New Feeder from Emerald to Blackwater

Business Case

17 January 2024

ERGON ENERGY NETWORK
Part of Energy Queensland

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DOCUMENT VERSION

Version Number	Change Detail	Date	Updated by
1.0	Review	08/12/2023	Principal Planning Engineer
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RELATED DOCUMENTS

Document Date	Document Name	Document Type
20/05/2022	Safety Net Application Guideline	EQL Standard

1 SUMMARY

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<tr><td>Identified need</td><td>☒ Legislation ☒ Regulatory compliance
☒ Reliability ☐ CECV ☐ Safety ☐ Environment ☐ Financial
☐ Other

Emerald 66/11kV substation (EMER) supplies over 8,700 premises and a maximum combined load of around 40MVA. Following a credible contingency on one of two 66kV feeders supplying Emerald the remaining feeder is unable to support the remaining load, resulting in up to 42% of customer load being shed from the network. The quantum of unsupplied load and the restoration timeframes do not comply with minimum criteria stipulated in the Distribution Authority for the DNSP. Load growth is forecast to exacerbate the situation substantially through the 2025-2030 regulatory period and beyond. Continued operation of the existing network supplying EMER results in increased organisational exposure to non-compliance with its DA, and increased exposure of the Emerald community to prolonged and widespread outages.</td></tr>
<tr><td>Summary of preferred option</td><td>All feasible network options have been identified and assessed. NPV analysis with various sensitivities have been applied to identify the most cost-effective option. The proposed option is to rebuild 66kV feeder 6056/6011 between Blackwater bulk supply substation and Emerald zone substation, utilising existing easements secured previously for the purpose.</td></tr>
<tr><td>Expenditure</td><td>
<table>
<tr><th>Year</th><th>Previous period</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 2022-2023</td><td>-</td><td>-</td><td>0.010</td><td>0.382</td><td>0.514</td><td>19.310</td><td>20.216</td></tr>
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</td></tr>
<tr><td>Benefits</td><td>The primary benefit is restoration of compliance with minimum network security criteria stipulated in the Distribution Authority for the DNSP.</td></tr>
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2 BACKGROUND

2.1 Community Supply and Network Arrangement

Emerald is a regional centre in Central Highlands Region, Queensland, Australia which is home to 28,530 people, supports 19,123 jobs and has an annual economic output of $13.778 billion[1]. The population of the locality of Emerald was 14,906 people in 2021. The power supply to the area is via 22kV distribution from Emerald 66/22kV zone substation (EMERSS) servicing 8,700 premises with a maximum combined load of around 40MVA.

EMERSS is supplied by two 66kV feeders:

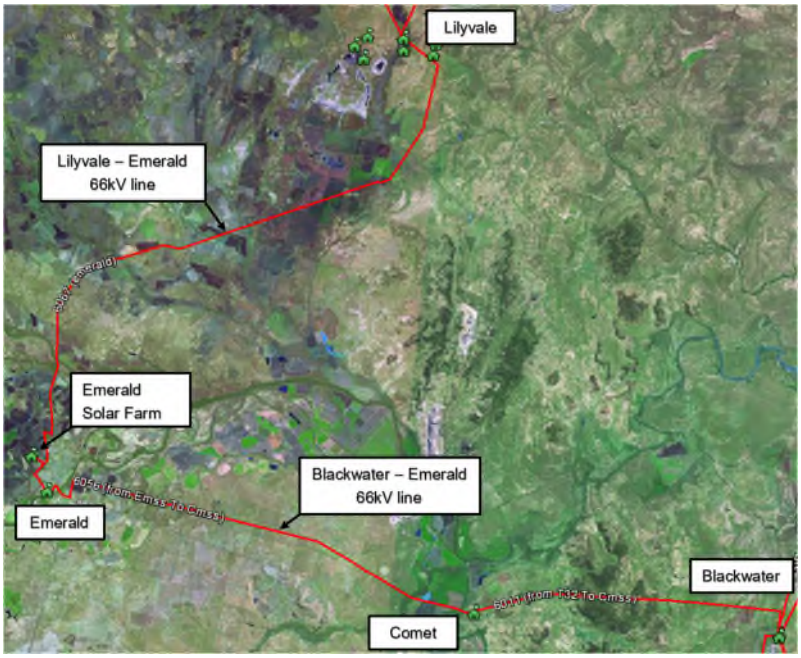
- F6067 (70km) from Lilyvale bulk supply substation (LILYSS); and
- F6011/F6056 (74km) from Blackwater bulk supply substation (BLACSS)

Geographic and schematic views of the network area are provided in Figure 1 and Figure 2.

Line easements have been acquired previously from BLACSS to EMERSS in a similar alignment to the existing F6011/F6056 line for approximately 95% of the line length, excluding through urban areas closer to EMERSS.

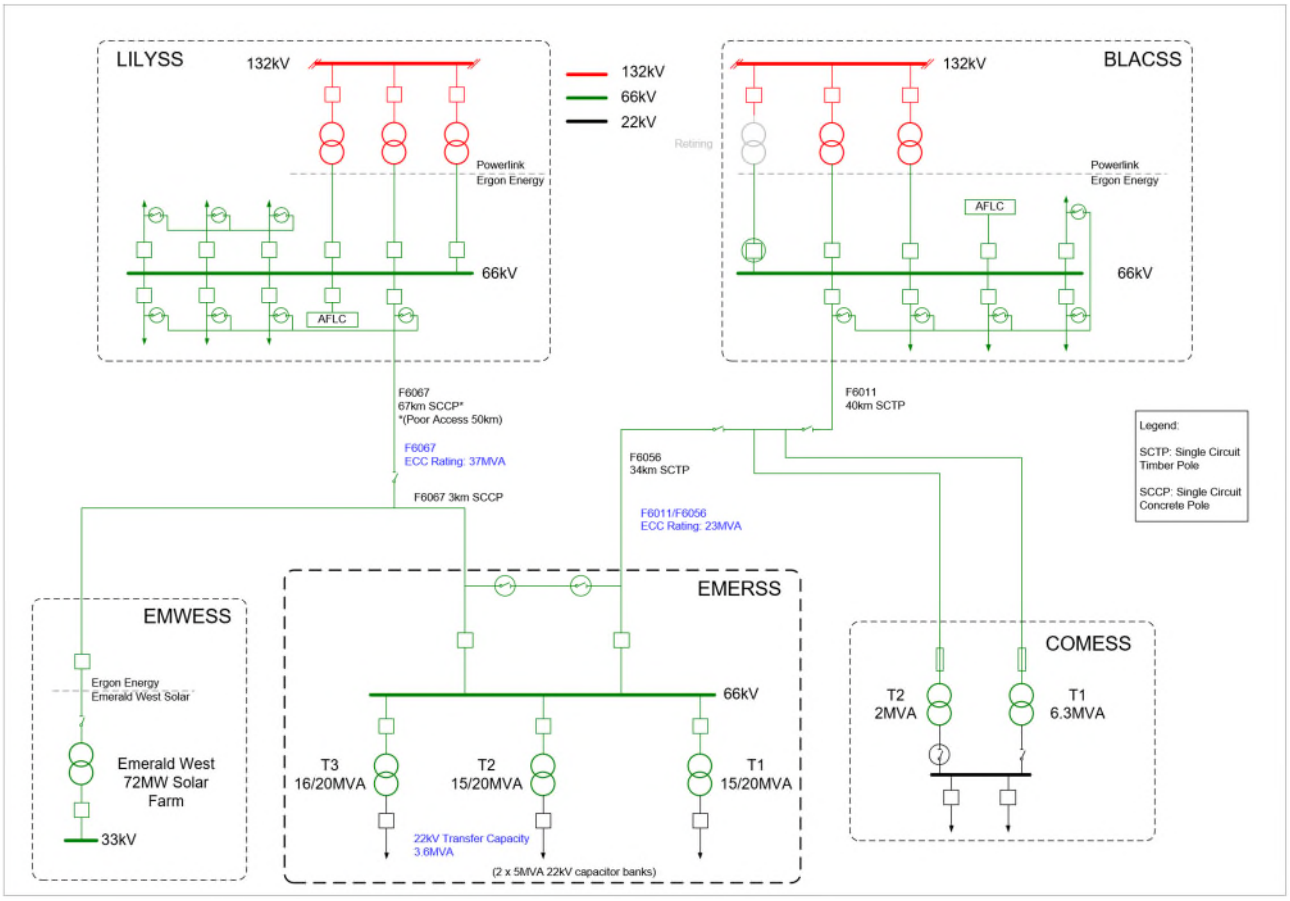
For reference, Emerald Solar Farm (72MW) is connected at 66kV via a tee arrangement on F6067 near Emerald, and Comet 66/22kV Substation (COMESS) is connected via tee arrangement midway between BLACSS and EMERSS. COMESS load is approximately 3MVA.

Figure 1: Existing network arrangement (geographic view)



[1] Business and economy - Central Highlands Regional Council (chrc.qld.gov.au)

Figure 2: Existing network arrangement (schematic view)



3 IDENTIFIED NEED

Following a single credible contingency removing one of the two feeders from service (F6067 from LILYSS), up to 43% of customers at Emerald would be shed. The quantum of load shed and credible restoration timeframes do not meet the network security standard "Safety Net" stipulated in the Distribution Authority for Ergon Energy. Forecast load growth will exacerbate the situation substantially through the 2025-2030 regulatory period and beyond over the life of the regulatory assets. The primary need for investment is to restore and maintain ongoing compliance with Ergon Energy's Distribution Authority regarding security of supply to network customers.

3.1 Compliance Criteria

3.1.1 Contingent Supply Capacity

Under its Distribution Authority, Ergon Energy must adhere to the Safety Net which identifies the principles that apply to the operation of network assets under network contingency conditions. System contingency related capability is assessed against available load transfers, emergency cyclic capacity (ECC), non-network response, mobile plant, mobile generators, and short-term ratings of plant and equipment, where available, using a 50% probability of exceedance (50PoE) forecast load.

Emerald substation is classified as a Regional Centre, with the following Safety Net criteria load not supplied must be:

- Less than 20MVA (8000 customers) after 1 hour
- Less than 15MVA (6000 customers) after 6 hours
- Less than 5MVA (2000 customers) after 12 hours
- Fully restored within 24 hours.

(Note: Customer numbers shown are indicative only. Unsupplied load in MVA is the primary measure for Safety Net compliance)

3.1.2 Normal Supply Capacity

Under clause 6.5.7 (a) (1) of the National Electricity Rules (refer Appendix 1) the DNSP is required to develop proposals to invest in an efficient and prudent manner to meet or manage the expected demand for standard control services.

Failing to invest to supply reasonable forecast load does not comply with requirements of the NER, could result in forced load shedding in peak load periods, and/or commercial and industrial developments not being able to connect to the network in a reasonable timeframe.

3.2 Primary Constraint

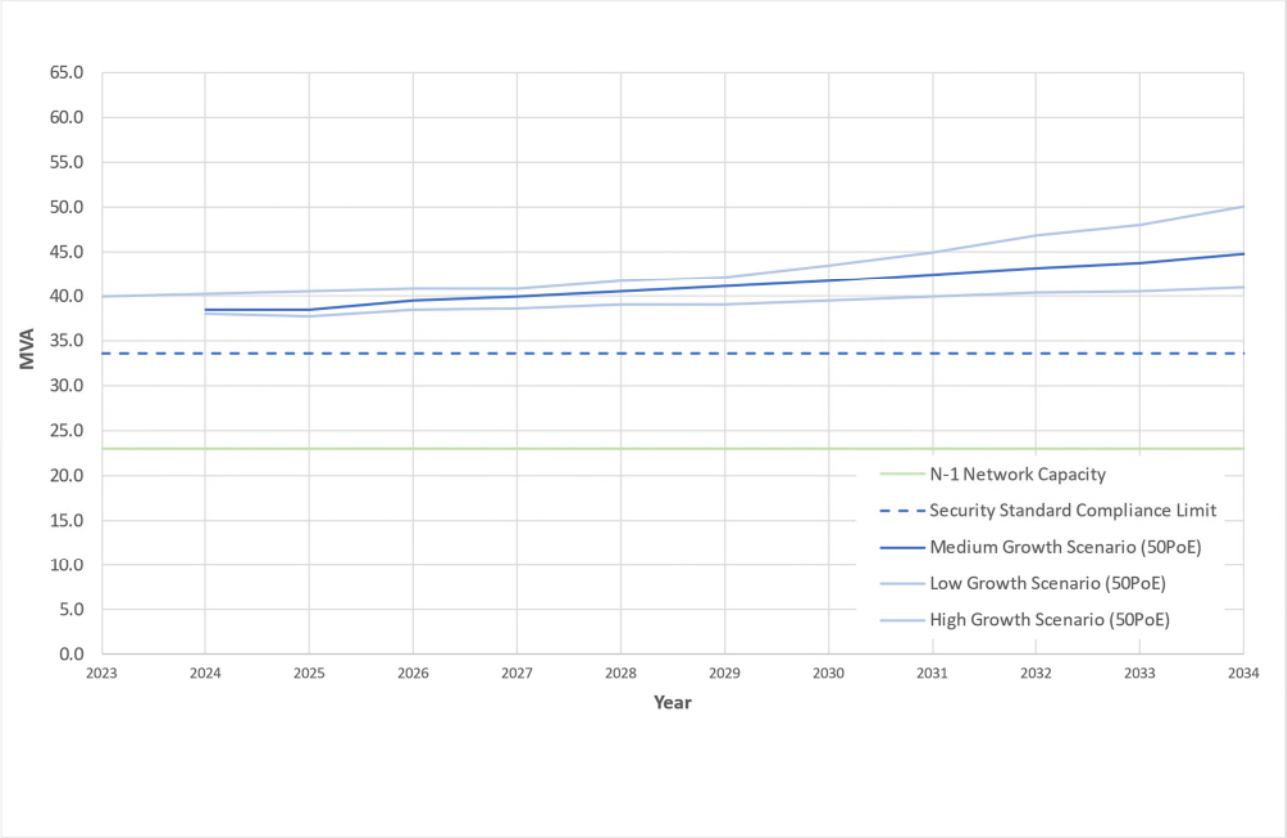
3.2.1 Contingent Supply Capacity (F6067 LILYSS-EMERSS OOS)

The primary constraint is that restoration of customer load after a single credible contingency to F6067 LILYSS-EMERSS does not comply with minimum criteria stipulated in the Distribution Authority for the DNSP.

Feeder F6067 from Lilyvale is a concrete pole line traversing approximately 50km of “black soil” territory with poor equipment access. Hardware failures on this line are credible and due to the access limitations are expected to take longer than 12 hours (but less than 24 hours) to repair. For restoration in this timeframe, the minimum security criteria stipulates that no more than 5MVA of customer load can be left unsupplied.

The remaining feeder F6011/F6056 can supply 23.0MVA, a further 2.6MVA can be transferred to neighbouring substations within 2 hours, and up to 3MVA of emergency generation can be deployed within 12 hours. With the security criteria allowance of 5MVA, this results in a compliance limit of 33.6MVA of 50PoE forecast load at Emerald. The compliance limit is exceeded currently as shown in Figure 3 below. Ergon Energy has mitigated to some extent the existing risk of non-compliance by placing fault location devices along feeder F6067 to reduce fault finding times, however exceeding 12 hours restoration remains credible due to poor access to the line.

Figure 3: Forecast Load vs Compliance Constraint (F6067 OOS)



3.3 Other Constraints

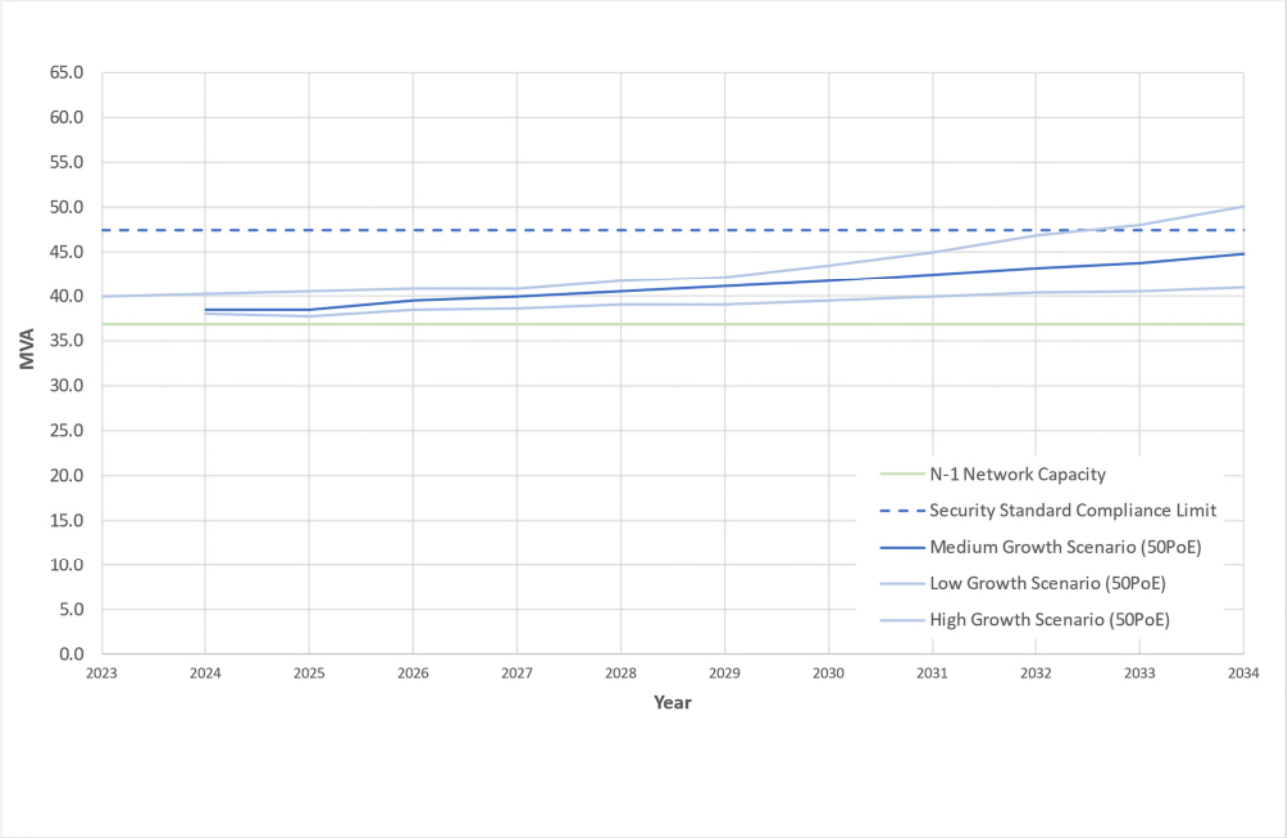
3.3.1 Contingent Supply Capacity (F6011/F6056 BLACSS-EMERSS OOS)

Other constraints that are secondary to the primary constraint include that restoration of customer load after a single credible contingency to F6011/F6056 BLACSS-EMERSS will not comply with minimum criteria stipulated in the Distribution Authority for the DNSP from 2037 onwards.

Feeder F6011/F6056 from Blackwater is a timber pole line. Pole failures on this line are credible are expected to take longer than 12 hours to repair but less than 24 hours. For restoration in this timeframe, the minimum security criteria stipulates that no more than 5MVA of customer load can be left unsupplied.

The remaining feeder F6011/F6056 can supply 36.8MVA, a further 2.6MVA can be transferred to neighbouring substations within 2 hours, and up to 3.0MVA of emergency generation can be deployed within 12 hours. With the security criteria of 5MVA, this results in a compliance limit of 47.4MVA for 50PoE forecast load at Emerald. The compliance limit is exceeded in approximately 2036 with medium forecast growth as shown in Figure 3 below. High and low growth scenarios are included for reference.

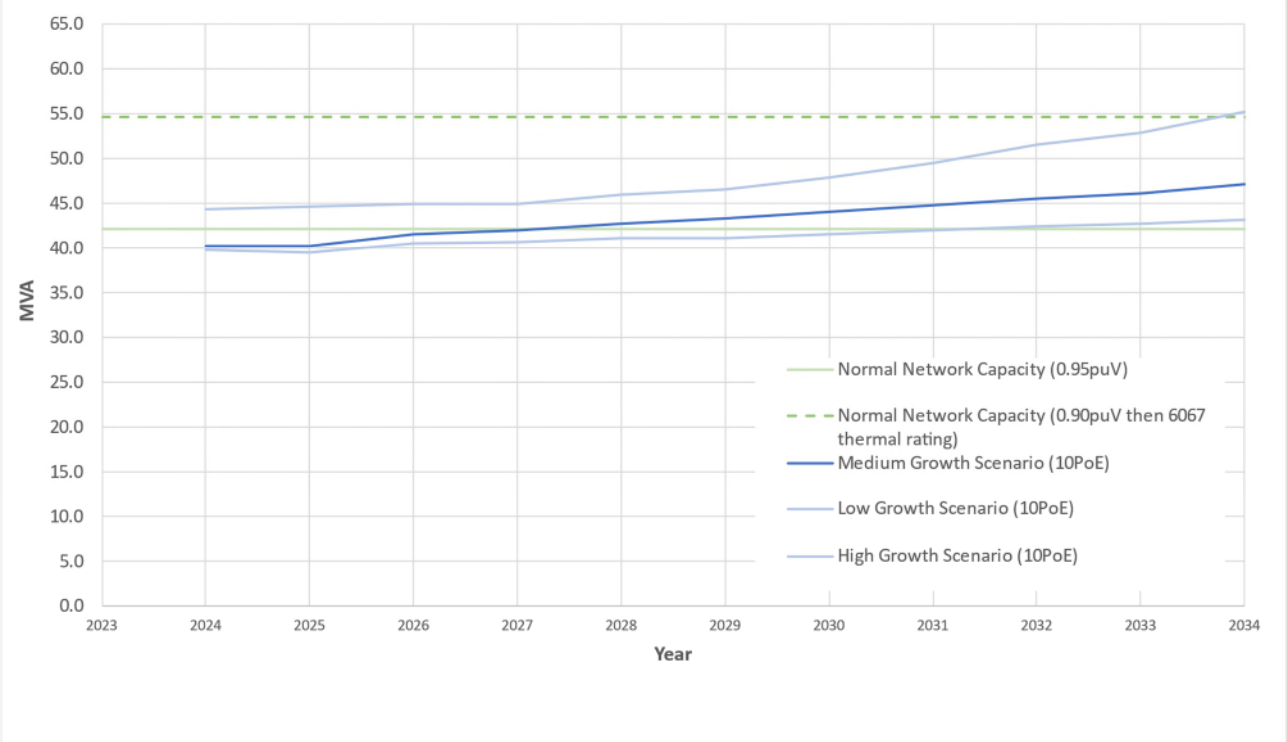
Figure 4: Forecast Load vs Compliance Constraint (F6011/F6056 OOS)



3.3.2 Normal Supply Capacity

Normal supply capacity at EMERSS is constrained by voltage at Emerald as shown in Figure 5. System normal supply capacity can be increased to a limit of 60MVA through the addition of reactive voltage support at Emerald without line uprating or rebuild works. System normal supply is not the primary need for the proposed investment.

Figure 5: Forecast Load vs Network Constraint (System Normal)



4 OPTIONS IDENTIFICATION

4.1 Options Summary

Ergon Energy Network has sought to identify a practicable range of technically feasible, alternative options to restore compliance with the minimum security criteria in the Distribution Authority in a timely and prudent manner. Options considered are detailed below and detailed further in the following sections. Options considered and rejected are discussed in Section 0. Non-network options if available will be identified and evaluated through the RIT-D process.

Option 1: Rebuild BLACSS-EMERSS

- Stage 1 (2031): Rebuild 74km 66kV feeder F6056/F6011 with higher rated conductor using majority pre-acquired easements in separate alignment ($44m).
- Stage 2 (2037): Add reactive voltage support ($4.2m).
    - Timing Sensitivity: High growth scenario (2033), Low growth scenario (2050)

Option 2: Uprate BLACSS-EMERSS and add reactive voltage support

- Stage 1 (2027): Uprate existing feeder F5056/F6011 and add reactive voltage support ($11.2m).
- Stage 2 (2031): Rebuild 66kV feeder F6056/F6011 from Blackwater to Emerald with larger conductor ($44m).
    - Timing Sensitivity: High growth scenario (2028), Low growth scenario (2040)

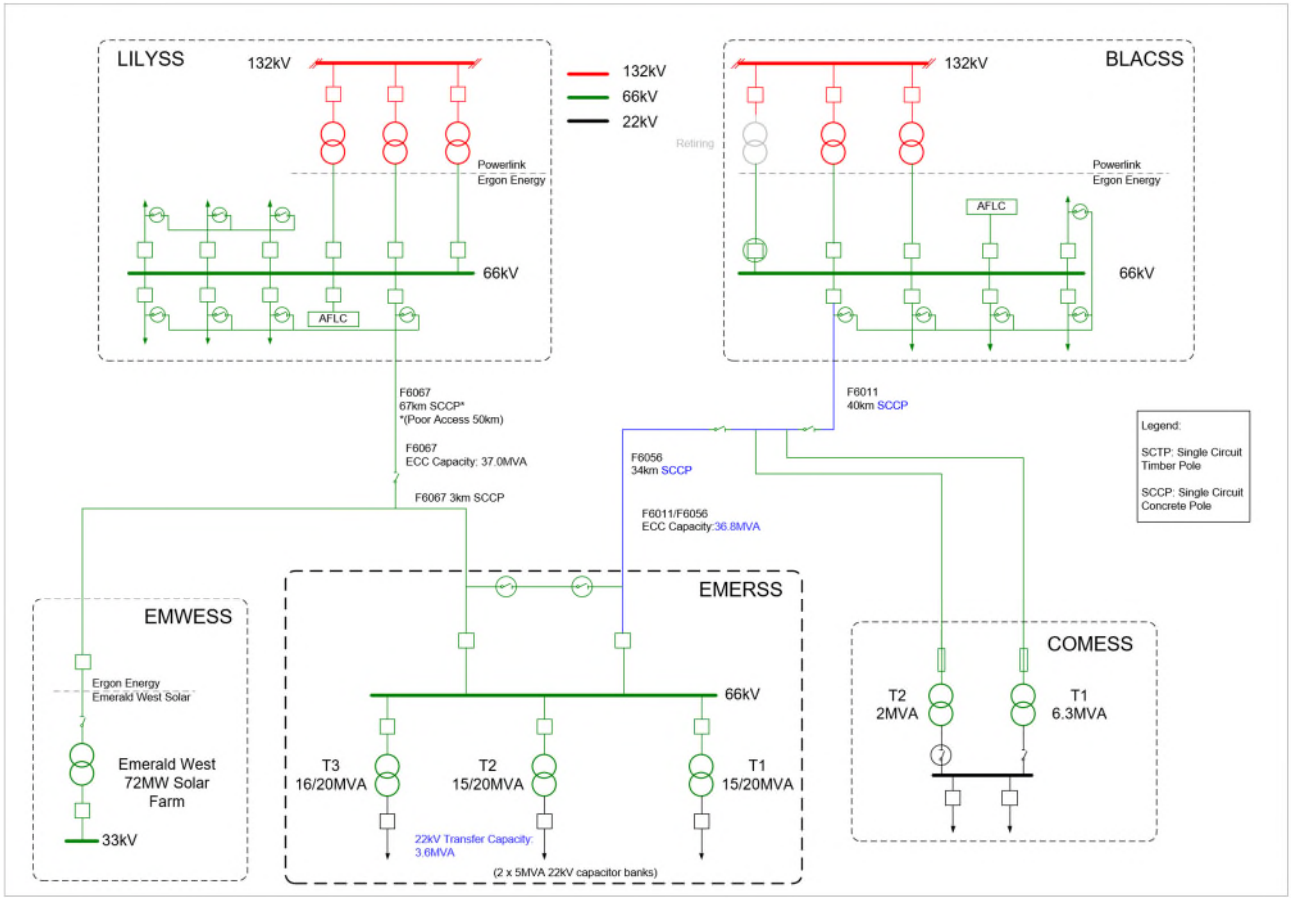
4.2 Option 1 – Rebuild 66kV feeder F6056/F6011 from Blackwater to Emerald

Option 1 is to rebuild in majority adjacent easements 66kV feeder F6056/F6011 from Blackwater to Emerald with higher rated conductor and recover the existing line, then add reactive voltage support at Emerald as future Stage 2.

This option involves the following:

- Stage 1 (2031)
    - Rebuilding existing 74km 1968 vintage timber pole line with current standard concrete pole line with a higher rating utilising the previously acquired easements
- Stage 2 (2037)
    - Add three 22kV capacitor banks at EMERSS to provide up to 18MVAr of reactive power for voltage support.
    - Timing Sensitivity: High growth scenario (2033), Low growth scenario (2050) (refer Section 4.2.1)

Figure 6: Option 1 network diagram (Option 1)



4.2.1 Contingent Supply Capacity (F6067 LILYSS-EMERSS OOS) (Option 1) (Primary Constraint)

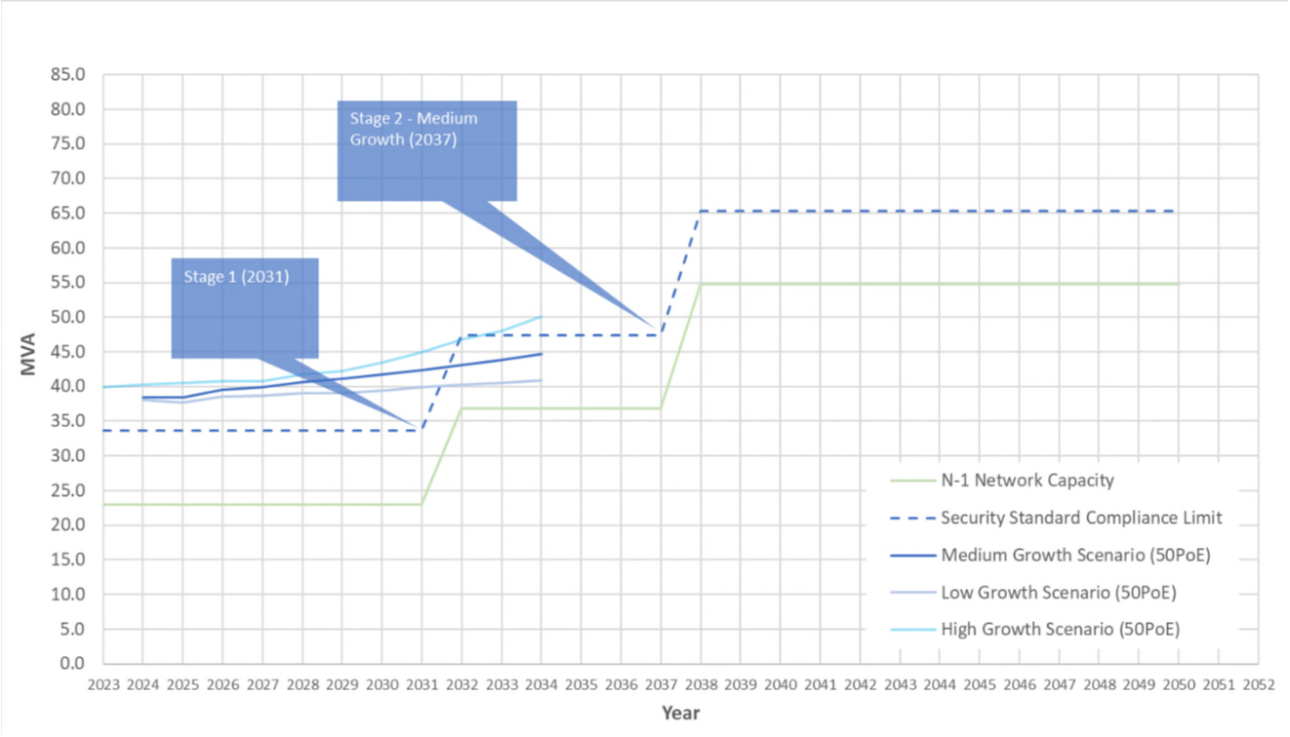
Option 1 will address the primary need for investment which is to restore compliance with minimum security standard criteria in the Distribution Authority for a credible contingency to feeder F6067 LILYSS-EMERSS.

50PoE load forecasts and capacity under Option 1 is shown in Figure 7 with high, medium and low growth scenarios.

- Stage 1 (2031) (rebuild) increases the N-1 network capacity to 36.8MVA and the security standard compliance limit to 47.4MVA.
- Stage 2 (reactive voltage support) increases N-1 network capacity to 54.7MVA and the security standard compliance limit to 65.3MVA.

Stage 2 is triggered by load growth in 2037. Timing sensitivity is 2033 for the high growth scenario and 2050 for the low growth scenario.

Figure 7: Forecast 50PoE Load vs Compliance Constraint (F6067 LILYSS-EMERSS OOS) (Option 1)



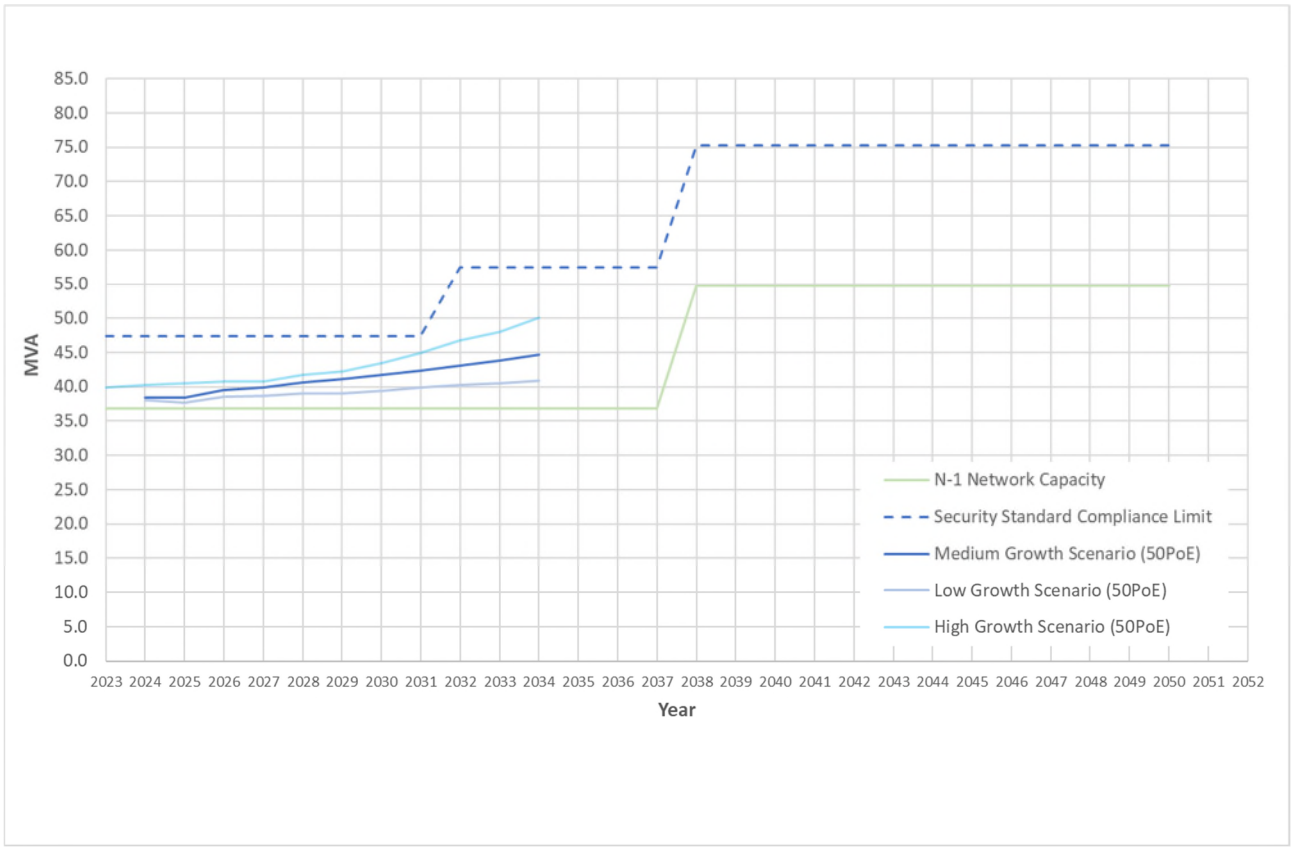
4.2.2 Contingent Supply Capacity (F6011/F6056 BLACSS-EMERSS OOS)(Option1)

Option 1 will ensure ongoing compliance with minimum security standard criteria in the Distribution Authority for a credible contingency to feeder F6011/F6056 BLACSS-EMERSS.

50PoE load forecasts and capacity under Option 1 is shown in Figure 8 with high, medium and low growth scenarios.

- Stage 1 (2031) line rebuild replaces timber poles, a failure of which is considered a credible contingency, with concrete poles. The line route will be designed to be accessible so hardware failures can be repaired within 12 hours. The allowable unsupplied load increased from 5MVA to 15MVA increasing the compliance limit to 57.4MVA.
- Stage 2 reactive voltage support increases N-1 network capacity to 54.7MVA and the security standard compliance limit to 65.3MVA.
    - Timing of Stage 2 is dictated by the primary constraint (refer Section 4.2.1)

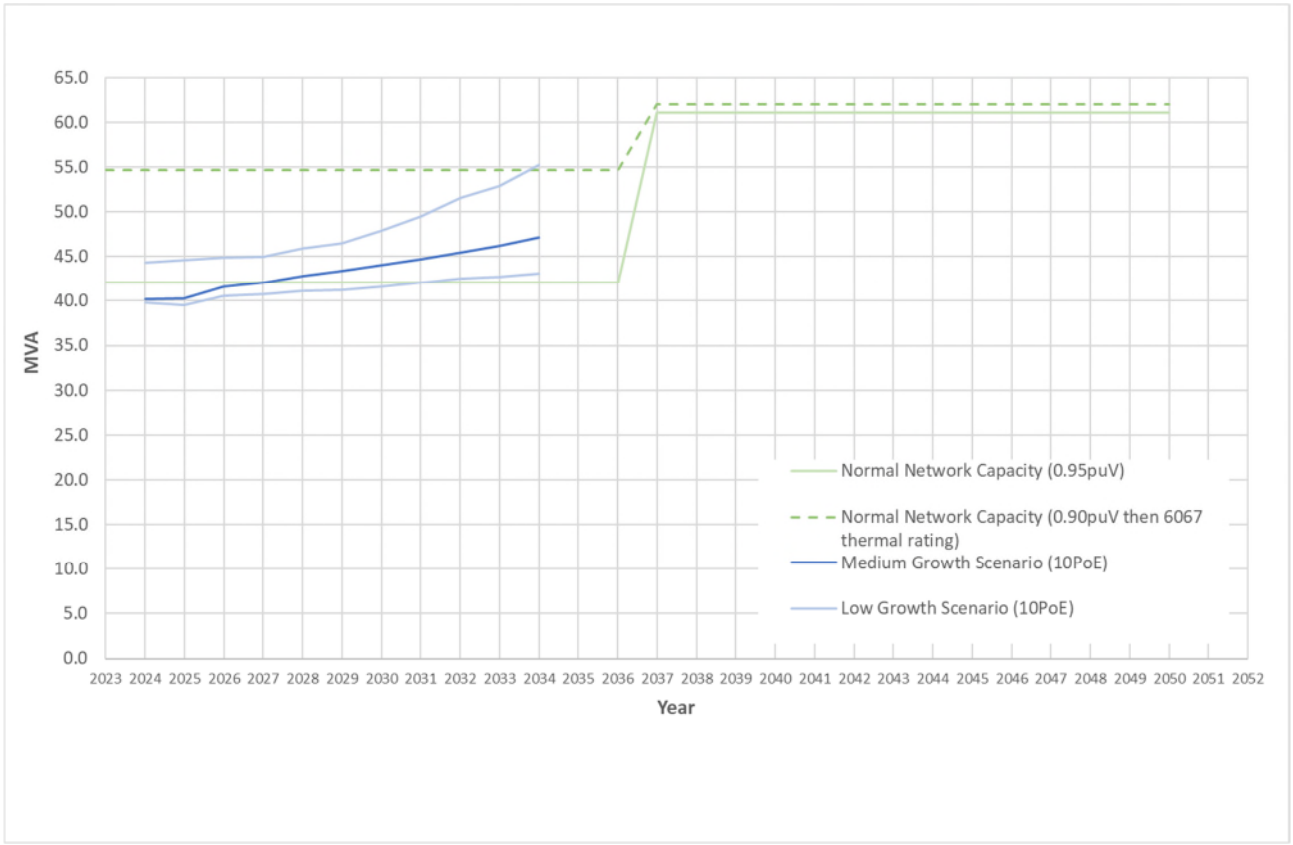
Figure 8: Forecast 50PoE Load vs Compliance Constraint (F6011/F6056 BLACSS-EMERSS OOS) (Option 1)



4.2.3 Normal Supply Capacity (Option 1)

Option 1 Stage 2 increases the normal supply capacity at EMERSS to 60MVA without voltage issues as shown in Figure 9below.

Figure 9: Forecast 10PoE Load vs Network Constraint (System Normal) (Option 1)



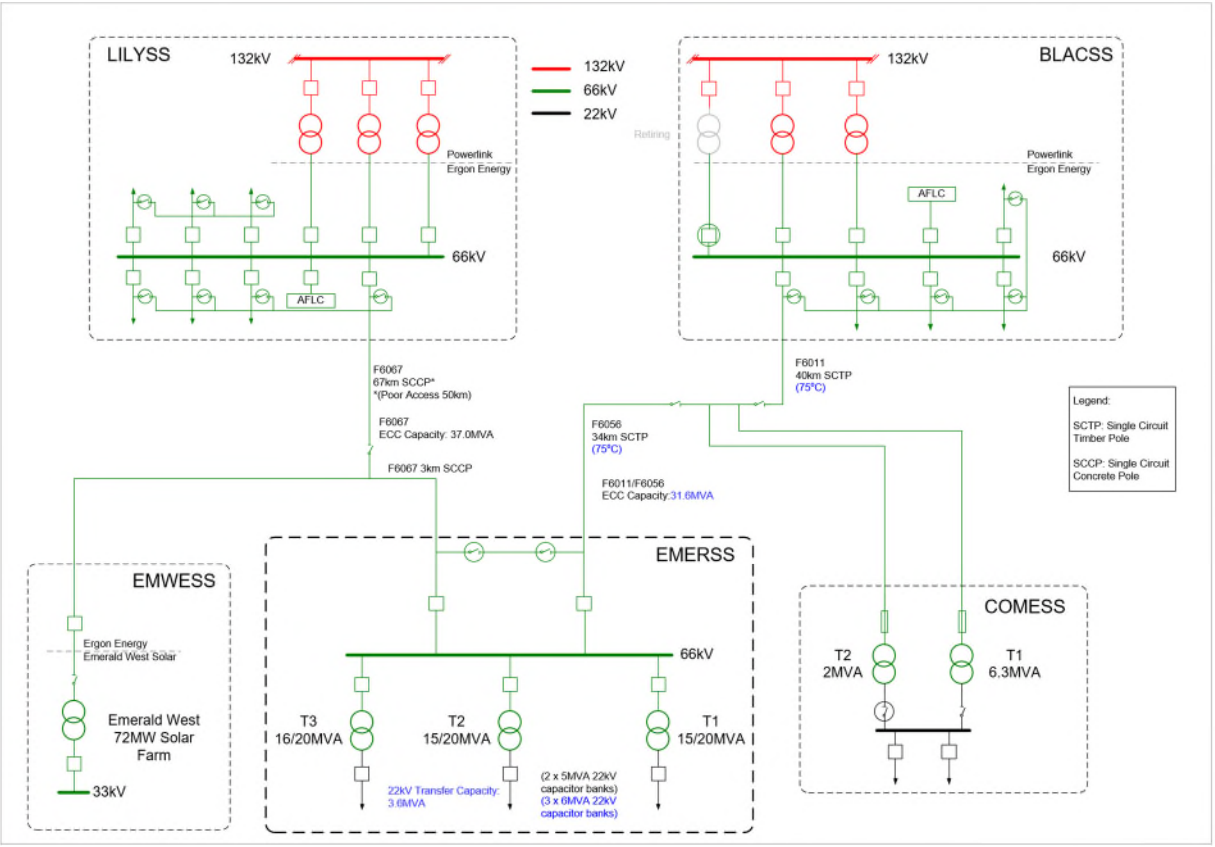
4.3 Option 2 – Re-tension F6056/6011 and add reactive voltage support

Option 2 will address the primary need for investment which is to restore compliance with minimum security standard criteria in the Distribution Authority for a credible contingency to feeder F6067 LILYSS-EMERSS.

This option involves:

- Stage 1 (2027)
  - Uprate the existing feeder F6011/F6056 66kV timber pole line of 1968 vintage from a design temperature of 65ºC to 75ºC through adding or replacing poles and/or increasing conductor tension to achieve higher clearance to ground.
  - Add three 22kV capacitor banks at EMERSS to provide up to 18MVAr of reactive power for voltage support.
- Stage 2 (2037)
  - Rebuild the existing line with current standard concrete pole construction and higher rated line.
  - Timing Sensitivity: High growth scenario (2028), Low growth scenario (2040) (refer Section 4.3.1)

Figure 10 – Option 2 network diagram



4.3.1 Contingent Supply Capacity (F6067 LILYSS-EMERSS OOS) (Option 2)(Primary Constraint)

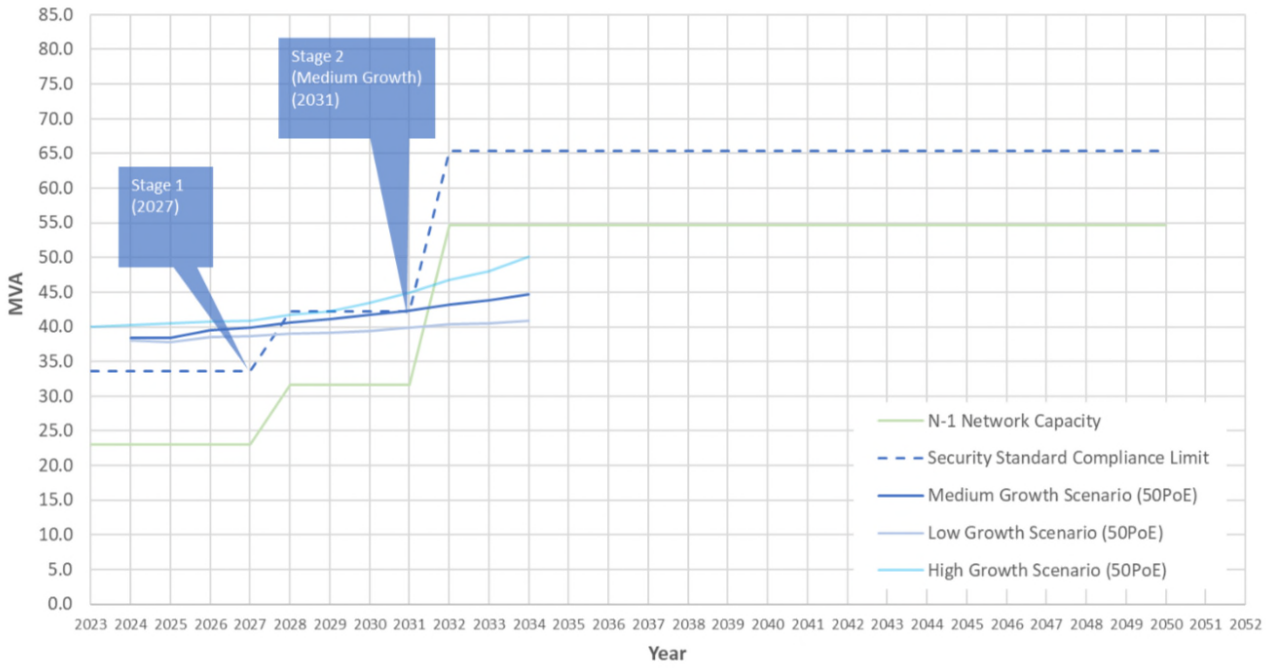
Option 2 will address the primary need for investment which is to restore compliance with minimum security standard criteria in the Distribution Authority for a credible contingency to feeder F6067 LILYSS-EMERSS

50PoE load forecasts and staged capacity under Option 2 is shown in Figure 11 with high, medium and low growth scenarios.

- Stage 1 (2027) line uprating works and reactive voltage support increases the N-1 network capacity to 31.6MVA and the security standard compliance limit to 42.2MVA.
- Stage 2 rebuild increases N-1 network capacity to 54.7MVA and the security standard compliance limit to 65.3MVA.

Stage 2 is triggered by load growth in 2031. Timing sensitivity is 2028 for the high growth scenario and 2040 for the low growth scenario.

Figure 11: Forecast 50PoE Load vs Compliance Constraint (F6067 OOS)(Option 2)



4.3.2 Contingent Supply Capacity (F6011/F6056 BLACSS-EMERSS OOS)(Option 2)

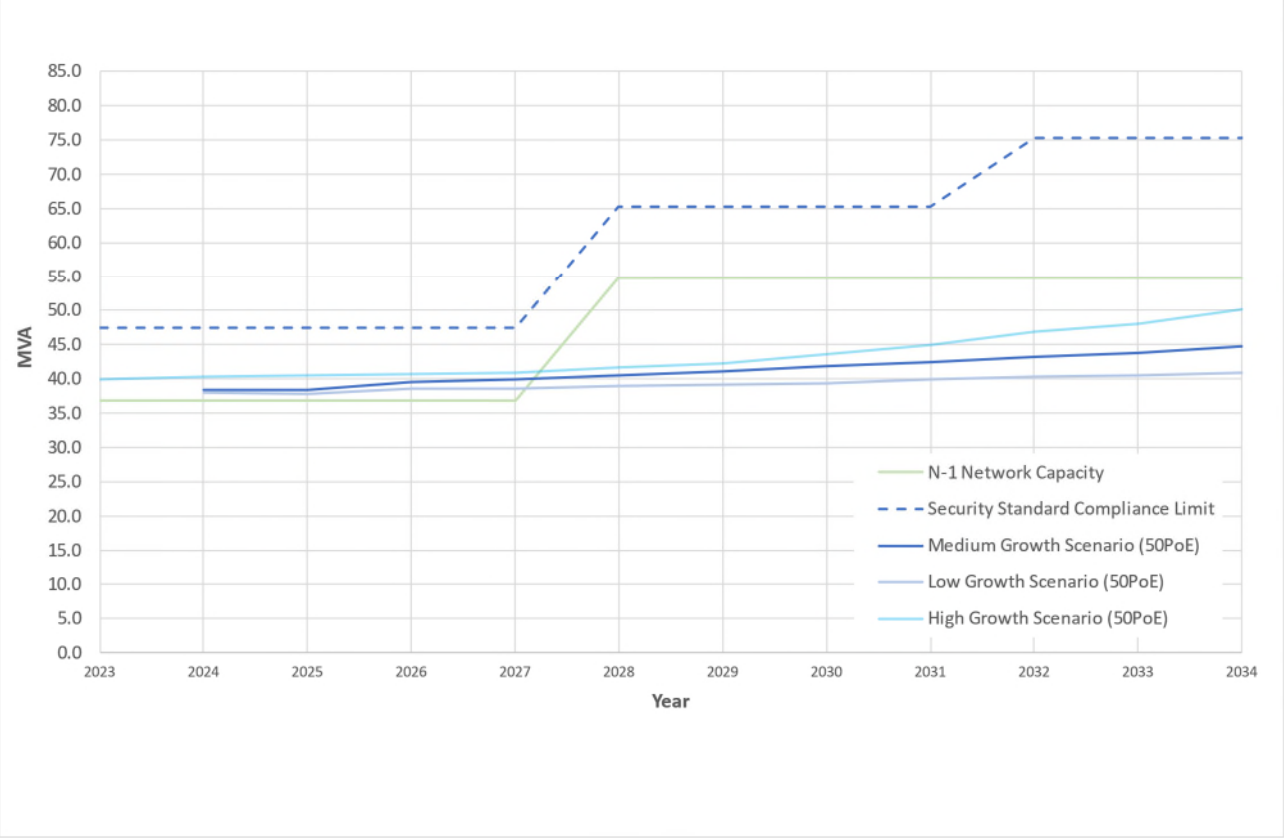
Option 2 will ensure compliance with minimum security standard criteria in the Distribution Authority for a credible contingency to feeder F6011/F6056 BLACSS-EMERSS between 2027 and 2031 for the base and high growth scenarios. The timing for stage two is dependent on load growth in the area.

50PoE load forecasts and capacity under Option 2 is shown in Figure 12 below with high, medium and low growth scenarios.

- Stage 1 (2027) (uprate and reactive voltage support) increases N-1 network capacity to 54.7MVA and the security standard compliance limit to 65.3MVA.
- Stage 2 (2031) (rebuild) replaces timber poles with concrete poles. Concrete pole failures are not considered credible contingencies and the line is accessible so hardware failures can be repaired within 12 hours. The allowable unsupplied load increased from 5MVA to 15MVA increasing the compliance limit to 75.3MVA.

Timing of Stage 2 is dictated by the primary constraint (refer Section 4.3.1)

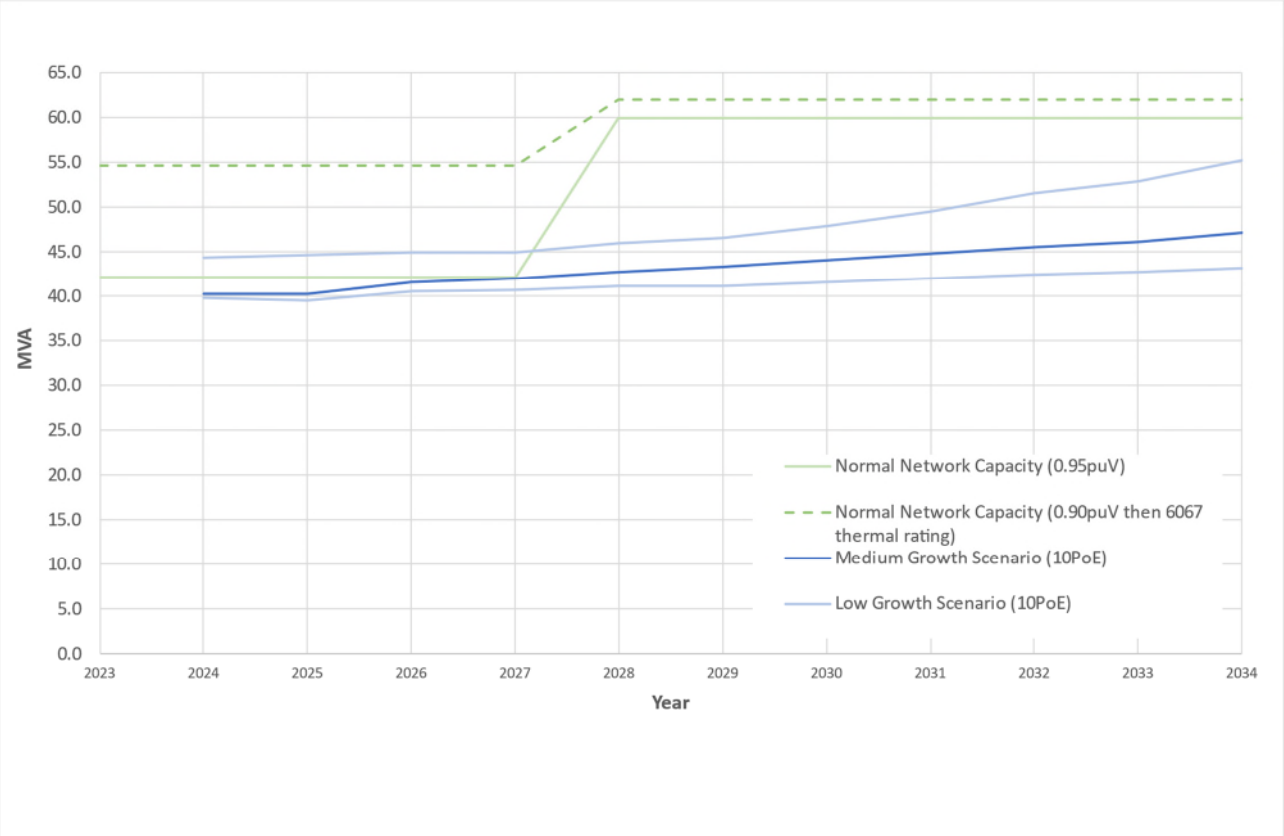
Figure 12: Forecast 50PoE Load vs Compliance Constraint (F6011/F6056 BLACSS-EMERSS OOS) (Option 2)



4.3.3 Normal Supply Capacity (Option 2)

Option 2 Stage 1 increases the normal supply capacity at EMERSS to 60MVA without voltage issues as shown in Figure 13 below.

Figure 13: Forecast 10PoE Load vs Network Constraint (System Normal) (Option 2)



4.4 Options considered and rejected

The following options were considered but rejected for the reasons listed:

a) Establish a new 66kV feeder from Lilyvale

Reasons rejected:

- Requires 100% line route easement widening/acquisition.
- Procuring additional easements will add to delivery timeframe leaving non-compliance with Safety Net unaddressed for longer.
- Easements already procured between Blackwater and Emerald would be wasted.
- Existing Feeder F6011 would need to be kept and maintained to supply to Comet.

b) Establish a new 66kV feeder from Lilyvale or Blackwater and keep existing line.

Advantages:

- Eliminates the need for additional reactive support at Emerald.
- Accommodates further load growth and block loads not currently in the forecast.
- Improves reliability to Emerald.

Reason rejected:

- Easements already procured between Blackwater and Emerald do not accommodate construction of a third line while keeping the existing line.
- Does not eliminate increasing maintenance of existing timber pole feeder F6011/F6056 (established 1968).

4.5 Options Analysis

4.5.1 Benefits

The need for this project is compliance with a legislative requirement to meet the minimum network security criteria stipulated in the Distribution Authority for the Ergon Energy DNSP, therefore a negative NPV is acceptable. NPV analysis is used to select the best investment to satisfy the obligation. Reliability benefits in terms of VCR do exist for each option and are included for reference and for comparison of options.

4.5.2 Capital Costs

The following Capex costs have been used in the NPV analysis for comparison of options:

- Uprating 74km of the existing 66kV feeder F6011/F6056 from design temperature of 65^{o}C to 75^{o}C has been estimated at $7.0m direct cost.
- Adding three 22kV capacitor banks at EMERSS has been estimated at $4.2m direct cost.
- Rebuilding the 74km 66kV feeder has been estimated at $46.65m direct cost.
- Recovery of the existing 66kV feeder has been estimated at $30k per km.

4.5.3 Operational Costs

Where the existing timber pole is kept in service under an option, and Opex cost of $100k pa was applied to model the additional defect rectification works associated with an aged 75km timber pole line established 1968 vs a new concrete pole line established 2027. An Opex cost of 1% was applied to the additional capacitor banks at Emerald.

4.5.4 Financial NPV analysis

Options were analysed on a scenario NPV basis with initial investments for each option and future investments occurring based on high, medium and low load growth scenarios (refer Figure 7 and Figure 11). Weightings of 20%, 60% and 20% were applied respectively to the load growth scenarios to obtain a "Net NPV". The results with the Capex, Opex and Benefits components are shown in Table 1. Sensitivity analysis was also applied to the discount rate used in the financial model. Table 2 shows the sensitivity to discount rate and growth scenarios. In all scenarios and sensitivities, Option 1 resulted in the best NPV.

Table 1: Base Case NPV Analysis ($k) (3.5% Discount Rate)

Option	Rank	Net NPV [2]	Capex NPV	Opex NPV	Benefits NPV
Option 1 – Rebuild Feeder in 2031	**1**	-35,485	-37,019	-847	2,381
Option 2 – Uprate Existing Feeder to defer Rebuild	2	-41,144	-42,285	-1,396	2,537

Table 2: NPV Sensitivity Analysis ($k)

Option	Discount rate		Growth scenario	
	2.5%	4.5%	Low	High
Option 1 – Rebuild Feeder	**-37,419**	**-33,343**	**-31,850**	**-30,746**
Option 2 – Uprate Existing Feeder to defer Rebuild	-43,387	-38,715	-34,564	-38,436

[2] A negative NPV is acceptable to meet legislative requirements stipulated in the Distribution Authority for the Ergon Energy DNSP.

5 RECOMMENDATION

It is recommended to proceed with Option 1 to rebuild 74km single circuit line from Blackwater bulk supply substation to Emerald zone substation in 2031. Table 3 summarises the options under consideration.

Table 3: Options Analysis Scorecard

Criteria	Option 1 – Rebuild 66kV Line 6056/6011	Option 2– Uprate 66kV Line 6056/6011 and add reactive support
Net Present Value	-$35.485m	-$41.144m
Investment cost (TCO)	$46.65m (direct) ($4.2m deferred)	$11.2m (direct) ($46.65m deferred)
Investment Risk	Medium	Medium
Benefits	Compliance	Compliance
Delivery time	2031	2031
Detailed analysis – Benefits	Achieves compliance with Safety Net minimum security with the existing and forecast load growth at Emerald	Achieves compliance with Safety Net minimum security with the existing and forecast load growth at Emerald
Detailed analysis – Risks	Forecast load at Emerald decreases significantly leading to poor utilisation/over investment in the network. Low, medium and high forecast scenario's have been considered to mitigate this risk.	Load at Emerald increases more than forecast or a larger customer block load is added bringing forward deferred cost as SCS works resulting in a more negative NPV. Uprating the existing feeder involves outages to F6056/F6011 with significant network risk if carried out in summer periods and significant disruption to existing solar farm generation at any time of year.
Detailed analysis - Advantages	This option results in an electricity supply to Emerald that complies with the security standard with the least NPV cost	This option results in an electricity supply to Emerald that complies with the security standard with the least initial cost

5.1 Cost summary 2025-30

The establishment of the new 74km of 66kV SCCP feeder has been estimated as $46.65m. The forecast expenditure by year in the 2023-30 period is shown in Table 4.

Table 4: Cost summary 2025-30 ($m, real 2022-23)

Option	2025-26	2026-27	2027-28	2028-29	2029-30	Total Direct 2025-30
Establish 66kV SCCP Line	-	0.010	0.382	0.514	19.310	20.216

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
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
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
6.5.7 (a) (4) maintain the safety of the distribution system through the supply of standard control services.	Section 3, Section 4
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 4.5
6.5.7 (c) (1) (ii) the costs that a prudent operator would require to achieve the capital expenditure objectives	Section 4.5
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