Establishing a new 110kV feeder to Caboolture Bulk Supply

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
2.0	Endorsed	08/12/2023	Manager Sub-Transmission Planning
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1 SUMMARY

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☒ Reliability ☐ CECV ☐ Safety ☐ Environment ☐ Financial
☐ Other

Caboolture bulk supply substation is being supplied by two 110kV feeders F745/3 and F746/3 constructed on a single tower line. A double circuit outage on F745/3 and F746/3 caused by a single tower failure will lead to major blackouts in the Caboolture and Beerwah supply areas.

The maximum demand recorded in Caboolture and Beerwah supply areas in past 12 months was 209MVA. In case of double circuit outage due to common mode of failure, the customers in these areas would lose supply due to feeders F745/3 and F746/3 constructed on a single tower line.</td></tr>
<tr><td>Summary of preferred option</td><td>The preferred option (Option 1 of this report) is to establish a new 5km single 110kV circuit from Caboolture bulk supply substation and to cut into the existing feeder F746/1 and rearranging F746/3 to connect into F746/2 which will then become an independent feeder which addresses load at risk at the Caboolture bulk-supply for the outage of 110kV feeder double-circuit under common mode failure scenario.</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>-</td><td>$0.094m</td><td>$0.249m</td><td>$2.078m</td><td>$8.645m</td><td>$11.065m</td></tr>
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</td></tr>
<tr><td>Benefits</td><td>The VCR benefits begin at $764k / annum in 2030, increasing to $801k / annum by 2040.</td></tr>
</table>

2 BACKGROUND

2.1 Network Arrangement

Caboolture bulk supply substation (SST11) has six 33kV feeders supplying eight zone substations; Caboolture West substation (SSCBW), Morayfield substation (SSMFD), Morayfield North substation (SSMFN), Wamuran substation (SSWMR), Caboolture substation (SSCBT), Ningi substation (SSNGI), Toorbul Point substation (SSTPT) and Bribie Island substation (SSBIS). SST11 provides electricity supply to approximately 54,000 predominantly domestic customers in the Caboolture, Campbells Pocket, Upper Caboolture, Elimbah, Meldale and Bribie Island areas. The maximum recorded demand at Caboolture bulk supply substation was 152.8MVA in Summer 2022/23.

Beerwah bulk supply substation (SSBWH) has five 33kV feeders supplying five zone substations; Beerwah substation (SSBWH), Kilcoy substation (SSKCY), Woodford substation (SSWFD), Landsborough substation (SSLBH) and Maleny substation (SSMLY). SSBWH provides electricity supply to approximately 15,000 predominantly domestic customers in the Beerwah, Kilcoy, Landsborough and Woodford areas. The maximum recorded demand at Beerwah bulk supply substation was 55.8MVA in Summer 2022/23.

Caboolture and Beerwah bulk supply substations are supplied by two 110kV feeders, F745 and F746. A significantly portion of the feeders are of double circuit on single tower construction. Due to this arrangement, a single tower failure could result in loss of supply to all 69,000 customers.

Figure 1 shows the 110kV network arrangement and Figure 2 shows the geographic layout.

Figure 1 – Existing network diagram of the 110kV network

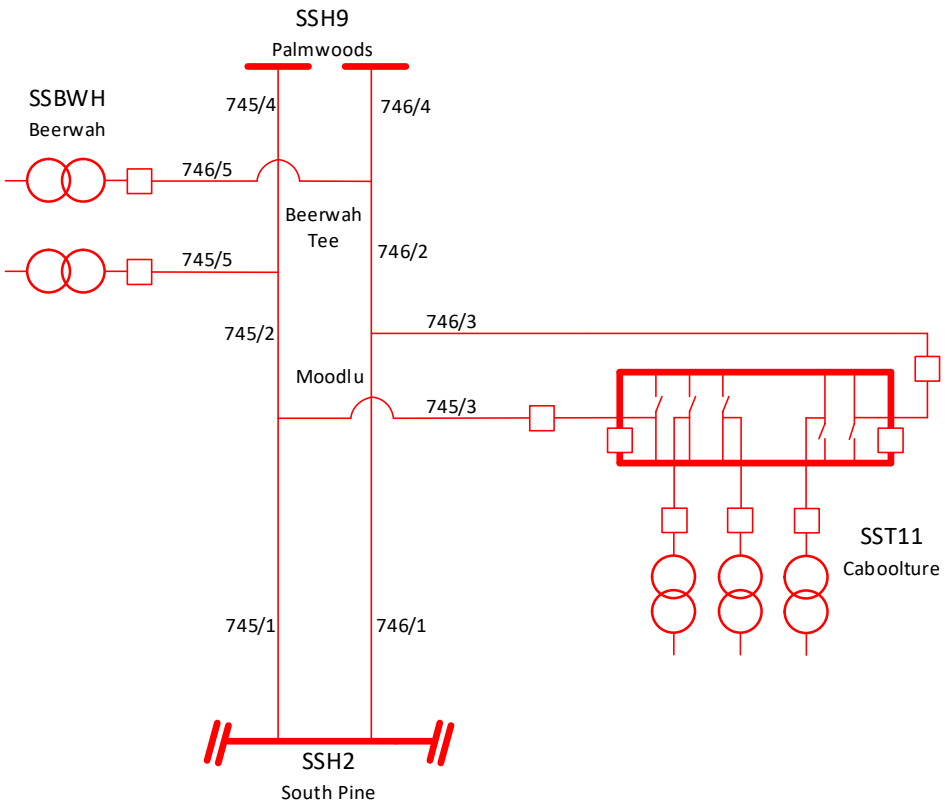


Figure 2 – Geographic view of the 110kV network

2.2 Sub-transmission Feeders

Caboolture bulk supply substation is supplied by two 110kV feeders 745/3 and 746/3 of 5km in length that are double circuit constructed on a single tower. Feeders 745/3 and 746/3 are teed into the existing double circuit transmission line which is approximately 73km between Powerlink's South Pine substation (SSH2) and Palmwoods substation (SSH9).

Although a double contingency outage is uncommon, both feeders 745/3 and 746/3 are constructed on a single tower, therefore, a single tower failure could lead to major blackouts and have extreme impact on the supply of the Caboolture and Beerwah area loads and network stability. Such double contingency outage in this case can happen due to a weather event, traffic incident or tower failure. An example of tower damage along F746 is shown on Appendix 6.

2.2.1 F745 & F746 Double Circuit Contingency Load at Risk

F745 and F746 provide the only source of supply to SST11 and SSBWH. Following an outage of 110kV feeders F745 and F746, with remote transfer of approximately 15.4MVA load of SSMFD to the Hays Inlet bulk supply substation via 33kV feeder 3251, 197MVA load is at risk in 2023-24. Apart from that, no alternative supply arrangements exist to alleviate the load at risk. The load at risk after remote transfers are shown in Figure 3.

Figure 3 – Load at risk following contingency of F745/3 & F746/3

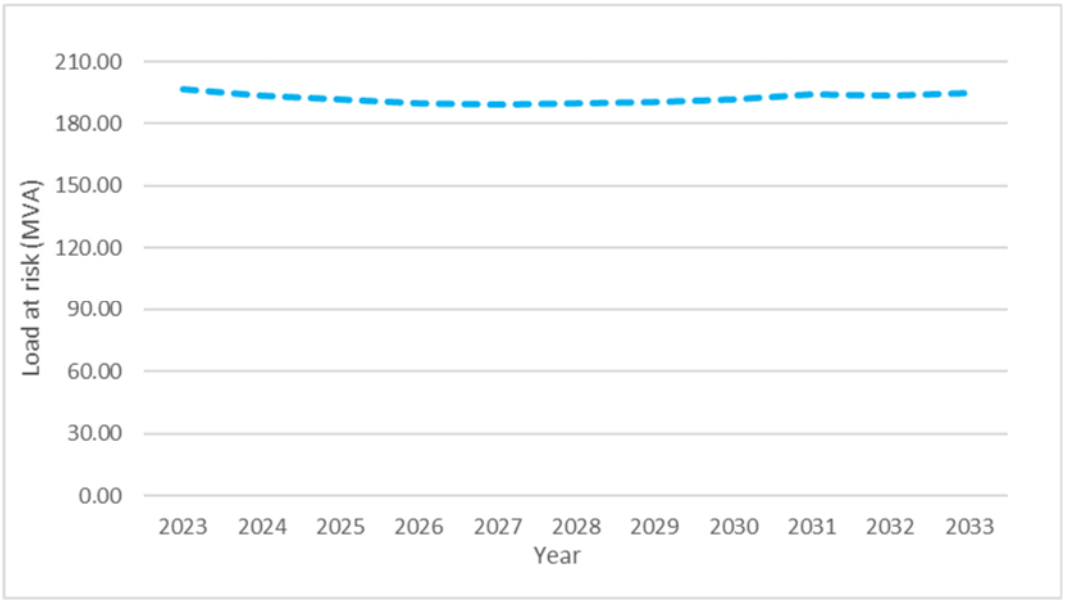
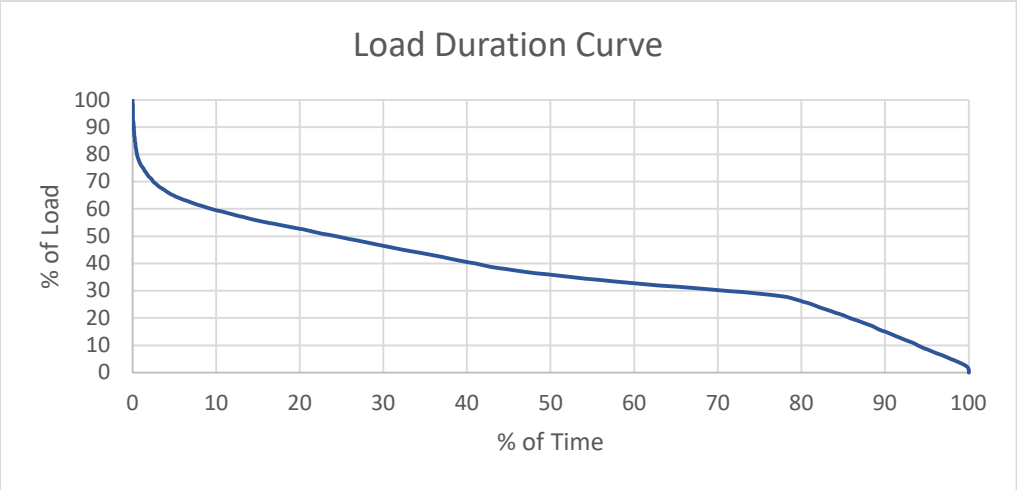


Figure 4 below shows the load duration curve for this potential lost energy.

Figure 4 – Load duration curve for the Caboolture network



3 IDENTIFIED NEED

The identified need for this investment is driven by a positive cost/benefit analysis based on Value of Customer Reliability (VCR). Specifically, there is energy at risk following a double contingency of F745 and F746.

In addition, any operational maintenance on either of feeders F745/3 and F746/3, an outage of both circuits is required due to electro-magnetic coupling and low clearance between the two circuits being on same towers.

The risk will increase as the population in Caboolture area alone is projected to grow from 125,544 in 2021 to 241,115 by 2041 based on the Queensland Regional Profiles as published by the Queensland Government Statistician's Office. To respond to the growing load in the area and to meet its regulatory obligations, Energex will be required to establish a dedicated 110kV – feeder section from the H9-H2 tee-off point at Moodlu to SST11 Caboolture by building a new 5km of 110kV OH feeder between SST11 and Moodlu.

3.1 Sub-transmission Network Limitations

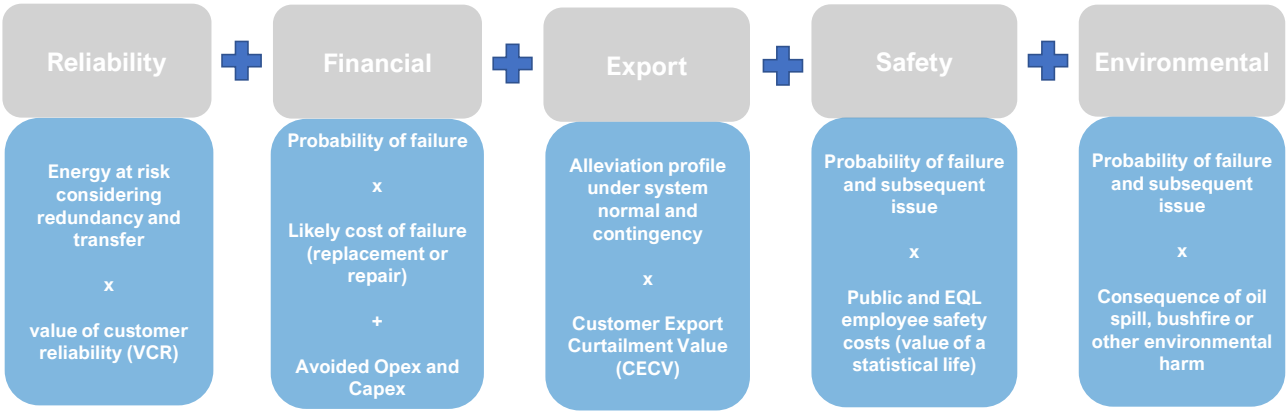
The network limitation that the proposed investment aims to address is the inability to supply all load at the Caboolture and Beerwah area following the outage of 110 kV feeders, F745 and F746.

3.2 Counterfactual analysis

3.2.1 Summary

Energex broadly considers five value streams for investment. These are shown in Figure 5.

Figure 5 – Value Streams for Investment



The main value stream that is relevant to this business case is reliability. The counterfactual is to continue to operate the network in its current configuration and has one primary element for consideration:

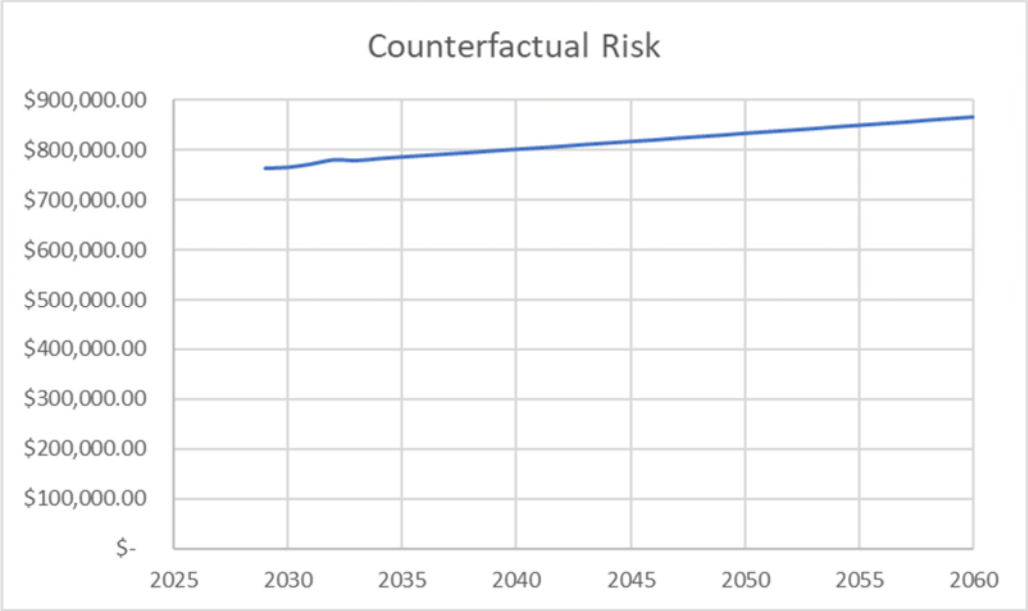
- There is potential unserved energy for the Caboolture and Beerwah network following an outage of F745 & F746 due to limited load transfer available.

3.2.2 Risk Quantification

The counterfactual risk is an outage of the double circuit feeder F745 & F746 between SSH2, SSH9 and SST11. In quantifying the VCR benefits of the existing network, the following assumptions have been used:

- **F745 & F746 Outage rate** – 0.07 outages / year.
- **Restoration** – following an outage, it has been estimated that the rectification of the outage would be in the order of 4 hours.
- **Transfers** – load transfer of half of SSMFD to SSHIL bulk supply substation.
- **VCR Rate** – a VCR rate of $35.94/kWh has been used, with the ratio of domestic customers usage 1.3 times greater than commercial customers.
- **Risk timeframe** – the risk has been quantified out to 2060.

Figure 6 – Counterfactual Risk



4 OPTIONS ANALYSIS

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

Three options have been identified to address supply reliability at SST11. Identified options are:

Option 1: Establish a new 110kV feeder to connect one end of the new circuit to F746/1 and the other end to SST11.

Option 2: Establish a new 110kV feeder to connect one end of the new circuit to F746/2 and the other end to SST11.

Option 3: Reinforcement of transmission towers carrying both feeders, F745/3 and F746/3. This option involves taking both feeders out of service for extended periods. Since no other alternative supply arrangements are available to supply SST11. As a result, there will be a breach of Safety Net at SST11. Due to Safety Net breach at SST11, this option was rejected and isn't considered any further.

As a result of this process, Energex has considered two option that represents a practical alternative to address supply reliability at SST11 in the required timeframe.

4.1 Option 1

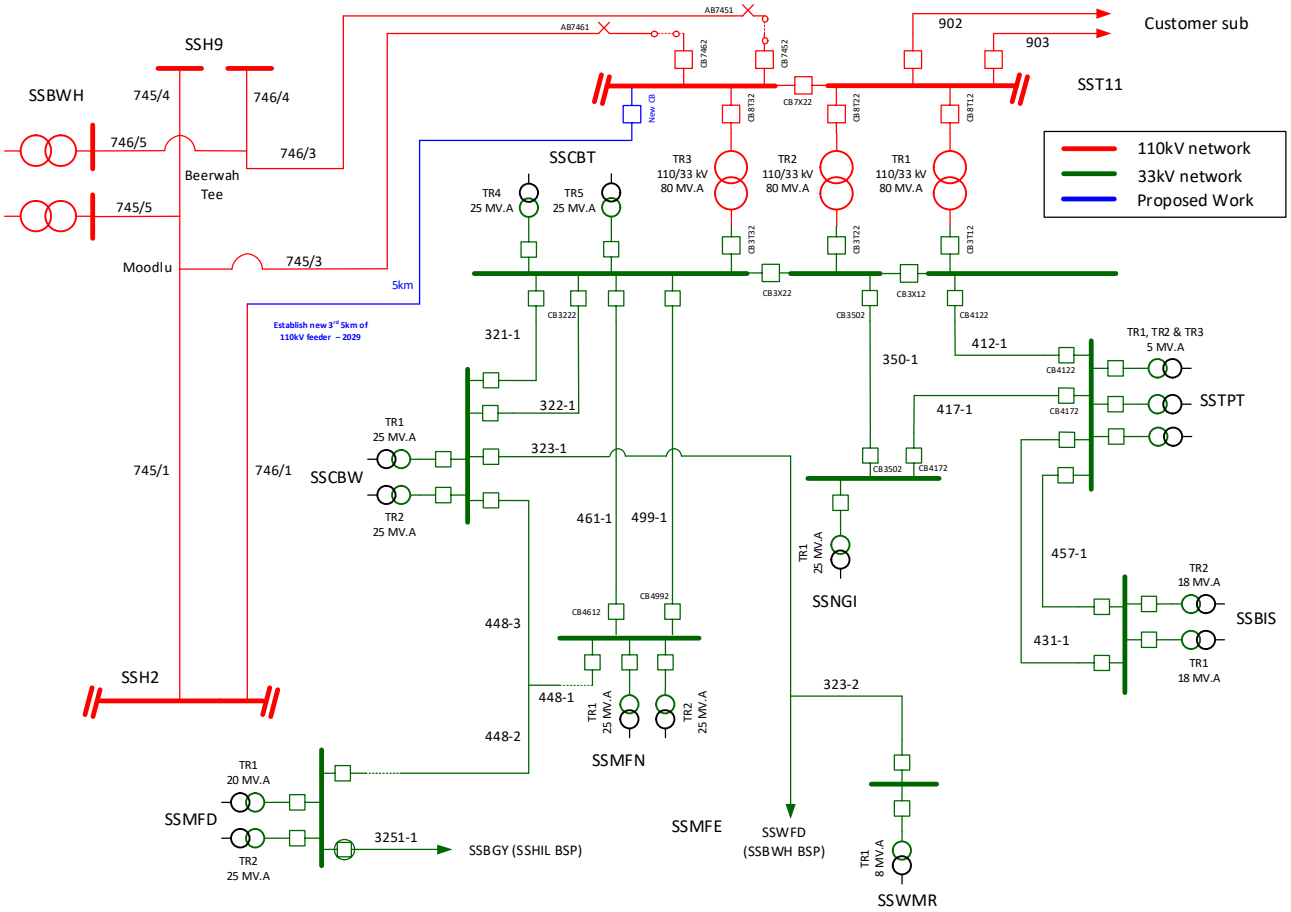
This option will help in permanently providing an additional 146MVA supply capacity to SST11 to address the substation limitation which involves Safety Net breaches at SST11.

This option involves:

- Establishing a new 5km of single circuit overhead 110kV feeder with standard oxygen conductor.
- Disconnect the existing section of the circuit between TW280 and TW389 to make the existing feeder 746/4 a three ended feeder.
- Connect one end of the new circuit to TW389. This will become a radial feeder from SSH2 to SST11.

The network required date for this option is 2029. This option improves the VCR for a double circuit contingency of F745 and F746 by keeping Caboolture bulk supply substation under supply via 746/1.

Figure 7 – Option 1 network diagram



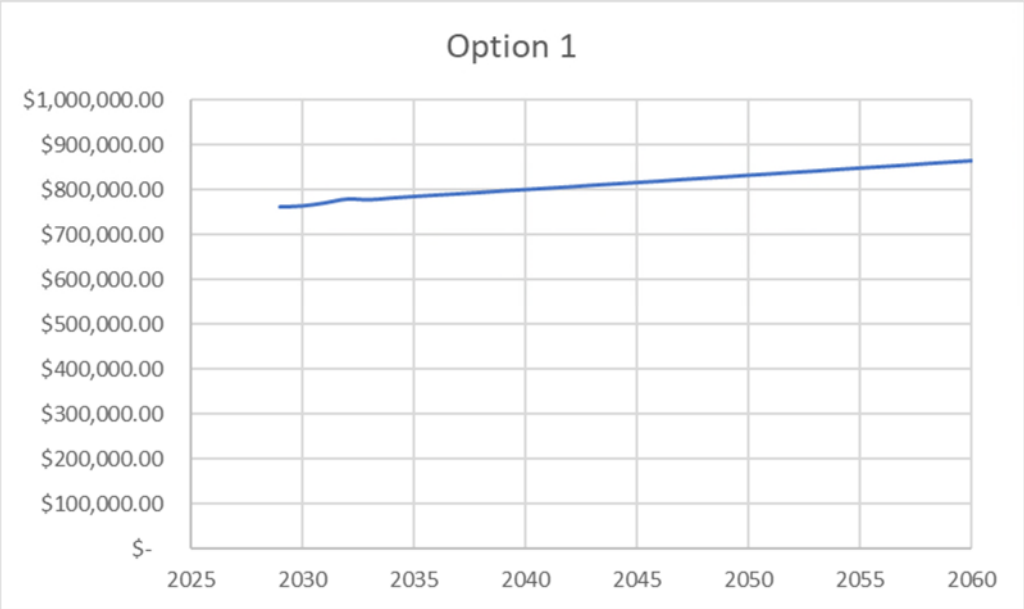
4.1.1 Costs

The establishment of the new 110kV SCCT tee feeder has been estimated at $12.6m direct cost, which has been factored into the NPV as a cost in 2029.

4.1.2 Benefits

Following the completion of the 110kV SCCT tee feeder, all load can be supplied following a single contingency or double contingency loss of F745/3 and F746/3 between SSH2, SSH9 and SST11. This option also provides the flexibility to maintain 110kV feeders between SSH2, SSH9 and SST11 without any loss of supply. As such, the entire VCR risk calculated as part of the counterfactual has been included in the NPV as benefits.

Figure 8 – Option 1 Benefits



4.2 Option 2

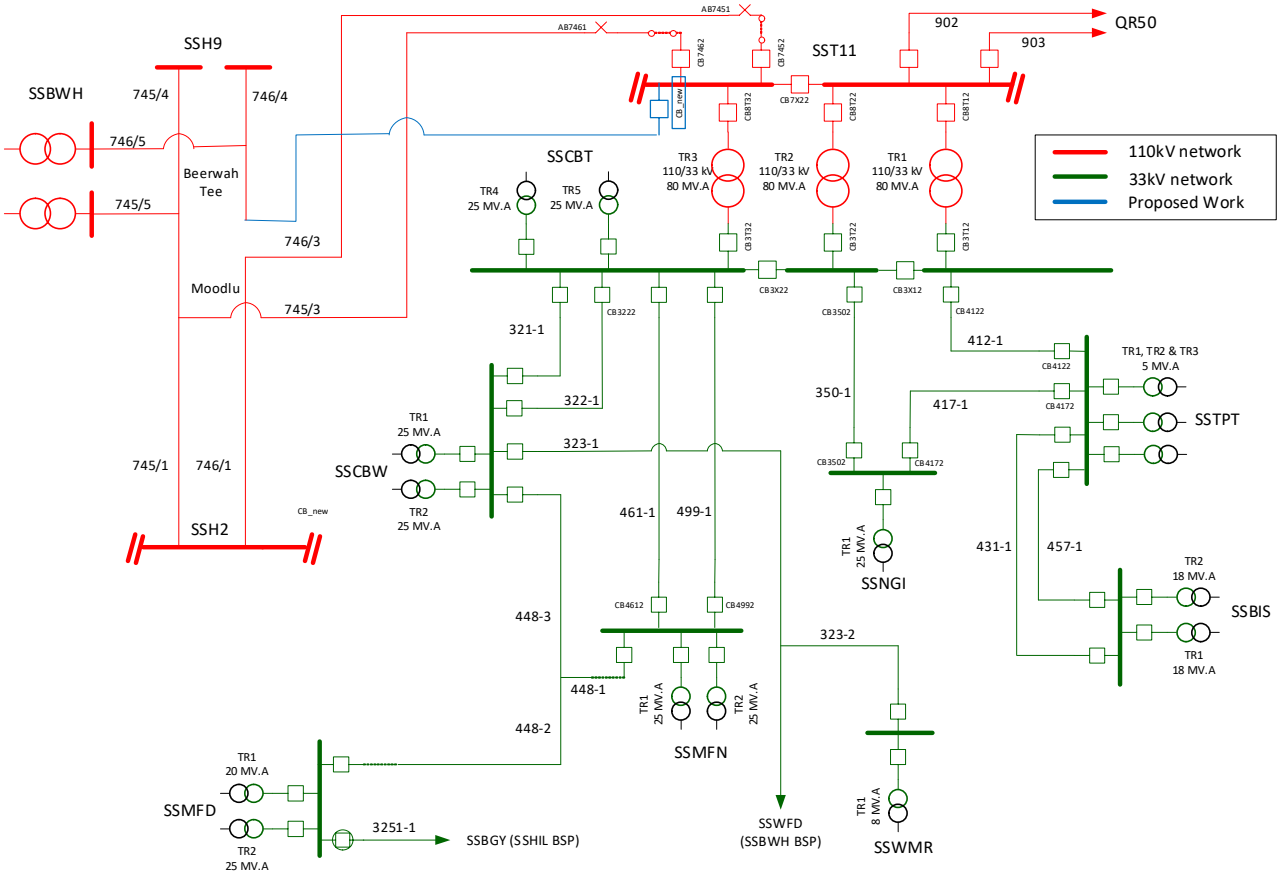
This option will help in permanently providing an additional 146MVA supply capacity to SST11 from SSH9-A to address the substation limitation which reliability of supply at SST11.

This option involves:

- Establishing a new 5.5km of single circuit overhead 110kV feeder with standard oxygen conductor.
- Connect one end of the new circuit into F746/2 at TW390 and the other end to SST11.

The network required date for this option is 2029. This option improves the VCR for a double circuit contingency of F745/3 and F746/3 by keeping Caboolture bulk supply substation under supply via new 110kV feeder.

Figure 9 – Option 2 network diagram



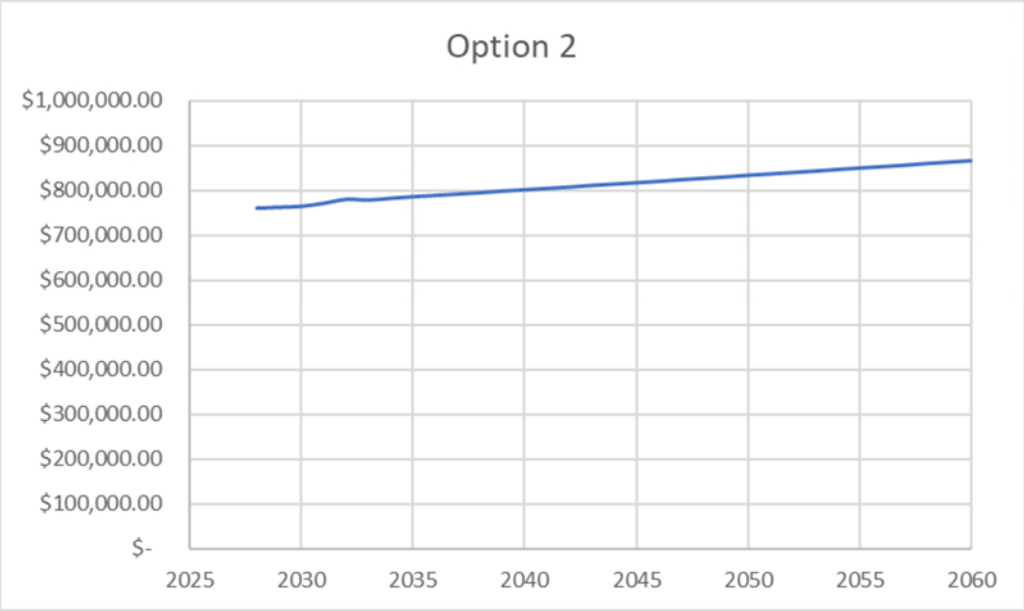
4.2.1 Costs

The establishment of the new 110kV SCCT tee feeder has been estimated at $13.6m direct cost, which has been factored into the NPV as a cost in 2029.

4.2.2 Benefits

Following the completion of the 110kV SCCT tee feeder, all load can be supplied following a single contingency or double contingency loss of F745/3 and F746/3 between SSH2, SSH9 and SST11. This option also provides the flexibility to maintain 110kV feeders between SSH2, SSH9 and SST11 without any loss of supply. Figure 10 below shows the portion of the VCR risk attributed to option 2 as a benefit. This has been included in the NPV.

Figure 10 – Option 2 Benefits



4.3 Economic Analysis

4.3.1 Cost summary 2025-30

Option 1 to establish a new 5km of 110kV SCCT tee feeder has been estimated as $12.56m. The forecast expenditure would span over 5 years, the expenditure across the 2025-30 regulatory period is shown in Table 1.

Table 1 – Cost summary 2025-30 2022/23 $

Option	2025-26	2026-27	2027-28	2028-29	2029-30	Total Direct 2025-30
Option 1. Establish 110kV SCCT Tee to connect into F746/1..	$0m	$0.094m	$0.249m	$2.078m	$8.645m	$11.065m

4.3.2 NPV analysis

From the table below, Option 1 is the preferred option. The NPV under the Option 1 is $10.69m, with the Capex, Opex and Benefits NPV shown in Table 2. Table 3 shows the results having changed various inputs in the financial model.

Table 2 – Base Case NPV analysis

Option	Rank	Net NPV	Capex NPV	Opex NPV	Benefits NPV
Establish 110kV SCCT Tee to connect into F746/1.	1	$10.686m	-$10.059m	-$0.417m	$21.162m
Establish 110/kV SCCT Tee to connect into F746/2.	2	$9.812m	-$10.933m	-$0.417m	$21.162m

Table 3 – NPV Sensitivity Analysis

Option	Discount rate		Failure rate		Benefits	
	2.5%	**4.5%**	**75%**	**125%**	**75%**	**125%**
Establish 110kV SCCT Tee to connect into F746/1.	$15.184m	$7.620m	$1.425m	$22.594m	$5.395m	$15.976m
Establish 110/kV SCCT Tee to connect into F746/2.	$14.268m	$6.790m	$0.551m	$21.721m	$4.522m	$15.103m

4.4 Optimal Timing

The most important aspect in the establishment of a new 110kV feeder to SST11 Caboolture bulk supply substation is to address the risk of blackout to over 50,000 customers following a double circuit outage of F745/3 and F746/3, which can be caused by just one single tower failure. As the population in the Caboolture area project to grow significantly in the coming years, the amount of energy at risk will continue to increase. The optimum timing for this project is in 2029.

5 RECOMMENDATION

It is recommended to establish a new 5km single circuit from Caboolture bulk supply substation and teed into the existing feeder F746/1, which will then become a radial feeder to eliminate any energy at risk following an outage of feeder F745/3 or F746/3, to improve security and reliability to customers, meet the projected load growth at SST11 and enabling Energex to continue to meet the Safety Net regulatory obligation.. Table 4 summarises the options under consideration.

Table 4 Options Analysis Scorecard

Criteria	Option 1 – Establish 110kV SCCT Tee to connect into F746/1	Option 2 – Establish 110/kV SCCT Tee to connect into F746/2
Net Present Value	$10.686m	$9.812m
Investment cost	$12.56m	$13.65m
Benefits	$21.204m	$21.204m
Delivery time	5 years	5 years
Detailed analysis – Benefits	The total blackout scenario caused by a single tower failure is alleviated.	The total blackout scenario caused by a single tower failure is alleviated.
Detailed analysis – Risks	This option requires reconfiguration of the TNSP's network, agreement with TNSP has not been reached.	This option requires reconfiguration of the TNSP's network, agreement with TNSP has not been reached.
Detailed analysis - Advantages	This option results in a secure and reliable supply for the Caboolture network.	This option results in a secure and reliable supply for the Caboolture network.

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 and Section 4.1
6.5.7 (a) (2) comply with all applicable regulatory obligations or requirements associated with the provision of standard control services;	Section 3 and Section 4.1
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 and Section 4.1
6.5.7 (a) (4) maintain the safety of the distribution system through the supply of standard control services.	Section 3 and Section 4.1
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, Section 3, 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	$0m	$0.094m	$0.249m	$2.078m	$8.645m	$11.065m

Appendix 3: Example of pole damage due to traffic incident

In July 2021, there was an incident where a car hit one of the towers (TW430) on the 110kV double-circuit single-tower feeder F746/2 as shown in Figure 11. This resulted in damaged steel work and cracked concrete cap which required significant repair work.

Figure 11 – Car hit tower TW430 on F746