Jemena Electricity Networks (Vic) Ltd

Sunbury - Diggers Rest Electricity Supply

RIT-D Stage 2: Draft Project Assessment Report

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Sunbury - Diggers Rest Electricity Supply

Authorisation

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1	25/01/2017	Initial document	Jason Pollock

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EXECUTIVE SUMMARY

Jemena is the licensed electricity distributor for the northwest of Melbourne's greater metropolitan area. The network service area ranges from Gisborne South, Clarkefield and Mickleham in the north to Williamstown and Footscray in the south and from Hillside, Sydenham and Brooklyn in the west to Yallambie and Heidelberg in the east.

Our customers expect us to deliver a reliable electricity supply at the lowest possible cost. To do this, we must choose the most efficient solution to address emerging network issues. This means choosing the solution that maximises the present value of net economic benefit to all those who produce, consume and transport electricity in the National Electricity Market (NEM).

This Draft Project Assessment Report (DPAR) presents the Sunbury Zone Substation supply capacity risk and outlines how this risk has been quantified. It outlines possible options for economically mitigating supply risks, and identifies the proposed preferred option to manage the forecast supply risk in the area.

This Sunbury Zone Substation Regulatory Investment Test for Distribution (RIT-D) Stage Two DPAR:

- Utilises Jemena Electricity Network's (JEN's) 2016 load demand forecasts;
- Incorporates detailed analysis undertaken as part of Stage One of the RIT-D, the non-network options report;
- Includes assessment of newly identified network and hybrid network/non-network credible options identified during Jemena's Electricity Distribution Price Review (EDPR) submission and the non-network options report consultation process; and
- Focusses on updated options centred on remaining at the existing SBY site, following the recent lease extension.

Identified need

Sunbury Zone Substation (SBY) comprises two 66/22 kV 10/16 MVA transformers, one 66/22 kV 10 MVA transformer and three 22 kV buses supplying six 22 kV feeders. SBY supplies over 15,000 customers in the areas of Sunbury, Diggers Rest, Bulla, Clarkefield and Gisborne South.

Despite having a total transformer nameplate rating of 42 MVA, the station's overall system normal ('N') capacity is limited to 32 MVA due to the load sharing between the three transformers. The three transformers share load approximately evenly, rather than based on their capacity, meaning that the 10 MVA transformer reaches its limit before the other two transformers can be fully utilised.

Based on JEN's 2016 Load Demand Forecasts Report, the:

- 50% probability of exceedence (POE) summer maximum demand is forecast to increase from 39.3 MVA in 2016/17 to 42.6 MVA in 2020/21.
- 10% POE summer maximum demand is forecast to increase from 43.1 MVA in 2016/17 to 46.9 MVA in 2020/21.

The drivers of the identified need to investment are:

- The overall thermal capacity of the zone substation's transformer (32 MVA under system normal conditions and 26.4 MVA under N-1 conditions);

- The low reliability of the zone station, due to its 22 kV outdoor switchgear which is prone to faults, and very basic 66 kV and 22 kV switching arrangements, which means a transformer or 22 kV bus fault, and in some cases a 66 kV bus fault, would interrupt supply to all customers supplied from SBY; and
- The condition of some aged assets which, based on Jemena's condition based risk management (CBRM) model, are at a higher than average risk of failing within the next five years and therefore require replacement to maintain supply reliability.

Non-network options report consultation submissions

On 21 October 2015, Jemena published Stage 1 of the Sunbury Zone Substation RIT-D, the non-network options report. This report sought submissions from Registered Participants, interested parties, the Australian Energy Market Operator (AEMO) and non-network service providers to ensure the optimal solution was identified to mitigate or manage the Sunbury Zone Substation thermal capacity and reliability limitations.

Jemena received two submissions to its non-network options report to address the SBY constraints. Both submissions presented credible non-network options capable of mitigating or managing the identified thermal capacity limitation.

The submission from GreenSync presented a demand-side management solution that incorporated both voluntary demand reduction and battery storage to manage the supply risk until a network augmentation was completed, while the other submission, from ZECO Energy, identified battery storage as a non-network solution to manage or mitigate the supply risk.

Hybrid network/non-network options have been included in the options assessed of this RIT-D Stage Two report based on the information provided in the two non-network options report submissions.

Proposed preferred option

The options analysis identifies that:

- Option 1a, upgrading the 10 MVA transformer, by replacing it with a new 20/33 MVA unit and undertaking segmentation works on both the 66 kV and 22 kV switchyards, is the preferred network option; and
- Engaging demand-side management services, either in the form of voluntary load reduction or a battery energy storage solution, does not defer the need for the preferred network augmentation.

Following consultation of this DPAR, Jemena will proceed to prepare a final project assessment report (FPAR). That report will include a summary of, and commentary on, any submissions to this report, and present the final preferred solution to address the Sunbury Zone Substation thermal capacity and reliability constraints. Publishing the FPAR will be the third and final stage in the RIT-D process.

Table ES–1 shows the project cost breakdown for Option 1a. Applying the discount rate of 6.37% per year, this preferred solution has a net economic benefit of $453 million (Real $2016) over the fourteen year assessment period.

Table ES–1: Option 1a – Cost estimate breakdown

	NPV project cost ($M Real2016)
Network augmentation capital cost	$12.46
Network augmentation operational cost (2017-2030)	$1.78
Total project expenditure	**$14.24**

Submission and next steps

Jemena invites written submissions on this report from Registered Participants, interested parties, AEMO and non-network providers.

All submissions and enquiries should be directed to:

Ashley Lloyd
Network Capacity Planning & Assessment Manager
Email: PlanningRequest@jemena.com.au
Phone: (03) 9173 8279

Submissions should be lodged with us on or before 10 March 2017.

All submissions will be published on Jemena's website. If you do not wish to have your submission published, please indicate this clearly.

Following our consideration of any submissions on this Draft Project Assessment Report (DPAR), we will proceed to prepare a Final Project Assessment Report (FPAR). That report will include a summary of, and commentary on, any submissions to this report, and present the final preferred solution to address the Sunbury Zone Substation thermal capacity and reliability constraints. Publishing the FPAR will be the third and final stage in the RIT-D process.

We intend to publish the Final Project Assessment Report by 24 March 2017.

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GLOSSARY

Amperes (A)	Refers to a unit of measurement for the current flowing through an electrical circuit. Also referred to as Amps.
Constraint	Refers to a constraint on network power transfers that affects customer service.
Continuous rating	The permissible maximum demand to which a conductor or cable may be loaded on a continuous basis.
Jemena Electricity Networks (JEN)	One of five licensed electricity distribution networks in Victoria, the JEN is 100% owned by Jemena and services close to 333,000 customers via an 11,000 kilometre distribution system covering north-west greater Melbourne.
Maximum demand (MD)	The highest amount of electrical power delivered (or forecast to be delivered) for a particular season (summer and/or winter) and year.
Megavolt ampere (MVA)	Refers to a unit of measurement for the apparent power in an electrical circuit. Also million volt-amperes.
Network	Refers to the physical assets required to transfer electricity to customers.
Network augmentation	An investment that increases network capacity to prudently and efficiently manage customer service levels and power quality requirements. Augmentation usually results from growing customer demand.
Network capacity	Refers to the network’s ability to transfer electricity to customers.
Probability of exceedance (POE)	The likelihood that a given level of maximum demand forecast will be met or exceeded in any given year:
Regulatory Investment Test for Distribution (RIT-D)	A test established and amended by the Australian Energy Regulator (AER) that establishes consistent, clear and efficient planning processes for distribution network investments over a certain limit ($5m), in the National Electricity Market (NEM).
Reliability of supply	The measure of the ability of the distribution system to provide supply to customers.
System normal	The condition where no network assets are under maintenance or forced outage, and the network is operating according to normal daily network operation practices.
10% POE condition (summer)	Refers to an average daily ambient temperature of 32.9ºC derived by NIEIR and adopted by JEN, with a typical maximum ambient temperature of 42ºC and an overnight ambient temperature of 23.8ºC.
50% POE condition (summer)	Refers to an average daily ambient temperature of 29.4ºC derived by NIEIR and adopted by JEN, with a typical maximum ambient temperature of 38.0ºC and an overnight ambient temperature of 20.8ºC.
50% POE and 10% POE condition (winter)	50% POE and 10% POE condition (winter) are treated the same, referring to an average daily ambient temperature of 7ºC, with a typical maximum ambient temperature of 10ºC and an overnight ambient temperature of 4ºC.

ABBREVIATIONS

AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
COO	Coolaroo Zone Substation
JEN	Jemena Electricity Network
MD	Maximum Demand
NEM	National Electricity Market
NER	National Electricity Rules
NPV	Net Present Value
POE	Probability of Exceedance
RIT-D	Regulatory Investment Test for Distribution
SBY	Sunbury Zone Substation
SHM	Sydenham Zone Substation
VCR	Value of Customer Reliability

1. INTRODUCTION

This section outlines the purpose of the Regulatory Investment Test for Distribution (RIT-D), Jemena's objective in undertaking its network planning role, and the structure of this draft project assessment report (DPAR).

1.1 RIT-D PURPOSE AND PROCESS

Distribution businesses are required to go through the Regulatory Investment Test for Distribution (RIT-D) process to identify the investment option that best addresses an identified need on the network, that is the credible option that maximises the present value of the net economic benefit to all those who produce, consume and transport electricity in the National Electricity Market (the preferred option).

The RIT-D applies in circumstances where a network problem (an "identified need") exists and the estimated augmentation component capital cost of the most expensive potential credible option to address the identified need is more than $5 million. As part of the RIT-D process, distribution businesses must also consider non-network options when assessing credible options to address the identified need.

Under the RIT-D consultation procedures, distribution businesses are required to prepare and publish a non-network options report. This report helps distribution businesses to identify potential non-network options and be better informed of the costs and market benefits associated with a potential option. These arrangements provide an opportunity for third parties to consider how they could address the identified need on the network.

Following completion of the non-network options report consultation period, distribution businesses are required to consider submissions, assess the market benefits of all credible options to address the identified need, and prepare a draft project assessment report outlining the proposed preferred option to address the identified need.

This document is Jemena's draft project assessment report (DPAR) for the Sunbury Zone Substation area. In accordance with the requirements of the National Electricity Rules, this report describes:

- the identified need in relation to the Sunbury network;
- submissions in response to the non-network options report;
- the credible options assessed that may address the identified need;
- the methodologies used to quantify market benefits;
- the net present value assessment results for the potential credible options assessed; and
- the technical characteristics of the proposed preferred credible option.

1.2 OBJECTIVE

Jemena's objective in planning its electricity distribution network is to ensure that reliable distribution services are delivered to its customers at the lowest sustainable cost.

This report is stage two of the RIT-D consultation process. It follows on from our non-network options report and considers additional network, non-network and hybrid options based on submissions to that report and the Australian Energy Regulator's (AER) input to our Electricity Distribution Price Review (EDPR) submission.

2. BACKGROUND

This section provides an overview of the Sunbury supply area, describes the general arrangement of Sunbury Zone Substation (SBY), and gives a brief overview of the network limitations.

The assessment is based on Jemena's 2016 Load Demand Forecasts Report.

2.1 NETWORK SUPPLY ARRANGEMENTS

Jemena is the licensed electricity distributor for the northwest of Melbourne's greater metropolitan area. The Jemena Electricity Networks (JEN) service area covers 950 square kilometres of northwest greater Melbourne and includes some major transport routes and the Melbourne International Airport, which is located at the approximate physical centre of the network. The network comprises over 6,000[1] kilometres of electricity distribution lines and cables, delivering approximately 4,400 GWh of energy to around 333,000 homes and businesses for a number of energy retailers. The network service area spans from Gisborne South, Clarkefield and Mickleham in the north to Williamstown and Footscray in the south and from Hillside, Sydenham and Brooklyn in the west to Yallambie and Heidelberg in the east.

Sunbury Zone Substation (SBY) comprises two 66/22 kV 10/16 MVA transformers and one 66/22 kV 10 MVA transformer, supplying six 22 kV feeders. SBY supplies over 15,000 customers in the areas of Sunbury, Diggers Rest, Bulla, Clarkefield and Gisborne South.

The two primary drivers limiting supply to customers connected from SBY are the thermal capacity of the zone substation, and the station's level of reliability.

Despite having a total transformer nameplate rating of 42 MVA, the station's overall system normal ('N') capacity is limited to 32 MVA, and its N-1 capacity is limited to 26.4 MVA. This lower than nameplate capacity results from the load sharing between the three transformers, as the 10 MVA transformer reaches its limit before the other two transformers can be fully utilised. The forecast demand on SBY has grown significantly over recent years, and is forecast to continue growing beyond this thermal capacity.

Based on Jemena's 2016 Load Demand Forecasts Report, the:

- 50% probability of exceedence (POE) summer maximum demand is forecast to increase from 39.3 MVA in 2016/17 to 43.7 MVA in 2021/22.
- 10% POE summer maximum demand is forecast to increase from 43.1 MVA in 2016/17 to 48.2 MVA in 2021/22.

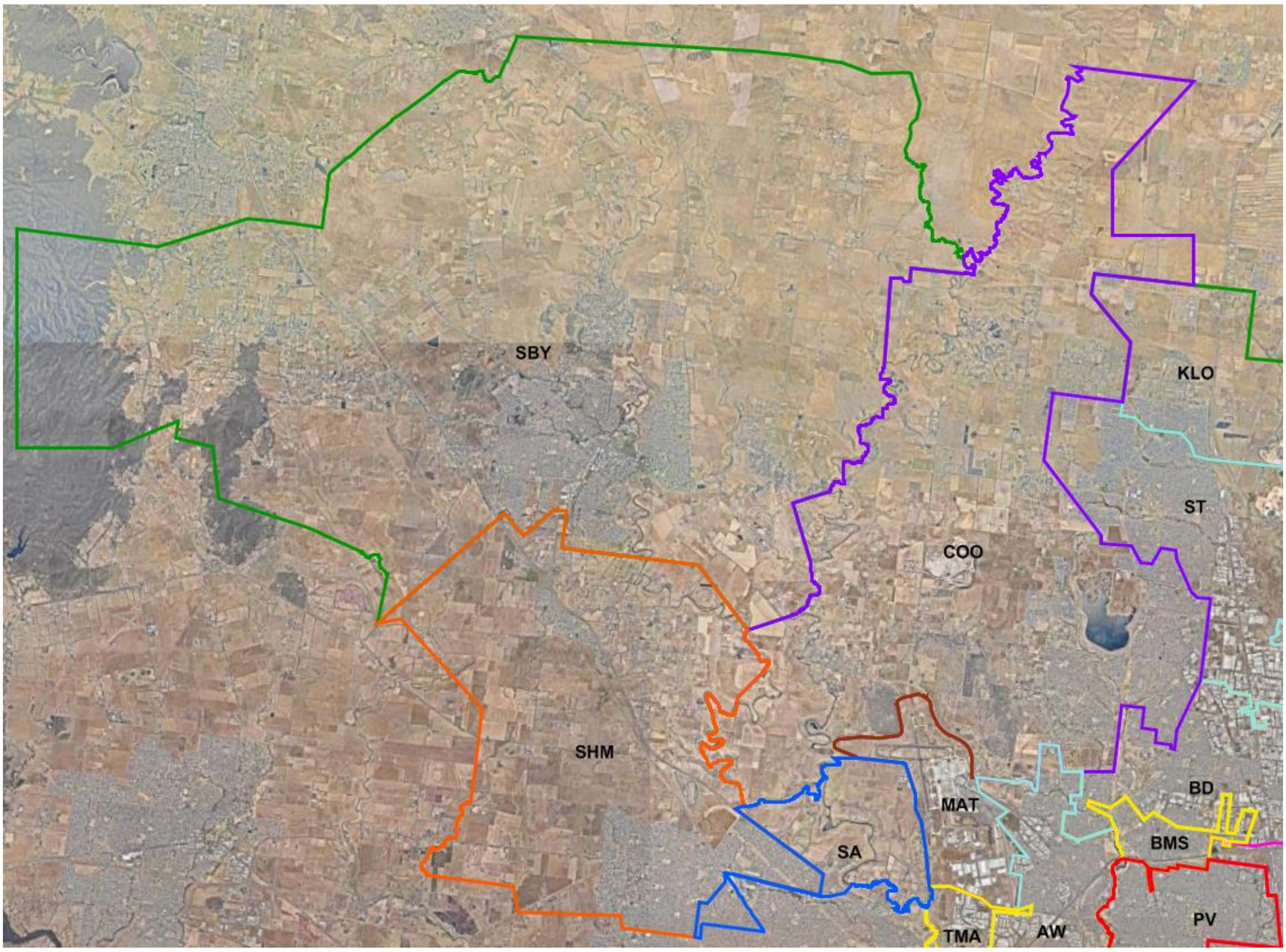
When SBY was originally developed, in 1964, it was built with a basic and cost effective switching arrangement that was appropriate for the small and remotely located load that it originally supplied. This arrangement consists of outdoor switchgear for both the 22 kV and 66 kV switchyards, and a single switching zone for all three transformers, meaning that a transformer or 22 kV bus fault, and some 66 kV bus faults, will interrupt supply to all SBY supplied customers.

[1] Does not include low voltage services

2.2 GENERAL ARRANGEMENT

Figure 2–1 shows the supply areas of Sunbury Zone Substation (SBY), Sydenham Zone Substation (SHM) and Coolaroo Zone Substation (COO).

Figure 2–1: Sunbury, Sydenham and Coolaroo zone substation supply areas



3. IDENTIFIED NEED

Sunbury Zone Substation (SBY) supply is limited in two key areas; thermal capacity and asset reliability. Both of which are driven by the demand growth on SBY.

The thermal capacity is limited by the station's usable transformer capacity, which is insufficient to meet the forecast demand, while the unreliability of the basic and outdoor switching arrangement has resulting in lower than sufficient supply availability.

With the relatively recent changes to the urban growth boundary, the load demand on SBY has increased and is forecast to continuing growing steadily. As demand is forecast to continue growing, so is the expected unserved energy at SBY, due to both the thermal and unreliability limitations.

Expected supply availability is also limited by the age and condition of some zone substation assets which, based on our condition monitoring results, are at a higher than average risk of failing.

In line with the purpose of the regulatory investment test for distribution (RIT-D), as outlined in Clause 5.17.1 (b) of the National Electricity Rules, the identified need to address the Sunbury area supply limitation is an increase in the sum of customer and producer surplus in the National Electricity Market (NEM); that is an increase in the net economic benefit. This net economic benefit increase is driven by reducing the cost of expected unserved energy (predominately by a change in the amount of involuntary load shedding in this case) through capacity and reliability augmentation, and balancing this benefit against each development option's cost to identify the optimal augmentation solution and timing.

This section summarises the station utilisation at SBY, based on Jemena's 2016 Load Demand Forecasts Report, and outlines the reliability risk that exists at the station.

3.1 DEMAND GROWTH DRIVERS

In August 2010, changes to the Urban Growth Boundary (UGB) released 2,270 hectares for potential development in and around the Sunbury area. Since these UGB changes, Jemena has experienced significant growth in the areas of Sunbury, Sydenham and Diggers Rest, and is continuing to see an increased number of applications for new residential, commercial and industrial customer connections in these areas.

In addition to the UGB changes, transport infrastructure development planned for the area is expected to continue driving strong residential and commercial activity, with the number of dwellings in the area expected to more than double to as much as 35,000 by the year 2030[2].

3.2 PRIMARY IDENTIFIED NEED

There is two key limitations associated with the identified need to invest; the thermal capacity of SBY, due to the transformer load sharing preventing full utilisation of two of the three transformers, and the network reliability level, due to the basic and outdoor switching arrangement of the station.

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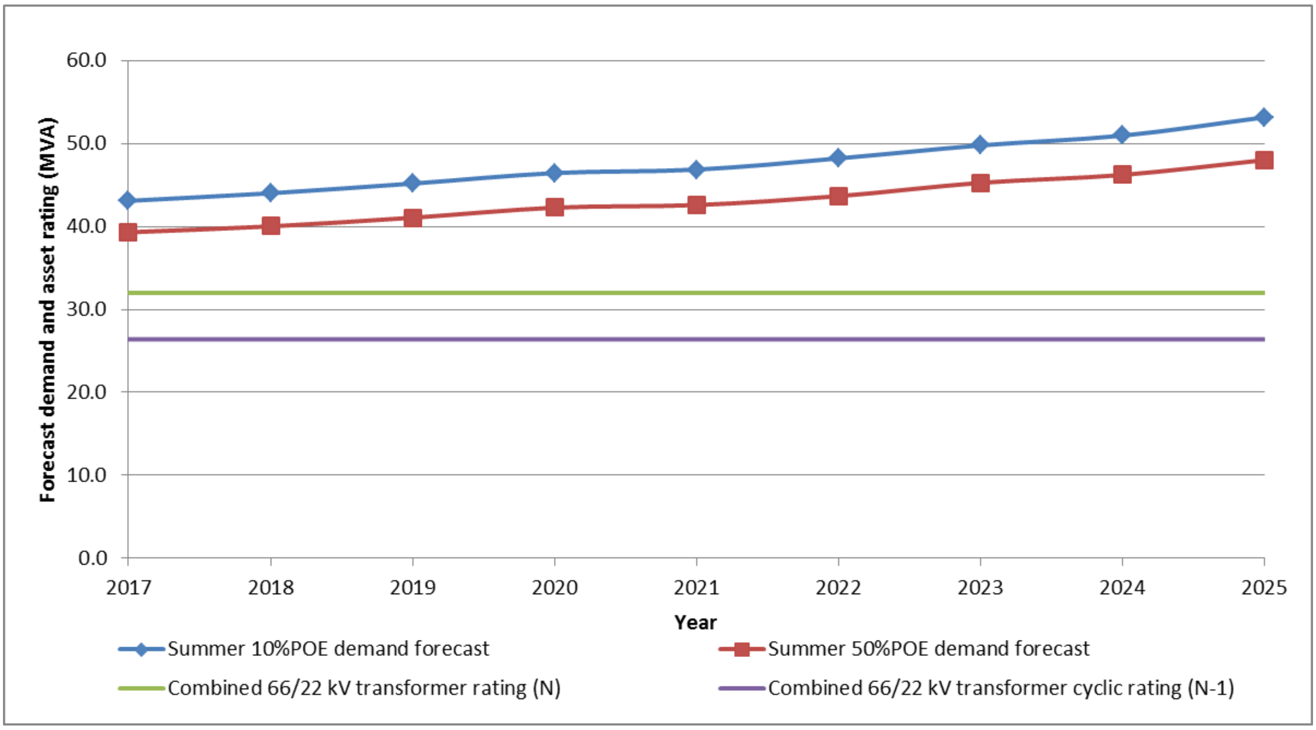
[2] "Growth Corridor Plans – Managing Melbourne's Growth" Growth Area Authority, November 2011

3.2.1 ZONE SUBSTATION TRANSFORMER LIMITATION

Figure 3–1 shows the forecast load demand on SBY, for 50% probability of exceedance (POE) and 10% POE maximum demand conditions, compared to the effective capacity of the three zone substation transformers combined. It shows that the station's capacity is limited to the combined effective transformer capacity under system normal (N) and network outage (N-1) conditions, and that load shedding would be required during maximum demand conditions to maintain network loading levels within the combined capacity of these transformers.

Figure 3–1: Maximum demand against ratings for Sunbury Zone Substation



Despite the three transformers having a combined transformer nameplate rating of 42 MVA, the station's overall system normal ('N') capacity is limited to 32 MVA due to the relatively even load sharing between the three transformers. This load sharing means that the 10 MVA transformer reaches its limit before the two 16 MVA transformers can be fully utilised. The approximate load sharing between the three transformers is shown in Table 3–1. The station's N-1 capacity is limited to 26.4 MVA, similarly due to the load sharing between transformers, based on the transformers' cyclic ratings and assuming the worst case outage of a 16 MVA transformer.

Table 3–1: SBY transformer load sharing

Transformer	Transformer nominal rating (MVA)	Transformer Cyclic rating (MVA)	Transformer load share (% of station load)
No.1 66/22 kV transformer	16.0	19.5	34%
No.2 66/22 kV transformer	10.0	12.8	32%
No.3 66/22 kV transformer	16.0	19.5	34%

3.2.2 ZONE SUBSTATION SWITCHING ARRANGEMENT

In addition to the transformer loading limitations, the supply capacity from SBY is also limited by the zone substation switching arrangement.

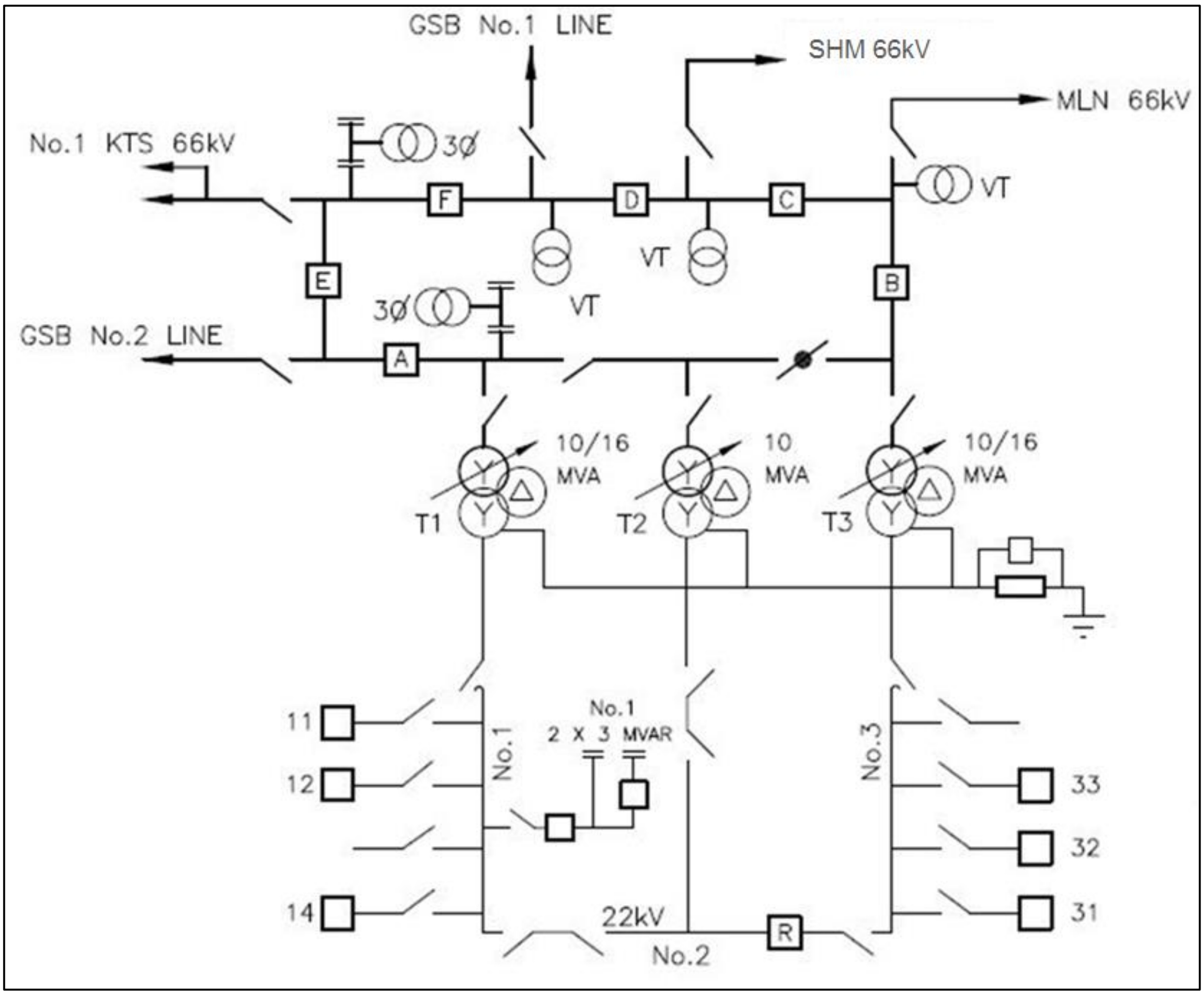
When the station was originally developed, in 1964, it was built with a basic and cost effective switching arrangement that was appropriate for the small and remotely located load that it originally supplied. The site was designed using outdoor switchgear and has the three transformers connected in a single switching zone, meaning a transformer or 22 kV bus fault, and in some cases a 66 kV bus fault, interrupts supply to all SBY connected customers.

Figure 3–2 shows the SBY switching arrangement, including the unsegmented 22 kV and 66 kV switchyards and the single switching zone for the three transformers.

The 22 kV buses are a mix of rigid and strung buses, whereas the entire 66 kV ring bus is a strung bus construction. The strung buses are composed of flexible conductors suspended between supporting structures with strain insulators.

Amplifying the high fault impact of the unsegmented switching arrangement and single transformer switching zone, the outdoor switching arrangement, and in particular the strung bus sections, have proven to be prone to faults caused by wildlife contact, conductor clashing and extreme weather conditions. In a twenty year period the station has been subjected to eighteen outages within the transformers' switching zone that resulted in a supply interruption to all SBY supplied customers.

Figure 3–2: Sunbury Zone Substation single line diagram



3.3 SECONDARY IDENTIFIED NEED

In addition to the transformer thermal capacity and network reliability limitations at Sunbury Zone Substation, some of the SBY assets are aged and in a poor condition requiring replacement to maintain safe and reliable supply.

3.3.1 ASSET CONDITION

Four of the circuit breakers at Sunbury Zone Substation were installed around fifty years ago. These circuit breakers are approaching the end of their serviceable life, are no longer supported by their manufactures and, based on Jemena's condition based risk management (CBRM) model, are at a higher than average risk of failing within the next five years.

Table 3–2 presents the current and forecast CBRM health indexes for these four circuit breakers. These health indexes are based on current network asset condition information, engineering knowledge and practical experience, and are used within Jemena to help guide asset investment. In the CBRM model, a health index above seven represents serious deterioration, typically contributed to by deterioration of the asset's main insulating material, and indicates that immediate replacement is prudent to avoid a potentially catastrophic asset failure.

With health indexes forecast to exceed acceptable levels before 2021, Jemena considers it prudent to replace the four circuit breakers within the next five years and, to maximise design and construction synergy benefits, to align these replacements with any zone substation capacity augmentation works undertaken at SBY within that period.

Table 3–2: Aged Circuit Breakers at Sunbury Zone Substation

Circuit Breaker (CB) type	Number of Circuit Breakers	Age (years)	CBRM Health Index - Current and Forecast Levels		
			2016	2021	2025
ASEA HLE 66 kV outdoor	2	51	5.50	7.36	8.38
AEI type JB424 22 kV outdoor	1	46	6.05	7.51	8.68
Reyrolle type OMT 22 kV outdoor	1	46	6.05	7.51	8.68

3.3.2 LIMITED TRANSFER AND EMERGENCY BACKUP CAPACITY

Insufficient load transfer capacity following an outage can result in extended customer outages. This has increased societal (market) costs, which, as required by the National Electricity Rules (NER) and the Regulatory Investment Test for Distribution (RIT-D), we aim to minimise through cost efficient augmentation. Extended customer outages also result in increased penalty costs to Jemena under the service target performance incentive scheme (STPIS), as outlined in Clause 6.6.2 of the NER.

During emergency outage conditions some load can be transferred off SBY to the adjacent Sydenham Zone Substation (SHM), from feeder SBY-33 to feeder SHM-11. Due to the additional risk it puts on the already heavily loaded SHM, as described in our Distribution Annual Planning Report, this transfer capacity away from SBY is minimal and cannot be relied on to manage system normal limitations. Utilising these transfers under system normal conditions would also limit Jemena's ability to maintain and operate the network in a secure manner because the available transfer capacity is currently utilised to take assets offline for maintenance during lighter loaded periods, and to quickly re-establish supply during outage events.

While there is also a connection between SBY and Coolaroo Zone Substation (COO), from feeder SBY-14 to COO-11, no load transfer capacity to COO has been included in the analysis due to a lack of capacity and significant forecast load growth on feeder COO-11.

Table 3–3 shows the available load transfer capacity included in the assessments. As shown, the available load transfer capacity is expected to diminish completely by 2020 due to forecast load growth on feeder SHM-11.

Table 3–3: Emergency load transfer capacity

Transfer Load from	Transfer load to	Emergency load transfer capacity (MVA)				
		2017	2018	2019	2020	2021
SBY-33	SHM-11	3.7	2.0	0.4	-	-

4. ASSUMPTIONS RELATING TO THE IDENTIFIED NEED

In accordance with clause 5.17.1(b) of the National Electricity Rules, Jemena's augmentation investment decisions aim to maximise the present value of the net economic benefit to all those who produce, consume and transport electricity in the National Electricity Market.

To achieve this objective, Jemena applies a probabilistic planning methodology that considers the likelihood and severity of critical network conditions and outages. The methodology compares the forecast cost to consumers of losing energy supply (e.g. when demand exceeds available capacity) against the proposed augmentation cost to mitigate the energy supply risk. The annual cost to consumers is calculated by multiplying the expected unserved energy (the expected energy not supplied based on the probability of the supply constraint occurring in a year) by the value of customer reliability (VCR). This is then compared with the annualised augmentation solution cost.

To ensure the net economic benefit is maximised, an augmentation will only be undertaken if the benefits, which are typically driven predominately by a reduction in the cost of expected unserved energy, outweigh the cost of the proposed augmentation resulting in that reduction in unserved energy. Augmentation is not always economically feasible and this planning methodology therefore carries an inherent risk of not being able to fully supply demand under some possible but rare events, such as a network outage coinciding with peak demand periods. The probabilistic planning methodology that we apply is further detailed in our Distribution Annual Planning Report.

The key assumptions that have been applied in quantifying the Sunbury Zone Substation limitations are outlined in this section, and include:

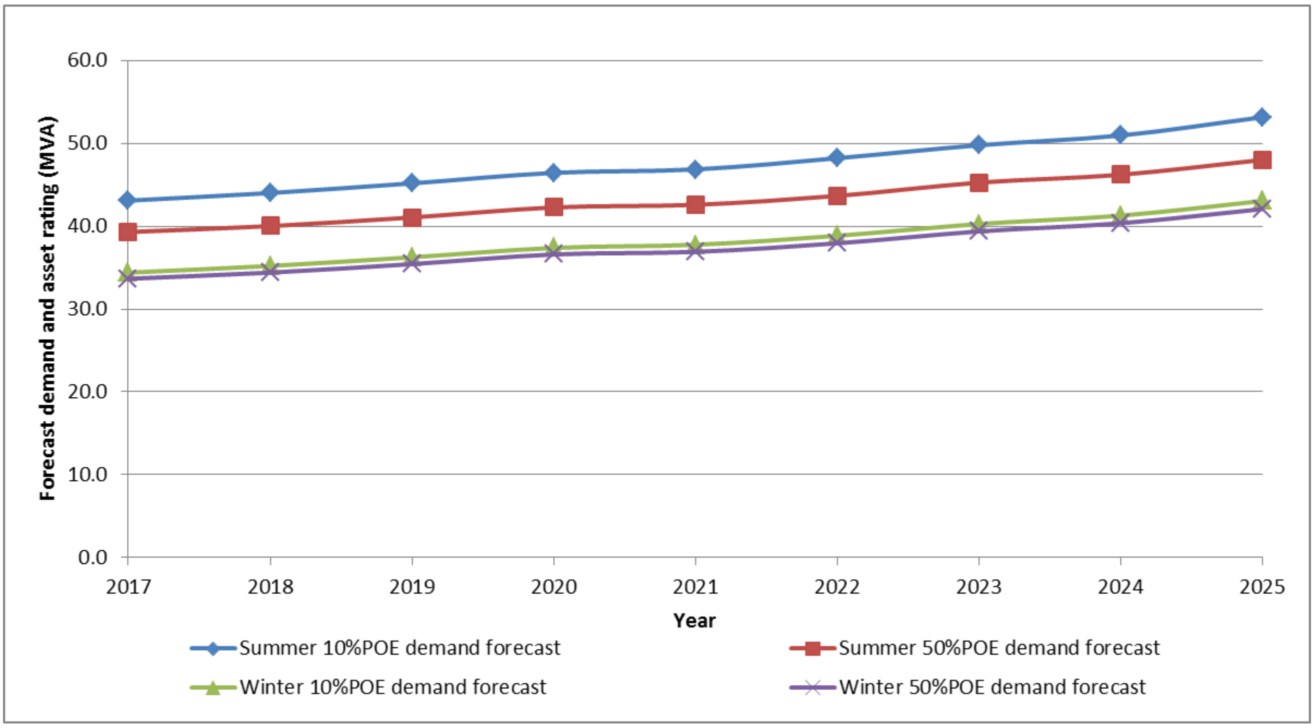
- Demand forecasts;
- Network asset ratings; and
- Network outage rates.

4.1 DEMAND FORECASTS

For the base (medium) scenario, demand forecasts have been based on the 2016 Load Demand Forecasts Report. Under this scenario, demand at SBY is forecast to increase by approximately 3.0% per annum.

Figure 4–1 shows the forecast summer and winter maximum demand for the base scenario 10% POE and 50% POE conditions.

Figure 4–1: Forecast peak demand



4.2 NETWORK ASSET RATINGS

In planning our network, Jemena applies a summer and winter rating to its temperature sensitive assets, which provides some recognition of the difference in ambient temperature between the two seasons and the heating or cooling effect that the ambient temperature has on an asset's rating.

Jemena also applies a cyclic rating to its transformers. This allows the SBY transformers to be loaded beyond their normal summer rating under emergency outage conditions, as outlined in Table 4–1.

The cyclic rating relies on the fact that asset loading is not constant over time, but that it cycles between the peak and some lesser loading level, allowing the assets time to dissipate heat and avoid long term heating overloads. Although cyclic ratings can be used for prolonged emergency periods, some loss of life occurs, and each twenty-four hour period that a transformer is loaded at its cyclic rating will result in a 0.03% reduction in the transformer's life expectancy.

The Sunbury Zone Substation asset ratings are outlined in Table 4–1 through to Table 4–4.

Table 4–1: SBY Zone Substation transformer ratings

Station asset	Continuous summer rating (MVA)	N-1 cyclic summer rating (MVA)	Continuous winter rating - (MVA)	N-1 cyclic winter rating (MVA)
No.1 66/22 kV transformer	16.0	19.5	16.0	19.5
No.2 66/22 kV transformer	10.0	12.8	10.0	12.8

Station asset	Continuous summer rating (MVA)	N-1 cyclic summer rating (MVA)	Continuous winter rating - (MVA)	N-1 cyclic winter rating (MVA)
No.3 66/22 kV transformer	16.0	19.5	16.0	19.5

Note: winter cyclic transformer ratings have been assumed equal to the summer cyclic ratings.

Table 4–2: SBY Zone Substation 22 kV and 66 kV bus ratings

Station asset	Summer rating (A)	Summer rating (MVA)
22 kV buses (feeder buses)	1470	56.0
22 kV buses (feeder tee-offs)	420	16.0
66 kV buses	490	56.0

Table 4–3: SBY Zone Substation circuit breaker ratings

Circuit Breaker (CB)	Continuous rating (A)	Continuous rating (MVA)
SBY No.1 Tx-No.2 GSB 66 kV CB	1600	182.9
SBY No.3 Tx-No.1 KTS 66 kV CB	1200	137.2
SBY No.1 KTS-No.1 GSB 66 kV CB	1600	182.9
SBY No.2 KTS-No.1 GSB 66 kV CB	1600	182.9
SBY No.2 KTS-No.2 GSB 66 kV CB	1200	137.2
SBY11 22 kV feeder CB	3150	120.0
SBY13 22 kV feeder CB	1250	47.6
SBY14 22 kV feeder CB	1250	47.6
SBY31 22 kV feeder CB	1250	47.6
SBY32 22 kV feeder CB	1250	47.6
SBY33 22 kV feeder CB	800	30.5
SBY No.1 Cap bank 22 kV CB	400	15.2

Table 4–4: SBY Zone Substation 22 kV feeder ratings

Feeder	Summer rating (A)	Winter rating (A)	Summer rating (MVA)	Winter rating (MVA)
SBY-11	330	370	12.6	14.1
SBY-13	375	375	14.3	14.3
SBY-14	375	375	14.3	14.3
SBY-31	375	375	14.3	14.3
SBY-32	290	290	11.1	11.1
SBY-33	375	375	14.3	14.3

4.3 NETWORK OUTAGE RATES

The network outage rates applied in a probabilistic economic planning assessment can have a large impact on selection of the preferred option and the optimal timing of that option. Jemena has considered the potential failure of outdoor 22 kV and 66 kV switchgear, indoor 22 kV switchgear and 66/22 kV transformers in its assessment of the SBY limitations and supply risk mitigation options.

The outdoor switchgear failure rates have been based on historical outage rates at SBY. There has been eighteen occasions over the past twenty years when all customer load at the zone substation was lost due to tripping of the transformer zone. Separating these outages by cause and location, Jemena has identified that eleven outages were specifically related to the outdoor switchgear, with eight of that eleven related to the 66 kV and three related to the 22 kV outdoor switchgear. Since there's three 66 kV buses and three 22 kV buses within the transformer switching zone, this equates to an average of 2.67 faults per outdoor 66 kV bus and one fault per outdoor 22 kV bus every eighteen years.

Since SBY doesn't currently have any indoor switchgear, indoor switchgear failure rates have been based on historical averages across the Jemena network. Indoor switchgear failure rates are included so the reliability improvement benefits of establishing indoor 22 kV switchgear can be incorporated into the options analysis of this RIT-D.

Based on the historical average, a mean time to repair of two hours has been applied for switchgear outages. While not all switchgear failures can be fixed within this time, this generally allows Jemena's network controllers sufficient time to manually isolate the faulted section and reinstate supply up to the capacity of the remaining in service assets.

Transformer outages are much less common than switchgear outages, and are therefore based on historical averages across the entire Jemena electricity network, rather than being based on the SBY transformers specifically. Historically, each transformer in Jemena's network is expected to fail once in every one hundred years. Due to procurement lead times and the typical work involved in repairing a transformer, the mean time to repair a transformer averages 2.6 months.

Table 4–5 shows the network outage rates applied in calculating the expected unserved energy for the augmentation analysis included in this report. The rates applied to a particular option analysis depend on the augmentation option being considered and the proposed post-augmentation configuration of that option, which could include any combination of indoor and outdoor switchgear.

Table 4–5: Network outage rates

	Transformer	66 kV outdoor switchgear	22 kV outdoor switchgear	22 kV indoor switchgear
Probability of failure	0.01	0.13	0.05	0.03
Mean time to repair (h)	1898	2	2	2
Number of assets (transformers or buses)	3	3	3	3
Unavailability rate	0.6500%	0.0091%	0.0034%	0.0023%

5. SUMMARY OF SUBMISSIONS

On 23 October 2015 Jemena published Stage One of the Sunbury – Diggers Rest Electricity Supply RIT-D, the non-network options report. The purpose of the non-network options reports was to commence engagement and encourage an open dialogue with non-network proponents in relation to the network capacity constraints associated with the Sunbury Zone Substation electricity supply area, and to ensure the best solution is adopted to manage the network capacity constraints in the area and meet forecast demand, whether those solutions involve a network, non-network or hybrid solution.

As required under the National Electricity Rules (NER), the non-network options report was open for a consultation period of three months. Submissions closed on 29 January 2016.

Jemena received two submissions to the non-network options report; one from GreenSync, which outlined a demand side management proposal, the other from ZECO Energy, which provided indicative battery storage costs for containerised battery connections at the street substation and/or zone substation level.

This section summarises the key aspects of the two non-network options report submissions.

5.1 GREENSYNC'S DEMAND MANANGEMENT PROPOSAL

GreenSync's submission proposes a partnered solution between Jemena and GreenSync to address the Sunbury – Diggers Rest electricity supply constraint. The proposal includes two key components:

- Deployment of GreenSync's PortfolioCM™ technology, which is a platform designed to give Jemena control and visibility of portfolio enrolled demand side management (DSM); and
- Enrolment of a diverse DSM portfolio through engagement with company partners within the local Sunbury area community.

5.1.1 CONSTRAINT MANAGEMENT PLATFORM

GreenSync's PortfolioCM™ is a cloud based software service designed to allow utilities to access and leverage DSM to smooth out network peaks, and increase long term network utilisation. Deploying the GreenSync PortfolioCM™ platform would give Jemena the capability to monitor constrained network elements to accurately predict when and where constraints exist, and dispatch DSM assets at minimum cost to maintain network security.

Once enrolled in the PortfolioCM™ platform, commercial and industrial (C&I), small business, utility and residential programs would create a holistic, integrated solution giving Jemena control and visibility of the DSM portfolio. The PortfolioCM™ technology allows the most economic dispatch of enrolled DSM assets weather via voluntary demand reduction of enrolled C&I, water utility or residential customers, or demand response via battery systems enrolled in the portfolio.

GreenSync's proposal provides Jemena with the opportunity to manage the energy at risk until a network augmentation can be implemented, or to defer the proposed network augmentation. The proposal is flexible in duration and the level of load or batteries enrolled. It allows for additional DSM enrolment in the future by Jemena, GreenSync, or a third party, and will allow the integration of a DSM solution with the proposed preferred network option to maximise the net market benefit.

For the purposes of project costing, GreenSync provided annual PortfolioCM™ licencing and other associated costs, which have been included in cost-benefit analysis but are not separately reported as they are commercial in confidence.

5.1.2 DSM PORTFOLIO

While their core business is around deployment, training and support of the PortfolioCM™ platform, as part of their RIT-D submission GreenSync has also engaged with solution partners, including AGL, Living Fundraisers, Hume City Council and local Sunbury energy uses, to develop a diverse portfolio of DSM that could be enrolled within the Sunbury Zone Substation supply area.

GreenSync identified six key client groups in the area, being storage opportunities, small businesses, commercial and industrial, and residential groups. The portfolio of customers that expressed interest in participating in DSM, and that GreenSync considers as being either committed or that are expected to commit, include utilities, commercial and industrial load (C&I) and small to medium enterprises (SME). Based on their engagement, GreenSync has developed a committed and expected DSM portfolio that increases from 5.20 MW in 2016, ramping up to 6.0 MW in 2018 and beyond. The portfolio customer split is shown in Table 5–1.

Table 5–1: GreenSync committed and expected DSM Portfolio

Customer Category	Load Available by Year		
	2016	2017	2018 and beyond
Utilities	1,250	2,000	2,000
Residential (Storage)	1,000	1,000	1,000
C&I (Fast Response)	1,000	1,000	1,000
Residential (Day Prior)	200	200	200
SME	250	275	300
C&I (Day Prior)	1,500	1,500	1,500
Total	**5,200**	**5,975**	**6,000**

As shown in Table 5–1, GreenSync's proposed portfolio includes battery storage as well as fast response and day prior voluntary load reduction. Fast response typically utilises automation to control or trip off the DSM enrolled customer's assets, and would be contracted to operate within an hour. Fast response requires the installation of hardware at the customer's site, and can be useful for managing network loading immediately following a network contingency. Day prior response typically involves an automated messaging service directing the portfolio enrolled customer to ramp down or disconnect their load. It requires twenty-four hours notification based on the day-ahead demand forecast, and is therefore more useful for managing system normal constraints where demand can accurately be predicted; typically where demand and ambient temperature are highly correlated.

Fast response customers would be paid a premium upfront capacity fee to incentivise participation. Day prior enrolled customers would be paid a lower upfront capacity fee, but receive higher energy curtailment (dispatch) fees if and when their load reduction services are called on. In their submission, GreenSync provided indicative capacity fees ($/kW) and dispatch fees ($/kWh) for each customer category. These costs have been applied in the cost-benefit analysis but are not separately reported as they are commercial in confidence.

In addition to the customer payments and the PortfolioCM™ licencing and management costs, GreenSync also provided an indicative, once off, project and portfolio establishment cost, which has also been included in the cost-benefit analysis.

As part of their submission, GreenSync engaged AGL and Living Fundraisers to increase the potential residential and small to medium enterprise portfolio recruitment and event participation during DSM events. In the submission, AGL noted its commitment to expanding its battery storage program to the Sunbury area, which would involve installing 6 kWh battery storage devices at residential and small to medium enterprise premises, to be controlled by the GreenSync PortfolioCM™ platform. Living Fundraisers noted their commitment to engaging with and incentivising the community to promote DSM enrolment and participation during DSM events.

GreenSync's submission demonstrated that their DSM proposal would provide a positive net market benefit relative to the do nothing scenario.

Based on portfolio and cost information provided in GreenSync's submission, Jemena has assessed a range of network/non-network hybrid solutions, as presented in Section 8.

5.2 ZECO ENERGY'S BATTERY STORAGE PROPOSAL

ZECO Energy is an energy storage provider and distributor of Samsung's residential and commercial energy storage products.

ZECO Energy's submission, prepared jointly with turnkey project service provider BMC Group, broadly outlines two battery energy storage solutions (BESS) that may address the identified need:

- BESS kiosk cabinets - designed to connect to the low voltage terminals of Jemena's substation kiosk transformers, multiple kiosk cabinets could be located throughout the Sunbury supply area to reduce localised loading throughout the supply area, thereby reducing the overall zone substation peak load.
- Containerised BESS - designed as a larger capacity larger footprint solution, containers could be located within Sunbury Zone Substation to reduce peak loading directly at the zone substation.

Each BESS is designed as a fully integrated system, with each cabinet or container housing the:

- Power conversion system
- Samsung SDI batteries
- Battery trays and racks
- Battery management system/s
- Switchgear, cables and connectors

ZECO Energy's submission did not identify specific battery installation quantities or propose specific connection locations, nor did it attempt to quantify market benefits of a battery storage solution.

While their submission did include battery technology information and indicative costs for supply and installation of their BESS kiosk cabinets and containers, ZECO Energy has requested that the bulk of their submission remain commercial in confidence. As such, much of the submission detail has been omitted from this assessment report.

Jemena has assessed battery storage market benefits based on information supplied in ZECO Energy's submission, battery technology information publically available on Samsung's website, and typical battery energy storage solution costs. Jemena's assessments are presented in Section 8.

6. OPTIONS CONSIDERED IN THE RIT-D

This section outlines the credible options that have been considered in the RIT-D, and outlines the proposed works associated with each credible option.

Since publishing the non-network options report we have progressed negotiations to secure a long term lease of the existing Sunbury Zone Substation site. With the progression of these negotiations we have eliminated previously considered options that involved moving to a new zone substation site. We have also added new network and hybrid network/non-network options based on the proposals and information outlined in submissions to the non-network options report consultation, and the AER's feedback to our EDPR submission.

The complete list of credible options considered in this RIT-D is:

- Option 1a - Upgrade the 10 MVA transformer and segment the 22 kV and 66 kV;
- Option 1b - Upgrade the 10 MVA transformer without segmenting the 22 kV or 66 kV;
- Option 2a - Upgrade the 10 MVA transformer with partial 22 kV segmentation and 66 kV segmentation;
- Option 2b - Upgrade the 10 MVA transformer with partial 22 kV segmenting but without 66 kV segmentation;
- Option 3a – Enrol DSM of 6.0 MVA in 2018, with network Option 1a delayed to 2019; and
- Option 3b – Install 6.0 MVAh of battery storage in 2018, with network Option 1a delayed to 2019.

The post augmentation capacities of the network options are summarised in Table 6–1.

Table 6–1: Post augmentation capacities of network options

Augmentation option	N summer capacity	N winter capacity	N-1 summer capacity	N-1 winter capacity
Base Case - Do Nothing	32.0	32.0	26.4	26.4
Option 1a - Upgrade the 10 MVA transformer and segment the 22 kV and 66 kV	45.0	45.0	32.0	32.0
Option 1b - Upgrade the 10 MVA transformer without segmenting the 22 kV or 66 kV	45.0	45.0	32.0	32.0
Option 2a - Upgrade the 10 MVA transformer with partial 22 kV segmentation and 66 kV segmentation	45.0	45.0	32.0	32.0
Option 2b - Upgrade the 10 MVA transformer with partial 22 kV segmenting but without 66 kV segmentation	45.0	45.0	32.0	32.0

The demand side management capacities for the Option 3 hybrid network/non-network solutions are summarised in Table 6–2. These capacities can effectively be considered as a reduction in the forecast demand, rather than an increase in the supply capacity.

Table 6–2: Post implementation DSM capacities of hybrid network/non-network options

Augmentation option	Demand reduction capacity (MVA)	Battery storage capacity (MVAh)	Power converter capacity (MVA)	Network capacity increase (MVA)
Option 3a – Enrol DSM of 6.0 MVA in 2018, with network Option 1a delayed to 2019	6.0	-	-	As per Option 1a (from 2019)
Option 3b – Install 6.0 MVAh of battery storage in 2018, with network Option 1a delayed to 2019	-	6.0	6.0	As per Option 1a (from 2019)

6.1 BASE CASE

The assessment of credible options is based on a cost-benefit analysis that considers the future expected unserved energy of each credible option compared with the base case, where no augmentation option is implemented.

Under this base case, the action required to ensure that loading levels remain within asset capabilities is involuntary load shedding of Jemena's customers. The cost of involuntary load shedding is calculated using the value of customer reliability (VCR) which, for the Jemena electricity network, is currently estimated at $39,463/MWh (Real $2016), as described in Section 7.3.1.1.

The 'Base Case' option gives the basis for comparing the cost-benefit assessment of each credible augmentation option. The base case is presented as a do nothing option, where we would continue managing network asset loading through involuntary load shedding but not initiate any augmentation project.

Since there is no augmentation associated with the base case (Do Nothing) option, this is a zero cost option.

6.2 OPTION 1A – UPGRADE THE 10 MVA TRANSFORMER AND SEGMENT THE 22 KV AND 66 KV

This option is to upgrade the thermally limited 10 MVA 66/22 kV transformer and segment the 22 kV and 66 kV switchyards. The proposed scope includes:

- Upgrade the 10 MVA 66/22 kV transformer by replacing it with a 20/33 MVA 66/22 kV transformer;
- Install three new 22 kV switchboards, in a new switchgear, protection and control building, to replace aged 22 kV assets and upgrade and segment the existing 22 kV switchyard;
- Install two new 66 kV circuit breakers to segment the existing 66 kV switchyard; and
- Install an additional two new 66 kV circuit breakers to replace aged 66 kV assets.

6.3 OPTION 1B – UPGRADE THE 10 MVA TRANSFORMER WITHOUT SEGMENTING THE 22 KV OR 66 KV

This option is to upgrade the thermally limited 10 MVA 66/22 kV transformer without segmenting the 22 kV or 66 kV switchyards. The proposed scope includes:

- Upgrade the 10 MVA 66/22 kV transformer by replacing it with a 20/33 MVA 66/22 kV transformer;
- Install one new 22 kV switchboard, in a new switchgear, protection and control building, to replace aged 22 kV assets; and
- Install two new 66 kV circuit breakers to replace aged 66 kV assets.

6.4 OPTION 2A – UPGRADE THE 10 MVA TRANSFORMER WITH PARTIAL 22 KV SEGMENTATION AND 66 KV SEGMENTATION

This option is to upgrade the thermally limited 10 MVA 66/22 kV transformer, partially segment the 22 kV and fully segment the 66 kV switchyards. The proposed scope includes:

- Upgrade the 10 MVA 66/22 kV transformer by replacing it with a 20/33 MVA 66/22 kV transformer;
- Install one new 22 kV switchboard, in a new switchgear, protection and control building, to replace aged 22 kV assets;
- Install two new 66 kV circuit breakers to segment the existing 66 kV switchyard; and
- Install an additional two new 66 kV circuit breakers to replace aged 66 kV assets.

6.5 OPTION 2B – UPGRADE THE 10 MVA TRANSFORMER WITH PARTIAL 22 KV SEGMENTATION BUT WITHOUT 66 KV SEGMENTATION

This option is to upgrade the thermally limited 10 MVA 66/22 kV transformer and partially segment the 22 kV switchyard, but not segment any of the 66 kV switchyard. The proposed scope includes:

- Upgrade the 10 MVA 66/22 kV transformer by replacing it with a 20/33 MVA 66/22 kV transformer;
- Install one new 22 kV switchboard, in a new switchgear, protection and control building, to replace aged 22 kV assets; and
- Install an additional two new 66 kV circuit breakers to replace aged 66 kV assets.

6.6 OPTION 3 – EMBEDDED GENERATION AND DEMAND SIDE MANAGEMENT

This option is to utilise embedded generation or establish demand side management to reduce peak demand on the transformers at Sunbury Zone Substation.

Jemena currently has no significant embedded generators (>1 MW) connected within the Sunbury Zone Substation supply area that could be used to defer the need for the proposed preferred solution. As such, the option of contracting embedded generation for network support during hours of peak demand is not considered to be a credible option.

Demand side management, such as voluntary load reduction or battery storage, can alleviate supply risks caused by network inadequacies by reducing and/or shifting the peak demand. The resulting reduction in peak demand can potentially defer the need for major network augmentation, or help to better manage the risk until a major network augmentation can be commissioned or is economically feasible.

Due to the limiting assets associated with the identified need, demand side management would need to be connected to, or downstream (demand side) of, SBY's 22 kV buses to effectively offload the 66/22 kV transformers.

Based on the non-network options report submissions received from GreenSync and ZECO Energy, as outlined in Section 5, Jemena has assessed hybrid network/non-network options that include voluntary load reduction or battery energy storage solutions.

The two alternative sub-options considered under Option 3 include:

- Option 3a - deploy GreenSync's PortfolioCM™ platform and enrol DSM of 6.0 MVA in 2018, with commissioning of network Option 1a delayed to 2019.
- Option 3b – install a BESS comprising 6.0 MVAh capacity of battery storage and a 6.0 MVA power converter in 2018, with commissioning of network Option 1a delayed to 2019.

7. MARKET BENEFIT ASSESSMENT METHODOLOGY

This section outlines the methodology that Jemena has applied in assessing market benefits associated with each of the credible options considered in this RIT-D. It describes how the classes of market benefits have been quantified and outlines why particular classes of market benefits are considered inconsequential to the outcome of this RIT-D.

It also describes the reasonable scenarios considered in comparing the base case ‘state of the world’ to the credible options considered.

The RIT-D has been assessed over a fourteen year period. Market benefits were calculated for first nine years (2017-2025), based on Jemena’s 2016 load demand forecasts, and the ninth year benefits were applied to each of the final five years (2026-2030) of the assessment period. This allows a longer assessment period without the need to develop longer term demand forecasts.

7.1 MARKET BENEFIT CLASSES QUANTIFIED FOR THIS RIT-D

This section outlines the classes of market benefits that Jemena considers will have a material impact on this RIT-D, and have therefore quantified.

The classes of market benefits quantified for this RIT-D include changes in:

- Involuntary load shedding and customer interruptions;
- Voluntary load curtailment; and
- Timing of the expenditure.

7.1.1 INVOLUNTARY LOAD SHEDDING AND CUSTOMER INTERRUPTIONS

Involuntary load shedding is where a customer’s load is interrupted (switched off or disconnected) from the network without their agreement or prior warning. Involuntary load shedding can occur unexpectedly due to a network outage event, or pre-emptively to maintain network loading to within asset capabilities. The aim of a credible option, such as demand side management or a network capacity augmentation, is to provide a change in the amount of involuntary load shedding expected.

A reduction in involuntary load shedding, relative to the Base Case, results in a positive contribution to the market benefits of the credible option being assessed. The involuntary load shedding of a credible option is derived by:

- The quantity (in MWh) of involuntary load shedding required assuming the credible option is completed, multiplied by
- The value of customer reliability (in $/MWh), which Jemena has calculated to be $39,436/MWh based on AEMO’s Value of Customer Reliability review[3].

Jemena forecasts and models hourly load for the forward planning period, and quantifies the expected unserved energy (involuntary load shedding) by comparing forecast load to network capabilities under system normal and network outage conditions.

[3] AEMO Value of Customer Reliability review. Available http://www.aemo.com.au/Electricity/Planning/Value-of-Customer-Reliability-review

Jemena has captured the reduction in involuntary load shedding as a market benefit of the credible options assessed in this RIT-D. The costs have been included in the net economic benefit assessments summarised in Section 8.

7.1.2 VOLUNTARY LOAD CURTAILMENT

Voluntary load curtailment is where a customer/s agrees to voluntarily curtail their electricity under certain circumstances, such as high network loading or during a network outage event. The customer will typically receive an agreed payment for making load available for curtailment, and for actually having it curtailed during a network event. A credible demand-side reduction option leads to a change in the amount of voluntary load curtailment.

An increase in voluntary load curtailment, compared to the Base Case, results in a negative contribution (a cost) to the market benefits of the credible option. This negative market benefit is derived by:

- The quantity (in MWh) of voluntary load shedding (demand side reduction) due to the credible option being assessed, multiplied by
- The payment (in $/MWh) made to the customer for voluntarily curtailing their load, plus
- Any availability fee (in $) made to the customer for making their load available for curtailment.

Jemena forecasts and models hourly load for the forward planning period and quantifies the expected voluntary load shedding by summating the available demand side reduction required to service that load under system normal and network outage conditions.

Despite being a market cost, voluntary load curtailment can form a credible option, having positive market benefits, by taking the place of higher priced involuntarily load curtailment.

Jemena has captured the expected voluntary load shedding and scheme management fees as operational costs of the demand side management programs assessed in this RIT-D. The operational costs are added to the capital cost to establish the scheme and enrol customers. These costs have been included in the net economic benefit assessments summarised in Section 8.

7.1.3 TIMING OF EXPENDITURE

The costs of credible options assessed in this RIT-D include the major works at Sunbury Zone Substation that are currently considered likely within the fourteen year period of 2017-2030.

By including the cost of the major works expected under each credible option, Jemena has captured potential changes in expenditure timing between the various credible options. These market costs, and any associated benefits, are captured in the NPV analysis, and applied to the credible option rankings, outlined in Section 8.

7.2 MARKET BENEFIT CLASSES NOT RELEVANT TO THIS RIT-D

This section outlines the classes of market benefits that Jemena considers immaterial to this RIT-D assessment, and our reasoning for their omission from this RIT-D assessment.

The market benefits that Jemena considers will not materially impact the outcome of this RIT-D assessment include changes in:

- Costs to other parties;

- Load transfer capacity and embedded generators;
- Option value; and
- Electrical energy losses.

7.2.1 COSTS TO OTHER PARTIES

The SBY capacity constraint is a localised thermal capacity and asset reliability limitation. The zone substation transformers radially supply Sunbury and its surrounding suburbs. As such, none of the credible options are expected to have a material impact on any surrounding areas or on the network development plans of any other network participants or other parties. Jemena has therefore not attempted to quantify any market benefit associated with costs to other parties.

7.2.2 CHANGES IN LOAD TRANSFER CAPACITY AND EMBEDDED GENERATORS

Load transfer capacity between Sunbury, Sydenham and Coolaroo zone substations is predominately limited by the high voltage feeders that connect between the three zone substations. Options that address the capacity constraints directly at Sunbury Zone Substation won't change feeder capacities, and therefore won't result in a load transfer capacity change. Options that could result in a load transfer capacity change are those that address capacity limitations along, or downstream of, the high voltage feeders. This could include feeder augmentations or reconfigurations, demand side management or embedded generation.

As outlined in Section 6.6, Jemena currently has no significant embedded generators (>1 MW) connected to the Sunbury, Sydenham or Coolaroo feeders or zone substations that could help address the identified need. Contracting embedded generation for network support is therefore not considered a credible option.

The identified need for this RIT-D is thermal capacity and reliability limitations at Sunbury Zone Substation. Jemena has not identified any credible high voltage feeder options that are capable of addressing the identified need.

For this RIT-D, the credible options that could result in a load transfer capacity change are those that include demand side reduction or distributed battery storage. Since constraint limitations at Sydenham and Coolaroo are currently insignificant compared to the Sunbury Zone Substation constraints, any potential market benefit from increased load transfer capacities is likely to be immaterial, and won't alter the option ranking for this RIT-D.

Additionally, Jemena's assessment of the market benefit for this RIT-D has been undertaken at the zone substation level. Assessing market benefits at the feeder level requires and added level of complexity that would likely exceed any potential additional benefit that may be identified. Jemena has therefore not attempted to quantify any market benefit associated with changes to the load transfer capacity or embedded generation.

7.2.3 OPTION VALUE

Jemena notes the AER's view that option value is likely to arise where there is uncertainty regarding future outcomes, the information that is available in the future is likely to change and the credible options considered by the RIT-D proponent are sufficiently flexible to respond to that change.

We also note the AER's view that appropriate identification of credible options is capable of capturing any option value, thereby meeting the requirement to consider option value as a class of market benefit under the RIT-D.

In addition to appropriate identification of credible options, Jemena has undertaken sensitivity studies on the forecast demand, value of customer reliability, discount rate, and credible option capital costs. Any calculation of option value benefit beyond this would require significant modelling, which is expected to be disproportionate to any additional option value benefit that may be identified. Jemena has therefore not attempted to estimate any additional option value market benefit for this RIT-D assessment.

7.2.4 ELECTRICAL ENERGY LOSSES

Reducing network utilisation, through network impedance or load changes in the Sunbury area can result in a change in network losses.

The network options considered in this RIT-D only result in small network impedance changes and the non-network option are not expected to significantly alter the power flow throughout the network, and are therefore not expected to result in material changes to the network losses.

Options 1a, 1b, 2a and 2b all involve removing the old 10 MVA transformer and installing a new 20/33 MVA transformer. While changing the transformers will result in a small network impedance change, the resultant change in network losses is immaterial. Options 3a and 3b both involve a reduction in the peak demand through demand side management, which can result in a change in network power flow, and therefore a change in network losses.

To estimate any materiality of changes in network losses, Jemena calculated the network losses on the sub-transmission lines and the zone substation at the time of peak demand under the Base Case option, following removal of the 10 MVA transformer and installation of the new 20/33 MVA transformer, and following a peak demand reduction of 6 MW at Sunbury Zone Substation. The network losses were calculated using PSSE load flow analysis with, each of these three alternative arrangements modelled in turn.

Upgrading the transformer at Sunbury Zone Substation is expected to reduce the network losses by less than 0.01% of the 2017 peak demand at SBY (less than 0.05 MW), compared to the Base Case network losses. A 6 MW load reduction at Sunbury Zone Substation has a similar result.

To estimate any market benefit of reducing network losses, the percentage change in network losses for each alternative option can be multiplied by the change in expected unserved energy for that option and by the cost of network losses.

Since higher losses will result in additional generation dispatch to supply those loses, the cost of network losses is assumed to equal the average Victorian spot price for generation, which has been calculated at $50/MWh based on average Victorian spot price data from AEMO's website[4].

Due to the very small change in losses and the low cost of network losses compared to the expected unserved cost costs, changes in network losses are considered immaterial to the result of this RIT-D, and have therefore been excluded from the market benefit assessments summarised in Section 8.

7.3 VALUING MARKET BENEFITS

Clause 5.17.1 of the NER requires that the RIT-D assessment is based on a cost-benefit analysis that includes an assessment of reasonable scenarios of future supply and demand. Since this RIT-D is driven by electricity demand in a predominately radial network with minimal demand side generation, future supply developments are not expected to significantly impact the assessment results, preferred option or optimal timing.

For this RIT-D Jemena has elected to assess three alternative demand scenarios:

- No demand growth scenario;

[4] AEMO: Average Victorian spot prices. Available http://www.aemo.com.au/Electricity/Data/Price-and-Demand/Average-Price-Tables

- Medium (planning) demand growth rate scenario; and
- High demand growth rate scenario.

The demand forecasts utilised for the medium (planning) demand growth rate scenario are those of the 2016 Load Demand Forecasts Report. Under this scenario, demand at SBY is forecast to grow at an average rate of approximately 3.0% per annum.

For the no demand growth scenario, Jemena has assumed no demand growth beyond the 2017 forecast demand.

For the high demand growth rate scenario, an annual growth rate of 4.5% has been applied.

In each of the three alternative demand scenarios, the summer and winter peak demand has been forecast for 10% POE and 50% POE conditions. In valuing market benefits for this RIT-D, the demand forecasts have been weighted 30% for the 10% POE demand forecasts and 70% for the 50% POE demand forecasts. The complete set of demand forecasts are tabulated in Appendix A.

7.3.1 SENSITIVITY ANALYSIS

There are three key inputs that could potentially vary the optimal timing or preferred option for mitigating the Sunbury Zone Substation limitations. Sensitivity studies to these key inputs have been assessed under each of the alternative demand scenarios. The preferred option is the one that maximises the present value of net economic benefit in the majority of reasonable scenarios and sensitivity studies.

The key variables applied in valuing the Sunbury area limitations and economic benefits are outlined in this section, and include:

- Value of customer reliability (VCR);
- Discount rate; and
- Project costs.

7.3.1.1 Value of customer reliability

The cost of unserved energy is calculated using the value of customer reliability (VCR). This is an estimate of how much value electricity consumers place on a reliable electricity supply.

In assessing the credible options to alleviate the impact of constraints on its network, Jemena applies VCR values based on the Australian Energy Market Operator's (AEMO) 2014 Value of Customer Reliability Review[5]. Applying the sectorial values developed by AEMO to Jemena's load composition of approximately 47% commercial, 31% residential and 22% industrial customers, Jemena determined a VCR of $39,436/MWh (in 2016 Australian dollars), which includes an escalation factor of 1.33% to account for CPI from AEMO's 2014 to 2015 value, and 1.25% to account for CPI from the 2015 to 2016 value. This VCR of $39,436/MWh has been applied as the base VCR.

Sensitivities to the base VCR of ±20% have been considered, resulting in a low VCR sensitivity of $31,549/MWh and a high VCR of $47,323/MWh.

[5] AEMO. Available http://www.aemo.com.au/Electricity/Planning/Value-of-Customer-Reliability-review

7.3.1.2 Discount rate

A discount rate of 6.37% has been applied in undertaking the Net Present Value (NPV) assessment of credible options.

Although lower than Jemena considers appropriate for the analysis of a private enterprise investment in the electricity sector, this discount rate is based on the AER's approved weighted average cost of capital (WACC) for Jemena's electricity network in 2016.

Jemena has applied a sensitivity discount rate of 8.26%. This is in line with the rate proposed in Jemena's revised 2016-2020 electricity distribution price review (EDPR) submission, and accounts for uncertainty surrounding annual changes to the AER approved WACC.

7.3.1.3 Project costs

The network project capital costs have been estimated by Jemena's internal estimation teams. Consideration has been given to recent similar augmentation projects and expected costs based on site specific construction complexities and industry experience. These project estimates have been prepared for planning purposes and are therefore subject to an estimate range of ±30%, which has therefore been applied to the sensitivity studies for this RIT-D.

Operational and maintenance costs for the network projects are estimated at ±1.5% of capital cost per annum.

The program establishment capital costs and operational costs of the non-network options are based on information provided in the non-network options report submissions. While estimate accuracy ranges for the non-network submissions were not provided, sensitivities of ±30% have also been applied to these costs for consistency with the network option sensitivity studies.

The program establishment capital costs and operational costs of the non-network options are based on information provided in the non-network options report submissions and industry available information. While estimate accuracy ranges for the non-network submissions were not provided, sensitivities of ±30% have also been applied to these costs for consistency with the network option sensitivity studies.

Project costs are generally presented in real $2016, or as noted throughout the report. A consumer price index (CPI) rate of 2.5% per annum has been applied to the project works planned in later years.

8. OPTIONS ANALYSIS

This section presents the base case limitation and summarises the augmentation analysis results of potential options. The annualised Base Case (Do Nothing) limitation cost for the next nine year period is presented, as is the net economic benefit calculated for each potential option. The net economic benefit analysis has been assessed considering the network risk and expected augmentation costs for the fourteen year period from 2017 to 2030.

The emergency load transfer capacity away from SBY to neighbouring Sydenham Zone Substations (SHM), as presented in Table 3–3, has been included in the expected unserved energy and cost of expected unserved energy values presented. While the load transfers can offload much of the expected unserved energy under emergency outage conditions, the assessment assumes these load transfers are not available to offload the system normal expected unserved energy. This assumption is made due to the additional risk that system normal load transfers would put on the adjacent zone substations and feeders, thereby only shifting the supply risk to another location within the network as opposed to actually mitigating it.

Each potential augmentation option has been ranked according to its net economic benefit, being the difference between the market benefit and the option’s costs within the assessment period.

Appendix B includes the load at risk and economic assessment spreadsheets.

8.1 EXISTING NETWORK LIMITATIONS

This section presents the existing annualised thermal limitation cost for the next nine year period, due to the thermal and reliability limitations.

8.1.1 BASE CASE

If no action is taken to increase the supply capacity, voluntarily reduce the demand, or improve the reliability at Sunbury Zone Substation (SBY), involuntary load shedding would be required under system normal and network outage conditions.

The impact of the network limitations under the base case is presented in Table 8–1.

Table 8–1: Limitation impact under Base Case

Year	Max load at risk under system normal conditions (MVA)	Annual hours at risk under system normal conditions (h)	Weighted expected unserved energy (MWh)	Cost of weighted expected unserved energy ($k)
2017	9.3	52	181.7	$7,166
2018	11.5	95	227.1	$8,957
2019	14.3	245	313.2	$12,352
2020	16.5	433	457.5	$18,044
2021	17.6	534	513.2	$20,240
2022	19.8	730	731.1	$28,834
2023	22.5	1015	1133.8	$44,716

Year	Max load at risk under system normal conditions (MVA)	Annual hours at risk under system normal conditions (h)	Weighted expected unserved energy (MWh)	Cost of weighted expected unserved energy ($k)
2024	24.6	1320	1480.3	$58,384
2025	26.8	1615	2228.1	$87,876

8.2 ECONOMIC BENEFITS

Net economic benefits are the market benefits less the cost (negative benefit) to implement the credible option being considered.

Table 8–2 shows the cost, net economic benefit, and the project ranking of each option relative to the Do Nothing option.

All feasible network options are based on commissioning in 2018 or, where a delayed network augmentation is considered alongside a non-network option, 2019.

The feasible options have been ranked based on their present value of net economic benefit, which is the total benefits provided over the 2017-2030 period, minus the project cost to implement, operate and maintain the credible option being considered.

The assessment results show that the feasible option that maximises the net economic benefit is Option 1a. This option includes upgrading the 10 MVA transformer, by replacing it with a 20/33 MVA unit, and segmenting the 22 kV and 66 kV switchyards to improve network reliability by November 2018. It also includes replacement of four aged circuit breakers which are showing signs of deterioration. This option is Jemena's proposed preferred option because it meets the identified need and maximises the net economic benefit compared to all the other options considered in this RIT-D.

Table 8–2: Market benefits of augmentation options relative to the base case

Augmentation option	Project cost (2017-2030) ($M)	NPV of net economic benefit ($M)	Project ranking
Base Case - Do Nothing	0.00	0.00	7
Option 1a - Upgrade the 10 MVA transformer and segment the 22 kV and 66 kV	14.24	452.99	1
Option 1b - Upgrade the 10 MVA transformer without segmenting the 22 kV or 66 kV	13.39	447.13	5
Option 2a - Upgrade the 10 MVA transformer with partial 22 kV segmentation and 66 kV segmentation	10.72	449.38	4
Option 2b - Upgrade the 10 MVA transformer with partial 22 kV segmenting but without 66 kV segmentation	9.89	450.23	2
Option 3a - deploy GreenSync's PortfolioCM™ platform and enrol DSM of 6.000 MVA in 2018, with commissioning of network Option 1a delayed to 2019	15.47	450.00	3

Augmentation option	Project cost (2017-2030) ($M)	NPV of net economic benefit ($M)	Project ranking
Option 3b – install a BESS comprising 6.0 MVAh capacity of battery storage and a 6.0 MVA power converter in 2018, with commissioning of network Option 1a delayed to 2019	19.18	443.11	6

The sensitivity analysis also shows that Option 1a maximises the net economic benefit under the majority of cases. The sensitivity analysis results are included in Appendix B spreadsheets.

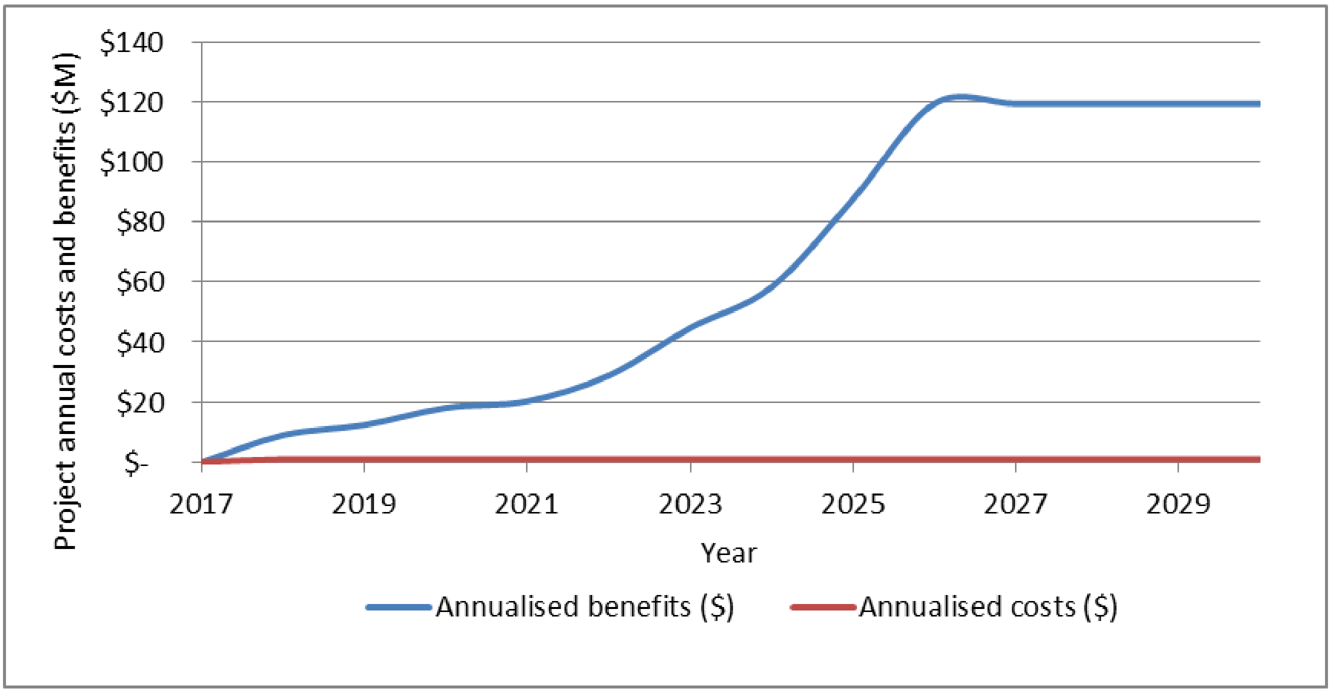
8.3 PREFERRED OPTION OPTIMAL TIMING

The optimal timing of works associated with the Option 1a works have been identified by taking the annualised augmentation market benefit (the change in voluntary and involuntary load shedding) associated with undertaking the proposed augmentation, and comparing it to the annualised cost of establishing, operating and maintain the proposed network augmentation from 2018. The annualised capital cost of augmentation is calculated using the project costs, a project life of fifty years, and a discount rate of 6.37% per annum.

The annualised cost of the proposed preferred option, Option 1a, is $950 thousand.

As shown in Figure 8–1, the annualised benefit exceeds the annualised costs. The optimal timing to complete the network augmentation is therefore as soon as possible, which given project lead times is expected to be by November 2018.

Figure 8–1: Annualised costs and benefits of Option 1a



9. CONCLUSION AND NEXT STEPS

The assessment outlined within this report shows that the primary limitations associated with Sunbury Zone Substation (SBY) are the thermal capability of the stations transformers and the level of reliability provided by the station's basic switching arrangement.

9.1 PREFERRED SOLUTION

The assessment shows that the preferred solution is to upgrade the 10 MVA transformer, by replacing it with a new 20/33 MVA transformer, segmenting the 22 kV switchyard by installing three new 22 kV switchboards, segmenting the 66 kV switchyard by installing two new 66 kV circuit breakers, and replacing two aged 66 kV circuit breakers, by November 2018.

Table 9–1 shows the total project cost breakdown for Option 1a.

Table 9–1: Option 1a - Cost estimate breakdown

	NPV project cost ($M Real2016)
Network augmentation capital cost	$12.46
Network augmentation operational and maintenance cost	$1.78
Total project expenditure	**$14.24**

Applying the discount rate of 6.37% per year, the preferred solution has a net economic benefit of $453 million over the fourteen year assessment period.

9.2 NEXT STEPS

Jemena invites written submission on this report from Registered Participants, interested parties, AEMO and non-network solution providers.

All submissions and enquiries should be directed to:

Ashley Lloyd
Network Capacity Planning & Assessment Manager
Email: PlanningRequest@jemena.com.au
Phone: (03) 9173 8279

Submissions must be lodged with us on or before 10 March 2017.

All submissions will be published on Jemena's website. If you do not wish to have your submission published, please indicate this clearly in your submission.

Following our consideration of any submissions on this Draft Project Assessment Report, we will proceed to prepare a Final Project Assessment Report (FPAR). That report will include a summary of, and commentary on, any submissions to this report and present the final preferred solution to address the Sunbury Zone Substation thermal capacity constraint. Publishing the FPAR will be the third and final stage in the RIT-D process.

We intend to publish the Final Project Assessment Report by 24 March 2017.

APPENDIX A: MAXIMUM DEMAND FORECASTS

This Appendix A presents the maximum demand forecasts at Sunbury Zone Substation for the zero demand growth rate scenario, the base demand growth rate, and the high demand growth rate scenario.

Table A–1: SBY maximum demand forecasts (no demand growth scenario)

Year	Summer 50% POE demand (MVA)	Winter 50% POE demand (MVA)	Summer 10% POE demand (MVA)	Winter 10% POE demand (MVA)
2017	39.3	33.7	43.1	34.4
2018	39.3	33.7	43.1	34.4
2019	39.3	33.7	43.1	34.4
2020	39.3	33.7	43.1	34.4
2021	39.3	33.7	43.1	34.4
2022	39.3	33.7	43.1	34.4
2023	39.3	33.7	43.1	34.4
2024	39.3	33.7	43.1	34.4
2025	39.3	33.7	43.1	34.4
2026	39.3	33.7	43.1	34.4

Table A–2: SBY maximum demand forecasts (base demand growth rate scenario)

Year	Summer 50% POE demand (MVA)	Winter 50% POE demand (MVA)	Summer 10% POE demand (MVA)	Winter 10% POE demand (MVA)
2017	39.3	33.7	43.1	34.4
2018	40.0	34.4	44.0	35.2
2019	41.1	35.4	45.2	36.3
2020	42.3	36.6	46.4	37.4
2021	42.6	36.9	46.9	37.8
2022	43.7	37.9	48.2	38.8
2023	45.3	39.4	49.8	40.3
2024	46.2	40.4	51.0	41.3
2025	48.0	42.1	53.2	43.1
2026	49.0	43.9	54.1	44.9

Table A–3: SBY maximum demand forecasts (high demand growth rate scenario)

Year	Summer 50% POE demand (MVA)	Winter 50% POE demand (MVA)	Summer 10% POE demand (MVA)	Winter 10% POE demand (MVA)
2017	39.3	33.7	43.1	34.4
2018	41.1	35.2	45.0	36.0
2019	42.9	36.8	47.1	37.6
2020	44.8	38.4	49.2	39.3
2021	46.9	40.1	51.4	41.0
2022	49.0	41.9	53.7	42.9
2023	51.2	43.8	56.1	44.8
2024	53.5	45.8	58.6	46.8
2025	55.9	47.9	61.3	48.9
2026	58.4	50.0	64.0	51.1

APPENDIX B: ECONOMIC ASSESSMENT SPREADSHEETS

Load at risk assessments are included as Microsoft Excel spreadsheet attachments.

These spreadsheet attachments show the annual expected unserved energy, between 2017 and 2030, that would remain following implementation of each potential option considered, with the available emergency load transfer capacity included in the assessments.

The spreadsheet attachments include:

- SBY RIT-D options analysis – Low demand growth rate scenario
- SBY RIT-D options analysis - Medium (base) demand growth rate scenario
- SBY RIT-D options analysis – High demand growth rate scenario