South Morang Terminal Station H1 & H2 Transformer Replacement

TRR Network Studies Results

Version 3.0

VOLT CONSULT

Document History

Revision	Date	Details
1	09/12/2024	Initial Issue
2	23/12/2024	Revised Scenarios 1 and 5 and added 1a
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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 H1 and H2 transformer at South Morang Terminal Station (SMTS) and are purely technical in nature.

2.0 Network Study Methodology

AusNet obtained an updated PSSE OPDMS network model from AEMO which includes the cut-in of the ELD-TTS and ROTS-TTS 220 kV lines into the SMTS 220 kV Bus. Using this PSSE network model, the specific operating scenarios shown in Table A were studied.

Table A – Network Study Scenarios to be Modelled

Study	Network State/Scenario	Asset Failure Contingency N-1	Asset Failure Contingency N-2	Asset Failure Contingency N-3	Secure Operating State Contingency	Notes
1	N	None	None	None	SMTS H3 Transformer OOS	H1 or H2 short time rating of 850 MVA limits parallel 330/220 kV transformation flow. Only two transformers can be in service with decoupled SMTS 220 kV bus bars. Post-contingent loading on H1 or H2 should be no more than 850 MVA to allow for a contingent outage of the H3. Study with only H1 or H2 in service at SMTS.
1a	N	None	None	None	SMTS H3 Transformer OOS	SMTS H1 and H2 transformers in service.
1b	N-2	SMTS H1 Transformer OOS	SMTS H2 Transformer OOS	None	SMTS H3 Transformer OOS	All SMTS H transformers OOS
2	N-1	SMTS H2 Transformer OOS	None	None	KTS A4 Transformer OOS	H1 or H2 short time rating of 850 MVA limits parallel 330/220 kV transformation flow. Only two transformers can be in service with decoupled SMTS 220 kV bus bars. Post-contingent loading on H1 or H2 should be no more than 850 MVA to allow for a contingent outage of the H3. Study with only H1 or H2 in service at SMTS. **This study may be the same as Study 1.**
3	N-2	SMTS H1 Transformer OOS	SMTS H2 Transformer OOS	None	KTS A4 Transformer OOS	Only H3 in service at SMTS if Secure operation state contingency is external to SMTS
4	N-3	SMTS H1 Transformer OOS	SMTS H2 Transformer OOS	SMTS H3 Transformer OOS	ROTS A1 Transformer OOS	All SMTS H transformers OOS so transformer ratings not important
5	N with New Transformers	None	None	None	SMTS H3 Transformer OOS	After replacement, both SMTS H transformers will have a 1000 MVA short time rating. Project replaces the H1 and H2 with one bank and a single-phase spare. H1 and H2 are retired.

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. Select the buses to be used as a sub-system for the assessment
3. Set the sub-system loads to the levels required
4. Conduct a load flow study to ensure the model is stable after load adjustments
5. Configure the system to match the specific scenario to be studied (i.e. disconnect the applicable plant or line)
6. Conduct a load flow
7. Analyse the load flows and take another key element out of service (OOS) from the network
8. Review the line, bus and transformer voltage and loading results for the sub-system using PSSE's reports function
9. If all parameters are within the required ranges, scale up the sub-system loads by a certain percentage
10. Conduct a load flow
11. Repeat steps 8-10 until a line or transformer reaches its maximum capacity or repeat steps 7-9 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 ATS, BLTS, BTS, CBTS, DPTS, ERTS, FBTS, GTS, HTS, KTS, MTS, RTS, RWTS, SMTS, SVTS, TSTS, TTS, and WMTS. The buses selected for the sub-system in PSSE were as follows:

100191,100282,100594,100647,100695,100721,100762,100765,100771,100785,100786,100789,100798,100809,100861,100889, 100911,302030,302031,302033,302080,314020,314021,314022,314023,314030,314031,314032,314033,314034,314035,314080, 314081,314082,315020,315030,315080,321030,321031,321032,321033,321080,321081,323530,323531,323532,323533,323534, 323535,323536,323580,324001,324031,324080,326030,326031,326032,326033,326080,326081,328030,328031,328032,328033, 328034,328035,328080,332030,332031,332032,332033,332080,341001,341030,341080,341081,341090,349020,349030,349080, 365022,365032,365080,366020,366021,366022,366023,366030,366031,366032,366033,366034,366035,366080,373030,373080, 373081,373090,373091,373092,373093,373096,373097,374001,374030,374080,377030,377031,377032,377033,377080,379001, 379002,379080,379081,379082,387020,387021,387022,387023,387024,387025,387030,387080

Loads at each of the stations listed above were set to Summer 2029 POE50 forecast levels and scaled up or down according to the requirements of each scenario modelled.

The following short time ratings were used in the assessments:

SMTS H1 and H2 Transformers – 850 MVA
SMTS H3 Transformer – 1,000 MVA
KTS A2, A3, A4 Transformers – 810 MVA
ROTS A1 and A2 Transformers – 1,500 MVA
BTS-RTS 220 kV Underground cable – 650 MVA
DDTS-SMTS 330 kV Line and Series Capacitor Bank – 1,086 MVA (Summer)
DDTS-SMTS 330 kV Line and Series Capacitor Bank – 1,343 MVA (Winter)

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	Maximum Supportable Sub-System Load (MW)	SMTS Transformers in Service	PSSE Filename	Results Text File
1	N	None	None	None	SMTS H3 Transformer OOS	**7,329**	H1	20240222-160037-max-demand-snapshot-SMTS_cut_in_SMTS H S1_H3 OOS MAX_No_DER_LDSH.sav	SMTS H Study 1 PSSE Reports
1a	N	None	None	None	SMTS H3 Transformer OOS	**7,732**	H1 and H2	20240222-160037-max-demand-snapshot-SMTS_cut_in_SMTS H S1a_H3 OOS MAX_No_DER_LDSH.sav	SMTS H Study 1a PSSE Reports
1b	N-2	SMTS H1 Transformer OOS	SMTS H2 Transformer OOS	None	SMTS H3 Transformer OOS	**7,198**	None	20240222-160037-max-demand-snapshot-SMTS_cut_in_SMTS H S1b_H1 H2 H3 OOS MAX_No_DER_LDSH.sav	SMTS H Study 1b PSSE Reports
2	N-1	SMTS H2 Transformer OOS	None	None	KTS A4 Transformer OOS	**5,864**	H1 and H3	20240222-160037-max-demand-snapshot-SMTS_cut_in_SMTS H S2_H2 KTS A4 OOS MAX_No_DER_LDSH.sav	SMTS H Study 2 PSSE Reports
3	N-2	SMTS H1 Transformer OOS	SMTS H2 Transformer OOS	None	KTS A4 Transformer OOS	**5,292**	H3	20240222-160037-max-demand-snapshot-SMTS_cut_in_SMTS H S3_H1 H2 KTS A4 OOS MAX_No_DER_LDSH.sav	SMTS H Study 3 PSSE Reports

Study	Network Configuration	Asset Failure Contingency N-1	Asset Failure Contingency N-2	Asset Failure Contingency N-3	Secure Operating State Contingency	Maximum Supportable Sub-System Load (MW)	SMTS Transformers in Service	PSSE Filename	Results Text File
4	N-3	SMTS H1 Transformer OOS	SMTS H2 Transformer OOS	SMTS H3 Transformer OOS	ROTS A1 Transformer OOS	**4,992**	None	20240222-160037-max-demand-snapshot-SMTS_cut_in_SMTS H S4_H1 H2 H3 ROTS A1 OOS MAX_No_DER_LDSH.sav	SMTS H Study 4 PSSE Reports
5	N with New Transformers	None	None	None	SMTS H3 Transformer OOS	**7,790**	New 1,000 MVA H1	20240222-160037-max-demand-snapshot-SMTS_cut_in_SMTS H S5_H3 OOS MAX_No_DER_LDSH.sav	SMTS H Study 5 PSSE Reports

3.1 Scenario 1

The maximum supportable sub-system load is approximately 7,329 MW when the SMTS H3 and SMTS H2 transformers are OOS.

Under these conditions the SMTS H1 transformer is at capacity with a load of 832.9 MW, 166.0 MVAr (849.3 MVA). The maximum rating for this transformer is 850 MVA.

The BTS-RTS 220 kV underground cable is also operating near its continuous rating capacity under these conditions. The BLTS B1 and B3 transformers are heavily overloaded, and the ATS B2 transformer is slightly overloaded at this sub-system load.

3.2 Scenario 1a

The maximum supportable sub-system load for this scenario is approximately 7,732 MW.

The SMTS H1 and H2 Transformers are operating at around 80% and 82% of their ratings respectively. The limiting factor in this scenario is the DDTS-SMTS 330 kV Line summer short time rating.

Under the sub-system load the DDTS-SMTS 330 kV Line is operating at its capacity with a load of 902.5 MW, 602.4 MVAr (1085.1 MVA). The BLTS B1 and B3 transformers are heavily overloaded, and the ATS B2 transformer is slightly overloaded at this sub-system load. The MTS 660 kV bus is also operating at just under 0.9 pu, and the SMTS B1 transformer, and SMTS-TTS No.1 220 kV line are operating close to their cyclic ratings.

The model becomes unstable at a sub-system load greater than this with the SMTS H3 transformer OOS. Therefore, this is the maximum supportable sub-system load for this operating scenario.

3.2 Scenario 1b

The maximum supportable sub-system load for this scenario is approximately 7,198 MW.

The limiting factor in this scenario is the KTS A3 Transformer short time rating. Under this sub-system load the KTS A3 transformer is operating at its capacity with a load of 801.3 MW, 117.9 MVAr (809.9 MVA). The BLTS B1 and B3 transformers are heavily overloaded, and the ATS B2 transformer is slightly overloaded at this sub-system load.

Since the KTS A3 transformer short time rating is the key limiting factor, the maximum supportable sub-system load for this scenario is the same for each season.

3.3 Scenario 2

The maximum supportable sub-system load is approximately 5,864 MW when the SMTS H2 and KTS A4 transformers are OOS.

Under these conditions the KTS A2 transformer is at capacity with a load of 803.7 MW, 100.1 MVAr (809.9 MVA). The maximum short time rating of this transformer is 810 MVA. The SMTS H1 and H3 transformers are operating at 57% and 46% of their respective ratings. The BLTS B1 and B3 transformers are heavily overloaded at this sub-system load.

Since the KTS A4 transformer short time rating is the key limiting factor, the maximum supportable sub-system load for this scenario is the same for each season. SMTS 330 kV buses are also operating at just over 1.1 pu. WMTS 66 kV buses are operating at around 1.15 pu.

3.4 Scenario 3

The maximum supportable sub-system load is approximately 5,292 MW when the SMTS H1 and H2, and KTS A4 transformers are OOS.

Under these conditions the KTS A2 transformer is at capacity with a load of 797.6 MW, 137.1 MVAr (809.3 MVA). The maximum short time rating of this transformer is 810 MVA. The SMTS H3 transformer is operating at 68% of its rating. The BLTS B1 and B3 transformers are heavily overloaded at this sub-system load.

Since the KTS A4 transformer short time rating is the key limiting factor, the maximum supportable sub-system load for this scenario is the same for each season.

3.5 Scenario 4

The maximum supportable sub-system load is approximately 4,992 MW when all the SMTS H transformers are OOS and the ROTS A1 transformer is OOS.

Under these conditions the RTS-BTS 220 kV underground cable is operating at its short time rating capacity (650 MVA) with a load of 643.7 MW, 93.8 MVAr (650.5 MVA).

Since the RTS-BTS 220 kV underground cable short time rating is the key limiting factor, the maximum supportable sub-system load for this scenario is the same for each season.

3.6 Scenario 5

The maximum supportable sub-system load for this scenario is approximately 7,790 MW. The new SMTS H1 Transformer with 1000 MVA rating is operating at approximately 98% of its rating.

Under these conditions, B transformers at ATS, BLTS and KTS are heavily loaded. Bus voltages within the sub-system are generally at the lower end of the required limits, with only the MTS 66 kV bus operating at less than 0.9 pu.

The model becomes unstable at a sub-system load greater than this with the SMTS H3 transformer OOS. Therefore, this is the maximum supportable sub-system load for this operating scenario.