constraints identified
7	Increase the OX1 rating from 300 MVA to 417 MVA

Change in KER-DLP utilisation

Table 20 shows the maximum active power flows for different KER-DLP line options (e.g. 330 kV or 220 kV). The results show that:

- The 330 kV options give more power flow as the line impedance reduces
- The 220 kV options, however, achieve higher utilisation as the capacities for 330 kV and 220 kV line options are assumed to be 1,000 MVA and 400 MVA respectively.

It is worth nothing that further connection of renewables along the KER-DLP path will directly increase the utilisation of the line(s).

Table 20: Comparison of maximum power flow and percentage utilization of different KER-DLP line configurations

Scenario	KER-DLP line(s) loading (export / import)	KER-DLP line(s) utilisation (export / import)
2 (330 kV KER-DLP single cct)	422 MW / 312 MW	42% / 31%
2 (modified, 220 kV KER-DLP single cct))	292 MW / 217 MW	70% / 52%
3 (330 kV KER-DLP double cct)	539 MW / 427 MW	27 % / 21%
3 (modified, 220 kV KER-DLP double cct))	428 MW / 331 MW	51% / 40%

Change in VIC renewable generation and NSW-VIC transfers

Table 21 shows the renewable generation that can be accommodated with the modified scenarios 2, 3, 5 and 7. Table 22 gives change in VIC-NSW transfers with the identified modifications. Key observations are:

- With the 330 kV KER-DLP lines converted to 220 kV, impedance increases, resulting in reduction in VIC export from the regional VIC renewables. This is seen in the modified cases of Scenario 2 and 3.
- In the modified Scenario 5, after removing the constraints from WET-KER and KER-BEN lines, the maximum VIC renewable generation is the similar to Scenario 4.
- Modification made for Scenario 7 results in increasing VIC renewable generation as well as NSW-VIC transfers (in both directions).

Table 21: Sensitivity study: Comparing maximum allowable VIC renewable generation under N-1 contingency

Scenario	System Intact	Contingency 1 BAL-WBT	Contingency 2 BAL-BEN	Contingency 3 BAL-MOO	Maximum RE generation (N-1)
2	**1,841**	**1,661**	**1,800**	**1,523**	**1,523**
2 (mod)	**1,741**	**1,637**	**1,740**	**1,467**	**1,467**
3	**1,941**	**1,701**	**1,921**	**1,661**	**1,661**
3 (mod)	**1,881**	**1,661**	**1,923**	**1,560**	**1,560**
5	**2,444**	**2,344**	**2,284**	**2,324**	**2,284**
5 (mod)	**2,564**	**2,364**	**2,464**	**2,464**	**2,364**
7	**1,864**	**1,764**	**1,684**	**1,784**	**1,684**
7 (mod)	**1,964**	**1,864**	**1,924**	**1,864**	**1,864**

Table 22: Sensitivity Study: Change in VIC-NSW transfers

Scenario	VIC export to NSW (MW)	VIC import from NSW (MW)	Comment
2	420	310	
2 (mod)	290	220	DLP-KER flow reduces for higher impedance
3	540	420	
3 (mod)	430	330	DLP-KER flow reduces for higher impedance
5	670	465	
5 (mod)	670	465	No significant change from Scenario 5 as it's more internal VIC augmentation.
7	670	465	
7 (mod)	750	550	Higher OX1 rating allow more interconnector flow

9. Further issues to consider

This study examines the steady state performance of each scenario and the corresponding steady state capacity available for transferring the proposed renewable generations in the regional VIC network. Some further points for consideration are:

1. This study considers only about 2,500 MW of renewable integrating into the regional VIC transmission network. According to AEMO's RIT-T PSCR document [3], this level will be reached in either 2021 (base case) or 2020 (sensitivity) scenarios – see Figure 11. It will take more than 5 years to complete any of the transmission augmentation project. Therefore, it is likely that some of the Western VIC renewable generations are to be constrained.
2. Scenario 4, which is proposed by AEMO, will be unable to address the potential overloading issue beyond 2021, based on the thermal capacity calculated in this study.

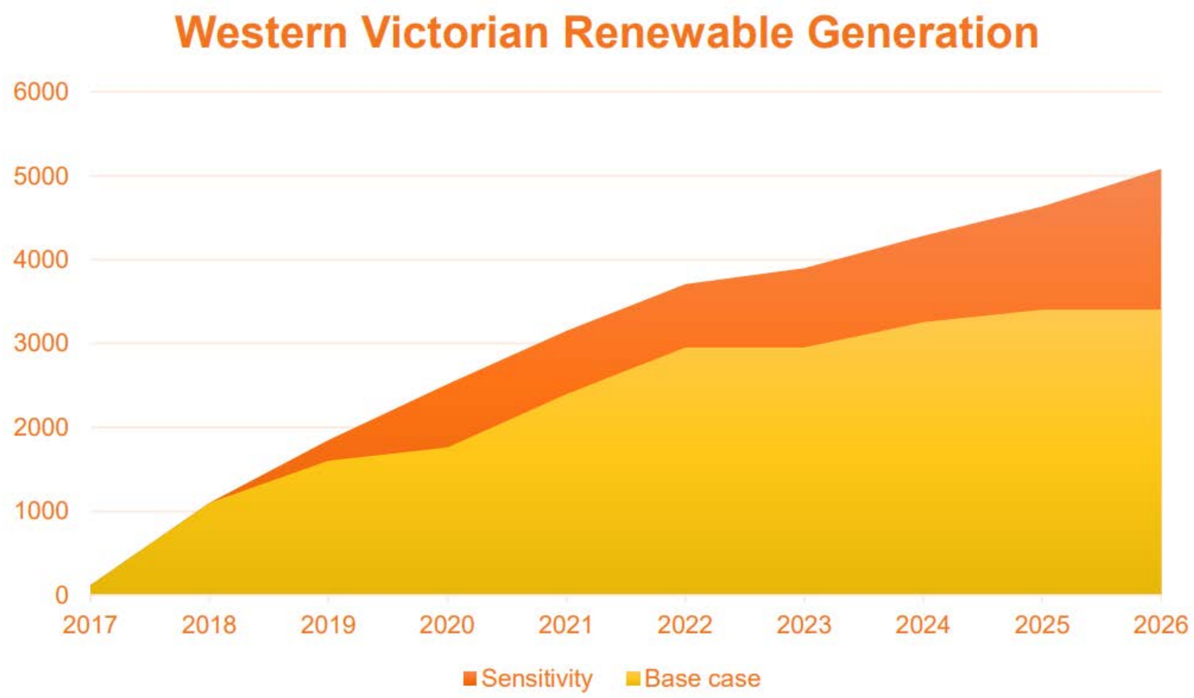

Figure 11: AEMO projected Western VIC renewable generation [3]

3. AEMO proposes to reinforce the network by either rebuilding double circuits or building extra single circuits on the existing easement for the regional VIC network. Circuit rebuild will cause considerable period of power disruption. In addition, having two single circuits in the same easement cannot have risk diversity, i.e. a bush fire or thunderstorm may take out both circuits in the same area.
4. TransGrid's complete scenario (Scenario 5) provides the following additional benefits:
    a. Geographical diversity: the new flow path can make the network less prone to common mode of failure.
    b. Increase interconnection between NSW and VIC, thus reducing the difference in regional electricity prices.
    c. New path for renewable connections: the proposed route can enable new renewable sites to connect to the network more economically.

5. Thermal congestions at KER-WET and BAL-BEN lines are seen in Scenario 5. Further upgrade of these two lines will relieve the overloading situation and further increase the capacity of this option for connecting more renewable generations.

10. Conclusions

Based on the analysis performed, the following key conclusions can be made.

Renewable generation capacity in western Victoria

With over 2,500 MW of renewable generations connecting to regional VIC network:

- The renewable generation will be constrained with no augmentation (Scenario 1)
- No constraint for Scenario 4, and small constraint for Scenario 5
- No constraint for Scenario 5 if additional KER-WET and KER-BAL lines are installed

Impact on VIC-NSW transfer capacity

- All scenarios with NSW connection augmentation (e.g. Scenarios 2, 3, 5, 6, 7 and 8) have increased the VIC-NSW interconnector transfers.

References

[1] AEMO, "National transmission network development plan (NTNDP)," December 2016.

[2] AEMO, Victorian Annual Planning Report, June 2016.

[3] AEMO, "Project Specification Consultation Report (PSCR) - Western Victoria Renewable Integration project," April 2017.

Appendix A – Single line diagrams

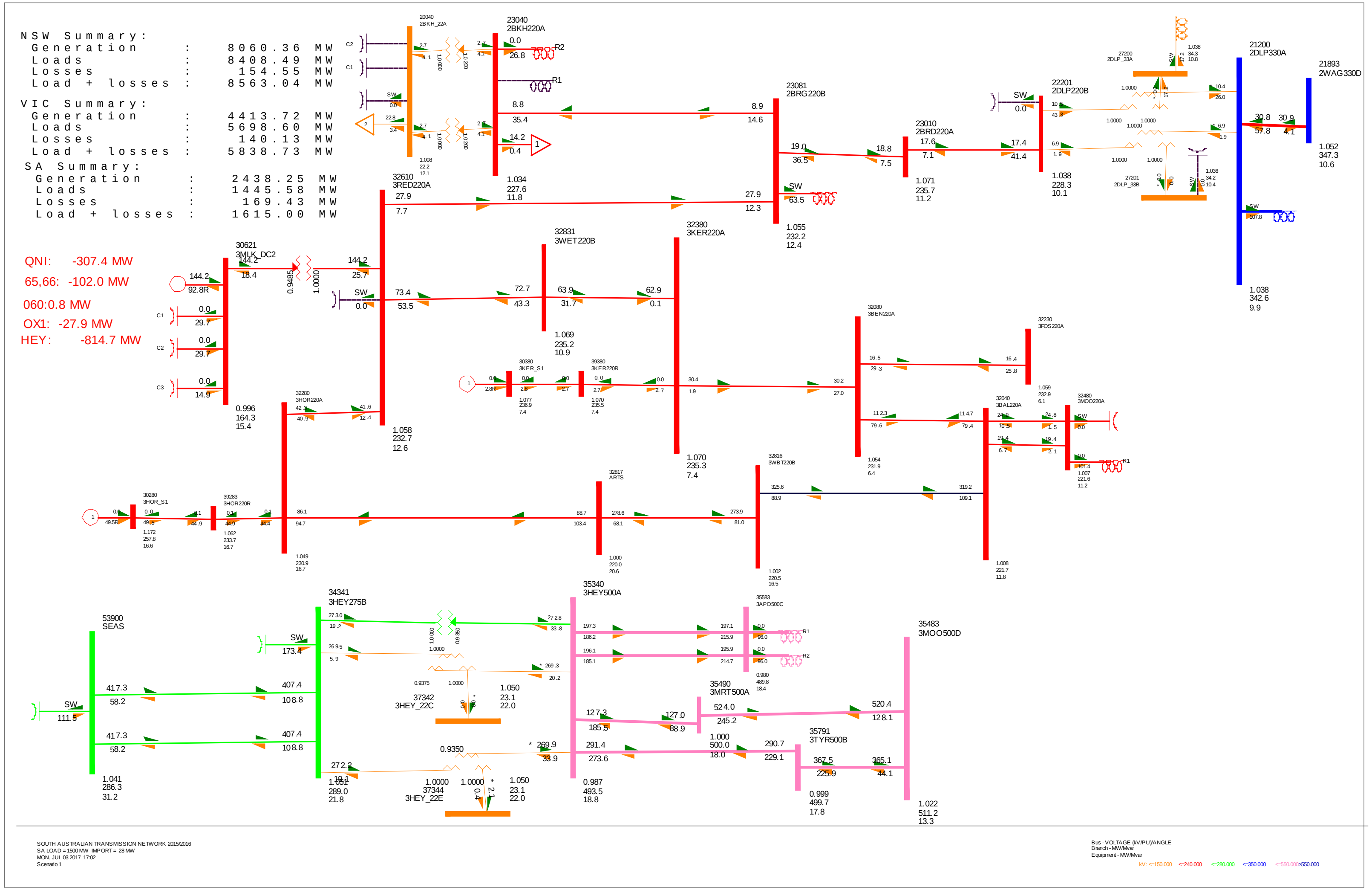

Figure 12: Scenario 1 – Original regional Victoria network (Base case)

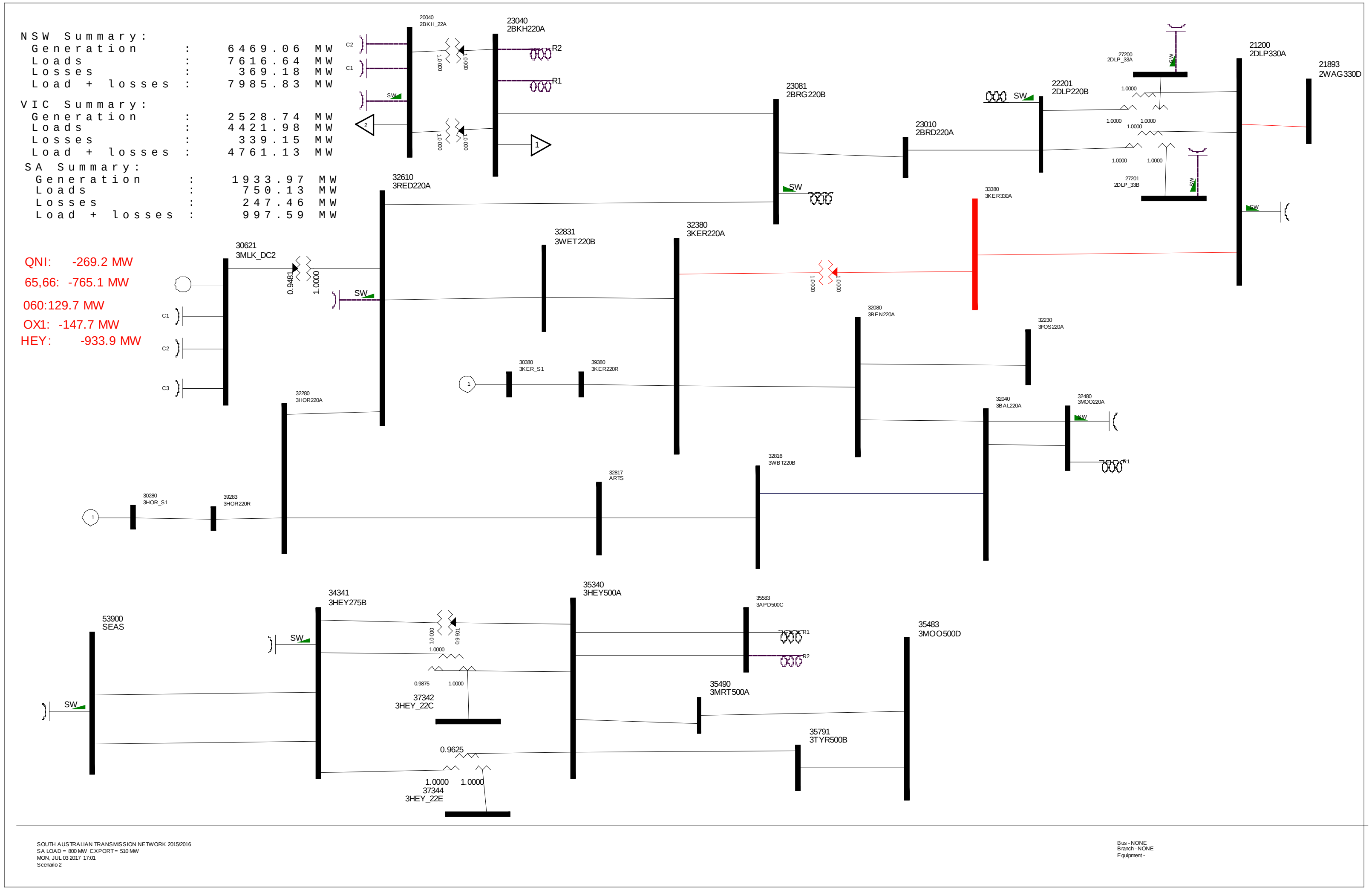

Figure 13: Scenario 2 – New 330 kV double circuit from Darlington Point to Kerang initially strung one side

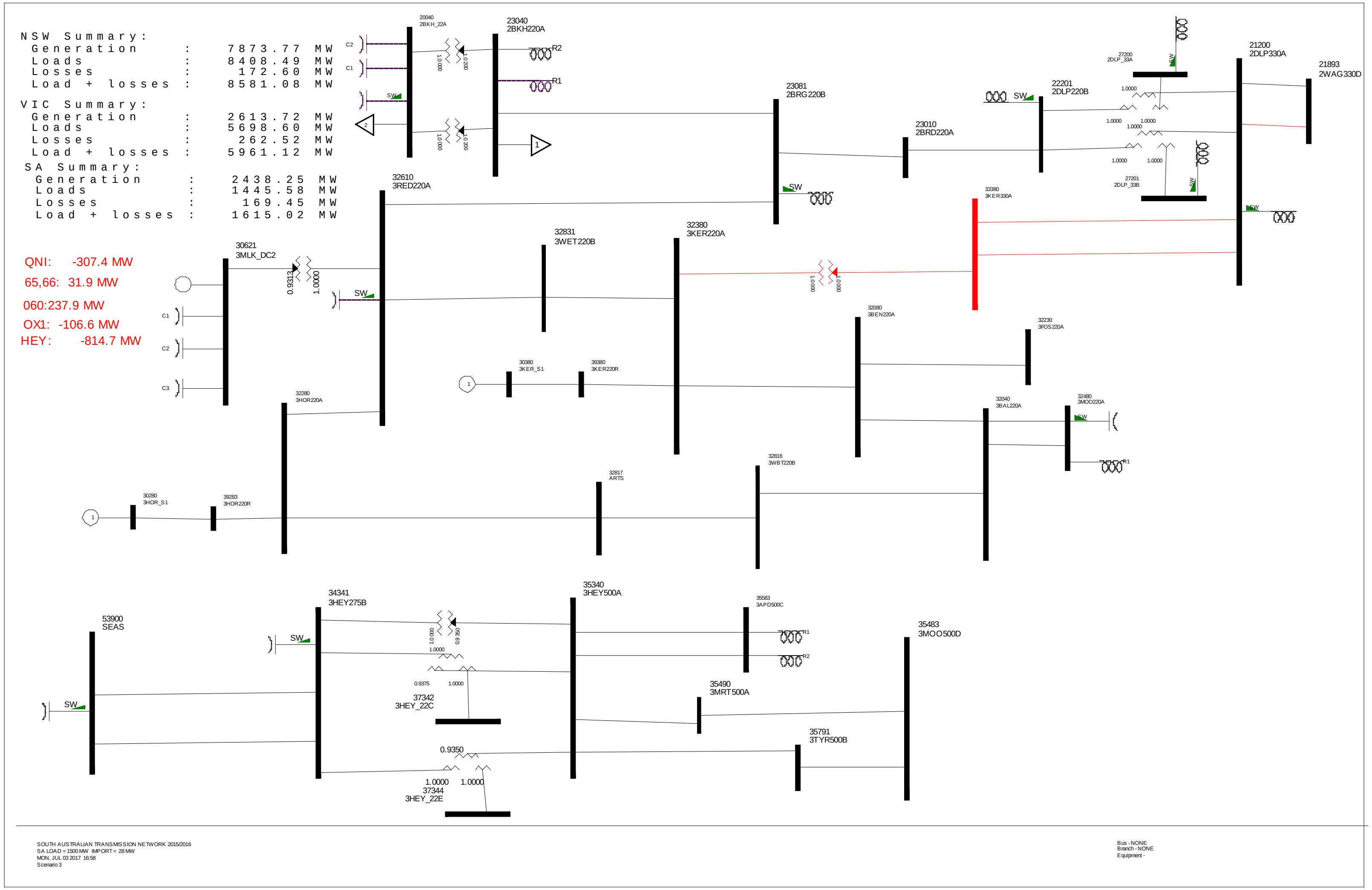

Figure 14: Scenario 3 – New 330 kV double circuit from Darlington Point to Kerang initially strung both sides

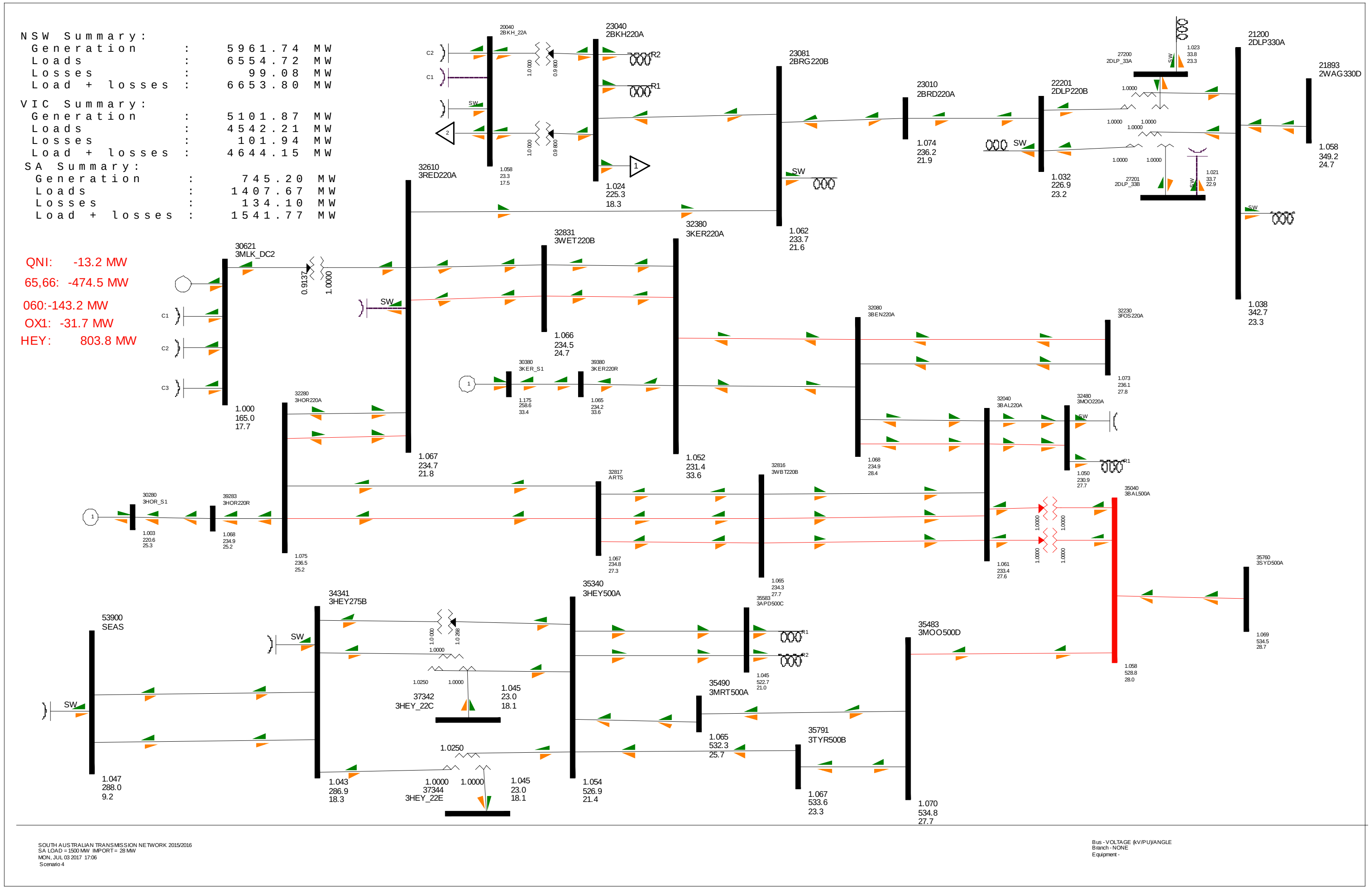

Figure 15: Scenario 4 – AEMO VIC RIT-T 220 kV line reinforcement

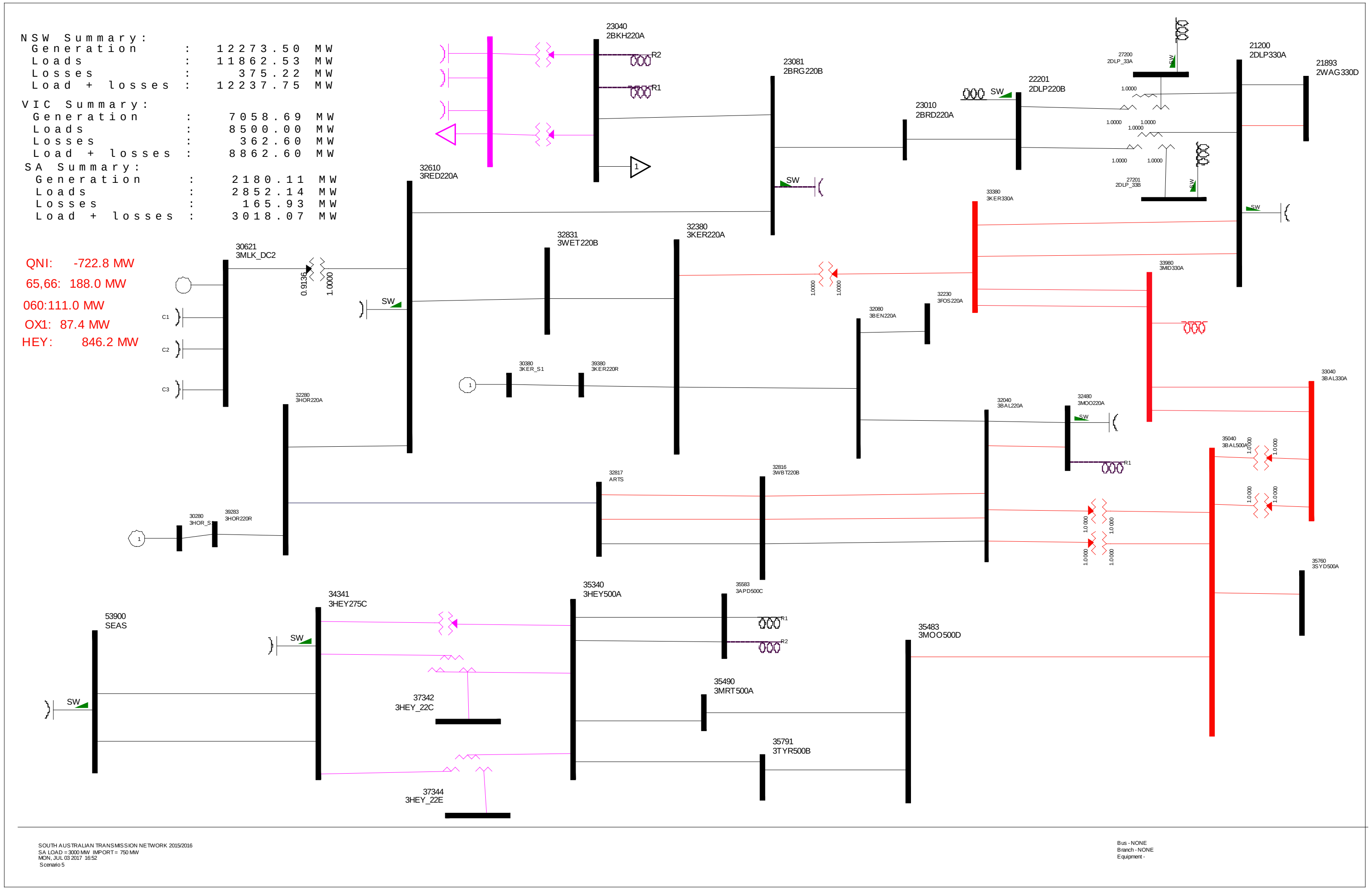

Figure 16: Scenario 5 – Complete Darlington Point to Kerang loop to Ballarat double circuit 330kV (via Mid Point), and Ballarat to Sydenham single circuit 500kV

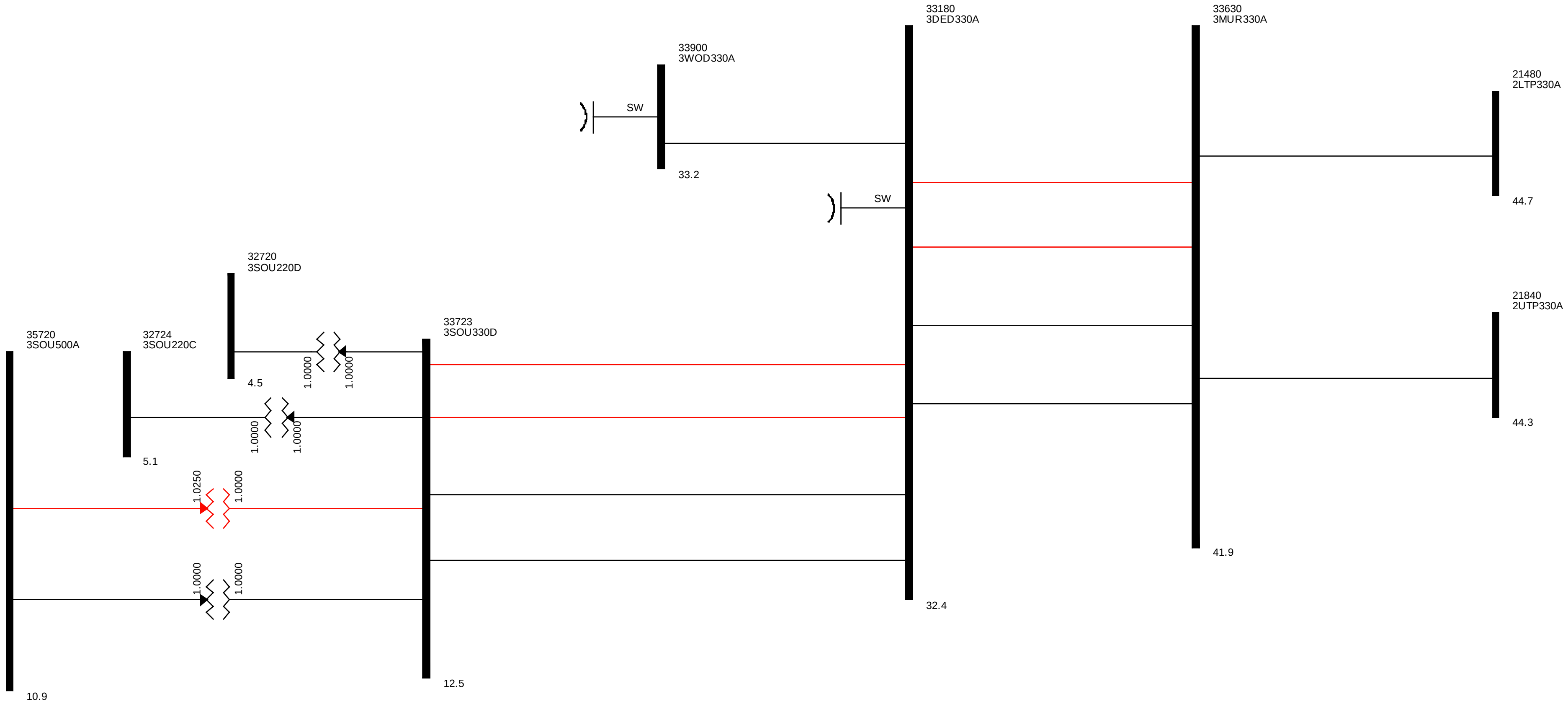

Figure 17: Scenario 6 – Snowy to South Morang upgrade with Victorian system option 2 (refer to Scenario 9 for the VRET partial upgrade)

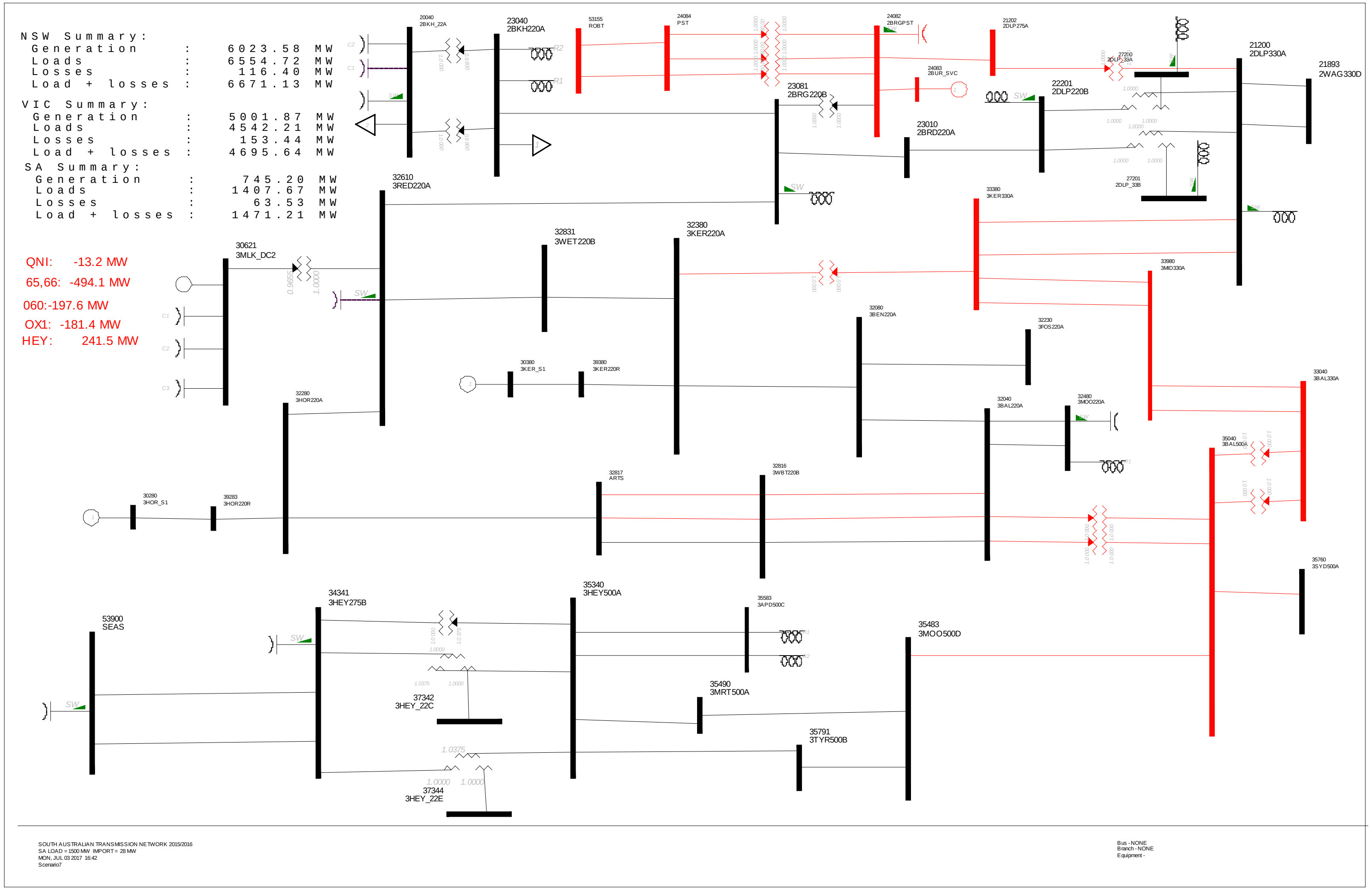

Figure 18: Scenario 7 – Scenario 5 + new medium capacity NSW-SA interconnector

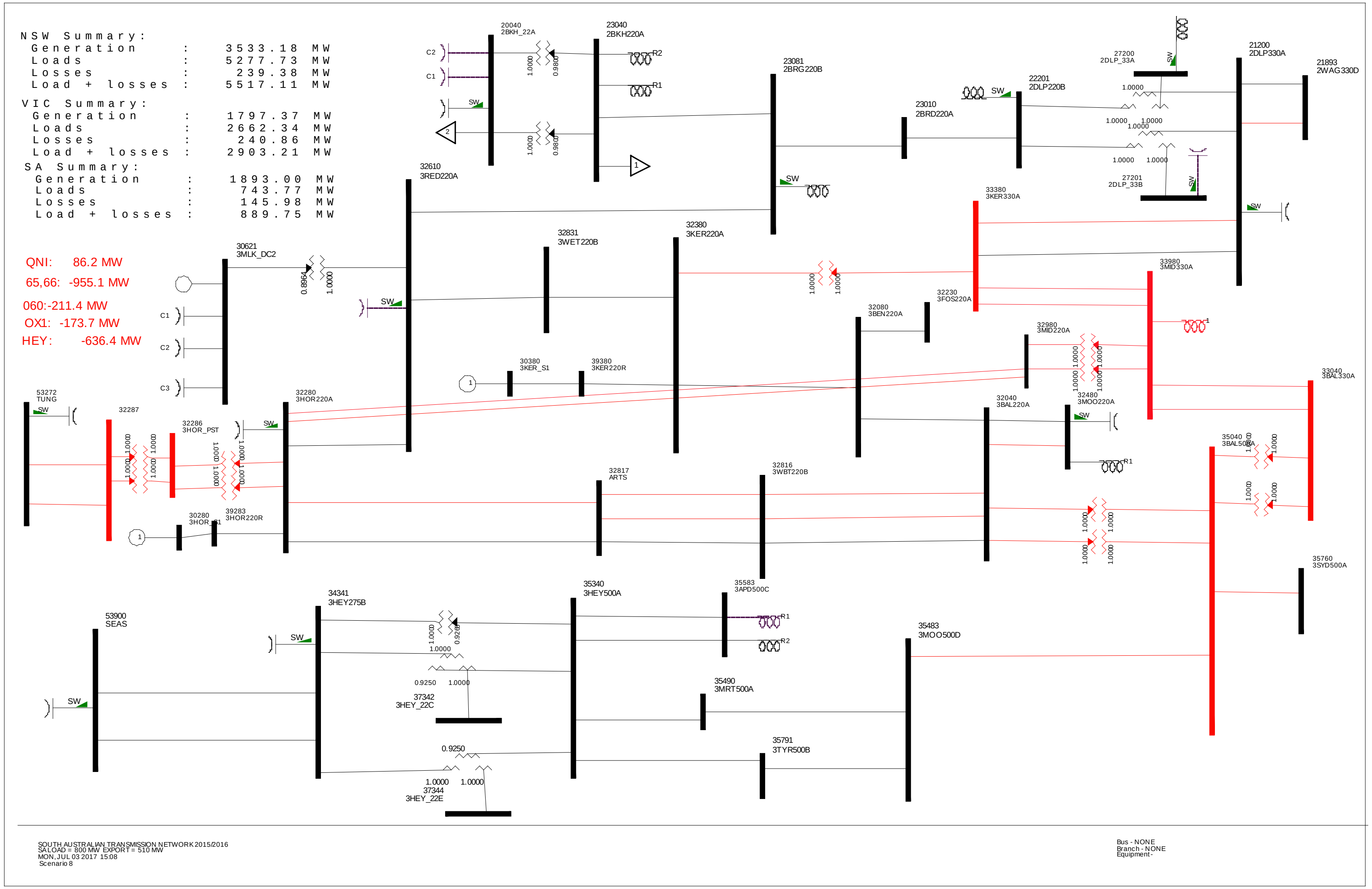

Figure 19: Scenario 8 – Scenario 5 + new medium capacity SA-VIC interconnector

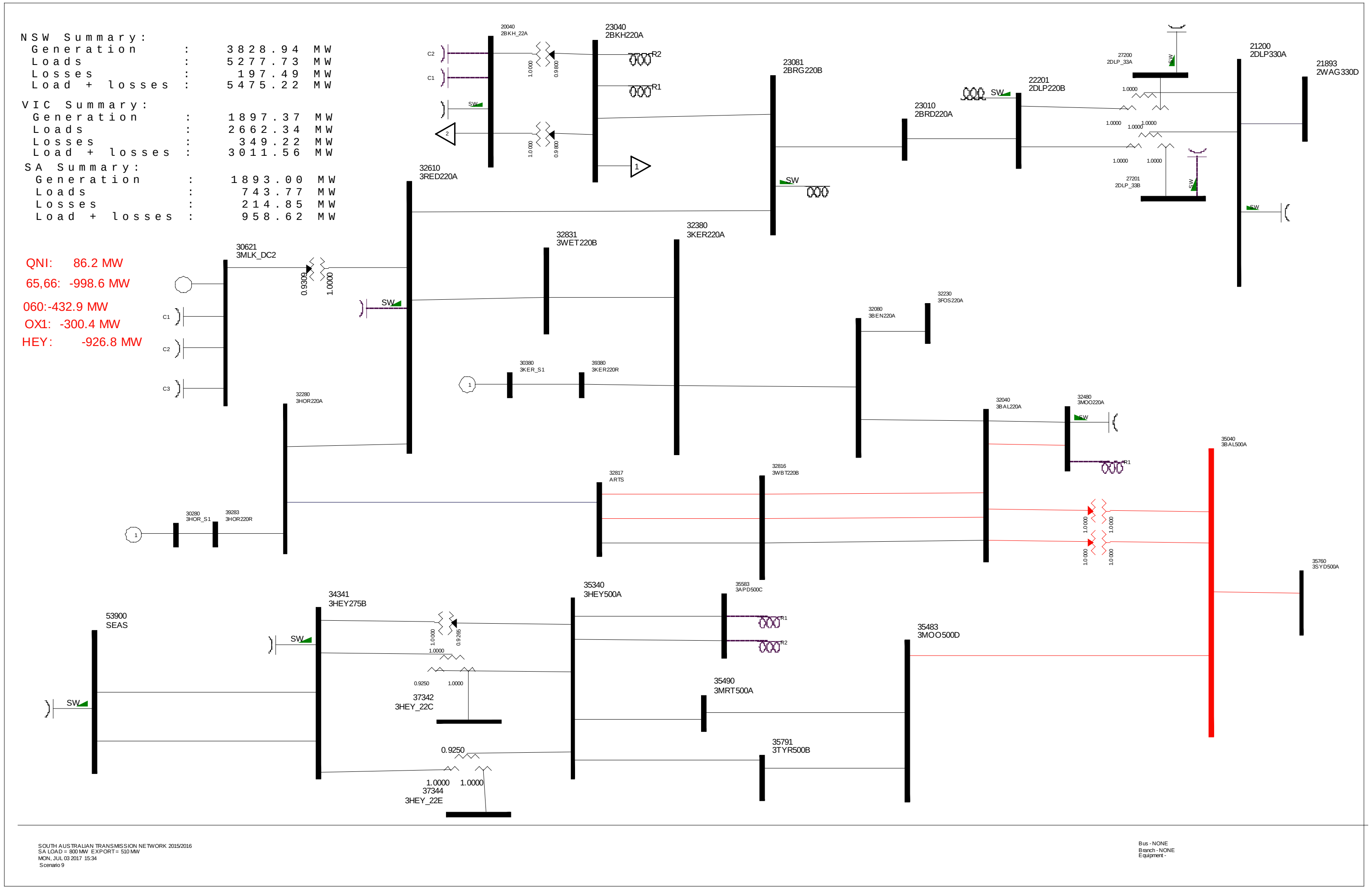

Figure 20: Scenario 9 – Partial Victoria VRET RIT-T option

Appendix C – Detailed study case information

Case	Gen - QLD	Gen - NSW	Gen - VIC	Gen - SA	Gen - TAS	Load - QLD	Load - NSW	Load - VIC	Load - SA	Load - TAS	Flow - QLD>NSW	Flow - NSW>VIC	Flow - SA>VIC	Flow - VIC>TAS
1	5103.6	4278.4	3798.2	1162.5	722.3	5032.4	5277.7	2784.2	747.6	703.6	-85.7	-1193.0	333.7	0.0
2	6685.7	7396.2	6866.1	1474.5	1593.8	6608.3	8483.7	5479.2	1423.0	1345.8	-94.6	-1377.1	-25.3	-189.3
3	5617.7	6039.4	6027.3	828.7	971.7	5418.1	6554.7	4618.1	1435.8	873.3	42.6	-570.7	-739.6	-74.6
4	7289.8	10046.5	7497.5	2288.4	1669.1	6267.7	9819.9	7857.2	2896.4	1013.3	814.8	787.9	-763.1	-566.8
5	7289.8	10429.2	8151.1	2132.1	1669.1	6267.7	9819.9	8500.0	2896.4	1013.3	814.8	782.3	-908.5	-566.8
6	7289.8	12470.7	8151.1	2180.1	1669.1	6267.7	11862.5	8500.0	2896.4	1013.3	814.8	698.6	-845.7	-566.8
7	7240.0	6340.2	5363.0	1184.1	1210.2	6710.8	7616.6	4480.1	747.6	835.0	319.0	-1314.5	359.5	-297.9
8	6810.2	7979.4	5835.3	1488.0	1460.7	6254.6	8408.5	5795.6	1423.0	1035.7	373.7	-222.1	-11.8	-339.3
9	6810.2	8080.5	6136.2	1104.1	1460.7	6254.6	8408.5	5795.6	1435.8	1035.7	373.7	-121.4	-398.8	-339.3
10	6808.6	8905.4	7175.0	2339.5	1165.7	6368.6	8262.9	6942.2	2896.4	1049.1	204.3	612.3	-695.1	-84.5

Appendix D – Results of regression analysis – Scenario 1

SUMMARY OUTPUT		**WET>KER**						
Regression Statistics								
Multiple R	0.997321							
R Square	0.994649							
Adjusted R Square	0.994492							
Standard Error	7.946984							
Observations	561							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	16	6386533	399158.3	6320.341	0			
Residual	544	34356.08	63.15456					
Total	560	6420889						
	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-228.872	27.58218	-8.29784	8.4E-16	-283.053	-174.692	-283.053	-174.692
Kerang	-0.41616	0.006318	-65.8663	2.2E-261	-0.42857	-0.40375	-0.42857	-0.40375
Ararat	0.057263	0.00238	24.05523	1.24E-87	0.052587	0.061939	0.052587	0.061939
Mortlake	-0.14768	0.00684	-21.5903	3.91E-75	-0.16112	-0.13424	-0.16112	-0.13424
Stockyard	-0.14055	0.006648	-21.1413	7.28E-73	-0.15361	-0.12749	-0.15361	-0.12749
Horsham	0.000401	0.006089	0.06589	0.94749	-0.01156	0.012363	-0.01156	0.012363
Moorabool	-0.14612	0.006826	-21.4049	3.39E-74	-0.15953	-0.13271	-0.15953	-0.13271
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	-0.16313	0.025159	-6.48406	#NUM!	-0.21255	-0.11371	-0.21255	-0.11371
Gen - VIC	-0.14551	0.006608	-22.0202	2.6E-77	-0.15848	-0.13253	-0.15848	-0.13253
Gen - SA	1.065502	0.064123	16.61662	1.9E-50	0.939543	1.19146	0.939543	1.19146
Load - NSW	0.177664	0.026566	6.687557	5.64E-11	0.125479	0.229849	0.125479	0.229849
Load - VIC	0.165128	0.007755	21.29398	1.23E-73	0.149895	0.180361	0.149895	0.180361
Load - SA	-1.13048	0.06748	-16.7528	4.2E-51	-1.26303	-0.99793	-1.26303	-0.99793
Flow - NSW>VIC	0.06319	0.021725	2.908647	0.003778	0.020515	0.105865	0.020515	0.105865
Flow - SA>VIC	-1.1435	0.066809	-17.116	7.38E-53	-1.27474	-1.01227	-1.27474	-1.01227
Flow - VIC>TAS	0.527923	0.049368	10.69371	2.36E-24	0.430949	0.624898	0.430949	0.624898

SUMMARY OUTPUT		**BEN>KER**						
Regression Statistics								
Multiple R	0.99879							
R Square	0.997582							
Adjusted R Square	0.997511							
Standard Error	10.81014							
Observations	561							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	16	26227364	1639210	14027.24	0			
Residual	544	63571.34	116.8591					
Total	560	26290935						
	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	439.2768	37.51954	11.70795	2.15E-28	365.5759	512.9777	365.5759	512.9777
Kerang	-0.48764	0.008595	-56.7384	1.3E-230	-0.50452	-0.47076	-0.50452	-0.47076
Ararat	-0.05998	0.003238	-18.5214	9.57E-60	-0.06634	-0.05361	-0.06634	-0.05361
Mortlake	0.197559	0.009304	21.2327	2.51E-73	0.179282	0.215836	0.179282	0.215836
Stockyard	0.190195	0.009044	21.03095	2.63E-72	0.172431	0.20796	0.172431	0.20796
Horsham	0.039468	0.008283	4.764831	2.43E-06	0.023197	0.055739	0.023197	0.055739
Moorabool	0.200491	0.009286	21.59095	3.88E-75	0.182251	0.218732	0.182251	0.218732
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	0.306514	0.034223	8.956275	#NUM!	0.239288	0.37374	0.239288	0.37374
Gen - VIC	0.193161	0.008988	21.48996	1.26E-74	0.175505	0.210818	0.175505	0.210818
Gen - SA	-1.60173	0.087225	-18.3632	5.79E-59	-1.77307	-1.43039	-1.77307	-1.43039
Load - NSW	-0.33047	0.036138	-9.14477	1.19E-18	-0.40146	-0.25948	-0.40146	-0.25948
Load - VIC	-0.23151	0.010549	-21.9471	6.1E-77	-0.25223	-0.21079	-0.25223	-0.21079
Load - SA	1.69136	0.091792	18.42607	2.83E-59	1.511051	1.87167	1.511051	1.87167
Flow - NSW>VIC	-0.13474	0.029552	-4.55925	6.35E-06	-0.19279	-0.07669	-0.19279	-0.07669
Flow - SA>VIC	1.730252	0.090879	19.03905	2.59E-62	1.551735	1.908769	1.551735	1.908769
Flow - VIC>TAS	-0.87629	0.067154	-13.0489	4.73E-34	-1.0082	-0.74437	-1.0082	-0.74437

SUMMARY OUTPUT			**BAL>BEN**					
Regression Statistics								
Multiple R	0.998528							
R Square	0.997057							
Adjusted R Square	0.996971							
Standard Error	7.789445							
Observations	561							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	16	11184395	699024.7	11520.72	0			
Residual	544	33007.45	60.67546					
Total	560	11217403						
	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	115.7427	27.0354	4.281154	2.2E-05	62.63613	168.8493	62.63613	168.8493
Kerang	-0.18143	0.006193	-29.2958	6.1E-114	-0.19359	-0.16926	-0.19359	-0.16926
Ararat	0.000557	0.002333	0.238547	0.811547	-0.00403	0.00514	-0.00403	0.00514
Mortlake	0.257177	0.006705	38.35882	7.9E-157	0.244007	0.270347	0.244007	0.270347
Stockyard	0.324959	0.006517	49.86688	4.8E-205	0.312158	0.33776	0.312158	0.33776
Horsham	0.192743	0.005969	32.29291	1.5E-128	0.181019	0.204467	0.181019	0.204467
Moorabool	0.28097	0.006691	41.99149	8.2E-173	0.267826	0.294114	0.267826	0.294114
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	-0.09401	0.02466	-3.81219	#NUM!	-0.14245	-0.04557	-0.14245	-0.04557
Gen - VIC	0.244686	0.006477	37.77886	3.3E-154	0.231963	0.257409	0.231963	0.257409
Gen - SA	-0.60392	0.062851	-9.60864	2.7E-20	-0.72738	-0.48046	-0.72738	-0.48046
Load - NSW	0.096489	0.02604	3.70545	0.000233	0.045338	0.14764	0.045338	0.14764
Load - VIC	-0.2287	0.007601	-30.088	7.7E-118	-0.24363	-0.21377	-0.24363	-0.21377
Load - SA	0.592385	0.066142	8.956234	5.33E-18	0.46246	0.722311	0.46246	0.722311
Flow - NSW>VIC	0.233738	0.021294	10.97659	1.85E-25	0.191909	0.275567	0.191909	0.275567
Flow - SA>VIC	0.842501	0.065485	12.86563	2.93E-33	0.713867	0.971135	0.713867	0.971135
Flow - VIC>TAS	-0.12782	0.048389	-2.64147	0.008492	-0.22287	-0.03277	-0.22287	-0.03277

SUMMARY OUTPUT			**HOR>RED**					
Regression Statistics								
Multiple R	0.993769							
R Square	0.987577							
Adjusted R Square	0.987211							
Standard Error	9.633031							
Observations	561							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	16	4012885	250805.3	2702.781	0			
Residual	544	50480.64	92.79529					
Total	560	4063366						
	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-157.87	33.43407	-4.72185	2.98E-06	-223.546	-92.1948	-223.546	-92.1948
Kerang	0.052766	0.007659	6.889713	1.55E-11	0.037722	0.06781	0.037722	0.06781
Ararat	0.071858	0.002886	24.9028	6.29E-92	0.06619	0.077526	0.06619	0.077526
Mortlake	0.230096	0.008291	27.75146	2.9E-106	0.213809	0.246383	0.213809	0.246383
Stockyard	0.239647	0.008059	29.73708	4.1E-116	0.223816	0.255477	0.223816	0.255477
Horsham	0.475033	0.007381	64.35703	1.5E-256	0.460534	0.489532	0.460534	0.489532
Moorabool	0.233676	0.008275	28.23959	1.1E-108	0.217421	0.24993	0.217421	0.24993
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	-0.28636	0.030497	-9.3897	#NUM!	-0.34626	-0.22645	-0.34626	-0.22645
Gen - VIC	0.227199	0.00801	28.36542	2.5E-109	0.211465	0.242932	0.211465	0.242932
Gen - SA	-0.1156	0.077727	-1.48723	0.137535	-0.26828	0.037084	-0.26828	0.037084
Load - NSW	0.297952	0.032203	9.252395	4.99E-19	0.234695	0.361209	0.234695	0.361209
Load - VIC	-0.18352	0.0094	-19.5233	9.94E-65	-0.20198	-0.16505	-0.20198	-0.16505
Load - SA	0.097061	0.081797	1.186613	0.235898	-0.06361	0.257737	-0.06361	0.257737
Flow - NSW>VIC	0.396088	0.026334	15.04087	5.25E-43	0.344359	0.447817	0.344359	0.447817
Flow - SA>VIC	0.291366	0.080983	3.597855	0.00035	0.132288	0.450445	0.132288	0.450445
Flow - VIC>TAS	0.273168	0.059842	4.564858	6.19E-06	0.15562	0.390717	0.15562	0.390717

SUMMARY OUTPUT **HOR>ART**

Regression Statistics	
Multiple R	0.998233
R Square	0.996469
Adjusted R Square	0.996365
Standard Error	9.069724
Observations	561

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	16	12627829	789239.3	9594.461	0
Residual	544	44749.38	82.25989		
Total	560	12672578			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	169.4767	31.47895	5.38381	1.09E-07	107.6415	231.3119	107.6415	231.3119
Kerang	-0.0434	0.007211	-6.01854	3.24E-09	-0.05756	-0.02923	-0.05756	-0.02923
Ararat	-0.08651	0.002717	-31.8426	2.2E-126	-0.09185	-0.08117	-0.09185	-0.08117
Mortlake	-0.2103	0.007806	-26.9387	3.4E-102	-0.22563	-0.19496	-0.22563	-0.19496
Stockyard	-0.21892	0.007588	-28.8519	9.6E-112	-0.23382	-0.20401	-0.23382	-0.20401
Horsham	0.501075	0.00695	72.10149	1.4E-280	0.487424	0.514726	0.487424	0.514726
Moorabool	-0.21266	0.007791	-27.2961	5.5E-104	-0.22796	-0.19736	-0.22796	-0.19736
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	0.269213	0.028713	9.375847	#NUM!	0.21281	0.325616	0.21281	0.325616
Gen - VIC	-0.20763	0.007541	-27.5326	3.6E-105	-0.22245	-0.19282	-0.22245	-0.19282
Gen - SA	0.122793	0.073182	1.677916	0.093938	-0.02096	0.266546	-0.02096	0.266546
Load - NSW	-0.2798	0.03032	-9.22829	6.07E-19	-0.33936	-0.22024	-0.33936	-0.22024
Load - VIC	0.152563	0.00885	17.2383	1.88E-53	0.135178	0.169948	0.135178	0.169948
Load - SA	-0.1076	0.077013	-1.39719	0.162926	-0.25888	0.043678	-0.25888	0.043678
Flow - NSW>VIC	-0.3629	0.024794	-14.6364	3.84E-41	-0.4116	-0.31419	-0.4116	-0.31419
Flow - SA>VIC	-0.28285	0.076248	-3.70957	0.000229	-0.43262	-0.13307	-0.43262	-0.13307
Flow - VIC>TAS	-0.30802	0.056342	-5.46698	6.98E-08	-0.4187	-0.19735	-0.4187	-0.19735

SUMMARY OUTPUT **ART>WBT**

Regression Statistics	
Multiple R	0.993383
R Square	0.986809
Adjusted R Square	0.986421
Standard Error	22.48171
Observations	561

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	16	20569210	1285576	2543.542	0
Residual	544	274952.5	505.4273		
Total	560	20844163			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-1309.8	78.02892	-16.7861	2.9E-51	-1463.07	-1156.52	-1463.07	-1156.52
Kerang	-0.02326	0.017874	-1.30123	0.193729	-0.05837	0.011852	-0.05837	0.011852
Ararat	0.679455	0.006734	100.8942	0	0.666226	0.692683	0.666226	0.692683
Mortlake	-0.19973	0.01935	-10.322	6.23E-23	-0.23775	-0.16172	-0.23775	-0.16172
Stockyard	-0.21518	0.018808	-11.4408	2.62E-27	-0.25212	-0.17823	-0.25212	-0.17823
Horsham	0.528645	0.017226	30.68809	8.8E-121	0.494806	0.562483	0.494806	0.562483
Moorabool	-0.21631	0.019312	-11.2008	2.4E-26	-0.25424	-0.17837	-0.25424	-0.17837
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	-1.05776	0.071174	-14.8616	#NUM!	-1.19757	-0.91795	-1.19757	-0.91795
Gen - VIC	-0.18601	0.018693	-9.95075	1.52E-21	-0.22273	-0.14929	-0.22273	-0.14929
Gen - SA	3.783424	0.1814	20.85675	1.99E-71	3.427093	4.139755	3.427093	4.139755
Load - NSW	1.124048	0.075155	14.95636	1.29E-42	0.976418	1.271678	0.976418	1.271678
Load - VIC	0.353045	0.021938	16.09308	6.03E-48	0.309952	0.396138	0.309952	0.396138
Load - SA	-3.97308	0.190898	-20.8126	3.32E-71	-4.34807	-3.59809	-4.34807	-3.59809
Flow - NSW>VIC	0.808656	0.061459	13.15767	1.59E-34	0.68793	0.929382	0.68793	0.929382
Flow - SA>VIC	-3.88066	0.189	-20.5326	8.56E-70	-4.25192	-3.5094	-4.25192	-3.5094
Flow - VIC>TAS	2.540639	0.139659	18.1917	4.06E-58	2.266302	2.814977	2.266302	2.814977

SUMMARY OUTPUT **WBT>BAL**

Regression Statistics	
Multiple R	0.986696
R Square	0.973569
Adjusted R Square	0.972792
Standard Error	32.56835
Observations	561

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	16	21254432	1328402	1252.386	0
Residual	544	577019.2	1060.697		
Total	560	21831451			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-1493.51	113.0373	-13.2126	9.16E-35	-1715.56	-1271.47	-1715.56	-1271.47
Kerang	0.286344	0.025893	11.05863	8.8E-26	0.235481	0.337207	0.235481	0.337207
Ararat	0.627899	0.009756	64.36194	1.5E-256	0.608735	0.647063	0.608735	0.647063
Mortlake	0.139583	0.028032	4.979392	8.58E-07	0.084518	0.194647	0.084518	0.194647
Stockyard	0.115991	0.027246	4.257156	2.44E-05	0.062471	0.169512	0.062471	0.169512
Horsham	0.810127	0.024955	32.4633	2.2E-129	0.761106	0.859147	0.761106	0.859147
Moorabool	0.150876	0.027976	5.393024	1.03E-07	0.095921	0.20583	0.095921	0.20583
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	-1.55615	0.103107	-15.0927	#NUM!	-1.75869	-1.35362	-1.75869	-1.35362
Gen - VIC	0.151018	0.02708	5.576738	3.87E-08	0.097824	0.204213	0.097824	0.204213
Gen - SA	4.267604	0.262788	16.23975	1.21E-48	3.751402	4.783807	3.751402	4.783807
Load - NSW	1.649469	0.108874	15.15021	1.63E-43	1.435603	1.863334	1.435603	1.863334
Load - VIC	0.085463	0.03178	2.689186	0.007382	0.023036	0.14789	0.023036	0.14789
Load - SA	-4.64454	0.276546	-16.7948	2.63E-51	-5.18777	-4.10131	-5.18777	-4.10131
Flow - NSW>VIC	1.604559	0.089033	18.02205	2.78E-57	1.429668	1.77945	1.429668	1.77945
Flow - SA>VIC	-4.04364	0.273797	-14.7688	9.48E-42	-4.58147	-3.50581	-4.58147	-3.50581
Flow - VIC>TAS	3.12489	0.202319	15.44538	6.86E-45	2.727468	3.522311	2.727468	3.522311

SUMMARY OUTPUT **BAL>MOO2**

Regression Statistics	
Multiple R	0.994011
R Square	0.988057
Adjusted R Square	0.987706
Standard Error	13.45555
Observations	561

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	16	8148444	509277.8	2812.883	0
Residual	544	98492.22	181.0519		
Total	560	8246936			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-646.76	46.70117	-13.8489	1.41E-37	-738.497	-555.024	-738.497	-555.024
Kerang	0.184487	0.010698	17.24536	1.74E-53	0.163473	0.205501	0.163473	0.205501
Ararat	0.200601	0.004031	49.76992	1.1E-204	0.192684	0.208519	0.192684	0.208519
Mortlake	-0.00811	0.011581	-0.70035	0.484007	-0.03086	0.014639	-0.03086	0.014639
Stockyard	0.293912	0.011257	26.10997	5.01E-98	0.2718	0.316024	0.2718	0.316024
Horsham	0.235934	0.01031	22.88363	1.09E-81	0.215682	0.256187	0.215682	0.256187
Moorabool	-0.00849	0.011558	-0.7344	0.463019	-0.03119	0.014216	-0.03119	0.014216
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	-0.57401	0.042598	-13.4749	#NUM!	-0.65769	-0.49033	-0.65769	-0.49033
Gen - VIC	0.000207	0.011188	0.018479	0.985264	-0.02177	0.022184	-0.02177	0.022184
Gen - SA	2.168166	0.10857	19.97018	5.75E-67	1.954898	2.381434	1.954898	2.381434
Load - NSW	0.612177	0.044981	13.60962	1.64E-36	0.523819	0.700535	0.523819	0.700535
Load - VIC	0.063612	0.01313	4.844822	1.65E-06	0.037821	0.089404	0.037821	0.089404
Load - SA	-2.30516	0.114255	-20.1757	5.34E-68	-2.5296	-2.08073	-2.5296	-2.08073
Flow - NSW>VIC	0.571539	0.036784	15.53776	2.53E-45	0.499283	0.643794	0.499283	0.643794
Flow - SA>VIC	-2.14188	0.113119	-18.9348	8.53E-62	-2.36408	-1.91967	-2.36408	-1.91967
Flow - VIC>TAS	1.168837	0.083588	13.98338	3.52E-38	1.004643	1.333031	1.004643	1.333031

Appendix E – Results of regression analysis – Scenario 4

SUMMARY OUTPUT		**WET>KER**						
Regression Statistics								
Multiple R	0.997627							
R Square	0.995259							
Adjusted R Square	0.995137							
Standard Error	4.026035							
Observations	636							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	16	2106409	131650.6	8122.088	0			
Residual	619	10033.34	16.20896					
Total	635	2116442						
	Coefficient	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-70.0614	18.30428	-3.8276	0.000143	-106.007	-34.1154	-106.007	-34.1154
Kerang	-0.22525	0.003664	-61.4745	9.5E-266	-0.23244	-0.21805	-0.23244	-0.21805
Ararat	0.028003	0.001147	24.40688	1.11E-92	0.02575	0.030256	0.02575	0.030256
Mortlake	-0.09414	0.003821	-24.6369	6.32E-94	-0.10164	-0.08663	-0.10164	-0.08663
Stockyard	-0.08803	0.003829	-22.9871	5.24E-85	-0.09555	-0.08051	-0.09555	-0.08051
Horsham	-0.015	0.003622	-4.14201	3.92E-05	-0.02212	-0.00789	-0.02212	-0.00789
Moorabool	-0.08914	0.003943	-22.6072	5.86E-83	-0.09688	-0.0814	-0.09688	-0.0814
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	-0.04121	0.016727	-2.46369	#NUM!	-0.07406	-0.00836	-0.07406	-0.00836
Gen - VIC	-0.09364	0.003699	-25.3154	1.35E-97	-0.1009	-0.08637	-0.1009	-0.08637
Gen - SA	0.478248	0.041145	11.62352	2.18E-28	0.397448	0.559049	0.397448	0.559049
Load - NSW	0.047069	0.017635	2.669116	0.007805	0.012438	0.0817	0.012438	0.0817
Load - VIC	0.094892	0.004894	19.39004	8.35E-66	0.085281	0.104502	0.085281	0.104502
Load - SA	-0.50649	0.043518	-11.6387	1.89E-28	-0.59195	-0.42103	-0.59195	-0.42103
Flow - NSW>VIC	-0.02028	0.013585	-1.49309	0.135923	-0.04696	0.006395	-0.04696	0.006395
Flow - SA>VIC	-0.53168	0.043109	-12.3334	2.09E-31	-0.61634	-0.44702	-0.61634	-0.44702
Flow - VIC>TAS	0.201491	0.033181	6.072492	2.2E-09	0.13633	0.266651	0.13633	0.266651

SUMMARY OUTPUT		**BEN>KER**						
Regression Statistics								
Multiple R	0.998986							
R Square	0.997974							
Adjusted R Square	0.997921							
Standard Error	5.301653							
Observations	636							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	16	8568461	535528.8	19052.86	0			
Residual	619	17398.56	28.10752					
Total	635	8585860						
	Coefficient	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	99.55971	24.10385	4.130448	4.12E-05	52.22448	146.895	52.22448	146.895
Kerang	-0.23726	0.004825	-49.1731	5.8E-216	-0.24674	-0.22778	-0.24674	-0.22778
Ararat	-0.02943	0.001511	-19.4797	2.82E-66	-0.0324	-0.02646	-0.0324	-0.02646
Mortlake	0.11898	0.005032	23.64628	1.44E-88	0.109099	0.128862	0.109099	0.128862
Stockyard	0.112736	0.005043	22.35639	1.31E-81	0.102833	0.122639	0.102833	0.122639
Horsham	0.038068	0.00477	7.981337	7.05E-15	0.028702	0.047435	0.028702	0.047435
Moorabool	0.113936	0.005192	21.94362	2.18E-79	0.103739	0.124132	0.103739	0.124132
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	0.047472	0.022026	2.155247	#NUM!	0.004217	0.090728	0.004217	0.090728
Gen - VIC	0.118228	0.004871	24.2734	5.86E-92	0.108663	0.127793	0.108663	0.127793
Gen - SA	-0.58118	0.054181	-10.7267	9.74E-25	-0.68759	-0.47478	-0.68759	-0.47478
Load - NSW	-0.05443	0.023222	-2.34382	0.019403	-0.10003	-0.00882	-0.10003	-0.00882
Load - VIC	-0.11888	0.006444	-18.4464	7.04E-61	-0.13153	-0.10622	-0.13153	-0.10622
Load - SA	0.612962	0.057306	10.6962	1.29E-24	0.500423	0.725501	0.500423	0.725501
Flow - NSW>VIC	0.039344	0.017889	2.199326	0.028224	0.004213	0.074476	0.004213	0.074476
Flow - SA>VIC	0.6592	0.056768	11.61217	2.43E-28	0.547719	0.770681	0.547719	0.770681
Flow - VIC>TAS	-0.24778	0.043694	-5.6707	2.18E-08	-0.33358	-0.16197	-0.33358	-0.16197

SUMMARY OUTPUT			**BAL>BEN**					
Regression Statistics								
Multiple R	0.999075							
R Square	0.998151							
Adjusted R Square	0.998103							
Standard Error	3.934631							
Observations	636							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	16	5173499	323343.7	20886.05	0			
Residual	619	9582.939	15.48132					
Total	635	5183082						
	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	72.66006	17.88872	4.061781	5.5E-05	37.53013	107.79	37.53013	107.79
Kerang	-0.06527	0.003581	-18.2286	9.43E-60	-0.07231	-0.05824	-0.07231	-0.05824
Ararat	-0.00977	0.001121	-8.71717	2.61E-17	-0.01198	-0.00757	-0.01198	-0.00757
Mortlake	0.195593	0.003734	52.37795	1.2E-229	0.18826	0.202926	0.18826	0.202926
Stockyard	0.212948	0.003742	56.90106	4.3E-248	0.205599	0.220298	0.205599	0.220298
Horsham	0.148351	0.00354	41.90901	6.5E-183	0.141399	0.155302	0.141399	0.155302
Moorabool	0.200872	0.003853	52.12857	1.3E-228	0.193305	0.20844	0.193305	0.20844
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	-0.08141	0.016347	-4.98	#NUM!	-0.11351	-0.04931	-0.11351	-0.04931
Gen - VIC	0.185447	0.003615	51.30239	4.1E-225	0.178349	0.192546	0.178349	0.192546
Gen - SA	-0.44136	0.040211	-10.9761	9.84E-26	-0.52032	-0.36239	-0.52032	-0.36239
Load - NSW	0.083505	0.017234	4.845279	1.6E-06	0.04966	0.11735	0.04966	0.11735
Load - VIC	-0.17011	0.004783	-35.5678	9.5E-152	-0.1795	-0.16072	-0.1795	-0.16072
Load - SA	0.42348	0.04253	9.95717	9.17E-22	0.339959	0.507	0.339959	0.507
Flow - NSW>VIC	0.184175	0.013277	13.87213	2.69E-38	0.158102	0.210247	0.158102	0.210247
Flow - SA>VIC	0.625359	0.04213	14.84339	7.35E-43	0.542623	0.708095	0.542623	0.708095
Flow - VIC>TAS	-0.0613	0.032428	-1.89026	0.05919	-0.12498	0.002385	-0.12498	0.002385

SUMMARY OUTPUT			**HOR>RED**					
Regression Statistics								
Multiple R	0.996198							
R Square	0.99241							
Adjusted R Square	0.992214							
Standard Error	4.05382							
Observations	636							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	16	1330136	83133.53	5058.798	0			
Residual	619	10172.31	16.43345					
Total	635	1340309						
	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-89.7699	18.43061	-4.8707	1.41E-06	-125.964	-53.5758	-125.964	-53.5758
Kerang	0.045148	0.003689	12.23744	5.43E-31	0.037903	0.052393	0.037903	0.052393
Ararat	0.0166	0.001155	14.36927	1.3E-40	0.014332	0.018869	0.014332	0.018869
Mortlake	0.152112	0.003847	39.53635	1.7E-171	0.144556	0.159667	0.144556	0.159667
Stockyard	0.150938	0.003856	39.14565	1.4E-169	0.143366	0.15851	0.143366	0.15851
Horsham	0.25342	0.003647	69.48606	1.6E-294	0.246258	0.260582	0.246258	0.260582
Moorabool	0.147958	0.00397	37.26774	2.6E-160	0.140161	0.155754	0.140161	0.155754
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	-0.16495	0.016842	-9.79367	#NUM!	-0.19802	-0.13187	-0.19802	-0.13187
Gen - VIC	0.14941	0.003724	40.11778	2.5E-174	0.142096	0.156724	0.142096	0.156724
Gen - SA	-0.12502	0.041429	-3.01767	0.002652	-0.20638	-0.04366	-0.20638	-0.04366
Load - NSW	0.170119	0.017756	9.580717	2.29E-20	0.135249	0.204989	0.135249	0.204989
Load - VIC	-0.1205	0.004928	-24.4535	6.21E-93	-0.13017	-0.11082	-0.13017	-0.11082
Load - SA	0.111661	0.043818	2.548257	0.011067	0.02561	0.197712	0.02561	0.197712
Flow - NSW>VIC	0.239568	0.013679	17.51384	4.42E-56	0.212705	0.26643	0.212705	0.26643
Flow - SA>VIC	0.2427	0.043407	5.591299	3.38E-08	0.157458	0.327942	0.157458	0.327942
Flow - VIC>TAS	0.140799	0.03341	4.214287	2.88E-05	0.075188	0.206409	0.075188	0.206409

SUMMARY OUTPUT **HOR>ART**

Regression Statistics	
Multiple R	0.998987
R Square	0.997976
Adjusted R Square	0.997923
Standard Error	3.849809
Observations	636

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	16	4522488	282655.5	19071.25	0
Residual	619	9174.215	14.82103		
Total	635	4531662			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	90.91252	17.50307	5.194089	2.8E-07	56.53992	125.2851	56.53992	125.2851
Kerang	-0.03733	0.003504	-10.655	1.87E-24	-0.04421	-0.03045	-0.04421	-0.03045
Ararat	-0.01981	0.001097	-18.055	7.42E-59	-0.02196	-0.01765	-0.02196	-0.01765
Mortlake	-0.14164	0.003654	-38.7642	1E-167	-0.14881	-0.13446	-0.14881	-0.13446
Stockyard	-0.14013	0.003662	-38.2698	2.7E-165	-0.14733	-0.13294	-0.14733	-0.13294
Horsham	0.246881	0.003464	71.28051	1.3E-300	0.24008	0.253683	0.24008	0.253683
Moorabool	-0.13727	0.00377	-36.4086	5.3E-156	-0.14468	-0.12987	-0.14468	-0.12987
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	0.152485	0.015994	9.533573	#NUM!	0.121075	0.183895	0.121075	0.183895
Gen - VIC	-0.13903	0.003537	-39.3098	2.1E-170	-0.14598	-0.13209	-0.14598	-0.13209
Gen - SA	0.147935	0.039344	3.760055	0.000186	0.070672	0.225199	0.070672	0.225199
Load - NSW	-0.15688	0.016863	-9.30325	2.32E-19	-0.18999	-0.12376	-0.18999	-0.12376
Load - VIC	0.105024	0.00468	22.44293	4.49E-82	0.095835	0.114214	0.095835	0.114214
Load - SA	-0.13794	0.041613	-3.31469	0.000971	-0.21966	-0.05621	-0.21966	-0.05621
Flow - NSW>VIC	-0.21776	0.01299	-16.7634	2.79E-52	-0.24327	-0.19225	-0.24327	-0.19225
Flow - SA>VIC	-0.25609	0.041222	-6.21234	9.58E-10	-0.33704	-0.17513	-0.33704	-0.17513
Flow - VIC>TAS	-0.14869	0.031728	-4.68632	3.42E-06	-0.211	-0.08638	-0.211	-0.08638

SUMMARY OUTPUT **ART>WBT**

Regression Statistics	
Multiple R	0.995551
R Square	0.991123
Adjusted R Square	0.990893
Standard Error	6.774703
Observations	636

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	16	3171815	198238.4	4319.241	0
Residual	619	28409.99	45.8966		
Total	635	3200225			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-813.975	30.80104	-26.4269	1.3E-103	-874.463	-753.488	-874.463	-753.488
Kerang	-0.05017	0.006166	-8.13743	2.22E-15	-0.06228	-0.03806	-0.06228	-0.03806
Ararat	0.231659	0.001931	119.9889	0	0.227868	0.235451	0.227868	0.235451
Mortlake	-0.12327	0.00643	-19.1719	1.16E-64	-0.1359	-0.11064	-0.1359	-0.11064
Stockyard	-0.13103	0.006444	-20.3347	8.57E-71	-0.14369	-0.11838	-0.14369	-0.11838
Horsham	0.14273	0.006095	23.41787	2.47E-87	0.130761	0.154699	0.130761	0.154699
Moorabool	-0.13019	0.006635	-19.6227	4.99E-67	-0.14322	-0.11716	-0.14322	-0.11716
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	-0.68912	0.028146	-24.4837	#NUM!	-0.7444	-0.63385	-0.7444	-0.63385
Gen - VIC	-0.11748	0.006224	-18.8761	4.09E-63	-0.12971	-0.10526	-0.12971	-0.10526
Gen - SA	2.146596	0.069235	31.00429	4.3E-128	2.010631	2.282561	2.010631	2.282561
Load - NSW	0.730036	0.029674	24.60162	9.81E-94	0.671761	0.78831	0.671761	0.78831
Load - VIC	0.223997	0.008235	27.20076	8.8E-108	0.207825	0.240169	0.207825	0.240169
Load - SA	-2.26347	0.073229	-30.9094	1.4E-127	-2.40727	-2.11966	-2.40727	-2.11966
Flow - NSW>VIC	0.500027	0.02286	21.87363	5.17E-79	0.455135	0.544919	0.455135	0.544919
Flow - SA>VIC	-2.23764	0.072541	-30.8466	2.9E-127	-2.3801	-2.09519	-2.3801	-2.09519
Flow - VIC>TAS	1.548759	0.055834	27.73852	1.1E-110	1.439111	1.658406	1.439111	1.658406

SUMMARY OUTPUT			WBT>BAL					
Regression Statistics								
Multiple R	0.990975							
R Square	0.982031							
Adjusted R Square	0.981567							
Standard Error	9.893886							
Observations	636							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	16	3311542	206971.4	2114.348	0			
Residual	619	60593.28	97.88898					
Total	635	3372135						
	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-1034.54	44.98234	-22.9989	4.52E-85	-1122.88	-946.208	-1122.88	-946.208
Kerang	0.078986	0.009004	8.771952	1.7E-17	0.061303	0.096669	0.061303	0.096669
Ararat	0.215154	0.00282	76.30697	0	0.209617	0.220691	0.209617	0.220691
Mortlake	0.009034	0.00939	0.962033	0.336409	-0.00941	0.027474	-0.00941	0.027474
Stockyard	-0.00198	0.009411	-0.21077	0.833138	-0.02046	0.016497	-0.02046	0.016497
Horsham	0.268329	0.008901	30.14546	1.5E-123	0.250849	0.285809	0.250849	0.285809
Moorabool	-0.00053	0.00969	-0.05451	0.956547	-0.01956	0.0185	-0.01956	0.0185
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	-0.99702	0.041105	-24.2552	#NUM!	-1.07774	-0.91629	-1.07774	-0.91629
Gen - VIC	0.015488	0.00909	1.703967	0.088889	-0.00236	0.033339	-0.00236	0.033339
Gen - SA	2.638553	0.101113	26.0952	8.2E-102	2.439988	2.837119	2.439988	2.837119
Load - NSW	1.053546	0.043337	24.31064	3.68E-92	0.968441	1.138651	0.968441	1.138651
Load - VIC	0.137592	0.012026	11.44075	1.25E-27	0.113974	0.16121	0.113974	0.16121
Load - SA	-2.83938	0.106945	-26.5499	2.9E-104	-3.04939	-2.62936	-3.04939	-2.62936
Flow - NSW>VIC	0.900901	0.033385	26.98531	1.3E-106	0.835339	0.966462	0.835339	0.966462
Flow - SA>VIC	-2.60351	0.10594	-24.5753	1.36E-93	-2.81155	-2.39546	-2.81155	-2.39546
Flow - VIC>TAS	2.002274	0.081541	24.55537	1.75E-93	1.842144	2.162405	1.842144	2.162405

SUMMARY OUTPUT			BAL>MOO2					
Regression Statistics								
Multiple R	0.994075							
R Square	0.988186							
Adjusted R Square	0.98788							
Standard Error	4.779786							
Observations	636							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	16	1182857	73928.58	3235.903	0			
Residual	619	14141.89	22.84635					
Total	635	1196999						
	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-372.765	21.73119	-17.1535	3E-54	-415.441	-330.089	-415.441	-330.089
Kerang	0.057567	0.00435	13.23362	2.21E-35	0.049024	0.06611	0.049024	0.06611
Ararat	0.064649	0.001362	47.46063	2E-208	0.061974	0.067324	0.061974	0.067324
Mortlake	-0.02309	0.004536	-5.09055	4.74E-07	-0.032	-0.01418	-0.032	-0.01418
Stockyard	0.074131	0.004546	16.30582	5.41E-50	0.065203	0.083059	0.065203	0.083059
Horsham	0.073479	0.0043	17.08751	6.48E-54	0.065035	0.081924	0.065035	0.081924
Moorabool	-0.0923	0.004681	-19.7186	1.56E-67	-0.1015	-0.08311	-0.1015	-0.08311
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	-0.33325	0.019858	-16.7814	#NUM!	-0.37225	-0.29425	-0.37225	-0.29425
Gen - VIC	-0.01505	0.004391	-3.42768	0.000649	-0.02368	-0.00643	-0.02368	-0.00643
Gen - SA	1.089871	0.048848	22.31148	2.29E-81	0.993943	1.185799	0.993943	1.185799
Load - NSW	0.353487	0.020936	16.88396	6.9E-53	0.312372	0.394601	0.312372	0.394601
Load - VIC	0.063959	0.00581	11.00826	7.3E-26	0.052549	0.075368	0.052549	0.075368
Load - SA	-1.15443	0.051666	-22.3442	1.53E-81	-1.25589	-1.05297	-1.25589	-1.05297
Flow - NSW>VIC	0.297108	0.016128	18.42145	9.48E-61	0.265435	0.328781	0.265435	0.328781
Flow - SA>VIC	-1.0991	0.05118	-21.4752	7.08E-77	-1.19961	-0.9986	-1.19961	-0.9986
Flow - VIC>TAS	0.679163	0.039393	17.24072	1.08E-54	0.601803	0.756523	0.601803	0.756523

Appendix F – Results of regression analysis – Scenario 5

SUMMARY OUTPUT		**WET>KER**						
Regression Statistics								
Multiple R	0.995816							
R Square	0.99165							
Adjusted R Square	0.991435							
Standard Error	10.50064							
Observations	636							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	16	8106110	506631.9	4594.736	0			
Residual	619	68253.13	110.2635					
Total	635	8174363						
	Coefficient	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-588.842	27.88212	-21.119	5.7E-75	-643.597	-534.087	-643.597	-534.087
Kerang	-0.39151	0.012505	-31.3087	1.1E-129	-0.41606	-0.36695	-0.41606	-0.36695
Ararat	0.033126	0.002917	11.35631	2.79E-27	0.027398	0.038855	0.027398	0.038855
Mortlake	-0.26954	0.012579	-21.4273	1.28E-76	-0.29424	-0.24483	-0.29424	-0.24483
Stockyard	-0.26085	0.012601	-20.7005	9.73E-73	-0.2856	-0.23611	-0.2856	-0.23611
Horsham	-0.11896	0.011846	-10.042	4.38E-22	-0.14222	-0.09569	-0.14222	-0.09569
Moorabool	-0.26573	0.012915	-20.5759	4.48E-72	-0.29109	-0.24037	-0.29109	-0.24037
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	-0.46868	0.021935	-21.3665	#NUM!	-0.51175	-0.4256	-0.51175	-0.4256
Gen - VIC	-0.26241	0.012256	-21.4101	1.58E-76	-0.28648	-0.23834	-0.28648	-0.23834
Gen - SA	1.996785	0.070802	28.20219	3.6E-113	1.857743	2.135827	1.857743	2.135827
Load - NSW	0.498626	0.023196	21.49591	5.49E-77	0.453073	0.544179	0.453073	0.544179
Load - VIC	0.325486	0.014436	22.54725	1.23E-82	0.297137	0.353834	0.297137	0.353834
Load - SA	-2.10901	0.072755	-28.9877	2.2E-117	-2.25189	-1.96613	-2.25189	-1.96613
Flow - NSW>VIC	0.235034	0.017358	13.54073	8.94E-37	0.200947	0.269121	0.200947	0.269121
Flow - SA>VIC	-2.19625	0.08138	-26.9876	1.2E-106	-2.35606	-2.03644	-2.35606	-2.03644
Flow - VIC>TAS	1.202178	0.048442	24.81696	6.71E-95	1.107048	1.297308	1.107048	1.297308

SUMMARY OUTPUT		**BEN>KER**						
Regression Statistics								
Multiple R	0.999287							
R Square	0.998575							
Adjusted R Square	0.998539							
Standard Error	2.988421							
Observations	636							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	16	3875126	242195.3	27119.54	0			
Residual	619	5528.078	8.930659					
Total	635	3880654						
	Coefficient	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	61.85407	7.935086	7.79501	2.74E-14	46.27112	77.43702	46.27112	77.43702
Kerang	-0.15357	0.003559	-43.152	9E-189	-0.16056	-0.14658	-0.16056	-0.14658
Ararat	-0.00528	0.00083	-6.36267	3.86E-10	-0.00691	-0.00365	-0.00691	-0.00365
Mortlake	0.087943	0.00358	24.56543	1.54E-93	0.080912	0.094973	0.080912	0.094973
Stockyard	0.096868	0.003586	27.01093	9.3E-107	0.089825	0.103911	0.089825	0.103911
Horsham	0.048353	0.003371	14.34256	1.73E-40	0.041732	0.054973	0.041732	0.054973
Moorabool	0.087377	0.003675	23.77309	2.98E-89	0.080159	0.094595	0.080159	0.094595
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	0.049187	0.006243	7.879169	#NUM!	0.036927	0.061446	0.036927	0.061446
Gen - VIC	0.087711	0.003488	25.14587	1.11E-96	0.080861	0.094561	0.080861	0.094561
Gen - SA	-0.40012	0.02015	-19.857	2.9E-68	-0.43969	-0.36055	-0.43969	-0.36055
Load - NSW	-0.05414	0.006602	-8.20161	1.37E-15	-0.06711	-0.04118	-0.06711	-0.04118
Load - VIC	-0.09589	0.004108	-23.3415	6.4E-87	-0.10396	-0.08783	-0.10396	-0.08783
Load - SA	0.421041	0.020706	20.3345	8.59E-71	0.380379	0.461703	0.380379	0.461703
Flow - NSW>VIC	-0.00349	0.00494	-0.70673	0.48	-0.01319	0.00621	-0.01319	0.00621
Flow - SA>VIC	0.464777	0.02316	20.06786	2.22E-69	0.419295	0.510259	0.419295	0.510259
Flow - VIC>TAS	-0.1638	0.013786	-11.8814	1.8E-29	-0.19087	-0.13673	-0.19087	-0.13673

SUMMARY OUTPUT **BAL>BEN**

Regression Statistics	
Multiple R	0.999337
R Square	0.998675
Adjusted R Square	0.998641
Standard Error	3.146659
Observations	636

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	16	4620359	288772.5	29164.63	0
Residual	619	6129.004	9.90146		
Total	635	4626488			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	75.3876	8.355251	9.022781	2.29E-18	58.97953	91.79567	58.97953	91.79567
Kerang	-0.00781	0.003747	-2.0829	0.03767	-0.01516	-0.00045	-0.01516	-0.00045
Ararat	0.008383	0.000874	9.589757	2.12E-20	0.006666	0.010099	0.006666	0.010099
Mortlake	0.206052	0.00377	54.66302	4.3E-239	0.19865	0.213455	0.19865	0.213455
Stockyard	0.237584	0.003776	62.91721	4E-271	0.230169	0.245	0.230169	0.245
Horsham	0.190108	0.00355	53.55452	1.5E-234	0.183136	0.197079	0.183136	0.197079
Moorabool	0.21623	0.00387	55.87253	5.5E-244	0.20863	0.22383	0.20863	0.22383
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	-0.04219	0.006573	-6.41878	#NUM!	-0.0551	-0.02928	-0.0551	-0.02928
Gen - VIC	0.197845	0.003673	53.86806	7.8E-236	0.190633	0.205058	0.190633	0.205058
Gen - SA	-0.31767	0.021217	-14.9723	1.77E-43	-0.35933	-0.276	-0.35933	-0.276
Load - NSW	0.042677	0.006951	6.139588	1.48E-09	0.029026	0.056327	0.029026	0.056327
Load - VIC	-0.18686	0.004326	-43.1959	5.6E-189	-0.19535	-0.17836	-0.19535	-0.17836
Load - SA	0.307135	0.021802	14.08739	2.7E-39	0.26432	0.34995	0.26432	0.34995
Flow - NSW>VIC	0.204699	0.005201	39.35451	1.3E-170	0.194485	0.214914	0.194485	0.214914
Flow - SA>VIC	0.516743	0.024387	21.18962	2.39E-75	0.468852	0.564633	0.468852	0.564633
Flow - VIC>TAS	-0.15723	0.014516	-10.8316	3.73E-25	-0.18574	-0.12873	-0.18574	-0.12873

SUMMARY OUTPUT **HOR>RED**

Regression Statistics	
Multiple R	0.992774
R Square	0.9856
Adjusted R Square	0.985228
Standard Error	7.895725
Observations	636

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	16	2641363	165085.2	2648.037	0
Residual	619	38589.99	62.34248		
Total	635	2679953			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	403.923	20.96534	19.26623	3.73E-65	362.7512	445.0949	362.7512	445.0949
Kerang	0.202535	0.009403	21.54016	3.18E-77	0.18407	0.221	0.18407	0.221
Ararat	0.029553	0.002193	13.47362	1.81E-36	0.025245	0.03386	0.025245	0.03386
Mortlake	0.277951	0.009459	29.38611	1.7E-119	0.259376	0.296526	0.259376	0.296526
Stockyard	0.288496	0.009475	30.44731	3.8E-125	0.269889	0.307104	0.269889	0.307104
Horsham	0.485066	0.008907	54.45714	3E-238	0.467573	0.502558	0.467573	0.502558
Moorabool	0.280398	0.009711	28.87451	9.1E-117	0.261328	0.299468	0.261328	0.299468
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	0.277963	0.016494	16.85276	#NUM!	0.245573	0.310354	0.245573	0.310354
Gen - VIC	0.271249	0.009216	29.43281	9.4E-120	0.253151	0.289348	0.253151	0.289348
Gen - SA	-1.35216	0.053238	-25.3983	4.8E-98	-1.45671	-1.24761	-1.45671	-1.24761
Load - NSW	-0.29727	0.017442	-17.0435	1.08E-53	-0.33152	-0.26302	-0.33152	-0.26302
Load - VIC	-0.31186	0.010855	-28.7305	5.3E-116	-0.33318	-0.29054	-0.33318	-0.29054
Load - SA	1.416774	0.054707	25.89761	9.6E-101	1.309341	1.524208	1.309341	1.524208
Flow - NSW>VIC	-0.03041	0.013052	-2.32993	0.020131	-0.05604	-0.00478	-0.05604	-0.00478
Flow - SA>VIC	1.585215	0.061192	25.90566	8.7E-101	1.465047	1.705384	1.465047	1.705384
Flow - VIC>TAS	-0.84396	0.036425	-23.17	5.39E-86	-0.91549	-0.77243	-0.91549	-0.77243

SUMMARY OUTPUT **HOR>ART**

Regression Statistics	
Multiple R	0.998917
R Square	0.997835
Adjusted R Square	0.997779
Standard Error	7.226734
Observations	636

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	16	14902139	931383.7	17833.82	0
Residual	619	32327.7	52.22569		
Total	635	14934466			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-329.139	19.18898	-17.1525	3.04E-54	-366.822	-291.455	-366.822	-291.455
Kerang	-0.17602	0.008606	-20.4526	2.03E-71	-0.19292	-0.15911	-0.19292	-0.15911
Ararat	-0.03438	0.002008	-17.1267	4.1E-54	-0.03832	-0.03044	-0.03832	-0.03044
Mortlake	-0.24937	0.008657	-28.8048	2.1E-116	-0.26637	-0.23237	-0.26637	-0.23237
Stockyard	-0.25796	0.008672	-29.7446	2.1E-121	-0.27499	-0.24093	-0.27499	-0.24093
Horsham	0.510935	0.008153	62.67149	3.2E-270	0.494925	0.526945	0.494925	0.526945
Moorabool	-0.25021	0.008888	-28.151	6.8E-113	-0.26766	-0.23275	-0.26766	-0.23275
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	-0.23392	0.015096	-15.4952	#NUM!	-0.26356	-0.20427	-0.26356	-0.20427
Gen - VIC	-0.24331	0.008435	-28.8453	1.3E-116	-0.25988	-0.22675	-0.25988	-0.22675
Gen - SA	1.239841	0.048728	25.44435	2.7E-98	1.14415	1.335532	1.14415	1.335532
Load - NSW	0.250968	0.015964	15.72078	4.18E-47	0.219618	0.282319	0.219618	0.282319
Load - VIC	0.263343	0.009935	26.50683	4.9E-104	0.243833	0.282853	0.243833	0.282853
Load - SA	-1.30005	0.050072	-25.9638	4.2E-101	-1.39838	-1.20172	-1.39838	-1.20172
Flow - NSW>VIC	0.021594	0.011946	1.807628	0.07115	-0.00187	0.045053	-0.00187	0.045053
Flow - SA>VIC	-1.44503	0.056007	-25.8007	3.2E-100	-1.55501	-1.33504	-1.55501	-1.33504
Flow - VIC>TAS	0.690497	0.033339	20.7117	8.48E-73	0.625027	0.755968	0.625027	0.755968

SUMMARY OUTPUT **ART>WBT**

Regression Statistics	
Multiple R	0.992112
R Square	0.984286
Adjusted R Square	0.98388
Standard Error	8.52192
Observations	636

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	16	2815796	175987.3	2423.295	0
Residual	619	44953.72	72.62313		
Total	635	2860750			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-327.688	22.62806	-14.4815	3.84E-41	-372.125	-283.251	-372.125	-283.251
Kerang	-0.12491	0.010148	-12.3084	2.69E-31	-0.14484	-0.10498	-0.14484	-0.10498
Ararat	0.248495	0.002367	104.9693	0	0.243846	0.253144	0.243846	0.253144
Mortlake	-0.12803	0.010209	-12.5416	2.6E-32	-0.14808	-0.10799	-0.14808	-0.10799
Stockyard	-0.13296	0.010227	-13.0011	2.43E-34	-0.15304	-0.11287	-0.15304	-0.11287
Horsham	0.125148	0.009614	13.01762	2.05E-34	0.106268	0.144027	0.106268	0.144027
Moorabool	-0.12973	0.010481	-12.3778	1.34E-31	-0.15032	-0.10915	-0.15032	-0.10915
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	-0.23149	0.017802	-13.0036	#NUM!	-0.26645	-0.19653	-0.26645	-0.19653
Gen - VIC	-0.12315	0.009947	-12.3813	1.3E-31	-0.14269	-0.10362	-0.14269	-0.10362
Gen - SA	1.088074	0.057461	18.93601	1.99E-63	0.975233	1.200915	0.975233	1.200915
Load - NSW	0.246873	0.018825	13.11393	7.61E-35	0.209904	0.283842	0.209904	0.283842
Load - VIC	0.161688	0.011715	13.80128	5.72E-38	0.138682	0.184695	0.138682	0.184695
Load - SA	-1.12365	0.059045	-19.0303	6.41E-64	-1.23961	-1.0077	-1.23961	-1.0077
Flow - NSW>VIC	0.128711	0.014087	9.137044	9.07E-19	0.101047	0.156375	0.101047	0.156375
Flow - SA>VIC	-1.18971	0.066045	-18.0137	1.21E-58	-1.31941	-1.06001	-1.31941	-1.06001
Flow - VIC>TAS	0.644502	0.039313	16.39392	1.97E-50	0.567299	0.721706	0.567299	0.721706

SUMMARY OUTPUT **WBT>BAL**

Regression Statistics	
Multiple R	0.979184
R Square	0.958801
Adjusted R Square	0.957736
Standard Error	14.19558
Observations	636

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	16	2902933	181433.3	900.349	0
Residual	619	124737.4	201.5144		
Total	635	3027671			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	344.3821	37.69319	9.136452	9.11E-19	270.36	418.4041	270.36	418.4041
Kerang	0.116918	0.016905	6.916259	1.16E-11	0.083721	0.150116	0.083721	0.150116
Ararat	0.252276	0.003943	63.97412	5.2E-275	0.244532	0.26002	0.244532	0.26002
Mortlake	0.069225	0.017005	4.070768	5.29E-05	0.03583	0.10262	0.03583	0.10262
Stockyard	0.0773	0.017035	4.537614	6.84E-06	0.043846	0.110754	0.043846	0.110754
Horsham	0.310542	0.016014	19.39158	8.2E-66	0.279093	0.34199	0.279093	0.34199
Moorabool	0.08055	0.017459	4.613622	4.81E-06	0.046263	0.114836	0.046263	0.114836
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	0.27571	0.029654	9.297685	#NUM!	0.217476	0.333944	0.217476	0.333944
Gen - VIC	0.066203	0.016569	3.995552	7.23E-05	0.033664	0.098741	0.033664	0.098741
Gen - SA	-0.34409	0.095716	-3.59487	0.00035	-0.53205	-0.15612	-0.53205	-0.15612
Load - NSW	-0.28981	0.031359	-9.2417	3.85E-19	-0.35139	-0.22822	-0.35139	-0.22822
Load - VIC	-0.10614	0.019515	-5.43906	7.72E-08	-0.14447	-0.06782	-0.14447	-0.06782
Load - SA	0.342128	0.098356	3.478459	0.00054	0.148976	0.535281	0.148976	0.535281
Flow - NSW>VIC	-0.14817	0.023465	-6.3144	5.18E-10	-0.19425	-0.10209	-0.19425	-0.10209
Flow - SA>VIC	0.460207	0.110016	4.183106	3.29E-05	0.244158	0.676257	0.244158	0.676257
Flow - VIC>TAS	-0.47614	0.065487	-7.27064	1.08E-12	-0.60474	-0.34753	-0.60474	-0.34753

SUMMARY OUTPUT **BAL>MOO2**

Regression Statistics	
Multiple R	0.990321
R Square	0.980735
Adjusted R Square	0.980237
Standard Error	6.111892
Observations	636

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	16	1177130	73570.6	1969.486	0
Residual	619	23122.89	37.35523		
Total	635	1200253			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	216.5466	16.22877	13.34338	7.05E-36	184.6765	248.4167	184.6765	248.4167
Kerang	0.091657	0.007278	12.59305	1.55E-32	0.077364	0.10595	0.077364	0.10595
Ararat	0.086766	0.001698	51.10401	2.9E-224	0.083432	0.0901	0.083432	0.0901
Mortlake	0.016445	0.007322	2.24613	0.025048	0.002067	0.030824	0.002067	0.030824
Stockyard	0.135216	0.007335	18.43547	8.02E-61	0.120813	0.14962	0.120813	0.14962
Horsham	0.113743	0.006895	16.49663	6.05E-51	0.100203	0.127283	0.100203	0.127283
Moorabool	-0.04255	0.007517	-5.66029	2.31E-08	-0.05731	-0.02779	-0.05731	-0.02779
Mid_point	0	0	65535	#NUM!	0	0	0	0
Gen - NSW	0.198931	0.012767	15.58121	#NUM!	0.173858	0.224003	0.173858	0.224003
Gen - VIC	0.019398	0.007134	2.719104	0.006729	0.005388	0.033407	0.005388	0.033407
Gen - SA	-0.17502	0.041211	-4.24702	2.5E-05	-0.25595	-0.09409	-0.25595	-0.09409
Load - NSW	-0.20769	0.013501	-15.3827	1.86E-45	-0.2342	-0.18117	-0.2342	-0.18117
Load - VIC	-0.05283	0.008402	-6.28747	6.1E-10	-0.06933	-0.03633	-0.06933	-0.03633
Load - SA	0.189139	0.042347	4.466385	9.46E-06	0.105977	0.2723	0.105977	0.2723
Flow - NSW>VIC	-0.13776	0.010103	-13.6356	3.3E-37	-0.1576	-0.11792	-0.1576	-0.11792
Flow - SA>VIC	0.217952	0.047367	4.601335	5.09E-06	0.124932	0.310972	0.124932	0.310972
Flow - VIC>TAS	-0.36036	0.028196	-12.7807	2.31E-33	-0.41573	-0.30499	-0.41573	-0.30499