APD ENGINEERING

H1 TRANSFORMER REPLACEMENT SOUTH MORANG TERMINAL STATION

TRANSMISSION REVENUE RESET (TRR) PROJECT SCOPING

REVISION HISTORY

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EXECUTIVE SUMMARY

AusNet Services has engaged APD Engineering to prepare project scopes and estimates relating to options for the replacement of the H1 330/220kV transformer at South Morang Terminal Station (SMTS), along with poor condition secondary equipment for inclusion in AusNet Services' 2022 – 2027 Transmission Revenue Reset.

APD Engineering has reviewed a functional scope prepared by AusNet Services and developed detailed scopes and estimates for each planning option required by AusNet Services.

It has been agreed with AusNet Services that APD Engineering will provide high level estimates for replacement projects only. Where a refurbishment option is presented in the functional requirements, AusNet Services will estimate the cost of refurbishment.

The planning options considered, along with the associated costs, are included in Table 1 below. These costs exclude contingency but include an allowance for overheads and finance charges. The cost estimates have an accuracy of ±30% and are based on the limitations outlined in Section 2 of this report.

Option	Option Title	Capital Cost (M)
1	Integrated project	$43.55
2	H1 Transformer Replacement	$35.56
3	Spare Phase	$5.65
4	220kV and 66kV secondary equipment replacement	$8.01

Table 1 - Capital Cost Estimates

[C-I-C]
DESIGN MANAGER

1. INTRODUCTION

AusNet Services engaged APD Engineering in prepare a project scopes and estimates relating to options for replacement of primary and secondary equipment at South Morang Terminal Station (SMTS) for inclusion in AusNet Services' 2022 – 2027 Transmission Revenue Reset.

AusNet Services has identified that the existing H1 and H2 transformers are in poor condition and may require capital expenditure for rectification. There are additional assets that are also in poor condition.

This document outlines the concept scope of works and capital estimates prepared by APD Engineering for the planning options as per reference [1] – South Morang Terminal Station (SMTS) H1 Transformer Replacement Project TD-0006169.

2. LIMITATIONS

In preparing this report, APD Engineering has relied on information provided by AusNet Services, including (but not limited to):

1. Site drawings and documentation outlining the existing equipment on site;

2. Condition assessments and functional scopes identifying poor condition primary and secondary assets for replacement prepared by AusNet Services, along with supporting information to allow the development of the scopes and estimates;

3. A top down estimating spreadsheet provided by AusNet Services to calculate the capital costs associated with each project;

4. Unit costs for major items of plant and equipment, labour costs and other costs assumptions provided by AusNet Services as part of the top down estimating spreadsheet.

3. ASSUMPTIONS

1. No allowance has been made for telecommunications replacement.

2. It is assumed that, where required, the existing 415 VAC and 250VDC equipment can be modified as part of the project. Replacement of the full 415V AC/ 250VDC or 48VDC distribution boards and batteries has not been considered.

3. It is assumed that SCIMS hardware can be modified as part of the project. Full replacement of the RTU/SCIMS alarm modification or panel replacement has not been considered.

4. Allowance has been made to replace all Condition 4 and Condition 5 relays, including relays older than 9 years under Condition 2 and 3.

4. OPTION 1 – INTEGRATED PROJECT

4.1.1. OUTLINE OF PROJECT

This option would require the replacement all poor condition primary and secondary equipment as a single project. This would include the H1 transformer with a new 330/220/22 transformer and all poor condition secondary equipment.

4.1.2. H1 TRANSFORMER WORKS

To replace the H1 transformer, it is proposed to construct a new transformer adjacent to the H3 transformer and the retirement of both the H1 and H2 transformers. In-situ replacement of the H1 transformer was considered, however due to the condition of the H2 transformer, the extended outage required for the replacement represents a significant risk of extended constraint on the transmission network.

This option will require the extension of both the 330kV and the 220kV yard to the north-west. The single line diagram for this option is shown in Figure 1.

This option also considers the purchase of a spare transformer phase suitable for installation for either the new transformer or the H3 transformer.

4.1.3. OTHER EQUIPMENT REPLACEMENT

AusNet Services has identified the need to replace the 330kV circuit breaker associated with the F2 transformer. AusNet Services has also identified the need to replace specific secondary assets for 220kV and 66kV plant.

A detailed scope of works has been prepared for this planning option to allow capital cost estimation.

4.1.4. PLANNING ESTIMATE

The cost to replace the H1 Transformer (including a spare transformer phase), the 330kV circuit breaker and the other works based on the scopes in Appendix AB, C and D has been estimated using the AusNet Services estimating spreadsheet at a total capital cost

of $43.55M (±30%). These costs exclude contingency but include an allowance for overheads and finance charges.

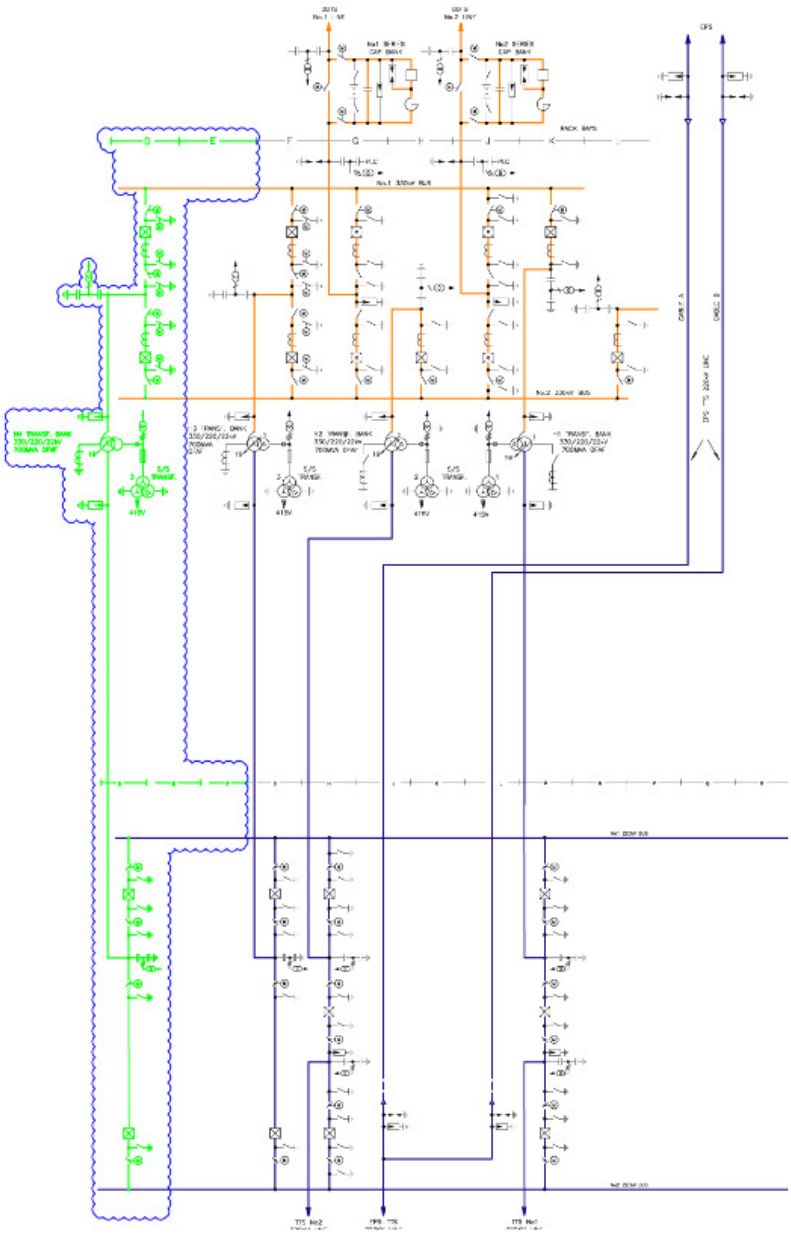

Figure 1 - SMTS H4 Transformer SLD

5. OPTION 2 – STAGED REPLACEMENT PROJECT

5.1.1. OUTLINE OF PROJECT

This option would require the separation of the replacement of the H1 transformer the and the poor condition secondary equipment into separate projects undertaken independently.

The independent projects options proposed by AusNet Services include:

- Replace H1 transformer and F2 330kV CB;
- Purchase a spare transformer phase; and
- Replace selected secondary equipment;

5.1.2. H1 TRANSFORMER WORKS

The scope of this project includes the replacement of the H1 transformer and the extension of the 330kV and 220kV yards to facilitate the connection.

5.1.3. SPARE TRANSFORMER PHASE

The scope of this project includes the purchase of a spare transformer phase suitable for any of the H1, H2 or H3 transformers. This spare transformer phase will be located in a bunded area on site with no primary or secondary connections.

5.1.4. OTHER EQUIPMENT REPLACEMENT

The scope of this project includes the replacement of all poor condition secondary assets excluding the transformer protection and controls.

5.1.5. PLANNING ESTIMATE

Based on the scopes in Appendices A, B, C and D each project option has been estimated using the AusNet Services estimating spreadsheet. Table 2 below outlines the capital cost (±30%) for each project option proposed by AusNet Services.

Option	Option Title	Capital Cost (M)
2	H1 Transformer Replacement	$35.56
3	Spare Transformer Phase	$5.65
4	220kV and 66kV secondary equipment replacement	$8.01

Table 2 - Capital Costs for each option

These costs exclude contingency but include an allowance for overheads and finance charges.

6. REFERENCES

The following document were applied in preparation of this report.

TYPE	OWNER	TITLE
Document	AusNet	South Morang Terminal Station (SMTS) H1 Transformer Replacement Project TD-0006169
Document	AusNet	Top-down Transmission Estimate for Option Selection Rev 2.7
Document	AusNet	Relays Condition Score Status as off 07.05.2019
Drawing	AusNet	South Morang Terminal Station 66kV, 220kV and 500kV Single Line Diagram – T14/31/157

APPENDIX A.

The new H1 Transformer 330/220kV installation works within SMTS includes the following new primary and secondary assets installation.

APPENDIX A.1.

The primary scope to replace the existing H1 Transformer and associated equipment.

330kV Bay	Activity	Description (Primary Equipment)
Existing H1 TRANSF	Remove	Decommissioning existing single phase H1 Transformer and associated equipment in SMTS 330kV Switchyard.
New H4 TRANSF	Install	New H4 Transformer Installation - Install Single Phase "R" - 330/220/22kV 233 MVA Power Transformer (H4) - Install Single Phase "W" - 330/220/22kV 233 MVA Power Transformer (H4) - Install Single Phase "B" - 330/220/22kV 233 MVA Power Transformer (H4) - Install three 330kV Surge Arresters - Install three 220kV Surge Arresters - Install new 22kV Neutral Isolators - Install two new 22kV Neutral CTs

APPENDIX A.2.

The primary scope to extend the 330kV and 220kV AIS Busbar and installation of 330kV and 220kV double switched AIS switchgear and associated equipment.

330kV Bay	Activity	Description (Primary Equipment)
Bay L F2 Transformer	Remove	Existing F2 Transformer / No 2 bus CB
	Install	New F2 Transformer / No 2 bus CB
Bay D (New Bay)	Install	New H4 TRANS No.1 Bus 330kV CB
		New H4 TRANS No.2 Bus 330kV CB
		New H4 TRANS No.1 Bus 330kV CB Bus Side CT and H1 TRANS No.1 Bus 330kV CB TRANS Side CT
		New H4 TRANS No.2 Bus 330kV CB Line Side CT and H1 TRANS No.2 Bus 330kV CB Bus Side CT
		New H4 500/330kV TRANS 330kV VT "R" Phase
		New H4 500/330kV TRANS 330kV VT "W" Phase
		New H4 500/330kV TRANS 330kV VT "B" Phase
		New H4 TRANS 330kV E/SW
		New H4 TRANS No.1 Bus 330kV CB Bus Side ROI - Including 1 x integrated earth switch
		New H4 TRANS No.1 Bus 330kV CB TRANS Side ROI - Including 1 x integrated earth switch
		New H4 TRANS No.2 Bus 330kV CB Line Side ROI - Including 1 x integrated earth switch
		New H4 TRANS No.2 Bus 330kV CB Bus Side ROI - Including 1 x integrated earth switch
		Extension of No.1 330kV Busbars (2 Bays)
		Extension of No.2 330kV Busbars (2 Bays)
		- Install three 330kV Surge Arresters

		- Install three 330kV Post Insulators
		- Install two CT Bay Marshalling Boxes
		- Install one VT Bay Marshalling Boxes
		- Install two Switchyard GPO and Lighting Marshalling Boxes
		- Install new two (2) off Interface Termination Cubicles Bay
Bay K	Remove	Existing - H1 TRANS 330kV VT "R" Phase Only
		Existing - H1 TRANS No.1 Bus 330kV CB Bus Side E/SW
		Existing - H1 TRANS 330kV E/SW
		Existing - H1 TRANS No.1 Bus 330kV CB Bus Side ROI
		Existing - H1 330/220kV TRANS 220kV Neutral Isolator

220kV Bay	Activity	Description (Primary Equipment)
New H4 TRANSF (New Bay)	Install	New H4 TRANS No.1 Bus 220kV CB
		New H4 TRANS No.2 Bus 220kV CB
		New H4 330/220kV TRANS 220kV VT "R, W, B" Phase - Including 3 x Single Phase Post Type 220kV CVT
		New H4 TRANS 220kV E/SW
		New H4 TRANS No.1 Bus 220 kV CB Bus Side ROI - Including 1 x integrated earth switch
		New H4 TRANS No.1 Bus 220kV CB TRANS Side ROI - Including 1 x integrated earth switch
		New H4 TRANS No.2 Bus 220 kV CB Line Side ROI - Including 1 x integrated earth switch
		New H4 TRANS No.2 Bus 220 kV CB Bus Side ROI - Including 1 x integrated earth switch
		Extension of No.1 220 kV Busbars (3 Bays)
		Extension of No.2 220 kV Busbars (3 Bays)
		- Install three 220 kV Surge Arresters
		- Install three 220 kV Post Insulators
		- Install two CT Bay Marshalling Boxes
		- Install one VT Bay Marshalling Boxes
		- Install two Switchyard GPO and Lighting Marshalling Boxes
		- Install new off Interface Termination Cubicles Bay

APPENDIX A.3.

The secondary scope to extend the 330kV and 220kV AIS Busbar and installation of 330kV and 220kV double switched AIS switchgear and associated equipment.

330kV Bay	Activity	Description (Secondary Equipment)
Existing H1 TRANS (Bay K)	Remove	H1 TR X Diff Protection Relay
		H1 TR X Current Check Relay
		H1 TR Y Fault Diff Protection Relay
		H1 TR Y LV Zone Diff Protection Relay
		H1 TR Y Overvoltage Alarm
		H1 TR 330kV OLTC TMR
		H1 TR 330kV OLTC Out of Step
		H1 Trans & H2 Trans 330kV Overload Alarm
New H4 TRANS (Bay D)	Install	Install new H4 Transformer X Protection & Control Scheme
		Install new H4 Transformer Y Protection & Control Scheme
		Install new H4 Transformer No.1 330kV Bus X & Y CB Management (CB Fail & Control) Scheme
		Install new H4 Transformer No.2 330kV Bus X & Y CB Management (CB Fail & Control) Scheme

220kV Bay	Activity	Description (Secondary Equipment)
New H4 TRANS (Bay D)	Remove	H1 TR X 220 Low Set Current Check Relay
		H1 TR 1B 220kV BU CB Fail & Control Relay (CBM)
		H1 TR/TTS 1 220kV BU CB Fail & Control (CBM)
		H1 TR/TTS 1 220kV CB Fail & Control (CBM)
		H1 TR Loading Critical Current Check

	Install	- Install new H4 Transformer No.1 220kV Bus X & Y CB Management (CB Fail & Control) Scheme
		- Install new H4 Transformer No.2 220kV Bus X & Y CB Management (CB Fail & Control) Scheme

APPENDIX A.4.

Scope to purchase a spare transformer phase.

330kV Bay	Activity	Description (Primary Equipment)
N/A		New Spare H Transformer Phase - Purchase spare one Single Phase - 330/220/22kV 233 MVA Power Transformer (H)

APPENDIX B.

APPENDIX B.1.

The primary scope to decommission the existing H2 Transformer and associated equipment

330kV Bay	Activity	Description (Primary Equipment)
Existing H2 TRANSF (Bay H)	Remove	Decommissioning of three existing single phase H2 Transformer and associated equipment in SMTS 330kV Switchyard.
		Existing – H2 TRANS 330kV VT "R" Phase Only
		Existing – H2 TRANS 330kV CB Bus Side E/SW
		Existing – H2 TRANS 330kV E/SW
		Existing – H2 TRANS CB Bus Side ROI
		Existing – H2 330/220kV TRANS 220kV Neutral Isolator
		Existing - H2 TRANS No.2 Bus 330kV CB

APPENDIX B.2.

The scope to decommission the existing H2 Transformer and associated equipment (Secondary).

330kV Bay	Activity	Description (Secondary Equipment)
Existing H2 TRANS (Bay H)	Remove	Decommissioning of existing H2 Transformer X and Y Protection & Control Scheme
		Decommissioning of existing H2 Transformer CB Management (CB Fail & Control) Scheme
		H2 TR X Diff Protection Relay
		H2 TR X Current Check Relay
		H2 TR Y Fault Diff Protection Relay
		H2 TR Y LV Zone Diff Protection Relay
		H2 TR Y Overvoltage Alarm
		H2 TR 330KV OLTC TMR
		H2 TR 330KV OLTC OUT OF STEP
		H2 Trans 330kV Overload Alarm

220kV Bay	Activity	Description (Secondary Equipment)
Existing H2 TRANS (Bay H)	Remove	Decommissioning of existing H2 Transformer CB Management (CB Fail & Control) Scheme
		H2 TR X 220 Low Set Current Check Relay
		H2 TR 1B 220K BU CB Fail & Control Relay (CBM)
		H2 TR/TTS 2 220kV BU CB Fail & Control (CBM)
		H2 TR/TTS 2 220kV CB Fail & Control (CBM)
		H2 TR Loading Critical Current Check

APPENDIX C.

220kV secondary scope of work also includes replacement of selected secondary equipment that were identified as poor condition. The 220kV secondary scope of works are as follows (Secondary):

220kV Bay	Activity	Description
B1 TRANSF	Remove	B1 TR X Differential Protection Relay
		B1 TR X 220 Low Set Current Check Relay
		B1 TR Y Protection & Control Relay
		B1 TR Y HV Zone Differential Protection Relay
		B1 TR 66 CBF X CB Fail & Control Relay
		B1 TR 66 CBF Y CB Fail & Control Relay
	Install	- Install new B1 Transformer X Protection & Control Scheme
		- Install new B1 Transformer Y Protection & Control Scheme
		- Install new B1 Transformer No.1 220kV Bus CB Management Scheme
		- Install new B1 Transformer No.1 66kV Bus CB Management Scheme
B3 TRANSF	Remove	B3 TR X Differential Protection Relay
		B3 TR X 220 Low Set Current Check Relay
		B3 TR Y Protection & Control Relay
		B3 TR Y HV Zone Differential Protection Relay
		B3 TR 66 CBF X CB Fail & Control Relay
		B3 TR 66 CBF Y CB Fail & Control Relay
		Voltage Control Equipment
		Voltage Control Equipment

	Install	- Install new B3 Transformer X Protection & Control Scheme
		- Install new B3 Transformer Y Protection & Control Scheme
		- Install new B3 Transformer No.1 220kV Bus CB Management Scheme
		- Install new B3 Transformer No.3 66kV Bus CB Management Scheme
Bay M	Remove	TTS 1 X Digital Current Differential
		TTS 1 2B CB Fail & Control Relay (CBM)
	Install	- Install new TTS No.1 330kV X Protection Relay
		- Install new TTS No.1 Line No.2 Bus CB X & Y CB Management (CB Fail & Control) Relay
Bay H	Remove	TTS 2 X Digital Current Differential
		TTS 2 2B CB Fail & Control Relay (CBM)
	Install	- Install new TTS No.2 330kV X Protection Relay - Install new TTS No.2 Line No.2 Bus CB X & Y CB Management (CB Fail & Control) Relay
Other Panels	Remove	#1 220kV Bus 4 Potential Selector #2 220kV Bus 4 Potential Selector No 1 Bus / H1 Transformer CB Controls / Monitors (CBM) H1 Transformer / TTS No 1 Line CB Controls / Monitors (CBM) TTS No 1 Line / No 2 Bus CB Controls / Monitors (CBM) No 1 Bus / H2 Transformer CB Controls / Monitors (CBM) H2 Transformer / TTS No 2 Line CB Controls / Monitors (CBM) TTS No 2 Line / No 2 Bus CB Controls / Monitors (CBM) High Speed Monitoring (Fault Recorder)

	Install	- Install new 220kV Bus Potential Selection Panel - Install new 220kV Bus Potential Selection Panel - Install 6 of CB X & Y CB Management (CB Fail & Control) Relay - Install new High Speed Monitoring Fault Recorder

APPENDIX D.

66kV secondary scope of work also includes replacement of selected secondary equipment that were identified as poor condition. The 66kV secondary scope of works are as follows (Secondary):

66kV Bay	Activity	Description (Secondary Equipment)
Bay G	Remove	SSS X Digital Current Diff Relay SSS Y Digital Current Diff Relay & Distance SSS X CB Fail & Control SSS-ST Anti-Islanding Scheme SSS-ST Anti-Islanding Scheme
	Install	- Install new SSS Feeder X & Y Protection Relay - Install new SSS Feeder X & Y Protection Relay to remote end.
Bay L	Remove	ST X Digital Current Diff Relay ST Y Digital Current Diff Relay & Distance
	Install	- Install new ST Feeder X & Y Protection Relay - Install new ST Feeder X & Y Protection Relay to remote end.

Bay H	Remove	EPG 1 X Digital Current Diff Relay EPG 1 Y Digital Current Diff Relay & Distance #2 66 X HV High Impedance Zone Protection #2 66 Y HV High Impedance Zone Protection 2-3 66 Bus-TIE X CB Fail & Control Relay 2-3 66 Bus-TIE Y CB Fail & Control Relay #3 66 X HV High Impedance Zone Protection #3 66 Y HV High Impedance Zone Protection
	Install	- Install new EPG 1 Feeder X & Y Protection Relay - Install new EPG 1 Feeder X & Y Protection Relay to remote end. - Install new No.2 66kV Bus X & Y Busbar Protection Scheme - Install new No.2-3 66kV Bus-Tie CB Management Scheme - Install new No.3 66kV Bus X & Y Busbar Protection Scheme
Bay J	Remove	EPG 2 X Digital Current Diff Relay EPG 2 Y Digital Current Diff Relay & Distance
	Install	- Install new EPG 2 Feeder X & Y Protection Relay - Install new EPG 2 Feeder X & Y Protection Relay to remote end.
Bay C	Remove	DRN 1 X Digital Current Diff Relay DRN 1 Y Digital Current Diff Relay & Distance
	Install	- Install new DRN 1 Feeder X & Y Protection Relay

		- Install new DRN 1 Feeder X & Y Protection Relay to remote end.
Bay F	Remove	DRN 2 X Digital Current Diff Relay DRN 2 Y Digital Current Diff Relay & Distance
	Install	- Install new DRN 2 Feeder X & Y Protection Relay - Install new DRN 2 Feeder X & Y Protection Relay to remote end.
Bay D	Remove	KMS X Digital Current Diff Relay KMS Y Digital Current Diff Relay & Distance 1-2 66 Bus-TIE X CB Fail & Control Relay 1-2 66 Bus-TIE Y CB Fail & Control Relay #1 66 X HV High Impedance Zone Protection #1 66 Y HV High Impedance Zone Protection
	Install	- Install new KMS Feeder X & Y Protection Relay - Install new KMS Feeder X & Y Protection Relay to remote end. - Install new No.1-2 66kV Bus-Tie CB Management Scheme - Install new No.1 66kV Bus X & Y Busbar Protection Scheme
Bay K	Remove	KLO/KMS X Digital Current Diff Relay
	Install	- Install new KLO/KMS Feeder X Protection Relay - Install new KLO/KMS Feeder X Protection Relay to remote end.

Common Panels	Remove	66kV Load Shedding Equipment 66kV Load Shedding Equipment SYTS Temporary Bypass Protection
	Install	- Install new 66kV Auto Load Shedding Control Scheme