New 110kV Feeder from Ann Street Zone Substation to McLachlan St Zone Substation

Business Case
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energex
Part of Energy Queensland

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DOCUMENT VERSION

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1.0	Reviewed	08/12/2023	Principal Planning Engineer
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1. SUMMARY

<table>
<tr><th>Title</th><th>New 110kV Feeder from Ann Street Zone Substation to McLachlan St Zone Substation</th></tr>
<tr><td>DNSP</td><td>Energex</td></tr>
<tr><td>Expenditure category</td><td>☐ Replacement ☒ Augmentation ☐ Connections ☐ Non-Network</td></tr>
<tr><td>Identified need</td><td>☐ Legislation ☐ Regulatory compliance
☒ Reliability ☐ CECV ☐ Safety ☐ Environment ☒ Financial
☐ Other

The identified need for this investment is driven by a positive cost/benefit analysis based on Value of Customer Reliability (VCR). Specifically, currently there is energy at risk following a double contingency of 110kV feeders F752 and F753.

This investment proposes to establish a new 110kV feeder to enhance the security and customer reliability in the Brisbane CBD.</td></tr>
<tr><td>Summary of preferred option</td><td>The proposed option is to establish a second 110kV feeder between McLachlan St zone substation and Ann St zone substation to eliminate any energy at risk following an outage of F752/F753.</td></tr>
<tr><td>Expenditure</td><td>
<table>
<tr><th>Year</th><th>2025-26</th><th>2026-27</th><th>2027-28</th><th>2028-29</th><th>2029-30</th><th>2025-30</th></tr>
<tr><td>$m, direct 2022-23</td><td>0.115</td><td>2.299</td><td>8.406</td><td>8.008</td><td>3.085</td><td>21.914</td></tr>
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</td></tr>
<tr><td>Benefits</td><td>The VCR benefits begin at around $776k / annum in 2030, increasing to around $1.5m / annum by 2040.

In addition, the proposed work will also provide increased supply reliability for the Brisbane CBD and the surrounding areas during the 2032 Olympics games in Brisbane.</td></tr>
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2. BACKGROUND

2.1. Network Arrangement

The Brisbane CBD is supplied by an interconnected 110kV feeder network, providing supply to eleven (11) 110/11kV zone substations, as well as two directly connected 110kV customers, with a third customer currently being connected. The network is split into two rings, known as the western and eastern rings. The eastern ring is supplied through two Powerlink-owned injection points at Murrarie and Belmont, while the western ring is also supplied through two Powerlink-owned injection points at Rocklea and Ashgrove West.

The seven connected substations on the eastern ring are summarised below:

- **Victoria Park substation (SSVPK)** – is a combined 110/11kV zone substation and a 110/33kV bulk supply substation supplying around 15,000 predominantly residential customers. The maximum recorded demand was 91.9 MVA in Summer 2022/23.
- **Newstead zone substation (SSNSD)** – is a 110/11kV zone substation which supplies around 7,000 predominantly residential customers. The maximum recorded demand was 44 MVA in Summer 2022/23.
- **McLachlan St zone substation (SSMLS)** – is a 110/11 kV zone substation which supplies around 10,000 predominantly residential customers. The maximum recorded demand was 51.6 MVA in Summer 2022/23.
- **Ann St zone substation (SSAST)** – is a 110/11kV zone substation which supplies around 400 predominantly business customers. The maximum recorded demand was 38.8 MVA in Summer 2022/23.
- **Charlotte St zone substation (SSCST)** – is a 110/11kV zone substation which supplies around 3,000 predominantly residential customers. The maximum recorded demand was 81.7 MVA in Summer 2022/23.
- **Wellington Rd zone substation (SSWRD)** – is a 110/11kV zone substation which supplies around 8,200 predominantly residential customers. The maximum recorded demand was 55.3 MVA in Summer 2022/23.
- **Coorparoo bulk supply substation (SSCPR)** – is a 110/33kV bulk supply substation which supplies around 34,000 predominantly residential customers. The maximum recorded demand was 81.1 MVA in Summer 2022/23.

Figure 1 shows a block diagram of the network arrangement for the Brisbane CBD. Figure 2 shows the geographic layout of the eastern CBD ring.

Figure 1 – Simplified Block Diagram of Brisbane CBD 110kV Network

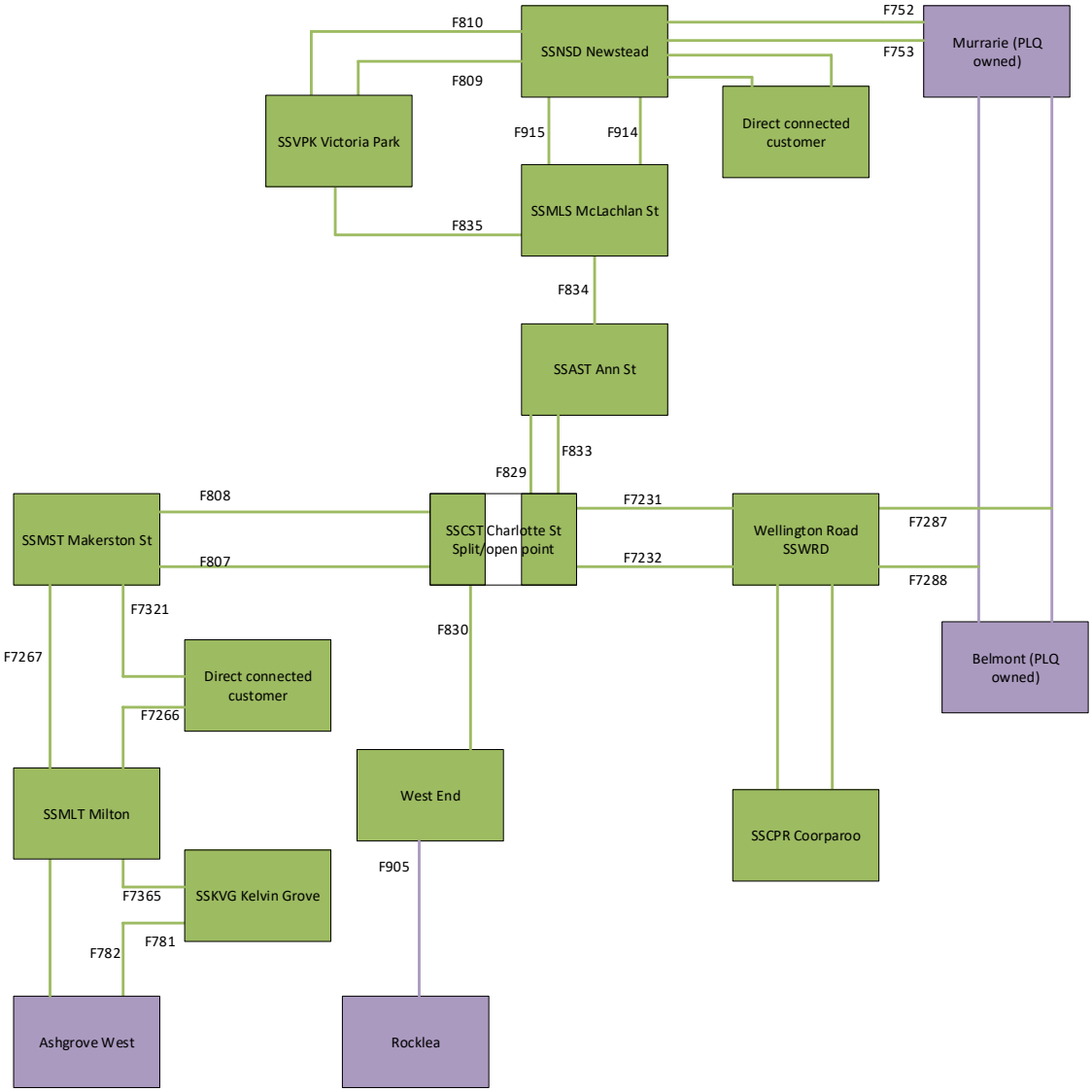


Figure 2 – Geographic of the eastern CBD ring

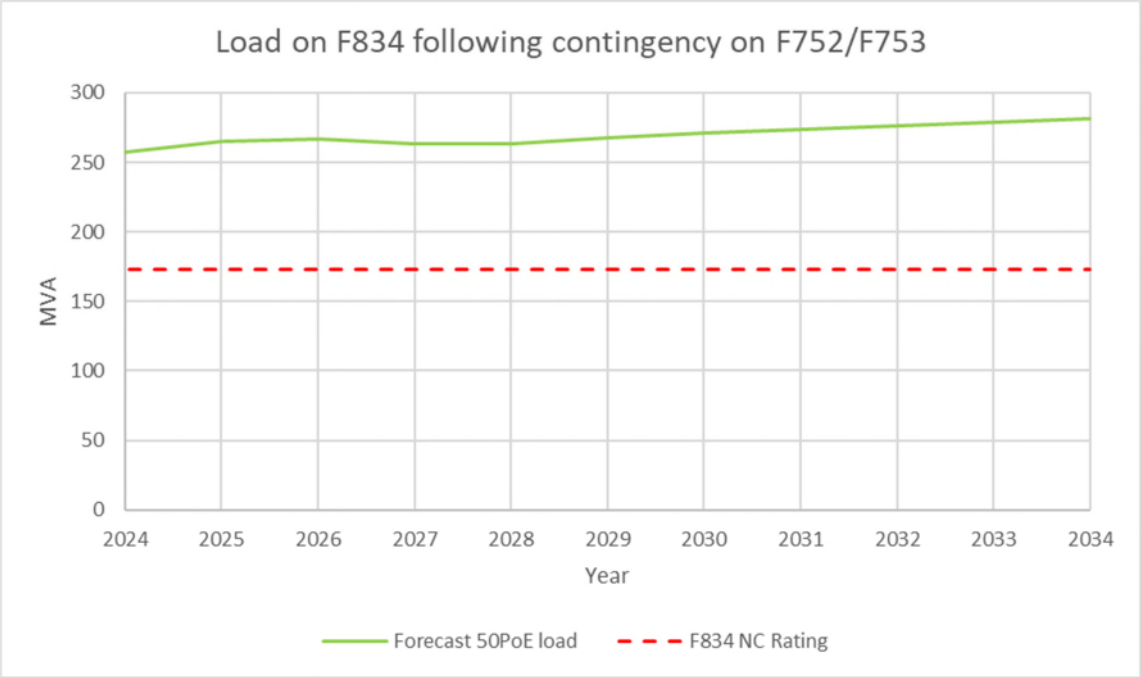
2.2. Sub-transmission Feeder Capacity

There are three important characteristics of the network to understand when considering the proposed investment – the feeder combinations F752/F753, F7287/F7288 and the transformer loading at SSMST.

2.2.1. F752 & F753 Double Circuit Contingency Load and Rating

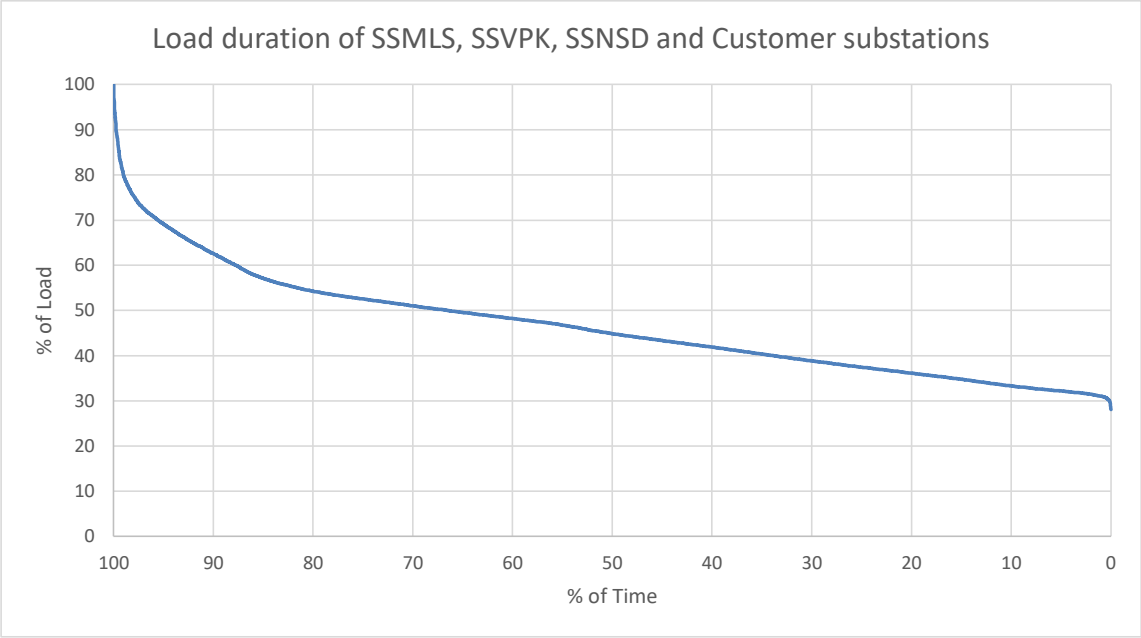
The Energex-owned feeders F752 and F753 supply the eastern ring from Murrarie injection point. These feeders are 9.5km largely double circuit, single pole construction through an urban area and are 40 years old. For an outage of both feeders, F834 will be required to supply the full load of SSMLS, SSNSD, SSVPK and the existing and future direct connected customers. The load forecast of these substations and the normal cyclic and two-hour emergency ratings of F834 are shown in Figure 3.

Figure 3 – Load on F834 following contingency on F752/F753



As shown above, the cyclic rating of F834 is significantly lower than the forecast 50PoE loads following the loss of F752/F753. It should be noted that following this contingency, there are no real alternative supply arrangements that Energex can undertake to alleviate the outage. Figure 4 below shows the load duration curve for this potential lost energy.

Figure 4 – Load duration curve of the substations supplied by F834 following contingency on F752/F753



2.2.2. F7287 & F7288 Double Circuit Contingency Load and Rating

These two feeders emanate from a double underground/overhead termination structure and are teed off the Powerlink owned feeders between Murrarie and Belmont injection points. While the nature of this construction means that this is a plausible outage, the network arrangement and 2-hour emergency rating of F834 of 304 MVA means that all loads can continue to be supplied until the network is reconfigured by closing the SSCST open-point and supplying SSWRD, SSCPR and SSCST through the western ring. As such, there is no energy at risk because of a double-circuit contingency of this sort.

3. IDENTIFIED NEED

The identified need for this investment is driven by a positive cost/benefit analysis based on Value of Customer Reliability. Specifically, currently there is energy at risk following a double contingency of 110kV feeders F752 and F753.

This investment aims to enhance the security and customer reliability in the Brisbane CBD.

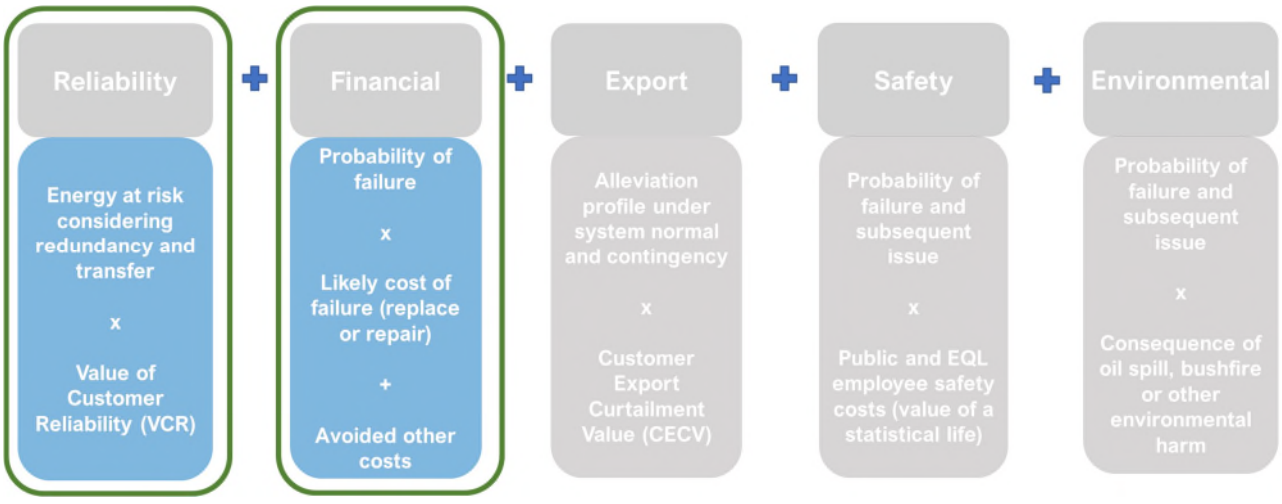
3.1. Counterfactual analysis

The counterfactual scenario is to continue operating the network as it is currently designed. The forecast load in the Brisbane CBD will increase substantially over the next 25 years, it is anticipated that an additional substation will be required by around 2050 which will alter the existing network configuration. As a result, the analysis is conducted on a time horizon up to 2050.

3.2. Value Streams

Energex broadly considers five value streams for investment. These are shown in Figure 5. The two value streams that are relevant to this business case are *reliability* and *financial*.

Figure 5 – Value Streams for Investment



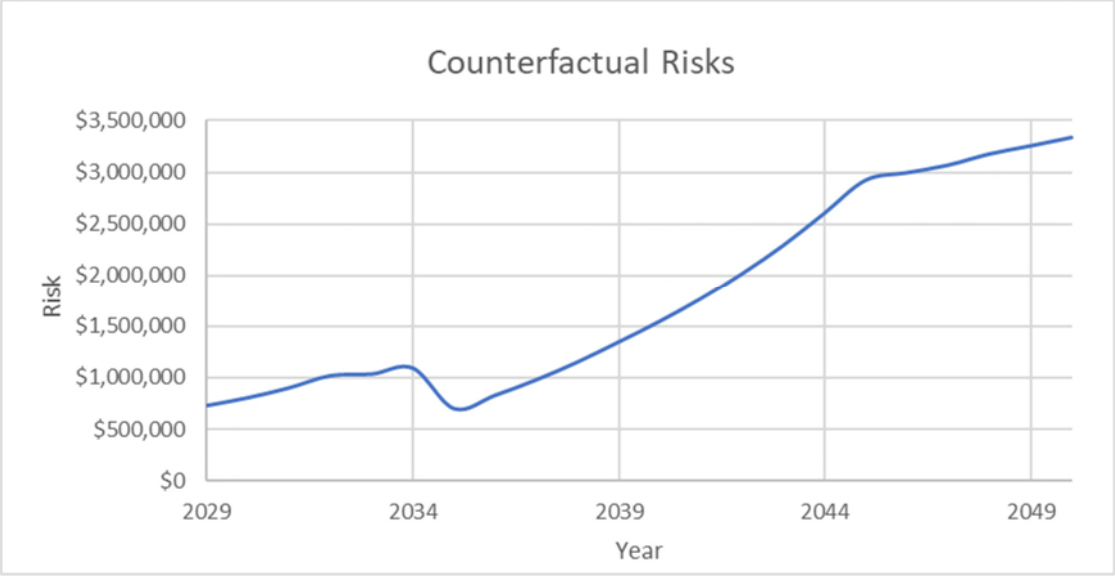
- **Reliability:** There is potential unserved energy for the eastern ring of the CBD following an outage of F752 & F753 because F834 is unable to supply the full load.
- **Financial:** Emergency repair cost after the failure of F752 & F753 has been considered in the evaluation.

3.2.1. Risk Quantifications

The counterfactual risk is an outage of the double circuit feeder F752 & F753 from Murrarie to SSNSD. In calculating the VCR implications of the existing network, the following assumptions have been used:

- **F752 & F753 Outage rate** – 0.04 outages / year. This is an extremely low rate given the age and condition of these feeders and that they are largely in an urban area, as well as having a river crossing near SSNSD.
- **Powerlink feeder outage rate** – 0.02 outage / year. This is an even lower rate than above given the lower likelihood of a failure of two tower lines.
- **Restoration** – following an outage, it has been estimated that the rectification of the outage would be in the order of 5 days.
- **Emergency repair cost** – an annual risk of $78,000 has been estimated.
- **Transfers** – no transfers have been assumed given the nature of the network in the area.
- **VCR Rate** – a VCR rate of $65.57/kWh has been used, with the mix of customers weighted towards commercial and industrial customers.
- **Risk timeframe** – the risk has been assumed to end in 2050 when the new substation is established as part of Safety Net compliance.

Figure 6 – Counterfactual Risk



4. OPTIONS ANALYSIS

This section describes the credible options to address the identified need with comparison to the counter factual.

4.1. Options identification

In the process of determining the most cost-effective solution to address the identified network limitations, Energex has sought to identify a practicable range of technically feasible, alternative options that could satisfy the network requirements in a timely and efficient manner.

The only feasible option to establish a new feeder in the Brisbane CBD is to construct an underground feeder. The use of overhead lines in the CBD is not feasible due to congested roadways, unavailability of easements and inadequate clearance to high rise buildings.

As a result, Energex has identified a single option that represents a practical alternative to address the network limitations in the required timeframe.

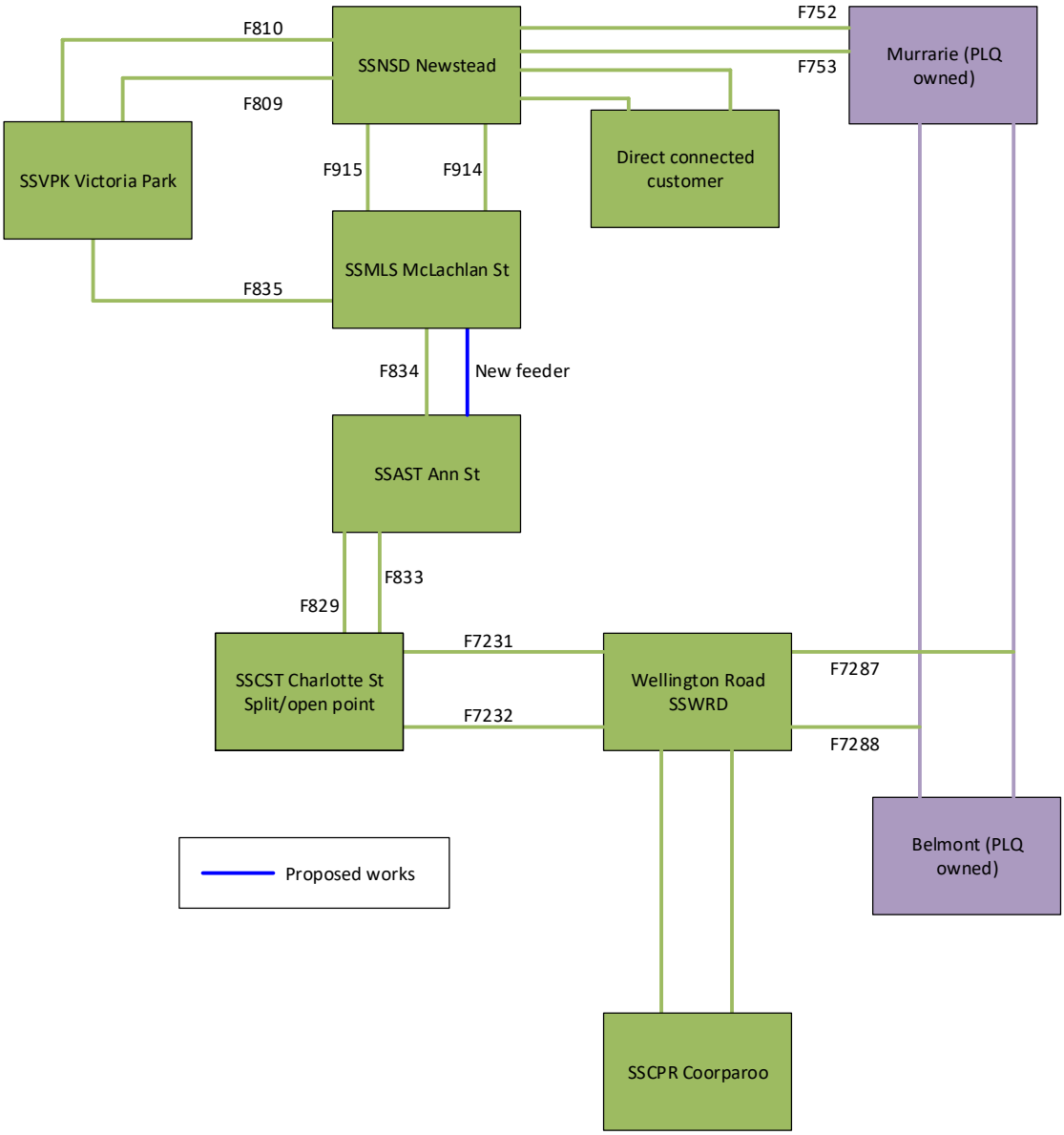
4.2. Option 1

This option involves establishing a new 4km underground 110kV feeder between SSAST and SSMLS. The recommended completion date for this option is 2029.

The key determinant in maximising the value to customers as part of this investment proposal is the VCR improvement for a double circuit contingency of F752 and F753

Figure 7 below shows the proposed network arrangement.

Figure 7 – Option 1 block diagram



4.2.1. Costs

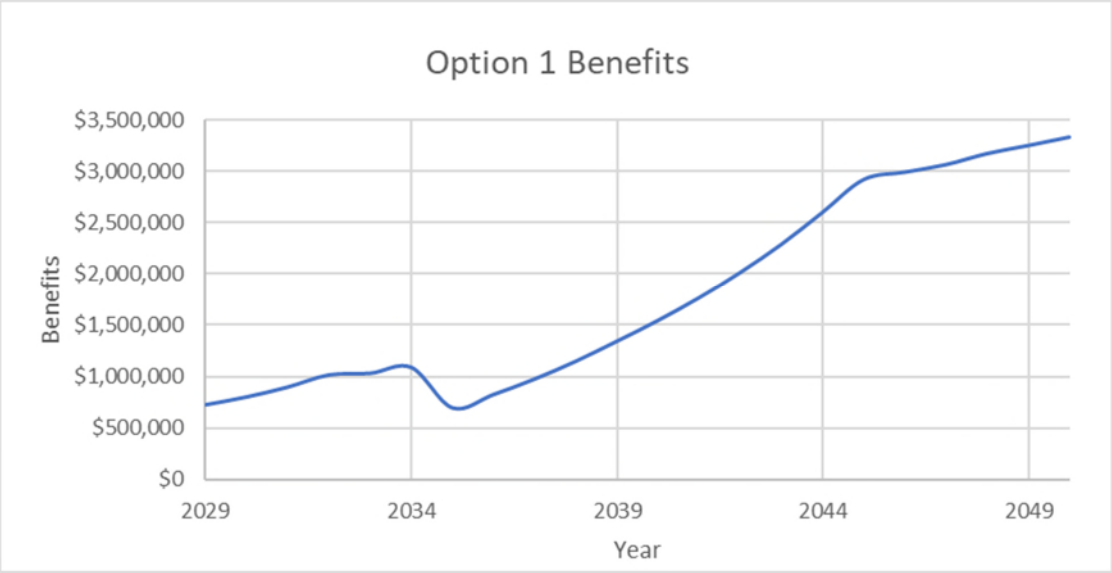
The establishment of the new 110kV feeder between SSAST and SSMLS has been estimated at $21.914m, which has been factored into the NPV as a cost in 2029. OPEX for this option is estimated to be $23.6k per annum.

4.2.2. Benefits

Following the completion of the feeder between SSMLS and SSAST, all load can be supplied following a double contingency loss of F752 and F753 or the two Powerlink feeders. As such, the entire VCR risk calculated as part of the counterfactual has been included in the NPV as benefits.

In addition, the proposed work will also provide increased supply reliability for the Brisbane CBD and the surrounding areas during the 2032 Olympics games in Brisbane.

Figure 8 – Option 1 Benefits



4.3. Economic Analysis

4.3.1. Cost summary 2025-30

The establishment of a new 110kV feeder between SSMLS and SSAST has been estimated as $21.914m. The forecast expenditure by year is shown in Table 1.

Table 1 – Cost summary 2025-30

Option	2025-26	2026-27	2027-28	2028-29	2029-30	Total 2025-30
Establishing a new 110kV feeder between SSMLS and SSAST	$0.115M	$2.299M	$8.406M	$8.008M	$3.085M	**$21.914M**

4.3.2. NPV analysis

The NPV under the base case is $3.025m, with the Capex, Opex and Benefits NPV shown in Table 2. Table 3 shows the results having changed various inputs into the financial model.

Table 2 – Base Case NPV analysis

Option	Rank	Net NPV	Capex NPV	Opex NPV	Benefits NPV
Establishing a new 110kV feeder between SSMLS and SSAST	1	$3.025M	-$17.827M	-$0.302M	$21.154M

Table 3 – NPV Sensitivity Analysis

Option	Discount rate		Failure rate		Benefits	
	2.5%	4.5%	75%	125%	75%	125%
Establishing a new 110kV feeder between SSMLS and SSAST	$6.068M	$0.684M	-$0.228M	$8.060M	-$0.480M	$8.314M

As shown above, the NPV remains positive amongst most of the sensitivities tested.

4.4. Optimal Timing

The most important aspect in the establishment of the new 110kV feeder between SSMLS and SSAST is that the benefits from the value of customer reliability exceeds the proposed expenditure, given the substantial amount of load at risk. Due to the Olympics infrastructure construction restrictions, Energex will be unable to undertake any major infrastructure projects between 2030 and 2033, failing to establish this feeder by 2029 will mean that it would be unable to be established until 2036 at the earliest. As this is an existing network risk, it is prudent that the establishment of the feeder is completed by 2029. As previously mentioned, the proposed timing for the completion of the work will also improve the supply reliability for the Brisbane CBD and the surrounding areas during the 2032 Olympics games in Brisbane.

5. RECOMMENDATION

It is recommended to establish a new 110kV feeder between SSMLS and SSAST to improve network security and reliability, while also contributing to the future establishment of a new zone substation in the Brisbane CBD. Table 4 summarises the option under consideration.

Table 4 - Options Analysis Scorecard

Criteria	Option 1 – Establish new 110kV Feeder from SSMLS to SSAST
Net Present Value	$3.025m
Investment cost	$21.914m
Investment Risk	Medium
Benefits	$21.154m
Delivery time	5 years
Detailed analysis – Benefits	This option delivers a positive reliability benefit to the CBD network of $700k, increasing to $1.5m / annum in 2040. The establishment of this feeder also offsets future costs of establishing a new feeder to the proposed new Energex substation in the Brisbane CBD to alleviate a future network limitation at SSMST.
Detailed analysis – Risks	Establishing a new feeder in the Brisbane CBD may provide some technical challenges, however the project has been estimated utilising the high complexity 110kV feeder establishment models, and so is a true representation of the cost of a 4km single circuit feeder.
Detailed analysis - Advantages	This option results in a secure and reliable CBD network, while also establishing part of a future feeder to a new Energex zone substation.

Appendix 1: Alignment with the National Electricity Rules

Table 5 - Recommended Option's Alignment with the National Electricity Rules

NER capital expenditure objectives	Rationale
A building block proposal must include the total forecast capital expenditure which the DNSP considers is required in order to achieve each of the following (the capital expenditure objectives):	
6.5.7 (a) (1) meet or manage the expected demand for standard control services over that period	Section 3, Section 4.2
6.5.7 (a) (2) comply with all applicable regulatory obligations or requirements associated with the provision of standard control services;	Section 3, Section 4.2
6.5.7 (a) (3) to the extent that there is no applicable regulatory obligation or requirement in relation to: (i) the quality, reliability or security of supply of standard control services; or (ii) the reliability or security of the distribution system through the supply of standard control services, to the relevant extent: (iii) maintain the quality, reliability and security of supply of standard control services; and (iv) maintain the reliability and security of the distribution system through the supply of standard control services	Section 3, Section 4.2
6.5.7 (a) (4) maintain the safety of the distribution system through the supply of standard control services.	Section 3, Section 4.2
NER capital expenditure criteria	**Rationale**
The AER must be satisfied that the forecast capital expenditure reflects each of the following:	
6.5.7 (c) (1) (i) the efficient costs of achieving the capital expenditure objectives	Section 4.3
6.5.7 (c) (1) (ii) the costs that a prudent operator would require to achieve the capital expenditure objectives	Section 4.3
6.5.7 (c) (1) (iii) a realistic expectation of the demand forecast and cost inputs required to achieve the capital expenditure objectives	Section 2.2, Section 4.3

Appendix 2: Reconciliation Table

Table 6 - Reconciliation

Expenditure	2025-26	2026-27	2027-28	2028-29	2029-30	2025-30
Expenditure in business case $m, direct 2022-23	0.115	2.299	8.406	8.008	3.085	21.914