APD ENGINEERING

KEILOR TERMINAL STATION

TRANSMISSION REVENUE RESET (TRR) PROJECT SCOPING

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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 primary and secondary equipment at Keilor Terminal Station (KTS) for inclusion in AusNet Services' 2022 – 2027 Transmission Revenue Reset.

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.

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.

The planning options considered, along with the associated costs, are included in Table 1 and Table 2. These costs exclude management contingency and have an accuracy of ±30%.

Option	**Option Title**	**Capital Cost (M)**	
		Two Transformers	Three Transformers
1	Integrated Project – 750MVA transformers and switchgear	N/A	$97.08
	Integrated Project – 1000MVA transformers and switchgear	$98.98	$123.92
2	All three A Transformers replaced with 750 MVA transformers	NA	$71.92
	All three A Transformers replaced with 1000 MVA transformers	$70.39	$98.76

Table 1 - Capital Cost Estimates

	1st Transformer	2nd Transformer	3rd Transformer
750 MVA Transformer	$32.65 M	$20.60 M	$20.60 M
1000 MVA Transformer	$40.91 M	$29.68 M	$29.68 M

Table 2 – Option 3 Costs - Staged Replacement of A transformers

The cost to replace the switchgear as a separate project has been estimated at $30.16M (±30%)

[C-I-C]
DESIGN MANAGER

1. INTRODUCTION

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

AusNet Services has identified that the existing A2, A3 and A4 500/2210kV transformers are in poor condition and may require capital expenditure for rectification. There are additional assets identified by AusNet Services in the 500kV, 220kV and 66kV yards 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] – Keilor Terminal Station (KTS) Transformer and CB Replacement Project TD-0003554.

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. 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.

2. 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.

3. 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. OUTLINE OF PROJECT

This planning option delivers a single integrated project undertaking all works required to replace poor condition assets at Keilor Terminal Station.

4.2. 500KV WORKS

AusNet Services identified the need to replace the A3 transformer 500kV circuit breaker along with several different instrumentation transformers, isolators and earth switches within the 500kV yard.

The 500kV A3 Transformer circuit breaker will be replaced as part of the transformer replacement.

Due to the nature of the other assets, APD Engineering recognises that the instrumentation transformers, isolators and earth switches can be replaced in-situ with short outages of adjacent primary equipment.

A detailed scope of works has been prepared for the 500kV primary and secondary replacement to allow capital cost estimation. This scope has been included in scope in Appendix A and B.

4.3. A2, A3 AND A4 TRANSFORMER WORKS

AusNet Services has identified the need to replace the A2, A3 and A4 transformers due to condition.

AusNet Services has asked APD Engineering to consider the works required to replace the transformers with either 750 MVA or 1000 MVA banks.

Given the age, risks and the system impact of the transformers, APD Engineering considers that the outage of a transformer for the duration required for an in-situ replacement would create supply risk and constraint on the network. APD Engineering has identified that there is enough space available at Keilor to allow the extension of the No. 2 500kV busbar and the installation of a 500/220kV transformer in a new location.

Once constructed, this transformer would be single switched to the No. 2 bus and would allow the demolition of the next transformer for replacement.

A new 220kV double switched bay would be established in Bay D for the connection of the new 500/220kV transformer.

Once established, the next transformer can be decommissioned and replaced in-situ.

This scope has been included in scope in Appendix A and B.

4.4. 220KV WORKS

AusNet Services has identified the need to replace one 220kV circuit breakers and several isolators and earth switches in the 220kV yard. Additionally, there is poor condition 220kV secondary systems that have been identified for replacement.

APD Engineering has identified that the replacement of the poor condition 220kV assets can be done with minimal outages in-situ.

A detailed scope of works has been prepared for the replacement of the poor condition 220kV primary and secondary assets and included in Appendix B.

4.5. 66KV WORKS

AusNet Services has identified the need to replace three circuit breakers in the 66kV yard, as well as assorted isolators and earth switches.

APD Engineering has identified that the replacement of the poor condition 66kV assets can be done with minimal outages and load at risk, primarily using the No. 1 bus extension as a temporary connection and in-situ replacement.

A detailed scope of works has been prepared for the replacement of the poor condition 66kV primary and secondary assets and included in Appendix C.

4.6. OTHER WORKS

AusNet Services has identified that additional works are required on site, specifically to remove redundant or poor condition 22kV auxiliary and secondary assets.

A detailed scope of works has been prepared for this planning option to allow capital cost estimation. This scope has been included in Appendix D.

4.7. PLANNING ESTIMATE

Based on the scopes included in Appendix A, B, C and D this option has been estimated using the AusNet Services estimating spreadsheet at a total capital cost as outlined in Table 3 below. These costs have an accuracy of ±30% and exclude management contingency.

	2 Transformer	**3 Transformers**
750 MVA Transformer	N/A	$97.08 M
1000 MVA Transformer	$98.98 M	$123.92 M

Table 3 - Integrated Project Costs

5. OPTION 2 – REPLACE THREE A TRANSFORMERS

5.1. OUTLINE OF PROJECT

This planning option only considers the works required to replace the three existing 500/220kV transformers only as a single project. This work excludes any 500kV, 220kV or 66kV equipment replacement not specifically related to the replacement of the transformers.

5.2. SWITCHYARD TRANSFORMER WORKS

The work required to replace the three transformers is identical to the works required in Option 1 to replace the transformers.

This would require the installation of a new 500/220kV transformer on site, the establishment of new 500kV and 220kV switchgear and the progressive in-situ replacement of the remaining transformers. This scope has been included in scope in Appendix A.

5.3. PLANNING ESTIMATE

Based on the scopes included in Appendix A and B this option has been estimated using the AusNet Services estimating spreadsheet at a total capital cost as outlined in Table 3 below. These costs have an accuracy of ±30% and exclude management contingency.

	2 Transformers	**3 Transformers**
750 MVA Transformer	N/A	$71.92 M
1000 MVA Transformer	$70.39 M	$98.76 M

Table 4 - Transformer Replacement Costs

6. OPTION 3 – STAGED REPLACEMENT OF 500/220KV TRANSFORMERS

6.1. OUTLINE OF PROJECT

This planning option only considers the works required to replace each of the three existing 500/220kV transformers only as individual projects.

6.2. SWITCHYARD TRANSFORMER WORKS

To replace the first transformer would require the installation of a new 500/220kV transformer on site, the establishment of new 500kV and 220kV switchgear. This would enable the demolition of one of the existing transformers.

The remaining transformers would then be replaced in-situ. The scope has been included in scope in Appendix A.

6.3. PLANNING ESTIMATE

Based on the scopes included in Appendix A, B, C and D this option has been estimated using the AusNet Services estimating spreadsheet at a total capital cost as outlined in Table 5 below. These costs have an accuracy of ±30% and exclude management contingency.

	1st Transformer	**2nd Transformer**	**3rd Transformer**
750 MVA Transformer	$32.65 M	$20.60 M	$20.60 M
1000 MVA Transformer	$40.91 M	$29.68 M	$29.68 M

Table 5 - Staged Replacement of A transformers

7. OPTION 4 – REPLACE POOR CONDITION SWITCHGEAR ONLY

7.1. OUTLINE OF PROJECT

This option would only address the poor condition primary and secondary equipment without replacing the 500/220kV transformers.

The scope of this project is identical to the 500kV, 220kV, 66kV and other works under option 1.

7.2. PLANNING ESTIMATE

Based on the scope in Appendix C, this option has been estimated using the AusNet Services estimating spreadsheet at a total capital cost of $30.16M (±30%). This cost excludes management contingency.

8. REFERENCES

The following document were applied in preparation of this report.

TYPE	OWNER	TITLE
Document	AusNet	Keilor Terminal Station (KTS)Transformer and CB Replacement Project TD-0003554
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	Keilor Terminal Station 66kV, 220kV and 500kV Single Line Diagram – T14/31/101

APPENDIX A.

500kV switchyard replacement primary works within KTS includes the following A.1 (Primary- switchgear), A.2 (Primary- transformer), A.3 (Secondary- switchgear) and A.4 (Secondary- transformer) assets replacement.

APPENDIX A.1. 500KV PRIMARY- SWITCHGEAR

500kV Bay	Activity	Description
Bay 1	Install	1 x 3 Phase 500kV 4000A Live tank CB 3 x 1 Phase 500kV 4000A CT 1 x 500kV Disconnector with two integrated earth switches 1 x 500kV Disconnector with one integrated earth switch 3 x 500kV 1 Phase CVT Busbar Extension for Bus1 500kV 2 x 500kV Rack Structure extension complete with footings

Bay 2	Remove	SMTS 500kV LINE NO.2 BUS CB LINE SIDE ROI SMTS 500kV LINE NO.2 BUS CB BUS SIDE ROI SMTS LINE/A2 TRANS 500kV CB LINE SIDE ROI SMTS LINE/A2 TRANS 500kV CB TRANS SIDE ROI A2 TRANS NO.1 BUS 500kV CB BUS SIDE ROI A2 TRANS NO.1 BUS 500kV CB TRANS SIDE ROI SMTS LINE/A2 TRANS 500kV CB TRANS SIDE E/SW SMTS LINE/A2 TRANS 500kV CB LINE SIDE E/SW SMTS 500kV LINE NO.2 BUS CB BUS SIDE E/SW SMTS 500kV LINE NO.2 BUS CB LINE SIDE E/SW SMTS 500kV LINE E/SW A2 TRANS NO.1 BUS 500kV CB BUS SIDE E/SW A2 TRANS NO.1 BUS 500kV CB TRANS SIDE E/SW A2 TRANS 500kV E/SW
	Install	6 x New 500kV ROI,4000A 50kA, 135kA, 1 Earth Switch 2 x New 500kV Earth Switch including Insulator, Quad Connection, Earthing
Bay 3	Remove	A3 TRANS 500kV CB A3 TRANS 500kV CB BUS SIDE ROI A3 TRANS NO.2 BUS 500kV CB BUS SIDE E/SW
Bay 4	Remove	A4 TRANS NO.1 BUS 500kV CB BUS SIDE ROI A4 TRANS NO.1 BUS 500kV CB TRANS SIDE ROI SYTS LINE/A4 TRANS 500kV CB TRANS SIDE ROI SYTS LINE/A4 TRANS 500kV CB LINE SIDE ROI SYTS 500kV LINE NO.2 BUS CB BUS SIDE ROI SYTS 500kV LINE NO.2 BUS CB LINE SIDE ROI

		A4 TRANS NO.1 BUS 500kV CB BUS SIDE E/SW A4 TRANS NO.1 BUS 500kV CB TRANS SIDE E/SW A4 TRANS 500kV E/SW SYTS LINE/A4 TRANS 500kV CB TRANS SIDE E/SW SYTS LINE/A4 TRANS 500kV CB LINE SIDE E/SW SYTS 500kV LINE NO.2 BUS CB BUS SIDE E/SW SYTS 500kV LINE E/SW SYTS 500kV LINE NO.2 BUS CB LINE SIDE E/SW
	Install	6 x New 500kV ROI,4000A 50kA, 135kA, 1 Earth Switch 2 x New 500kV Earth Switch including Insulator, Quad Connection, Earthing

APPENDIX A.2. 500KV PRIMARY- TRANSFORMER (1000 MVA)

500kV Bay	Activity	Description
Bay 1	Install	Install 3 x 333MVA single phase 500/220kV kV Power Transformers Install 3 off 500kV Surge Arresters Install 1 off 500kV Neutral Isolators Install 3 off 500kV VT Install 3 off 220kV VT Install 3 off 220kV Surge Arresters Install 1 off 220kV Neutral Isolators Install 2 off Neutral CT's Install Footing & Draining & Firewall &Noise Enclosure & Rack& Earthing & Secondary Cable
Bay 2	Remove	A2 500/220kV TRANS R, W, B/PH A2 500/220kV TRANS 500kV VT R, W, B/PH A2 500/220kV TRANS 500kV SA R, W, B/PH A2 500/220kV TRANS 22kV/415V UNIT TRANS R, W, B/PH A2 500/220kV TRANS 220kV VT R, W, B/PH A2 500/220kV TRANS 220kV SA R, W, B/PH A2 500/220kV TRANS NEUTRAL ISOLATOR
	Install	Install 1*333MVA off 500/220kV kV Power Transformer as a spare phase
Bay 3	Remove	A3 500/220kV TRANS R, W, B/PH A3 500/220kV TRANS 500kV VT R, W, B/PH A3 500/220kV TRANS 500kV SA R, W, B/PH A3 500/220kV TRANS 22kV/415V UNIT TRANS R, W, B/PH A3 500/220kV TRANS 220kV VT R, W, B/PH

		A3 500/220kV TRANS 220kV SA R, W, B/PH A3 500/220kV TRANS NEUTRAL ISOLATOR
Bay4	Remove	A4 500/220kV TRANS R, W, B/PH A4 500/220kV TRANS 500kV VT R, W, B/PH A4 500/220kV TRANS 500kV SA R, W, B/PH A4 500/220kV TRANS 22kV/415V UNIT TRANS R, W, B/PH A4 500/220kV TRANS 220kV VT R, W, B/PH A4 500/220kV TRANS 220kV SA R, W, B/PH A4 500/220kV TRANS NEUTRAL ISOLATOR
	Install	Install 3 x 333MVA single phase 500/220kV kV Power Transformers Install 3 off 500kV Surge Arresters Install 1 off 500kV Neutral Isolators Install 3 off 500kV VT Install 3 off 220kV VT Install 3 off 220kV Surge Arresters Install 1 off 220kV Neutral Isolators Install 2 off Neutral CT's Install Footing & Draining & Firewall &Noise Enclosure & Rack& Earthing & Secondary Cable

APPENDIX A.3. 500KV PRIMARY- TRANSFORMER (750 MVA)

500kV Bay	Activity	Description
Bay 1	Install	Install 3 x 250 MVA single phase 500/220kV kV Power Transformers Install 3 off 500kV Surge Arresters Install 1 off 500kV Neutral Isolators Install 3 off 500kV VT Install 3 off 220kV VT Install 3 off 220kV Surge Arresters Install 1 off 220kV Neutral Isolators Install 2 off Neutral CT's Install Footing & Draining & Firewall &Noise Enclosure & Rack& Earthing & Secondary Cable
Bay 2	Remove	A2 500/220kV TRANS R, W, B/PH A2 500/220kV TRANS 500kV VT R, W, B/PH A2 500/220kV TRANS 500kV SA R, W, B/PH A2 500/220kV TRANS 22kV/415V UNIT TRANS R, W, B/PH A2 500/220kV TRANS 220kV VT R, W, B/PH A2 500/220kV TRANS 220kV SA R, W, B/PH A2 500/220kV TRANS NEUTRAL ISOLATOR
	Install	Install 3x250MVA single phase 500/220kV kV Power Transformer Install 3 off 500kV Surge Arresters Install 1 off 500kV Neutral Isolators Install 3 off 500kV VT Install 3 off 220kV VT Install 3 off 220kV Surge Arresters

		Install 1 off 220kV Neutral Isolators Install 2 off Neutral CT's Install Footing & Draining & Firewall &Noise Enclosure & Rack& Earthing & Secondary Cable
Bay 3	Remove	A3 500/220kV TRANS R, W, B/PH A3 500/220kV TRANS 500kV VT R, W, B/PH A3 500/220kV TRANS 500kV SA R, W, B/PH A3 500/220kV TRANS 22kV/415V UNIT TRANS R, W, B/PH A3 500/220kV TRANS 220kV VT R, W, B/PH A3 500/220kV TRANS 220kV SA R, W, B/PH A3 500/220kV TRANS NEUTRAL ISOLATOR
	Install	Install 1*250MVA single phase 500/220kV kV Power Transformer as a spare phase
Bay4	Remove	A4 500/220kV TRANS R, W, B/PH A4 500/220kV TRANS 500kV VT R, W, B/PH A4 500/220kV TRANS 500kV SA R, W, B/PH A4 500/220kV TRANS 22kV/415V UNIT TRANS R, W, B/PH A4 500/220kV TRANS 220kV VT R, W, B/PH A4 500/220kV TRANS 220kV SA R, W, B/PH A4 500/220kV TRANS NEUTRAL ISOLATOR
	Install	Install 3x250MVA single phase 500/220kV kV Power Transformer Install 3 off 500kV Surge Arresters Install 1 off 500kV Neutral Isolators Install 3 off 500kV VT Install 3 off 220kV VT Install 3 off 220kV Surge Arresters Install 1 off 220kV Neutral Isolators Install 2 off Neutral CT's

		Install Footing & Draining & Firewall &Noise Enclosure & Rack& Earthing & Secondary Cable

APPENDIX A.4. 500KV SECONDARY- SWITCHGEAR

500kV Bay	Activity	Description
Bay 4	Remove (SYTS LINE)	X DIGITAL CURRENT DIFFERENTIAL(7SD522-3808) BU REMOTE TRIP INTERLOCK RELAY(RAKZB-2817) Y DIGITAL CURRENT DIFF/DIST RELAY(P546-3747) BU SLOW CB FAIL TIMER RELAY(VAT-647B) BU FAST CB FAIL TIMER RELAY(VAT-647B) 3* OVERVOLTAGE PROTECTION RELAY(VEB-2876) 2* OVERVOLTAGE PROTECTION RELAY(SLV-9999) 1* OVERVOLTAGE PROTECTION RELAY(CV7-960) 3* BU THREE ELEMENT INSTANT(CAG39-1020) 2* Y DC TIMER RELAY 2T649 SYTS 2B 500KV X CB FAIL & CONTL(P145-4052) 500KV STN SYNC CHK TMR
	Install	Install new one-off SYTS 500kV X DIFF/DIS/SYNC Protection Scheme Install new one-off SYTS 500kV Y DIFF/DIS/SYNC Protection Scheme Install new one-off SYTS 500kV X Protection Scheme to remote end. Install new one-off SYTS 500kV Y Protection Scheme to remote end. Install new one-off SYTS Line CB X CB Management (CB Fail & Control) Scheme Install new one-off SYTS Line CB Y CB Management (CB Fail & Control) Scheme
Bay 2	Remove (SMTS LINE)	X DIGITAL CURRENT DIFFERENTIAL(7SD522-3808) Y DIGITAL CURRENT DIFF/DIST RELAY(P544-3683) 3* OVERVOLTAGE PROTECTION RELAY(VEB-2876)

		2* OVERVOLTAGE PROTECTION RELAY(SLV-9999) 1* OVERVOLTAGE PROTECTION RELAY(CV7-960) 2* Y DC TIMER RELAY 2T649 ROTS3 (SMTS BYPASS) X DISTANCE RELAY(7SA522) ROTS3 (SMTS BYPASS) Y DIGITAL CURRENT(LFCB) BU SLOW CB FAIL TIMER RELAY(VAT-647B) BU FAST CB FAIL TIMER RELAY(VAT-647B) 3* BU THREE ELEMENT INSTANT(CAG39-1020) SMTS 2B 500KV X CB FAIL & CONTL(P145-4052) 500KV STN SYNC CHK TMR
	Install	Install new one-off SMTS 500kV X DIFF/DIS/SYNC Protection Scheme Install new one-off SMTS 500kV Y DIFF/DIS/SYNC Protection Scheme Install new one-off SMTS 500kV X Protection Scheme to remote end. Install new one-off SMTS 500kV Y Protection Scheme to remote end. Install new one-off SMTS Line CB X CB Management (CB Fail & Control) Scheme Install new one-off SMTS Line CB Y CB Management (CB Fail & Control) Scheme
500kV BUS 1	Remove	1 500KV SYNC POT BUS POT SELECTOR(POTSEL-2411) 1 500 X INSTANTANEOUS CURRENT RELAY(CAG34-1363) 1 500 Y INSTANTANEOUS CURRENT RELAY(CAG34-1363) 1 500kV POT BUS POT SEL 1A
	Modify	Modification of Existing No.1 500V Bus X & Y Busbar Protection Panel 500kV Bus Potential Selection Panel
500kV BUS 2	Remove	2 500KV SYNC POT BUS POT SELECTOR(POTSEL-2411) 2 500 X INSTANTANEOUS CURRENT RELAY(CAG34-1363)

		2 500 Y INSTANTANEOUS CURRENT RELAY(CAG34-1363) 2 500kV POT BUS POT SEL 2B(2P48K3) 2 500kV POT BUS POT SEL 2A (2P48K3)
	Modify	Modification of Existing No.2 500V Bus X & Y Busbar Protection Panel 500kV Bus Potential Selection Panel

APPENDIX A.5. 500KV SECONDARY- TRANSFORMER

500kV Bay	Activity	Description
Bay 1	Install	Install new one off KTS 500kV A2 Transformer X Protection with Differential/ Instantaneous Current/High IMP/ DC Timer Scheme Install new one off KTS 500kV A2 Transformer Y Protection with Differential/ Instantaneous Current/High IMP/ DC Timer Scheme Install new one-off A4 TR No.1 Bus CB X & Y CB Management (CB Fail & Control) Scheme Install new one-off A4 TR No.2 Bus CB X & Y CB Management (CB Fail & Control) Scheme Install new one off 500/220kV Transformer Voltage Control Scheme
Bay2	Remove	Decommissioning of existing A2 Transformer X Protection & Control Scheme Decommissioning of existing A2 Transformer Y Protection & Control Scheme Decommissioning of existing A2 Transformer X, Y CB Management (CB Fail & Control) Scheme A2 TR Y BIASSED DIFF HV ZONE(B30-4056) A2 TR/SMTS 500KV Y CB FAIL & CONTL(C60-4049) A2 TR 1B 500KV Y CB FAIL & CONTL(C60-4049) A2 TR Y DC TIMING RELAY VAT-725 A2 TR Y INSTANTANEOUS CURRENT RELAY(CAG34-1363) 3* A2 TR Y TRANSFORMER DIFFERENTIAL RELAY(DUOBIAS-959) A2 TR/SMTS 500KV X CB FAIL & CONTL(P145-4052) A2 TR 1B 500KV X CB FAIL & CONTL(P145-4052)
Bay 3	Remove	A3 TR Y DC TIMING RELAY (VAT-725)

		A3 TR Y HIGH IMP ZONE PROT RELAY(CAG34) 2* A3 TR Y INSTANTANEOUS CURRENT RLY (CAG34) 3* A3 TR Y TR DIFF RELAY(DUOBIAS-959) A3 TR X 220 HIGH IMP ZONE PROT RELAY(CAG34-1363) 2* A3 TR X INSTANTANEOUS CURRENT RELAY(CAG34-1363) Relay, GP3-1608 BUCHHOLZ A3 TR 2B 500KV X CB FAIL & CONTL(P145-4052)
	Install A4 TR	Install new one off KTS 500kV A4 Transformer X Protection with Differential/ Instantaneous Current/High IMP/ DC Timer Scheme Install new one off KTS 500kV A4 Transformer Y Protection with Differential/ Instantaneous Current/High IMP/ DC Timer Scheme Install new one-off A3 TR No.1 Bus CB X & Y CB Management (CB Fail & Control) Scheme Install new one-off A3 TR No.2 Bus CB X & Y CB Management (CB Fail & Control) Scheme Install new one off 500/220kV Transformer Voltage Control Scheme
Bay4	Remove	A4 TR Y DC TIMER RELAY (VAT-725) A4 TR Y 220 HIGH IMPEDANCE ZONE PROT(CAG34) A4 TR X INSTANTANEOUS CURRENT RELAY(CAG34) 3* A4 TR Y TRANSFORMER DIFFERENTIAL RELAY(DUOBIAS-959) A4 TR X 220 HIGH IMPEDANCE ZONE PROT(CAG34) 2* A4 TR X INSTANTANEOUS CURRENT RELAY(CAG34-1363) Relay, GP3-1608 BUCHHOLZ A4 TR/SYTS 500KV X CB FAIL & CONTL(P145-4052) A4 TR 1B 500KV X CB FAIL & CONTL(P145-4052)

APPENDIX B.

220kV replacement primary and secondary works within KTS includes the following B.1(220kV Primary), B.2 (220kV Secondary- switchgear), B.3(220kV Secondary-transformer) and B.4 (220kV overhead line) assets replacement.

APPENDIX B.1. 220KV PRIMARY

220kV Bay	Activity	Description
Bay D	Install	2 x 220kV Dead Tank CB 4000A 40kA 4 x 220kV ROI 4000A (HL 2ES) 1 x 220kV CVTs (Single Phase) 1 x 220kV Rack Structure (Complete)
Bay F	Remove	Existing 1 220kV CAP Bank CB Existing 1 220kV CAP Bank CB BUS SIDE ROI Existing 1 220kV CAP Bank CB BUS SIDE E/SW
	Install	1 x New 220kV 3150A Outdoor Live Tank CB 1 x New 220kV 3150A ROI with 1 integrated earth switch
Bay N	Remove	Existing B4 Trans No.1 Bus 220kV CB Bus Side ROI Existing B4 Trans No.1 Bus 220kV CB Bus Side E/SW
	Install	1 x New 220kV 3150A ROI with 1 integrated earth switch

APPENDIX B.2. 220KV SECONDARY- SWITCHGEAR

220kV Bay	Activity	Description
BLTS LINE	REMOVE	BLTS1 REAC CB CONTROL/MONITOR RELAY T2E BLTS2 REAC CB CONTROL/MONITOR RELAY T2E BLTS 220KV L X PROT Relay, P546-4051 BLTS 1B 220 CB BU O/C & CB FAIL PROT & BLTS 220KV L CB FAIL PROT BLTS 2B 220 CB BU O/C & CB FAIL PROT & BLTS 220KV L CB FAIL PROT
	INSTALL	BLTS 1B CB FAIL MANAGEMENT PROT. BLTS 2B CB FAIL MANAGEMENT PROT
ATS LINE	REMOVE	220KV L X PROT Relay, P546-4051 ATS/A2 TR 220 CB BU O/C & CB FAIL PROT- P143 ATS 1B CB BU O/C & CB FAIL PROT & CONT
	INSTALL	ATS X LINE DIFF Protection and Control Panel No. XX ATS A CB FAIL MANAGEMENT PROT ATS B CB FAIL MANAGEMENT PROT
DPTS LINE	REMOVE	DPTS 220KV L X PROT Relay, P546-4051
	INSTALL	DPTS X LINE DIFF Protection and Control Panel No. XX
GTS1 LINE	REMOVE	GTS1 X DIGITAL CURRENT DIFFERENTIAL 7SD522 GTS1 Y DIGITAL CURRENT DIFF/DIST RELAY P546 GTS1 3B 220 CB BU O/C & CB FAIL PROT- P143 GTS1 1B 220 CB BU O/C & CB FAIL PROT- P143
	INSTALL	X LINE DIGITAL CURRENT DIFFERENTIAL

		Y LINE DIIF/DIS RELAY 3B CB MANAGEMET RELAY 1B CB MANAGEMENT RELAY
GTS3 LINE	REMOVE	GTS3 X DIGITAL CURRENT DIFFERENTIAL 7SD522 GTS3 Y DIGITAL CURRENT DIFF/DIST P546 GTS3/B4 TR 220 CB BU O/C & CB FAIL PROT P143 GTS3 3B 220 CB BU O/C & CB FAIL PROT P143
	INSTALL	X LINE DIGITAL CURRENT DIFFERENTIAL Y LINE DIIF/DIS RELAY B4 CB MANAGEMET RELAY 3B CB MANAGEMENT RELAY
WMTS 1 LINE	REMOVE	WMTS1 Y DIGITAL CURRENT DIFFERENTIAL 7SD511 WMTS1 X DIGITAL CURRENT DIFFERENTIAL LFCB WMTS1 1B 220 CB BU O/C & CB FAIL PROT P143 TTS1/WMTS1 220 CB BU O/C & CB FAIL PROT P143
	INSTALL	X LINE DIGITAL CURRENT DIFFERENTIAL Y LINE DIIF/DIS RELAY 1B CB MANAGEMET RELAY TTS1 CB MANAGEMENT RELAY
WMTS 2 LINE	REMOVE	WMTS2 Y DIGITAL CURRENT DIFFERENTIAL 7SD511 WMTS2 X DIGITAL CURRENT DIFFERENTIAL LFCB WMTS2 1B 220 CB BU O/C & CB FAIL PROT P143 TTS2/WMTS2 220 CB BU O/C & CB FAIL PROT P143
	INSTALL	X LINE DIGITAL CURRENT DIFFERENTIAL Y LINE DIIF/DIS RELAY 1B CB MANAGEMET RELAY TTS2 CB MANAGEMENT RELAY
TTS 1	REMOVE	TTS 1 220KV L X PROT Relay, P546-4051

LINE		TTS1 2B 220 CB BU O/C & CB FAIL PROT P143
	INSTALL	X LINE DIGITAL CURRENT DIFFERENTIAL TTS1 2B CB MANAGEMENT RELAY
TTS 2 LINE	REMOVE	TTS 2 220KV L X PROT Relay, P546-4051 TTS2 2B 220 CB BU O/C & CB FAIL PROT P143
	INSTALL	X LINE DIGITAL CURRENT DIFFERENTIAL TTS2 2B CB MANAGEMENT RELAY
220KV CAPBK	REMOVE	Y OVERLOAD RELAY SPAJ160C Y OVERCURRENT & EARTH FAULT SPAJ140 X OVERCURRENT & EARTH FAULT SPAJ140 3* X OVERLOAD & CURRENT SPAJ160C AUTO CONTROL RELAY M40 CB BU O/C & CB FAIL BACKUP PROT- P143
	INSTALL	X O/C E/F CAPBK ROTECTION Y O/C E/F CAPBK ROTECTION X & Y CB MANAGEMENT CAPBK CB
220kV BUS 1	REMOVE	Y INSTANTANEOUS CURRENT RELAY CAG34 X INSTANTANEOUS CURRENT RELAY CAG34 3* BUS BU DC TIMING RELAY VAT-647 1 220KV SYNC POT BUS POT SELECTOR POTSEL
	INSTALL	X HIGH IMPEDANCE BUS PROT. Y HIGH IMPEDANCE BUS PROT. 1 220KV SYNC POT BUS POT SELECTOR
220kV BUS 2	REMOVE	Y INSTANTANEOUS CURRENT RELAY CAG34 X INSTANTANEOUS CURRENT RELAY CAG34 3* BUS BU DC TIMING RELAY VAT-647 2 220KV SYNC POT BUS POT SELECTOR POTSEL
	INSTALL	X HIGH IMPEDANCE BUS PROT. Y HIGH IMPEDANCE BUS PROT.

		2 220KV SYNC POT BUS POT SELECTOR
220kV BUS 3	REMOVE	Y INSTANTANEOUS CURRENT RELAY CAG34 X INSTANTANEOUS CURRENT RELAY CAG34 3* BUS BU DC TIMING RELAY VAT-647
	INSTALL	X HIGH IMPEDANCE BUS PROT. Y HIGH IMPEDANCE BUS PROT.

APPENDIX B.3. 220KV SECONDARY TRANSFORMER

220kV Bay	Activity	Description
B4 TR	REMOVE	Y BIAS DIFF & GAS RELAY SEL3875 X TRIP RELAY MVAJ X HV HIGH IMPEDANCE ZONE PROT X ALARM AUXILIARY RELAY ARTV X TRIP RELAY GROUP-1327 X BIAS DIFF & O/C RELAY SPAD346C2
	INSTALL	Install new one off KTS 220kV B4 Transformer X Protection with Differential/ Instantaneous Current/High IMP/ DC Timer Scheme Install new one off KTS 220kV B4 Transformer Y Protection with Differential/ Instantaneous Current/High IMP/ DC Timer Scheme
B3 TR	REMOVE	X DIFF PROT RELAY DBM B3 220/66KV TR OIL COOL CONTL B3 220/66KV TR OIL WTI BIAS DIFF, O/C & GAS RELAY 220/63KV TR Y PROT 3B 220 CB CURRENT CHECK RELAY
	INSTALL	Install new one off KTS 220kV B3 Transformer X Protection with Differential/ Instantaneous Current/High IMP/ DC Timer Scheme Install new one off KTS 220kV B3 Transformer Y Protection with Differential/ Instantaneous Current/High IMP/ DC Timer Scheme
B2 TR	REMOVE	X DIFF PROT RELAY DBM 1B 220 X CB FAIL & CONTROL RELAY P145
	INSTALL	Install new one off KTS 220kV B2 Transformer X Protection with Differential/ Instantaneous Current/High IMP/ DC Timer Scheme
B1 TR	REMOVE	X DIFF PROT RELAY DBM
	INSTALL	Install new one off KTS 220kV B1 Transformer X Protection with Differential/ Instantaneous Current/High IMP/ DC Timer Scheme

APPENDIX B.4. 220KV OVERHEAD LINE

220kV Bay	Activity	Description
Bay B	Remove	2 Tower 220kV TTS No.2 Line
	Install and Relocate	2 Tower 220kV TTS No.2 Line
Bay A	Remove	2 Tower 220kV TTS No.1 Line
	Install and Relocate	2 Tower 220kV TTS No.1 Line

APPENDIX C.

66kV switchyard replacement primary works within KRTS includes the following C.1(primary) and C.2 (Secondary) assets replacement.

APPENDIX C.1. 66KV PRIMARY

66kV Bay	Activity	Description
Bay A	INSTALL	1 x 66kV DTCB 3150A, 31.5kA 2 x 66kV Disconnector 2000A 3Phase 3 x 66kV MVT 1 Phase 1 x 66kV Surge Diverters 3 Phase
Bay E SUB ES	REMOVE	Existing 66kV Line Bay SUB ES (Jemena) No.1 SUB ES FDR 66kV CB No.2 66kV Disconnector 2000A 3Phase No.1 66kV Surge Diverters 3 Phase No.1 Single Venus Droppers No.1 66kV Flexible HV Connections -Single Venus 3 Phase
	INSTALL	1 x 66kV DTCB 3150A, 31.5kA 2 x 66kV Disconnector 2000A 3Phase 3 x 66kV MVT 1 Phase 1 x 66kV Surge Diverters 3 Phase 2 x 66kV Bus Section (8m incl Supports, Bipods, etc) No.1 Exit structure 66kV feeder No.1 Single Venus Droppers No.1 66kV Single Triton Exit Line per span
Bay G	REMOVE	Existing 66kV Line Bay SUB O.O.S (PC)

SUB O.O. S		No.1 SUB ES FDR 66kV CB No.2 66kV Disconnector 2000A 3Phase No.1 66kV Surge Diverters 3 Phase No.1 Single Venus Droppers No.1 66kV Flexible HV Connections -Single Venus 3 Phase
	INSTALL	1 x 66kV DTCB 3150A, 31.5kA 2 x 66kV Disconnector 2000A 3Phase 3 x 66kV MVT 1 Phase 1 x 66kV Surge Diverters 3 Phase 2 x 66kV Bus Section (8m incl Supports, Bipods, etc)
BAY B	REMOVE	1B 66kV CAP Bank CB
	INSTALL	1 x 66kV LTCB 2000A, 31.5kA (POW)
MLN FDR	REMOVE	66KV FDR CB FDR SIDE ISOL 66KV FDR CB NO.4 BUS SIDE ISOL
	INSTALL	66KV FDR CB FDR SIDE ISOL 66KV FDR CB NO.4 BUS SIDE ISOL
SA NO.2 FDR	REMOVE	66KV FDR CB FDR SIDE ISOL
	INSTALL	66KV FDR CB FDR SIDE ISOL
BUS.3	REMOVE	NO.3 66KV BUS VT ISOL
	INSTALL	NO.3 66KV BUS VT ISOL

APPENDIX C.2. 66KV SECONDARY

63kV Bay	Activity	Description
CAP BK	REMOVE	CAPBK AUTO CONTROL RELAY T2E 1A 1B 66KV CAP BANK X CURR UNBAL SPAJ140C 1A 1B 66KV CAP BANK X CURR UNBAL 1A B PH 1A 1B 66KV CAP BANK Y CURR UNBAL 1B B PH CAPBK X CURRENT BALANCE RELAY 3* 66 CAPBK Y CURRENT BALANCE RELAY SPAJ160C 2* CAPBK X CURRENT BALANCE RELAY SPAJ140C 3* CAPBK Y OVERCURRENT RELAY CDG14 3* CAPBK X OVERLOAD RELAY CDG14 Relay, Cooling Control
	INSTALL	Install new X and Y Capacitor Bank Protection & Control Scheme
FDR SA 1	REMOVE	Y DIGITAL CURRENT DIFF RELAY 7SD522 BU THREE ELEMENT INSTANT OVERCURRENT CAG39
	INSTALL	Install new 66kV Feeder Y DIFF Protection & Control Scheme
FDR SA 2	REMOVE	Y DIGITAL CURRENT DIFF RELAY 7SD522
	INSTALL	Install new 66kV Feeder Y DIFF Protection & Control Scheme
FDR SHM	REMOVE	Y DISTANCE RELAY 7SA522 X DISTANCE & BACKUP RELAY SEL311C CB CONTROL/MONITOR RELAY T2E
	INSTALL	Install new 66kV Feeder X, Y DIFF Protection & Control Scheme
FDR	REMOVE	66KV FDR Y PROT Relay,7SA522-3601

SBY 1		66KV FDR X PROT Relay, SEL311C-3645 66KV FDR CB MONTRG & CONTL Relay, T2E-3770
	INSTALL	Install new 66kV Feeder X, Y DIFF Protection & Control Scheme
FDR SBY 2	REMOVE	66KV FDR Y PROT Relay,7SA522-3601 66KV FDR X PROT Relay, SEL311C-3645
	INSTALL	Install new 66kV Feeder X, Y DIFF Protection & Control Scheme
FDR SSE 2	REMOVE	66KV FDR X PROT Relay, SEL311L-3698 66KV FDR X PROT Relay, T2E-3770 66KV FDR Y PROT Relay,7SD610-3735
	INSTALL	Install new 66kV Feeder X, Y DIFF Protection & Control Scheme
FDR AW	REMOVE	BU NEGATIVE SEQUENCE RELAY RXIG2 BU SENSITIVE CURRENT CHECK RELAY RXIB BU THREE ELEMENT INSTANT OVERCURRENT
	INSTALL	Install new 66kV Feeder Y Distance Protection & Control Scheme
FDR TMA	REMOVE	Y DIGITAL CURRENT DIFF RELAY
	INSTALL	Install new 66kV Feeder Y DIFF Protection & Control Scheme
BUS 1 66kV	REMOVE	Y HIGH IMPEDANCE PROT RELAY MCAG34 X HIGH IMPEDANCE PROT RELAY MCAG34 B1 TR 66 CB FAIL TIMER RELAY RXKL1 1-2 BUS TIE CURRENT CHECK RELAY SEL551 1-4 BUS TIE CURRENT CHECK RELAY SEL551 1-2 66 X UNDERVOLTAGE RELAY P922 BU BUS FAULT, CB FAIL & DEAD ZONE
	INSTALL	Install new 66kV Bus X & Y Protection & Control Scheme

BUS 2 66kV	REMOVE	Y HIGH IMPEDANCE PROT RELAY MCAG34 X HIGH IMPEDANCE PROT RELAY MCAG34 BU BUS FAULT, CB FAIL & DEAD ZONE B2 TR 66 CB FAIL TIMER RELAY RXKL1 2-5 66 B/T X CB FAIL & CONTROL RELAY
	INSTALL	Install new 66kV Bus X & Y Protection & Control Scheme
BUS 5 66kV	REMOVE	Y HIGH IMPEDANCE PROT RELAY MCAG34 X HIGH IMPEDANCE PROT RELAY MCAG34
	INSTALL	Install new 66kV Bus X & Y Protection & Control Scheme
BUS 3 66kV	REMOVE	Y HIGH IMPEDANCE PROT RELAY MCAG34 3-4 66 X UNDERVOLTAGE RELAY P922 X HIGH IMPEDANCE PROT RELAY MCAG34 BU BUS FAULT, CB FAIL & DEAD ZONE B3 TR 66 CB FAIL TIMER RELAY RXKL1
	INSTALL	Install new 66kV Bus X & Y Protection & Control Scheme
BUS 4 66kV	REMOVE	Y HIGH IMPEDANCE PROT RELAY MCAG34 X HIGH IMPEDANCE PROT RELAY MCAG34 BU BUS FAULT, CB FAIL & DEAD ZONE B4 TR 66 CB FAIL TIMER RELAY RXKL1 X DC TIMING RELAY VAT-647
	INSTALL	Install new 66kV Bus X & Y Protection & Control Scheme

APPENDIX D.

Station Services replacement primary and secondary works within KTS includes the following primary and secondary assets replacement.

	Activity	Description
Station Services Transformer	REMOVE	Decommissioning of existing No.1 22kV/415V Station Services Transformer 22kV Disconnector Switch
		Decommissioning of existing No.1 22kV/415V Station Services Transformer 22kV Fused Isolator
		Decommissioning of existing No.2 22kV/415V Station Services Transformer 22kV Fused Isolator
	INSTALL	Install 3 Phase off 22kV/415V Unit Transformer
		Install 3 Phase off 22kV/415V Unit Transformer