Jemena Electricity Networks (Vic) Ltd

2016-20 Electricity Distribution Price Review Regulatory Proposal

Revocation and substitution submission

Attachment 7-13 WSP Parsons Brinckerhoff - Independent review of Flemington development strategy

Public

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JEMENA ELECTRICITY NETWORKS

FLEMINGTON ZONE SUBSTATION

INDEPENDENT ASSESSMENT OF SUPPLY CAPACITY LIMITATIONS

DECEMBER 2015

FLEMINGTON ZONE SUBSTATION

INDEPENDENT ASSESSMENT OF SUPPLY CAPACITY LIMITATIONS

Jemena Electricity Networks

Final Report

Project no: 2265052A
Date: December 2015

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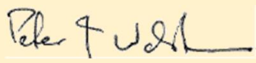
Signature				
Project number	2265052A			

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EXECUTIVE SUMMARY

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

In 'Jemena Electricity Networks (Vic) Ltd Regulatory Proposal 1 January 2016 - 31 December 2020' (JEN's Regulatory Proposal) JEN proposed to upgrade Flemington Zone Substation to address supply risks associated with capacity constraints and reliability. The AER reviewed JEN's proposal but did not include the proposed capex for this project in its alternative estimate of JEN's Augex requirements because it was not satisfied that replacement was necessary in the 2016–20 period to maintain network reliability, safety or security.

WSP | Parsons Brinckerhoff undertook an independent review of JEN's proposal. We found that the fundamental driver of the Flemington Zone Substation supply capacity limitation is insufficient capacity to meet existing and forecast demand increases. A secondary driver is declining reliability as a result of aged assets and safety. JEN developed five options in response to the drivers. The options presented by JEN appear to be correctly structured to address these issues. The preferred option identified by JEN was to upgrade the transformer cables and the 11 kV switchboards in a new building, with installation of a third switchboard, at a cost of $8.0m (real, 2015 direct un-escalated cost).

In our assessment, however, WSP | Parsons Brinckerhoff identified that the options presented by JEN do not encompass all viable technical solutions or consider the optimal timing of options, and hence it was not clear that the most prudent option had been selected.

WSP | Parsons Brinckerhoff identified eight options (with one option having 3 sub-options), each offering different benefits in terms of safety and reliability of supply risks. Three of these options are the same options as considered by JEN including their preferred option to upgrade the transformer cables and 11 kV switchboards in a new building; five are new options. An analysis of expected unserved energy under each option and the expenditure required shows that several options have similar NPVs of around $160m indicating that there is no immediately obvious preferred option:

- Option 4b – Replace the transformer cables and the 11 kV switchboards in the existing building plus installation of third switchboard
- Option 4c – Replace the transformer cables and the 11 kV switchboards in a new building
- Option 5 – Rebuild Flemington Zone Substation
- Option 6 – Install third transformer, third 11 kV switchboard, and two 66 kV bus-tie circuit breakers

To identify the preferred option a sensitivity analysis was performed. The results of the analysis show that Option 4b has a consistently higher NPV of all options and therefore the greatest benefit will be realised by replacing the transformer cables and the 11 kV switchboards in the existing building at a cost of $5.4m (real, 2015 direct un-escalated cost).

1 PURPOSE OF REPORT

The purpose of this report is to provide an independent assessment of JEN's proposal to upgrade the Flemington Zone Substation. 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 29 October 2015 (Preliminary Decision). In the Preliminary Decision, the AER rejected the expenditure related to the Flemington Zone Substation capacity constraint. JEN is required to submit a response to the AER's Preliminary Decision paper by 6 January 2016.

2.1 JEN'S PROPOSAL

The Flemington Zone Substation (FT) is supplied by two 66 kV lines from West Melbourne Terminal Station (WMTS) and consists of two 66/11 kV 20/30 MVA transformers, two 11 kV buses and ten 11 kV feeders. It supplies close to 15,000 domestic, commercial and industrial customers in the Flemington, Kensington, Ascot Vale and surrounding areas, with major customers including Flemington Racecourse and the Melbourne Showgrounds.

In its 2015 Network Development Strategy paper "Flemington Zone Substation" (ELE PL 0027), JEN set out five credible options to address supply risks associated with capacity constraints and reliability.

The preferred option identified in the Network Development Strategy was to replace the FT Zone Substation 11 kV assets, including:

- Installation of a new indoor 11 kV switch room.
- Installation of three new 11 kV switchboards, two to replace the existing aged assets and one new 11 kV switchboard to allow for connection of new 11 kV feeders.
- Installation of two new 11 kV transformer cables.

This option will remove the three most limiting constraints in supplying the Flemington area: thermal capacity of the 11 kV transformer cables, thermal capacity of the 11 kV transformer circuit breakers and thermal capacity, age, condition, and expansion capability of the existing 11 kV switchboards. This will increase the station's N-1 summer rating from 23.9 MVA to a cyclic rating of 34.8 MVA, and its system normal rating from 30.5 MVA to 45 MVA.

JEN included an amount of $8.0 million ($2015 real direct un-escalated) in its April 2015 regulatory proposal for the 2016-2020 period.

WSP | Parsons Brinckerhoff was advised by JEN that JEN's initial assessment was based on the nameplate capacity of assets, which did not include the system normal secure limits of the station. The system normal secure limit of the station is 30.5 MVA, which is limited by the 11 kV transformer circuit breakers and 11 kV buses. A system normal rating of 47.8 MVA was incorrectly applied in the initial assessment.

2.2 AER'S PRELIMINARY DECISION

The AER did not include the proposed capex of $10.2 million ($8.0 million $2015 real direct un-escalated) to upgrade FT in its alternative estimate of JEN's augex requirements on the basis that 'While we recognise that the assets in this zone substation will reach the end of their life within the next ten years, it is not clear that replacement is necessary in the 2016–20 period to maintain network reliability, safety or security' (P6-51).

The AER noted that FT is forecast to operate at 73 per cent capacity by 2020 under normal capacity conditions on its transformers which does not suggest that immediate augmentation is required to alleviate load pressure. However, JEN submitted that limited capacity on its 11 kV transformers cables and circuit-breakers means that the transformers cannot be fully utilised. This means that this zone substation currently operates above its N-1[1] emergency capacity' (P6-49).

The AER noted that 'Jemena has some limited ability to transfer load to adjacent substations with the completion of feeder upgrade works. This will allow Jemena to partially reduce congestion in this substation by up to 6 MVA (which is approximately 40 per cent of the expected demand in excess of capacity by 2020). Based on our review of Jemena's supporting documents and modelling, it appears that Jemena has not taken this ability to transfer load into its calculation of the cost to consumers due to capacity constraints' (P6-49).

The AER believes that the primary constraint is the capacity of the 11kV transformer cables and that augmentation of existing cables alone would increase the N-1 capacity of the substation from 23.9 MVA to 30.5 MVA, which is sufficient to remove capacity constraints and allow the zone substation transformers to be nearly fully utilised. This would be a lower cost option and could

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

potentially have less of an impact on supply security and reliability than more extensive augmentation and replacement work program (P6-50).

The AER proposed an alternative estimate of $0.32m which they consider reflects 'the prudent and efficient amount for Jemena to meet expected demand growth for the Flemington zone substation and maintain reliability and safety. This amount reflects the cost of replacing the 11 kV transformer cables which are the primary capacity constraint within the zone substation' (P6-49).

Whilst the AER understands the safety and security risks, it believes that the following reasons suggest JEN will be able to effectively and safely augment the existing transformer cables in this zone substation:

1. The work to replace existing transformer cables with higher capacity cables is similar to replacing faulty transformer cables. This would involve removing the existing cables from the cable ducts and installing new cables through these same ducts. Because this fault replacement work would not require concrete flooring excavation and other potentially dangerous civil works, it is not clear why installing a new transformer cable would require such civil works.
2. Similar transformer cable upgrades have been successfully performed by other distributors. In particular, ActewAGL installed two 11kV transformer cables in its Belconnen zone substation in 2013 which upgraded the emergency capacity in the substation (P6-50 and 51).

In concluding, the AER stated 'if Jemena considers that these assets need to be replaced within the 2016–20 period, it should submit more detailed information about the existing reliability performance of these assets and quantify the costs to consumers from any expected reliability deterioration (or alternatively provide information about why this capex cannot be considered within our repex allowance if necessary)' (P6-51).

3 REVIEW OF JEN'S PROPOSAL

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

3.1 DRIVERS

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

Table 3.1 JEN's identified drivers

Constraint	Impact
Capacity – zone substation asset utilisation	The supply capacity of FT Zone Substation is limited, during summer and winter peak demand periods, by the 'N-1' capability of the 11 kV transformer cables (23.9 MVA) and circuit breakers (30.5 MVA). The full capacity of the two existing transformers can therefore not currently be fully utilised. Based on JEN's 2014 Load Demand Forecasts Report, the: → 50% probability of exceedance (POE) summer maximum demand is forecast to increase from 33.7 MVA in 2016 to 35.6 MVA in 2021. → 10% POE summer maximum demand is forecast to grow from 36.7 MVA in 2016 to 38.9 MVA in 2021.

Constraint	Impact
Capacity – 11 kV feeder utilisation	The 11 kV feeders, particularly those supplying the central, north and north-east areas of the zone substation supply area, are already heavily utilised. The peak utilisation rate is expected to average approximately 67% across all feeders in 2015, with some feeders loaded considerably higher. These heavily loaded feeders (including FT01, FT02, FT09 and FT10) are not in the vicinity of lightly loaded feeders and therefore don't have transfer capacity to or from them, as such there is very minimal load transfer capacity available during feeder or station outage conditions.
Capacity – limited transfer and emergency back up	Since the 11 kV area supplied by FT is largely separated from the 22 kV network surrounding the east, west and south of FT, there is only limited opportunity to transfer capacity away from FT, currently limited to approximately 6 MVA during peak demand periods at FT. JEN does not currently have a spare 66/11 kV transformer that is suitable for installation at FT. Emergency backup capacity, in the case of a transformer outage, would therefore be limited to the remaining transformer's supply capacity until the faulted transformer could be repaired or replaced, or until supply could be reinstated by other support measures such as a temporary embedded generator installation.
Asset condition and safety	As the assets continue to age and their condition further degrades, it is expected that the likelihood they will fail will increase dramatically.

WSP \| Parsons Brinckerhoff's assessment shows that the key driver is the utilisation constraints, particularly due to the 11 kV transformer cables, with a secondary driver the need to replace assets that are approaching the end of service life. JEN have correctly assessed that supply capability is limited by a combination of insufficient thermal capacity to supply the forecast load, particularly under network outage (N-1) conditions, and the age and condition of the FT 11 kV switchboards, which are expected to result in an increased number of failures and an increased probability of a failure having a catastrophic result. As energy demand continues to grow, this is expected to result in an increase in the expected unserved energy.

WSP | Parsons Brinckerhoff notes that:

→ Capacity:
  - Further emphasis could be placed on capacity constraints resulting in a risk that JEN may not meet the growing demand and ensure the safety and security of supply to customers.
  - The risks associated with heavy utilisation of FT feeders have not been adequately considered in the Network Development Strategy (ELE PL 0027). JEN states 'with peak utilisation rate expected to be average approximately 67% across all feeders in 2015, there is very minimal load transfer capacity available during feeder or station outage conditions'. At 67% loading, the adjacent feeders can accept 50% load from a faulted feeder on a day of maximum demand. This is a load at risk versus cost issue.

→ Asset condition:
  - Limited analysis into the expected increase in deterioration of assets and the cost specific to decreasing reliability did not adequately support the asset condition and safety driver.

3.2 OPTIONS DEVELOPMENT

JEN considered five credible options in addition to the base case option:

- Base case: No augmentation with planned replacement of 11 kV switchboards
- Option 1: Replace 11 kV assets at Flemington Zone Substation (FT)
- Option 2: Redevelop FT
- Option 3: Establish a new zone substation to replace FT
- Option 4: Install a third 66/11 kV transformer and three new 11 kV buses at FT
- Option 5: Embedded generation and demand management.

WSP | Parsons Brinckerhoff believes that the options presented do not encompass all viable technical solutions. For instance, within option 1 there are a number of variations to replacing the 11kV assets that may prove prudent and efficient ranging from replacement of the transformer cables only to replacement of the 11kV circuit breakers and switchboards. Each variation appears to offer different reliability and safety benefits. We conclude that the most prudent option may not have been investigated.

3.3 OPTIONS ANALYSIS

JEN did not include a discussion on non-credible options. Hence the full range of options considered by JEN is unknown and the logic behind their exclusion. Responding to AER questions JEN AER IR#016.1 indicated that the option of replacing transformer cables alone is considered a non-credible option as it is ‘not feasible or practical and it poses significant and unacceptable health and safety risk to JEN personnel and its contractors and an unacceptable supply security and reliability risks to our customers during construction’.

Of the credible options presented:

- Option 1 addresses the three most limiting constraints and increases the station’s ‘N-1’ summer rating to the cyclic rating of 34.8MW, i.e. limited by the rating of the existing transformers
- Option 2 addresses the three most limiting constraints and increases the station’s ‘N-1’ summer rating to the cyclic rating of 49.5, i.e. limited by the rating of the new transformers.
- Options 3 and 4 exceed the supply capacity constraints and

  Options 2, 3 and 4 are to occur in 2017, however no further information regarding investigation into optimal timing of this project occurring in 2017.

JEN did include a high level analysis of the implications of reliability (section 3.2.3 value of customer reliability) but did not provide detail of cost associated with expected reliability deterioration only.

A sensitivity analysis was undertaken for options 1 through 4 based on:

- Demand growth rate
- VCR
- Augmentation cost; and
- Discount rate.

Of the options presented, JEN determined Option 1 represented the most prudent and efficient option.

WSP | Parsons Brinckerhoff reviewed the analysis of options and notes:

- An assessment of the optimal timing of options was not presented. Net market benefit analysis demonstrated for the replacement of 11 kV switchboards (base case) only. No further assessment of timing for other replacement activities.
- Only one non-credible demand response option was presented (JEN AER IR#016).
- JEN notes that 'following implementation of the proposed preferred solution, there will be some residual risk due to the existing transformers' thermal capacities. However, based on the demand levels presented in the 2014 Load Demand Forecasts Report, this residual risk is considered to be economically manageable until approximately 2025, by which time the existing transformers will be fifty-five years old and their replacement, potentially with larger units or with installation of a third unit, is expected to be economic, along with replacement of the existing 66 kV switch room with outdoor gas insulated switchgear.' The impact of the replacement of transformers in 2025 was not included in the NPV assessment.
- JEN have since assessed the AER's option of replacing the transformer cables alone and found it is likely to be technically feasible, noting however that this provides only a small increase in capacity due to the limits of the transformer circuit breakers.

WSP | Parsons Brinckerhoff concludes that the most prudent option may not have been selected.

3.4 SUMMARY

The drivers of the Flemington Zone Substation are suitable but may be presented more comprehensively to better support the need for augmentation.

WSP | Parsons Brinckerhoff believes that the options presented do not encompass all viable technical solutions or the optimal timing of options, and hence the most prudent option may not have been selected.

4 RECOMMENDATIONS

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

4.1 DRIVERS

WSP | Parsons Brinckerhoff has established that the three drivers for the Flemington Zone Substation upgrade are:

1. insufficient capacity to meet increasing demand
2. declining reliability as a result of aged assets
3. increasing potential for catastrophic asset failure with associated safety implications.

Each of these drivers is discussed below.

4.1.1 INSUFFICIENT CAPACITY TO MEET INCREASING DEMAND

Demand on the Flemington Zone Substation is forecast to grow at an average rate of 1.9% per annum over the next 10 years. The forecast demand at FT for 50% Probability of Exceedance (POE) and 10% POE maximum demand conditions is presented in Figure 4-1, based on JEN's

Load Demand Forecasts 2015. Key station asset ratings are also presented in Figure 4-1 and Table 4.1 to demonstrate the limiting assets. It can be seen that the 66 /11 kV transformer rating of 34.8 MVA has sufficient capacity to meet the 50% POE forecast maximum demand until 2017 with load at risk from 2018 onwards. However, other key assets (11 kV transformer cables at 23.9 MVA and circuit breaker and the 11 kV buses at 30.5 MVA) currently limit the capacity of FT to below the current and forecast demand conditions, resulting in considerable load at risk and expected unserved energy under system normal and network outage (N-1) conditions as discussed in section 4.1.4.

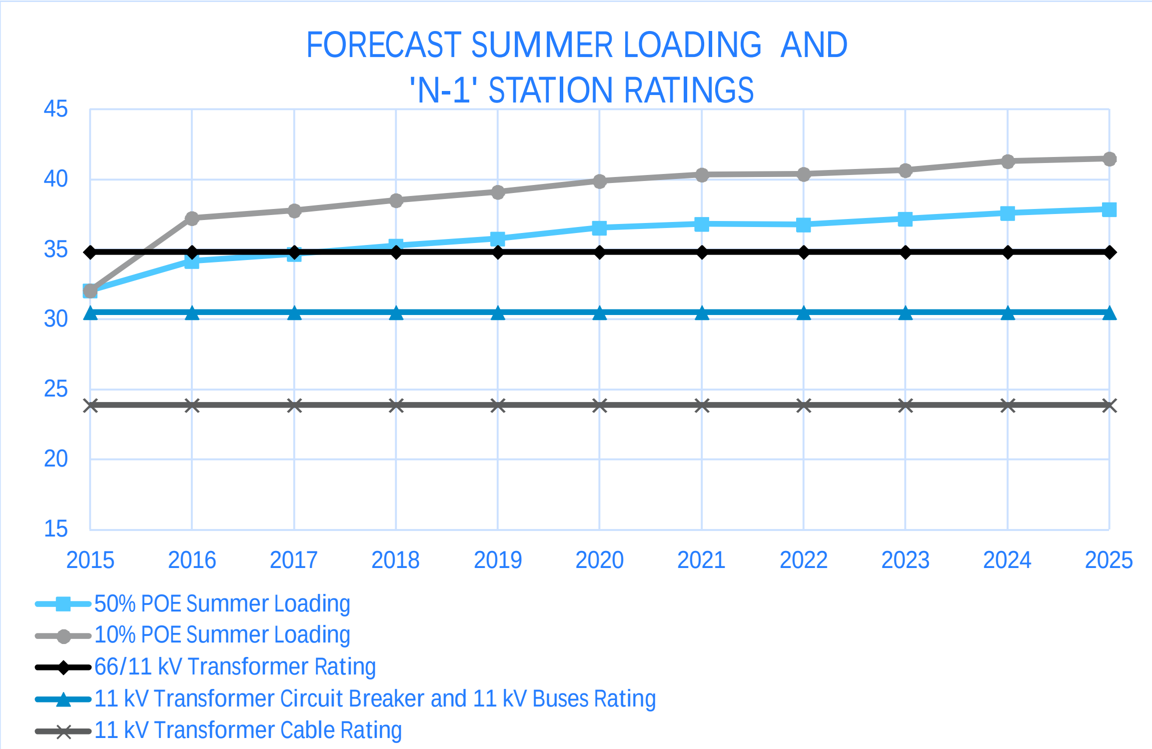

Figure 4-1 Forecast summer loading against 'N-1' station ratings

Table 4.1: Flemington Zone Substation asset ratings (MVA)

STATION ASSET	CONTINUOUS RATING	N-1 CYCLIC[2] SUMMER RATING
No.1 66/11 kV transformer	30.0	34.8
No.2 66/11 kV transformer	30.0	34.8
No.1 11 kV transformer cable	23.9	23.9
No.2 11 kV transformer cable	23.9	23.9
No.1 11 kV bus	30.5	30.5

2 Based on a transformer being loaded 115% of its normal summer rating under emergency outage conditions.

STATION ASSET	CONTINUOUS RATING	N-1 CYCLIC[2] SUMMER RATING
No.2 11 kV bus	30.5	30.5
No.1 11 kV transformer CB	30.5	30.5
No.2 11 kV transformer CB	30.5	30.5

Though some load transfer to NS and ES may be possible during network outage conditions, the load transfer capacity is minimal. Due to heavy loading already existing on these surrounding stations, their feeders, and the sub-transmission lines supplying them, emergency load transfer capacity from FT is currently limited to approximately 2.7 MVA during peak demand periods.

Reconfiguration of the FT-01 11 kV feeder and construction of a new 11 kV feeder from ES (ES-22) is due for completion before the end of 2015. This will provide approximately 6 MVA of additional capacity during a single contingency event, increasing the total load transfer capacity away from FT from 2.7 MVA to 8.7MVA in 2016 (JEN AER IR#016).

In summary, the Flemington zone substation 66 / 11 kV transformer rating of 34.8 MVA has sufficient capacity to meet the 50% POE forecast maximum demand until 2017 with load at risk from 2018 onwards, however capacity is currently limited under system normal and outage conditions by the:

- → 11 kV transformer cables at 23.9 MVA and
- → 11 kV circuit breakers and buses at 30.5 MVA

4.1.2 DECLINING RELIABILITY AS A RESULT OF AGED ASSETS

As key assets age and their condition degrades, it's expected that the likelihood they will fail will increase significantly. Table 4.2 shows the condition of assets at FT as assessed by JEN.

Table 4.2: Station asset condition

STATION ASSET	YEAR OF REPLACEMENT	CONDITION	COMMENT
No.1 66/11 kV transformer	2030	Very good condition for age	Assumed asset age life of 60 years, 15 years remaining
No.2 66/11 kV transformer	2030	Very good condition for age	Assumed asset age life of 60 years, 15 years remaining
No.1 11 kV transformer cable	2025	Unknown	The transformer cables are also 45 years old; however, condition testing is not undertaken on underground cables.
No.2 11 kV transformer cable	2025	Unknown	The transformer cables are also 45 years old; however, condition testing is not undertaken on underground cables.

STATION ASSET	YEAR OF REPLACEMENT	CONDITION	COMMENT
No.1 11 kV bus	2020	Condition monitoring indicates that the main insulating material have degraded significantly	Continuing the operate the station in this state increases the risk of asset failure
No.2 11 kV bus	2020	Condition monitoring indicates that the main insulating material have degraded significantly	Continuing the operate the station in this state increases the risk of asset failure
No.1 11 kV transformer CB	2020	Approaching end of service life, accelerated due to insulation degradation identified through condition monitoring tests.	Continuing the operate the station in this state increases the risk of asset failure
No.2 11 kV transformer CB	2020	Approaching end of service life, accelerated due to insulation degradation identified through condition monitoring tests	Continuing the operate the station in this state increases the risk of asset failure
11 kV switchgear	2020	Approaching end of service life, accelerated due to insulation degradation identified through condition monitoring tests	Potentially catastrophic consequence of failure. Switchboards use bulk oil filled breakers with probability of an oil fuelled fire high.

When considering options to meet increasing demand, total lifecycle costs can be minimised by considering those assets that are near end of life and must soon be replaced. The potential to replace assets with increased capacity (rather than a like for like replacement) may influence the analysis and selection of the most prudent and therefore preferred option. The table shows a majority of assets at FT are soon due for replacement, and therefore should be considered in the options analysis.

4.1.3 SAFETY

The existing 11kV switchgear is bulk oil with both switchboard sections mounted in the same room. Though the Network Development Strategy ELE PL 0027 identifies the risk of catastrophic circuit breaker failure, the report appears to significantly underestimate return to service times or the risk of a complete switchboard loss. An oil fire due to circuit breaker failure can result in significant smoke contamination (in addition to potential blast and fire damage). If both switchboard sections are affected then extended return to service times are likely.

While safety is not usually a driver for augmentation, it may influence the analysis and selection of the most prudent and therefore preferred option.

4.1.4 DISCUSSION ON ENERGY AT RISK

The two key drivers identified are insufficient capacity to meet increasing demand and declining reliability as a result of aged assets. When both drivers are taken into consideration, the energy at risk under the current conditions is considerable as shown in Table 4.3. The greater risk is associated with a transformer failure.

Table 4.3: Expected unserved energy

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
TRANSFORMER FAILURE EXPECTED UNSERVED ENERGY (ACCOUNTS FOR CAPACITY CONSTRAINTS)										
System normal expected unserved energy (MWh)	70.3	94.4	131.5	171.7	241.3	283.7	285.0	334.9	407.7	460.5
N-1 (MWh)	0.1	0.1	0.2	0.2	0.3	0.4	0.4	0.4	0.6	0.6
N-2 (MWh)	1.7	1.7	1.8	1.9	1.9	2.0	2.0	2.0	2.1	2.1
Subtotal (MWh)	72.0	96.2	133.4	173.7	243.6	286.1	287.4	337.3	410.3	463.2
Value of expected unserved energy (A$m FY15 Real)	$2.8	$3.8	$5.2	$6.8	$9.5	$11.2	$11.2	$13.2	$16.0	$18.1
SWITCHBOARD FAILURE EXPECTED UNSERVED ENERGY										
Sub Total (MWh)	2.4	2.7	3.0	3.4	3.8	4.1	4.5	4.9	5.4	5.8
Value of expected unserved energy (A$m FY15 Real)	$0.1	$0.1	$0.1	$0.1	$0.1	$0.2	$0.2	$0.2	$0.2	$0.2
TOTAL										
Total (MWh)	74.5	98.9	136.4	177.1	247.3	290.2	291.9	342.2	415.7	469.1
Total value of expected unserved energy (A$m FY15 Real)	$2.9	$3.9	$5.3	$6.9	$9.6	$11.3	$11.4	$13.3	$16.2	$18.3

4.2 OPTIONS ANALYSIS

WSP | Parsons Brinckerhoff has identified the following options for consideration to address the key drivers in 2016-2020 period:

- Option 1 – Do-Nothing (BAU)
- Option 2 – Replace 11 kV transformer cables
- Option 3 – Replace 11 kV transformer cables and 11 kV transformer circuit breakers
- Option 4a – Replace the transformer cables and the 11 kV switchboards in the existing building

- Option 4b – Replace the transformer cables and the 11 kV switchboards in the existing building plus installation of third switchboard
- Option 4c – Replace the transformer cables and the 11 kV switchboards in a new building Option 5 – Rebuild Flemington Zone Substation
- Option 6 – Install third transformer, third 11 kV switchboard, and two 66 kV bus-tie circuit breakers
- Option 7 – Embedded generation
- Option 8 – Demand management

Option 4c is the same as JEN's preferred option to upgrade the transformer cables and 11 kV switchboards in a new building, plus installation of a third switchboard. JEN also considered Option 5, 6, 7 and 8. The remaining options are new.

Table 4.4: Options identification

OPTION	DESCRIPTION
Option 1 – Do-Nothing (BAU)	→ Capacity rating (Summer and Winter) ▪ N: 30.5 MVA ▪ N-1: 23.9 MVA ▪ N-2: 0.0 MVA
Option 2 – Replace 11 kV transformer cables	→ Capacity rating (Summer and Winter) ▪ N: 30.5 MVA ▪ N-1: 30.5 MVA ▪ N-2: 0.0 MVA → Optimal timing: 2016
Option 3 – Replace 11 kV transformer cables and 11 kV transformer circuit breakers	→ Capacity rating (Summer and Winter) ▪ N: 30.5 MVA ▪ N-1: 30.5 MVA ▪ N-2: 0.0 MVA → Optimal timing: 2016
Option 4a – Replace the transformer cables and the 11 kV switchboards in the existing building	→ Capacity rating (Summer and Winter) ▪ N: 45.0 MVA ▪ N-1: 34.6 MVA ▪ N-2: 0.0 MVA → Optimal timing: 2017
Option 4b – Replace the transformer cables and the 11 kV switchboards in the existing building plus installation of third switchboard	→ Capacity rating (Summer and Winter) ▪ N: 45.0 MVA ▪ N-1: 34.6 MVA ▪ N-2: 0.0 MVA → Optimal timing: 2018
Option 4c – Replace the transformer cables and the 11 kV switchboards in a new building plus installation of third switchboard	→ Capacity rating (Summer and Winter) ▪ N: 45.0 MVA ▪ N-1: 34.8 MVA ▪ N-2: 0.0 MVA

	→ Optimal timing: 2019
Option 5 – Replace Flemington Zone Substation	→ Capacity rating (Summer and Winter) ▪ N: 66.0 MVA ▪ N-1: 49.5 MVA ▪ N-2: 0.0 MVA → Optimal timing: 2019
Option 6 – Install third transformer, third 11 kV switchboard, and two 66 kV bus-tie circuit breakers	→ Capacity rating (Summer and Winter) ▪ N: 61.0 MVA ▪ N-1: 30.5 MVA ▪ N-2: 23.9 MVA → Optimal timing: 2018
Option 7 – Embedded Generation	Refer to Flemington Electricity Supply RIT-D Stage 1: Non-Network Options Report
Option 8 – Demand Management	Refer to Flemington Electricity Supply RIT-D Stage 1: Non-Network Options Report

Optimal timing of options has been determined by comparing the capex of each option against the cost of expected unserved energy should no augmentation occur for that year to determine the point where the cost benefit outweighs the capex, shown in Figure 4-2.

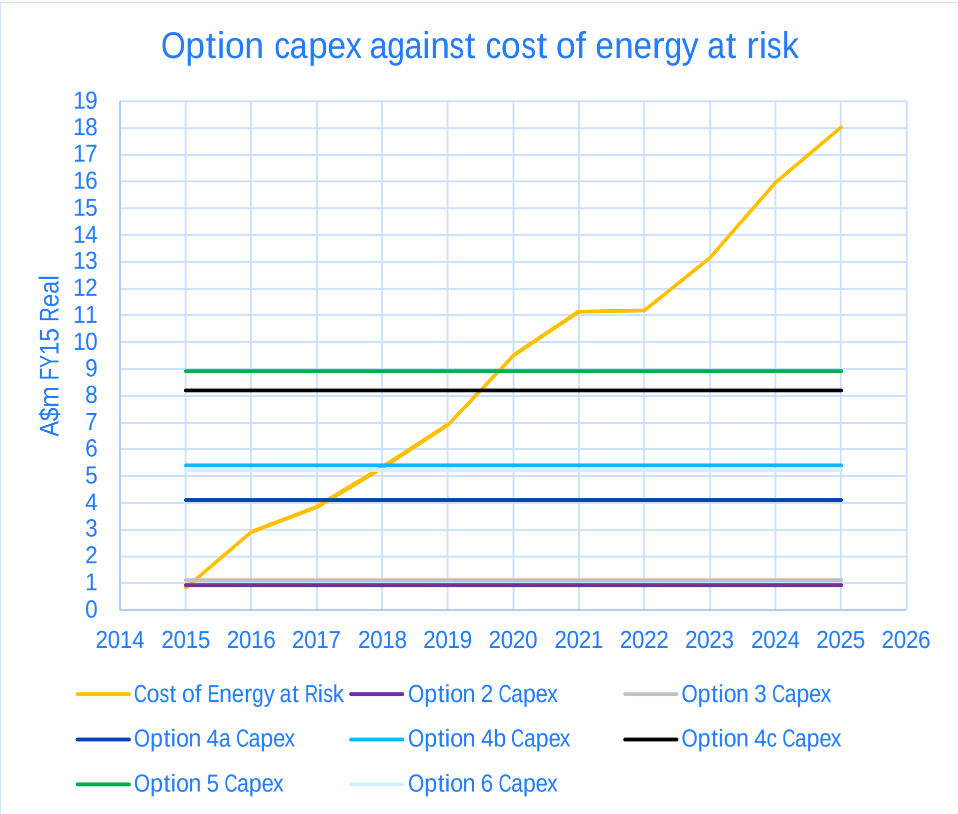

Figure 4-2 Optimal timing of options

4.2.1 NON-VIABLE OPTIONS

WSP | Parsons Brinckerhoff have identified a set of non-viable options, outlined in Table 4.5 based on the preliminary NPV and the option's ability to realise benefits.

Table 4.5: Preliminary options analysis – non-viable options

OPTION	PRELIMINARY NPV	COMMENTARY
Option 1 – Do-Nothing (BAU)		
Option 3 – Replace 11 kV transformer cables and 11 kV transformer circuit breakers	(0.51)	Cost: $1.12m real, 2015 un-escalated direct costs This option is deemed to be not viable as it is not practical to replace the 11kV transformer incomer circuit breaker without replacing the switchboards for the following reasons → The existing 11kV equipment is aged (1970) and has evidence of insulation deterioration. Carrying out modification works to the panels and subjecting them to increased load runs the risk of further degrading switchboard performance. → The 11kV J22 switchgear is due for replacement in 2020 due to age and poor condition. The value of any refurbishment or augmentation work done prior to that date would be lost when the replacement was carried out unless the replacement switching device could be used elsewhere on the network. → Space and heating constraints may prevent a unit with a 2000A rating to be used within the existing 1600A cubicles. Also, the rating of the buswork in the incomer cubicle is equally limiting, and replacing only the transformer circuit breakers does not address this limitation. → If a full cubicle replacement is considered, there is risk associated with the practical removal of the transformer cubicles from the run of switchgear and replacement due to manufacturing differences between the original boards and available modern products. → Mounting new transformer incomer cubicles on the ends of the switchboards is likely to exceed the existing busbar ratings during single transformer outages. The existing incomers have been mounted close to the middle of the bus section for this reason.
Option 4a – Replace the transformer cables and the 11 kV switchboards in the existing building	168.42	Cost: $4.1m real, 2015 un-escalated direct costs This option is deemed to be not viable as JEN's standard feeders have one less feeder circuit breaker than the switchboards that are currently installed at FT; therefore this option would only

		allow the connection of eight of the ten feeders, in addition to the two capacitor banks.
Option 7 – Embedded Generation	N/A	No generation responses received – will not address asset condition issues
Option 8 – Demand Management	N/A	Demand Management options investigated in AER JEN #16 are demonstrated to be non-viable options

4.2.2 VIABLE OPTIONS

WSP | Parsons Brinckerhoff has identified a set of viable options, outlined in Table 4.6. An analysis of the options was undertaken considering capital cost and the reliability impacts of potential capacity constraints and asset failures. The assumptions made in this analysis are set out in section 4.4.

Table 4.6: Preliminary options identification – viable options

OPTION	COST ($M, real 2015 direct costs)	PRELIMINARY NPV ($M, real $2015)
Option 2 – Replace 11 kV transformer cables	0.92	(0.63)
Option 4b – Replace the transformer cables and the 11 kV switchboards in the existing building plus installation of third switchboard	5.39	163.20
Option 4c – Replace the transformer cables and the 11 kV switchboards in a new building plus installation of third switchboard	8.0	156.05
Option 5 – Replace Flemington Zone Substation	8.92	156.21
Option 6 – Install third transformer, third 11 kV switchboard, and two 66 kV bus-tie circuit breakers	5.23	160.52

Option 4b shows the highest NPV however Options 4b, 4c, 5 and 6 all demonstrate NPV's within a close range and therefore no obvious preferred option is distinguishable. Therefore, sensitivity analysis was undertaken to determine the option that demonstrates the most consistently favourable NPV. Table 4.7 shows that Option 4b proved to consistently have the highest NPV of all options and is therefore the preferred option.

Table 4.7: Sensitivity analysis

Sensitivity parameter		Option 4b	Option 4c	Option 5	Option 6
	Base	163.2	155.92	164.29	160.52
Average feeder outage duration (Base case: 1 hour)	2 hrs	163.42	156.18	156.31	157.34
	3 hrs	163.63	156.30	156.41	154.17
Transformer age	45 (Actual age)	91.85	84.70	86.68	90.65

Sensitivity parameter		Option 4b	Option 4c	Option 5	Option 6
(Base case 22 years)	24 (+10% base case)	163.28	156.13	156.53	160.52
	20 (-10% base case)	147.91	140.76	141.73	145.66
Augmentation cost	+30%	161.94	154.25	154.46	159.21
	-30%	164.46	157.86	157.96	161.83

4.2.3 PREFERRED OPTION

Option 4b: Replacement of the transformer cables and the 11 kV switchboards in the existing building plus the installation of a third switchboard is the preferred option. The expenditure profile for this option is shown in Table 4.8.

Table 4.8 Expenditure profile for preferred option

Heading	2016	2017	2018	2019	2020	Total 2016-20	Post 2020
Capex	0	0	5.39	0	0	5.39	3.4
Opex	0*	0*	0*	0*	0*	0*	0*
Total	0	0	5.39	0	0	5.39	3.4

** Negligible*

4.3 COMMENTS ON AER'S PRELIMINARY DECISION

The AER stated that it was not satisfied with JEN's option to replace the Flemington Zone Substation 11 kV assets to increase the supply capacity to 34.8 MVA to meet the forecast demand 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: The AER proposed an alternative estimate of $0.32 million which they consider reflects 'the prudent and efficient amount for JEN to meet expected demand growth for the Flemington zone substation and maintain reliability and safety. This amount reflects the cost of replacing the 11 kV transformer cables which are the primary capacity constraint within the zone substation.' (P6-49).

The cost of $0.32 million proposed by the AER was based on JEN's response to AER questions JEN AER IR#016.1 stating the 'the forecast cost to replace the two 11 kV transformer cables is $322k'. The cost provided by JEN was for the material cost only. This cost did not include any project setup costs, labour, implementation, construction management etc. The full cost to conduct this option as a stand-alone project is $0.92M (real $2015 un-escalated direct costs).

Additionally, while replacement of a faulted cable in the existing ducts would be possible, the higher capacity cables required to meet the existing and forecast demand may not fit within the existing ducts. JEN's standard for 11 kV cables connecting 30 MVA transformers is three single core 630mm Cu cables per phase per transformer installed in conduits with a minimum diameter of 150mm. Flemington was designed with only two ducts per phase per transformer, and uses

100mm diameter conduits. To guarantee the required ratings a third duct per phase per transformer would be required. Obtaining additional ducts would require significant civil excavation works throughout the concrete slab floor and hence JEN rejected this as a viable option.

Further analysis shows that a non-standard cable can likely be installed within the cable ducts to meet the capacity requirements. WSP | Parsons Brinckerhoff evaluated the AER proposed option as Option 2 – Replace 11 kV transformer cables. This option was shown to have a lower NPV than the preferred option of replacing the transformer cables and the 11 kV switchboards in the existing building.

Statement 2: The AER noted that 'JEN has some limited ability to transfer load to adjacent substations with the completion of feeder upgrade works. This will allow JEN to partially reduce congestion in this substation by up to 6 MVA (which is approximately 40 per cent of the expected demand in excess of capacity by 2020). Based on our review of JEN's supporting documents and modelling, it appears that JEN has not taken this ability to transfer load into its calculation of the cost to consumers due to capacity constraints.' (P6-49).

The completion of feeder upgrade works will increase the load transfer capacity by 6 MVA, bringing the total transfer capacity up to a total of 8.7 MVA. Since the load demand forecasts at adjacent substations ES and NS are relatively flat, it is expected that the 8.7 MVA emergency load transfer capacity will not reduce significantly in the next five years.

The AER appears to have assumed that the load transfer capability from adjacent substations and FT can be used to provide for increasing demands on FT. This is not the situation. The load transfer capability is required to achieve reliability outcomes under emergency situations and to enable safe access to maintain the assets. In such cases, a network segment must be taken out of service and customer loads transferred to adjacent assets in order to maintain supply. To utilise the load transfer capacity to supply load under normal conditions would result in a restriction of operational access to network assets, delaying maintenance activities and new/upgraded connections.

Additionally, the constraint remains present in the summer 10% POE forecast and re-emerges in the summer 50% POE forecast in 2020. From 2016, the transfer capacity would be required for up to 55 hours per year in the summer 10% POE scenario.

In the assessment of options, WSP | Parsons Brinckerhoff's has considered the load transfer capacity when determining the load at risk.

Statement 3: 'While we recognise that the assets in this zone substation will reach the end of their life within the next ten years, it is not clear that replacement is necessary in the 2016–20 period to maintain network reliability, safety or security' (P6-51).

In WSP | Parsons Brinckerhoff's opinion, replacement is not necessary in the 2016–20 period to maintain network reliability, safety or security. The primary driver is to address forecast capacity constraints. Replacement is considered as the prudent option, given that the assets will shortly be due for replacement and that a non-like for like replacement will address the forecast capacity constraints. This approach results in minimal life cycle costs, as is demonstrated by the NPV analysis of the viable options.

When both insufficient capacity to meet increasing demand and declining reliability as a result of aged assets are taken into consideration the energy at risk under the current conditions is considerable as shown in Figure 4-3. Figure 4-3 also demonstrates that the system normal supply risk alone, due to capacity limitations, is sufficiently high to justify augmentation.

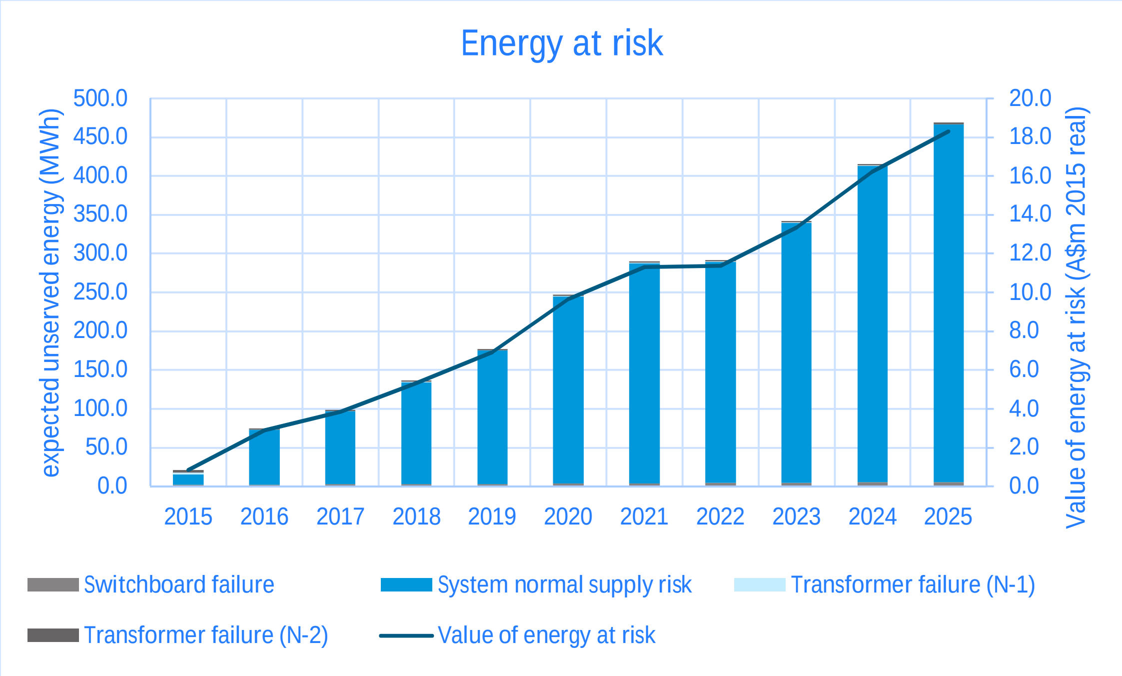

Figure 4-3 Energy at risk as a result of capacity constraints and reliability degradation

4.4 ASSUMPTIONS MADE

CAPITAL COSTS

The capital cost estimates for all network options are indicative costs only. They have been provided by JEN, 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 zone substations, the following assumptions have been applied:

- A station fault on a circuit breaker or bus 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.
- Transformer N-1 Outage duration = 2.6 months

- Transformer N-2 Outage duration = 2.6 months

DEMAND BASED UNSERVED ENERGY

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