Jemena Electricity Networks (Vic) Ltd

2016-20 Electricity Distribution Price Review Regulatory Proposal

Revocation and substitution submission

Attachment 7-15 WSP Parsons Brinckerhoff - Independent review of Preston development strategy

Public

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JEMENA ELECTRICITY NETWORKS

PRESTON AREA NETWORK DEVELOPMENT STRATEGY

INDEPENDENT REVIEW

DECEMBER 2015

PRESTON AREA NETWORK DEVELOPMENT STRATEGY

INDEPENDENT REVIEW

Jemena Electricity Networks

Final Report

Project no: 2265052A
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WSP | Parsons Brinckerhoff
Level 15, 28 Freshwater Place
Southbank VIC 3006

Tel: +61 (3) 9861 1260
www.wspgroup.com
www.pbworld.com

QUALITY MANAGEMENT

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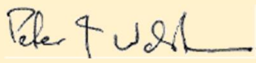
Signature				
Authorised by	A. McQueen	A. McQueen	A. McQueen	A. McQueen
Signature				
Project number	2265052A			

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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 convert 6.6kV assets in the Preston and East Preston areas (Preston Conversion project) to operate at 22kV.

In 'Jemena Electricity Networks (Vic) Ltd Regulatory Proposal 1 January 2016 - 31 December 2020' (JEN's Regulatory Proposal) JEN proposed the conversion to relieve capacity constraints as 22kV assets have about 3 times the capacity compared to 6.6kV assets. The conversion program, which commenced in 2008, was reviewed in 2015 and confirmed as the preferred option.

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).

WSP | Parsons Brinckerhoff undertook an independent review of JEN's proposed Preston Conversion Project. The options presented by JEN appear to be correctly structured to address the issues caused by assets in poor condition, particularly at zone substations Preston and East Preston. They also address capacity constraints on the 6.6kV network that is preventing further load to be connected at an efficient cost. In developing options to address these issues, the logical approach is to develop replacement options that also consider the future augmentation requirements. This is the approach taken by JEN. WSP | Parsons Brinckerhoff concludes that JEN has appropriately considered the key drivers.

JEN developed seven options in response to the drivers. However, the suite of options did not consider non-standard substation designs that might have reduced the overall scope of the required works. JEN also did not include evidence for the optimal timing of options. WSP | Parsons Brinckerhoff considers that it is not clear that the most prudent option had been selected.

WSP | Parsons Brinckerhoff developed augmentation options that consider the whole of life cycle costs of future replacements and the potential impact of asset failures. In addition to the do-nothing option, these options included the two key options considered by JEN:

- Option 2: Replacement of 6.6 kV distribution assets
- Option 3: Conversion of the 6.6 kV network to 22 kV using standard design substations

and two new options:

- Option 4: Conversion of the 6.6 kV network to 22 kV using non-standard design substations
- Option 5: Conversion of the 6.6 kV network to 22 kV using standard design substations, with load transfers.

Our option analysis, which includes the reliability impacts of potential asset failures and capacity constraints to determine the optimal timing for each option, clearly shows that the greatest benefit will be realised by continuing with JEN's preferred option to undertake the conversion program (Option 3) using standard design substations. This option also has the lowest cost of $45.2m (direct un-escalated real $2015) of which $25.8m is required in the period 2016-20.

Our analysis shows that substantial load is at risk currently, valued at $39.8m, which exceeds the cost of the preferred option on an NPV basis ($35m). WSP | Parsons Brinckerhoff concludes that the works should be carried out as soon as is practicable so as to reduce the risk.

1 PURPOSE OF REPORT

The purpose of this report is to provide an independent assessment of Jemena Electricity Networks' (JEN) proposal to convert 6.6kV assets in the Preston and East Preston areas to operate at 22kV. It provides an independent view on:

- what the drivers are and their implications
- the 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 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 rejected the expenditure related to JEN's proposed Preston Conversion project. JEN is required to submit a response to the AER's Preliminary Decision paper by 6 January 16.

2.1 JEN'S PROPOSAL

In its 2015 Network Development Strategy paper "Preston Area Conversion", JEN set out seven options to address declining asset condition and forecast capacity constraints. The work to address these issues was started in 2008 and was reviewed in 2015.

The preferred option is to convert all 6.6kV feeders from the existing zone substations (ZSS) at Preston (P) and East Preston (EP) to operate at 22kV. This requires the construction of two new 66kV to 22kV zone substations and the retirement of existing 6.6kV substations P and EP. These substations are in poor condition and the need to remove them from service is driving the timing of the works.

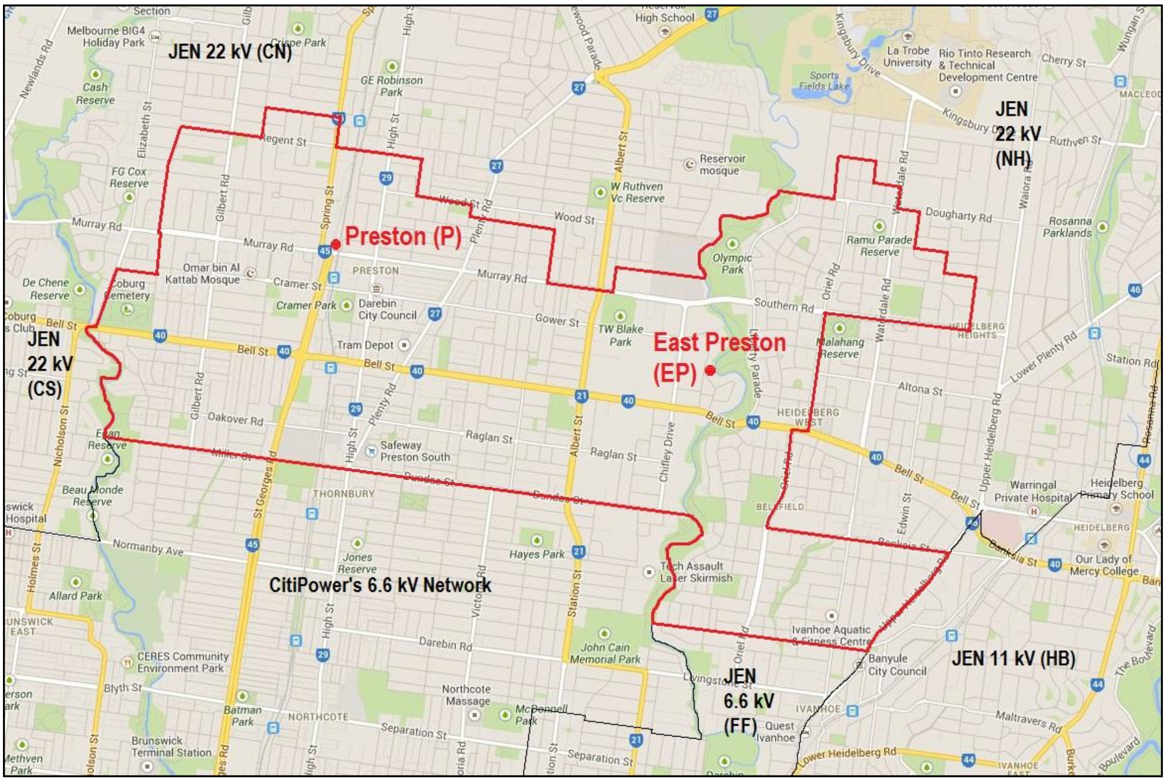

Figure 1 Map

Works completed to date are the conversion of feeders in stages 1, 2 and 3 at P and stages 1, 2 and 3 at EP, including the establishment of a new 66kV to 22kV zone substation EPN on vacant land on the existing EP site. The cost of these works is estimated at $26.7m[1] ($2014).

JEN included an amount of $33.5m ($2014 escalated with overheads) in its regulatory proposal for the 2016-2020 period. A further $25.3m ($2014 escalated with overheads) is required to complete the works in the 2021-2022 period.

2.2 AER'S PRELIMINARY DECISION

The AER did not include the proposed capex of $33.5m ($27.5m $2015 direct escalated cost only) for this project in its alternative estimate of JEN's augex requirements on the basis that 'we are not satisfied that this project is justified by the need to expand the capacity or capability of the network. It is not clear that Jemena would have proposed this augmentation project if it were not for its assessment of the condition of the relevant assets' (p.6-53).

The AER also expressed concerns with the options analysis:

→ Jemena's planning approach for the Preston conversion was largely deterministic and was based on the physical condition of the assets instead of the reliability performance of the assets. This approach does not comply with Jemena's Augmentation Planning Criteria to use probabilistic planning method for zone substation and HV feeder augmentations. Jemena has not provided evidence that the reliability performance of the Preston zone substation and surrounding feeder network has been deteriorating over the recent period or that Jemena is unable to maintain reliability levels over the 2016–20 period without

[1] Nominal dollars as incurred at the time of project completion.

replacing assets. This contrasts with Jemena's probabilistic planning for its other augmentation projects where it conducted cost benefit analysis and considered the cost of reliability to consumers (e.g. VCR).

- Jemena dismissed other potential credible options that will alleviate capacity concerns in 6.6kV feeders and ease pressure of aging assets. This included transferring load to the new East Preston zone substation (which has three new 22kV feeders that are available to pick up load), upgrading feeder sections where capacity constraints exist, building new feeder ties to improve load sharing among feeders, and adopting non-network options to address potential reliability and capacity shortages. Jemena appeared to largely dismiss these options because they do not address the proposed risk due to the condition of the assets. However, as we state above, Jemena has not demonstrated the expected consequences from asset condition in terms of reliability performance. These alternative options may be prudent lower cost options that address any expected performance degradation from capacity concerns of the 6.6kV feeders and aging assets and consistent with good industry practice (p.6-54).

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)." (p.6-54).

3 REVIEW OF JEN'S PROPOSAL

WSP | Parsons Brinckerhoff undertook an independent review of JEN's proposal to convert 6.6kV assets in the Preston and East Preston areas to operate at 22kV. In this section, we present the outcomes of this review.

3.1 DRIVERS

In 2008, the key driver was to meet forecast increases in demand. Due to the relatively low capacity of 6.6kV feeders, multiple feeders had been established, often on the same overhead pole line. Congestion of overhead assets also resulted in the establishment of 6.6kV underground feeders at a correspondingly higher cost. It was determined that new capacity could not be efficiently meet by further expansion of the 6.6kV network and a conversion to 22kV was adopted as the preferred option.[2]

In 2014-15, a review of the conversion strategy was undertaken. The review confirmed that the conversion strategy remained the preferred option. The key drivers as stated by JEN were a need to replace assets that are in poor condition, constraints on ZSS Coburg South (CS) due to forecast demand increases, and an inability to economically supply further loads from the 6.6kV network due to congestion in overhead line routes.

To assess the prudency of JEN's approach, WSP | Parsons Brinckerhoff listed the network constraints that existed in 2014. Table 3.1 sets out the constraints and their critical dates.

[2] 22kV feeders have approximately 3 times the capacity of 6.6kV feeders.

Table 3.1 Constraints in Preston area

CONSTRAINT	IMPACT	TIMING	COMMENT
Deteriorating asset condition at ZSS P	Potential asset failures resulting in significant loss of supply for an extended period. Potential failure of the 6.6kV switchboard also carries a substantial safety risk to personnel working in the vicinity	2015	Optimal timing based on reliability impacts. Cost of risk is currently estimated at $11.6m
Deteriorating asset condition at ZSS EP	Potential asset failures resulting in significant loss of supply for an extended period	2015	Optimal timing based on reliability impacts. Cost of risk is currently estimated at $28.0m
Load at ZSS CS is above N-1 rating[3]	Significant loss of supply under a contingency event	2015 N rating[4] exceeded in 2018	Deliberate load above normal to suit conversion program until ZSS PTN commissioned in 2018. Cost of risk is currently estimated at $0.03m but will rise substantially if the N rating is exceeded
6.6 kV distribution feeders are at or near maximum capacity	Inability to connect new customers at 6.6kV at an efficient cost	2008	Congestion of overhead lines means new major load in the 6.6kV areas may not be able to be connected until a conversion to 22kV is undertaken or would be via long underground cables from the adjacent 22kV network[5].
Insufficient spare capacity exists on feeders to cover emergency feeder outage conditions. This includes feeders from EP Zone Substation and surrounding 22kV feeders from Coburg North (CN), Coburg South (CS) and North Heidelberg (NH) due to the different voltage levels	Inability to restore supply to customers under single feeder outage condition during peak loading periods.	2008	Due to the different voltage levels in the area, there is insufficient feeder transfer capacity and operational flexibility to cover for feeder outage condition during peak times. This condition will worsen as the loading increase which would result in significant rotational loading shedding of customers. Cost of risk is currently estimated at $0.05m.
Electrical losses	Losses at 6.6kV are up to 9 times higher than at 22kV	N/A	For the Preston and East Preston areas, JEN has estimated that the reduction in electrical losses for 22kV compared to 6.6kV distribution will give a saving of about $225,000 per annum (at $30 per MWhr).

3 The N-1 rating (normal minus one) will allow all electrical load to be supplied following the loss of any one item of equipment

4 The N rating (normal) will allow all electrical load to be supplied only with all equipment in service.

5 An example provided by JEN is in 2007, just prior to the conversion project commencing, an extension of a 6.6kV feeder P59 was made to connect a new customer at a cost exceeding $1m (nominal). The cost today to connect to the 22kV system would be significantly reduced.

WSP I Parsons Brinckerhoff's assessment of the cost of risk suggests that the key driver is the need to replace assets that are in poor condition. It also shows a secondary driver is the forecast capacity constraints on the 22kV ZSS CS, and the lack of transfer capability to cover for single contingency feeder outage condition, created by the different voltage levels in the area. New customers in the 6.6kV areas may not be able to be connected until a conversion to 22kV is undertaken. The logical conclusion is to develop replacement options that also consider the future augmentation requirements. This is the approach taken by JEN. WSP | Parsons Brinckerhoff concludes that JEN has appropriately considered the key drivers.

3.2 OPTIONS DEVELOPMENT

JEN considered six options in addition to the do nothing base case.

- A. Conversion of the 6.6 kV network to 22 kV
- B. Replacement of 6.6 kV distribution assets
- C. Feeder Augmentation
- D. Zone Substation Augmentation
- E. Embedded Generation
- F. Demand Management
- G. Do Nothing or Deferral of Current Program.

These options were correctly structured for the entire program of works to address forecast capacity requirements and aged assets from 2015, ignoring the sunk cost of the conversion work to date.

3.2.1 JEN'S PREFERRED OPTION

JEN's preferred Option A considered two sub-options for maintaining reliability of supply to the Preston area during the conversion works, but did not include:

- timing options for the Preston area based on the impact on consumer reliability and safety
- load transfer options to delay the need to install the new PTN zone substation.

Option A also establishes a higher ZSS capacity than is required to supply the Preston and surrounding area. Table 3.2 shows that the proposed arrangement of installing two 20/33MVA transformers at both PTN and EPN will increase the N-1 capacity from 184 MVA to 190 MVA, when the capacity required in 2024 is only 154 MVA.

Table 3.2 Area demand compared to zone substation capacity (CN, CS, EP, P)

DEMAND ASSUMPTION	DEMAND			CURRENT CAPACITY		PROPOSED CAPACITY	
	2015	2020	2024	N-1	N	N-1	N
50%POE	152.1	153.1	153.9	184.2	224.0	190.7	285.0
10% POE	166.3	168.4	170.1	184.2	224.0	190.7	285.0

A check of capacity at the 10% POE level (170 MVA) against the N rating (224 MVA) again shows that more than sufficient capacity is proposed.

JEN appears to have included the additional capacity in its proposal for the upcoming regulatory period because of:

- a lack of viable options to make use of the spare capacity at ZSS CN to supply into the Preston area
- the staging of the works to allow replacement of assets at ZSS P as soon as possible.

Existing 22kV feeder ties between ZSS CN and ZSS CS have already been configured to provide the maximum transfer possible. To make use of the spare capacity at ZSS CN, new bulk supply feeders would need to be constructed. JEN advised that it did not include this as a viable option because of the high cost of establishing such feeders. However, the potential deferral of works to establish PTN or EPN were not considered in a cost/benefit analysis and hence it is not clear that this option is not economically viable.

The staging of the works has been designed to replace assets at ZSS P first as these are in poor condition. If it was possible to decommission ZSS EP before ZSS P, then the works could be rescheduled to avoid the installation of ZSS PTN entirely. This would require a third transformer at CS (or possibly at EPN), to meet demand requirements to 2024, reducing the “area” N-1 capacity to about 170 MVA, more closely matching the required capacity. ZSS PTN could then be established when required based on demand forecasts (about 2030). WSP | Parsons Brinckerhoff was, however, unable to develop alternative options that avoided the need to build ZSS PTN given the need to replace assets at ZSS P first and concludes that there are no alternative staging options that JEN could have considered that would reduce the scope of works required.

We were able to develop an option that avoided the need to install four new 66kV/22kV transformers. This option establishes the new ZSS EPN as a two 20/33 MVA transformer station and PTN as a single 20/33 MVA transformer station with a tie line established to link the 22kV buses. In the event of the loss of a transformer at PTN, all load would be resupplied via the tie line. While this option is technically challenging, the closeness of the two ZSS site (3.5km apart) makes this option potentially viable. The tie line would be established as a part overhead and part underground line of capacity of about 30 MVA, operated as normally open at one end with an auto change-over scheme. This option is not a standard design and carries some operational risk.

WSP | Parsons Brinckerhoff concludes that:

- as JEN only considered stations of standard design and did not include a load transfer option in its economic analysis, it may not have identified all viable technical solutions, and hence the most prudent option may not have been selected
- as the timing of the works has not been based on reliability impacts, the timing of the preferred option may not be optimal.

3.2.2 OTHER OPTIONS

WSP | Parsons Brinckerhoff examined the other options considered by JEN.

Option B replaces like for like. It does not provide for future capacity increases as would be required to connect the new large customers in the Preston area who are currently negotiating supply agreements. JEN appears to have correctly assessed this option, in particular the difficulty in replacing the ZSS assets on the same sites and the limitations associated with continuing congestion of 6.6kV assets in the streetscape.

Option C feeder augmentations addresses only a part of the issue being the lack of feeder capacity. While the works associated with this option were not originally costed[6], they appear to be non-viable as they would involve significant expenditures on new underground cables (no additional overhead line routes are available) that would not be required once the conversion was completed. This is because the conversion triples the feeder capacity, meaning that additional line routes are not required in the final state of the network.

Option D addresses only a part of the issues being the overloading at Zone Substation CS. The overloading is a direct result of the conversion program competed to date as converted feeders are re-supplied at 22kV from ZSS CS. In the longer term, establishment of new ZSS PTN at 22kV will allow the loading on ZSS CS to be reduced to within normal operating parameters. Hence, this option to augment the capacity of ZSS CS is really a sub-option of Option A that has been rejected by JEN on a risk basis.

Options E Embedded generation and Option D Demand Management were found not to be feasible options to address the constraints at P and EP Zone Substations, as they fail to address the primary driver for the program, the aging and deteriorating condition of the 6.6kV assets.

WSP | Parsons Brinckerhoff concludes that JEN's assessment of the other options is appropriate.

3.3 SUMMARY

Based on an assessment of the drivers, and the options identification and analysis, WSP | Parsons Brinckerhoff concludes that:

- JEN may not have selected the most prudent option as it did not consider stations of non-standard design and did not include a load transfer option in its economic analysis
- as the timing of the works has not been based on reliability impacts, the timing of the preferred option may not be optimal.

4 RECOMMENDATIONS

This section includes WSP | Parsons Brinckerhoff's independent assessment of the drivers, options and analysis for the Preston and East Preston areas.

4.1 DRIVERS

WSP | Parsons Brinckerhoff has established that the key drivers are:

- Poor condition of equipment at zone substations P and EP. This is an asset replacement driver.
- Forecast demand in the Preston area. This is an augmentation driver.

Appendix A provides asset condition information[7] that shows that ZSS assets in poor condition at ZSS P must be addressed as soon as possible, closely followed by assets at ZSS EP. Assets

[6] JEN have now costed Option C at $7.9m (Business Case, Preston (P) / East Preston (EP) Conversion Stage 4)

[7] See also asset condition information in the Jemena Preston Area Conversion Network Development Strategy, ELE PL 0029, 24 August 2015 – Appendix E Condition Monitoring Reports

with a Health Index of 7 are considered to be in poor condition with the probability of failure in service rising rapidly with higher values. Table 4.1 shows the percentage of assets above 7.This does not include assets already taken out of service at ZSS P as a result of the conversion program commenced in 2008.

Table 4.1 Asset condition assessment

ZONE SUBSTATION	% ASSETS WITH A HEALTH INDEX ABOVE 7		
	2014	2017	2022
P	30%	50%	-
EP 'A'	17%	-	88%
EP 'B'	5%	-	80%

Appendix B provides demand forecasts that show that ZSS CS currently exceeds its N-1 rating and will exceed its N rating in 2018, requiring load shedding from that date.

In effect, asset replacement is driving the timing of the works with the augmentation driver affecting the range of replacement options that are prudent.

4.2 OPTION ANALYSIS

WSP | Parsons Brinckerhoff developed the following options to address the identified drivers:

- Option 1: Do nothing
- Option 2: Replacement of 6.6 kV distribution assets
- Option 3: Conversion of the 6.6 kV network to 22 kV using standard design substations
- Option 4: Conversion of the 6.6 kV network to 22 kV using non-standard design substations
- Option 5: Conversion of the 6.6 kV network to 22 kV using standard design substations, with load transfers.

Options 2 and 3 are the same as options proposed by JEN, while options 4 and 5 are new. Table 4.2 describes each option while Appendix C sets out the scope and cost breakdown of the new options.

Table 4.2 Options identification

OPTION	DESCRIPTION
Option 1 - Do-Nothing (BAU)	This option establishes the risk profile of the current arrangement. It is not considered a viable option, given that ZSS CS is operating above its N-1 capacity rating and is forecast to exceed its N capacity rating in 2018. Deteriorating asset condition will result in a rising probability of asset failure, particularly at ZSSs P and EP, with impacts on supply reliability and safety.
Option 2 - Replacement of 6.6 kV distribution assets	This option is the same as JEN's Option B. It involves retaining 6.6 kV as the primary distribution voltage level for the Preston and East Preston areas and replacing the ageing 6.6 kV assets progressively as end of life is reached.
Option 3 - Conversion of the 6.6 kV network to 22 kV using standard design substations	This option is the same as JEN's preferred option, establishing 2 new 66kV to 22kV substations both with two 20/33 MVA transformers on the sites of current ZSSs P and EP. All existing 6.6kV feeders would be converted to operate at 22kV.
Option 4 - Conversion of the 6.6 kV network to 22 kV using non-standard design substations	This option establishes one new 66kV to 22kV substation with two 20/33 MVA transformers on the EP site and one new 66kV to 22kV substation with one 20/33 MVA transformer on the P site. A 22kV tie line would link the 22kV busses via an auto changeover scheme. All existing 6.6kV feeders would be converted to operate at 22kV.
Option 5 - Conversion of the 6.6 kV network to 22 kV using standard design substations, with load transfers	Similar to option 3, this option makes use of load transfers to access spare capacity at ZSS CN/CS to provide an improved staging. This option establishes one new 66kV to 22kV substation with two 20/33 MVA transformers on the EP site and two bulk supply feeders to ZSS CN/CS. All existing 6.6kV feeders would be converted to operate at 22kV. ZSS PTN would not be built until 2020 (instead of 2018 per option 3).

4.2.1 NON-VIABLE OPTIONS

WSP | Parsons Brinckerhoff has identified a set of non-viable options, outlined in Table 4.3 based on the option's ability to realise benefits.

Table 4.3 Preliminary options analysis

OPTION	REASON FOR NON-VIABILITY
Demand side responses	Insufficient potential capacity – will not address asset condition issues
Generation	No generation responses received – will not address asset condition issues

Demand side responses have the potential to reduce demand at peak periods, which would not only reduce the capacity required to be replaced but would provide more flexibility in the staging of the works. To relieve overloading at ZSS CS would require a minimum of 7 MVA (at 50% POE and carrying some risk of load shedding at a 10% POE), although a reduction of 3 MVA would be useful in staging. In our experience, however, reductions of this amount are unlikely to be realised.

No demand-side or generation proponents were identified during public consultation on the conversion project.

4.2.2 VIABLE OPTIONS

An analysis of the options was undertaken considering the reliability impacts. Table 4.4 shows that Option 3 has the most favourable NPV and the lowest cost.

Table 4.4 NPV of options

OPTION	COST ($M DIRECT, 2015)	NET PRESENT VALUE ($M, 2015)
Option 1: Do nothing	0	(2,517)
Option 2: Replacement of 6.6 kV distribution assets	73.8	(242)
Option 3: Conversion of the 6.6 kV network to 22 kV using standard design substations*	45.2	**(206)**
Option 4: Conversion of the 6.6 kV network to 22 kV using non-standard design substations	46.9	(207)
Option 5: Conversion of the 6.6 kV network to 22 kV using standard design substations, with load transfers	49.5	(410)

** Note: excludes costs incurred to 2015*

With the information available we have undertaken a quantitative analysis, refer Table 4.5. The analysis includes the reliability impacts of asset failures costed at the Value of Consumer Reliability. Assumptions in the analysis are set out in section 4.4. Table 4.5 shows that the biggest risk is a failure of the 6.6kV bus at ZSS EP ‘A’, closely followed by a bus failure at ZSS EP ‘B’. ZSS EP represents the highest risk even though the transformers at ZSS P are in poor condition because the load on ZSS P has been substantially reduced as a part of the conversion program.

Table 4.5 Load at risk assessment – do nothing

ZONE SUBSTATION	RISK FACTOR	LOAD AT RISK 2015 ($M)	LOAD AT RISK 2022 ($M)
CS	transformer fail	0.0	0.6
CN	transformer fail	0.1	0.6
EP'A'	transformer fail	1.7	9.4
	switchboard fail	0.0	0.0
	bus fail	14.8	14.2
EP'B'	transformer fail	0.0	0.0
	switchboard fail	0.0	11.2
	bus fail	11.5	11.2

ZONE SUBSTATION	RISK FACTOR	LOAD AT RISK 2015 ($M)	LOAD AT RISK 2022 ($M)
EPN	transformer fail	-	-
P	transformer fail	2.6	13.2
	switchboard fail	0.0	0.0
	bus fail	9.0	9.2
TOTAL		**39.8**	**69.7**

Source: WSP | Parsons Brinckerhoff analysis

The table shows that substantial load is at risk currently valued at $39.8m and rising to $69.7m in 2022. Comparing the value of energy at risk against the cost (on an NPV basis) of each project option will indicate the optimal timing of the option. Figure 2 shows that the value of energy at risk already exceeds the cost of options 3, 4 and 5 and will exceed the cost of option 2 in 2017. WSP | Parsons Brinckerhoff concludes that the works should be carried out as soon as is practicable.

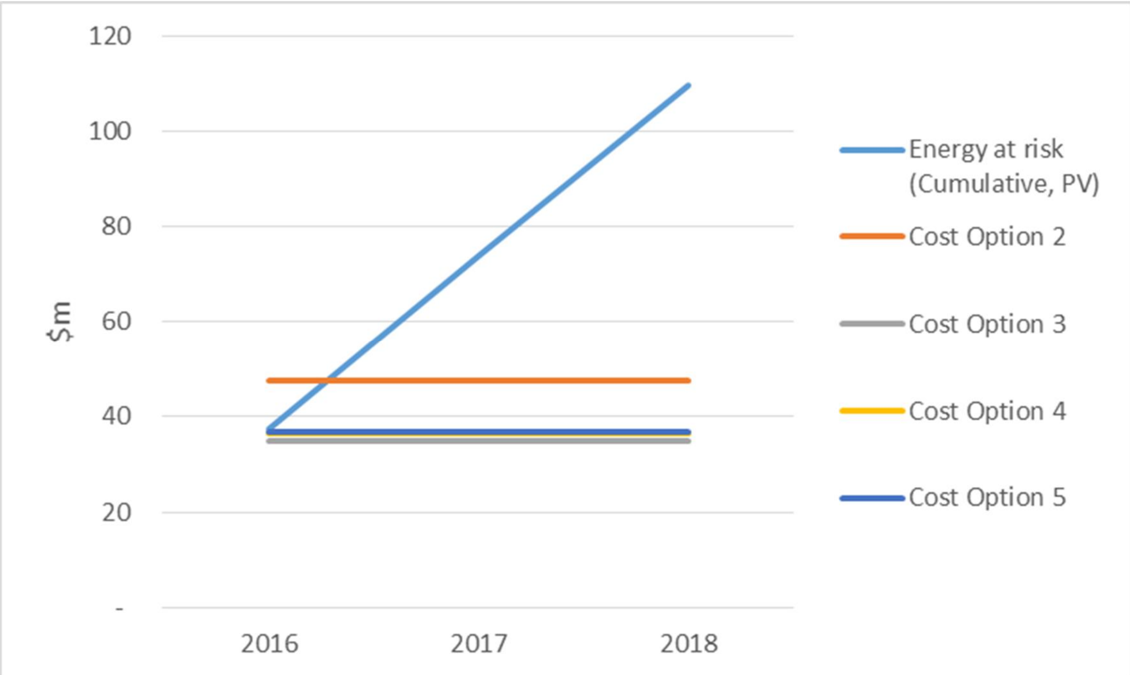

Figure 2 Energy at risk vs option cost

4.2.2.1 PREFERRED OPTION

Option 3 Conversion of the 6.6 kV network to 22 kV using standard design substations is the preferred option. The staging for this option is shown in Table 4.6.

Table 4.6 Staging for preferred option from 2016

STAGE	DATE	COMMENT
P & EP Stage 4	2016	Conversion of P & EP feeders and distribution substations
P Stage 5	2017	Conversion of remaining P feeders and distribution substations in order to retire and rebuilt P
P Stage 6	2018	Decommission P Zone Substation & construct new two 66/22 kV transformer PTN Zone Substation
EP Stage 5	2019	Conversion of EP A feeders and distribution substations
EP Stage 6	2021	Decommission of EP 'A' zone substation & install 2nd transformer at EPN zone substation
EP Stage 7	2022	Conversion of EP B feeders and distribution substations
EP Stage 8	2022	Conversion of EP feeders and distribution substations. Decommission of EP 'B' zone substation

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

Table 4.7 Expenditure profile for preferred option

Expenditure Type ($m, 2015 real)	2016	2017	2018	2019	2020	Total 2016-20	Post 2020
Capex	4.85	3.74	12.19	$5.02	0	25.80	19.39
Opex	0	0	0	0	0	0	0
Total	4.85	3.74	12.19	5.02	0	25.80	19.39

4.3 COMMENTS ON AER'S PRELIMINARY DECISION

The AER stated that it was not satisfied that this project is justified by the need to expand the capacity or capability of the network. It made several statements to support this view. WSP | Parsons Brinckerhoff's comments on these statements are presented below.

Statement 1 - It is not clear that Jemena would have proposed this augmentation project if it were not for its assessment of the condition of the relevant assets' (p.6-53).

WSP | Parsons Brinckerhoff agrees with the AER that the key driver for the timing of those expenditures proposed for the 2016-2010 period is replacement of assets in poor condition. This is different to the original driver when the project was initiated in 2008, which was driven by augmentation requirements.

Options to replace assets in poor condition, however, must consider the future capacity constraints and how these might be addressed to achieve lowest life cycle costs. The need to meet potential load increases of several MVA (JEN has already had enquires totalling more than 3.5 MVA) with an inability to establish further network capacity at 6.6kV at a reasonable cost, means that a like for like replacement is not a viable replacement option. For instance, JEN has already responded to several requests for new connections where the 6.6kV option cost was in excess of $1.5m and 22kV options were implemented.

Statement 2- The AER also stated that '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' (p.6-54).

A non-like for like replacement option is required to address forecast capacity constraints. The cost of the replacement assets at 22kV is expected to be slightly higher than assets at 6.6kV, but will provide the future required capacity at a much lower cost. Overall, the total cost is minimised, meeting the requirements of the capex objectives. This is demonstrated by comparing Option 2 (like for like replacement at 6.6kV at a cost of $73.8m real, 2015 direct) that does not provide for any future capacity increases and Option 3 (conversion to 22kV at a cost of $45.2m real, 2015 direct) which does provide additional capacity.

Statement 3 – Jemena's planning approach for the Preston conversion was largely deterministic and was based on the physical condition of the assets instead of the reliability performance of the assets. This approach does not comply with Jemena's Augmentation Planning Criteria to use probabilistic planning method for zone substation and HV feeder augmentations. Jemena has not provided evidence that the reliability performance of the Preston zone substation and surrounding feeder network has been deteriorating over the recent period or that Jemena is unable to maintain reliability levels over the 2016–20 period without replacing assets. This contrasts with Jemena's probabilistic planning for its other augmentation projects where it conducted cost benefit analysis and considered the cost of reliability to consumers (e.g. VCR).

A reliability assessment is provided in section 4.2.2 that shows the cost of load at risk currently exceeds the cost of the works to address the issues. There is no doubt that the works are required to be undertaken as soon as is possible.

Statement 4 – Jemena dismissed other potential credible options that will alleviate capacity concerns in 6.6kV feeders and ease pressure of aging assets. This included transferring load to the new East Preston zone substation (which has three new 22kV feeders that are available to pick up load), upgrading feeder sections where capacity constraints exist, building new feeder ties to improve load sharing among feeders, and adopting non-network options to address potential reliability and capacity shortages. Jemena appeared to largely dismiss these options because they do not address the proposed risk due to the condition of the assets. However, as we state above, Jemena has not demonstrated the expected consequences from asset condition in terms of reliability performance. These alternative options may be prudent lower cost options that address any expected performance degradation from capacity concerns of the 6.6kV feeders and aging assets and consistent with good industry practice (p.6-54).

The current spare capacity created by installing new ZSS EPN is required to offload ZSS P and is not available to meet new loads or increases in demands as is suggested by the AER. The staged approach includes:

- → Commission EPN with one transformer (in progress)
- → Convert remaining 6.6kV feeders from P and resupply from EPN (as a one transformer station, EPN will have load at risk of a single contingency)
- → Demolish ZSS P and install new ZSS PTN on the same site
- → Convert 6.6kV feeders from EP 'A' supplied from ZSS PTN

- Demolish EP ‘A’ and install a second transformer at EPN on the demolished site
- Convert EP ‘B’ feeders and resupply from EPN
- Convert remaining feeders from EP ‘B’
- Demolish EP ‘B’.

As the conversion progresses, the greater capacity of the converted feeders to 22kV will provide for potential load increases.

Building new feeder ties to improve load sharing among feeders has been discussed as Option 5 and shown to be non-preferred on a cost/benefit basis.

Demand side options have been discussed in section 4.2.1 and shown not to be viable.

4.4 ASSUMPTIONS MADE

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

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 6.25% has been utilised.

STATION FAULTS AND RELIABILITY BASED UNSERVED ENERGY

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

- A station fault on a circuit breaker etc. is repaired in 1 hour (on average)
- A fault on a 6.6kV bus will render the bus unserviceable (with a correspondingly low probability of 1%). This is based on two bus failures (not involving a loss of load) having occurred in the last 7 years, indicating that the bus is in a deteriorated state.

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. Conditional probability has then been applied to the Weibull curve to reflect the change in probability of a specific asset given the asset has reached its current age, effectively reducing the likelihood of failure.

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. Conditional probability has then been applied to the Weibull curve to reflect the change in probability of a specific asset given the asset has reached its current age, effectively reducing the likelihood of failure.

DEMAND BASED UNSERVED ENERGY

The options analysis in this report utilises the JEN calculation methodology (based on JEN Network Augmentation Planning Criteria document number JEN PR 0007) for Load at Risk calculations.

Appendix A

ASSET CONDITIONS

Table 1 Asset condition ZSS P

ASSET DESCRIPTION	MANUFACTURER	TYPE/ MODEL	YEAR	AGE	2014 HEALTH INDEX	2017 HEALTH INDEX
1-2 6.6KV BUS TIE CB	English Electric	OLX-SERIES-1	1964	50	6.60	7.32
1-2 66KV BUS TIE CB	ASEA	HKEYC 60/800	1966	48	5.50	6.08
2-3 6.6KV BUS TIE CB	English Electric	OLX-SERIES-1	1958	56	6.60	7.24
FDR P 56 CB	English Electric	OLX-SERIES-1	1958	56	6.60	7.24
FDR P 57 CB	English Electric	OLX-SERIES-1	1958	56	10.00	11.13
FDR P 58 CB	English Electric	OLX-SERIES-1	1958	56	6.33	6.93
FDR P 59 CB	English Electric	OLX-SERIES-1	1958	56	6.33	6.93
FDR P 61 CB	English Electric	OLX-SERIES-1	1976	38	4.27	4.89
FDR P 62 CB	English Electric	OLX-SERIES-1	1958	56	6.33	6.93
FDR P 63 CB	English Electric	OLX-SERIES-1	1958	56	6.60	7.24
FDR P 65 CB	English Electric	OLX-SERIES-1	1966	48	8.80	9.92
FDR P 66 CB	English Electric	OLX-SERIES-1	1959	55	8.80	9.77
NO.1 CAP BANK CB	EATON HOLEC	NVL 18CA-1716	2008	6	0.66	0.78
NO.1 TRANSFORMER NO.1 BUS 6.6KV CB	English Electric	OLX-SERIES-1	1958	56	6.33	6.93
NO.1 TRANSFORMER NO.2 BUS 6.6KV CB	English Electric	OLX-SERIES-1	1958	56	6.33	6.93
NO.2 TRANSFORMER NO.2 BUS 6.6KV CB	English Electric	OLX-SERIES-1	1958	56	6.33	6.93
NO.2 TRANSFORMER NO.3 BUS 6.6KV CB	English Electric	OLX-SERIES-1	1959	55	6.33	6.94
NO.1 6.6KV BUS	English Electric	OLX	1958	56	8.25	9.12
NO.2 6.6KV BUS	English Electric	OLX	1958	56	8.25	9.12
NO.3 6.6KV BUS	English Electric	OLX	1958	56	8.25	9.12

Source: JEN

Table 2 Asset condition ZSS EP "A"

ASSET DESCRIPTION	MANUFACTURER	TYPE/ MODEL	YEAR	AGE	2014 HEALTH INDEX	2022 HEALTH INDEX
1-2 6.6KV BUS TIE CB	English Electric	OLX-SERIES-1	1960	54	6.05	7.74
1-2 66KV BUS TIE CB	ASEA	HKEYC 60/800	1966	48	5.50	7.18
2-3 6.6KV BUS TIE CB	EMAIL	J18-LC	1970	44	4.74	6.42
2-3 66KV BUS TIE CB	AEI	LG4C/66G	1967	47	6.60	8.85
EP-APF 66KV CB	AEI	LG4C/66G	1967	47	6.60	8.85
FDR EP 11 CB	EMAIL	J18-LC	1971	43	5.56	7.49
FDR EP 16 CB	English Electric	OLX-SERIES-1	1963	51	6.88	9.04
FDR EP 17 CB	English Electric	OLX-SERIES-1	1970	44	6.37	8.67
FDR EP 18 CB	English Electric	OLX-SERIES-1	1970	44	6.37	8.67
FDR EP 2 CB	English Electric	OLX-SERIES-1	1967	47	6.33	8.44
FDR EP 20 CB	English Electric	OLX-SERIES-1	1967	47	8.80	12.18
FDR EP 3 CB	English Electric	OLX-SERIES-1	1967	47	6.33	8.44
FDR EP 4 CB	English Electric	OLX-SERIES-1	1967	47	6.33	8.44
FDR EP 7 CB	English Electric	OLX-SERIES-1	1967	47	6.33	8.44
FDR EP 9 CB	EMAIL	J18-LC	1975	39	4.50	6.36
NO.1 CAP BANK CB	English Electric	OLX-SERIES-1	1967	47	6.05	8.03
NO.1 TRANSFORMER 6.6KV CB 'A'	EMAIL	J18-LC	1971	43	5.01	6.81
NO.1 TRANSFORMER 6.6KV CB 'B'	English Electric	OLX-SERIES-1	1967	47	6.13	8.15
NO.3 CAP BANK CB	English Electric	OLX-SERIES-1	1963	51	6.33	8.25
NO.4 TRANSFORMER NO.1 BUS 6.6KV CB	English Electric	OLX-SERIES-1	1967	47	5.86	7.75
SUB P FDR CB	AEI	LG4C/66G	1971	43	5.83	7.90
NO.1 6.6KV BUS	English Electric	OLX	1967	47	7.14	9.66
NO.2 6.6KV BUS	English Electric	OLX	1967	47	7.14	9.66
NO.3 6.6KV BUS	English Electric	OLX	1967	47	7.14	9.66

Source: JEN

Table 3 Asset condition ZSS EP "B"

ASSET DESCRIPTION	MANUFACTURER	TYPE/ MODEL	YEAR	AGE	2014 HEALTH INDEX	2022 HEALTH INDEX
4-5 6.6KV BUS TIE CB	EMAIL	J18-LC	1967	47	5.48	7.19
5-6 6.6KV BUS TIE CB	EMAIL	J18-LC	1967	47	5.72	7.54
FDR EP 27 CB	EMAIL	J18-LC	1967	47	6.33	8.44
FDR EP 34 CB	EMAIL	J18-LC	1975	39	4.50	6.36
FDR EP 35 CB	EMAIL	J18-LC	1970	44	5.60	7.51
FDR EP 36 CB	EMAIL	J18-LC	1967	47	6.60	8.85
FDR EP 37 CB	EMAIL	J18-LC	1970	44	5.86	7.89
FDR EP 41 CB	EMAIL	J18-LC	1967	47	6.60	8.85
FDR EP 42 CB	EMAIL	J18-LC	1970	44	6.37	8.67
NO.2 TRANSFORMER 6.6KV CB 'A'	EMAIL	J18-LC	1967	47	6.13	8.15
NO.2 TRANSFORMER 6.6KV CB 'B'	EMAIL	J18-LC	1967	47	6.13	8.15
NO.3 TRANSFORMER NO.3 BUS 6.6KV CB	EMAIL	J18-LC	1970	44	5.04	6.79
NO.3 TRANSFORMER NO.4 BUS 6.6KV CB	EMAIL	J18-LC	1967	47	8.53	11.77
NO.4 CAP BANK CB	EMAIL	J18-LC	1978	36	4.19	6.13
NO.4 TRANSFORMER NO.6 BUS 6.6KV CB	EMAIL	J18-LC	1967	47	6.40	8.54
NO.6 CAP BANK CB	EMAIL	J18-LC	1978	36	4.37	6.38
NO.4 6.6KV BUS	Email	J18	1967	47	5.48	7.19
NO.5 6.6KV BUS	Email	J18	1967	47	5.48	7.19
NO.6 6.6KV BUS	Email	J18	1967	47	5.72	7.54
4-5 6.6KV BUS TIE CB	EMAIL	J18-LC	1967	47	5.48	7.19

Source: JEN

Appendix B

FORECAST LOADINGS ON SUBSTATIONS

Table 4 Forecast loadings on zone substations at 50% POE

ZONE SUBSTATION	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	N-1 RATING (MVA)	N RATING (MVA)	COMMENT
CN	62.8	60.8	58.7	58.1	57.6	57.8	57.8	57.9	57.9	57.6	72.5	93.0	
CS	48.3	49.5	52.2	54.3	55.1	55.6	55.9	56.2	56.5	56.6	42.2	60.0	N-1 rating is exceeded
EP A	17.4	17.1	16.9	16.7	16.4	16.4	16.4	16.4	16.4	16.3	22.5	22.5	
EP B	13.2	13.2	13.2	13.1	12.9	12.9	12.9	12.9	12.9	12.8	27.0	28.5	
P	10.4	10.3	10.3	10.3	10.3	10.4	10.4	10.5	10.5	10.5	20.0	20.0	one transformer is hot spare, so N rating same as N-1

Source: JEN

Table 5 Forecast loadings on zone substations at 10% POE

ZONE SUBSTATION	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	N-1 RATING (MVA)	N RATING (MVA)	COMMENT
CN	69.3	67.3	64.9	64.3	63.8	64.1	64.1	64.0	64.3	64.2	72.5	93.0	
CS	53.6	55.1	58.0	60.5	61.5	62.0	62.4	62.6	63.2	63.4	42.2	60.0	N rating is exceeded
EP A	18.1	17.9	17.6	17.5	17.2	17.2	17.2	17.2	17.2	17.2	22.5	22.5	
EP B	13.9	14.0	14.0	13.8	13.6	13.7	13.7	13.6	13.7	13.6	27.0	28.5	
P	11.4	11.3	11.3	11.3	11.4	11.4	11.5	11.5	11.6	11.6	20.0	20.0	one transformer is hot spare, so N rating same as N-1

Source: JEN

Appendix C

SCOPE OF OPTIONS 4 AND 5

Table 6 and **Table 7** show the breakdown of the cost and high level scope for the two new options 4 and 5.

Table 6 Scope for Option 4: Conversion of the 6.6 kV network to 22 kV using non-standard design substations

STAGE	COMPLETION DATE	COST DIRECT UN-ESCALATED REAL $2015	SCOPE
P & EP Stage 4	2016	$4.85M	Conversion of P & EP feeders and distribution substations from 6.6kV to 22kV
P Stage 5	2017	$3.74M	Conversion of remaining P feeders and distribution substations from 6.6kV to 22kV in order to retire and rebuilt P
P Stage 6	2018	$13.9M	Decommission P Zone Substation & construct one new 66/22 kV 30/33MVA transformer PTN Zone Substation and establish a 22kV bus tie with auto-changer over scheme between PTN and EPN zone substation. The bus tie is approximately 3.5km of overhead and underground line.
EP Stage 5	2019	$5.02M	Conversion of EP A feeders and distribution substations from 6.6kV to 22kV
EP Stage 6	2021	$7.05M	Decommission of EP 'A' zone substation & install a 2nd new 66/22 kV 30/33MVA transformer at EPN zone substation
EP Stage 7	2022	$8.94M	Conversion of EP B feeders and distribution substations from 6.6kV to 22kV
EP Stage 8	2022	$3.41M	Conversion of EP feeders and distribution substations from 6.6kV to 22kV. Decommission of EP 'B' zone substation.

Table 7 Scope for Option 5: Conversion of the 6.6 kV network to 22 kV using standard design substations, with load transfers

STAGE	COMPLETION DATE	COST DIRECT UN-ESCALATED REAL $2015	SCOPE
New CN & CS feeders	2016	$5.69M	Establish new CN and CS feeders including 3rd 22kV bus at CS. Each new feeder is approx. 4km of underground cable.
P Stage 4	2017	$2.30M	Conversion of P feeders and distribution substations from 6.6kV to 22kV
P Stage 5	2018	$3.76M	Conversion of remaining P feeders and distribution substations from 6.6kV to 22kV in order to retire and rebuilt P
P Stage 6	2019	$12.3M	Decommission P Zone Substation & construct two new 66/22 kV 30/33MVA transformers PTN Zone Substation
EP Stage 4	2020	$2.53M	Conversion of EP A feeders and distribution substations from 6.6kV to 22kV
EP Stage 5	2020	$4.83M	Conversion of remaining EP A feeders and distribution substations from 6.6kV to 22kV
EP Stage 6	2021	$6.90M	Decommission of EP 'A' zone substation & install a 2nd new 66/22 kV 30/33MVA transformer at EPN zone substation
EP Stage 7	2022	$9.05M	Conversion of EP B feeders and distribution substations from 6.6kV to 22kV
EP Stage 8	2023	$3.41M	Conversion of EP feeders and distribution substations from 6.6kV to 22kV. Decommission of EP 'B' zone substation.