Jemena Electricity Networks (Vic) Ltd

2016-20 Electricity Distribution Price Review Regulatory Proposal

Revocation and substitution submission

Attachment 7-11 WSP Parsons Brinckerhoff - Independent review of Sunbury development strategy

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JEMENA ELECTRICITY NETWORKS

SUNBURY PROJECT

INDEPENDENT ASSESSMENT

DECEMBER 2015

WSP | PARSONS BRINCKERHOFF

SUNBURY PROJECT

INDEPENDENT ASSESSMENT

Jemena Electricity Networks

Final Report

Project no: 2265052A
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EXECUTIVE SUMMARY

WSP | Parsons Brinckerhoff has been engaged by Jemena Electricity Networks (JEN) to provide an independent assessment of JEN's proposal to upgrade the Sunbury Zone Substation.

In 'Jemena Electricity Networks (Vic) Ltd Regulatory Proposal 1 January 2016 - 31 December 2020' (JEN's Regulatory Proposal) JEN proposed to rebuild Sunbury Zone substation to relieve capacity constraints.

The Australian Energy Regulator (AER) reviewed JEN's proposal and did not include the proposed capex for this project in its alternative estimate of JEN's Augex requirements because it is not satisfied that this capex is necessary to maintain network reliability, security or safety in accordance with the capex objectives of the National Electricity Rules (NER). The AER allowed $1.3m for the upgrade of the 10 MVA transformer.

WSP | Parsons Brinckerhoff undertook an independent review of JEN's proposal to upgrade the Sunbury Zone Substation assets. WSP | Parsons Brinckerhoff concludes that JEN did not include the impact of asset condition and the switching arrangements on the assessment of customer reliability. These drivers should be incorporated into the assessment identifying the preferred option.

The options presented by JEN were correctly structured to address capacity constraints from 2018 based on JEN"s ten year demand forecast. However, the suite of options did not consider any staged works that address the capacity constraint now and that have the flexibility to mitigate the impact of asset condition reliability as the demand on the substation increases over time.

WSP | Parsons Brinckerhoff developed augmentation options that also consider the whole of life cycle costs of future replacements and the impact of failures and switching arrangements on reliability with the forecast increasing demand:

- Option 2D - Upgrade Transformer No. 2 with protection in situ, 66 and 22kV segmentation
- Option 4A - Upgrade Transformer No. 2 with new protection in new control room
- Option 4D - Upgrade Transformer No. 2 with new protection in new control room, 66 segmentation and 22kV segmentation (partly indoor)
- Option 4E - Upgrade Transformer No. 2 with new protection in new control room, 66kV segmentation and 22kV segmentation (indoor).

WSP | Parsons Brinckerhoff's options analysis clearly shows that the greatest benefit will be realised by replacing the 10 MVA Transformer No. 2 with a new 20/33 MVA unit and undertaking segmentation works on both the 66kV and 22kV assets. The NPV clearly identifies a preferred option for implementing these works; which includes a new control room and 22kV indoor switch room (Option 4E). This option has a cost of $9.6m (real, 2015 direct un-escalated), all of which is required in the period 2016-20.

Option 4E reduces the cost of energy at risk by $597m on a net present cost basis. This greatly exceeds the cost of the preferred option showing that the works should be undertaken as soon as practical to realise these benefits.

1 PURPOSE OF REPORT

The purpose of this report is to provide an independent assessment of the Sunbury Zone Substation upgrade in respect of Jemena Electricity Networks' (JEN) regulatory proposal and the AER's Preliminary Decision. It provides an independent view on:

- what the drivers are and their implications
- viable technical options to address drivers and needs, including Non-network options such as embedded generation and demand management
- reasons for the rejection of non-viable options considered
- cost benefit analysis of viable options
- WSP | Parsons Brinckerhoff's recommended preferred option.

WSP | Parsons Brinckerhoff has utilised and relied upon the knowledge of JEN subject matter experts (SME) and cost estimators to the extent required and provides an independent judgement of the information gathered.

1.1 STATEMENT ABOUT WSP | PARSONS BRINCKERHOFF

WSP and Parsons Brinckerhoff have combined and are now one of the world's leading engineering professional services consulting firms, with more than 31,000 employees world-wide. We have assisted most network services businesses in Australia to develop their investment plans, including drafting and/or reviewing network strategic plans, asset strategy plans and network investment business cases.

Our work processes are quality assured through accreditation to AS/NZS ISO 9001:2008.

2 BACKGROUND

On 30 April 2015, JEN submitted *Jemena Electricity Networks (Vic) Ltd Regulatory Proposal 1 January 2016 - 31 December 2020* (JEN's Regulatory Proposal). The Australian Energy Regulator (AER) published *Preliminary Decision Jemena distribution determination 2016 to 2020 Overview* on October 2015 (Preliminary Decision). In the Preliminary Decision, the AER partially rejected the expenditure related to JEN's proposed Sunbury Zone Substation rebuild and replacement. JEN is required to submit a response to the AER's Preliminary Decision paper by 6 January 2016.

2.1 JEN'S PROPOSAL

In its 2014 paper "Network Development Strategy Sunbury Diggers Rest growth corridor", JEN set out five credible options to address forecast capacity constraints. The work to address these issues has not yet been started and is under review in 2015-16.

The preferred option is to redevelop Sunbury Zone Substation. This requires the construction of a new control room, indoor 22kV switch room, upgrade of the 66kV bus and replacement of the

10 MVA transformer with a new 20/33 MVA transformer. The increasing demand is driving the timing of the works.

JEN included an amount of $9.68m ($2014, direct un-escalated cost) to redevelop Sunbury Zone Substation assets (not including land acquisition) in its regulatory proposal for the 2016-2020 period.

JEN has also published the RIT-D Stage 1: Non-Network Options Report on 21 October 2015 to invite non-network proponents input to addressing the identified need for Sunbury Zone Substation.

2.2 AER'S PRELIMINARY DECISION

The AER did not include the proposed capex $10.9m for this project in its alternative estimate of JEN's Augex requirements on the basis that it 'is primarily driven by age condition of some assets and reliability concerns. Based on our review of Jemena's supporting information, we are not satisfied that this capex is necessary to maintain network reliability, security or safety in accordance with the capex objectives of the NER' (P6-47).

The AER noted that 'Jemena submitted that some of these assets are approaching the end of their useful life and need to be replaced. This includes the transformer that will be upgraded, the 66 kV circuit breakers, and the control room. However, other assets that Jemena proposed to replace are relatively new including the outdoor 22 kV circuit breakers (which were replaced in 2002)' (P6-47).

The AER believes that JEN has not justified the need to rebuild because:

1. Unlike its augmentation assessments, did not present details of the impact on customers from further outages in terms of the value of expected unserved energy. Rather, Jemena's analysis appears to be qualitative in nature and places no probability of the likelihood of further outages and the cost to consumers. This makes it difficult to determine whether the proposed cost to rebuild the substation is less than the cost to consumers from not proceeding.
2. Similarly, while several of the assets may be aging, Jemena has not provided evidence that the assets need to be immediately replaced in the 2016–20 period (including in addition to the capex that is proposed within its repex forecast). This is because Jemena has not established that replacing these assets is necessary to maintain network reliability, security, safety or quality to satisfy the capex objectives.
3. Most of the outdoor 22kV circuit breakers that Jemena proposed to replace were replaced in 2000 and are not reaching the end of their life (P6-47).

In concluding, the AER stated "If Jemena is of the view that, given the condition of the assets, it requires more than business as usual repex to meet the capex objectives, then it should provide supporting information to this effect in its revised proposal (including updating any historical and forecast expenditure of this type in the form of an updated response to RIN template 2.2, and other supporting material such as business cases, options analysis and cost benefit analysis)." (P6-49).

3 REVIEW OF JEN'S PROPOSAL

WSP | Parsons Brinckerhoff undertook an independent review of JEN's proposal to upgrade the Sunbury Zone Substation assets. In this section, we present the outcomes of this review.

3.1 DRIVERS

The key drivers, as stated by JEN, were forecast capacity constraints in 2018, a need to replace assets that are in poor condition and a limiting switching arrangement, outlined in Table 3.1.

Table 3.1: JEN's identified drivers

CONSTRAINT	IMPACT	TIMING
Forecast demand increasing at 2.8% for next ten years	For system normal condition there will be insufficient capacity at SBY Zone Substation over the summer peak load period	From 2018
Deteriorating asset condition	Asset failures resulting in significant loss of supply for an extended period	Not- specified
Switching arrangement	Most faults within the station will result in a supply interruption to all customers supplied from SBY Zone Substation	Not- specified
Land availability	The Sunbury Zone substation land will need to be secured beyond 2032 or a new substation developed	From 2032

Source: Jemena Electricity Networks (Vic) Ltd Sunbury - Diggers Rest Growth Corridor Network Development Strategy ELE PL 0030

The table shows that the key driver is the forecast capacity constraints in 2018, based on JEN's ten year demand forecast. It also shows a secondary driver is the need to replace assets that are in poor condition. There are further impacts on reliability because the Sunbury Zone Substation utilises a manual switching arrangement that is appropriate for its legacy rural use, but that will have an increasing impact on reliability with the forecast increasing demand.

The logical conclusion is to develop augmentation options that also consider the whole of life cycle costs of future replacements and the impact of failures and switching arrangements on reliability with the forecast increasing demand. This is not the approach taken by Jemena. WSP | Parsons Brinckerhoff concludes that JEN did not include the impact of asset condition and the switching arrangements on the assessment of customer reliability. These drivers should be incorporated into the assessment identifying the preferred option.

3.2 OPTIONS DEVELOPMENT

Jemena considered five viable options, and three non-viable options, in addition to the do nothing base case:

- Do Nothing
- Option 1 – Redevelop SBY Zone Substation
- Option 2 – Redevelop SBY and Develop new zone substation by 2024/25
- Option 3 – Develop new zone substation by 2018
- Option 4 - Embedded generation
- Option 5 - Demand management
- Option I - Transfer load to nearby zone substations
  - Option I1 - Transfer load to COO Zone Substation
  - Option I2 - Transfer load to SHM Zone Substation
- Option II – Improve transformer load sharing
  - Option II1 – Optimise the transformer tappings between transformers
  - Option II2 – Install cooling fans to increase the rating of 10MVA transformer
  - Option II3 – Split the 22kV bus and reconfigure the feeders
- Option III – Loading transformers to their cyclic ratings under system normal condition

These options were correctly structured to address capacity constraints from 2018.

The suite of options did not consider any staged works that address the capacity constraint now and have the flexibility to mitigate the impact of asset condition reliability as the demand on the substation increases over time.

Option 1 (Redevelop SBY Zone Substation) addresses the capacity driver, as well as the deteriorating asset condition and switching arrangement.

Option 2 (Redevelop SBY and Develop new zone substation by 2024/25) and Option 3 (Develop new zone substation by 2018) are really sub-options of Option 1 to address the possibility of the land not being secured beyond 2032.

Option 4 (Embedded generation) and Option 5 (Demand management) address the key driver of capacity constraints.

3.3 OPTIONS ANALYSIS

WSP | Parsons Brinckerhoff reviewed the options I to III and agrees with JEN that these are not viable as follows:

- Option I - Transfer load to nearby zone substations:
  - Option I1 – 'Transfer load to COO Zone Substation' requires significantly higher Capex to install a third transformer at COO, two feeders and works within Sunbury Zone Substation and will introduce further reliability constraints
  - Option I2 – 'Transfer load to SHM Zone Substation' requires significantly higher Capex to install a third transformer at SHM, two feeders and works within Sunbury Zone Substation and will introduce further reliability constraints

- Option II – Improve transformer load sharing:
  - Option II1 – 'Optimise the transformer tappings between transformers' has already been implemented, does not reduce the unserved energy, fails to address the primary driver for the program and does not provide long term capacity increases.
  - Option II2 – 'Install cooling fans to increase the rating of 10MVA transformer' does not reduce the unserved energy, fails to address the primary driver for the program and does not provide long term capacity increases.
- Option III – 'Loading transformers to their cyclic ratings under system normal condition' does not reduce the unserved energy, fails to address the primary driver for the program and does not provide long term capacity increases.

Non – viable Option II3 – 'Split the 22kV bus and reconfigure the feeders' is technically viable but has not been included in the options analysis presented by JEN. JEN advised that it did not include this as a viable option because it has minimal improvement to customer reliability, and introduces operational complexity. However, the potential deferral of works to meet the capacity at Sunbury Zone Substation were not considered in a cost/benefit analysis and hence it is not clear that this option is not economically viable.

Of the viable options 1, 2 and 3, JEN did not include an assessment of the reliability impacts of the switching arrangements. Such an assessment would have provided the optimal switching layout.

These options primarily considered the development of a new current-standard zone substation on the existing site or a new site with varied implementation times. The options did not consider undertaking staged redevelopment works, or partial redevelopment.

The preferred option 1 included a sensitivity analysis that determined that the optimal timing of the redevelopment would be 2017, which is not practically deliverable. The proposed 2018 implementation seems reasonable.

Option 4 (Embedded generation) and Option 5 (Demand management) are considered in "Jemena Electricity Networks (Vic) Ltd Sunbury - Diggers Rest Electricity Supply RIT-D Stage 1: Non-Network Options Report". These options are assessed against the preferred network option, Option 1. The assessment provided is predominantly qualitative and does not quantify the reliability costs/benefits.

3.4 SUMMARY

JEN did not include the impact of asset condition and the switching arrangements on the assessment of customer reliability. Additional options to fully assess the reliability impacts of switching arrangements, and the staging options for the redevelopment, should have been included in the assessment.

4 RECOMMENDATIONS

4.1 DRIVERS

WSP | Parsons Brinckerhoff has established that the 3 key drivers for the Sunbury Zone Substation upgrade are:

1. Demand

2. Maintaining reliability
3. Safety

In effect, capacity constraints due to increasing demand are driving the timing of the works with the replacement driver affecting the range of replacement options that are prudent.

DEMAND

The primary driver for the Sunbury Zone Substation upgrade is an increase in forecast demand at a rate of 3% over the next ten years, which will not be able to be served by the current capacity of the substation. JEN has provided revised forecast demands for Sunbury Zone Substation, refer to assumptions in section 4.4 for details.

The current summer (50% POE) demand exceeds Sunbury Zone Substation's 32MVA N Rating, requiring load transfers to nearby Sydenham Zone Substation and Coolaroo Zone Substation.

The forecast summer (50% POE) demand for Sunbury Zone Substation will exceed the capacity, including transfers, from 2017 under normal conditions.

MAINTAINING RELIABILITY

The reliability impacts of a station outage at Sunbury Zone Substation will increase with the forecast increasing demand. The reliability is impacted by:

- Limited switching
- Outdoor switching
- The condition of assets and their likely failure rates.

Sunbury Zone Substation has historically been a rural zone substation. It was designed to provide both a 66kV switching station for the sub-transmission network supplying the wider area to the north and west of Melbourne, and to provide distribution supply to the township of Sunbury and its surrounds. It has three transformers, outdoor switchgear and limited station switching, resulting in a single switching zone for all transformers. In the event of a fault within the switch yard, the fault affects the entire station load.

The 66kV switching is supplied in a ring bus arrangement and the local distribution is via transformers in a single switching zone. The current substation layout largely reflects its initial design with outdoor 66kV and 22kV switch gear and a strung bus arrangement for both 66kV and 22kV buses. The strung bus arrangement is less reliable than a rigid bus configuration as the probability of conductor clashing during faults, wild life contact and extreme weather conditions is higher due to conductor flexibility.

JEN has scheduled the replacement of:

- 66/22kV TX2 transformer (2032)
- 66kV 2 x HLE CBs (2021)
- 22kV SBY 33 CB (AEI type JB424) (2021)
- 22kV Reyrolle type OMT No.1 capacitor bank CB (2021)

The reliability will also be impacted by the probable failure, requiring refurbishment, of 4 Crompton Greaves – 30-SFGP-25A 22kV CBs. There have been ongoing issues with these CBs installed at Airport West, Coburg North and Yarraville zone substations. Gas leaks were found in one CB at SBY and one CB at YTS; both of these CBs had all three poles replaced with refurbished poles.

In March 2014, while doing corrective maintenance on the AW No.4 22kV transformer CB the shock absorber was found to have been dislodged. Further investigation found a gas leak from one of the poles of the CB. All three poles were replaced with refurbished poles and the CB was put back in service.

Whilst it is not expected that fault events or failures will increase at the station, the impact of the faults and failures will be greater as the demand increases over time.

HEALTH, SAFETY AND ENVIRONMENT

Sunbury Zone Substation has some existing HSE constraints, including:

- The presence of asbestos in the control room building and panels
- Manual switching required to undertake work during a fault
- Oil leaks on Transformer No.2
- No Humeceptor pit within the station

Whilst these are not driving the need to do work, they are driving the selection and assessment of the options via a quantitative risk analysis.

4.2 OPTION ANALYSIS

WSP | Parsons Brinckerhoff has identified a suite of options that consider undertaking staged redevelopment works or partial redevelopment, including:

- Option 1 - Do-Nothing (BAU)
- Option 2 - Upgrade TX2 with protection in situ
- Option 3 - Upgrade TX2 with new protection cabinet
- Option 4 - Upgrade TX2 with new protection in new control room
- Option 5 - 22kV load reconfiguration
- Option 6 - Embedded Generation
- Option 7 - Demand Management
- Option 8 - Uprate transformer to cyclic rating
- Option 9 - Load transfers
- Option 10 - Lightning mast
- Option 11 - Balance load - taps
- Option 12 - Bird Proofing

Further sub-options address the segmentation solutions to the reliability driver, as outlined in Table 4.1.

Table 4.1: Options identification

OPTION	DESCRIPTION
Option 1 - Do-Nothing (BAU)	Scheduled replacement of equipment identified as requiring replacement over 2016 - 2032
Option 2A - Upgrade TX2 with protection in situ	Replace existing 10 MVA TX2 with new 20/33 MVA (2017/18) with protection, SCADA and Communications in existing panel and undertake scheduled replacements
Option 2B - Upgrade TX2 with protection in situ, 66kV Segmentation	Replace existing 10 MVA TX2 with new 20/33 MVA (2017/18) with protection, SCADA and Communications in existing panel, install 66kV segmentation including uprating the 66kV bus and undertake scheduled replacements
Option 2C - Upgrade TX2 with protection in situ, 22kV segmentation	Replace existing 10 MVA TX2 with new 20/33 MVA (2017/18) with protection, SCADA and Communications in existing panel, install 22kV segmentation and undertake scheduled replacements
Option 2D - Upgrade TX2 with protection in situ, 66kV and 22kV segmentation	Replace existing 10 MVA TX2 with new 20/33 MVA (2017/18) with protection, SCADA and Communications in existing panel, install 66kV segmentation including uprating the 66kV bus, install 22kV segmentation and undertake scheduled replacements
Option 3A - Upgrade TX2 with new protection cabinet	Replace existing 10 MVA TX2 with new 20/33 MVA (2017/18) with protection, SCADA and Communications in new control panel and undertake scheduled replacements
Option 3B - Upgrade TX2 with new protection cabinet, 66kV Segmentation	Replace existing 10 MVA TX2 with new 20/33 MVA (2017/18) with protection, SCADA and Communications in new control panel, install 66kV segmentation including uprating the 66kV bus and undertake scheduled replacements
Option 3C - Upgrade TX2 with new protection cabinet, 22kV segmentation	Replace existing 10 MVA TX2 with new 20/33 MVA (2017/18) with protection, SCADA and Communications in new control panel, install 22kV segmentation and undertake scheduled replacements
Option 3D - Upgrade TX2 with new protection cabinet, 66 and 22kV segmentation	Replace existing 10 MVA TX2 with new 20/33 MVA (2017/18) with protection, SCADA and Communications in new control panel, install 66kV segmentation including uprating the 66kV bus, install 22kV segmentation and undertake scheduled replacements
Option 4A - Upgrade TX2 with new protection in new control room	Replace existing 10 MVA TX2 with new 20/33 MVA (2017/18) with all protection SCADA and communications in a new control room and undertake scheduled replacements
Option 4B - Upgrade TX2 with new protection in new control room, 22kV segmentation (partly indoor)	Replace existing 10 MVA TX2 with new 20/33 MVA (2017/18) with all protection SCADA and communications in a new control room, install 22kV segmentation in a new 22kV switch room and undertake scheduled replacements of any items not replaced.
Option 4C - Upgrade TX2 with new protection in new control room, 22kV segmentation (indoor)	Replace existing 10 MVA TX2 with new 20/33 MVA (2017/18) with all protection SCADA and communications in a new control room, install all 22kV in a new 22kV switch room, install 22kV segmentation and undertake scheduled replacements of any items not replaced.
Option 4D - Upgrade TX2 with new protection in new control room, 66kV segmentation and 22kV segmentation (partly indoor)	Replace existing 10 MVA TX2 with new 20/33 MVA (2017/18) with all protection SCADA and communications in a new control room, install 66kV segmentation including uprating the 66kV bus, install 22kV segmentation in a new 22kV switch room and undertake scheduled replacements of any items not replaced.
Option 4E - Upgrade TX2 with new protection in new control room, 66kV segmentation and 22kV segmentation (indoor)	Replace existing 10 MVA TX2 with new 20/33 MVA (2017/18) with all protection SCADA and communications in a new control room, install 66kV segmentation including uprating the 66kV bus, install all 22kV in a new 22kV switch room, install 22kV segmentation and undertake scheduled replacements of any items not replaced.
Option 5 - 22kV load reconfiguration	Balance load on the transformers by installing 22kV bus tie CBs and reconfiguring the feeders, move 2 feeders between the bus ties.
Option 6 - Embedded Generation	Refer to Sunbury-Diggers-Rest-Electricity-Supply-RIT-D-Stage-1-(Non-Network-Options-Report)
Option 7 - Demand Management	Refer to Sunbury-Diggers-Rest-Electricity-Supply-RIT-D-Stage-1-(Non-Network-Options-Report)
Option 8 - Uprate transformer to cyclic rating	Utilise cyclic rating to provide for increased demand.
Option 9 - Load transfers	Transfer load to COO and SHM
Option 10 - Lightning mast	Install lightning mast
Option 11 - Balance load - taps	Balance load taps to increase station rating
Option 12 - Bird Proofing	Install bird proofing to reduce station outages

RISKS

WSP | Parsons Brinckerhoff has included a probabilistic risk assessment in the Cost-benefit analysis, refer to Appendix A, of the options, using the probabilities and costs outlined in Table 4.2 and Table 4.3 to address the cost of risks associated with:

- Construction
- Access
- Safety
- Operations

The probability weighted costs have been included in the cost benefit analysis to determine the most efficient option.

Table 4.2: Risk Likelihood

Likelihood	Probability
5 – Almost Certain	75%
4 - Likely	51% - 75%
3 – Possible	26% - 51%
2 - Unlikely	5% - 25%
1 – Rare	<5%

Table 4.3: Risk Cost

Likelihood	Cost
5 - Catastrophic	$10,000,000
4 - Major	$6,750,000
3 - Severe	$2,250,000
2 - Serious	$550,000
1 - Minor	$100,000

The probability weighted costs of each risk are displayed in Table 4.4.

Table 4.4: Probabilistic risk

Risk	Description	Likelihood	Consequence	PROBABILITY WEIGHTED COST ($2015)
1 - Construction	May require protection of TX2 to be out of service for duration of cut-over, which is likely to result in the whole station outage	5 – Almost Certain	5 - Catastrophic	7,500,000
2 - Construction	May require replacements of all wiring on panel (brittle condition) and probably outages from disrupting existing protection	5 – Almost Certain	3 - Severe	1,687,500
3 - Construction	Possibility of asbestos breach, causing construction delay and increased construction costs	4 - Likely	3 - Severe	1,417,500
4- Construction	Possibility of geotechnical issue in new control room	2 - Unlikely	2 - Serious	82,500
5 - Access	There are access issues to route cables	5 – Almost Certain	2 - Serious	412,500
6 - Access	Whilst there is space to install a protection panel, there are access issues to install the panel, route cables	5 – Almost Certain	4 - Major	5,062,500
7 - Safety	Manual switching of increased load may result in flashing, serious injury	4 - Likely	3 - Severe	1,417,500
8 - Operational	Access issues for maintenance of cables	4 - Likely	1 - Minor	4,200 /year
9 - Operational	Access issues for maintenance of panel	4 - Likely	3 - Severe	94,500 /year
10 - Operational	Combination of indoor and outdoor switchgear increases switching time, fault finding time and maintenance	5 – Almost Certain	4 - Major	337,500 /year

Risk 1, 2, 3 and 10 include estimated costs associated with likely impact on reliability utilising the value of consumer reliability (VCR) and probability information shown in section 4.4.

4.2.1 NON - VIABLE OPTIONS

WSP | Parsons Brinckerhoff's options analysis has highlighted a set of non-viable options, outlined in Table 4.5, with an unfavourable NPV or an inability to realise benefits.

The net present cost (NPC) includes:

- Capital costs
- Demand based expected unserved energy costs (utilising VCR)
- Reliability based expected unserved energy (utilising VCR)
- Inspection and maintenance costs
- Probability weighted cost of risks (refer to section 4.2.1)

The net present value (NPV) compares the NPC of each option to the do nothing case, i.e. the benefit compared to business as usual.

Table 4.5: Options analysis

OPTION	NPC ($M, 2015 DIRECT)	NPV ($M, 2015 DIRECT)	STATUS
Option 1 - Do-Nothing (BAU)	$(605.22)	$-	-
Option 2A - Upgrade TX2 with protection in situ	$(27.21)	$578.01	Rejected – low NPV
Option 2B - Upgrade TX2 with protection in situ, 66 kV Segmentation	$(27.81)	$577.41	Rejected – low NPV
Option 2C - Upgrade TX2 with protection in situ, 22kV segmentation	$(27.64)	$577.58	Rejected – low NPV
Option 2D - Upgrade TX2 with protection in situ, 66 and 22kV segmentation	$(19.65)	$585.57	Requires further analysis
Option 3A - Upgrade TX2 with new protection cabinet	$(25.91)	$579.31	Rejected – low NPV
Option 3B - Upgrade TX2 with new protection cabinet, 66 kV Segmentation	$(26.64)	$578.58	Rejected – low NPV
Option 3C - Upgrade TX2 with new protection cabinet, 22kV segmentation	$(26.47)	$578.75	Rejected – low NPV
Option 3D - Upgrade TX2 with new protection cabinet, 66 and 22kV segmentation	$(18.46)	$586.76	Rejected – low NPV
Option 4A - Upgrade TX2 with new protection in new control room	$(20.71)	$584.51	Requires further analysis
Option 4B - Upgrade TX2 with new protection in new control room, 22kV segmentation (partly indoor)	$(27.29)	$577.92	Rejected – low NPV

Option 4C - Upgrade TX2 with new protection in new control room, 22kV segmentation (indoor)	$(23.44)	$581.78	Rejected – low NPV
Option 4D - Upgrade TX2 with new protection in new control room, 66 segmentation and 22kV segmentation (partly indoor)	$(19.31)	$585.91	Requires further analysis
Option 4E - Upgrade TX2 with new protection in new control room, 66 segmentation and 22kV segmentation (indoor)	$(16.16)	$589.06	Requires further analysis
Option 5 - 22kV load reconfiguration	$(278.53)	$326.69	Rejected – low NPV
Option 6 - Embedded Generation	N/A	N/A	Rejected – Refer to Sunbury-Diggers-Rest-Electricity-Supply-RIT-D-Stage-1-(Non-Network-Options-Report)
Option 7 - Demand Management	N/A	N/A	Rejected – Refer to Sunbury-Diggers-Rest-Electricity-Supply-RIT-D-Stage-1-(Non-Network-Options-Report)
Option 8 - Uprate transformer to cyclic rating	-	-	Rejected – Already implemented, provides capacity until 2017, no further benefits to be realised
Option 9 - Load transfers	-	-	Rejected – Already implemented, no further benefits to be realised
Option 10 - Lightning mast	-	-	Rejected – Does not meet demand need
Option 11 - Balance load - taps	-	-	Rejected – Already implemented, no further benefits to be realised
Option 12 - Bird Proofing	-	-	Rejected – Already implemented, no further benefits to be realised

4.2.2 VIABLE OPTIONS

The options analysis, refer to Table 4.5, clearly shows that the greatest benefit will be realised by replacing the 10 MVA TX2 with a new 20/33 MVA and undertaking segmentation works on both the 66kV and 22kV. The risk assessment has been included in the cost benefit analysis. The NPV, summarised in Table 4.6, clearly shows that option 4E is the most efficient option.

Table 4.6: Options analysis viable options

OPTION	NP CAPEX COST ($M, 2015)	NPC ($M, 2015 DIRECT)	NPV ($M, 2015)	RANK
Option 1 - Do-Nothing (BAU)	$(0.65)	$(605.22)	$-	-
Option 2D - Upgrade TX2 with protection in situ, 66kV and 22kV segmentation	$(3.56)	$(19.65)	$585.57	3
Option 4A - Upgrade TX2 with new protection in new control room	$(4.00)	$(20.71)	$584.51	4
Option 4D - Upgrade TX2 with new protection in new control room, 66kV segmentation and 22kV segmentation (partly indoor)	$(7.93)	$(19.31)	$585.91	2
Option 4E - Upgrade TX2 with new protection in new control room, 66kV segmentation and 22kV segmentation (indoor)	$(8.43)	$(16.16)	$589.06	1

4.2.3 PREFERRED OPTION

The NPV identifies that Option 4E (Upgrade TX2 with new protection in new control room, 66 segmentation and 22kV segmentation indoor) is the most efficient to address the capacity and increasing reliability constraints at Sunbury Zone substation.

This option has a cost of $9.6m (real, 2015 direct un-escalated), all of which is required in the period 2016-20, as shown in Table 4.7.Option 4E reduces the cost of energy at risk by $597m on a net present cost basis, refer to section 4.4 Table 4.14. This greatly exceeds the cost of the preferred option showing that the works should be undertaken as soon as practical to realise these benefits.

The expenditure profile for this option is shown in Table 4.7.

Table 4.7: Expenditure profile for Option 4E ($ real, 2015 direct)

ITEM	2016	2017	2018	2019	2020	TOTAL
Capex - Augmentation	-	$8,152,439	$1,446,605	-	-	$9,599,044
Capex - Replacement	-	-	($144,000)	-	-	-$75,000
Opex	($15,000)	($15,000)	($15,000)	($15,000)	($15,000)	-$144,000
Total	($15,000)	$8,137,439	$1,287,605	($15,000)	($15,000)	$9,380,044

4.3 COMMENTS ON AER'S PRELIMINARY DECISION

The AER stated that it was not satisfied that JEN's option to completely rebuild the sub-station is required to meet forecast demand or maintain the reliability of the substation in the 2016–20 period. It made several statements to support this view. WSP | Parsons Brinckerhoff's comments on these statements are presented below.

Statement 1 - We have included $1.3 million capex for a new transformer in our alternative estimate which reflects the prudent and efficient amount for Jemena to meet expected demand growth …Given Jemena's demand forecasts, Jemena calculated that the cost to of unmet demand and higher outages to consumers from increases in demand will be $3.6 million by 2018. On this basis, it is clear that Jemena's proposed $1.3 million cost to augment transformer capacity is outweighed by the benefit to consumers in terms of preventing outages and maintaining reliability in the northern growth area of the network. (p. 6-47 – 48)

The AER has included only the costs of the transformer materials and installation. In order to alleviate the demand constraint further capex is required, as outlined in Table 4.8.

Table 4.8: Capital cost to upgrade TX2

ITEM	COST ($2015)
Replace existing 10MVA TX2 with new 20/33MVA	$1,307,401
Uprate 66kV Bus (Only bus structure, no allowance for VT, disconnectors)	$787,166
Installation and civil works	$229,035
Protection, SCADA and Comms in existing panel	$266,685
Control building asbestos control	$200,000
Design and PM	$163,499
Total	**$2,953,785**

On this basis, WSP | Parsons Brinckerhoff has evaluated the replacement of the transformer (Option 2A), and found it to be NPV positive, and a prudent option for meeting the required capacity. However, the options analysis shows that this is not the most efficient option to relieve the capacity constraint.

Statement 2 - Unlike its augmentation assessments, Jemena did not present details of the impact on customers from further outages in terms of the value of expected unserved energy. Rather, Jemena's analysis appears to be qualitative in nature and places no probability of the likelihood of further outages and the cost to consumers. This makes it difficult to determine whether the proposed cost to rebuild the substation is less than the cost to consumers from not proceeding.

WSP | Parsons Brinckerhoff agrees with the AER that the analysis of options put forward by JEN does not quantitatively assess the impact of asset condition and the switching arrangement on customers.

The options to address the capacity constraints must consider the future replacement of assets in poor condition, limitations of a manually switched station and how these might be addressed to achieve lowest life cycle costs.

As presented in section 4.2, the cost of unserved energy posed by a whole of station fault (included in the NPV) and an increasing demand on Sunbury Zone Substation means that it is prudent for JEN to install segmentation on the 66kV and 22kV switchyards.

Statement 3 - Similarly, while several of the assets may be aging, Jemena has not provided evidence that the assets need to be immediately replaced in the 2016–20 period (including in addition to the capex that is proposed within its repex forecast). This is because Jemena has not established that replacing these assets is necessary to maintain network reliability, security, safety or quality to satisfy the capex objectives.

WSP | Parsons Brinckerhoff agrees with the AER that the analysis of options put forward by JEN has not established that replacing these assets is necessary to maintain network reliability, security, safety or quality to satisfy the capex objectives.

The options analysis, presented in section 4.2, includes the impact of poor condition assets on network reliability assessed against the premature replacement of these assets.

Statement 4 - Most of the outdoor 22 kV circuit breakers that Jemena proposed to replace were replaced in 2000 and are not reaching the end of their life. (p.6-47)

WSP | Parsons Brinckerhoff agrees with the AER that the outdoor 22 kV circuit breakers (4 Crompton Greaves – 30-SFGP-25A 22kV CBs) that JEN proposed to replace were replaced in 2000 and are not reaching the end of their life.

However, there have been ongoing issues with these CBs, refer to section 4.1. The options, in WSP | Parsons Brinckerhoff's analysis, that replace the 22kV switchyard with a 22kV switch room include a return to spares (included in the NPV) of 4 x 22kV CBs with an estimated 2/3 life left, for future use at Airport West, Coburg North and Yarraville zone substations. It is likely that these spares will be used because of the issues that have been present in this CB type. Removing these from service and returning them to stores does not represent an in-efficient approach.

Statement 5 - AER stated "If Jemena is of the view that, given the condition of the assets, it requires more than business as usual repex to meet the capex objectives, then it should provide supporting information to this effect in its revised proposal (including updating any historical and forecast expenditure of this type in the form of an updated response to RIN template 2.2, and other supporting material such as business cases, options analysis and cost benefit analysis)." (P6-49)

A non-like for like replacement option is required to address increasing reliability impacts. The cost of the replacement with indoor 22kV assets will be higher than outdoor 22kV assets, but will provide the required capacity and reliability at a lower cost. Overall, the total cost is minimised, meeting the requirements of the capex objectives.

4.4 ASSUMPTIONS MADE

WSP | Parsons Brinckerhoff's made the following assumptions in relation to our analysis of JEN's Proposal and our Recommendations.

CAPACITY

The effective normal summer rating of the substation is limited by the amount of power that can be supplied through the smallest (10 MVA) transformer. Due to the transformer impedance differences, and the resultant load sharing across the three transformers, the load through the 10 MVA transformer reaches its rated value at a station load of 32 MVA. This 32 MVA capacity has therefore been assigned as the effective normal summer rating of SBY Zone Substation, as shown in Table 4.9:

Table 4.9: Sunbury Zone Substation option capacity (MVA)

	TX1	TX2	TX3	N RATING	N-1 CYCLIC RATING[1]
Do Nothing	10/16	10	10/16	32	26.4
Replace 10 MVA with 20/33 MVA transformer	10/16	20/33	10/16	65	39
22kV load reconfiguration	10/16	10	10/16	42	26.4

DEMAND FORECASTS

The revised forecasts outlined in Table 4.10 have been utilised:

Table 4.10: Revised Sunbury Zone Substation load demand forecast (MVA)

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Summer (50% POE)	36.5	38.9	39.6	40.9	42.2	43.7	45.2	46.2	48.0	49.7	51.3
Winter (50% POE)	33.1	33.7	34.7	36.0	37.4	38.9	40.4	41.5	43.2	45.0	46.9
Summer (10% POE)	36.5	42.8	43.7	45.1	46.7	48.2	50.0	51.3	53.0	55.2	56.9
Winter (10% POE)	33.9	34.5	35.5	36.7	38.3	39.7	41.3	42.4	44.2	46.1	48.1

Source: ZSLoad at risk assessment spreadsheet_Ver5_SBY paper_SBY forecast revised 26112015

The forecast demand for Sunbury Zone Substation exceeds the capacity, including transfers, from 2017 under normal conditions, refer Table 4.11. The forecast demand for Sunbury Zone Substation exceeds the capacity, including transfers, from 2015 under contingency conditions, refer Table 4.12.

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[1] Based on loss if TX1 or TX3

Table 4.11: Sunbury Zone Substation Summer (50% POE) forecast Load at risk (MVA)

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Sunbury Zone Substation capacity N Rating	32	32	32	32	32	32	32	32	32	32
Transfer Capacity	5.7	5.1	4.3	3.4	2.7	1.9	1.0	0.0	0.0	0.0
Total capacity	**37.7**	**37.1**	**36.3**	**35.4**	**34.7**	**33.9**	**33.0**	**32.0**	**32.0**	**32.0**
Summer (50% POE)	38.9	39.6	40.9	42.2	43.7	45.2	46.2	48.0	49.7	51.3
Load at risk	**-**	**-**	**4.6**	**6.8**	**9.0**	**11.3**	**13.2**	**16.0**	**17.7**	**19.3**

Table 4.12: Sunbury Zone Substation Summer (50% POE) forecast Load at risk (MVA) in contingent event

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Sunbury Zone Substation capacity N-1 Rating	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4
Transfer Capacity	5.7	5.1	4.3	3.4	2.7	1.9	1.0	0.0	0.0	0.0
Total capacity	**32.1**	**31.5**	**30.7**	**29.8**	**29.1**	**28.3**	**27.4**	**26.4**	**26.4**	**26.4**
Summer (50% POE)	38.9	39.6	40.9	42.2	43.7	45.2	46.2	48.0	49.7	51.3
Load at risk	**6.8**	**8.1**	**10.2**	**12.4**	**14.6**	**16.9**	**18.8**	**21.6**	**23.3**	**24.9**

There is likely to be a requirement for increased capacity in the years following JEN's ten year demand forecast, but this is common to all options and has not been included in the cost benefit analysis.

LAND

It is assumed that the land on which Sunbury Zone Substation resides will be secured by 2032.

CAPITAL COSTS

The capital cost estimates for all network options are indicative costs only. They have been provided by JEN's Works Delivery team, with consideration given to recent similar augmentation projects and typical unit costs based on industry experience.

VALUE CUSTOMER RELIABILITY

A VCR of $38,950/MWh has been utilised.

DISCOUNT RATE

A discount rate of 6.24% has been utilised.

STATION FAULTS AND RELIABILITY BASED UNSERVED ENERGY

For unserved energy related to faults within Sunbury Zone Substation the following assumptions have been applied:

- A station fault is repaired in 1 hour (on average)
- Probability of failure of a transformer is based on the health index from CBRM. A Weibull curve, with transformer average age to failure of 60 years, using a steep curve so that the failure rate starts to increase quickly from a health index of 7.
- Probability of failure of a switchboard is based on the health index from CBRM. A Weibull curve, with switchboard average age to failure of 50 years, using a steep curve so that the failure rate starts to increase quickly from a health index of 7.
- Where the option includes segmentation of both the 66kV and 22kV buses, the fault will affect 1/3 of the load
- Faults have been derived from the data in Table 4.13:
  - Faults on the 66kV yard occur 0.4 times per year
  - Faults on the 22kV yard occur 0.15 times per year
  - Faults on the 22kV indoor switch room occur 0.10 times per year.

Table 4.13 Likely yard faults – Analysis of historic faults 1994 - 2014

Faulted Zone	Faults	Remarks	Assumptions	66kV Yard Faults	22kV Yard Faults	22kV SWR Faults
66kV Bus and Lines	6	In each case substation was lost due to other factors e.g. protection mal-operation which caused back up protection to operate	Station outage likely to re-occur	6		
Human Error	2	Errors whilst switching	Inherent risk in all scenarios	2		
Transformer Zone	5	Four bird strikes on the 22 kV side of the transformer, and one trip on overload	1 station outage likely to re-occur 4 station outages unlikely to occur since the implementation of bird-proofing	-	1	1
22kV feeder Fault	1	Back up earth fault operated – simultaneous feeder faults	Station outage likely to re-occur	-	1	1
Lightning	1	In 22 kV transformer/bus zone	Station outage likely to re-occur where	-	1	

			switchyard remains outdoors			
22kV Bus Fault	1	Possum on insulator within switchyard	Station outage unlikely to occur since the implementation of bird-proofing	-	-	-
Equipment Failure	1	22kV CB failed (exploded)	Station outage unlikely to re-occur subject to scheduled replacements	-	-	-
Unknown	1		Not included in analysis	-		
Total				8	3	2
Frequency (faults/year)				0.4	0.15	0.10

Source: Sunbury - Diggers Rest Growth Corridor Network Development Strategy, Table 10: SBY Zone Substation outage summary

DEMAND BASED EXPECTED UNSERVED ENERGY

The options analysis in this report utilises the JEN calculation methodology for Load at Risk.

The net present cost of expected unserved energy for each option and compared to the base case is shown in Table 4.14.

Table 4.14: Cost of expected unserved energy

OPTION	NPC ($M, 2015 DIRECT)	NPV ($M, 2015 DIRECT)
Option 1 - Do-Nothing (BAU)	$(604.23)	$-
Option 2A - Upgrade TX2 with protection in situ	$(15.12)	$589.11
Option 2B - Upgrade TX2 with protection in situ, 66kV Segmentation	$(15.12)	$589.11
Option 2C - Upgrade TX2 with protection in situ, 22kV segmentation	$(15.12)	$589.11
Option 2D - Upgrade TX2 with protection in situ, 66kV and 22kV segmentation	$(7.82)	$596.41
Option 3A - Upgrade TX2 with new protection cabinet	$(15.12)	$589.11
Option 3B - Upgrade TX2 with new protection cabinet, 66kV Segmentation	$(15.12)	$589.11
Option 3C - Upgrade TX2 with new protection cabinet, 22kV segmentation	$(15.12)	$589.11
Option 3D - Upgrade TX2 with new protection cabinet, 66kV and 22kV segmentation	$(7.82)	$596.41
Option 4A - Upgrade TX2 with new protection in new control room	$(15.12)	$589.11

OPTION	NPC ($M, 2015 DIRECT)	NPV ($M, 2015 DIRECT)
Option 4B - Upgrade TX2 with new protection in new control room, 22kV segmentation (partly indoor)	$(15.12)	$589.11
Option 4C - Upgrade TX2 with new protection in new control room, 22kV segmentation (indoor)	$(14.13)	$590.11
Option 4D - Upgrade TX2 with new protection in new control room, 66kV segmentation and 22kV segmentation (partly indoor)	$(7.82)	$596.41
Option 4E - Upgrade TX2 with new protection in new control room, 66kV segmentation and 22kV segmentation (indoor)	$(7.49)	$596.74
Option 5 - 22kV load reconfiguration	$(276.02)	$328.21
Option 6 - Embedded Generation	$(604.23)	-
Option 7 - Demand Management	$(604.23)	-
Option 8 - Uprate transformer to cyclic rating	$(604.23)	-
Option 9 - Load transfers	$(604.23)	-
Option 10 - Lightning mast	$(604.23)	-
Option 11 - Balance load - taps	$(604.23)	-
Option 12 - Bird Proofing	$(604.23)	-

Appendix A

RISK ANALYSIS

Table 4.15: Qualitative risk analysis

OPTION	RISK	DESCRIPTION	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Option 1 - Do-Nothing (BAU)	N/A	No specific identified risk	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
Option 2A - Upgrade TX2 with protection in situ	Construction	May require protection of TX2 to be out of service for duration of cut-over, which is likely to result in the whole station outage (2 weeks outage)	$-	$-	$7,500,000	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Construction	May require replacements of all wiring on panel (brittle condition)	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Construction	Possibility of asbestos breach, causing construction delay and increased construction costs	$-	$-	$1,417,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Access	There are access issues to route cables	$-	$-	$412,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Safety	Manual switching of increased load may result in flashing, serious injury	$-	$-	$1,417,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Operational	Access issues for maintenance of cables	$-	$-	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200
Option 2B - Upgrade TX2 with protection in situ, 66 kV Segmentation	Construction	May require protection of TX2 to be out of service for duration of cut-over, which is likely to result in the whole station outage (2 weeks outage)	$-	$-	$7,500,000	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Construction	May require replacements of all wiring on panel (brittle condition)	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Construction	Possibility of asbestos breach, causing construction delay and increased construction costs	$-	$-	$1,417,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Access	There are access issues to route cables	$-	$-	$412,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Safety	Manual switching of increased load may result in flashing, serious injury	$-	$-	$1,417,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Operational	Access issues for maintenance of cables	$-	$-	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200
Option 2C - Upgrade TX2 with protection in situ, 22kV segmentation	Construction	May require protection of TX2 to be out of service for duration of cut-over, which is likely to result in the whole station outage (2 weeks outage)	$-	$-	$7,500,000	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-

OPTION	RISK	DESCRIPTION	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
	Construction	May require replacements of all wiring on panel (brittle condition)	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Construction	Possibility of asbestos breach, causing construction delay and increased construction costs	$-	$-	$1,417,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Access	There are access issues to route cables	$-	$-	$412,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Safety	Manual switching of increased load may result in flashing, serious injury	$-	$-	$1,417,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Operational	Access issues for maintenance of cables	$-	$-	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200
Option 2D - Upgrade TX2 with protection in situ, 66 and 22kV segmentation	Construction	May require protection of TX2 to be out of service for duration of cut-over, which is likely to result in the whole station outage (2 weeks outage)	$-	$-	$7,500,000	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Construction	May require replacements of all wiring on panel (brittle condition)	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Construction	Possibility of asbestos breach, causing construction delay and increased construction costs	$-	$-	$1,417,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Access	There are access issues to route cables	$-	$-	$412,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Operational	Access issues for maintenance of cables	$-	$-	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200	$4,200
Option 3A - Upgrade TX2 with new protection cabinet	Construction	Possibility of asbestos breach, causing construction delay and increased construction costs	$-	$-	$1,417,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Access	There are access issues to route cables	$-	$-	$412,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Access	Whilst there is space to install a protection panel, there are access issues to install the panel, route cables	$-	$-	$5,062,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Safety	Manual switching of increased load may result in flashing, serious injury	$-	$-	$1,417,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Operational	Access issues for maintenance of panel	$-	$-	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500

OPTION	RISK	DESCRIPTION	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Option 3B - Upgrade TX2 with new protection cabinet, 66 kV Segmentation	Construction	Possibility of asbestos breach, causing construction delay and increased construction costs	$-	$-	$1,417,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Access	There are access issues to route cables	$-	$-	$412,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Access	Whilst there is space to install a protection panel, there are access issues to install the panel, route cables	$-	$-	$5,062,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Safety	Manual switching of increased load may result in flashing, serious injury	$-	$-	$1,417,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Operational	Access issues for maintenance of panel	$-	$-	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500
Option 3C - Upgrade TX2 with new protection cabinet, 22kV segmentation	Construction	Possibility of asbestos breach, causing construction delay and increased construction costs	$-	$-	$1,417,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Access	There are access issues to route cables	$-	$-	$412,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Access	Whilst there is space to install a protection panel, there are access issues to install the panel, route cables	$-	$-	$5,062,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Safety	Manual switching of increased load may result in flashing, serious injury	$-	$-	$1,417,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Operational	Access issues for maintenance of panel	$-	$-	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500
Option 3D - Upgrade TX2 with new protection cabinet, 66 and 22kV segmentation	Construction	Possibility of asbestos breach, causing construction delay and increased construction costs	$-	$-	$1,417,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Access	There are access issues to route cables	$-	$-	$412,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Access	Whilst there is space to install a protection panel, there are access issues to install the panel, route cables	$-	$-	$5,062,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Operational	Access issues for maintenance of panel	$-	$-	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500	$94,500
Option 4A - Upgrade TX2 with	Construction	Possibility of geotechnical issue in new control room	$-	$-	$82,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-

OPTION	RISK	DESCRIPTION	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
new protection in new control room	Safety	Manual switching of increased load may result in flashing, serious injury	$-	$-	$1,417,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
Option 4B - Upgrade TX2 with new protection in new control room, 22kV segmentation (partly indoor)	Construction	Possibility of geotechnical issue in new control room	$-	$-	$82,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Safety	Manual switching of increased load may result in flashing, serious injury	$-	$-	$1,417,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Operational	Combination of indoor and outdoor switchgear increases switching time, fault finding time and maintenance	$-	$-	$337,500	$337,500	$337,500	$337,500	$337,500	$337,500	$337,500	$337,500	$337,500	$337,500	$337,500	$337,500	$337,500	$337,500	$337,500
Option 4C - Upgrade TX2 with new protection in new control room, 22kV segmentation (indoor)	Construction	Possibility of geotechnical issue in new control room	$-	$-	$82,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Safety	Manual switching of increased load may result in flashing, serious injury	$-	$-	$1,417,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
Option 4D - Upgrade TX2 with new protection in new control room, 66 segmentation and 22kV segmentation (partly indoor)	Construction	Possibility of geotechnical issue in new control room	$-	$-	$82,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Operational	Combination of indoor and outdoor switchgear increases switching time, fault finding time and maintenance	$-	$-	$337,500	$337,500	$337,500	$337,500	$337,500	$337,500	$337,500	$337,500	$337,500	$337,500	$337,500	$337,500	$337,500	$337,500	$337,500
Option 4E - Upgrade TX2 with new protection in new control room, 66 segmentation and 22kV segmentation (indoor)	Construction	Possibility of geotechnical issue in new control room	$-	$-	$82,500	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
Option 5 - 22kV load reconfiguration	N/A	No specific identified risk	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-