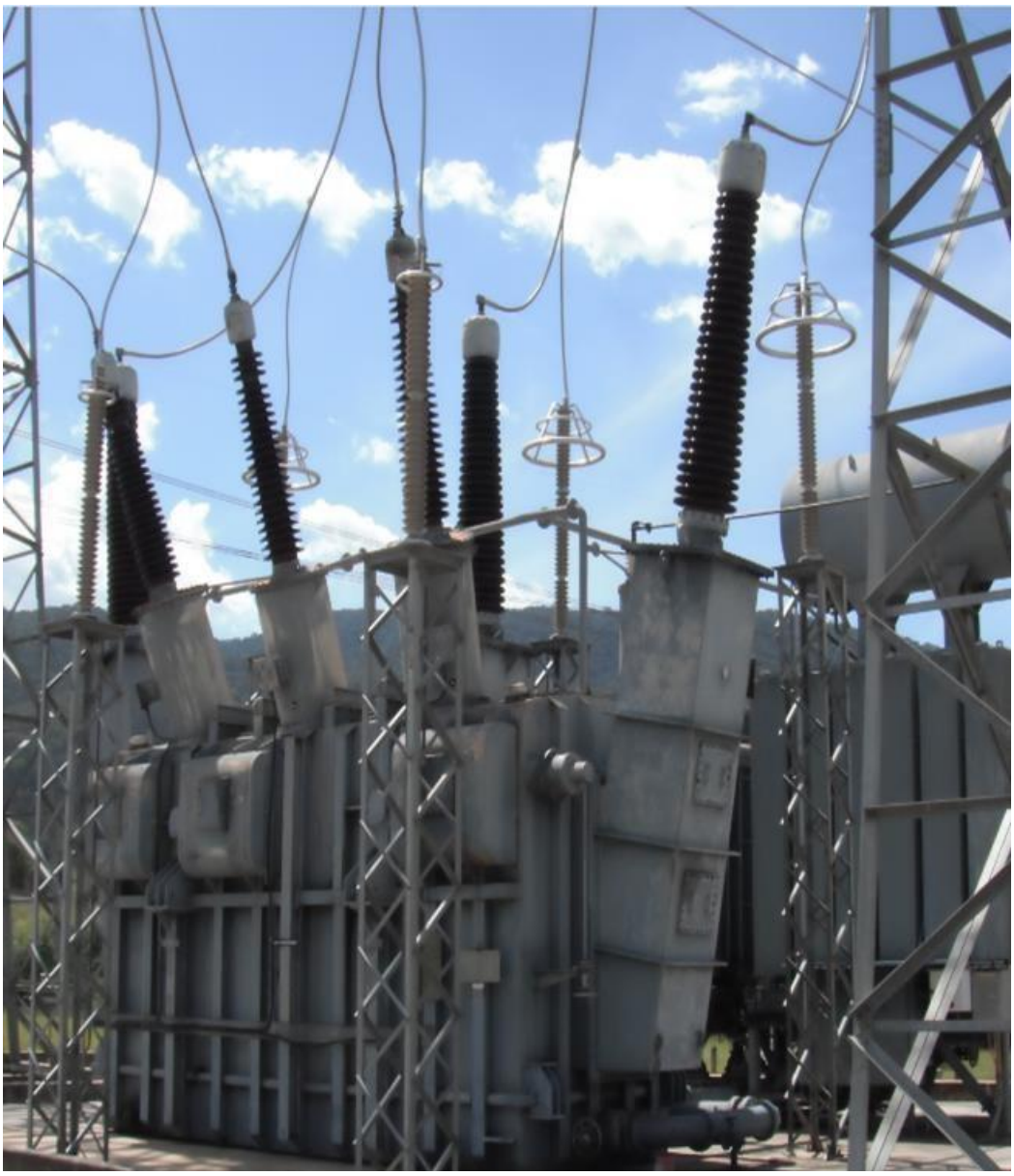
Dederang Terminal Station H3 Transformer Replacement

TRR Network Studies Results



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Document History

Revision	Date	Details
1	29/10/2024	Initial Issue
2	13/11/2024	Included results of additional scenarios – 1e, 1f, 5a, 5b, 6a and 6b
3	3/12/2024	Adjusted results of scenarios 5a, 5b, 6a, and 6b

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1.0 Introduction

AusNet is preparing business cases for several major station replacement projects in connection with the 2027-2032 Transmission Revenue Reset (TRR). Some of these projects require network studies (steady-state load flow studies) to assess the market impact of asset failures. To that end, VoltConsult Pty Ltd ("VoltConsult") were engaged by AusNet to conduct load flow studies for certain projects and scenarios using software, models, information and equipment provided by AusNet.

The avoided cost of an asset failure will be used to economically justify the investment in support of AusNet's TRR Capex forecast and will be used as supporting information for the TRR revenue application. The economic justification and related calculations for these projects are not included in VoltConsult's scope but will be completed by others.

The results in this document refer to network studies carried out for the potential replacement of the H3 transformer at Dederang Terminal Station (DDTS) and are purely technical in nature.

2.0 Network Study Methodology

Using the PSSE transmission network model provided by AusNet, the specific operating scenarios shown in Table A were studied.

Table A – Network Study Scenarios to be Modelled

Study	Network Configuration	Asset Failure Contingency N-1	Asset Failure Contingency N-2	Asset Failure Contingency N-3	Secure Operating State Contingency	Notes
1a	Existing	DDTS H3 Transformer OOS	None	None	Summer – External to DDTS	DDTS H1 and H2 Ratings set to 340 MVA. (H3 rating is 240 MVA)
1b	Existing	DDTS H3 Transformer OOS	None	None	Winter – External to DDTS	DDTS H1 and H2 Ratings set to 340 MVA. (H3 rating is 240 MVA)
1c	Existing	DDTS H3 Transformer OOS	None	None	Summer – At DDTS	DDTS H1 and H2 Ratings set to 340 MVA. (H3 rating is 240 MVA)
1d	Existing	DDTS H3 Transformer OOS	None	None	Winter – At DDTS	DDTS H1 and H2 Ratings set to 340 MVA. (H3 rating is 240 MVA)
1e	Existing	DDTS H3 Transformer OOS	None	None	Summer – DDTS H1 Transformer OOS	DDTS H1 and H2 Ratings set to 400 MVA. (H3 rating is 240 MVA)
1f	Existing	DDTS H3 Transformer OOS	None	None	Winter – DDTS H1 Transformer OOS	DDTS H1 and H2 Ratings set to 400 MVA. (H3 rating is 240 MVA)
2a	Existing	None	None	None	Summer – DDTS H1 Transformer OOS	DDTS H1 and H2 Ratings set to 340 MVA. (H3 rating is 240 MVA)
2b	Existing	None	None	None	Winter – DDTS H1 Transformer OOS	DDTS H1 and H2 Ratings set to 340 MVA. (H3 rating is 240 MVA)
3a	Existing	None	None	None	Summer – DDTS H1 Transformer OOS	This case is after replacement of the H3 and all transformer ratings to be set to 340 MVA
3b	Existing	None	None	None	Winter – DDTS H1 Transformer OOS	This case is after replacement of the H3 and all transformer ratings to be set to 340 MVA

4a	Existing	None	None	None	Summer – DDTS H1 Transformer OOS	This case is after replacement of the H3 and all transformer ratings to be set to 400 MVA
4b	Existing	None	None	None	Winter – DDTS H1 Transformer OOS	This case is after replacement of the H3 and all transformer ratings to be set to 400 MVA
5a	Existing	DDTS H3 Transformer OOS	DDTS H1 Transformer OOS	None	Summer – ROTS A1 Transformer OOS	DDTS H1 and H2 Ratings set to 400 MVA. (H3 rating is 240 MVA)
5b	Existing	DDTS H3 Transformer OOS	DDTS H1 Transformer OOS	None	Winter - ROTS A1 Transformer OOS	DDTS H1 and H2 Ratings set to 400 MVA. (H3 rating is 240 MVA)
6a	Existing	DDTS H3 Transformer OOS	DDTS H1 Transformer OOS	DDTS H2 Transformer OOS	Summer - ROTS A1 Transformer OOS	DDTS H1 and H2 Ratings set to 400 MVA. (H3 rating is 240 MVA)
6b	Existing	DDTS H3 Transformer OOS	DDTS H1 Transformer OOS	DDTS H2 Transformer OOS	Winter - ROTS A1 Transformer OOS	DDTS H1 and H2 Ratings set to 400 MVA. (H3 rating is 240 MVA)

Each study followed the general procedure outlined below:

1. Conduct a load flow study (with transformer tap stepping and switched shunt adjustments enabled) on the system in its normal operation configuration
2. Configure the system to match the specific scenario to be studied (i.e. disconnect the applicable plant or line)
3. Select the buses to be used as a sub-system for the assessment
4. Conduct a load flow
5. Review the line, bus and transformer voltage and loading results for the sub-system using PSSE's reports function
6. If all parameters are within the required ranges, scale up the sub-system loads by a certain percentage
7. Conduct a load flow
8. Repeat steps 5-7 until the sub-system loads are similar to the forecast loads of a particular year
9. Analyse the load flows and take another key element out of service (OOS) from the network
10. Conduct a load flow
11. Repeat steps 5-7 until a line or transformer reaches its maximum capacity or repeat steps 9-10 if the results show that a different element might be more critical
12. Once the most critical element has been determined and is operating at its maximum capacity while the system is within appropriate voltage limits, record the sub-system loadings
13. Compare the maximum sub-system loading against the forecast loading and ascertain the load at risk

The sub-system in this assessment included loads at GNTS, SHTS, MBTS, TTS, FVTS and BETS. The buses selected for the sub-system in PSSE were as follows:

323090,323080,311080,311001,311020,311021,355080,355030,325080,329080,329030,369080,369001,373091,373080,373081,379001,379002,379080,379081,379082,327080,327021

Loads at GNTS, SHTS, MBTS, TTS, FVTS and BETS were set to Summer 2033 POE50 forecast levels and scaled up or down according to the requirements of each scenario modelled. Sensitivity checks were conducted by scaling loads at downstream stations KGTS, BATS, RWTS, TSTS and BTS. Of these downstream stations, only RWTS and TSTS loads were found to have an impact on the maximum supportable loads in the defined sub-system. Thus, RWTS and TSTS loads were set to Summer 2033 POE50 forecast levels and kept static for each scenario except Scenario 6.

Scenario 1 seeks to establish the maximum supportable load (and subsequent load at risk) resulting from a failure of the DDTS H3 transformer.

Scenarios 2-3 seek to establish the maximum supportable load (and subsequent load at risk) due to the DDTS H3 transformer's presently limited capacity of 240 MVA when compared to its replacement with one rated at 340 MVA. In both scenarios the DDTS H1 is OOS.

Scenario 4 seeks to determine the maximum supportable load (and subsequent load at risk) if all DDTS H transformers had a rating of 400 MVA and the H1 was OOS.

Scenario 5 seeks to establish the maximum supportable load (and subsequent load at risk) resulting from a failure of the DDTS H3 and H1 transformers (N-2), where the H1 and H2 ratings are 400 MVA, and the ROTS A1 transformer being OOS.

Scenario 6 seeks to establish the maximum supportable load (and subsequent load at risk) resulting from a failure of all DDTS H transformers (N-3), where the H1 and H2 ratings are 400 MVA, and the ROTS A1 transformer being OOS.

3.0 Results

A summary of the key outcomes of each study are shown in Table B below:

Table B – Network Study Scenarios Summary of Outcomes

Study	Network Configuration	Asset Failure Contingency N-1	Asset Failure Contingency N-2	Asset Failure Contingency N-3	Secure Operating State Contingency	PSSE Filename	Results Text File
1a	Existing	DDTS H3 Transformer OOS	None	None	Summer - SMTS H1 Transformer OOS	VAPR2023 max yr1 issue v15_DDTS_S1a_DLR_SMTS H1 OUT_MAX.sav	DDTS Study 1a PSSE Reports
1b	Existing	DDTS H3 Transformer OOS	None	None	Winter – SMTS H1 Transformer OOS	VAPR2023 max yr1 issue v15_DDTS_S1b_DLR_SMTS H1 OUT_MAX.sav	DDTS Study 1b PSSE Reports
1c	Existing	DDTS H3 Transformer OOS	None	None	Summer - DDTS H1 Transformer OOS	VAPR2023 max yr1 issue v15_DDTS_S1c_DLR_SMTS H1 OUT_MAX.sav	DDTS Study 1c PSSE Reports
1d	Existing	DDTS H3 Transformer OOS	None	None	Winter - DDTS H1 Transformer OOS	VAPR2023 max yr1 issue v15_DDTS_S1d_DLR_SMTS H1 OUT_MAX.sav	DDTS Study 1d PSSE Reports
1e	Existing	DDTS H3 Transformer OOS	None	None	Summer – DDTS H1 Transformer OOS	VAPR2023 max yr1 issue v15_DDTS_S1e_DLR_DDTS H1 OUT_MAX.sav	DDTS Study 1e PSSE Reports
1f	Existing	DDTS H3 Transformer OOS	None	None	Winter – DDTS H1 Transformer OOS	VAPR2023 max yr1 issue v15_DDTS_S1f_DLR_DDTS H1 OUT_MAX.sav	DDTS Study 1f PSSE Reports
2a	Existing	None	None	None	Summer - DDTS H1 Transformer OOS	VAPR2023 max yr1 issue v15_DDTS_S2a_DLR_DDTS H1 OUT_MAX.sav	DDTS Study 2a PSSE Reports
2b	Existing	None	None	None	Winter - DDTS H1 Transformer OOS	VAPR2023 max yr1 issue v15_DDTS_S2b_DLR_DDTS H1 OUT_MAX.sav	DDTS Study 2b PSSE Reports
3a	Existing	None	None	None	Summer - DDTS H1 Transformer OOS	VAPR2023 max yr1 issue v15_DDTS_S3a_DLR_DDTS H1 OUT_MAX.sav	DDTS Study 3a PSSE Reports
3b	Existing	None	None	None	Winter - DDTS H1 Transformer OOS	VAPR2023 max yr1 issue v15_DDTS_S3b_DLR_DDTS H1 OUT_MAX.sav	DDTS Study 3b PSSE Reports
4a	Existing	None	None	None	Summer - DDTS H1 Transformer OOS	VAPR2023 max yr1 issue v15_DDTS_S4a_DLR_DDTS H1 OUT_MAX.sav	DDTS Study 4a PSSE Reports
4b	Existing	None	None	None	Winter - DDTS H1 Transformer OOS	VAPR2023 max yr1 issue v15_DDTS_S4b_DLR_DDTS H1 OUT_MAX.sav	DDTS Study 4b PSSE Reports
5a	Existing	DDTS H3 Transformer OOS	DDTS H1 Transformer OOS	None	Summer – ROTS A1 Transformer OOS	VAPR2023 max yr1 issue v15_DDTS_S5a_DLR_DDTS H1 H3 ROTS A1 OUT_MAX.sav	DDTS Study 5a PSSE Reports

5b	Existing	DDTS H3 Transformer OOS	DDTS H1 Transformer OOS	None	Winter - ROTS A1 Transformer OOS	VAPR2023 max yr1 issue v15_DDTS_S5b_DLR_DDTS H1 H3 ROTS A1 OUT_MAX.sav	DDTS Study 5b PSSE Reports
6a	Existing	DDTS H3 Transformer OOS	DDTS H1 Transformer OOS	DDTS H2 Transformer OOS	Summer - ROTS A1 Transformer OOS	VAPR2023 max yr1 issue v15_DDTS_S6a_DLR_DDTS H1 H2 H3 ROTS A1 OUT_MAX.sav	DDTS Study 6a PSSE Reports
6b	Existing	DDTS H3 Transformer OOS	DDTS H1 Transformer OOS	DDTS H2 Transformer OOS	Winter - ROTS A1 Transformer OOS	VAPR2023 max yr1 issue v15_DDTS_S6b_DLR_DDTS H1 H2 H3 ROTS A1 OUT_MAX.sav	DDTS Study 6b PSSE Reports

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3.1 Scenario 1

This scenario assumes that the DDTS H3 transformer is OOS.

3.1.1 Scenario 1a – Summer

AEMO's Summer POE50 forecasts have been used to calculate load at risk. The load at risk for this scenario is shown below.

Table C – Scenario 1a Maximum Load and Load at Risk at Secure Operating Contingency

	Location Type			Study 1a Max Load (MW)	2029 Load At Risk (MW)	2030 Load At Risk (MW)	2031 Load At Risk (MW)	2032 Load At Risk (MW)	2033 Load At Risk (MW)
BETS	Entire	22	MW	**28.8**	48.5	48.7	49.8	51.3	52.9
BETS	Entire	66	MW	**59.4**	103.6	104.5	105.9	107.4	108.8
FVTS	Entire	11	MW	**5.5**	11.5	11.5	11.5	11.5	11.5
GNTS	Entire	66	MW	**84.9**	9.8	11.7	13.6	15.6	17.4
MBTS	Entire	66	MW	**19.1**	12.8	13.2	13.7	14.2	14.6
SHTS	Entire	66	MW	**169.7**	103.6	103.9	104.5	106.8	108.5
TTS	Entire	66	MW	**197.2**	301.9	314.9	332.7	347.4	361.4
RWTS	Entire	22	MW	**96.0**	0.0	0.0	0.0	0.0	0.0
RWTS	Entire	66	MW	**517.7**	0.0	0.0	0.0	0.0	0.0
TSTS	Entire	66	MW	**369.8**	0.0	0.0	0.0	0.0	0.0
			Yearly Load @ Risk (MW)		**591.6**	**608.4**	**631.7**	**654.2**	**675.1**

For this scenario DDTS H1 and H2 transformer ratings are set to 340 MVA, and the H3 transformer rating is set to 240 MVA.

The maximum supportable sub-system load is approximately 564 MW when the DDTS H3 and SMTS H1 transformers are OOS. Under these conditions the DDTS H1 and H2 transformers are operating within rating. All bus voltages are within the required band. However, the SMTS H3 Transformer is at capacity with a load of 691.8 MW, 109.2 MVAr (700.3 MVA). The maximum rating for this transformer is 700 MVA. Refer to results text file for more information.

In practice, a failure of the SMTS H1 transformer can be addressed reasonably quickly by switching in the H2 transformer. Therefore, while this scenario does represent a critical contingency event, it will not require significant time to recover from. Scenario 1c presents another critical contingency event that will require more time to address.

3.1.2 Scenario 1b – Winter

The secure operating contingency in this study is the same as that for Study 1a. The SMTS H1 Transformer has the same summer and winter ratings. Since the SMTS H1 load is the key limiting factor, the sub-system's winter line and transformer ratings do not allow for larger loadings when the DDTS H3 and SMTS H1 transformers are OOS. Refer to results text file for more information.

AEMO's Winter POE50 forecasts have been used to calculate load at risk. The load at risk for this scenario is shown below.

Table D – Scenario 1b Maximum Load and Load at Risk at Secure Operating Contingency

	Location Type			Study 1b Max Load (MW)	2029 Load At Risk (MW)	2030 Load At Risk (MW)	2031 Load At Risk (MW)	2032 Load At Risk (MW)	2033 Load At Risk (MW)
BETS	Entire	22	MW	**28.8**	40.0	41.7	42.8	44.2	46.4
BETS	Entire	66	MW	**59.4**	92.3	94.7	95.9	97.8	101.0
FVTS	Entire	11	MW	**5.5**	13.0	13.0	13.0	13.0	13.0
GNTS	Entire	66	MW	**84.9**	24.2	25.9	27.7	29.4	31.0
MBTS	Entire	66	MW	**19.1**	23.5	24.1	24.6	25.0	25.4
SHTS	Entire	66	MW	**169.7**	62.1	63.9	64.5	66.4	69.1
TTS	Entire	66	MW	**197.2**	314.7	328.3	344.9	357.9	371.0
RWTS	Entire	22	MW	**96.0**	0.0	0.0	0.0	0.0	0.0
RWTS	Entire	66	MW	**517.7**	0.0	0.0	0.0	0.0	0.0
TSTS	Entire	66	MW	**369.8**	0.0	0.0	0.0	0.0	0.0
			Yearly Load @ Risk (MW)		**569.7**	**591.6**	**613.4**	**633.7**	**656.9**

In practice, a failure of the SMTS H1 transformer can be addressed reasonably quickly by switching in the H2 transformer. Therefore, while this scenario does represent a critical contingency event, it will not require significant time to recover from. Scenario 1d presents another critical contingency event that will require more time to address.

3.1.3 Scenario 1c – Summer

AEMO's Summer POE50 forecasts have been used to calculate load at risk. The load at risk for this scenario is shown below.

Table E – Scenario 1c Maximum Load and Load at Risk at Secure Operating Contingency

LOCATIONID	Location Type	VOLTAGE	UNIT	Study 1c Max Load (MW)	2029 Load At Risk (MW)	2030 Load At Risk (MW)	2031 Load At Risk (MW)	2032 Load At Risk (MW)	2033 Load At Risk (MW)
BETS	Entire	22	MW	**58.0**	19.3	19.5	20.6	22.1	23.7
BETS	Entire	66	MW	**119.6**	43.4	44.3	45.7	47.2	48.6
FVTS	Entire	11	MW	**11.1**	5.9	5.9	5.9	5.9	5.9
GNTS	Entire	66	MW	**121.0**	0.0	0.0	0.0	0.0	0.0
MBTS	Entire	66	MW	**22.6**	9.3	9.7	10.2	10.7	11.1
SHTS	Entire	66	MW	**269.5**	3.8	4.1	4.6	7.0	8.7
TTS	Entire	66	MW	**397.1**	102.0	115.0	132.8	147.5	161.5
RWTS	Entire	22	MW	**96.0**	0.0	0.0	0.0	0.0	0.0
RWTS	Entire	66	MW	**517.7**	0.0	0.0	0.0	0.0	0.0
TSTS	Entire	66	MW	**369.8**	0.0	0.0	0.0	0.0	0.0
			Yearly Load @ Risk (MW)		**183.7**	**198.5**	**219.9**	**240.4**	**259.4**

For this scenario DDTS H1 and H2 transformer ratings are set to 340 MVA, and the H3 transformer rating is set to 240 MVA.

The maximum supportable sub-system load is approximately 998 MW when the DDTS H3 and H1 transformers are OOS. Under these conditions the DDTS H2 transformer is at capacity with a load of 335.4 MW, 51.5 MVAr (339.3 MVA). All bus voltages are within the required band. Refer to results text file for more information.

3.1.4 Scenario 1d – Winter

The secure operating state contingency for this study is the same as for Study 1c. The DDTS H2 Transformer has the same summer and winter ratings. Since the DDTS H2 load is the key limiting factor, the sub-system's winter line and transformer ratings do not allow for larger loadings when the DDTS H3 and H1 transformers are OOS. Refer to results text file for more information.

AEMO's Winter POE50 forecasts have been used to calculate load at risk. The load at risk for this scenario is shown below.

Table F – Scenario 1d Maximum Load and Load at Risk at Secure Operating Contingency

	Location Type			Study 1d Max Load (MW)	2029 Load At Risk (MW)	2030 Load At Risk (MW)	2031 Load At Risk (MW)	2032 Load At Risk (MW)	2033 Load At Risk (MW)
BETS	Entire	22	MW	**58.0**	10.8	12.5	13.6	15.0	17.2
BETS	Entire	66	MW	**119.6**	32.1	34.5	35.7	37.6	40.8
FVTS	Entire	11	MW	**11.1**	7.4	7.4	7.4	7.4	7.4
GNTS	Entire	66	MW	**121.0**	0.0	0.0	0.0	0.0	0.0
MBTS	Entire	66	MW	**22.6**	20.0	20.6	21.1	21.5	21.9
SHTS	Entire	66	MW	**269.5**	0.0	0.0	0.0	0.0	0.0
TTS	Entire	66	MW	**397.1**	114.8	128.4	145.0	158.0	171.1
RWTS	Entire	22	MW	**96.0**	0.0	0.0	0.0	0.0	0.0
RWTS	Entire	66	MW	**517.7**	0.0	0.0	0.0	0.0	0.0
TSTS	Entire	66	MW	**369.8**	0.0	0.0	0.0	0.0	0.0
			Yearly Load @ Risk (MW)		**185.1**	**203.4**	**222.8**	**239.6**	**258.4**

3.1.5 Scenario 1e – Summer

AEMO's Summer POE50 forecasts have been used to calculate load at risk. The load at risk for this scenario is shown below.

Table G – Scenario 1e Maximum Load and Load at Risk at Secure Operating Contingency

LOCATIONID	Location Type	VOLTAGE	UNIT	Study 1e Max Load (MW)	2029 Load At Risk (MW)	2030 Load At Risk (MW)	2031 Load At Risk (MW)	2032 Load At Risk (MW)	2033 Load At Risk (MW)
BETS	Entire	22	MW	**75.3**	2.0	2.2	3.3	4.8	6.4
BETS	Entire	66	MW	**155.1**	7.9	8.8	10.2	11.7	13.1
FVTS	Entire	11	MW	**14.2**	2.8	2.8	2.8	2.8	2.8
GNTS	Entire	66	MW	**140.7**	0.0	0.0	0.0	0.0	0.0
MBTS	Entire	66	MW	**25.2**	6.7	7.1	7.6	8.1	8.5
SHTS	Entire	66	MW	**328.4**	0.0	0.0	0.0	0.0	0.0
TTS	Entire	66	MW	**515.0**	0.0	0.0	14.9	29.6	43.6
RWTS	Entire	22	MW	**96.0**	0.0	0.0	0.0	0.0	0.0
RWTS	Entire	66	MW	**517.7**	0.0	0.0	0.0	0.0	0.0
TSTS	Entire	66	MW	**369.8**	0.0	0.0	0.0	0.0	0.0
			Yearly Load @ Risk (MW)		**19.4**	**20.9**	**38.8**	**57.0**	**74.4**

For this scenario the DDTS H1 and H2 ratings were set to 400 MVA, and the DDTS H3 rating was set to 240 MVA.

The maximum supportable sub-system load is approximately 1,253 MW when the DDTS H3 and H1 transformers are OOS. Under these conditions the DDTS H2 transformer is at capacity with a load of 389.8 MW, 89.8 MVAr (400.0 MVA). All bus voltages are within the required band. Refer to results text file for more information.

3.1.6 Scenario 1f – Winter

The secure operating state contingency for this study is the same as for Study 1e. The DDTS H2 Transformer has the same summer and winter ratings. Since the DDTS H2 load is the key limiting factor, the sub-system's winter line and transformer ratings do not allow for larger loadings when the DDTS H3 and H1 transformers are OOS. Refer to results text file for more information.

AEMO's Winter POE50 forecasts have been used to calculate load at risk. The load at risk for this scenario is shown below.

Table H – Scenario 1f Maximum Load and Load at Risk at Secure Operating Contingency

	Location Type			Study 1f Max Load (MW)	2029 Load At Risk (MW)	2030 Load At Risk (MW)	2031 Load At Risk (MW)	2032 Load At Risk (MW)	2033 Load At Risk (MW)
BETS	Entire	22	MW	**75.3**	0.0	0.0	0.0	0.0	0.0
BETS	Entire	66	MW	**155.1**	0.0	0.0	0.2	2.1	5.3
FVTS	Entire	11	MW	**14.2**	4.3	4.3	4.3	4.3	4.3
GNTS	Entire	66	MW	**140.7**	0.0	0.0	0.0	0.0	0.0
MBTS	Entire	66	MW	**25.2**	17.4	18.0	18.5	18.9	19.3
SHTS	Entire	66	MW	**328.4**	0.0	0.0	0.0	0.0	0.0
TTS	Entire	66	MW	**515.0**	0.0	10.5	27.1	40.1	53.2
RWTS	Entire	22	MW	**96.0**	0.0	0.0	0.0	0.0	0.0
RWTS	Entire	66	MW	**517.7**	0.0	0.0	0.0	0.0	0.0
TSTS	Entire	66	MW	**369.8**	0.0	0.0	0.0	0.0	0.0
			Yearly Load @ Risk (MW)		**21.7**	**32.8**	**50.1**	**65.5**	**82.1**

3.2 Scenario 2

The objective of this scenario is to ascertain the maximum supportable load when only the DDTS H1 is OOS and there are no other network contingency events. This scenario assumes that the DDTS H2 and H3 transformers have their present ratings of 340 MVA and 240 MVA respectively.

3.2.1 Scenario 2a – Summer

AEMO's Summer POE50 forecasts have been used to calculate load at risk. The load at risk for this scenario is shown below.

Table I – Scenario 2a Maximum Load and Load at Risk at Secure Operating Contingency

	Location Type			Study 2a Max Load (MW)	2029 Load At Risk (MW)	2030 Load At Risk (MW)	2031 Load At Risk (MW)	2032 Load At Risk (MW)	2033 Load At Risk (MW)
BETS	Entire	22	MW	**84.0**	0.0	0.0	0.0	0.0	0.0
BETS	Entire	66	MW	**172.9**	0.0	0.0	0.0	0.0	0.0
FVTS	Entire	11	MW	**16.0**	1.0	1.0	1.0	1.0	1.0
GNTS	Entire	66	MW	**151.2**	0.0	0.0	0.0	0.0	0.0
MBTS	Entire	66	MW	**25.8**	6.1	6.5	7.0	7.5	7.9
SHTS	Entire	66	MW	**358.0**	0.0	0.0	0.0	0.0	0.0
TTS	Entire	66	MW	**574.7**	0.0	0.0	0.0	0.0	0.0
RWTS	Entire	22	MW	**96.0**	0.0	0.0	0.0	0.0	0.0
RWTS	Entire	66	MW	**517.7**	0.0	0.0	0.0	0.0	0.0
TSTS	Entire	66	MW	**369.8**	0.0	0.0	0.0	0.0	0.0
				Yearly Load @ Risk (MW)	**7.1**	**7.5**	**8.0**	**8.5**	**8.9**

The maximum supportable sub-system load is approximately 1,382 MW when the DDTS H1 is OOS. Under these conditions the DDTS H3 is at capacity with a load of 234.4 MW, 48.6 MVAr (239.4 MVA). All bus voltages are within the required limits. Refer to results text file for more information.

3.2.2 Scenario 2b – Winter

The DDTS H3 Transformer has the same summer and winter ratings. Since the DDTS H3 is the key limiting factor in this scenario, the sub-system's winter line and transformer ratings do not allow for larger loadings when the DDTS H1 transformer is OOS. Refer to results text file for more information.

AEMO's Winter POE50 forecasts have been used to calculate load at risk. The load at risk for this scenario is shown below.

Table J – Scenario 2b Maximum Load and Load at Risk at Secure Operating Contingency

	Location Type			Study 2b Max Load (MW)	2029 Load At Risk (MW)	2030 Load At Risk (MW)	2031 Load At Risk (MW)	2032 Load At Risk (MW)	2033 Load At Risk (MW)
BETS	Entire	22	MW	**84.0**	0.0	0.0	0.0	0.0	0.0
BETS	Entire	66	MW	**172.9**	0.0	0.0	0.0	0.0	0.0
FVTS	Entire	11	MW	**16.0**	2.5	2.5	2.5	2.5	2.5
GNTS	Entire	66	MW	**151.2**	0.0	0.0	0.0	0.0	0.0
MBTS	Entire	66	MW	**25.8**	16.8	17.4	17.9	18.3	18.7
SHTS	Entire	66	MW	**358.0**	0.0	0.0	0.0	0.0	0.0
TTS	Entire	66	MW	**574.7**	0.0	0.0	0.0	0.0	0.0
RWTS	Entire	22	MW	**96.0**	0.0	0.0	0.0	0.0	0.0
RWTS	Entire	66	MW	**517.7**	0.0	0.0	0.0	0.0	0.0
TSTS	Entire	66	MW	**369.8**	0.0	0.0	0.0	0.0	0.0
			Yearly Load @ Risk (MW)		**19.3**	**19.9**	**20.4**	**20.8**	**21.2**

3.3 Scenario 3

The objective of this scenario is to ascertain the maximum supportable load when only the DDTS H1 is OOS and there are no other network contingency events. This scenario assumes that the DDTS H2 transformer has its present rating of 340 MVA, and the H3 transformer has been replaced with a new one rated at 340 MVA.

3.3.1 Scenario 3a – Summer

AEMO's Summer POE50 forecasts have been used to calculate load at risk. The load at risk for this scenario is shown below.

Table K – Scenario 3a Maximum Load and Load at Risk at Secure Operating Contingency

	Location Type			Study 3a Max Load (MW)	2029 Load At Risk (MW)	2030 Load At Risk (MW)	2031 Load At Risk (MW)	2032 Load At Risk (MW)	2033 Load At Risk (MW)
BETS	Entire	22	MW	**110.8**	0.0	0.0	0.0	0.0	0.0
BETS	Entire	66	MW	**228.3**	0.0	0.0	0.0	0.0	0.0
FVTS	Entire	11	MW	**21.0**	0.0	0.0	0.0	0.0	0.0
GNTS	Entire	66	MW	**182.1**	0.0	0.0	0.0	0.0	0.0
MBTS	Entire	66	MW	**29.5**	2.4	2.8	3.3	3.8	4.2
SHTS	Entire	66	MW	**449.4**	0.0	0.0	0.0	0.0	0.0
TTS	Entire	66	MW	**758.1**	0.0	0.0	0.0	0.0	0.0
RWTS	Entire	22	MW	**96.0**	0.0	0.0	0.0	0.0	0.0
RWTS	Entire	66	MW	**517.7**	0.0	0.0	0.0	0.0	0.0
TSTS	Entire	66	MW	**369.8**	0.0	0.0	0.0	0.0	0.0
			Yearly Load @ Risk (MW)		**2.4**	**2.8**	**3.3**	**3.8**	**4.2**

The maximum supportable sub-system load is approximately 1,779 MW when the DDTS H1 is OOS. Under these conditions the DDTS H3 and H2 are operating within their ratings, and the BATS-BETS 220 kV line is operating at close to its maximum rating. The TTS B1 transformer is also at its limit. Refer to results text file for more information.

A comparison of the results with Scenario 2a shows that there is a lower load at risk when the H3 transformer is replaced with one rated at 340 MVA.

3.3.2 Scenario 3b – Winter

The BATS-BETS 220 kV line has a higher winter rating and can thus support a higher sub-system load of 1,849 MW in this scenario. However, this is the maximum supportable load in winter as the SHTS 22 kV Bus voltage does not remain within the required limits at higher loads. The loads at TTS were not changed for this study as the B1 transformer was already at its limit. Refer to results text file for more information.

AEMO's Winter POE50 forecasts have been used to calculate load at risk. The load at risk for this scenario is shown below.

Table L – Scenario 3b Maximum Load and Load at Risk at Secure Operating Contingency

LOCATIONID	Location Type	VOLTAGE	UNIT	Study 3b Max Load (MW)	2029 Load At Risk (MW)	2030 Load At Risk (MW)	2031 Load At Risk (MW)	2032 Load At Risk (MW)	2033 Load At Risk (MW)
BETS	Entire	22	MW	**119.8**	0.0	0.0	0.0	0.0	0.0
BETS	Entire	66	MW	**246.4**	0.0	0.0	0.0	0.0	0.0
FVTS	Entire	11	MW	**22.7**	0.0	0.0	0.0	0.0	0.0
GNTS	Entire	66	MW	**193.7**	0.0	0.0	0.0	0.0	0.0
MBTS	Entire	66	MW	**29.4**	13.2	13.8	14.3	14.7	15.1
SHTS	Entire	66	MW	**479.5**	0.0	0.0	0.0	0.0	0.0
TTS	Entire	66	MW	**758.1**	0.0	0.0	0.0	0.0	0.0
RWTS	Entire	22	MW	**96.0**	0.0	0.0	0.0	0.0	0.0
RWTS	Entire	66	MW	**517.7**	0.0	0.0	0.0	0.0	0.0
TSTS	Entire	66	MW	**369.8**	0.0	0.0	0.0	0.0	0.0
			Yearly Load @ Risk (MW)		**13.2**	**13.8**	**14.3**	**14.7**	**15.1**

A comparison of the results with Scenario 2b shows that there is a lower load at risk when the H3 transformer is replaced with one rated at 340 MVA.

3.4 Scenario 4

The objective of this scenario is to ascertain the maximum supportable load when only the DDTS H1 is OOS and there are no other network contingency events. This scenario assumes that all DDTS H transformers have a rating of 400 MVA.

3.4.1 Scenario 4a – Summer

AEMO's Summer POE50 forecasts have been used to calculate load at risk. The load at risk for this scenario is shown below.

Table M – Scenario 4a Maximum Load and Load at Risk at Secure Operating Contingency

LOCATIONID	Location Type	VOLTAGE	UNIT	Study 4a Max Load (MW)	2029 Load At Risk (MW)	2030 Load At Risk (MW)	2031 Load At Risk (MW)	2032 Load At Risk (MW)	2033 Load At Risk (MW)
BETS	Entire	22	MW	**110.8**	0.0	0.0	0.0	0.0	0.0
BETS	Entire	66	MW	**228.3**	0.0	0.0	0.0	0.0	0.0
FVTS	Entire	11	MW	**21.0**	0.0	0.0	0.0	0.0	0.0
GNTS	Entire	66	MW	**182.1**	0.0	0.0	0.0	0.0	0.0
MBTS	Entire	66	MW	**29.5**	2.4	2.8	3.3	3.8	4.2
SHTS	Entire	66	MW	**449.4**	0.0	0.0	0.0	0.0	0.0
TTS	Entire	66	MW	**758.1**	0.0	0.0	0.0	0.0	0.0
RWTS	Entire	22	MW	**96.0**	0.0	0.0	0.0	0.0	0.0
RWTS	Entire	66	MW	**517.7**	0.0	0.0	0.0	0.0	0.0
TSTS	Entire	66	MW	**369.8**	0.0	0.0	0.0	0.0	0.0
			Yearly Load @ Risk (MW)		**2.4**	**2.8**	**3.3**	**3.8**	**4.2**

The results for this study are the same as that for Study 3a. A larger transformer capacity at DDTS will not increase the maximum supportable load when the DDTS H1 transformer is OOS, as the key limiting factor is the summer rating of the BATS-BETS 220 kV line. Refer to results text file for more information.

3.4.2 Scenario 4b – Winter

The results for this study are the same as that for Study 3b. A larger transformer capacity at DDTS will not increase the maximum supportable load when the DDTS H1 transformer is OOS, as the key limiting factor is the SHTS 22 kV Bus voltage. Refer to results text file for more information.

AEMO's Winter POE50 forecasts have been used to calculate load at risk. The load at risk for this scenario is shown below.

Table N – Scenario 4b Maximum Load and Load at Risk at Secure Operating Contingency

	Location Type			Study 4b Max Load (MW)	2029 Load At Risk (MW)	2030 Load At Risk (MW)	2031 Load At Risk (MW)	2032 Load At Risk (MW)	2033 Load At Risk (MW)
BETS	Entire	22	MW	**119.8**	0.0	0.0	0.0	0.0	0.0
BETS	Entire	66	MW	**246.4**	0.0	0.0	0.0	0.0	0.0
FVTS	Entire	11	MW	**22.7**	0.0	0.0	0.0	0.0	0.0
GNTS	Entire	66	MW	**193.7**	0.0	0.0	0.0	0.0	0.0
MBTS	Entire	66	MW	**29.4**	13.2	13.8	14.3	14.7	15.1
SHTS	Entire	66	MW	**479.5**	0.0	0.0	0.0	0.0	0.0
TTS	Entire	66	MW	**758.1**	0.0	0.0	0.0	0.0	0.0
RWTS	Entire	22	MW	**96.0**	0.0	0.0	0.0	0.0	0.0
RWTS	Entire	66	MW	**517.7**	0.0	0.0	0.0	0.0	0.0
TSTS	Entire	66	MW	**369.8**	0.0	0.0	0.0	0.0	0.0
			Yearly Load @ Risk (MW)		**13.2**	**13.8**	**14.3**	**14.7**	**15.1**

3.5 Scenario 5

The objective of this scenario is to ascertain the maximum supportable load when the DDTS H1 and H3 transformers are OOS and there is another network contingency event.

3.5.1 Scenario 5a – Summer

AEMO's Summer POE50 forecasts have been used to calculate load at risk. The load at risk for this scenario is shown below.

Table O – Scenario 5a Maximum Load and Load at Risk at Secure Operating Contingency

LOCATIONID	Location Type	VOLTAGE	UNIT	Study 5a Max Load (MW)	2029 Load At Risk (MW)	2030 Load At Risk (MW)	2031 Load At Risk (MW)	2032 Load At Risk (MW)	2033 Load At Risk (MW)
BETS	Entire	22	MW	**40.0**	37.3	37.5	38.6	40.1	41.7
BETS	Entire	66	MW	**82.6**	80.4	81.3	82.7	84.2	85.6
FVTS	Entire	11	MW	**7.6**	9.4	9.4	9.4	9.4	9.4
GNTS	Entire	66	MW	**99.8**	0.0	0.0	0.0	0.7	2.5
MBTS	Entire	66	MW	**20.8**	11.1	11.5	12.0	12.5	12.9
SHTS	Entire	66	MW	**208.2**	65.1	65.4	66.0	68.3	70.0
TTS	Entire	66	MW	**274.3**	224.8	237.8	255.6	270.3	284.3
RWTS	Entire	22	MW	**82.5**	3.5	5.6	7.9	10.4	12.5
RWTS	Entire	66	MW	**412.7**	54.3	64.4	76.0	91.2	103.4
TSTS	Entire	66	MW	**330.2**	0.0	6.9	15.1	26.9	38.2
			Yearly Load @ Risk (MW)		**485.9**	**519.7**	**563.3**	**613.9**	**660.4**

For this scenario the DDTS H1 and H2 ratings were set to 400 MVA, and the DDTS H3 rating was set to 240 MVA.

The maximum supportable sub-system load is approximately 733 MW when the DDTS H1 and H3, and ROTS A1 transformers are OOS. Under these conditions the RWTS-TTS 220 kV Line is at capacity with a load of 704.1 MW, 12.1 MVAr (705 MVA). Refer to results text file for more information.

3.5.2 Scenario 5b – Winter

AEMO's Winter POE50 forecasts have been used to calculate load at risk. The load at risk for this scenario is shown below.

Table P – Scenario 5b Maximum Load and Load at Risk at Secure Operating Contingency

LOCATIONID	Location Type	VOLTAGE	UNIT	Study 5b Max Load (MW)	2029 Load At Risk (MW)	2030 Load At Risk (MW)	2031 Load At Risk (MW)	2032 Load At Risk (MW)	2033 Load At Risk (MW)
BETS	Entire	22	MW	**71.6**	0.0	0.0	0.0	1.4	3.6
BETS	Entire	66	MW	**147.4**	4.3	6.7	7.9	9.8	13.0
FVTS	Entire	11	MW	**13.6**	4.9	4.9	4.9	4.9	4.9
GNTS	Entire	66	MW	**136.3**	0.0	0.0	0.0	0.0	0.0
MBTS	Entire	66	MW	**24.9**	17.7	18.3	18.8	19.2	19.6
SHTS	Entire	66	MW	**315.8**	0.0	0.0	0.0	0.0	0.0
TTS	Entire	66	MW	**489.9**	22.0	35.6	52.2	65.2	78.3
RWTS	Entire	22	MW	**101.0**	0.0	0.0	0.0	0.0	0.0
RWTS	Entire	66	MW	**505.5**	0.0	0.0	0.0	0.0	0.0
TSTS	Entire	66	MW	**404.6**	0.0	0.0	0.0	0.0	0.0
			Yearly Load @ Risk (MW)		**48.9**	**65.5**	**83.8**	**100.6**	**119.4**

For this scenario the DDTS H1 and H2 ratings were set to 400 MVA, and the DDTS H3 rating was set to 240 MVA.

The maximum supportable sub-system load is approximately 1,199 MW when the DDTS H1 and H3, and ROTS A1 transformers are OOS. The higher sub-system loading in comparison to Scenario 5a is due to higher winter line ratings. Under these conditions the limiting factor is the DDTS H2 transformer which is at capacity with a load of 398.1 MW, 32.0 MVAr (399.4 MVA). Refer to results text file for more information.

3.6 Scenario 6

The objective of this scenario is to ascertain the maximum supportable load when all the DDTS H transformers are OOS and the ROTS A1 transformer is OOS.

3.6.1 Scenario 6a – Summer

AEMO's Summer POE50 forecasts have been used to calculate load at risk. The load at risk for this scenario is shown below.

Table Q – Scenario 6a Maximum Load and Load at Risk at Secure Operating Contingency

LOCATIONID	Location Type	VOLTAGE	UNIT	Study 6a Max Load (MW)	2029 Load At Risk (MW)	2030 Load At Risk (MW)	2031 Load At Risk (MW)	2032 Load At Risk (MW)	2033 Load At Risk (MW)
BETS	Entire	22	MW	**40.0**	37.3	37.5	38.6	40.1	41.7
BETS	Entire	66	MW	**82.6**	80.4	81.3	82.7	84.2	85.6
FVTS	Entire	11	MW	**7.6**	9.4	9.4	9.4	9.4	9.4
GNTS	Entire	66	MW	**100.4**	0.0	0.0	0.0	0.1	1.9
MBTS	Entire	66	MW	**20.2**	11.7	12.1	12.6	13.1	13.5
SHTS	Entire	66	MW	**208.1**	65.2	65.5	66.1	68.4	70.1
TTS	Entire	66	MW	**274.2**	224.9	237.9	255.7	270.4	284.4
RWTS	Entire	22	MW	**82.2**	3.8	5.9	8.2	10.7	12.8
RWTS	Entire	66	MW	**412.0**	55.0	65.1	76.7	91.9	104.1
TSTS	Entire	66	MW	**329.6**	0.0	7.5	15.7	27.5	38.8
			Yearly Load @ Risk (MW)		**487.7**	**522.1**	**565.7**	**615.7**	**662.2**

The secure operating state contingency for this study is essentially the same as that for Study 5a, since the RWTS-TTS 220 kV Line is still the limiting factor. The maximum supportable sub-system load is also approximately 733 MW when all the DDTS H transformers are OOS, and the ROTS A1 transformer is OOS. Under these conditions the RWTS-TTS 220 kV Line is at capacity with a load of 705.3 MW, 7.0 MVAr (705.4 MVA). Refer to results text file for more information.

3.6.2 Scenario 6b – Winter

The maximum supportable sub-system load is approximately 875 MW when all the DDTS H transformers are OOS, and the ROTS A1 transformer is OOS. The higher sub-system loading of this scenario compared to Study 6a is due to a higher winter line rating for the RWTS-TTS 220 kV Line. Under these conditions the limiting factor is the SMTS-TTS No. 2 220 kV Line which is operating at capacity with a load of 607.5 MW, 45.6 MVAr (609.2 MVA). The summer and winter ratings for this line are the same, 609 MVA. Refer to results text file for more information.

AEMO's Winter POE50 forecasts have been used to calculate load at risk. The load at risk for this scenario is shown below.

Table R – Scenario 6b Maximum Load and Load at Risk at Secure Operating Contingency

LOCATIONID	Location Type	VOLTAGE	UNIT	Study 6b Max Load (MW)	2029 Load At Risk (MW)	2030 Load At Risk (MW)	2031 Load At Risk (MW)	2032 Load At Risk (MW)	2033 Load At Risk (MW)
BETS	Entire	22	MW	**52.0**	16.8	18.5	19.6	21.0	23.2
BETS	Entire	66	MW	**107.2**	44.5	46.9	48.1	50.0	53.2
FVTS	Entire	11	MW	**9.8**	8.7	8.7	8.7	8.7	8.7
GNTS	Entire	66	MW	**113.7**	0.0	0.0	0.0	0.6	2.2
MBTS	Entire	66	MW	**22.4**	20.2	20.8	21.3	21.7	22.1
SHTS	Entire	66	MW	**249.0**	0.0	0.0	0.0	0.0	0.0
TTS	Entire	66	MW	**320.7**	191.2	204.8	221.4	234.4	247.5
RWTS	Entire	22	MW	**90.0**	0.0	0.0	0.0	0.0	0.6
RWTS	Entire	66	MW	**450.1**	0.0	7.7	21.6	34.6	47.9
TSTS	Entire	66	MW	**360.1**	0.0	0.0	0.0	0.0	3.0
			Yearly Load @ Risk (MW)		**281.4**	**307.4**	**340.7**	**371.0**	**408.4**

3.7 Transformer Capacity Comparison

Scenarios 2-4 are essentially the same except for differing transformer ratings. Tables M and N provide a comparison of the sub-system loads that can be supported in each scenario.

Table S – Supportable Load Comparison Between Scenario 2a, 3a and 4a at Secure Operating Contingency

LOCATIONID	Location Type	VOLTAGE	UNIT	Study 2a Max Load (MW)	Study 3a Max Load (MW)	Study 4a Max Load (MW)	Additional Supportable Transformer Replacement (MW)
BETS	Entire	22	MW	84.0	110.8	110.8	**26.8**
BETS	Entire	66	MW	172.9	228.3	228.3	**55.4**
FVTS	Entire	11	MW	16.0	21.0	21.0	**5.0**
GNTS	Entire	66	MW	151.2	182.1	182.1	**30.9**
MBTS	Entire	66	MW	25.8	29.5	29.5	**3.7**
SHTS	Entire	66	MW	358.0	449.4	449.4	**91.4**
TTS	Entire	66	MW	574.7	758.1	758.1	**183.4**
RWTS	Entire	22	MW	96.0	96.0	96.0	**0.0**
RWTS	Entire	66	MW	517.7	517.7	517.7	**0.0**
TSTS	Entire	66	MW	369.8	369.8	369.8	**0.0**
						Total:	**396.6**

Table T – Suppor table Load Comparison Between Scenario 2b, 3b and 4b at Secure Operating Contingency

LOCATIONID	Location Type	VOLTAGE	UNIT	Study 2b Max Load (MW)	Study 3b Max Load (MW)	Study 4b Max Load (MW)	Additional Supportable Load from Transformer Replacement (MW)
BETS	Entire	22	MW	84.0	119.8	119.8	**35.8**
BETS	Entire	66	MW	172.9	246.4	246.4	**73.5**
FVTS	Entire	11	MW	16.0	22.7	22.7	**6.7**
GNTS	Entire	66	MW	151.2	193.7	193.7	**42.5**
MBTS	Entire	66	MW	25.8	29.4	29.4	**3.6**
SHTS	Entire	66	MW	358.0	479.5	479.5	**121.5**
TTS	Entire	66	MW	574.7	758.1	758.1	**183.4**
RWTS	Entire	22	MW	96.0	96.0	96.0	**0.0**
RWTS	Entire	66	MW	517.7	517.7	517.7	**0.0**
TSTS	Entire	66	MW	369.8	369.8	369.8	**0.0**
						Total:	**467.0**