# Planning Proposal

## Grid Planning & Optimisation

# WR1273666
# Mossman Substation Replacement
# Ergon Energy
# 2020-25

January 2019

Part of the Energy Queensland Group

# 1. EXECUTIVE SUMMARY

## 1.1. Background

Mossman 66/22 kV Substation (MOSS) was constructed in 1964 and supplies some 3,250 customers in the surrounding Douglas Shire area of Mossman, Port Douglas and the Daintree. In 2018 MOSS had a peak load of 7.3MVA. The Mossman substation is supplied by two, 80km long, aged 66 kV timber pole lines from Powerlink's Turkinje 132/66 kV substation via Mossman 1 Feeder (MOSS 1) constructed in 1975 and Mossman 2 Feeder (MOSS 2) constructed in 1958.

The 66kV feeders to and the distribution network supplied by MOSS are shown in the diagram below.


Initiated by a range of end of life assets at MOSS, the purpose of this planning proposal is to outline the risk currently associated with the age and condition of the overhead 66kV feeders that supply the Mossman substation and numerous primary plant items within MOSS. The planning proposal considers the feasible options to effectively manage those risks and presents the recommendation for the most cost-effective option.

## 1.2. Summary of Need for Investment

In July 2017 a Substation Condition Assessment Report (SCAR) was compiled concerning the Mossman (MOSS) 66/22 kV substation and upstream 66 kV feeders from Turkinje (TURK) 132/66 kV substation. The issues identified in the SCAR form the key drivers for this planning proposal.

The health and safety of staff is put at risk when performing routine maintenance and repair activities within proximity of the substation plant and equipment. Due to advanced age and poor condition, plant items within the substation are becoming a high likelihood of failure with the potential to cause injury and harm. MOSS is 54 years old with the majority of its assets being of similar vintage. A substantial proportion of the primary assets are due for replacement over the next 10 years including; 2 x 10 MVA 66/22 kV power transformers, 66 kV circuit breakers, high voltage instrument transformers, protection relays, the control building and support structures.

The timber pole 66 kV Mossman feeders are of 1958 vintage. These have access difficulties, poor reliability and represent an exceptionally high ongoing CAPEX and OPEX cost. The route the two lines take is through the World Heritage listed areas of the Rex Range which is managed by the Wet Tropics Management Authority. Legacy distribution network businesses have committed to the management authority and the community to remove the 66kV feeders. The delay in fulfilling those commitments has the potential to damage the current distribution network business's reputation.

The Mossman, Yalkula and Northern Tablelands is an area of growth potential for industrial, agricultural and commercial development and the integration of renewable energy generation. Projects like Mossman Sugar Mill, Lakeland Storage and Solar, Cape York Solar Farm (committed), Lakeland Wind Farm (proposed) and a proposed development north of the Daintree demonstrate actual and potential for economic development in the area. Optimising the existing infrastructure to enable these developments is intrinsically linked with the Queensland Government's renewables target policy and other supporting strategies.

## 1.1. Summary of Feasible Options

Four options have been identified in this report:

- Base Case (BAU) – Continue refurbishment and maintenance on a business as usual basis.
- Option A – Convert MOSS to a 132/22 kV substation, upgrade nearby Yalkula substation YALK to fully switched 132 kV substation and retire MOSS 1 and MOSS 2 66 kV feeders back to Mount Molloy Substation (MOMO).
- Option B – Replacement of MOSS 1 and MOSS 2 66 kV feeders and ongoing refurbishment and maintenance of MOSS substation.
- Option C – Upgrade CRAI 132/22 kV substation, establish additional underground feeders to supply MOSS 22 kV network and retire MOSS 1 and MOSS 2 66 kV feeders back to MOMO.

## 1.2. Recommendation

Based on the analysis contained, this planning proposal recommends Option A, which rebuilds the Mossman substation as a single 132 kV tee, single 132/22 kV transformer and establishes a fully switched 132 kV bus at the Yalkula substation by December 2021. The scope of work includes:

1. Stage 1 – 22 kV line works to provide manageable supply security from Craiglie (CRAI) 132/22 kV substation and vice versa during substation/line works and removal of 66 kV & 22 kV TF1 substation plant assets at MOSS;
2. Stage 2a – Installation of a simplified 132 kV tee, single 132/22 kV transformer and 22 kV indoor switchgear at MOSS;
3. Stage 2b – Upgrade of YALK to a fully switched 132 kV substation and circuit cut in/out to enable a 3-way communicating distance protection scheme with Craiglie (CRAI) and Mossman 132 kV substations;
4. Stage 3 – Removal of 66 kV TF2 and Mossman 2 66 kV feeder bay assets; and
5. Stage 4 – Removal of 66 kV Mossman feeders/assets towards MOMO.

The total estimated DCV cost (2018/19) for the recommended works is $13.6M.

The primary investment driver for this project is Repex, addressing both asset safety and performance risks. A successful Non-Network Solution may be able to assist in reducing the scope required for the replacement project but will not be able to impact the project timing due to the aged equipment risk. As the cost of options considered as part of this report is greater than $6M this investment will be subject to RiT-D in 2019 as a mechanism for customer and market engagement on solutions, to explore this further.

### 1.3. Project Information

| | | | |
|---|---|---|---|
| **Work Request Description** | NI K N Douglas Shire Reinforcement | | |
| **Work Request Number** | 1273666 | **Target Capacity Available Date:** | 30/09/2021 |
| **Initiating Work Group** | NW PLANNING NORTHERN | **RWR/Scope Approver/Contact** | |
| **Business Owner** | | | |
| **Project Funding Source (A7 J1 code):** | D-Asset Replacement - Sub Transmission | **Ellipse Estimate No/s** | 185397 |
| **Strategic No:** | | **Direct Cost Value:** | $13.6 |
| **Forecast Version:** | | **RIT-D Required:** | Yes |

### 1.5. Document Tracking Details

| Network and Non-Network Document Hierarchy Reference Number | Regulatory Proposal Chapter Reference | Document | File Name |
|---|---|---|---|
| NET AUG - 011 | 7.085 | Planning Proposal – Mossman Reinforcement | EGX ERG 7.085 Planning Proposal - Mossman Reinforcement JAN19 PUBLIC |

# CONTENTS

## 2. BACKGROUND

Mossman 66/22 kV Substation was constructed in 1964 and supplies some 3250 customers in the surrounding Douglas Shire area of Mossman, Port Douglas and the Daintree.

Key customers supplied from the Mossman zone substation include the local hospital & ambulances, schools, aged care and retirement village, water and sewerage treatment plants, Mossman Sugar Mill, aquaculture farm, tourist resorts and Telstra towers. A part CARE (i.e. Cyclone Area Reliability Enhancement) project was undertaken in 2005 to fully underground 22kV supply to selected essential sites within the Mossman township but not back to MOSS substation. The CARE initiative was to improve post-cyclone recovery response and integrate with a Pegasus (i.e. LV diesel generator / 22 kV step-up unit) should the need arise.

The Mossman substation is supplied by two aged 66 kV timber pole lines from Powerlink's Turkinje 132/66 kV substation via Mossman 1 Feeder (MOSS 1) constructed in 1975 and Mossman 2 Feeder (MOSS 2) constructed in 1958, as seen in the single line diagram (refer Figure 1).

The substation configuration can be seen in the SCADA screen capture below (i.e. Figure 2) comprising two incoming 66 kV overhead feeders which supply the two outdoor 66 kV bus sections, four circuit breaker bays and isolators. The two 66/22 kV transformers supply two outdoor 22 kV bus sections, seven 22 kV CBs, a single station service transformer and thirteen isolators. Outgoing from the substation are four 22 kV feeders, which have intra-ties and inter-ties to the adjacent 132/22 kV Craiglie Substation 22 kV distribution network which supplies approx. 4280 customers.

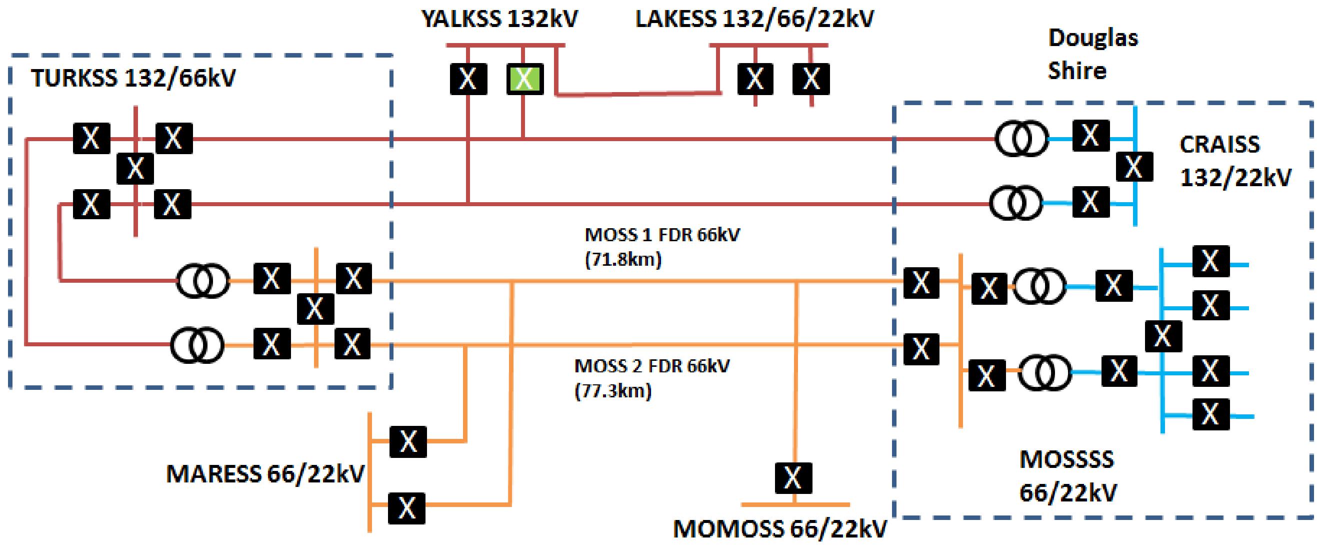



**Figure 1 – Single Line Diagram (SLD) of the existing Northern Tablelands 132 and 66 kV Network**

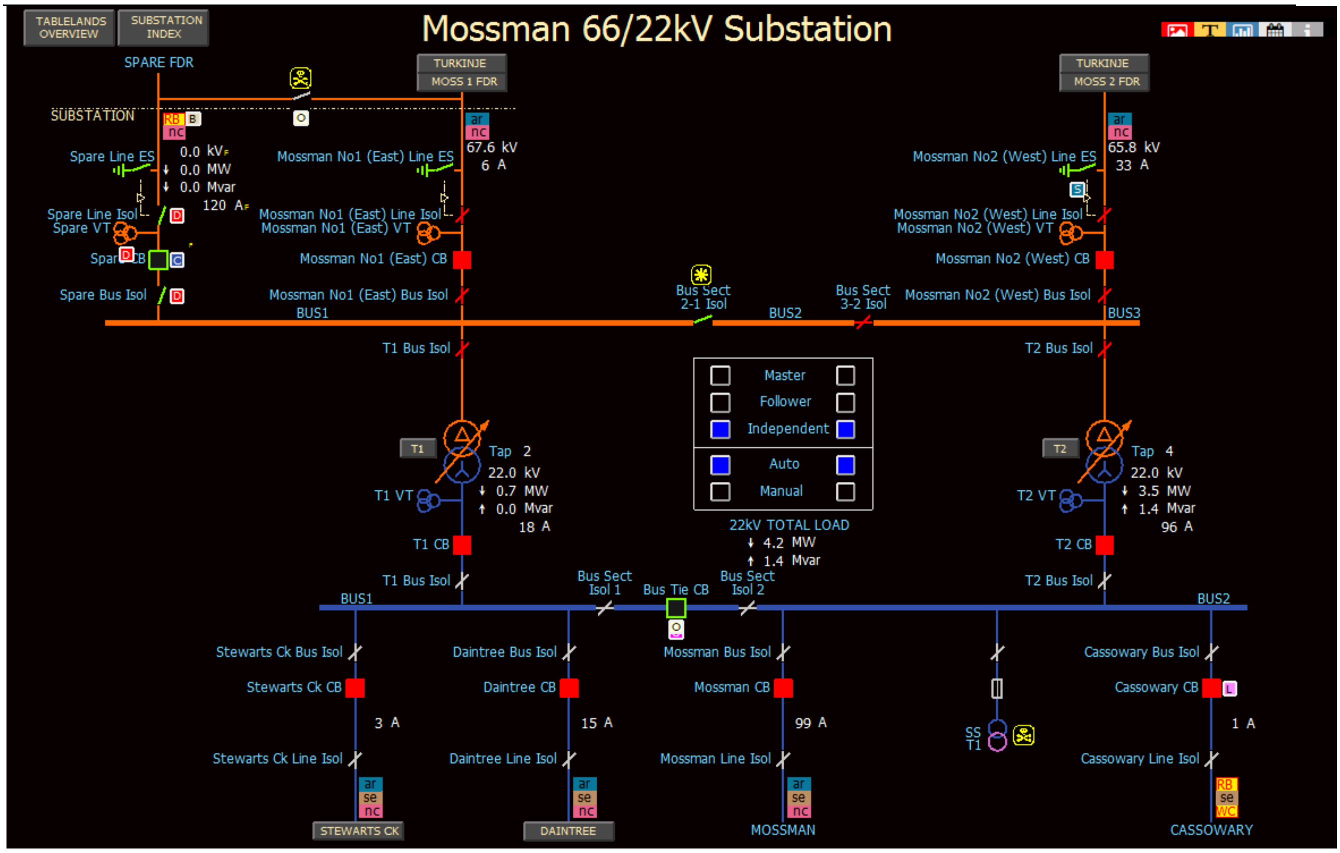



**Figure 2 - SCADA screen capture of MOSS single-line operating diagram**

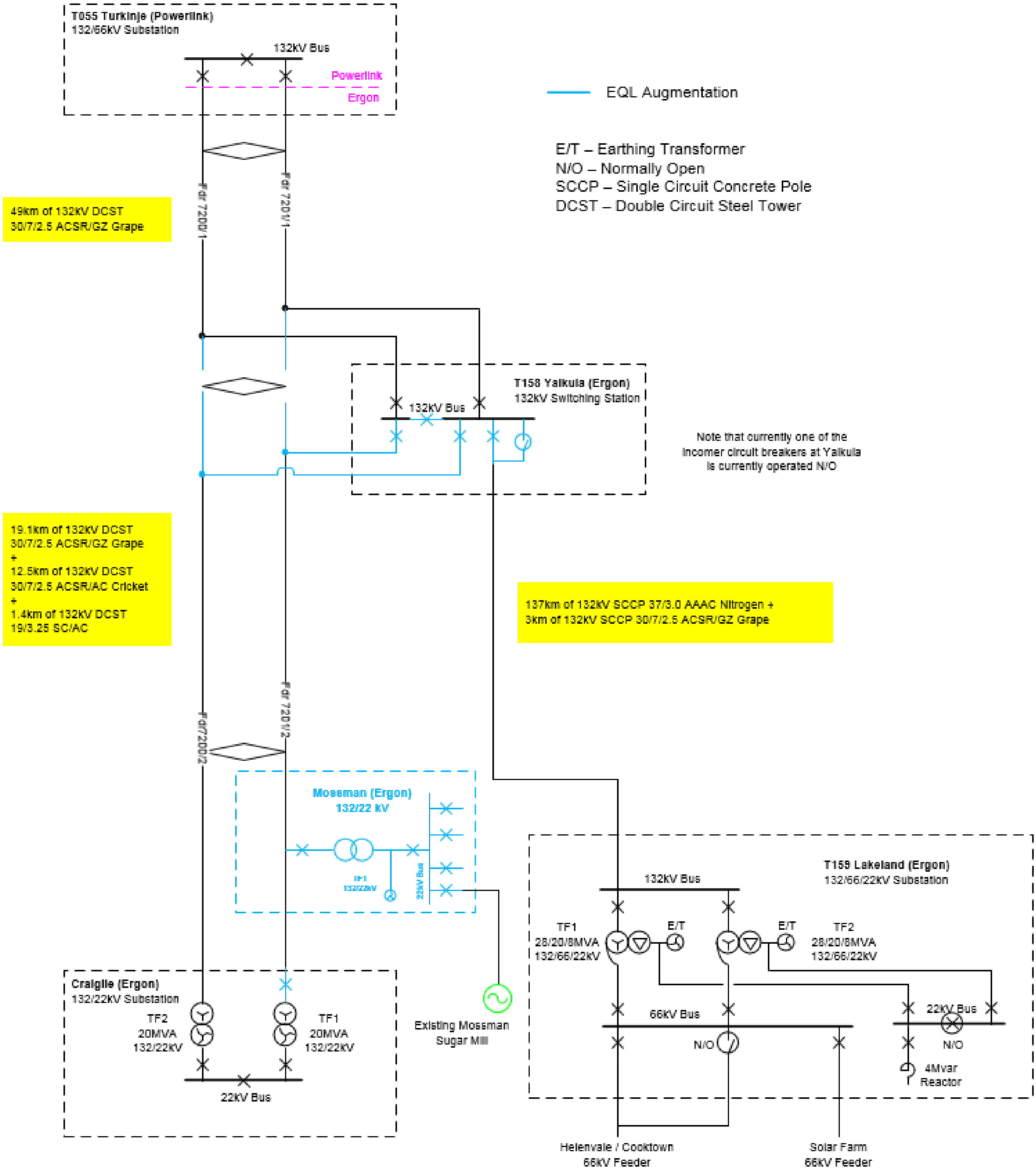



**Figure 3: Recommended Option A MOSS and YALK 132 kV network development**

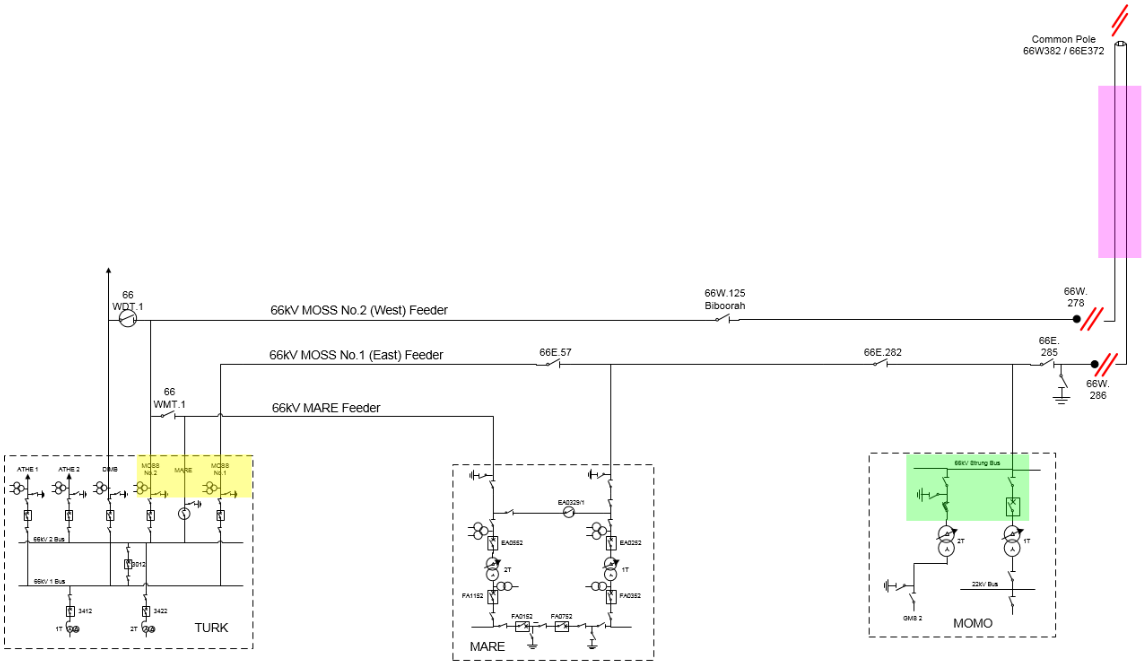



**Figure 4: Proposed TURK to MOSS 66 kV network development – post MOSS / YALK re-development**

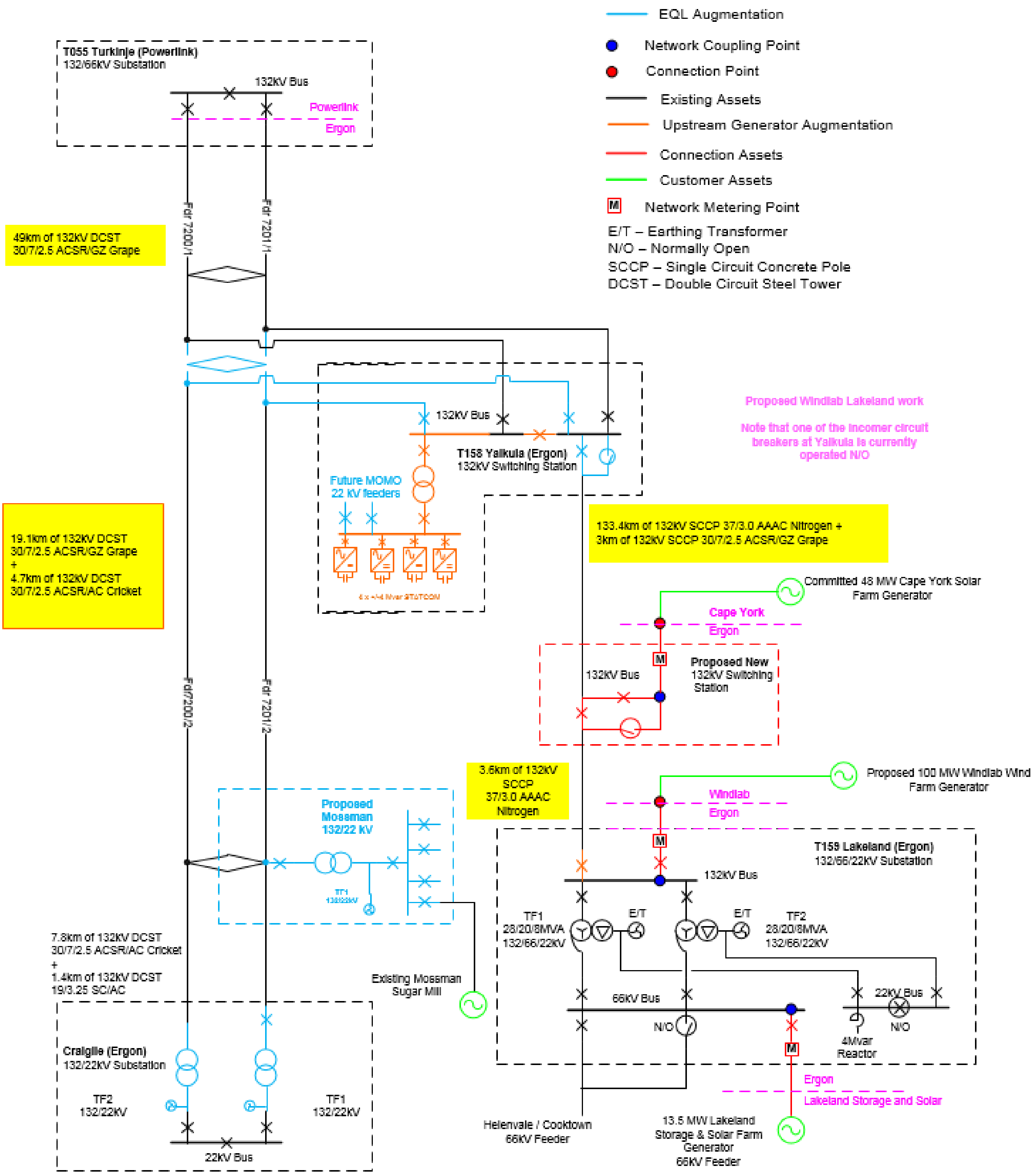



**Figure 5: Proposed TURK to MOSS 132 kV network development – post MOSS / YALK / TURK / Lakeland Generators**

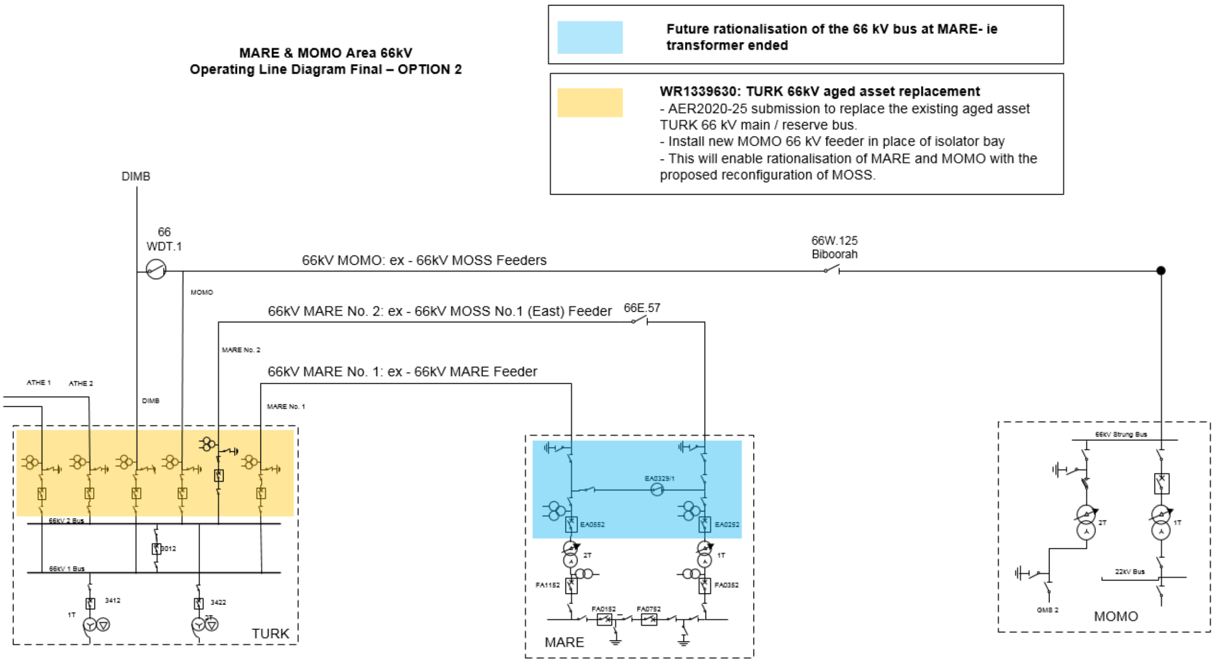



**Figure 6: Proposed TURK to MOSS 66 kV network development – post MOSS / YALK /TURK re-development (note that in future the MARE 66 kV switchyard will be rationalised)**

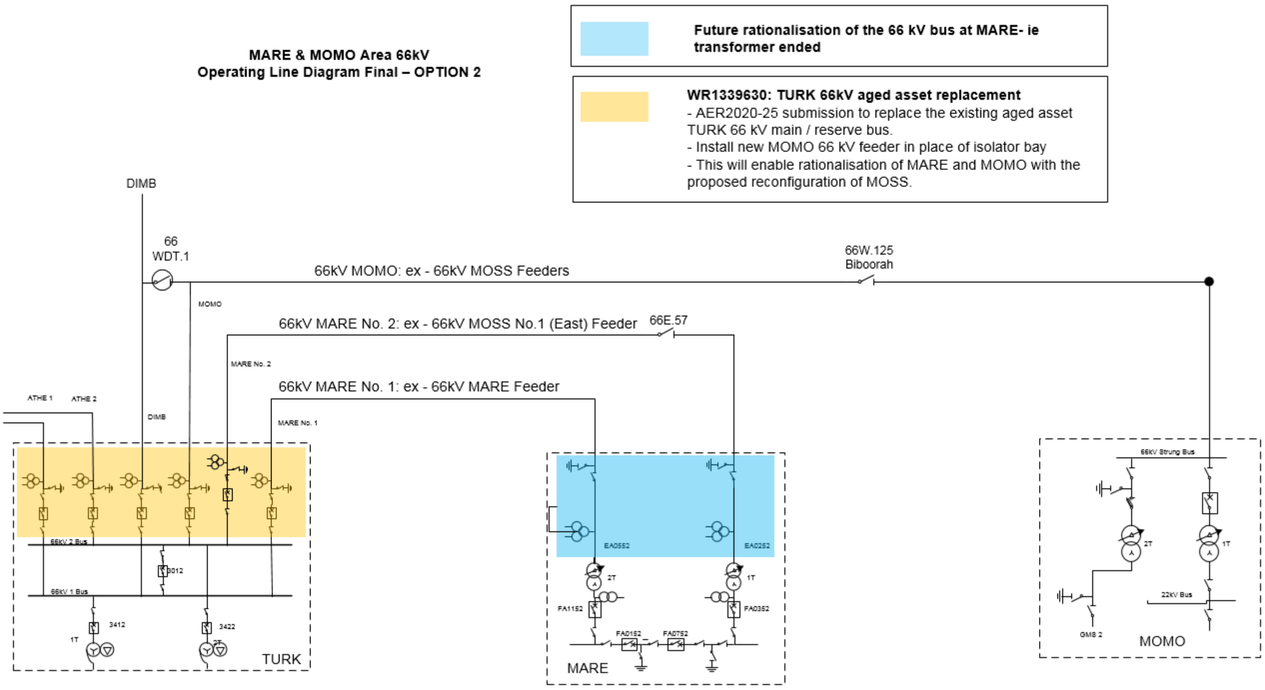



**Figure 7: Proposed TURK to MOSS 66 kV network development – post MOSS / YALK /TURK re-development and MARE 66 kV switchyard rationalisation**

## 2.1. Primary Project Driver

The primary driver for this project is Repex. A condition assessment project conducted on MOSS highlighted a number of aged and poor condition assets. These present significant safety, environmental, customer and business risks. These assets include 66 kV CBs, 66 kV isolators, 22 kV CBs, 22 kV VTs and the concrete control building which has spalling in the ceiling exposing fully corroded reinforcement. The age and location of the 66 kV feeders have also resulted in increased operational maintenance and capital cost.

## 2.2. Secondary Project Driver

There are a number of other issues in the supply area which the project aims to address:

- Safety of the staff and community, working on or living near these ageing assets as the approach end of life
- Poor reliability performance, largely due to sub-transmission network performance, is not meeting community expectations and the area has become a community hot spot issue after several major outages
- Environmental impacts of operating the existing 66kV lines in sensitive wet-tropics
- Strategic development of the 132 kV and 66 kV network is enabled by decisions surrounding the replacement of aged plant assets at MOSS and the associated upstream 66 kV lines to MOMO/TURK. Once the 66 kV is retired from MOSS, staged removal of the 66 kV lines back towards TURK / MARE can be progressed.

# 3. LIMITATIONS OF THE EXISTING NETWORK: (CONDITION BASED LIMITATIONS)

## 3.1. MOSS Substation Condition Assessment Report (SCAR)

The purpose of this report is to provide a condition assessment of the Mossman 66/22 kV Zone Substation and present recommendations on replacement and/or refurbishment of the substation including the incoming Mossman 66 kV feeders.

This report considers the condition of all the assets pertaining to the secondary system, communication systems, control building and both incoming 66 kV feeders.

The body of this report focuses on the assets planned for replacement or retirement in the next 20 years; the Appendix includes full substation CBRM details for all assets, DGA analysis, defects, feeder reports, etc.

MOSSSS Condition Assessment Report 1

Some of the key issues are discussed further below.

## 3.2. Safety and Environmental Consideration

There are currently safety concerns with the 66 kV EIB C/Bs at the site TF1 C/B and TF2 C/B. Network Access Restriction (NAR) 518 is in place to address this safety issue with a 25m RMHZ. The NAR was to be removed once acceptable maintenance and testing were completed, however, maintenance works on TF2 66 kV C/B were unsuccessful. At present, the C/Bs are bridged out, the 66 kV and 22 kV bus section is open and 66 kV protection is provided from the incoming 66 kV circuit breakers – this enables the NAR to be removed until a permanent decision is made on the network development proposed in this report. In the meantime, reliability of 22 kV supply to the MOSS 22 kV area will be adversely impacted.

The control room building concrete ceiling has been investigated and requires replacement which will be difficult as it also provides structural support to the walls. The full report can be found in the SCAR and embedded report above.


**Figure 8- Spalling of concrete ceiling exposing fully corroded reinforcement**

Concern also exists around the operating of the older 66 kV isolators, as they have signs of rust and corrosion and their mechanical strength is unknown. Similar corrosion has been found in many steel structures and attempted treatment was completed in 2016.

The existing transformers (YOM 1963) do not have bunding, as this was not required when constructed. These transformers are considerably wet (high levels of moisture in the insulating papers and/or oil) and have previously been leaking. As a result, this is considered a contaminated site. Given that it is also a very wet tropical location, there is a possibility of this contamination spreading to outside the site. Environmental assessment needs to be completed as a part of the future replacement of these transformers, and the new transformers will require adequate bunding.

Figure 9 - Oil from leaking Transformer with no bund

### 3.3. MOSS TF1 and TF2 transformer condition

| Concat Name | Asset ID | YOM | Age | Optimum year to replace | HI Yr 0 | HI @Y10 | HI when replaced |
|---|---|---|---|---|---|---|---|
| FN MOSS T1 - 10MVA WESTINGHOUSE (A3Q3982/1) | 000000672066 | 1963 | 54 | 2022 | 5.46 | 14.77 | 10.96 |
| FN MOSS T2 - 10MVA ENGLISH ELECTRIC (A3Q3982/2) | 000000672129 | 1963 | 54 | 2031 | 6.00 | 9.68 | 12.89 |

Table 1: MOSS 66/22 kV transformer asset information

CBRM indicates that transformer replacement for TF1 should be in the next 5 years (YOM 1963, proposed retirement age of 60 at the end of 5 years). Given that TF1 / TF2 are sister transformers and the DGA analysis indicates that the sister transformer should be replaced in a similar time frame, both TF1 and TF2 will require replacement within 5 years.

Both transformers are ranked in the top 20 priority replacement strategy across the state.

Over the past 5 years, several attempts have been made to repair leaks on the transformers and to dry out the transformer insulation using the Trojan online oil dry-out system which is rotated between MOSS, CRAI and MOGA.

The total cost of these corrective maintenance works on the transformers over the past 5 years is $57,570.

## 3.4. Primary Plant (Other)

**66 kV:**

**Circuit Breakers:**

Mossman has 5 x 66kV C/Bs ranging in ages from 15 to 36 years. Two are planned for replacement by 2030 and the 1981 EIB Sprecher C/Bs which are also currently affected by NAR518.

At present, the EIB Sprecher C/Bs are bridged out, the 66 kV and 22 kV bus section is open and 66 kV protection is provided from the incoming 66 kV C/Bs. This enables the NAR to be removed until a permanent decision is made on the network development proposed in this report. In the meantime, reliability of 22 kV supply to the MOSS 22 kV area will be adversely impacted.

**Current Transformers:**

CBRM analysis has identified that 12 of the15 single phase 66 kV Current Transformers will require replacement within the next 20 years. The 6 highlighted in light orange and light green in the SCAR are to be replaced as a part of WR1074599 - they are being replaced due to their age and known issues with this model of CTs as a part of a statewide replacement program. The WR1074599 MOSS replacement work will be placed on hold until a permanent decision is made on the network development proposed in this report.

**Voltage Transformers:**

CBRM analysis has identified that both 66 kV VT sets should have been replaced in 2016, one set being 53 years old and the other 45 years old. This is subject to works under WR1074599. The WR1074599 MOSS replacement work will be placed on hold until a permanent decision is made on the network development proposed in this report.

**22 kV Plant:**

**Circuit Breakers:**

Mossman has 7 x 22 kV C/Bs with 6 being 27 years old (1990 YOM) and the last C/B being 12 years old (YOM 2005). Two are planned for replacement in 2037, with a further 4 to be replaced the following year. There is no DGA for these C/Bs as samples have not been taken or ordered.



Ergon Energy Corporation Limited ABN 50 087 646 062
Energy Queensland Limited ABN 96 612 535 583
Energex Limited ABN 40 078 849 055

**Current Transformers:**

CBRM analysis has identified that none of the 21 single-phase 22kV CTs will require replacement within the next 20 years. Two sets (6 CTs) are 53 years old and the remaining 5 sets (15 CTs) are 29 years old. There is no DGA for these CTs as samples have not been taken or ordered.

**Voltage Transformers:**

CBRM analysis has identified that both 53 year old 22 kV VTs are to be replaced, one set in 2032 and the other in 2031. There is no DGA for these VTs as samples have not been taken or ordered.

## 3.5. Outside Bus, Structures, Insulators and Isolators

Of all the isolators onsite only one 22 kV has been identified for replacement in 2034. However, it would be unlikely that the remainder will remain operational until 2040 and would likely need replacement in the next 10-15 years along with most bus conductors and supports.

An allowance has been made for replacement of the steel lattice structures with concrete poles/landing beams in 2028/29 (i.e. at 65 years of age).

**Figure 10 – 22 kV feeders and structures**

**Figure 11 – 66 kV feeders, TF1 and structures**

## 3.6. Secondary Plant (i.e. Protection Relays)

The control system at Mossman has a planned upgrade of the Conitel protocol to DNP3, which has been included in the Protection Upgrade project WR1171858.

A number of the 66 kV relays (i.e. transformer differential and feeder X,Y protection) are proposed for replacement under WR1171858.

Until a permanent decision is made on the network development proposed in this report, WR1171858 will be placed on hold.

A number of auxiliary and 22 kV protection relays are yet to be replaced.

## 3.7. 66 kV Feeders (MOSS 1 and MOSS 2)

Although the supplying 66kV feeders are not considered substation assets, their condition and maintenance cost greatly impacts the site asset management plan and NPV costs.

The timber pole lines were constructed to a 1959 design standard that did not include an overhead earth wire. As such these two lines have relatively high exposure to and no shielding from lightning strikes. MOSS 1 and 2 timber pole lines are a build vintage of 1958 (i.e. 60 yrs age) and 1975 (43 yrs age) respectively.

The historical performance data indicates that the fault rate associated with lightning strikes on these two feeders is relatively high. Despite the redundancy provided in the sub transmission network that supplies the Mossman substation, the customers serviced by it have suffered 24 separate supply interruption events associated with faults occurring in the sub transmission feeders over the past 10 years. Causes of these 24 interruptions are; 6 due to lightning strikes, 5 were a result of animals, 8 other feeder faults, 4 due to upstream 132kV outages and 1 unknown cause.

The age of the substation (54 years) and 66 kV feeders has resulted in increased operational maintenance and capital cost. Over the last ten years total expenditure including overheads was:

| Element | OPEX | CAPEX | TOTAL |
|---|---|---|---|
| **Substation** | $ 1,904,429 | $ 130,337 | $ 1,382,781 |
| **66 kV Feeder** | $ 6,579,885 | $ 1,252,443 | $ 8,484,314 |
| **TOTAL** | $ 8,484,314 | $ 1,382,780 | $ 9,867,095 |

**Table 2: 10-year actual expenditure (MOSS and 66 kV lines)**

These expense elements are expected to increase with the aging of the assets unless replacement or refurbishment proceeds.

On average, over a 10 year period the annual expense for the 66 kV lines is:

- OPEX (excluding O/H based on 1.6 multiplier for DCV)- approx. DCV $411,000pa for both circuits from TURK-MOSS;
- A similar calculation was undertaken for lines CAPEX (i.e. approx. DCV $78,000pa).

Substation and feeder costs for the NPV calculations were based on the last 5 years of CAPEX/OPEX costs but in the subsequent post 2021 cycle, the feeder costs were based on the significant C3 defects forecast and SCAR / CBRM assessments.

Over the last five years total expenditure for the substation costs being $1,368,436 OPEX and $141,858 CAPEX and the feeder costs being $ 1,235,000 OPEX and $158,000 CAPEX.

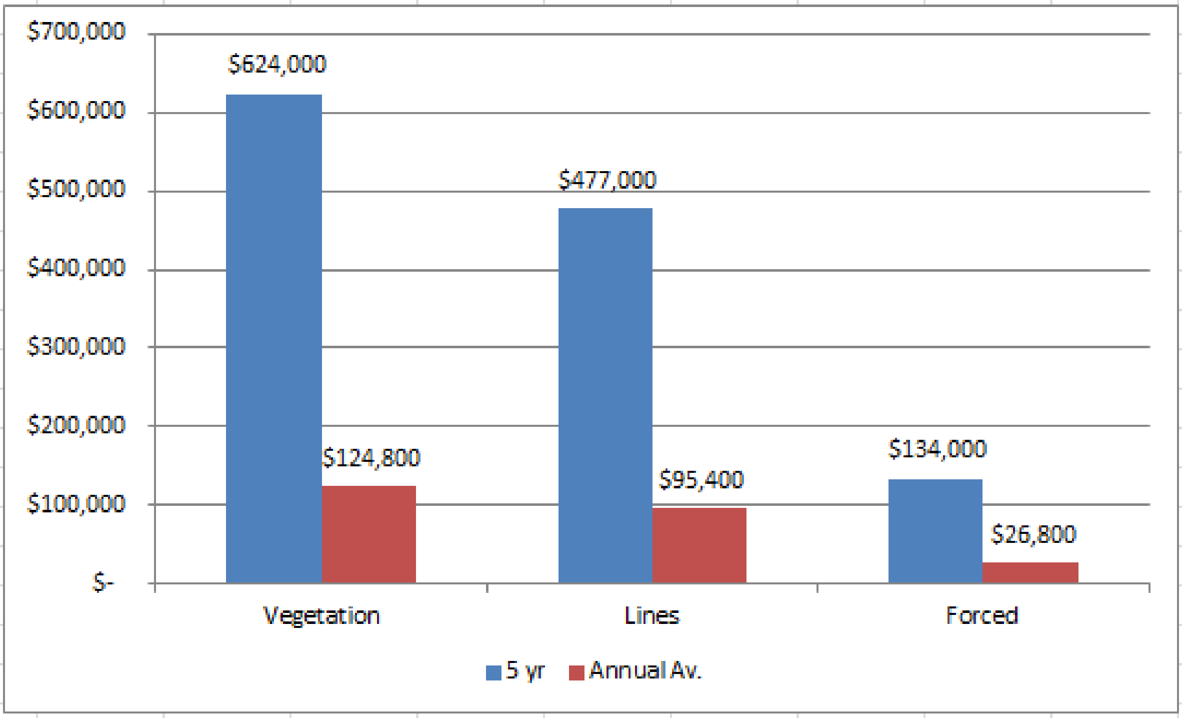
On average, over the past 5 year period the annual expense for the MOSS substation was:

- $1,368,436: OPEX (excluding O/H based on 1.6 multiplier for DCV)- approx. DCV $171,055pa; and
- $141,858: A similar calculation was undertaken for CAPEX (i.e. approx. DCV $17,732pa).

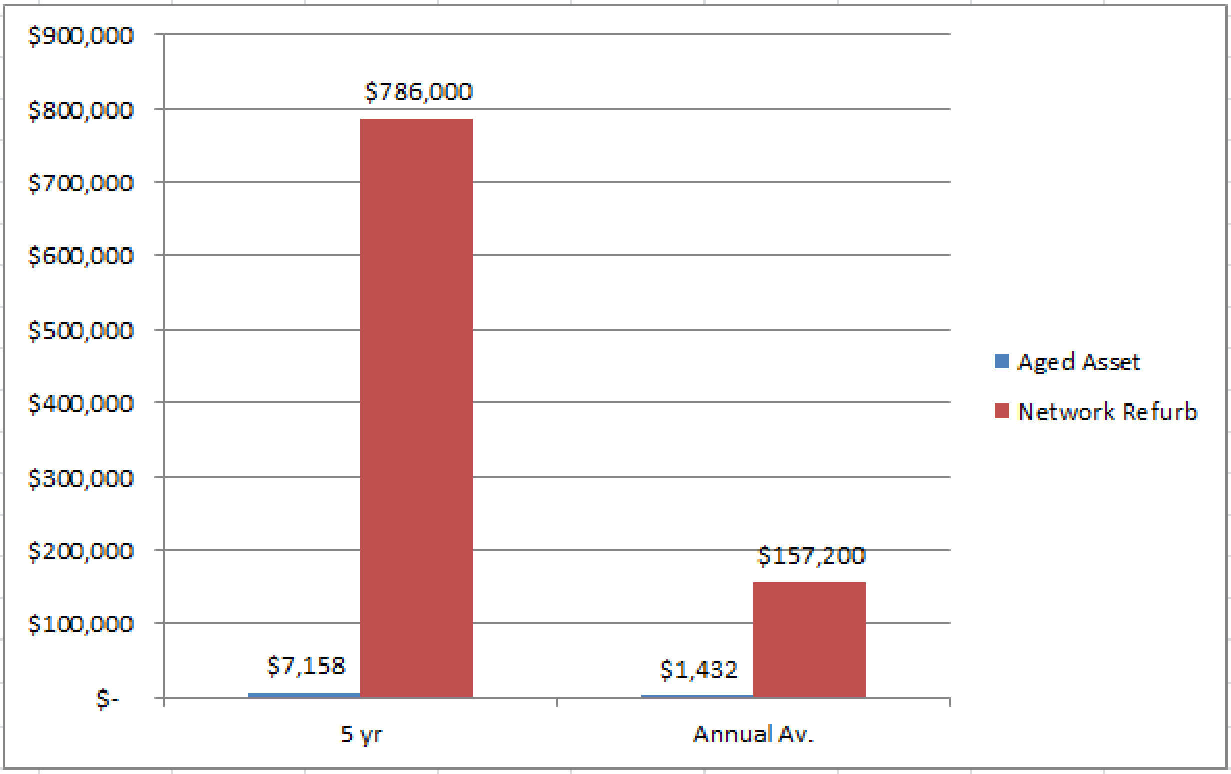
On average, over past 5 year period, the annual expense for the 66 kV lines was:

- $1,235,000: OPEX (excluding O/H based on 1.6 multiplier for DCV)- approx. DCV $154,375pa for both circuits from TURK-MOSS; and
- Approx. $790,000: A similar calculation was undertaken for lines CAPEX (i.e. approx. DCV $98,750pa)

These expense elements are expected to increase with the aging of the assets unless replacement or refurbishment proceeds.




**Plot 1: OPEX AP costs for 66 kV lines MOSS 1 (FD-6111) / MOSS 2 (FD-6112) – past 5 years**




**Plot 2: CAPEX AP costs for 66 kV lines MOSS 1 (FD-6111) / MOSS 2 (FD-6112) – past 5 years**

*Note:

- Asset hierarchy names have changed over the years, so some OPEX cost will not have been captured.
- 4 years ago, capital projects were not linked to equipment, so further costs were not captured
- Cyclone Larry and Yasi cost occurred but did not have a great effect on the MOSS substation or 66 kV feeders.

3MO1_3MO2 maint costs from 28112011

In order to validate that 66 kV line expenses from the past 5/10 years that could be expected over the next inspection and maintenance periods, an assessment of the P1/P2/C3 defect remediation and vegetation/access track maintenance program was examined.

OPEX Corrective work orders have been raised for:

- Vegetation: VZ-1005053 for both feeders (MOSS 1 & 2):
    - actual cost of $132,000 (Feb. 2018);
    - 2 year cycle budget of $138,000 (Feb. 2020).
    - this translates to an annual cost of $69,000pa;
- Access tracks: MZ-0003084 (MOSS 1 cost), MZ-0003158 (MOSS 2 cost yet to be raised)
    - actual cost of $35,000 (May. 2018) each;
    - this translates to an annual cost of $70,000pa for both.

Actual historical AP OPEX costs for these elements have been approx. $124,800pa vs the next 2 year cycle cost of $139,000pa.

P1/P2/C3 defects are recorded in the 4-year cycle and defined as:

- P1: Serious deterioration or damage, which requires some specific action or indicates an unacceptable risk of failure in the short term or presents an imminent danger or risk of asset failure;
- P2: Moderate deterioration or damage, which requires some specific action or indicates an unacceptable risk to safety, environment, operations, or reliability in the medium term; and
- C3: Minor deterioration or damage which requires no specific action or does not indicate an unacceptable risk of failure in the medium term.

The next cycle (i.e. MZ-0003084, MZ-0003158) for above/below ground inspections is due in 2021 when a major number of C3 poles, crossarms and stays are anticipated for replacement.

| Defect classification | Mossman 1 total number of defects | Mossman 1 number of defects in section of line to be recovered | Mossman 2 total number of defect | Mossman 2 number of defects in section of line to be recovered |
|---|---|---|---|---|
| P1 | 8 | 5 | 35 | 12 |
| P2 | 73 | 40 | 256 | 117 |
| C3 | 1395 | 796 | 1321 | 645 |
| **Total** | **1476** | **841** | **1612** | **774** |

**Table 3: MOSS 1 and MOSS 2, 4-year inspection cycle repair requirements**

As can be seen from the asset inspection outcomes, the section from MOMO to MOSS which is less than a third of the line, contributes 40-50% of the number of maintenance issues of the entire line. This is entirely different when compared to the cost split which reflects higher costs in the MOMO to MOSS section (see below).

*Please note, these inspections do not assess the overhead line conductor (ie 35 year old sections of 7/0.104 HDBC) which still remains the build age of the line.*

| MOSS 1: FD-6111 (forecast DCV costs) | | |
|---|---|---|
| | **TURK to MOSS** | **MOMO to MOSS** |
| **P1 only:** | $19,052.00 | $18,545.00 |
| **P2 only:** | $86,437.00 | $44,854.00 |
| **C3 only:** | $4,609,878.00 | $3,076,935.00 |
| **All works:** | $4,715,368.00 | $3,140,335.00 |

| MOSS 2: FD-6112 (forecast DCV costs) | | |
|---|---|---|
| | **TURK to MOSS** | **MOMO to MOSS** |
| **P1 only:** | $166,790.00 | $68,688.00 |
| **P2 only:** | $278,392.00 | $70,824.00 |
| **C3 only:** | $4,026,278.00 | $2,072,680.00 |
| **All works:** | $4,471,461.00 | $2,213,712.00 |

**Table 4: MOSS 1 and MOSS 2 forecast C3 REPEX DCV CAPEX costs**

The next cycle (i.e. MZ-0003084, MZ-0003158) for above/below ground inspections is due in 2021 when a major number of C3 poles are anticipated for replacement based on reporting from this most current cycle. This would be considered reflective of end of life of the existing aged asset and represents high-cost items such as poles, crossarms and stays.

As can be seen, nearly 60% of the C3 major costs (i.e. typically pole, stay and crossarm replacements) can be attributed to the higher cost area between MOMO and MOSS.

Based on a 15-year average, post-2021, these assets will require annual replacement which is reflective of the past 10-year average OPEX costs. If the plant is not replaced on a planned CAPEX basis, this will result in increased OPEX.

On average, over a 15 year period, the annual forecast C3 spend for the 66 kV lines is forecast as:

- TURK - MOSS:
  - $8.636M OPEX - approx. DCV $575,733pa for both circuits;
- MOSS - MOMO:
  - $5.150M OPEX - approx. DCV $343,000pa for both circuits;
- MOMO - TURK:
  - $3.486M OPEX - approx. DCV $232,000pa for both circuits;

As such, the NPV estimates, when allowing for P1/P2/C3 TURK-MOMO-MOSS amounts to:

- MOMO to MOSS: $343,000pa; and
- TURK to MOMO: $232,000pa.

Compared to the existing historical DCV CAPEX spend of $78,000 and $98,750pa respectively, this represents a significant escalation of cost which is anticipated for both aged feeders, however, the significant offset is the OPEX cost if the asset is not replaced during the CAPEX cycle.

*Whilst pole nailing and detailed aerial inspections will aim to prolong asset age, the C3 forecast costs are more reflective of the past 10-year average.*

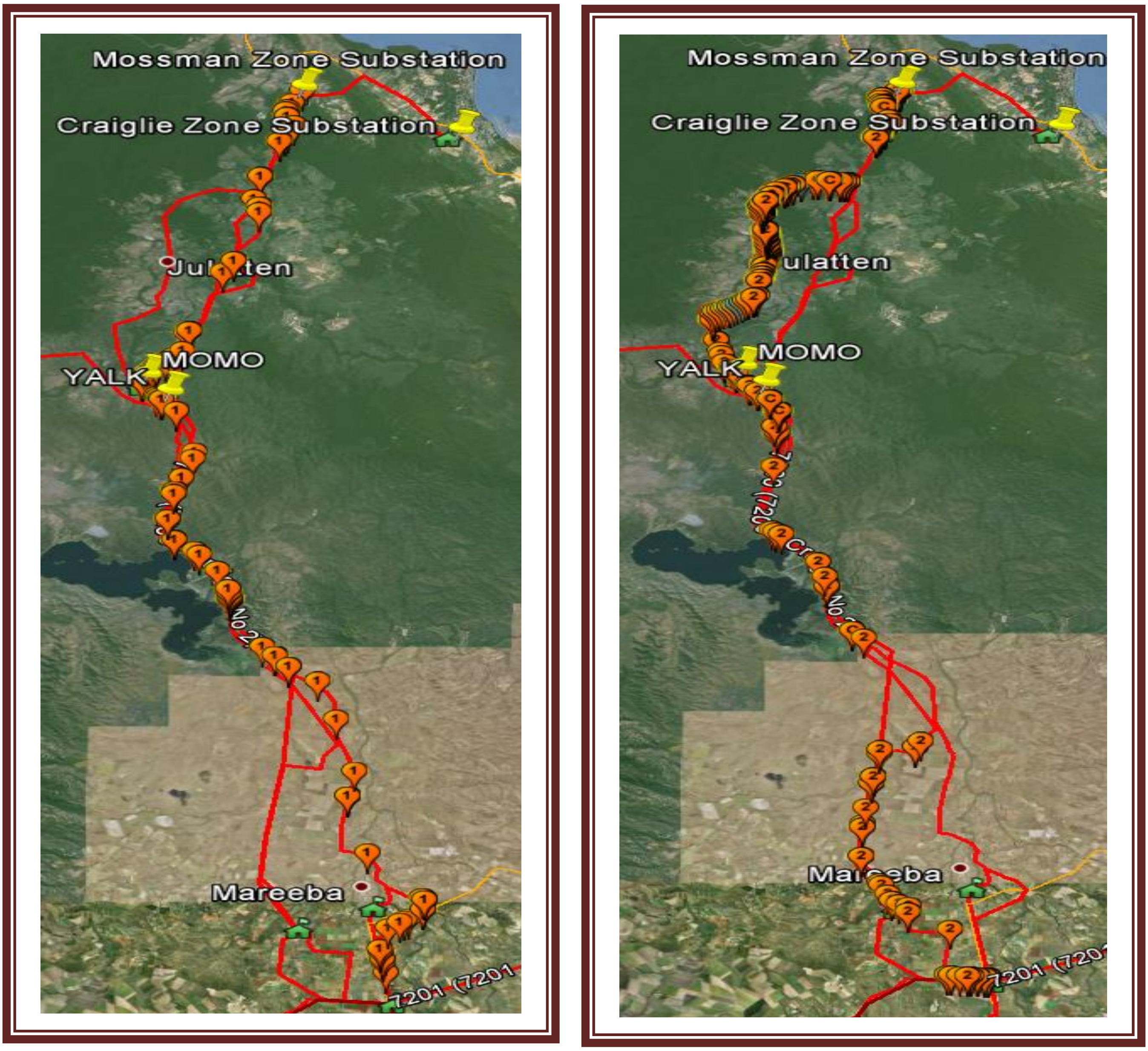



**Figure 12 – MOSS 1 FD-6111 P1/P2 poles / MOSS 2 FD-6112 P1/P2 poles for current inspection cycle**

A significant cost is attributed to the repair and maintenance of these lines particularly the area between MOMO and MOSS that crosses the Rex Range and Wet Tropics Area.

The Original 66 kV Mossman feeder was constructed in 1958 from the Turkinje Zone Substation at Mareeba to supply the newly constructed Mossman Zone Substation. Design typically involved two crossarms and suspension disc construction.

In 1975 as part of Augmentation works for Mossman Zone Substation a second 66 kV feeder was constructed. It was not possible at the time to build a completely separate feeder on a completely new alignment. The new sections of the feeders were of a delta construction using 3 piece pin insulators on steel cross-arms using 6/.186+7/.062 ACSR/GZ Dog conductor.

In the early 1990’s when Port Douglas started to boom, the design rating of the 7/0.104 HDBC conductor due to ground clearance issues was augmented. On identified poles the 66kV suspension construction was converted using a 22 kV pole bracket, 22 kV pin and a second hand 66 kV 3 piece insulator to provide an 1.5m ground clearance.

The remaining 7/0.104 HDBC conductor on the Mossman 66 kV feeders is approximately 55 years of age and has been subject to a large number of faults during its life as well as being pushed to its full current rating during the Port Douglas boom in the 1990’s prior to construction of the Craiglie Zone Sub and feeders. The conductors are full of line splices and are annealed affecting their mechanical strength.

Records show that there is approximately 35 km of the original 1958 vintage feeder with 7/0.104 HDBC conductor remaining on the 2 Mossman 66 kV feeders.

The line length from TURK to MOSS is approx. 80km

**Figure 13: Various 66 kV design constructions**

**Figure 14: 132 kV and 66 kV across the Rex Range**

## 3.8. CRAI TF1 and TF2 Transformer Condition

| Concat Name | Ellipse ID | YOM | Age | Optimum year to replace | Hi Yr 0 | Hi Yr 10 | HI when replaced | Comments |
|---|---|---|---|---|---|---|---|---|
| FN CRAI T02 - TR92897804 1967 132/22 kV 20MVA ENGLISH ELECTRIC (A3T6658/2) | 000000672261 | 1967 | 51 | 2032 | 5.8 | 9 | | Nov17 - Priority Rank 14 - Age 50 in 2017, Location Factor driving earlier replacement Srini: 50 years old, DGA normal, only factor is location which is very close to coast (2km). Candidate for deferral if smoothing required |
| FN CRAI T01 - TR92896167 1967 132/22 kV 20MVA ENGLISH ELECTRIC (A3T6658/1) | 000000672296 | 1967 | 51 | 2032 | 5.5 | 8 | | Nov17 - Priority Rank 14 - Age 50 in 2017, Location Factor driving earlier replacement Srini: 50 years old, DGA normal, only factor is location which is very close to coast (2km). Candidate for deferral if smoothing required |

**Table 5: CRAI 132/22 kV transformer asset information**

Whilst the transformers are ranked in the top 20 priority replacement strategy across the state, they are both candidates for deferral with replacement deferred from the 2020-25 AER period to just beyond 2025.

CBRM indicates that TX replacement should be in the next 5 years (i.e. YOM 1967), however with a proposed retirement post 2025, the plant age will be 58+ and respective NPV modelling will take age, condition and risk into account.

Over the past 5 years, several attempts have been made to repair leaks on the transformers and to dry out the transformer insulation using the Trojan online oil dry-out system which is rotated between MOSS, CRAI and MOGA. Considering the proposed deferral, the Trojan dry out program will continue.

Both Craiglie transformers were relocated from Powerlink Queensland's Innisfail substation in 1997 and purchased on the same technical specification and order.

These transformers have been exposed to harsh climatic conditions in Innisfail and Craiglie, mainly comprising of excessive moisture levels which raises questions regarding their effectiveness/performance at higher loading levels.

Should both the CRAI and MOSS load be consolidated onto a single substation as proposed in Option C, one of the CRAI transformers should be replaced for security purposes as soon as possible and the 2$^{nd}$ transformer replacement deferred to 2025/26 (i.e. 58 yr age).

In Option A, given there is some security available from the new MOSS single transformer, the CRAI transformers are proposed for replacement in 2025/26 (i.e. 58 yrs of age) and 2031/32 (i.e. 64 yr of age) replacement.

It should also be kept in mind that the molecular sieve and trojan oil dry-out remediation can distort the test results. Given that the trojan online oil dry-out is regularly rotated on these transformers, an accurate assessment can be difficult.

000144426
A3T6658-1 RED FN C

000144427
A3T6658-2 RED FN C

# 4. LIMITATIONS ON THE EXISTING NETWORK: (NETWORK PLANNING & DEVELOPMENT)

## 4.1. Substation Limitations

**MOSS:**

The Mossman zone substation comprises:

- two transformers, 66/22 kV Dyn11 10MVA OLTC; and
- outdoor 22 kV switchgear c/w four 22 kV feeders and a bus section breaker.

The transformer technical characteristics are:

- 2.5% buck, 17.5% boost;
- iron losses of 16.4 kW and 16.3 kW; and
- impedance of 9.18% and 9.02% respectively on a 10 MVA base.

| SCAMS | Sub | Region | Tx No | Rating | Highest Rating | Voltage | Winding being | HRT Test | Cooling | Nominal NC | | Nominal LTEC | | Operational NC | | Operational LTEC | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plant Number | Code | Region | Tx No | MVA | MVA | kV | rated (kV) | MVA | Cooling | Summer (MVA) | Winter (MVA) | Summer (MVA) | Winter (MVA) | Summer (MVA) | Winter (MVA) | Summer (MVA) | Winter (MVA) |
| TR92926358 | MOSSSS | FN | 1 | 10 | 10 | 66/22 | 22 | 10.00 | ONAN | 9.9 | 11.8 | 11.9 | 13.0 | 9.3 | 10.3 | 9.3 | 10.3 |
| TR92772128 | MOSSSS | FN | 2 | 10 | 10 | 66/22 | 22 | 10.00 | ONAN | 9.9 | 11.8 | 12.0 | 13.0 | 9.3 | 10.3 | 9.3 | 10.3 |

**Table 6: MOSS 66/22 kV transformer rating details**

The 2028 forecast peak demand of 7.8 MVA (i.e. refer Appendix A);

**In summary, transformer:**

- **capacity is not a constraint; whilst**
- **buck range is a constraint in managing to the new 230 V LV standard.**

**CRAI:**

The Craiglie zone substation comprises:

- two transformers, 132/22 kV Yz11 15/20 MVA OLTC ex-Innisfail substation units;
- indoor 2000A, 16 kA for 1 sec. switchgear c/w:
  - eight 22 kV feeders (3 spares- one spare will require truck repairs and the spare will require new relays which have been used for replacement repairs of others);
  - two transformer and bus section circuit breakers;
- 132 kV busbar rated at 1250A, 31.5 kA for 1 sec.;

The transformer technical characteristics are:

- 2.5% buck, 17.5% boost;
- Iron losses of 26.4 kW and 25.7 kW; and
- Impedance of 10.2% and 10.14% respectively on a 20 MVA base.

| SCAMS | Sub | Region | Tx No | Rating | Highest Rating | Voltage | Winding being | HRT Test | Cooling | Nominal NC | | Nominal LTEC | | Operational NC | | Operational LTEC | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plant Number | Code | Region | Tx No | MVA | MVA | kV | rated (kV) | MVA | Cooling | Summer (MVA) | Winter (MVA) | Summer (MVA) | Winter (MVA) | Summer (MVA) | Winter (MVA) | Summer (MVA) | Winter (MVA) |
| TR92896167 | CRAISS | FN | 1 | 15/20 | 20 | 132/22 | 22 | 20.00 | OB | 23.5 | 26.7 | 27.6 | 29.8 | 23.5 | 26.7 | 27.6 | 29.8 |
| TR92897804 | CRAISS | FN | 2 | 15/20 | 20 | 132/22 | 22 | 20.00 | OB | 23.5 | 26.7 | 27.6 | 29.8 | 23.5 | 26.7 | 27.6 | 29.8 |

**Table 7: CRAI 66/22 kV transformer rating details**

The 2028 forecast peak demand of 17.3 MVA (i.e. refer Appendix A);

**In summary, transformer:**

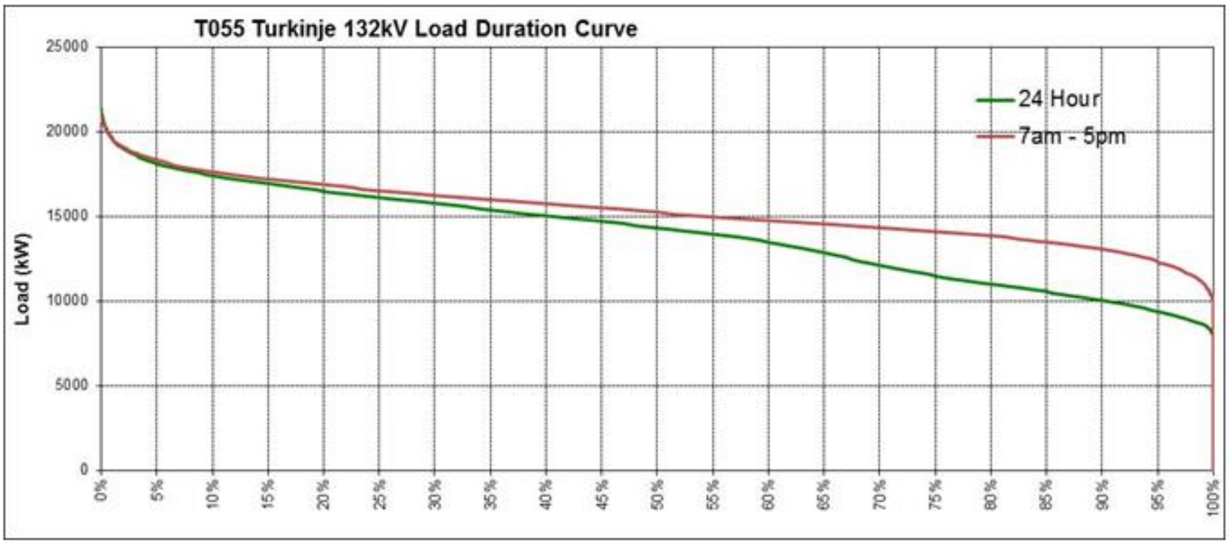
- **capacity is not a constraint; whilst**
- **buck range is a constraint in managing to the new 230 V LV standard.**

## 4.2. Sub-Transmission Network Limitation

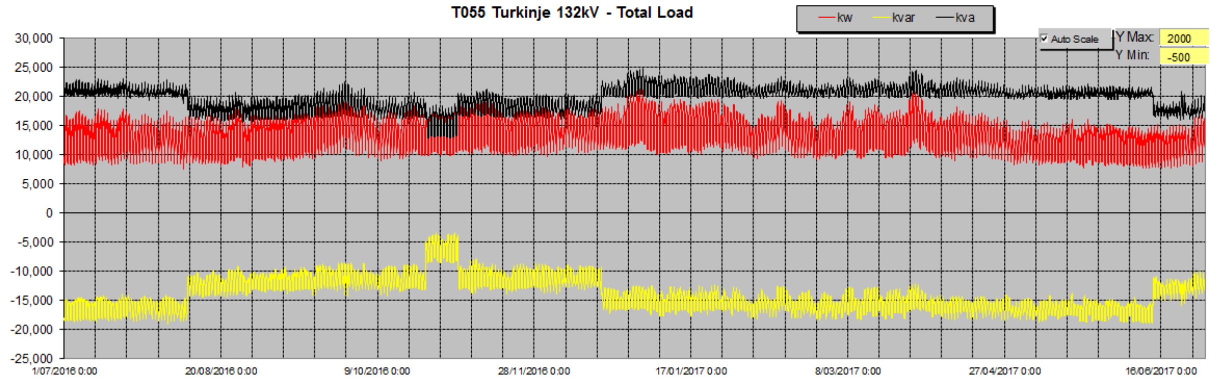
**Line Rating**

| Description | Value | Summer Day 9am-5pm | Summer Evening 5pm-10pm | Summer Night/Morning 10pm-9am | Winter Day 9am-5pm | Winter Evening 5pm-10pm | Winter Night/Morning 10pm-9am |
|---|---|---|---|---|---|---|---|
| Turkinje-Craiglie 132 kV Feeder #1 (Turkinje-Yalkula Section) | Rating (A) | 452 | 476 | 427 | 502 | 483 | 443 |
| Turkinje-Craiglie (132 kV) Feeder #1 (Yalkula-Craiglie Section) | Rating (A) | 379 | 370 | 322 | 395 | 359 | 329 |
| Turkinje-Craiglie 132 kV Feeder #2 (Turkinje-Yalkula Section) | Rating (A) | 452 | 476 | 427 | 502 | 483 | 443 |
| Turkinje-Craiglie 132 kV Feeder #2 (Yalkula-Craiglie Section) | Rating (A) | 379 | 370 | 322 | 395 | 359 | 329 |
| Yalkula-Lakeland 132 kV Feeder | Rating (A) | 468 | 523 | 480 | 539 | 539 | 494 |

**Table 8: Static Thermal Line rating of the Turkinje to Craiglie and Yalkula to Lakeland 132kV feeders**




**Plot 3: T055 Turkinje Substation 132kV load duration curve for the period Jan 2016 to Apr 2017**




**Plot 4: T055 Turkinje Substation 132kV load (2016/17)**

From Table 8, Plots 3 and 4 above, the thermal ratings of the 132 kV feeders supplying Craiglie and Lakeland area will not be constrained under system load conditions.

Generator impacts are assessed in separate planning reports, however full generator exports from the combined renewable generators capability will cause line constraints and dispatch constraint which is subject to separate generator connection reports.

**Additional Load or Generation from MOSS:**

The co-incident additional load on the 132 kV circuits from MOSS zone substation is approx. 7 MVA which will not cause adverse impacts.

The Mossman Sugar Mill presently uses low-pressure gas steam turbines which limits the export capability of the bagasse fired turbine and generators. Similar to other sites (i.e. Tableland Sugar Mill, Tully Sugar Mill and South Johnstone / Mulgrave Sugar Mills) high-pressure gas steam turbines are being installed/proposed to better utilise steam production and efficiency of export generation. This would typically mean an export increase of approx. 10 -15 MW (e.g. when compared to Tableland Mill and Tully Mill), however, if 22 kV supply was provided from CRAI and the 22 kV from MOSS was retired, the cost to extend 22 kV supply from the CRAI bus would be prohibitively expensive. At an export level of 15 MW, a high capacity 22 kV double circuit feeder from MOSS would be an option that would enable such an expansion without the cost of extending 132 kV to the Mossman Sugar Mill approx. 7 route-km away adjacent the Mossman township.

Mossman Sugar Mill presently has an import demand of 1.8 MW along with an export demand of 4.0 MW which is seldom achieved.

**Additional Generation from the Lakeland Area (i.e. Cape York Solar Farm and Future Generators).**

**Cape York Solar Farm (WR1138785):**

Planning studies suggest that the loading on the Turkinje – Craiglie 132 kV feeders and the Yalkula – Lakeland 132 kV feeder are not expected to exceed the thermal ratings for exports up to 80 MW from the proposed Solar Farm for the selected loading conditions. Noting that Cape York Solar is most likely to proceed but at a reduced export from 80 MW previously enquired upon to 48 MW presently agreed upon to circumvent installation of a STATCOM at YALK which future generators may have to install if higher export is desired.

The initial Cape York Solar farm studies suggest that the steady state voltages are expected to be within acceptable limits for exports up to 80 MW from the proposed Solar Farm for the selected loading conditions.

Note that in the plots negative MVAr's refer to the absorption of reactive power (i.e. inductive) and the positive MVAr's refer to the supply of reactive power (i.e. capacitive).

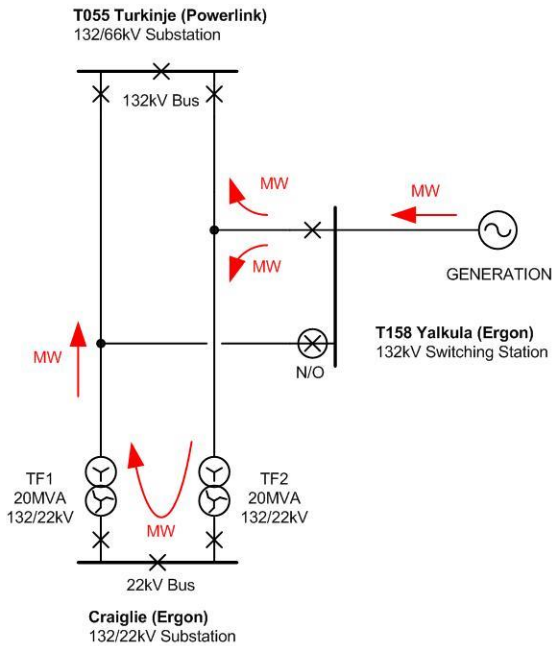



**Figure 15: Sketch of the Lakeland 132 kV network showing the case of reverse power flows through one of the Craiglie Substation 132/22 kV transformers**

With the existing network configuration with one of the 132 kV incomers at Yalkula switching station operated normally open (i.e. current state) the connection of generation to the Lakeland 132kV feeder will alter the power flows through the Craiglie Substation 132/22 kV transformers.

The Craiglie Substation 132/22 kV 15/20 MVA transformers each have a normal cyclic summer rating of around 23 MVA.

Note that the automatic voltage regulation for the Craiglie Substation 132/22 kV transformers is currently set up in a master follower arrangement.

| | **Summer Day Light Load (PV Farm Offline)** | **Summer Day Light Load (PV Farm 80 MW export)** | **Winter Day Light Load (PV Farm Offline)** | **Winter Day Light Load (PV Farm 80 MW export)** |
|---|---|---|---|---|
| **Craiglie TF1 MW** | 4.42 | *-2.78* | 3.47 | *-3.79* |
| **Craiglie TF2 MW** | 5.82 | 13.04 | 4.96 | 12.25 |

**Table 9: Estimated steady state power flows through the Craiglie Substation 132/22 kV transformers (Light Load conditions)**

| | Summary Day Peak Load (PV Farm Offline) | Summer Day Peak Load (PV Farm 80 MW export) | Winter Day Peak Load (PV Farm Offline) | Winter Day Peak Load (PV Farm 80 MW export) |
|---|---|---|---|---|
| **Craiglie TF1 MW** | 8.45 | 1.48 | 7.23 | 0.16 |
| **Craiglie TF2 MW** | 9.25 | 16.24 | 8.26 | 15.35 |

**Table 10 Estimated steady state power flows through the CRAI 132/22 kV TFers (Peak Load conditions)**

The tables above show the estimated power flows through the Craiglie Substation 132/22 kV transformers for each of the network loading conditions.

The studies show that:

- the loading on the transformers will become unbalanced when the proposed generator is exporting up to 80 MW; and
- during light load conditions there are expected to be reverse power flows through one of the Craiglie Substation 132/22 kV transformers.

**Proposed Windlab Wind Farm (WR926741):**

Should the proposed Windlab Lakeland Wind Farm resolve present equity funding issues and proceed, a 132 V bus section circuit breaker and STATCOM will be installed at YALK with the existing state N/O 132 kV circuit breaker operated in a closed state resulting in balanced power flows to CRAI. As part of the Windlab project, a new 132 kV bus section bay and extension of the existing yard to the south was proposed (see Appendix F).

Windlab presently has equity funding risks that will now need to take account of full impact system strength assessment requirements under the NER generator performance stability analysis. The project is presently on hold until new funding arrangements are secured. If Windlab does not proceed, any future generation connections will also need to take account of full impact system strength assessment requirements which, under the current system arrangement at YALK, leads to additional costs and is, therefore, a hindrance to generator connection.

Under the MOSS project, it is proposed that the YALK bus be developed (i.e. add 2 x 132 kV feeder bays, 1 x 132 kV bus section bay, part LAKE circuit 7285 feeder bay and a bypass ABS for LAKE) and configured with two incoming switched feeder C/Bs from TURK, three outgoing switched feeder C/Bs (i.e. two to CRAI/MOSS, one to LAKE) including a 132 kV bus section C/B. This is to allow MOSS to be connected as a tee sub from the 132 kV network.

This proposed arrangement will result in balanced power flows, simplify the voltage management strategy at CRAI, resolve protection scheme constraints and result in a YALK general arrangement that will enable the existing and northern yard area to be used whereas presently an additional land purchase and site development to the south is required. The proposed works will, therefore, lead to savings when future generation connections seek connection to the 132 kV network.

As an example, the estimated cost of the substation extension and funding would have a minimum saving of a 132 kV bus section bay (i.e. DCV cost of $1.082M) and proposed extension costs to the south of the existing yard including property survey and purchase, roadworks, yard and fence extension (i.e. DCV cost of approx. $0.1M).

**132 kV Protection:**

The T55 Turkinje – Craiglie - tee – T158 Yalkula feeders (7200 and 7201) are each protected by dual (X and Y) Distance Protection relays, located at T55 Turkinje and Craiglie, with some DIT and blocking signals are sent as required between all three substations.

The T158 Yalkula-T159 Lakeland feeder 7285 is protected by dual (X and Y) Distance Protection relays, located at T158 Yalkula, with DIT and blocking signals sent from T159 Lakeland to T158 Yalkula as required, and with DIT and blocking signals sent to and from T55 Turkinje, Craiglie and T158 Yalkula for some upstream protection issues.

The T55 Turkinje end feeder 7200 and 7201 distance relays essentially look to Craiglie and T158 Yalkula with zone 1 as 80% distance to the T158 Yalkula tee zone 2 as 120% distance to Craiglie into the Craiglie transformers. There is no reverse reach programmed into these relays. Zone 2 overlaps into the T158 Yalkula - T159 Lakeland feeder 7285, and all outputs are delayed long enough for the Yalkula relays to identify downstream faults, and send blocking signals to inhibit unnecessary operation.

The Craiglie feeder distance relays essentially look to T158 Yalkula and T55 Turkinje with zone 1 as 80% distance to the Yalkula tee and zone 2 as 120% distance to T55 Turkinje into the T55 Turkinje substation. There is a reverse-looking zone 3 that will see through the Craiglie transformers and into the Craiglie 22 kV bus. Zone 2 (forward reaching zone) overlaps into the T158 Yalkula-Lakeland feeder 7285, so the outputs are delayed long enough for the T158 Yalkula-Lakeland feeder 7285 relays to identify downstream faults, and send blocking signals to inhibit unnecessary operation and load shed.

The T158 Yalkula feeder 7285 distance relays essentially look to T159 Lakeland with 80% distance to zone 1 and 120% to zone 2 into the T159 Lakeland transformers. There is no reverse reach on these relays.

T158 Yalkula switching station provides a duplicated source of supply to the Yalkula-Lakeland feeder, and each incoming leg has a dedicated CT. The CTs are summated and this output is provided as the input to the Yalkula-Lakeland feeder 7285 protection relays. In effect, the status of the C/Bs will not impact upon the sensitivity of the distance protection relays for faults on the T158 Yalkula-T159 Lakeland feeder 7285.

A similar proposal is recommended once YALK is a fully switched 132 kV site, however, detailed protection analysis is required.

The proposal to create another 132 kV tee at MOSS as a 4-way communicating distance protection scheme is not possible based on presently available relay technology (i.e. protection scheme redundancy) and protection standards.

## 132 kV Outage History:

| Event Year | Outage Date | Outage Name | Outage Type | Interruption Duration (min) | Customer Interruptions | Cust. Mins | Protective Voltage | Protective Asset | Outage Trigger | FdrStat Notes | Summary Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2011_12 | 25/02/2012 | 12FN2222 | UNPLN | <1min | 6038 | 0 | 132 | 72000 | Trip & Auto Reclose - No Trigger Found | Trip and autoreclose. | 132kV Craiglie Fdrs Trip |
| 2012_13 | 21/04/2013 | 13FN4031 | UNPLN | 4 | 30965 | 126,195 | 132 | 72852/2 | Non EE Transmission | Powerlink problem. Unsure of cause as yet. | **Total LoS at Turkinje** |
| 2012_13 | 24/04/2013 | 13FN4121 | UNPLN | 1 | 30959 | 31,991 | 132 | 132KV 1 BUS | Non EE Transmission fault | 132kV Chalumbin-Turkinje Feeder CB 71662 TRIPPED when CB 71652 was reclosed after an unknown opening. Refer Powerlink communications for further details. | **Total LoS at Turkinje** |
| 2014_15 | 6/12/2014 | 14FN10412 | UNPLN | <1min | 6342 | 0 | 132 | 72012 | Trip & Auto Reclose - No Trigger Found | Transient Fault of Unknown Origin on 132kV 7201 Craiglie Fdr CB 72012 | 7201 132kV Craiglie No. 1 Fdr Trip. |
| 2014_15 | 9/12/2014 | 14FN10759 | UNPLN | <1min | 31628 | 0 | 132 | 132KV 1 BUS | Non EE Transmission fault | Double Circuit Trip & auto reclose on P/Link 132kVNetwork. At 1519 hrs Chalumbin - Turkinje 132kV fdrs 7165 & 7166 tripped and AR. Loss of approx 20mw. | **Total LoS at Turkinje** Trip and Auto-Reclose. |
| 2014_15 | 14/12/2014 | 14FN10957 | UNPLN | 9 | 6350 | 57,044 | 132 | 72002 | Lightning | 132kV 7200 Feeder Tripped causing loss of supply to all Yalkula, Lakeland, Cooktown, Helenvale & Bloomfield. Crew carried out fault finding - Trojan unit placed on Transformer No. 2 and placed into service. Customers were restored via 7201 feeder shortly after supply loss. | Loss of 132kV 7200 Fdr |
| 2014_15 | 16/01/2015 | 15FN0638 | UNPLN | 32 | 31643 | 879,737 | 132 | 4412 | Non EE Transmission fault | 66kV Mossman 1 Fdr CB tripped. SCADA Interface automated outage. Outage due to PLQ fault. | **Total LoS at Turkinje** |
| 2015_16 | 28/12/2015 | 15FN12429 | UNPLN | 2 | 2260 | 4,143 | 132 | 72002 | Other Zone Sub Outage | 7200 132kV Craiglie No. 2 Fdr Trip. Transformer 2 had water ingress into pressure relief valve. After maintenance was performed, T2 was put back into service. | 7200/2 132kV Craiglie No. 2 Fdr Trip. |
| 2015_16 | 3/02/2016 | 16FN1257 | UNPLN | 11 | 2272 | 25,901 | 132 | 72002 | Other Zone Sub Outage | Protection indicates a possible pressure relief trip on T2 at Craiglie | 7200/2 132kV Craiglie No. 2 Fdr Trip. |
| 2015_16 | 24/10/2016 | | UNPLN | Unknown | | | 132 | 72002 | Unknown | Unknown (most probably '0') | 7200/2 132kV Craiglie No. 2 Fdr Trip. |
| 2015_16 | 3/11/2016 | | UNPLN | Unknown | | | 132 | 72002 | Unknown | Unknown (most probably '0') | 7200/2 132kV Craiglie No. 2 Fdr Trip. |
| 2016_17 | 21/11/2017 | 17FN15611 | PLN | 37 | | | 132 | 72012 | Unknown | Unknown (most probably '0') | 7201 132kV Craiglie No. 1 Fdr Trip. |
| 2016_17 | 24/11/2017 | 17FN15769 | UNPLN | 21 | | | 132 | 72012 | Unknown | Unknown (most probably '0') | 7201 132kV Craiglie No. 1 Fdr Trip. |
| 2016_17 | 12/12/2017 | | UNPLN | 24 | | | 132 | 72002 | Unknown | Unknown (most probably '0') | 7200/2 132kV Craiglie No. 2 Fdr Trip. |
| 2016_17 | 15/12/2017 | | UNPLN | 34 | | | 132 | 72002 | Unknown | Unknown (most probably '0') | 7200/2 132kV Craiglie No. 2 Fdr Trip. |
| 2016_17 | 28/12/2017 | | UNPLN | 20 | | | 132 | 72002 | Unknown | Unknown (most probably '0') | 7200/2 132kV Craiglie No. 2 Fdr Trip. |
| 2016_17 | 28/12/2017 | | UNPLN | 14 | | | 132 | 72002 | Unknown | Unknown (most probably '0') | 7200/2 132kV Craiglie No. 2 Fdr Trip. |

**Table 11: 132 kV Circuit Outages (last 5 years)**

*It is recommended that the proposed new TF1 at MOSS be connected to the more reliable 7201/2 which also aligns to the circuit closest to the proposed 132 kV tee and landing span.*

**Schematically and circuit connectivity:**

TURK to YALK double circuit:

- circuits 7200/1, 7201/1;

YALK to CRAI double circuit:

- circuits 7200/2, 7201/2;

YALK to LAKE single circuit (circuit 7285):

- normally via 7200 normally closed 132 kV c/b;
- 7201 132 kV c/b is normally open.

**Substation transformer connections:**

CRAI:

- TF1 is supplied from 7201/2; and
- TF2 is supplied from 7200/2

MOSS:

- TF1 proposed supply via 7201/2 (i.e. 3 x less likely to experience an outage compared to cct 7200);
- on av. will experience 1 EECL outage each year, say for 12 min. each outage over 5 years.

Note loss of feeder circuits:

- on 4 occasions, total loss of supply from Powerlink which would also impact the TURK 66 kV supply;
- on 1 occasion, double circuit outage of <1 min., total loss of supply from EQL 7200/7201;

- CRAI 22 kV customer supply via circuits 7200 & 7201;
  - on 3 occasions, 7201 Turkinje No. 1 is interrupted:
    - <1 min., 37 and 21 minutes respectively;
  - on 9 occasions, 7200/2 Turkinje No. 2 is interrupted:
    - 7285 YALK – LAKE 132 kV supplied via 7200;
    - 9, 2,11 x2 unknown,24, 34, 20 and 14

**66 kV Outage History:**

The timber pole lines were constructed to a 1959 design standard that did not include an overhead earth wire.

As such these two lines have a relatively high exposure to and no shielding from lightning strikes.

The historical performance data indicates that the fault rate associated with lightning strikes on these two feeders is relatively high.

Despite the redundancy provided in the sub transmission network that supplies the Mossman substation the customers serviced by it have suffered 24 separate supply interruption events associated with faults occurring in the sub transmission feeders over the past 10 years.

Causes of these 24 interruptions are:

- 6 due to lightning strikes;
- 5 were a result of animals;
- 8 other feeder faults;
- 4 dues to upstream 132kV outages; and
- and 1 unknown cause.

MOSS:

- on average, customers will experience 2.0 outages each year from the existing EECL 66 kV timber pole lines and substation.

*These dual outages are largely expected to be resolved with changes to the auto-reclose enabled on the MOSS 1 and MOSS 2 66 kV zone 1 and 2 distance protection schemes.*

## 4.3. Distribution Network Limitation

Although there is no 22 kV augmentation planned for capacity and voltage for the 22 kV distribution network at MOSS or CRAI, it should be recognised that the:

- reliability of the MOSS feeder 2SCK; and
- 230 V standard application once setpoints are lowered from the exiting 1.029puV to 1.005puV as the OLTC tap range of both the MOSS and CRAI are buck limited to 2.5% with any replacement transformer recommended to have a 10% buck capability.

The alternative solution in the interim is to use the additional buck range of the distribution transformers which are typically set at 2.5% buck and are able to tap to 5.0% buck on the older transformers and 10% on the newer units.

| ASSET NO | ASSET NAME | MD DAY SUM KVA | MD EVENING SUM KVA | MD NIGHT SUM KVA | PREV MD DAY SUM KVA | PREV MD EVENING SUM KVA | PREV MD NIGHT SUM KVA | MD DAY WIN KVA | MD EVENING WIN KVA | MD NIGHT WIN KVA | PREV MD DAY WIN KVA | PREV MD EVENING WIN KVA | PREV MD NIGHT WIN KVA | MD DAY SUM AMPS | MD EVENING SUM AMPS | MD NIGHT SUM AMPS | MD DAY WIN AMPS | MD EVENING WIN AMPS | MD NIGHT WIN AMPS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2CAS | CASSOWARY | 178 | 198 | 134 | 174 | 213 | 178 | 138 | 158 | 110 | 127 | 158 | 149 | 5 | 5 | 4 | 4 | 4 | 3 |
| 2MOS | MOSSMAN | 4630 | 3941 | 4475 | 5269 | 4752 | 4550 | 4499 | 4349 | 4104 | 4799 | 4420 | 4063 | 122 | 103 | 117 | 118 | 114 | 108 |
| 2DAI | DAINTREE | 2852 | 3560 | 3105 | 2852 | 3560 | 3105 | 2121 | 2536 | 2407 | 2121 | 2536 | 2407 | 75 | 93 | 81 | 56 | 67 | 63 |
| 2SCK | STEWART CREEK | 215 | 288 | 231 | 200 | 216 | 185 | 169 | 210 | 182 | 178 | 206 | 199 | 6 | 8 | 6 | 4 | 6 | 5 |

**Table 12: MOSS 22 kV feeder peaks (2016/17, 2017/18)**

| ASSET NO | ASSET NAME | MD DAY SUM KVA | MD EVENING SUM KVA | MD NIGHT SUM KVA | PREV MD DAY SUM KVA | PREV MD EVENING SUM KVA | PREV MD NIGHT SUM KVA | MD DAY WIN KVA | MD EVENING WIN KVA | MD NIGHT WIN KVA | PREV MD DAY WIN KVA | PREV MD EVENING WIN KVA | PREV MD NIGHT WIN KVA | MD DAY SUM AMPS | MD EVENING SUM AMPS | MD NIGHT SUM AMPS | MD DAY WIN AMPS | MD EVENING WIN AMPS | MD NIGHT WIN AMPS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2INL | INLET | 2500 | 2545 | 2129 | 2284 | 2366 | 2150 | 1820 | 1829 | 1744 | 1965 | 2047 | 1840 | 66 | 67 | 56 | 48 | 48 | 46 |
| 2FOM | FOUR MILE BEACH | 5212 | 5101 | 3225 | 5240 | 5360 | 4668 | 3858 | 3924 | 1765 | 3943 | 4118 | 3403 | 137 | 134 | 85 | 101 | 103 | 46 |
| 2OAB | OAK BEACH | 1157 | 1244 | 989 | 1201 | 1206 | 1046 | 984 | 1038 | 989 | 1037 | 1013 | 973 | 30 | 33 | 26 | 26 | 27 | 26 |
| 2REE | REEF PARK | 5949 | 5711 | 4218 | 5836 | 5823 | 4937 | 4564 | 4547 | 3598 | 4776 | 4744 | 3881 | 156 | 150 | 111 | 120 | 119 | 94 |
| 2GLK | GOLF LINKS | 2747 | 2792 | 2164 | 2742 | 2822 | 2429 | 1785 | 1986 | 1525 | 1705 | 1975 | 1620 | 72 | 73 | 57 | 47 | 52 | 40 |

**Table 13: CRAI 22 kV feeder peaks (2016/17, 2017/18)**

Should the 132 kV cut in/out require an extended outage to CRAI, the proposed MOSS 132 kV works should not be undertaken until such time as the 22 kV security works are completed as part of the planned outage works.

The proposed 22 kV works will enable transfers from CRAI to MOSS during the period of May when CRAI loads are at their lowest.

1. Proposed 22 kV distribution works included in the estimated cost of works and NPVs entails:
2. 200 A closed delta 22 kV regulators (i.e. PDT.8) on 2INL at the proposed new open point (i.e. PDT.21) to 2DAI;
3. Remote controlled recloser at the proposed new open point PDT.21 between 2DAI / 2INL;
4. Remote controlled recloser at 66C40.GO38 between 2MOS/2SCK; and
5. Remote controlled recloser at GO.2 on the 2MOS feeder.

Reclosers under items 3 and 4 will also assist with reliability of the 2MOS feeder which has a hospital and aged care connection on this proposed switched section.

Single 132/22 kV transformer contingencies at MOSS will be secured via alternate supply from the CRAI 22 kV feeder, 2INL.

Under peak load conditions of 2INL (66 A) combined with the peak MOSS load (i.e. 7.8 MVA or 205 A) results in a 2INL re-configured peak load of approx. 318 A.

Whilst 99 % of the time, the MOSS load will be less than 6.2 MVA (i.e. 163 A) which under peak 2INL conditions will result in 230 A load or 243 A allowing for 10 % losses.

The 2INL Cook Hwy cable load of 44 A that supplies into the Port Douglas township can be transferred to adjacent feeders to reduce this load to approx. 200 A.

2DAI back towards MOSS is adequately capacity rated and voltage levels are acceptable with the proposed new regulators at PDT.21.

Voltage levels to 2MOS extremities are marginal at peak load and acceptable for 99 % of the time.

Along the Captain Cook Highway, the 2INL feeder exit is limited to 250 A by the 185Al. XLPE cable. Sections of the 2INL feeder (i.e. 50 A) in Port Douglas will be transferred to the adjacent 2FOM feeder (i.e. peak demand of 137 A).

It should be noted that the 132 kV circuit 7201 will experience based on history, 3 outages over 5 years and this is expected to be further improved with YALK being fully switched and a 132 kV C/B being installed on the aged TF1 at CRAI to prevent aged related trips as these transformer replacements are deferred.

| CRAI | CRAI | 2INL | | | PDT.21 2INL Reg. | | | | MOSS | | 2DAI | | 2MOS | | 2SCK | | 2CAS | | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | V | I | P | Q | I | Tap | Before | After | incomer MOSS on 2DAI | MOSS bus | I | D98-pre reg. V | I | V | I | SC2A-pre reg. V | I | V | |
| | (puV) | (A) | (MW) | (MVAr) | (A) | (%) | | | (A) | (puV) | (A) | (puV) | (A) | (puV) | (A) | (puV) | (A) | (puV) | |
| Normal MOSS | 1.026 | | | | | | | | | | 95 | 0.988 | 123 | 0.986 | 7.0 | 1.007 | 6.2 | 1.022 | Current State MOSS |
| Normal 2INL | 1.03 | 65 | 2.3 | 1.07 | 0 | 0.8% boost | 1.023 | 1.026 | | | n/a | | n/a | | n/a | | n/a | | 2INL spur to Port= 43A |
| Switch 2DAI | 1.015 | 165 | 5.8 | 2.6 | 98 | fixed | 0.981 | 0.986 | | | | | | | | | | | transfer 2DAI<br>2INL spur to Port= 45 A |
| | 1.50% | | | | | | | 4.00% | | | | | | | | | | | step on transfer |
| | 1.029 | 162 | 5.8 | 2.6 | 97 | 3.4% boost | 0.996 | 1.027 | | 1.027 | n/a | 1.002 | | | | | | | S/S |
| Switch 2MOS | 1.001 | 316 | 10.6 | 5.6 | 247 | fixed | 0.923 | 0.95 | | 0.931 | | 0.922 | 137 | | | | | | transfer 2MOS<br>2INL spur to Port= 45 A |
| | 2.80% | | | | | | 7.30% | 7.70% | | 9.60% | | 8.00% | 135 | | | | | | step on transfer |
| | 1.03 | 301 | 10.5 | 5.4 | 235 | 7.4% boost | 0.956 | 1.027 | | 1.009 | 0.982 | 1.002 | 125 | | | | | | transfer 2MOS<br>2INL spur to Port= 45 A |
| alternative 2MOS switch-pre cond. | 1.029 | 163 | 5.8 | 2.6 | 97 | 3.4% boost | 0.995 | 1.026 | 40 | 1.027 | | 1.001 | 1 | | | | | | transfer 2MOS via MDT1 switch point<br>2INL spur to Port= 45 A |
| | 1.003 | 309 | 10.5 | 5.5 | 241 | fixed | 0.927 | 0.954 | | 0.949 | | 0.926 | | | | | | | |
| | | | | | | | 6.80% | 7.20% | | 7.80% | | 7.50% | 1 | | | | | | step on transfer |
| alternative 2MOS switch-pre cond. (2MOS town)-section 1 | 1.029 | 163 | 5.8 | 2.6 | 97 | 3.4% boost | 0.995 | 1.026 | 70 | 1.027 | 58 | 1.001 | 70 | | | | | | transfer 2MOS all but GO2 switch point near Bowls Club<br>Change open points to load this spur (ie SS8433 Hospital & SS775358 Aged Care) via GO16A<br>2INL spur to Port= 45 A |
| | 1.003 | 241 | 8.4 | 4.1 | 174 | fixed | 0.959 | 0.989 | | 0.979 | | 0.97 | | | | | | | |
| | | | | | | | 3.60% | 3.70% | | 4.80% | | 3.10% | 1 | | | | | | step on transfer |
| alternative 2MOS switch-pre cond. (GO2 hospital)-Section 2 | 1.029 | 163 | 8.3 | 4.1 | 170 | 5.6% boost | 0.975 | 1.028 | 67 | 1.018 | 55 | 0.997 | 67 | 1.001 | | | | | transfer 2MOS GO2 switch point near Bowls Club section<br>Change open points to load this spur (ie SS8433 Hospital & SS775358 Aged Care) via GO16A<br>2INL spur to Port= 45 A |
| | 1.015 | 310 | 10.6 | 5.5 | 241 | fixed | 0.939 | 0.989 | | 0.971 | 58 | 0.963 | | 0.934 | | | | | |
| | | | | | | | 3.60% | 3.90% | | 4.70% | | 3.40% | | 6.70% | | | | | step on transfer |
| Section 3 step (GO19 gas switch to 2SCK 66C40.GO38 | | | | | | | | | | | | | | 0.957 | | | | | To resolve th step issue, permannetly transfer GO19 to 2SCK before switching Hospital area |
| | | | | | | | | | | | | | | 4.40% | | | | | |
| Switch 2SCK / 2CAS | 1.028 | 318 | 11.1 | 5.6 | 250 | 8.0% boost | 0.95 | 1.027 | 138 | 1.008 | 0.983 | 1.001 | 125 | 0.969 | 7 | 0.998 | 6 | 1.008 | transfer 2SCK/2CAS- minor<br>2INL spur to Port= 44 A |
| Fully switched MOSS, unload Port | 1.023 | 273 | 9.6 | 4.6 | 250 | 8.0% boost | 0.95 | 1.027 | 138 | 1.008 | 0.983 | 1.001 | 125 | 0.969 | 7 | 0.998 | 6 | 1.008 | 2INL spur to Port= 44 A<br>2INL Cook Hwy cable load- 256A |
| Outcome | | O/C setting is 300 A- Adjacent feeders are lightly loaded enabling greater load on exit. For 99% of the time, rating is accpetable | | | 250 | Addbonus, tap limit to +/-12 taps. | Connections in this area before reg. are single DT/service connections | | No constraint | | Better than exsiting voltage levels | | Allowable rural drop is 4.9%, this is 5.4% at peak load and low risk | | Marginal difference | | No constraint | | Place regulators at PDT.13 |

**Table 14: MOSS 22 kV feeder transfers to 2INL (progressive and controlled switching)**

The protection settings of the respective impacts feeders are:

| Substation | Feeder | Reach via 2INL | Protection Settings (A) | | | Fault level via 2INL CRAI (A) | | |
|---|---|---|---|---|---|---|---|---|
| | | | O/C | E/F | SE/F | P-P O/C | E/F | SE/F |
| MOSS | 2DAI | | 250 | 95 | 8 | 714 | 598 | |
| | | | | | | SS10066 | SS10066 | |
| | | | | | | | Newell Bch spur | |
| | 2MOS | | 250 | 95 | 8 | 731 | 600 | |
| | | | | | | | SS48 | |
| | | | | | | | AOG Mission | |
| | 2CAS | | 150 | 40 | 8 | 386 | 404 | |
| | | | | | | SS581028 | | |
| | | | | | | | Shannonvale area | |
| | | | | | | | Fuse spur similar to Cassowary spur line | |
| | 2SCK | | 250 | 95 | 8 | 725 | 560 | |
| | | | | | | | Syndicate Rd recloser- 66C67A | |
| | | | | | | | | |
| CRAI | 2INL | | 300 | 75 | 10 | | same | |

**Table 15: MOSS/CRAI 22 feeder protection settings**

Safe reach to the next recloser when supply is from 2INL is acceptable under contingent conditions and SE/F settings will be coordinated.

A detailed protection study will be required for the proposed new 22 kV switchboard and it is likely that MOSS secondary relay setting groups will be activated during contingency supply loss of MOSS and transfer to CRAI.

The sequence of events once a permanent outage occurs to the incoming 132 kV line or 132/22 kV OLTC at MOSS would be to:

- Remotely open the MOSS transformer and feeder C/Bs (i.e. 132 kV and 22 kV);
- Remotely close the PDT.21 tie; and
- Remotely close the remaining MOSS 22 kV feeders at MOSS commencing with 2MOS;
    - Section 1: close 2MOS section to main township and Mossman sugar mill; and
    - Section 2: close GO2 of hospital and aged care area.

This will manage the voltage steps and allow cold load inrush and the proposed regulator at PDT.8 to settle before the next transfer.

In future, it is suspected that a Distribution Management System (i.e. DMS) would automate the present state manual operational response.

## 4.4. Applied Service Standards

Tables 16 – 24 outline the Minimum Service Standard (MSS) values for Mossman (ie 2MOS, 2SCK, 2CAS and 2DAI) and Craiglie (ie 2REE, 2INL, 2FOM, 2OAB and 2GLK) 22 kV feeders including MAIFIe at the circuit breaker level.

*Note: Tables 16 – 19 are all YTD Figures for the Mossman 22 kV feeders

| MSS Type | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18* |
|---|---|---|---|---|---|
| SAIDI | 267.8 | 239.4 | 429.3 | 331.6 | 232.8 |
| SAIFI | 2.12 | 3.49 | 3.45 | 3.32 | 5.09 |
| MAIFIe | 1.01 | 2.01 | 4.0 | 3.0 | 4.97 |
| Reliability Status | Green | Green | Yellow | Green | Green |

**Table 16: 2MOS Feeder - 5 year MSS performance (SR feeder category)**

The proposed remotely controlled recloser at GO.2 will assist with normal operation and improve reliability to the hospital and aged care. As this section will have a remotely controlled recloser to the 2SCK feeder, improvements will be provided to essential services.

| MSS Type | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18* |
|---|---|---|---|---|---|
| SAIDI | 1325 | 1684.5 | 467.2 | 895.7 | 1676.1 |
| SAIFI | 5.18 | 9.14 | 3.09 | 5.38 | 8.96 |
| MAIFIe | 1.0 | 3.02 | 3.03 | 1.41 | 2.5 |
| Reliability Status | Red | Red | Yellow | Red | Red |

**Table 17: 2SCK Feeder – 5 year MSS performance (SR feeder category)**

| MSS Type | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18* |
|---|---|---|---|---|---|
| SAIDI | 489 | 611.9 | 1410.6 | 259.4 | 229.6 |
| SAIFI | 1.92 | 4.12 | 2.58 | 3.57 | 4.07 |
| MAIFIe | 1,0 | 0.98 | 2.99 | 0.97 | 2.97 |
| Reliability Status | Yellow | Yellow | Red | Green | Green |

**Table 18: 2CAS Feeder - 5 year MSS performance (SR feeder category)**

| MSS Type | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18* |
|---|---|---|---|---|---|
| SAIDI | 373.9 | 377.6 | 888.2 | 429.7 | 540.8 |
| SAIFI | 2.38 | 4.52 | 6.71 | 4.07 | 5.01 |
| MAIFIe | 32.4 | 3.12 | 4.44 | 5.63 | 3.01 |
| Reliability Status | Green | Green | Red | Yellow | Yellow |

**Table 19: 2DAI Feeder - 5 year MSS performance (SR feeder category)**

**Note: Tables 20 – 24 are all YTD Figures for the Craiglie 22 kV feeders**

| MSS Type | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18* |
|---|---|---|---|---|---|
| SAIDI | 1.74 | 94.6 | 166.2 | 22.5 | 234.2 |
| SAIFI | 0.01 | 2.13 | 2.31 | 0.27 | 1.48 |
| MAIFIe | 0.0 | 4.95 | 0.0 | 0.0 | 0.0 |
| Reliability Status | Green | Green | Yellow | Green | Amber |

**Table 20: 2REE Feeder - 5 year MSS performance (UR feeder category)**

| MSS Type | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18* |
|---|---|---|---|---|---|
| SAIDI | 34.3 | 25.9 | 244.4 | 20.8 | 136.4 |
| SAIFI | 0.14 | 1.07 | 2.40 | 0.18 | 1.13 |
| MAIFIe | 1.98 | 0.0 | 4.04 | 1.99 | 1.02 |
| Reliability Status | Green | Green | Green | Green | Green |

**Table 21: 2INL Feeder - 5 year MSS performance (SR feeder category)**

| MSS Type | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18* |
|---|---|---|---|---|---|
| SAIDI | 30.3 | 31.0 | 187.4 | 312.5 | 42.6 |
| SAIFI | 0.12 | 2.16 | 1.08 | 1.64 | 0.35 |
| MAIFIe | 0.0 | 0.99 | 2.0 | 1.0 | 0.0 |
| Reliability Status | Green | Green | Yellow | Red | Green |

**Table 22: 2FOM Feeder - 5 year MSS performance (SR feeder category)**

| MSS Type | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18* |
|---|---|---|---|---|---|
| SAIDI | 51.8 | 487.9 | 345.5 | 566.9 | 20.9 |
| SAIFI | 0.39 | 4.47 | 2.91 | 2.36 | 0.14 |
| MAIFIe | 1.97 | 2.26 | 6.32 | 0.0 | 3.96 |
| Reliability Status | Green | Yellow | Green | Yellow | Green |

**Table 23: 2OAB Feeder - 5 year MSS performance (SR feeder category)**

| MSS Type | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18* |
|---|---|---|---|---|---|
| SAIDI | 4.3 | 46.6 | 65.6 | 1.8 | 241.9 |
| SAIFI | 0.07 | 1.19 | 0.50 | 0.05 | 0.58 |
| MAIFIe | 1.04 | 2.02 | 1.0 | 0.99 | 0.0 |
| Reliability Status | Green | Green | Green | Green | Amber |

**Table 24: 2GLK Feeder - 5 year MSS performance (SR feeder category)**

Key notes are that 2INL is a high-reliability feeder with low outage statistics whilst further 22 kV feeder reliability works is required on 2SCK.

## 4.5. Safety Net Compliance

The proposed single transformer 132/22 kV Option A or 66/22 kV BAU at MOSS meets safety net criteria and will be secured by:

- Remote controlled 22 kV transfer capability via CRAI, 2INL;
- 66/22 kV 10/12 MVA hot spare at Mount Molloy; or the
- 132/22 kV system spare held at Hartley St. depot, Cairns respectively.

Should a long term fault be experienced on the MOSS 132/22 kV OLTC, the 50 MVA 132/22 kV Hartley St. system spare will be installed as an interim solution. Contingent 22 kV feeder transfer to CRAI will be undertaken in the meantime. An earthing transformer spare is also held at Hartley St.

The CRAI supply area of Port Douglas will continue to be serviced by two 132/22 kV OLTC's at CRAI zone substation.

## 4.6. Fault Level Limitation

Once the 2 x 10 MVA 66/22 kV transformers are replaced at MOSS with a single 132/22 kV OLTC, the fault levels will need to be checked. As can be seen, the 1ph.-G is similar which assists with remediation of the earth mat. Whilst the 3ph. has increased, powder-filled fuses need only replace EDOs at 6 kA for 22 kV units.

Note, the comparison was done with a 50/63 MVA OLTC which is the worst case system spare install.

From the CRAI study, the impact of the low impedance ex-Innisfail units cause a higher fault level than the proposed new 50/63 MVA units that would be installed.

Further discussions will occur as to the preferred transformer size which will be a balance between holding a system spare for a smaller unit (i.e. 25/32 MVA) vs installing a 50/63 MVA unit which is a standard size around Cairns.

| Substation | Description | MOSS 22 (kA) | | | CRAI 22 (kA) | | | 132/22 kV txer | Comments |
|---|---|---|---|---|---|---|---|---|---|
| | | 3ph. | 2ph.-G | 1ph.-G | 3ph. | 2ph.-G | 1ph.-G | | |
| MOSS | Current State | 3.47 | 5.00 | 4.08 | | | | 2 x 10 MVA via 66kV | negligible difference |
| MOSS | Future | 5.07 | 4.96 | 4.24 | | | | 1 x 50/63 MVA via 132kV | |
| CRAI | Current State | | | | 5.47 | 7.94 | 14.5 | 2 x 15/20 MVA via 132kV | due to low impedance ex-Innisfail units, the fault level will be lower in future |
| CRAI | Future | | | | 6.5 | 6.8 | 6.3 | 2 x 50/63 MVA via 132kV | |

**Table 25: 22 kV sub-transient fault levels**

### 4.7. Network Losses

System losses have been costed at $287/kW which is a legacy figure. This cost is not a significant factor in the NPV.

### 4.8. Asset Life Cycle Summary

As part of the analysis, both CAPEX and REPEX costs have been allowed for. This is particularly critical where high maintenance cost assets like the 66 kV lines from TURK to MOSS are being progressively retired as part of the recommended solution.

The MOSS SCAR has been attached, prediction of the repair/maintenance costs and a schedule of CAPEX works have been detailed in the appendices and above report (refer Section 3.0).

### 4.9. VCR Value

Energy Queensland utilises the AEMO 2014 Value of Customer Reliability (VCR) values as part of its investment and project planning process. VCR is an economic value applied to customers' unserved energy for any particular year and is intended to represent customers' willingness to pay for their reliability of electricity supply. VCR is used to supplement Ergon Energy and Energex's Jurisdictional Security Criteria requirements by helping compare project options in a project business case or RiT-D, where reliability is assessed to have a material impact. VCR analysis can also be used to demonstrate the customer benefits of investment above mandatory requirements, to achieve an improved, efficient customer reliability outcome, but in practice, this application is very rare. Detail about how VCR is applied in investment analysis is included in each DNSP's Distribution Annual Planning Report (DAPR)[1] under Section 6.4 on Network Planning Criteria and can be found under the following links.

Whilst MOSS is proposed to be supplied via a single 132/22 kV transformer supply, it is still an improvement to the 66 kV which on the surface has N-2 reliability but has experienced double circuit outages on a number of occasions when auto-reclose on the 66 kV was problematic.

Due to various reasons pertaining to the 66 kV build (i.e. steel crossarms, 3 piece pin insulators, common timber poles, no OHEW, terrain and environment characteristics), the DCST 132 kV offers a more reliable supply than the 66 kV.

Contingent 22 kV supply will be available from CRAI via remotely controlled plant to assist response transfer to 2INL feeder.

A VCR factor has not been included in the NPVs, however, a 132 kV circuit breaker has been included in the Option A CRAI transformer bay. Given the proposed deferral of the CRAI 132/22 kV transformers and outages attributed to these units, the install of the CB to retain the high security of the 132 kV of the line can be justified using VCR if required. The existing 132 kV transformer bay is fully established except for the CB.

[1] https://www.ergon.com.au/network/network-management/future-investment/distribution-annual-planning-report

# 5. RISK ASSESSMENT

| Risk Category | Equipment | Risk Scenario | Inherent/Untreated Risks | | | Target (Residual) | |
|---|---|---|---|---|---|---|---|
| | | | C | L | Risk Score | L | Risk Score |
| Safety | Substation Building | Catastrophic failure of building or partial building collapse results in multiple fatalities. | 6 | 2 | 12 (Moderate) | 1 | 6 (Low) ALARP |
| Customer | | Ergon Energy is unable to meet commitment to Wet Tropics Management Authority resulting in adverse regional media attention. | 3 | 4 | 12 (Moderate) | 1 | 3 (Very Low) ALARP |
| Business | Circuit Breaker/ Transformer | Catastrophic failure of primary plant results in substation to operate in abnormal configuration for an extended period. | 3 | 4 | 12 (Moderate) | 1 | 3 (Very Low) ALARP |
| Customer | Circuit Breaker/ Transformer/ 66 kV OH Lines | Failure of aged plant results in interruption to hospital and sugar mill. | 3 | 5 | 15 (Moderate) | 1 | 4 (Very Low) ALARP |
| Environment | Transformer | Failure to contain transformer oil leak results in spill or release into local water table. | 5 | 2 | 10 (Low) | 1 | 5 (Very Low) ALARP |
| Safety | Circuit Breaker/ Transformer | Catastrophic failure of aged plant results in a single fatality from exploding debris. | 5 | 3 | 15 (Moderate) | 1 | 5 (Very Low) ALARP |

**Table 26: Risk Assessment**

**Network Risk Evaluation Matrices:**

Network Risk Sub-Scales.pdf

**Risk Assessment Outcome:**

The network (business) risks the organisation would be exposed to if the project was not undertaken (Inherent Risk) are **not** deemed to be as low as reasonably practicable (ALARP). Addressing the risks, as detailed above, through the implementation of the preferred option (Option A) will reduce Energy Queensland's risk exposure (Residual Risk) in the most cost-effective manner.

## Risk Assessment Map:

The risk assessment map for the most significant risk present at the study area of this project (Mossman and the Douglas Shire) is shown in Figure 16.

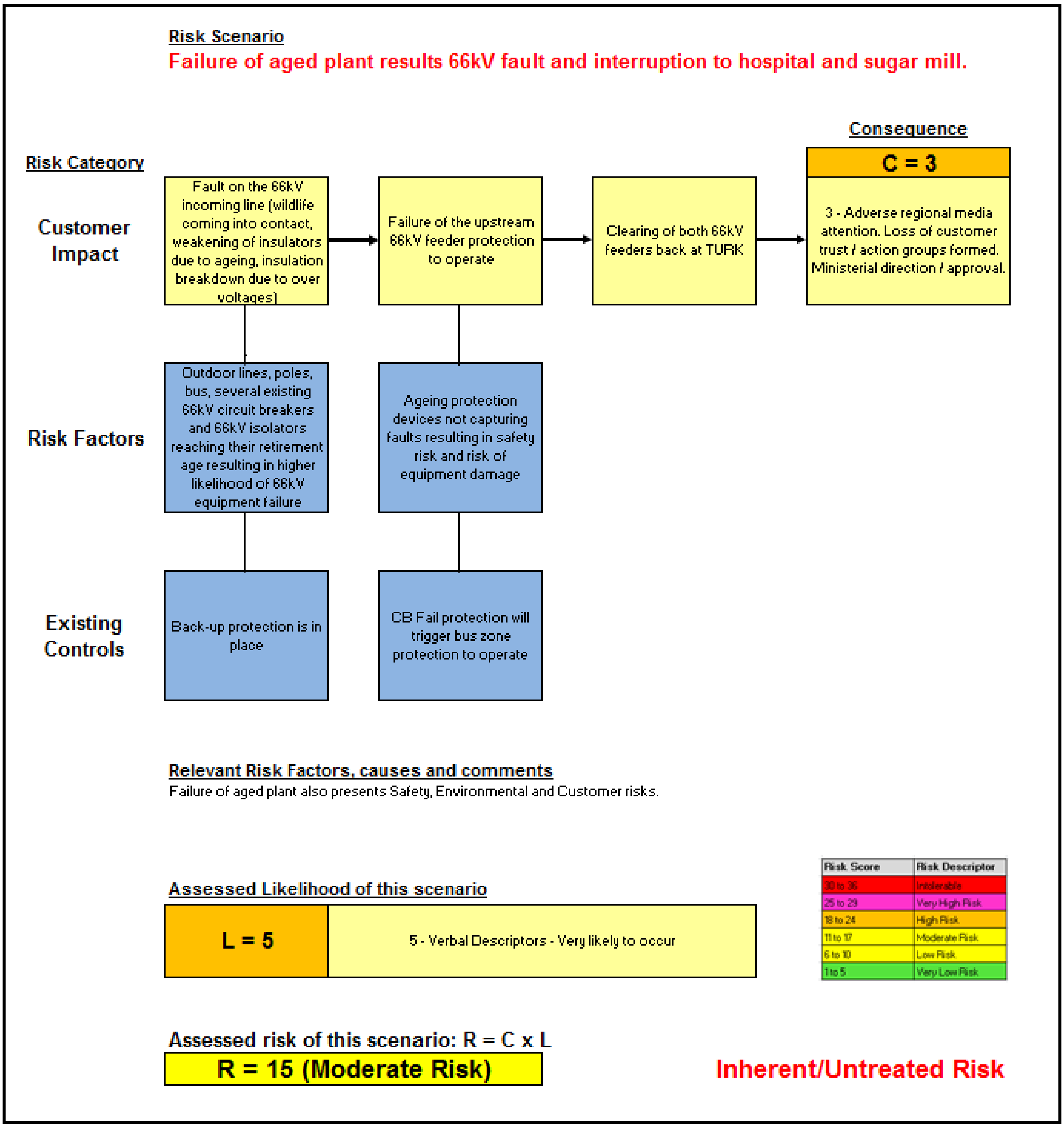



**Figure 16: Risk Assessment Map for the Greatest Inherent/Untreated at MOSS and the Douglas Shire Sub-Transmission Network**

**Relevant Risk Factors Causes for all Scenarios:**

- Mossman has two incoming 66 kV overhead feeders which supply the two outdoor 66 kV buses, four circuit breakers and isolators;
- The two 66/22 kV transformers supply the two outdoor 22 kV buses, 7 x 22 kV CBs, a single station service transformer and thirteen isolators;
- Outgoing from the substation are four 22 kV feeders, which have inter-ties and also ties to the 132/22 kV Craiglie Substation 22 kV Network;
- The age of the substation (54 years) and 66 kV feeders has resulted in increased operational maintenance and capital cost;
- Given the age & condition of the building roof slab, it has reached the end of its expected design life and can now be considered a safety issue. Restoration is not considered viable;
- The existing transformers (YOM 1963) do not have bunding, as this was not required when constructed. These transformers are considerably wet and have previously been leaking. As a result, this is considered a contaminated site. Given that it is also a very wet tropical location, there is the possibility of this contamination spreading outside of the site;
- Ergon has previously made a commitment to the WTMA to remove the 66 kV Mossman lines out of the World Heritage Area. This commitment was dependent upon making supply available to the Mossman area via the 132 kV. Failing to uphold this commitment may lead to negative connotations for Ergon’s corporate reputation;
- The timber pole lines were constructed to a 1959 design standard that did not include an overhead earth wire. As such these two lines have a relatively high exposure to and no shielding from lightning strikes. The historical performance data indicates that the fault rate associated with lightning strikes on these two feeders is relatively high;
- Despite the redundancy provided in the sub transmission network that supplies the Mossman substation, the customers serviced by it have suffered 24 separate supply interruption events associated with faults occurring in the sub transmission feeders over the past 10 years; and
- Causes of these 24 interruptions are; 6 due to lightning strikes, 5 were a result of animals, 8 other feeder faults, 4 due to upstream 132 kV outages and 1 unknown cause.

# 6. OPTIONS ANALYSIS

## 6.1. Base Case (BAU)

The total estimated DCV cost (2018/19) of the base case is $8.408M.

BAU is not recommended as it exposes the network to undue risk and high ongoing maintenance costs. Maintaining the two 66 kV Mossman feeders will continue to result in high costs that are likely to become more frequent and severe.

A single transformer at MOSS has been allowed for this option, consistent with the proposed 132/22 kV single transformer scenario in Option A.

Whilst BAU is the cheapest upfront option, the significant CAPEX/OPEX costs of the MOSS substation and 66 kV lines indicate that this is the 3rd ranked NPV option. The C3 replacement of the 66 kV line assets over a 10 year period would result in an NPV of $15.70M or approximately $2.13M worse than Option A when compared to the 15 year period C3 program applied.

Under BAU, the proposed Yalkula 132 kV switching station works will not proceed and the minimum saving of $1.182M will not be enabled.

The BAU option:

1. Results in high ongoing maintenance costs and subsequent elevated risk of equipment damage and personnel safety. Through aged asset reviews and equipment failures, plant will be replaced only when deemed necessary in an effort to reduce capital expenditure. This strategy will elevate the level of risk on the network of plant failures and subsequent outages; and
2. Does not consider a strategic and holistic view of the Northern Tablelands and Douglas Shire area including the:
   - Transmission network (i.e. 132 kV and 66 kV) back towards the Yalkula 132 kV switching station, Powerlink Connection Point at Turkinje nor the Turkinje 66 kV supply configuration from Turkinje to Mossman;
   - Craiglie 132/22 kV zone substation at Port Douglas; and
   - Renewable generation energy developments supplied from Yalkula 132 kV switching station to Lakeland which is intrinsically linked with the Queensland Government's renewables target policy and supporting strategies.

This option is not considered an acceptable option.

### 6.2. Option A: Recommended - Upgrade Substation from 66/22 kV to 132/22 kV and Redevelop YALK 132 kV

The total estimated DCV cost (2018/19) of the scope of works covered by Option A is $13.6M.

This is the recommended option which involves the conversion of the existing 66/22 kV substation into a single 132/22 kV transformer and 132 kV tee, 132 kV feeder works at YALK and minor 22 kV distribution security work between CRAI and MOSS.

Mossman 66 kV feeders MOSS 1 & MOSS 2 will be removed back to MOMO and supply will instead be delivered from Yakula 132 kV substation feeders 7201/2 as seen below in Figure 17:

- The design of MOSS 132/22 kV substation will be located in the existing substation space, minimising civil works and enabling transition whilst securing the 22 kV network supply;
    - This could be achieved by removing one 66 kV bay and one 66/22 kV transformer;
    - The design should be staged with the initial install of one 132/22 kV transformer and 132 kV lines works with space allowance for a second transformer installation at a later date; and
    - Deferral of the two CRAI transformers is enabled with the proposed security of supply tie works proposed between CRAI and MOSS via 2INL / 2DAI – the proposed works provides increased 22 kV transfer capacity without elevating the risk to intolerable levels.
- 132 kV switching station feeder, bus section, 132 kV lines to cut in/out, LAKE circuit 7285 bypass and bay works;
- 22 kV lines works to bolster the transfer capability of Mossman 22 kV network onto the Craiglie 22 kV networks to ensure that Safety Net is still met for the Mossman Network; and
- Recovery of the 66 kV feeders between MOMO and MOSS including one of the 66 kV circuits back towards MARE – this will significantly reduce the capital and operating maintenance budget for these aged lines.

Option A provides a strategic and holistic view of the Northern Tablelands and Douglas Shire area including the:

- Transmission network (i.e. 132 kV and 66 kV) back towards the Yalkula 132 kV switching station, Powerlink Connection Point at Turkinje and the Turkinje 66 kV supply configuration from Turkinje to Mossman;
- Craiglie 132/22 kV zone substation at Port Douglas; and
- Renewable generation energy developments supplied from Yalkula 132 kV switching station to Lakeland.

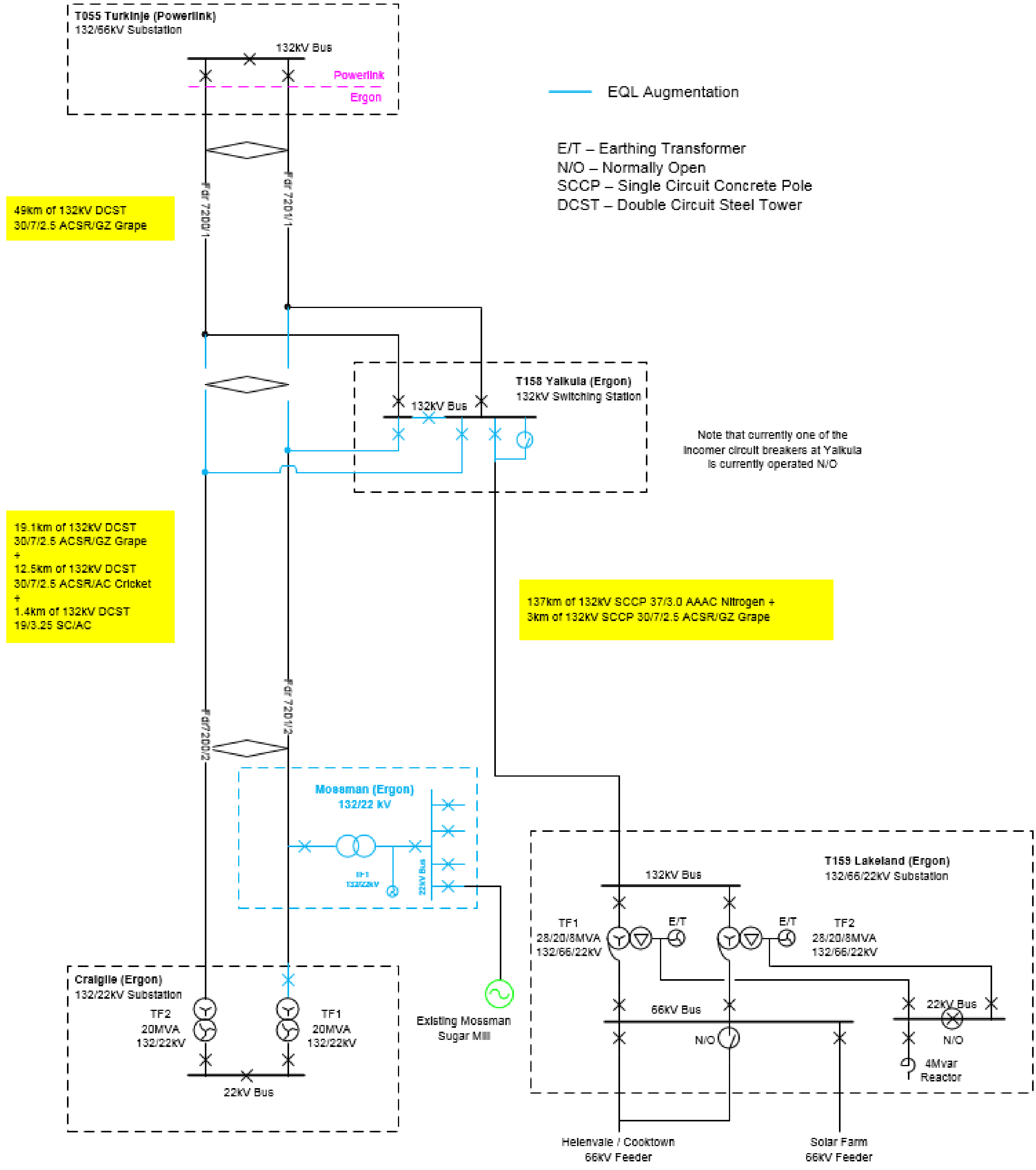



**Figure 17 – Option A Single Line Diagram (SLD) of the Northern Tablelands Network**

### 6.3. Option B: Base Case with 66 kV Line Replacement Immediately and Substation HI 7.5

The total estimated DCV cost (2018/19) of Option B is $13.46M.

This option involves the replacement of plant at Mossman 66/22 kV Substation on an as required basis, however, includes the complete replacement of the aging 66 kV feeders to reduce the anticipated increase in C3 replacements forecast from the last inspection cycle. This $15M capital expenditure (c/w 60% overheads or $9.375M DCV) seeks to reduce ongoing maintenance costs associated with the aging lines in the high-risk zones.

This option was considered for sensitivity analysis but was not explored further due to the significant capital expenditure, sub-par reduction of ongoing OPEX costs and lack of strategic benefit to the wider network development.

### 6.4. Option C: Full Retirement/Recovery of MOSS 66/22 kV Substation, Upgrade a CRAI 132/22 kV Transformer in 2021/22, 22 kV Underground Feeders Extended to Tollentini Rd to Supply 2DAI, 2MOS and a Combined 2SCK/2CAS from CRAI

The total estimated DCV cost (2018/19) of Option C is $14.53M.

This option involves the retirement/recovery of the Mossman 66/22 kV zone substation and supplying 2DAI, 2MOS and 2SCK/2CAS with 22 kV underground feeders from CRAI spare feeder bays.

One of the CRAI 132/22 kV 20 MVA OLTC will be replaced in 2021/22 due to the extra security required of this substation with MOSS retired and the combined loading expectations.

This option does not provide the strategic 132 kV network development (reduced cost for future generator connections) at YALK nor enable expansion of the Mossman Sugar Mill to high pressure steam generation (e.g. equivalent to Tableland Mill exports in excess of 10 MW) or potentially to supply loads North of the Daintree where past expectations of supply indicated a demand of up to 4.0 MVA.

North of the Daintree will not be reticulated under current legislation given its high-value wet tropics area.

This proposal does enable retirement of the upstream 66 kV lines.

The proposal has an NPV that is equivalent to the recommended Option A but the upfront CAPEX cost is higher due to the underground feeders required to supply 2MOS, 2DAI and 2SCK/2CAS via three new feeders from CRAI 22 kV switchboard that has spare circuit breakers.

It should be noted that additional overhead circuits are unlikely to be approved as the original install of the overhead 132 kV transmission line was accompanied with undergrounding of the existing 2INL feeder as part of the original Douglas Shire Council approvals along the Captain Cook Highway.



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Energy Queensland Limited ABN 96 612 535 583
Energex Limited ABN 40 078 849 055

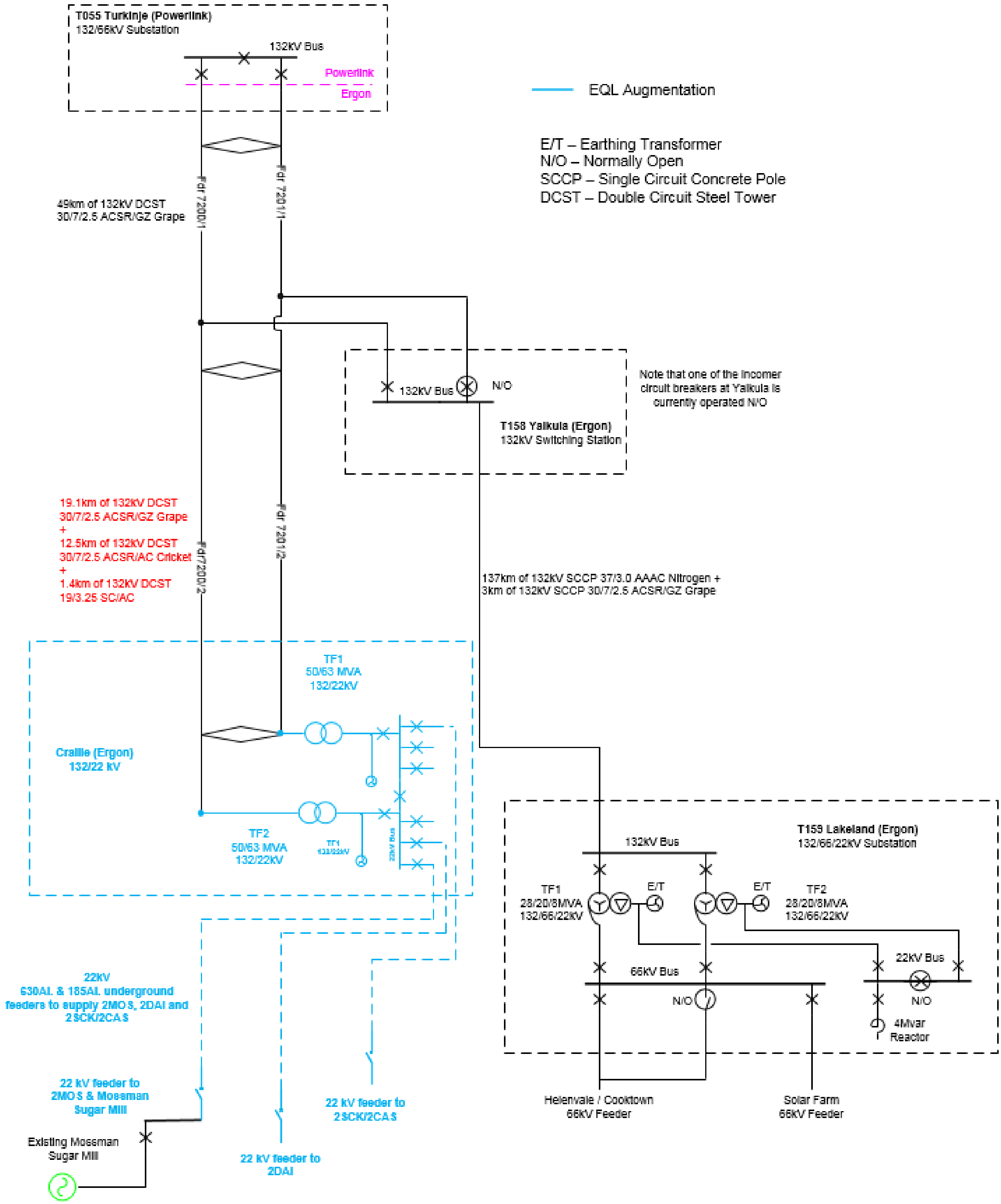



**Figure 18 – Option C Single Line Diagram (SLD) of the CRAI/MOSS 22 kV Network**

### 6.5. Non-Network Alternatives

Energy Queensland is committed to the implementation of Non-Network Solutions to reduce the scope or need for traditional network investments. Our approach to Demand Management is listed in Chapter 7 of our Distribution Annual Planning Report but involves early market engagement around emerging constraints as well as effective use of existing mechanisms such as the Demand Side Engagement Strategy and Regulatory Investment Test for Distribution (RiT-D). We see that the increasing penetration and improving functionality of customer energy technology, such as embedded generation, Battery Storage Systems and Energy Management Systems, have the potential to present a range of new non-network options into the future.

The primary investment driver for this project is REPEX, addressing both asset safety and performance risks. A successful Non-Network Solution may be able to assist in reducing the scope required for the replacement project but will not be able to impact the project timing due to the aged equipment risk. As the cost of options considered as part of this report is greater than $6M this investment will be subject to RiT-D as a mechanism for customer and market engagement on solutions to explore this further. This is currently planned in early 2019.

The customer base in the study area is predominantly established domestic and has a medium opportunity to reduce demand or provide economic non-network solutions.

Expenditure for the proposed project has been modelled as CAPEX and included in the forecast for the current regulatory control period. Funding of any successfully identified NNA solutions will be treated as an efficient OPEX/CAPEX trade-off, consistent with existing regulatory arrangements.

# 7. PROJECT DEPENDENCIES

There are four projects currently planned at Mossman Substation, which have been placed on hold pending this Business Case (WR1273666).

| WR Number | WR Name | Description | AP Budget | Funding Source | PIA | RBD |
|---|---|---|---|---|---|---|
| **1165865** | FN MOSSZS Building Roof Investigation | Concrete cancer assessment, replacement of concrete roof. | Approx. $250,000 | CA - Capital | 20160923 | 20170630 |
| **1074599** | Mossman Sub Refurb | 06-CBRM-PP-Portfolio CT & VT Replacement | $911,279 | CA - Capital | 20151214 | 20180531 |
| **1171858** | MOSS Protection Upgrade | Install TF Diff and 66 kV Bus Zone Relays | $526,024 | CA - Capital | 20161014 | 20191229 |
| **1216596** | ARP CBRM FN MOSS Replace 1 C/B | 06-CBRM-PP-Portfolio-C/B Replacement | $342,907* | CA - Capital | 20170216 | 20200630 |
| | | Total | $2,030,210 | | | |

*(With OH rate of 60% applied)

**Table 27: Future Projects**

| Works Request No. | Works Request Description | Relationship | Sequence | RBD | Dependency requirements/issues |
|---|---|---|---|---|---|
| **WR1138785** | Cape York Solar Farm (48 MW solar generator) | Supplied from YALK | **Cape York proceeds first** | **3 Dec 2019** | **YALK protection scheme, CRAI power flows and voltage management** |
| **WR926741** | Windlab Lakeland (100 MW wind farm generator). | Supplied from YALK | Equity partner risks - project may not proceed | **10 Dec. 2019** | **YALK: 132/22 kV STATCOM tfer, 132 kV bus section and STATCOM** |

**Table 28: Major Generation Projects supplied from YALK (i.e. at Lakeland)**

## 8. FINANCIAL ANALYSIS SUMMARY

Options BAU_A_B_C_Final_28

WR1273666 MOSS upgrade_021218.xlsr

WR1273666 MOSS upgrade_021218_Fin

WR1273666 MOSS upgrade_021218_ex

| $ Millions | Base Case | Option A | Option B | Option C |
|---|---|---|---|---|
| Capex | (11.10) | (11.77) | (12.99) | (12.16) |
| Opex | (3.48) | (1.80) | (2.01) | (1.62) |
| Direct Benefits | 0.00 | 0.00 | 0.00 | 0.00 |
| **Commercial NPV** | **(14.58)** | **(13.57)** | **(15.01)** | **(13.79)** |
| *Ranking* | *3* | *1* | *4* | *2* |
| | | | | |
| Indirect/Risk | 0.00 | 0.00 | 0.00 | 0.00 |
| **Commercial + Risk** | **(14.58)** | **(13.57)** | **(15.01)** | **(13.79)** |
| *Ranking* | *3* | *1* | *4* | *2* |

**Table 29: NPV of Options (15 yr C3 cycle for BAU but excluding potential generator connection savings in 2021/22)**

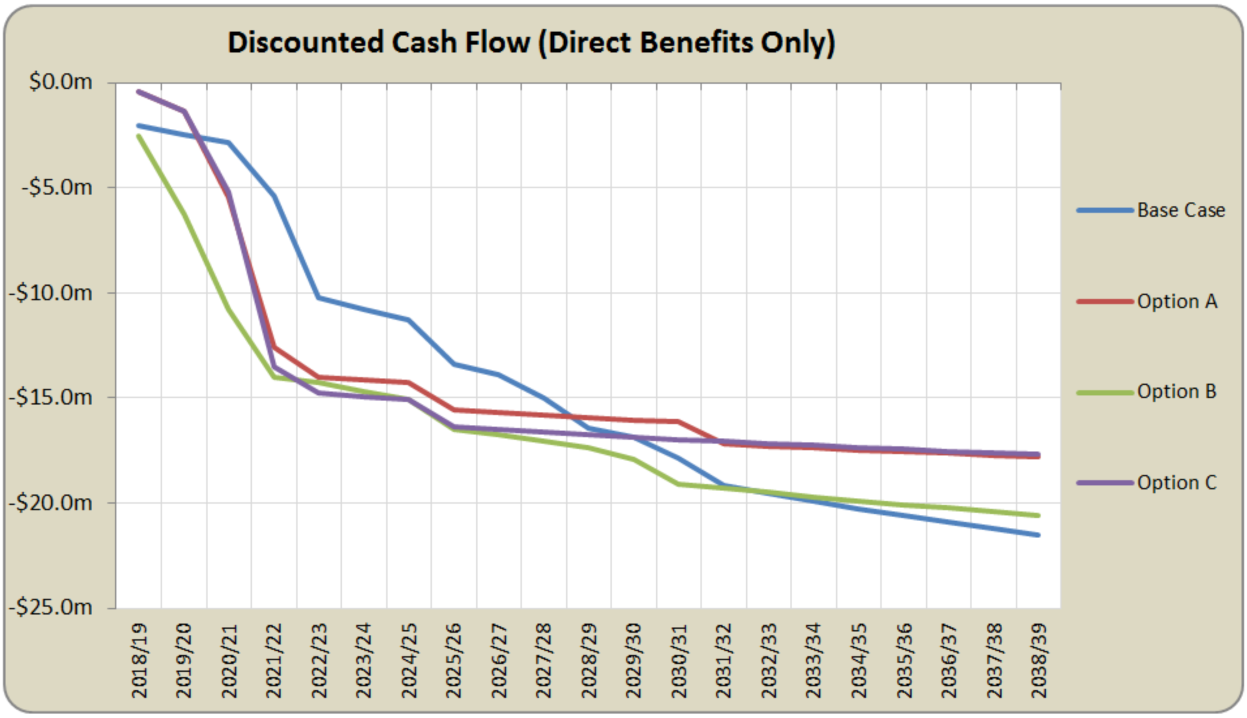



**Figure 19 – Discounted Cash Flow (Direct Benefits Only) for all Assessed Options with a 15 yr C3 Cycle for BAU but Excluding Potential Generator Connection Savings in 2021/22**

| $ Millions | Base Case | Option A | Option B | Option C |
|---|---|---|---|---|
| Capex | (12.21) | (11.77) | (12.99) | (12.16) |
| Opex | (3.48) | (1.80) | (2.01) | (1.62) |
| Direct Benefits | 0.00 | 0.00 | 0.00 | 0.00 |
| **Commercial NPV** | **(15.70)** | **(13.57)** | **(15.01)** | **(13.79)** |
| *Ranking* | *4* | *1* | *3* | *2* |
| | | | | |
| Indirect/Risk | 0.00 | 0.00 | 0.00 | 0.00 |
| **Commercial + Risk** | **(15.70)** | **(13.57)** | **(15.01)** | **(13.79)** |
| *Ranking* | *4* | *1* | *3* | *2* |

**Table 30: NPV of Options including a BAU 10 yr C3 replacement cycle (no generator connection savings)**

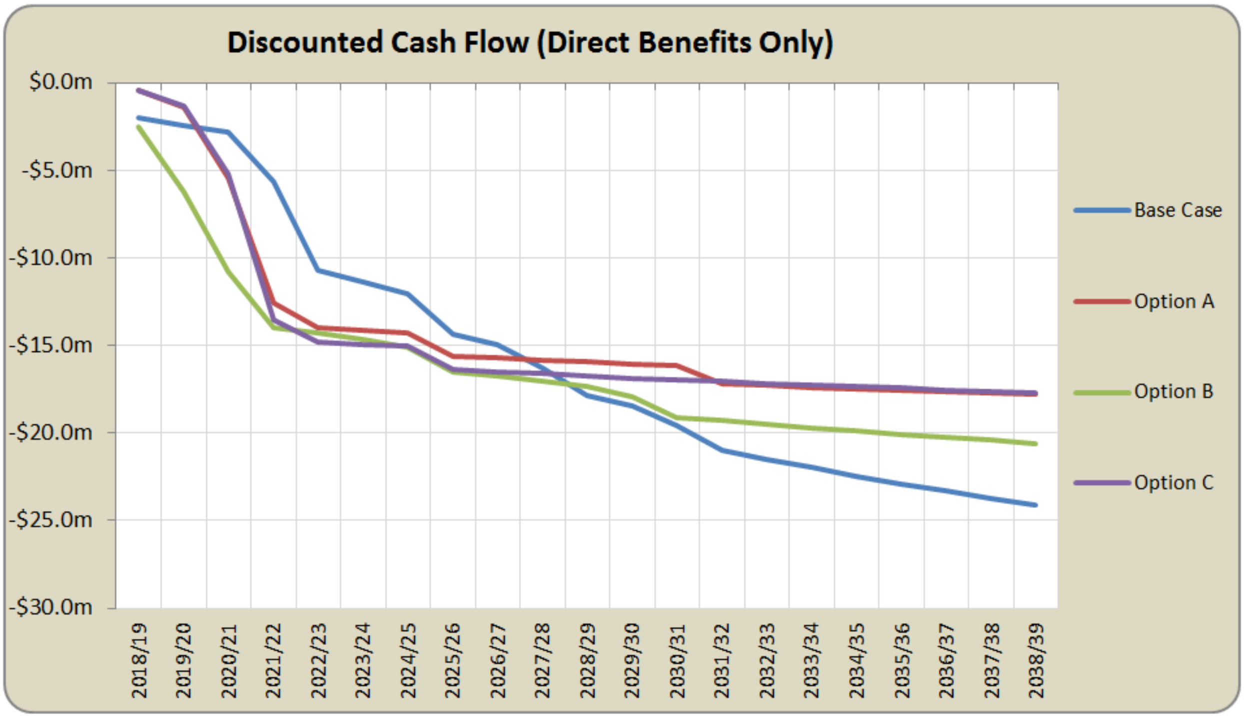



**Figure 20 – Discounted Cash Flow (Direct Benefits Only) for all Assessed Options with a 10 yr C3 Cycle for BAU but Excluding Potential Generator Connection Savings in 2021/22**

| $ Millions | Base Case | Option A | Option B | Option C |
|---|---|---|---|---|
| Capex | (11.10) | (10.92) | (12.99) | (12.16) |
| Opex | (3.48) | (1.80) | (2.01) | (1.62) |
| Direct Benefits | 0.00 | 0.00 | 0.00 | 0.00 |
| **Commercial NPV** | **(14.58)** | **(12.72)** | **(15.01)** | **(13.79)** |
| *Ranking* | *3* | *1* | *4* | *2* |
| | | | | |
| Indirect/Risk | 0.00 | 0.00 | 0.00 | 0.00 |
| **Commercial + Risk** | **(14.58)** | **(12.72)** | **(15.01)** | **(13.79)** |
| *Ranking* | *3* | *1* | *4* | *2* |

**Table 31: NPV of Options including a savings of $1.182M in 2021/22 from proposed generator connection works which results in an Option A NPV of $12.72 M (but retaining a 15 yr C3 cycle for BAU)**

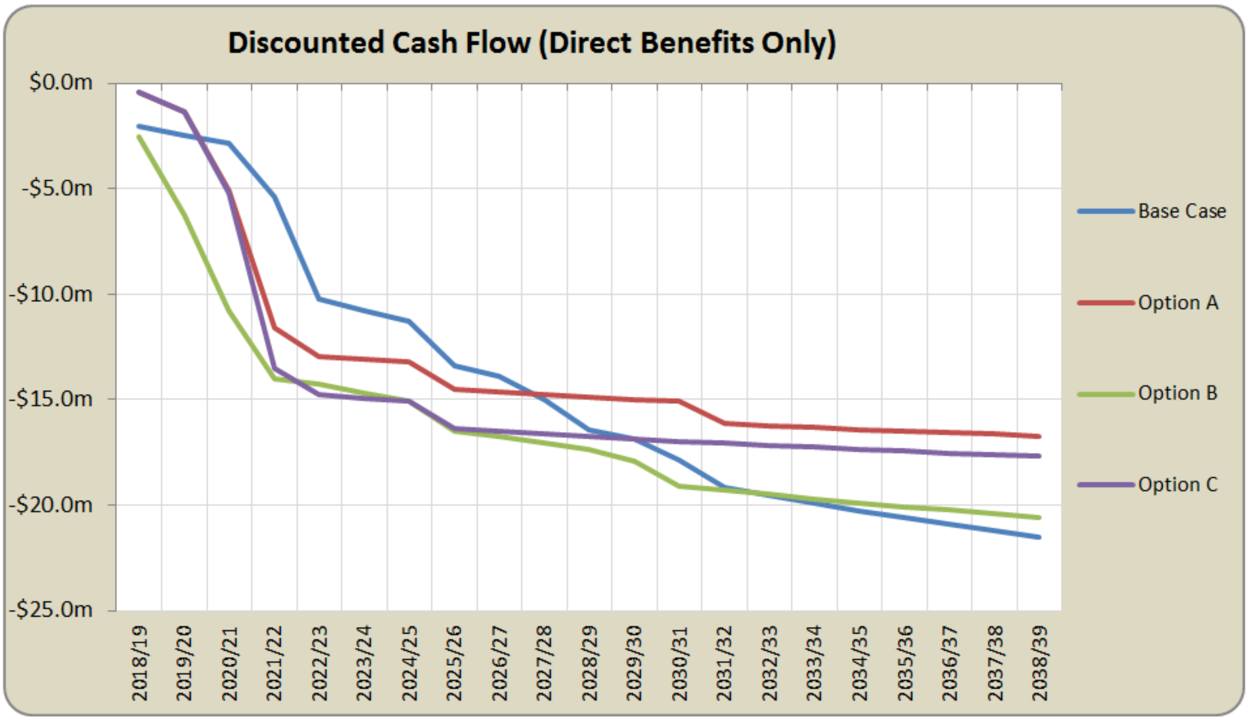



**Figure 21 – Discounted Cash Flow (Direct Benefits Only) for all Assessed Options with a 15 yr C3 Cycle for BAU and Including Potential Generator Connection Savings in 2021/22**

| | |
|---|---|
| **Base Case** | Business as Usual - not an acceptable solution |
| **Option A** | Recommended: 132/22 kV conversion at MOSS, YALK 132 kV and retire MOSS 1 & 2 66 kV feeders back to MOMO (refer Appendix F). |
| **Option B** | Capital cost replacement of 66 kV lines (MOSS 1 & 2), ongoing refurbishment and maintenance of MOSS substation (refer Appendix G) |
| **Option C** | Upgrade a CRAI 132/22 kV transformer early in the cycle, install underground feeders to supply 2DAI, 2MOS and 2SCK/2CAS from CRAI 22 kV bus and retire MOSS 1 & 2 back to MOMO (refer Appendix H) |

**Table 32: Summary of Options**

| | Base Case | | Option A | | Option B | | Option C | |
|---|---|---|---|---|---|---|---|---|
| | Advantage | Disadvantage | Advantage | Disadvantage | Advantage | Disadvantage | Advantage | Disadvantage |
| **Safety** | | Aged MOSS ZS plant and overhead MOSS 1 & 2 timber pole line / aged conductor risks | Addresses safety issues for all assets | | | Aged 66 kV line conductor for balance of 66 kV feeders | Addresses safety issues for all assets. | |
| **Economics** | Lowest upfront capital cost | Least preferred NPV<br><br>High CAPEX risk to C3 defects per 10 vs 15yr program | Lowest NPV<br>Low OPEX | High upfront CAPEX<br>Save $1.182M should proposed generator connection proceed | | Least preferred NPV | Similar NPV to Opt. A | Highest upfront CAPEX<br>Won't save $1.182M from proposed generator connections |
| **Resources** | Use normal resources for routine maintenance | Major OPEX commitment and timing risk of ongoing aged plant/line failures | New plant, simplified 132 kV network. Reduced 66 kV line OPEX resourcing. | Major CAPEX resource (design & construction) | Use normal resources for routine maint. | Major OPEX commitment and timing risk of ongoing aged plant/line failures | Upgrades a CRAI tfer early in the asset cycle | Major CAPEX resource (design & construction) |
| **Utilisation** | | Poor strategic 132 kV & 66 kV network development | Strategic rationalisation of 132 kV & 66 kV network | | | Poor strategic 132 kV & 66 kV network development | Strategic rationalisation of 132 kV & 66 kV network | Limits future expansion of Mossman Sugar Mill and future supply North of the Daintree |
| **Other** | | WTA lines will not be removed. Ongoing exposure to cyclones & bushfires | Remove WTA 66 kV lines and low risk to cyclone/fires | | | WTA lines will not be removed. Ongoing exposure to cyclones & bushfires | Remove WTA 66 kV lines and low risk to cyclone/fires | |

**Table 33: Summary of Options – Advantages/Disadvantages**

# 9. CONCLUSION

This Planning Report seeks to present the cost-benefit analysis of several options to address the age and condition-driven risks in the Mossman substation and the 66 kV sub transmission network that supplies it.

Option A is the recommended Northern Tableland and Douglas Shire strategic development solution that will enable:

- Removal of major aged 66 kV substation plant assets at Mossman 66/22 kV zone substation (MOSS);
- Removal of major aged 66 kV line assets between Mount Molloy and Mossman initially and back towards MARE/TURK ultimately;
- Simplification of the protection and operational management of the Northern Tablelands 132 kV network from Turkinje (TURK) to Yalkula (YALK), Yalkula to Lakeland (LAKE) and Yalkula to Mossman/Craiglie zone substations;
- Simplification of the protection and operational management of the Northern Tablelands 66 kV network from Turkinje to Mossman zone substations;
- Future rationalisation of Turkinje (TURK) and Mareeba (MARE) 66 kV substation plant;
- The ultimate retirement of the Mount Molloy (MOMO) 66/22 kV substation and aged 66 kV lines back towards Mareeba and Turkinje; and
- Retains capacity at MOSS for potential expansion at Mossman Sugar Mill and supply north of the Daintree.

Recommended Option A proposes upgrade of the Mossman substation from 66/22 kV to a single 132 kV tee, single 132/22 kV OLTC YnD11 transformer and switched Yalkula 132 kV bus (refer to Appendix F):

1. Stage 1 – 22 kV line works to provide supply security from Craiglie and vice versa during substation/transmission line works and removal of 66 kV & 22 kV TF1 substation plant assets at Mossman;
2. Stage 2a – Installation of a simplified 132 kV tee, single 132/22 kV transformer and 22 kV indoor switchgear at Mossman;
3. Stage 2b – Upgrade of YALK to a fully switched 132 kV substation (i.e. add 3 x 132 kV bays, part 132 kV LAKE bay) to enable a 3-way communicating distance protection scheme with Craiglie and Mossman 132 kV substations;
4. Stage 3 – Removal of 66 kV TF2 and Mossman 2 feeder bay assets; and
5. Stage 4 – Removal of 66 kV Mossman feeders/assets towards Mount Molloy.

The total estimated DCV cost (2018/19) of Option A is as follows:

- CAPEX spend to the end of the AER period 2020-25 of $13.390M including:
  - MOSS installation works:
    - Single 132 kV tee;
    - 132/22 kV OLTC transformer and earthing transformer;
    - New demountable building; and
    - 22 kV distribution augmentation to enable load transfers from MOSS to CRAI and vice versa.
  - MOSS recovery works:
    - 66 kV and 22 kV primary plant including building and structures.
  - CRAI installation works:
    - New 132 kV circuit breaker in the already established transformer bay; and
    - 132 kV protection and duplicate DC supplies in accordance with NER requirements.
  - YALK installation works:
    - fully switched 132 kV switching station including cut in/out lines works; and
    - 132 kV feeder bays (x2), bus section bay, 132 kV circuit breaker in the 7285 circuit bay to LAKE and associated bypass capability.

The proposed works strategically develops the northern tableland network enabling replacement of aged 66 kV plant and lines between Mount Molloy and Mossman, ultimate retirement of the Mount Molloy 66/22 kV substation and 66 kV lines back towards MARE and TURK and optimal integration of renewable generation sources at Lakeland which is intrinsically linked with the Queensland Government's renewables target policy and supporting strategies.

## 9.1. Summary of Need for Investment

There are a number of drivers for Option A. These will be explored below:

1. The timber pole 66 kV lines were constructed to a 1959 design standard that did not include an overhead earth wire with some sections built using steel crossarms and three-piece pin insulators. As such these two lines have a relatively high exposure to and no shielding from lightning strikes. The historical performance data indicates that the fault rate associated with lightning strikes on these two feeders is relatively high (refer Section 3.6);

2. The age of the substation constructed in 1964 (i.e. 54 years old) and 66 kV feeders has resulted in increased operational maintenance and capital cost. The present P1/P2/C3 inspection cycle indicates a significant increase in C3 defects (excluding the 35 km of aged 7/0.104 HDBCC conductor of MOSS 1 and 2) identifying an increase in major cost to replace items such as poles, crossarms and stays. These expense elements (refer Section 3.6) are expected to cause an increased CAPEX spend with the aging of the asset unless removal, replacement or refurbishment proceeds;

3. There are currently safety concerns with the 66 kV EIB C/Bs at the Mossman site TF1 C/B and TF2 C/B. Network Access Restriction (NAR) 518 is in place to address this safety issue with a 25m RMHZ. The NAR will be removed once acceptable maintenance and testing is complete or an alternate acceptable solution is provided;

4. The control room building concrete ceiling has been investigated and requires replacement. As the ceiling also provides structural support to the walls, replacement of the concrete ceiling will be difficult. The full report can be found in Section 3.0;

5. There is also a concern regarding the operation of the older 66 kV isolators, as they have signs of rust and corrosion and their mechanical strength is unknown;

6. The existing transformers (YOM 1963) do not have bunding, as this was not required when constructed. These transformers are considerably wet and have previously been leaking. As a result, this is considered a contaminated site. Given that it is also a very wet tropical location, there is a possibility of this contamination spreading to outside the site;

7. Ergon has previously made a commitment to the Wet Tropics Management Authority to remove the 66 kV Mossman lines out of the World Heritage Area. This commitment was dependent upon making supply available to the Mossman area via the 132 kV. Failing to uphold this commitment may lead to negative connotations for Ergon’s corporate reputation; and

8. Supply of the Mossman zone substation from the 132 kV network enables significant rationalisation and retirement of aged 66 kV substation plant and lines from Turkinje to Mossman including Mount Molloy and Mareeba where major future CAPEX can be avoided.

## 9.2. Summary of Feasible Options

Four main options have been explored in the planning report:

- Base Case (BAU) (refer Appendix E):
  - Complete replacement through aged asset replacement and RTS projects; and
  - Continue maintenance on MOSS and 66 kV lines.
- Option A: 132/22 kV conversion at MOSS, fully switched YALK 132 kV and retire MOSS 1 & MOSS 2 back to MOMO (refer Appendix F):
  - 22 kV feeder works to provide manageable security of supply during the construction phase and provide long term benefits to the security of essential services (i.e. Mossman Hospital and aged care facility);
  - Conversion of MOSS into a single TF1 132/22 kV OLTC YnD11 transformer supply;
  - Single 132 kV feeder tee into MOSS;
  - Switched 132 kV bus at YALK (i.e. 3 x 132 kV bays, part 132 kV LAKE bay) to enable a 3-way communicating distance protection scheme between YALK, MOSS and CRAI;
  - Modular 22 kV switchgear and a new control room;
  - Removal of 66 kV feeders;
  - Reduction in maintenance;
  - Upgrade aged CRAI 132/22 kV transformers; and
  - Strategic rationalisation of the 66 kV network back towards Turkinje.
- Option B capital cost replacement of a high-risk section of the 66 kV line (MOSS 1 & MOSS 2), ongoing refurbishment and maintenance of MOSS substation (refer Appendix G):
  - Same as the base case except for 66 kV line replacement at $8.82M (DCV cost) for the problem section through the Wet Tropics Area (WTA);
  - Reduction in lines maintenance costs once replacement completed; and
  - Includes replacements of assets according to CBRM HI 7.5 dates.
- Option C Upgrade CRAI aged OLTCs and install 22 kV underground feeders from CRAI to Tollentini Rd, no works at YALK (refer Appendix H):
  - Install 22 kV underground feeders from the existing CRAI 22 kV switchboard to Tollentini Rd to supply 2DAI, 2MOS and 2SCK/2CAS feeders direct from CRAI;
  - Removal of 66 kV feeders;
  - Retire and recover MOSS zone substation;
  - Reduction in maintenance;
  - Upgrade aged CRAI 132/22 kV transformers; and
  - No change at Yalkula.

There has been consideration of major assets where there is a material impact on the NPVs. Alternatives of the above options have been briefly mentioned in Appendix I but they have not been considered in the detailed analysis.

# 10. APPENDIX A: GEOGRAPHICAL OVERVIEW OF DOUGLAS SHIRE CURRENT STATE


Figure A1: Geographical of Current State (22 kV distribution network, MOSS and CRAI)



Ergon Energy Corporation Limited ABN 50 087 646 062
Energy Queensland Limited ABN 96 612 535 583
Energex Limited ABN 40 078 849 055

Forecast | Fcast Graph | Load History | Daily Load Profile | Assessed Steps | Start Values | Coinc Factors | Ratings | Transfers | Growth Rates | Capacitors | CCDM | Embedded Gen | Block Loads | Source | At

Display Basis | Excel Export | Compare Forecasts: | Coincident Source: Local Peak | Reconciled | Network? | Compensated | Curtailable Demand Mngt

| Year | Summer Day | | | | Summer Night | | | | Winter Day | | | | Winter Night | | | | Peak |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MVA | MW | MVAR | Comp | MVA | MW | MVAR | Comp | MVA | MW | MVAR | Comp | MVA | MW | MVAR | Comp | |
| 2018 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.95 | 6.49 | 2.49 | 0.00 | 6.95 | 6.49 | 2.49 | 0.00 | WD |
| 2019 | 7.76 | 7.10 | 3.13 | 0.00 | 7.76 | 7.10 | 3.13 | 0.00 | 6.88 | 6.42 | 2.47 | 0.00 | 6.88 | 6.42 | 2.47 | 0.00 | SD |
| 2020 | 7.61 | 6.97 | 3.07 | 0.00 | 7.61 | 6.97 | 3.07 | 0.00 | 6.74 | 6.29 | 2.42 | 0.00 | 6.74 | 6.29 | 2.42 | 0.00 | SD |
| 2021 | 7.64 | 6.99 | 3.08 | 0.00 | 7.64 | 6.99 | 3.08 | 0.00 | 6.68 | 6.24 | 2.40 | 0.00 | 6.68 | 6.24 | 2.40 | 0.00 | SD |
| 2022 | 7.69 | 7.04 | 3.10 | 0.00 | 7.69 | 7.04 | 3.10 | 0.00 | 6.84 | 6.38 | 2.45 | 0.00 | 6.84 | 6.38 | 2.45 | 0.00 | SD |
| 2023 | 7.75 | 7.09 | 3.13 | 0.00 | 7.75 | 7.09 | 3.13 | 0.00 | 6.89 | 6.43 | 2.47 | 0.00 | 6.89 | 6.43 | 2.47 | 0.00 | SD |
| 2024 | 7.66 | 7.00 | 3.09 | 0.00 | 7.66 | 7.00 | 3.09 | 0.00 | 6.74 | 6.29 | 2.42 | 0.00 | 6.74 | 6.29 | 2.42 | 0.00 | SD |
| 2025 | 7.61 | 6.97 | 3.07 | 0.00 | 7.61 | 6.97 | 3.07 | 0.00 | 6.80 | 6.35 | 2.44 | 0.00 | 6.80 | 6.35 | 2.44 | 0.00 | SD |
| 2026 | 7.66 | 7.01 | 3.09 | 0.00 | 7.66 | 7.01 | 3.09 | 0.00 | 6.85 | 6.39 | 2.45 | 0.00 | 6.85 | 6.39 | 2.45 | 0.00 | SD |
| 2027 | 7.64 | 6.99 | 3.08 | 0.00 | 7.64 | 6.99 | 3.08 | 0.00 | 6.75 | 6.30 | 2.42 | 0.00 | 6.75 | 6.30 | 2.42 | 0.00 | SD |
| 2028 | 7.68 | 7.03 | 3.10 | 0.00 | 7.68 | 7.03 | 3.10 | 0.00 | 6.80 | 6.35 | 2.44 | 0.00 | 6.80 | 6.35 | 2.44 | 0.00 | SD |

**Figure A2: MOSS zone substation load forecast**

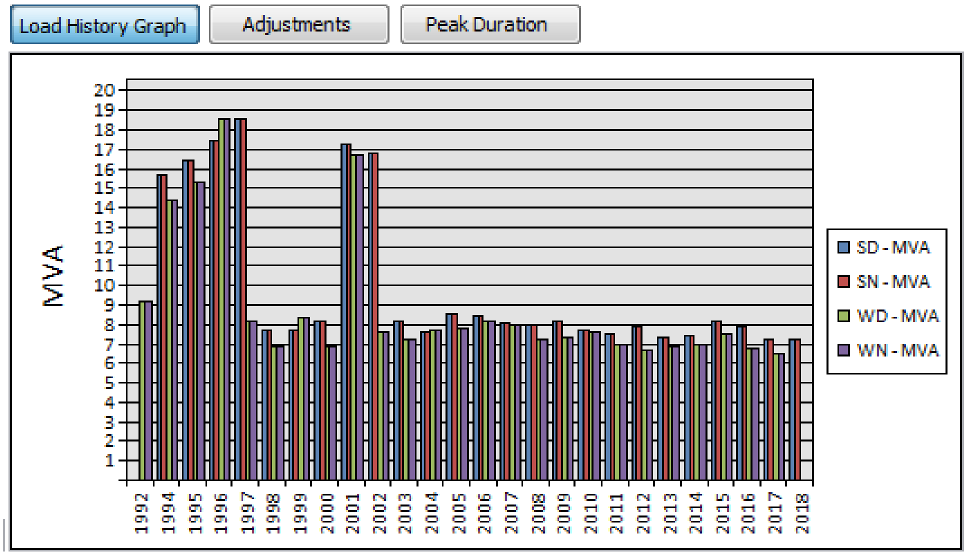
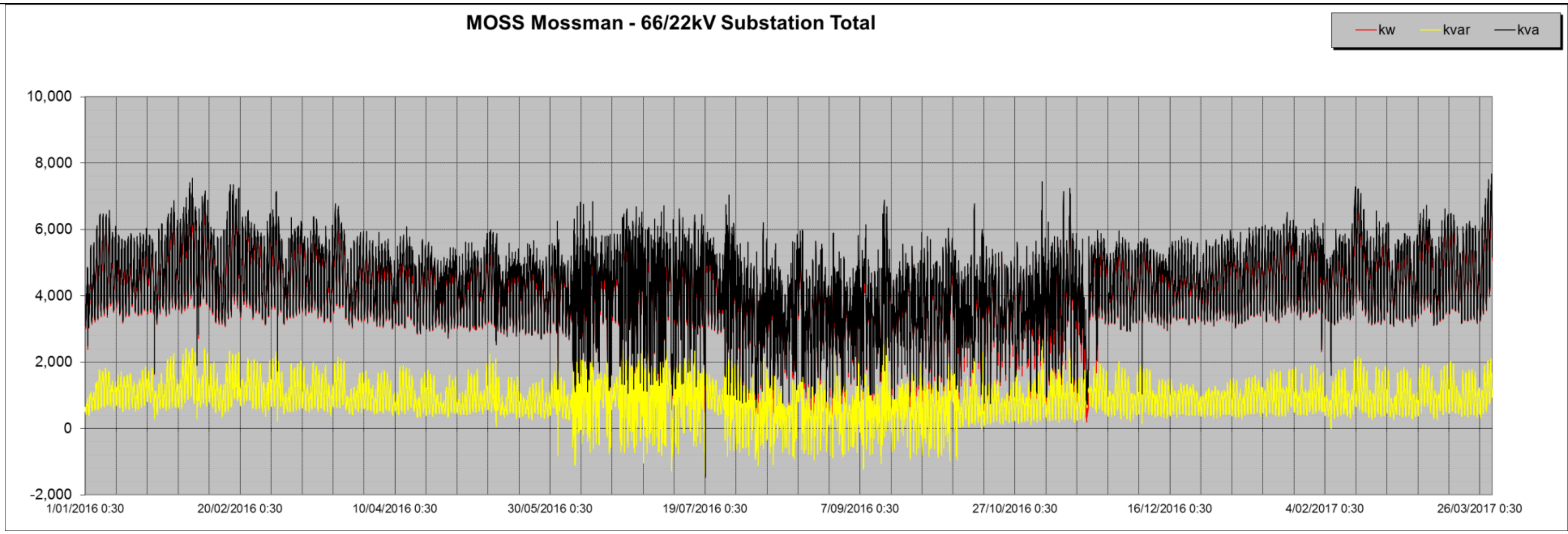
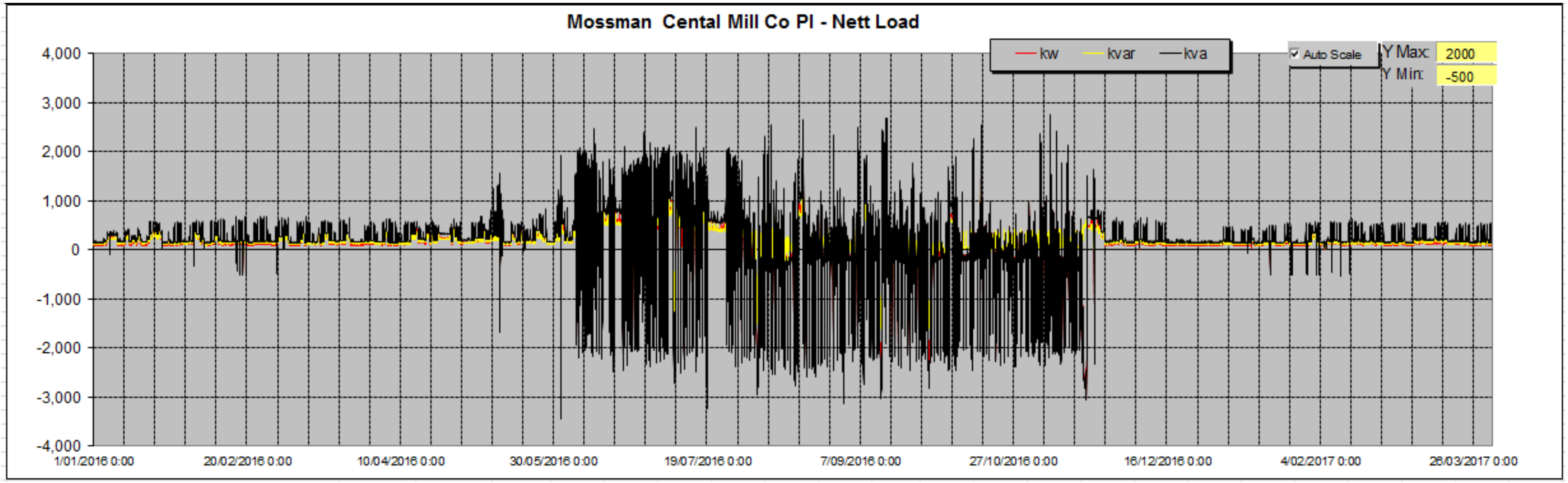



**Figure A3: MOSS zone substation – historical load including pre-CRAI**


MOSS Mossman - 66/22kV Substation Total
kw
kvar
kva
10,000
8,000
6,000
4,000
2,000
0
-2,000
1/01/2016 0:30
20/02/2016 0:30
10/04/2016 0:30
30/05/2016 0:30
19/07/2016 0:30
7/09/2016 0:30
27/10/2016 0:30
16/12/2016 0:30
4/02/2017 0:30
26/03/2017 0:30


Mossman Cental Mill Co Pl - Nett Load
kw
kvar
kva
Auto Scale
Y Max: 2000
Y Min: -500
4,000
3,000
2,000
1,000
0
-1,000
-2,000
-3,000
-4,000
1/01/2016 0:00
20/02/2016 0:00
10/04/2016 0:00
30/05/2016 0:00
19/07/2016 0:00
7/09/2016 0:00
27/10/2016 0:00
16/12/2016 0:00
4/02/2017 0:00
26/03/2017 0:00

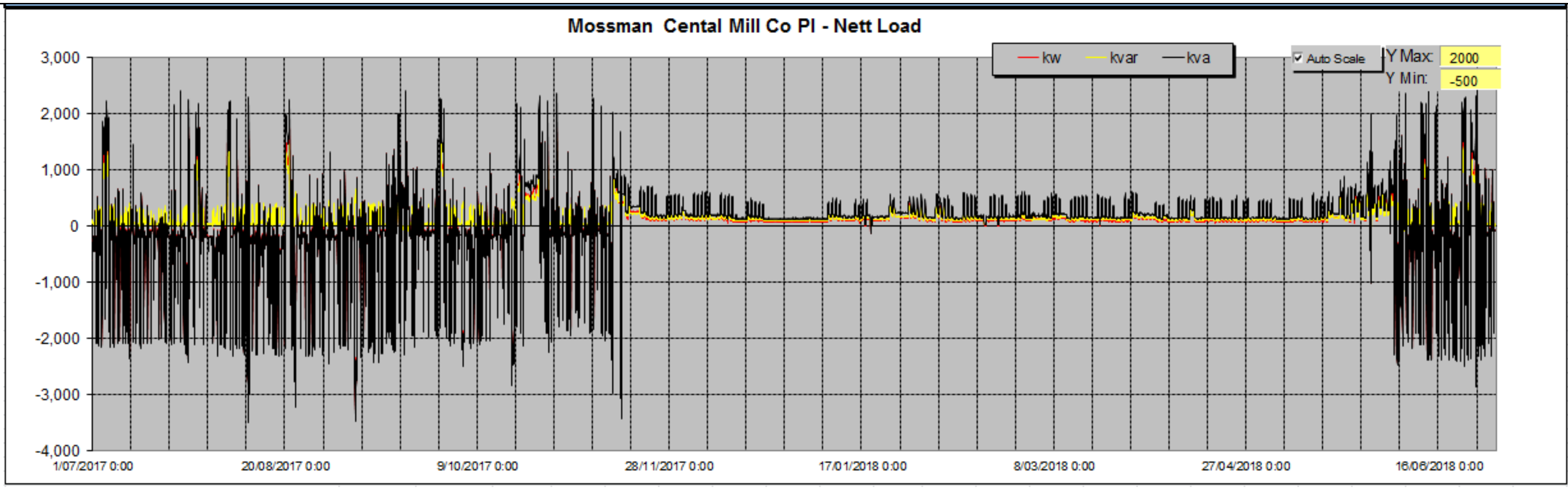



**Figure A4: MOSS actual load- 2016/17 and Mossman Sugar Mill (export/import) 2016/17 & 2017/18 periods**

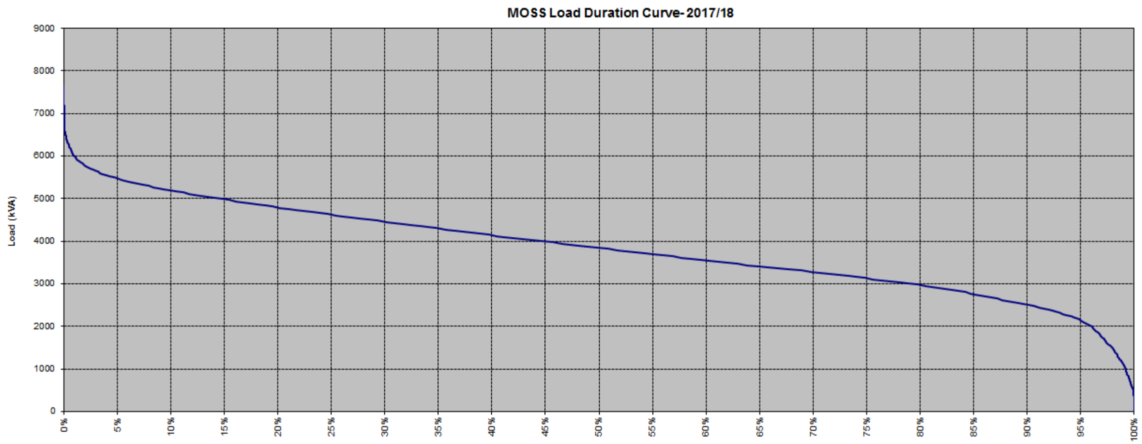
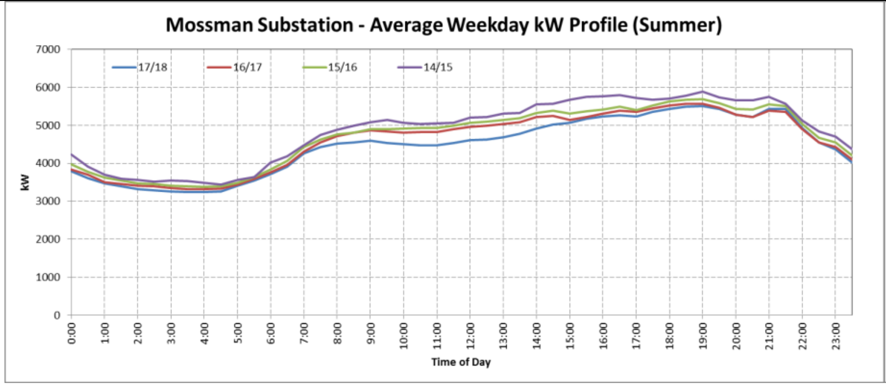
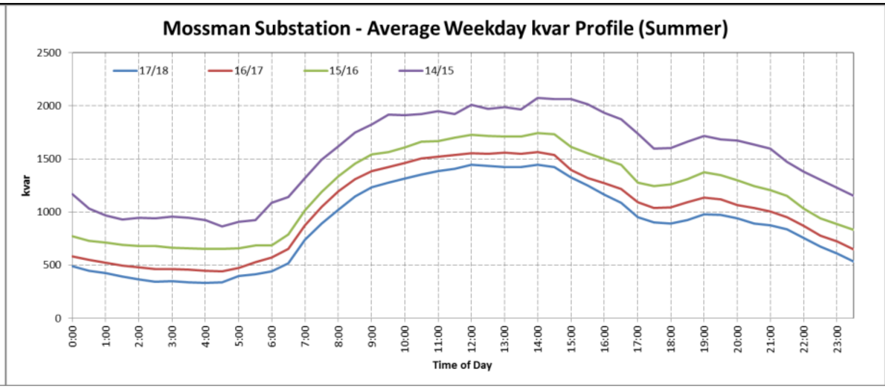
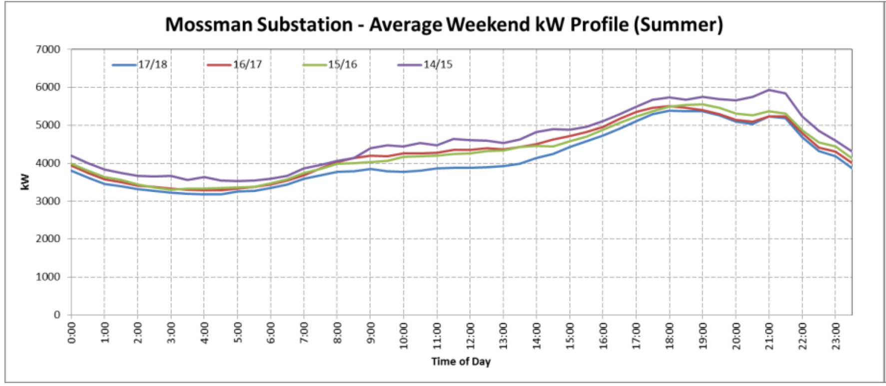
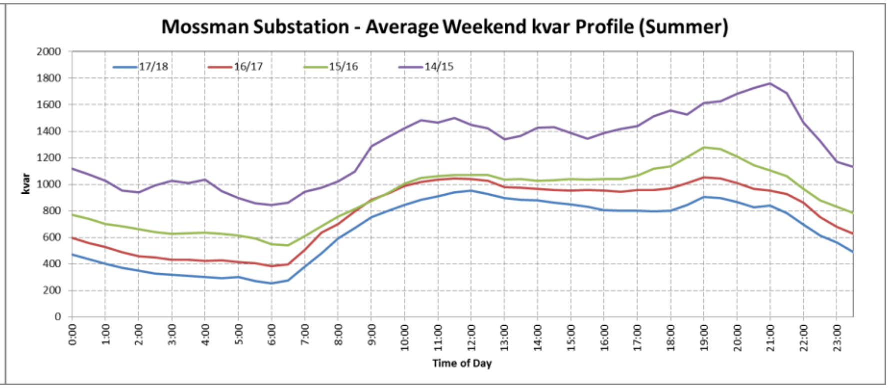



**Figure A5: MOSS actual load- load duration plot for 2016/17 period**


Mossman Substation - Average Weekday kW Profile (Summer)
17/18
16/17
15/16
14/15
kW
Time of Day


Mossman Substation - Average Weekday kvar Profile (Summer)
17/18
16/17
15/16
14/15
kvar
Time of Day


Mossman Substation - Average Weekend kW Profile (Summer)
17/18
16/17
15/16
14/15
kW
Time of Day


Mossman Substation - Average Weekend kvar Profile (Summer)
17/18
16/17
15/16
14/15
kvar
Time of Day

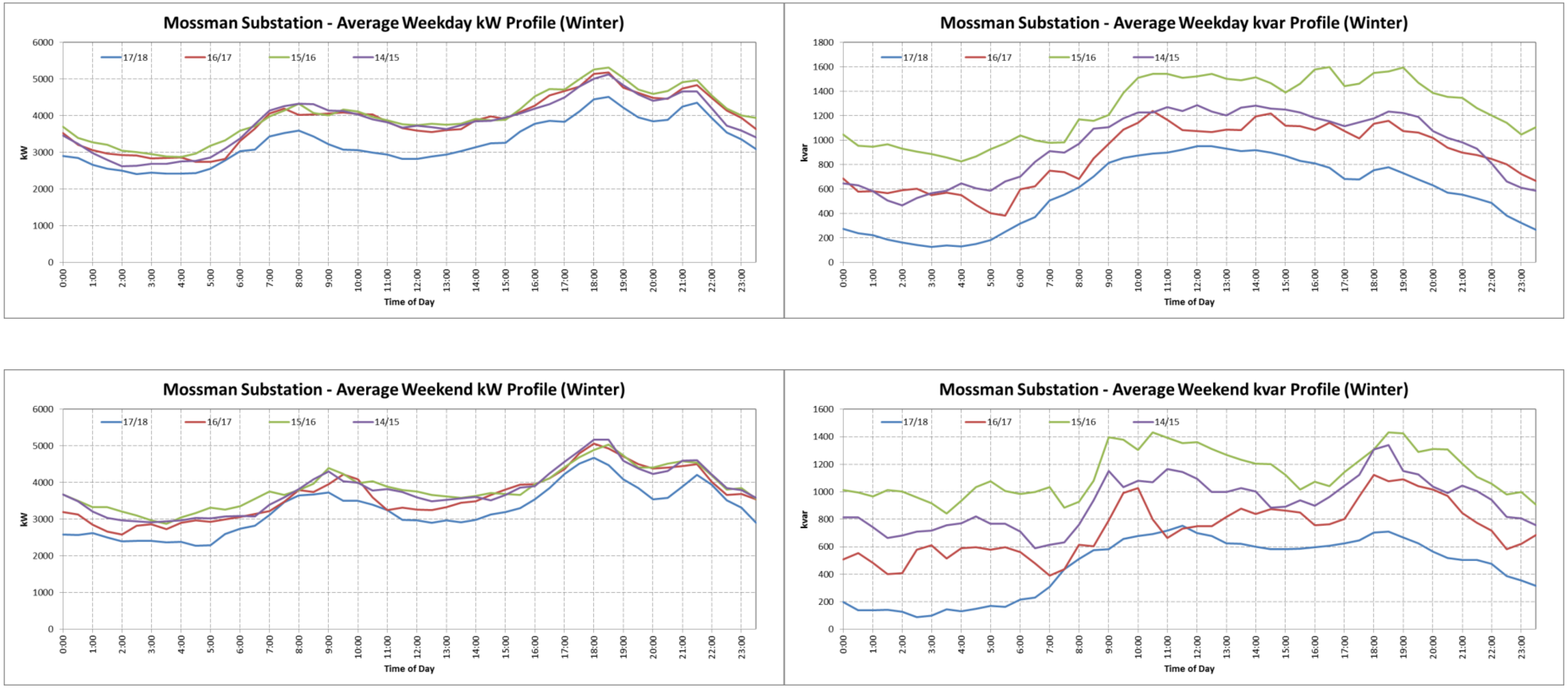



**Figure A6: MOSS average kW/kVAr loads- weekday/weekend Summer/Winter**

| Year | Summer Day MVA | Summer Day MW | Summer Day MVAR | Summer Day Comp | Summer Night MVA | Summer Night MW | Summer Night MVAR | Summer Night Comp | Winter Day MVA | Winter Day MW | Winter Day MVAR | Winter Day Comp | Winter Night MVA | Winter Night MW | Winter Night MVAR | Winter Night Comp | Peak |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2018 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.34 | 13.68 | 4.29 | 0.00 | 14.34 | 13.68 | 4.29 | 0.00 | WD |
| 2019 | 17.29 | 16.36 | 5.59 | 0.00 | 17.29 | 16.36 | 5.59 | 0.00 | 14.19 | 13.54 | 4.24 | 0.00 | 14.19 | 13.54 | 4.24 | 0.00 | SD |
| 2020 | 16.95 | 16.04 | 5.48 | 0.00 | 16.95 | 16.04 | 5.48 | 0.00 | 13.91 | 13.27 | 4.16 | 0.00 | 13.91 | 13.27 | 4.16 | 0.00 | SD |
| 2021 | 17.01 | 16.09 | 5.50 | 0.00 | 17.01 | 16.09 | 5.50 | 0.00 | 13.78 | 13.15 | 4.12 | 0.00 | 13.78 | 13.15 | 4.12 | 0.00 | SD |
| 2022 | 17.13 | 16.21 | 5.54 | 0.00 | 17.13 | 16.21 | 5.54 | 0.00 | 14.10 | 13.45 | 4.21 | 0.00 | 14.10 | 13.45 | 4.21 | 0.00 | SD |
| 2023 | 17.27 | 16.34 | 5.59 | 0.00 | 17.27 | 16.34 | 5.59 | 0.00 | 14.21 | 13.56 | 4.25 | 0.00 | 14.21 | 13.56 | 4.25 | 0.00 | SD |
| 2024 | 17.05 | 16.13 | 5.52 | 0.00 | 17.05 | 16.13 | 5.52 | 0.00 | 13.90 | 13.27 | 4.15 | 0.00 | 13.90 | 13.27 | 4.15 | 0.00 | SD |
| 2025 | 16.96 | 16.05 | 5.49 | 0.00 | 16.96 | 16.05 | 5.49 | 0.00 | 14.02 | 13.38 | 4.19 | 0.00 | 14.02 | 13.38 | 4.19 | 0.00 | SD |
| 2026 | 17.06 | 16.15 | 5.52 | 0.00 | 17.06 | 16.15 | 5.52 | 0.00 | 14.12 | 13.48 | 4.22 | 0.00 | 14.12 | 13.48 | 4.22 | 0.00 | SD |
| 2027 | 17.01 | 16.10 | 5.50 | 0.00 | 17.01 | 16.10 | 5.50 | 0.00 | 13.92 | 13.29 | 4.16 | 0.00 | 13.92 | 13.29 | 4.16 | 0.00 | SD |
| 2028 | 17.11 | 16.19 | 5.54 | 0.00 | 17.11 | 16.19 | 5.54 | 0.00 | 14.03 | 13.39 | 4.19 | 0.00 | 14.03 | 13.39 | 4.19 | 0.00 | SD |

**Figure A7: CRAI zone substation load forecast**

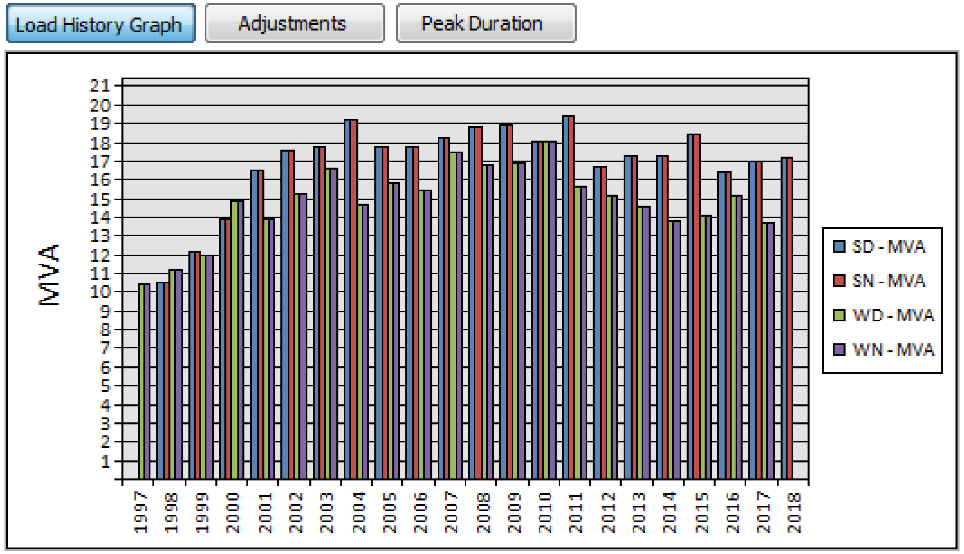



**Figure A8: CRAI zone substation – historical load including pre-CRAI**

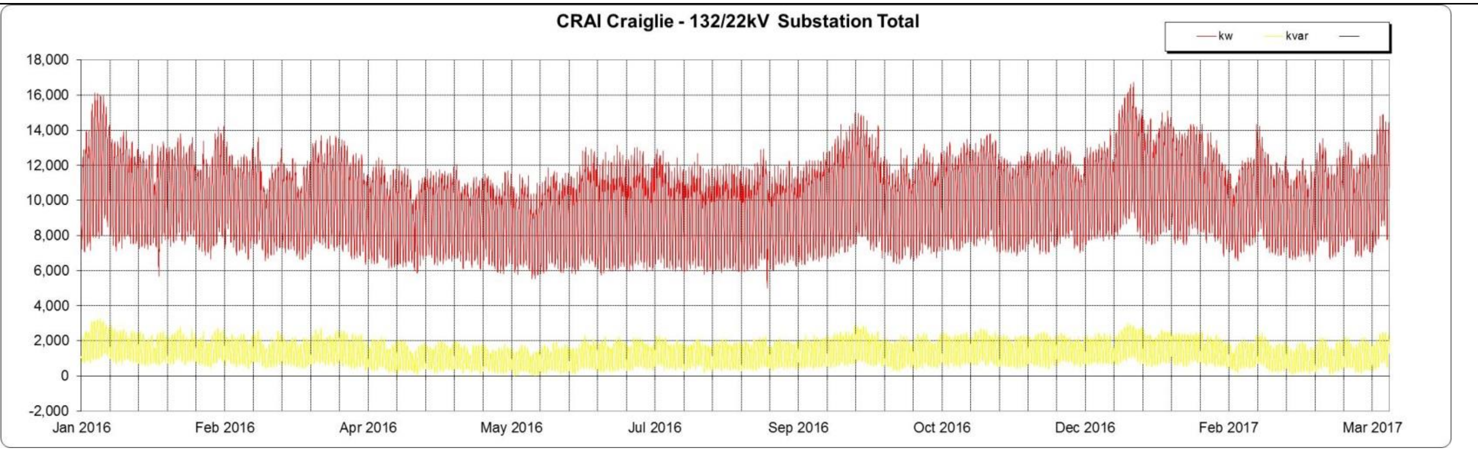



**Figure A9: CRAI actual load- 2016/17 period**

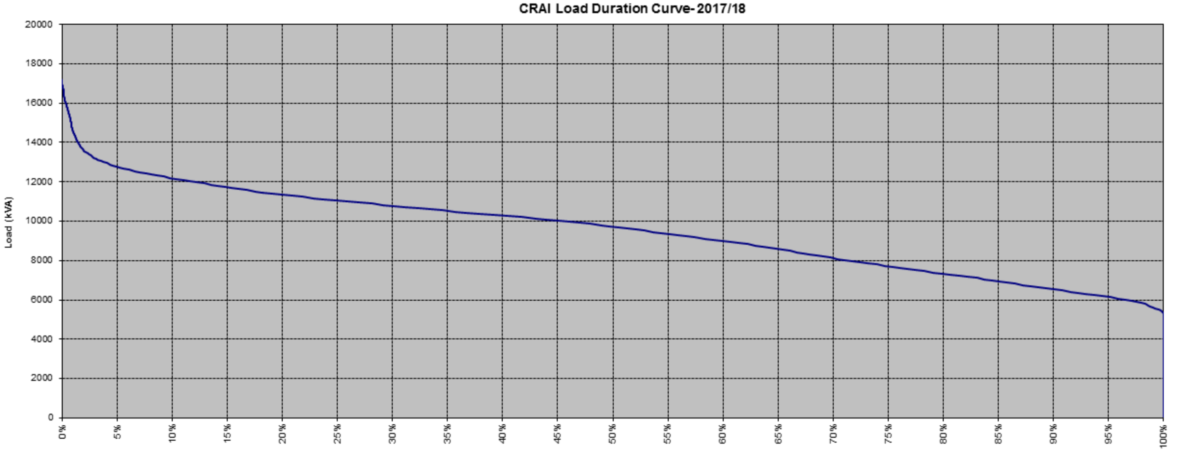
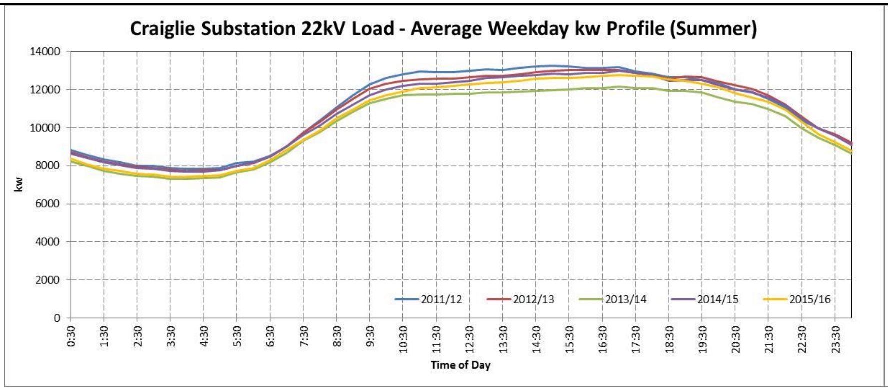
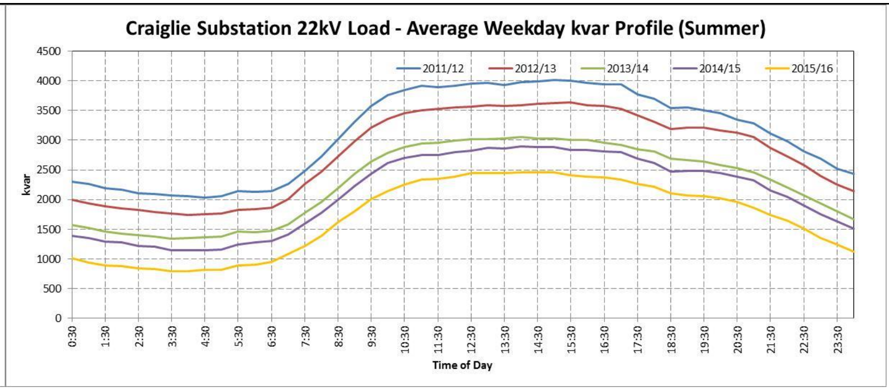
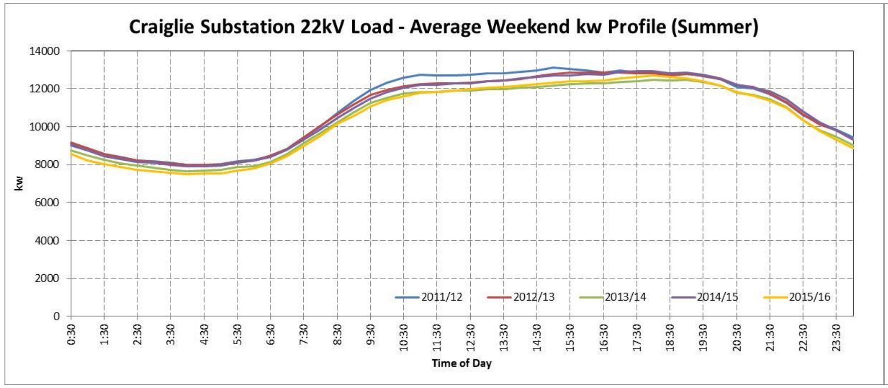


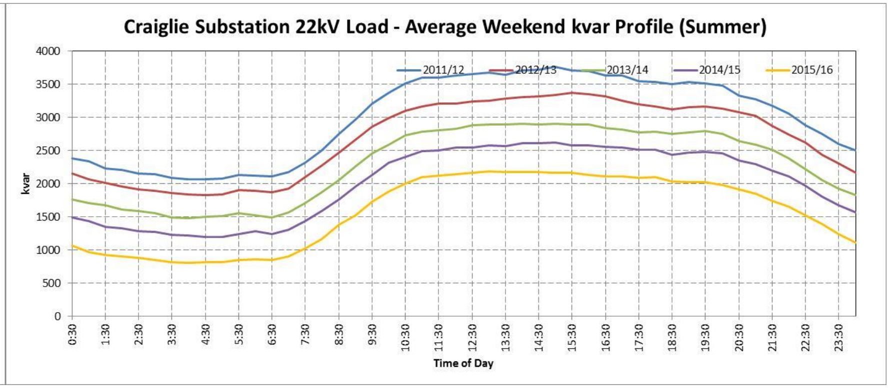

**Figure A10: CRAI actual load- load duration plot for 2016/17 period**

Planning Proposal



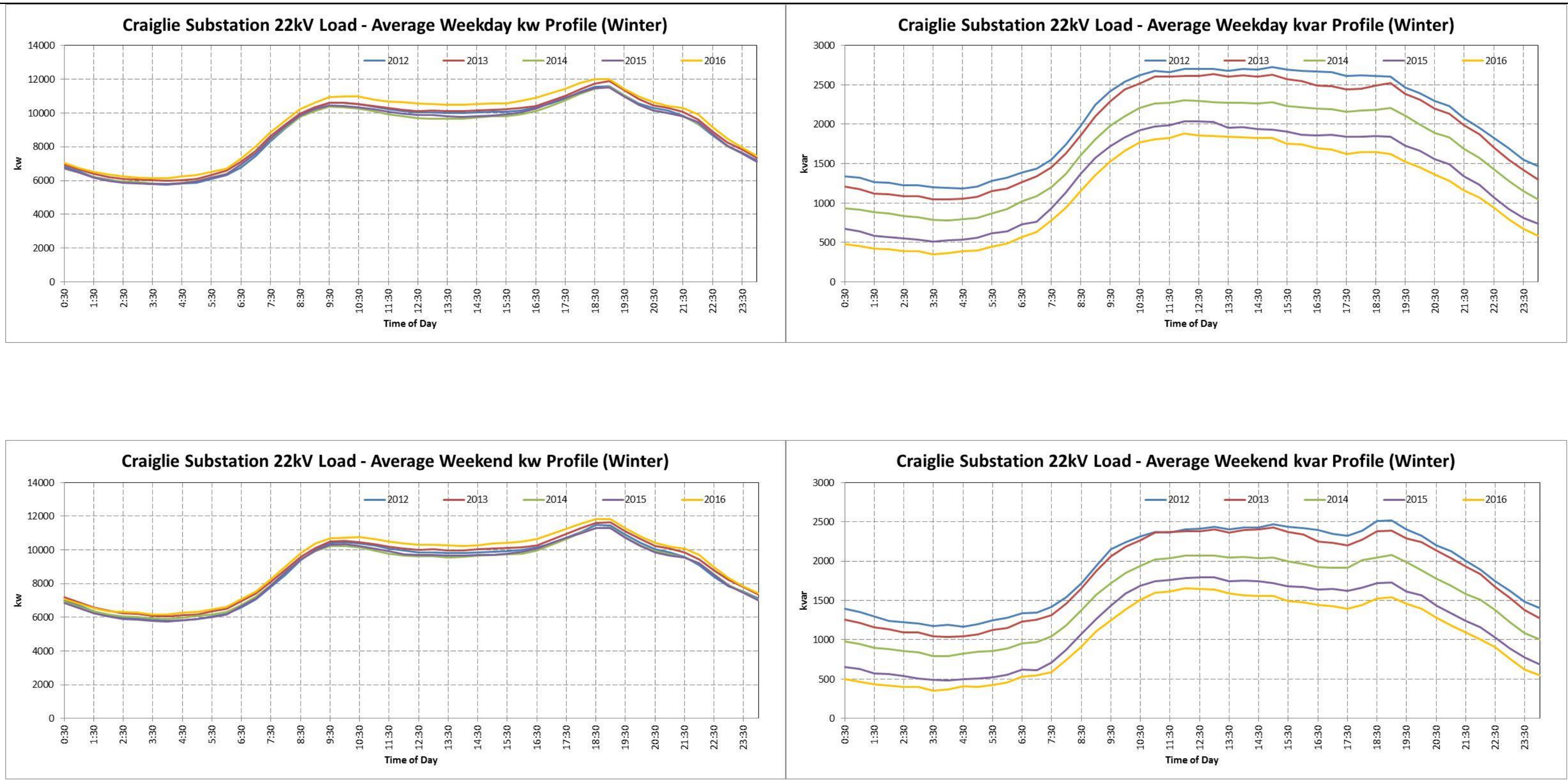



**Figure A11: CRAI average kW/kVAr loads- weekday/weekend Summer/Winter**

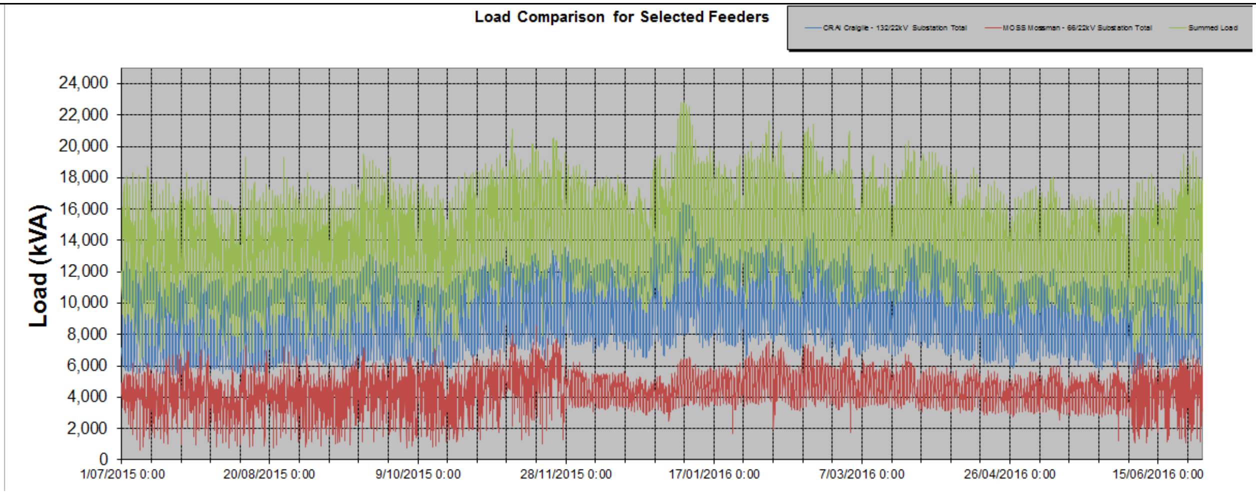



**Figure A12: Combined MOSS and CRAI 22 zone substation load (2015/16)**

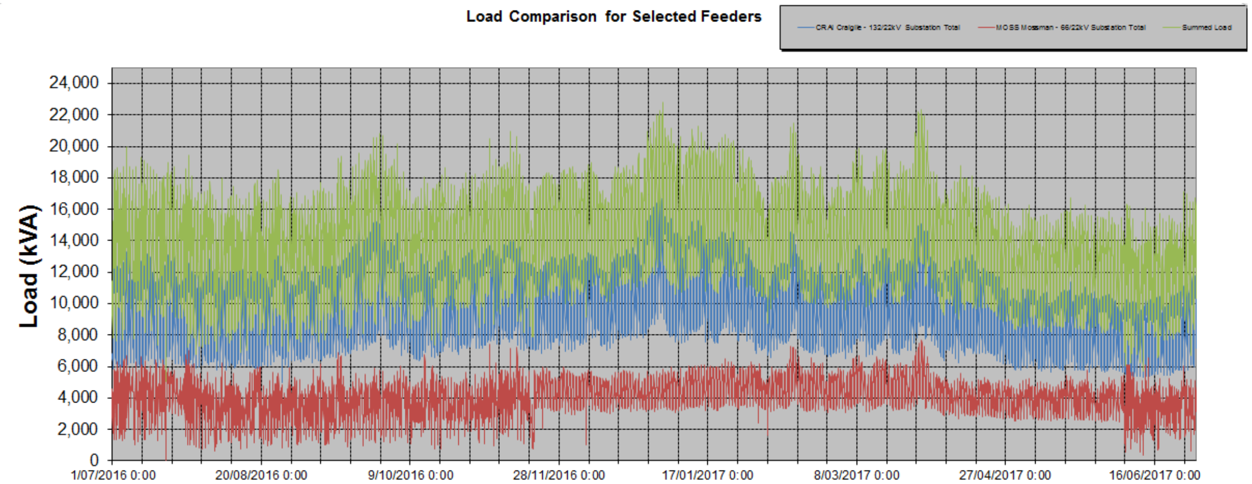



**Figure A13: Combined MOSS and CRAI 22 zone substation load (2016/17)**



Ergon Energy Corporation Limited ABN 50 087 646 062
Energy Queensland Limited ABN 96 612 535 583
Energex Limited ABN 40 078 849 055

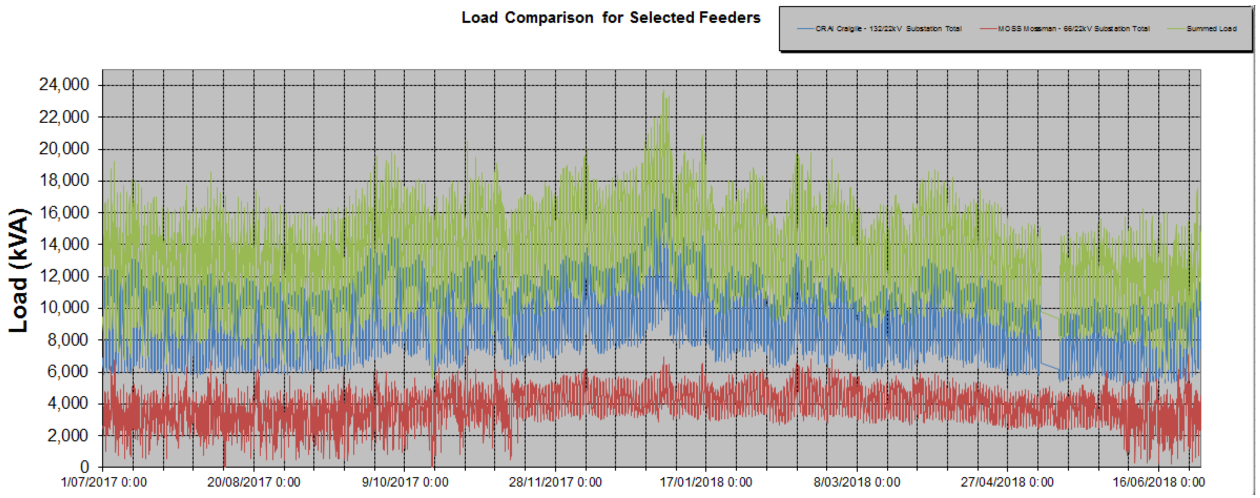



**Figure A14: Combined MOSS and CRAI 22 zone substation load (2017/18)**

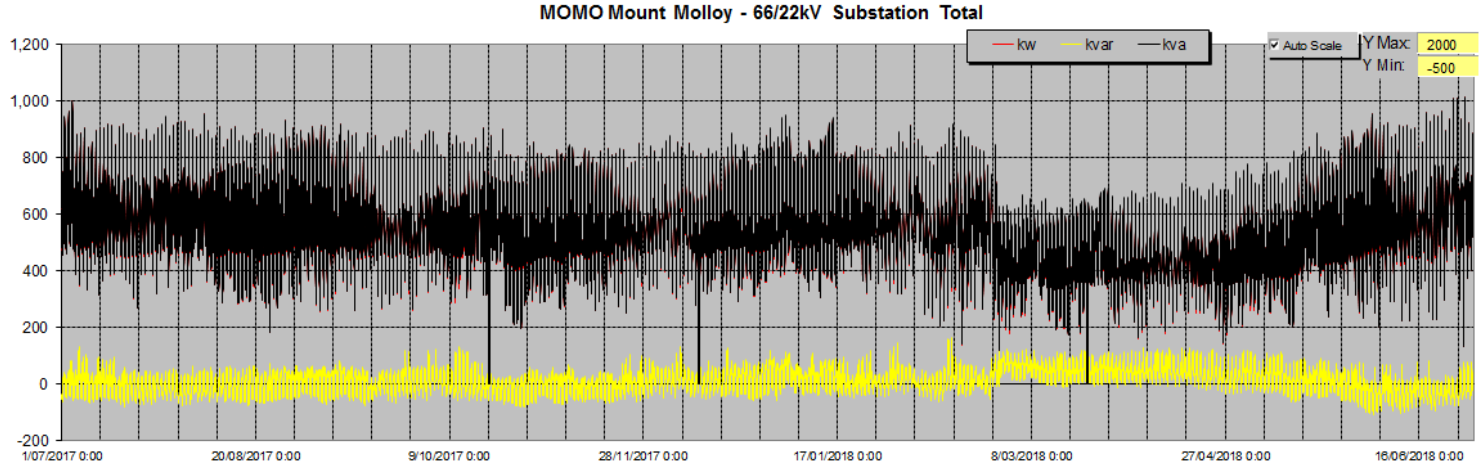



**Figure A15: MOMO actual load 2018/18 period**

Forecast | Fcast Graph | Load History | Daily Load Profile | Assessed Steps | Start Values | Coinc Factors | Ratings | Transfers | Growth Rates | Capacitors | CCDM | Embedded Gen | Block Loads | Source | At

Display Basis | Excel Export | Compare Forecasts: | Coincident Source: Local Peak | ☑ Reconciled | ☐ Network? | ☑ Compensated | ☑ Curtailable Demand Mngt

| Year | Summer Day | | | | Summer Night | | | | Winter Day | | | | Winter Night | | | | Peak |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MVA | MW | MVAR | Comp | MVA | MW | MVAR | Comp | MVA | MW | MVAR | Comp | MVA | MW | MVAR | Comp | |
| 2018 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.07 | 1.04 | 0.26 | 0.00 | 1.07 | 1.04 | 0.26 | 0.00 | WD |
| 2019 | 1.00 | 0.95 | 0.30 | 0.00 | 1.00 | 0.95 | 0.30 | 0.00 | 1.06 | 1.03 | 0.26 | 0.00 | 1.06 | 1.03 | 0.26 | 0.00 | WD |
| 2020 | 0.98 | 0.93 | 0.30 | 0.00 | 0.98 | 0.93 | 0.30 | 0.00 | 1.04 | 1.01 | 0.26 | 0.00 | 1.04 | 1.01 | 0.26 | 0.00 | WD |
| 2021 | 0.98 | 0.94 | 0.30 | 0.00 | 0.98 | 0.94 | 0.30 | 0.00 | 1.03 | 1.00 | 0.25 | 0.00 | 1.03 | 1.00 | 0.25 | 0.00 | WD |
| 2022 | 0.99 | 0.94 | 0.30 | 0.00 | 0.99 | 0.94 | 0.30 | 0.00 | 1.05 | 1.02 | 0.26 | 0.00 | 1.05 | 1.02 | 0.26 | 0.00 | WD |
| 2023 | 1.00 | 0.95 | 0.30 | 0.00 | 1.00 | 0.95 | 0.30 | 0.00 | 1.06 | 1.03 | 0.26 | 0.00 | 1.06 | 1.03 | 0.26 | 0.00 | WD |
| 2024 | 0.98 | 0.94 | 0.30 | 0.00 | 0.98 | 0.94 | 0.30 | 0.00 | 1.04 | 1.01 | 0.26 | 0.00 | 1.04 | 1.01 | 0.26 | 0.00 | WD |
| 2025 | 0.98 | 0.93 | 0.30 | 0.00 | 0.98 | 0.93 | 0.30 | 0.00 | 1.05 | 1.01 | 0.26 | 0.00 | 1.05 | 1.01 | 0.26 | 0.00 | WD |
| 2026 | 0.99 | 0.94 | 0.30 | 0.00 | 0.99 | 0.94 | 0.30 | 0.00 | 1.05 | 1.02 | 0.26 | 0.00 | 1.05 | 1.02 | 0.26 | 0.00 | WD |
| 2027 | 0.98 | 0.94 | 0.30 | 0.00 | 0.98 | 0.94 | 0.30 | 0.00 | 1.04 | 1.01 | 0.26 | 0.00 | 1.04 | 1.01 | 0.26 | 0.00 | WD |
| 2028 | 0.99 | 0.94 | 0.30 | 0.00 | 0.99 | 0.94 | 0.30 | 0.00 | 1.05 | 1.02 | 0.26 | 0.00 | 1.05 | 1.02 | 0.26 | 0.00 | WD |

**Figure A16: MOMO zone substation load forecast**

| ASSET NO | ASSET NAME | MD DAY SUM KVA | MD EVENING SUM KVA | MD NIGHT SUM KVA | PREV MD DAY SUM KVA | PREV MD EVENIN G SUM KVA | PREV MD NIGHT SUM KVA | MD DAY WIN KVA | MD EVENING WIN KVA | MD NIGHT WIN KVA | PREV MD DAY WIN KVA | PREV MD EVENIN G WIN KVA | PREV MD NIGHT WIN KVA | MD DAY SUM AMPS | MD EVENING SUM AMPS | MD NIGHT SUM AMPS | MD DAY WIN AMPS | MD EVENING WIN AMPS | MD NIGHT WIN AMPS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2CAS | CASSOWARY | 178 | 198 | 134 | 174 | 213 | 178 | 138 | 158 | 110 | 127 | 158 | 149 | 5 | 5 | 4 | 4 | 4 | 3 |
| 2MOS | MOSSMAN | 4630 | 3941 | 4475 | 5269 | 4752 | 4550 | 4499 | 4349 | 4104 | 4799 | 4420 | 4063 | 122 | 103 | 117 | 118 | 114 | 108 |
| 2DAI | DAINTREE | 2852 | 3560 | 3105 | 2852 | 3560 | 3105 | 2121 | 2536 | 2407 | 2121 | 2536 | 2407 | 75 | 93 | 81 | 56 | 67 | 63 |
| 2SCK | STEWART CREEK | 215 | 288 | 231 | 200 | 216 | 185 | 169 | 210 | 182 | 178 | 206 | 199 | 6 | 8 | 6 | 4 | 6 | 5 |

**Table A1: MOSS 22 feeder peaks (2016/17, 2017/18)**

| ASSET NO | ASSET NAME | MD DAY SUM KVA | MD EVENING SUM KVA | MD NIGHT SUM KVA | PREV MD DAY SUM KVA | PREV MD EVENING SUM KVA | PREV MD NIGHT SUM KVA | MD DAY WIN KVA | MD EVENING WIN KVA | MD NIGHT WIN KVA | PREV MD DAY WIN KVA | PREV MD EVENING WIN KVA | PREV MD NIGHT WIN KVA | MD DAY SUM AMPS | MD EVENING SUM AMPS | MD NIGHT SUM AMPS | MD DAY WIN AMPS | MD EVENING WIN AMPS | MD NIGHT WIN AMPS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2INL | INLET | 2500 | 2545 | 2129 | 2284 | 2366 | 2150 | 1820 | 1829 | 1744 | 1965 | 2047 | 1840 | 66 | 67 | 56 | 48 | 48 | 46 |
| 2FOM | FOUR MILE BEACH | 5212 | 5101 | 3225 | 5240 | 5360 | 4668 | 3858 | 3924 | 1765 | 3943 | 4118 | 3403 | 137 | 134 | 85 | 101 | 103 | 46 |
| 2OAB | OAK BEACH | 1157 | 1244 | 989 | 1201 | 1206 | 1046 | 984 | 1038 | 989 | 1037 | 1013 | 973 | 30 | 33 | 26 | 26 | 27 | 26 |
| 2REE | REEF PARK | 5949 | 5711 | 4218 | 5836 | 5823 | 4937 | 4564 | 4547 | 3598 | 4776 | 4744 | 3881 | 156 | 150 | 111 | 120 | 119 | 94 |
| 2GLK | GOLF LINKS | 2747 | 2792 | 2164 | 2742 | 2822 | 2429 | 1785 | 1986 | 1525 | 1705 | 1975 | 1620 | 72 | 73 | 57 | 47 | 52 | 40 |

**Table A2: CRAI 22 feeder peaks (2016/17, 2017/18)**

| Feeder | Line route length (km) | Distribution Transformer Connected Capacity (MVA) | IES (no.) |
|---|---|---|---|
| **Mossman 66/22 kV zone substation, 22 kV feeders** | | | |
| **2MOS** | 28.0 | 16.08 | 168 |
| **2SCK** | 76.9 | 1.63 | 12 |
| **2CAS** | 15.3 | 0.66 | 26 |
| **2DAI** | 135.9 | 19.46 | 342 |
| **TOTAL** | **256.1** | **37.84** | **548** |
| | | | |
| **Feeder** | **Line route length (km)** | **Distribution Transformer Connected Capacity (MVA)** | **IES (no.)** |
| **Craiglie 132/22 kV zone substation, 22 kV feeders** | | | |
| **2REE** | 11.1 | 13.53 | 64 |
| **2INL** | 18.9 | 8.58 | 23 |
| **2FOM** | 13.4 | 13.42 | 50 |
| **2OAB** | 36.1 | 7.59 | 66 |
| **2GLK** | 6.64 | 6.06 | 121 |
| **TOTAL** | **86.2** | **49.18** | **324** |

**Table A3: Feeder General Data (NetDash)**

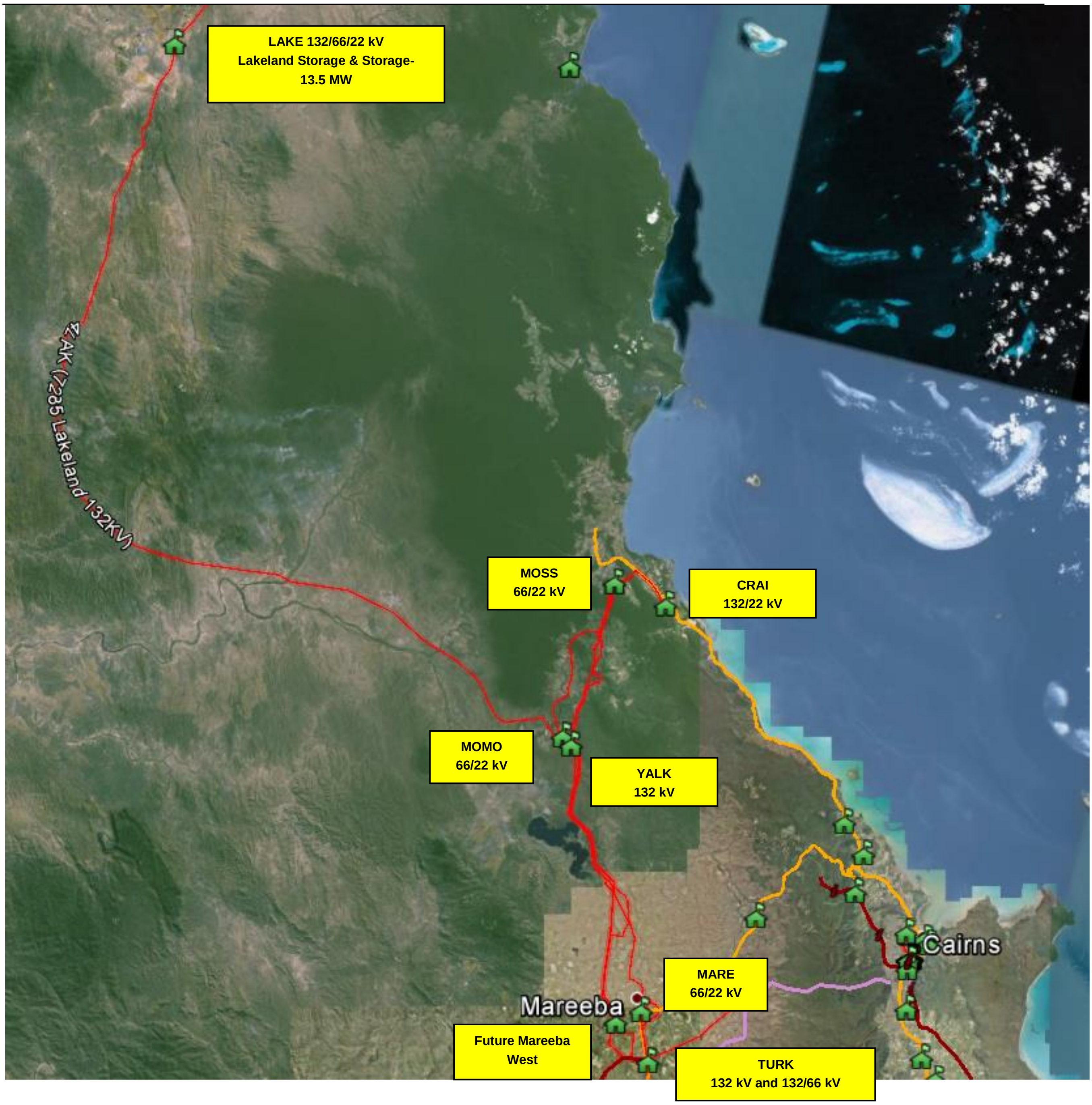



**Figure A17: Geographical Current State (132 & 66 kV lines and Substations)**

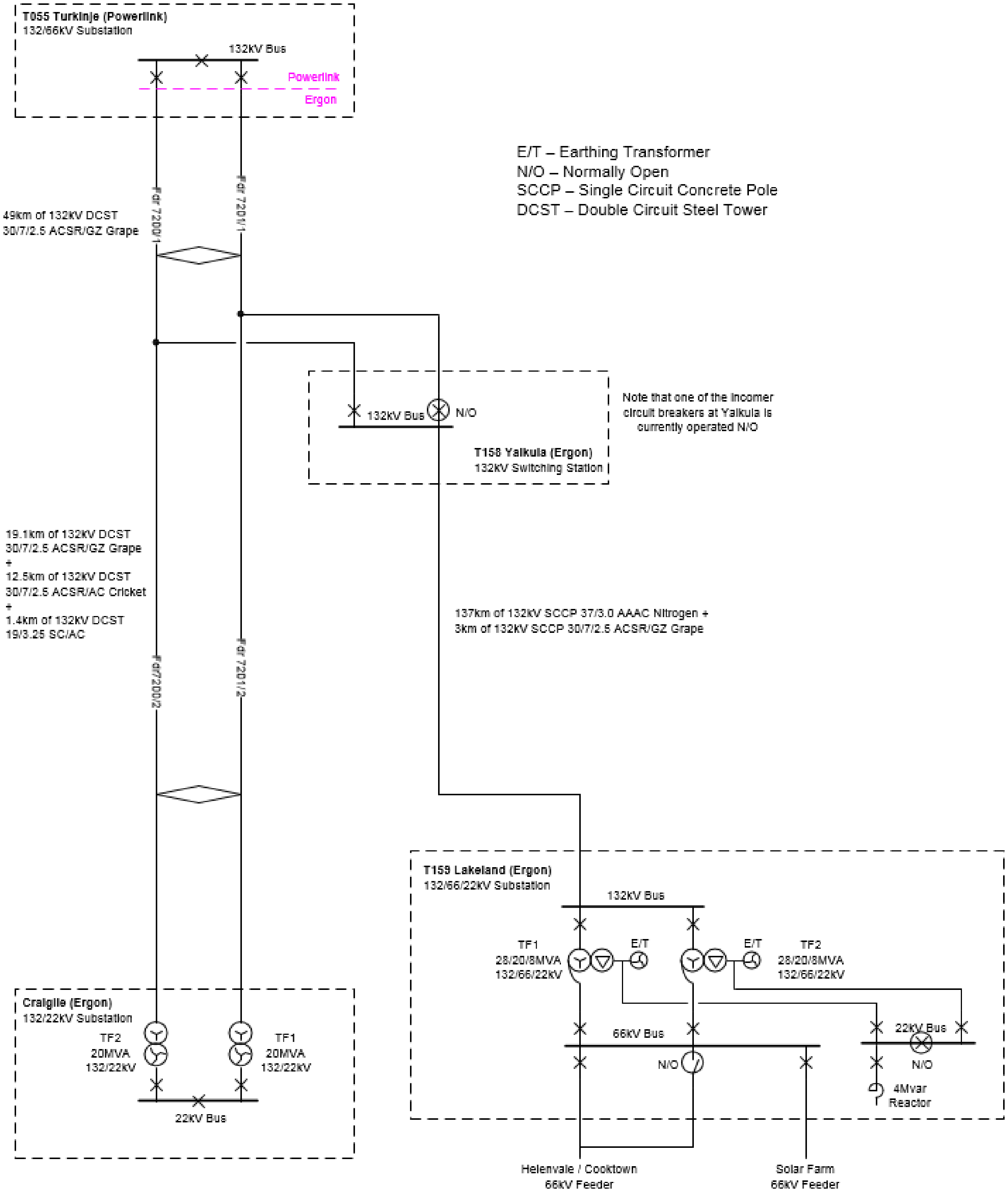
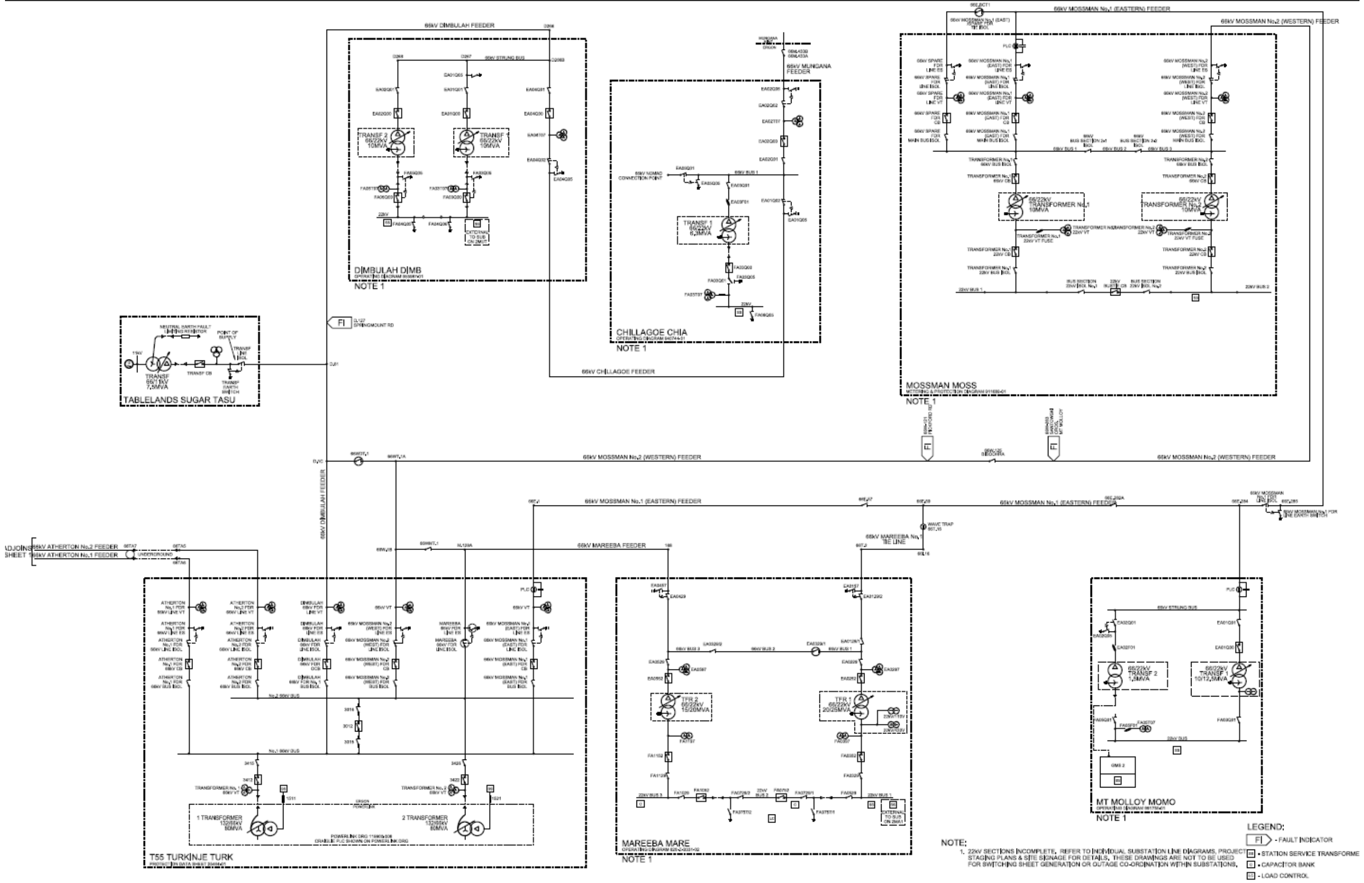



**Figure A18: Electrical Current State (132 kV lines and Substations)**




Mossman Sugar Mill supplied from MOSS 22 kV embedded lines

**Figure A19: Electrical Current State- Turkinje 66 kV (TURK) to Mareeba (MARE), Mount Molloy (MOMO) and Mossman (MOSS) substations**

ERGON ENERGY FN
REGION ZONE SUBST

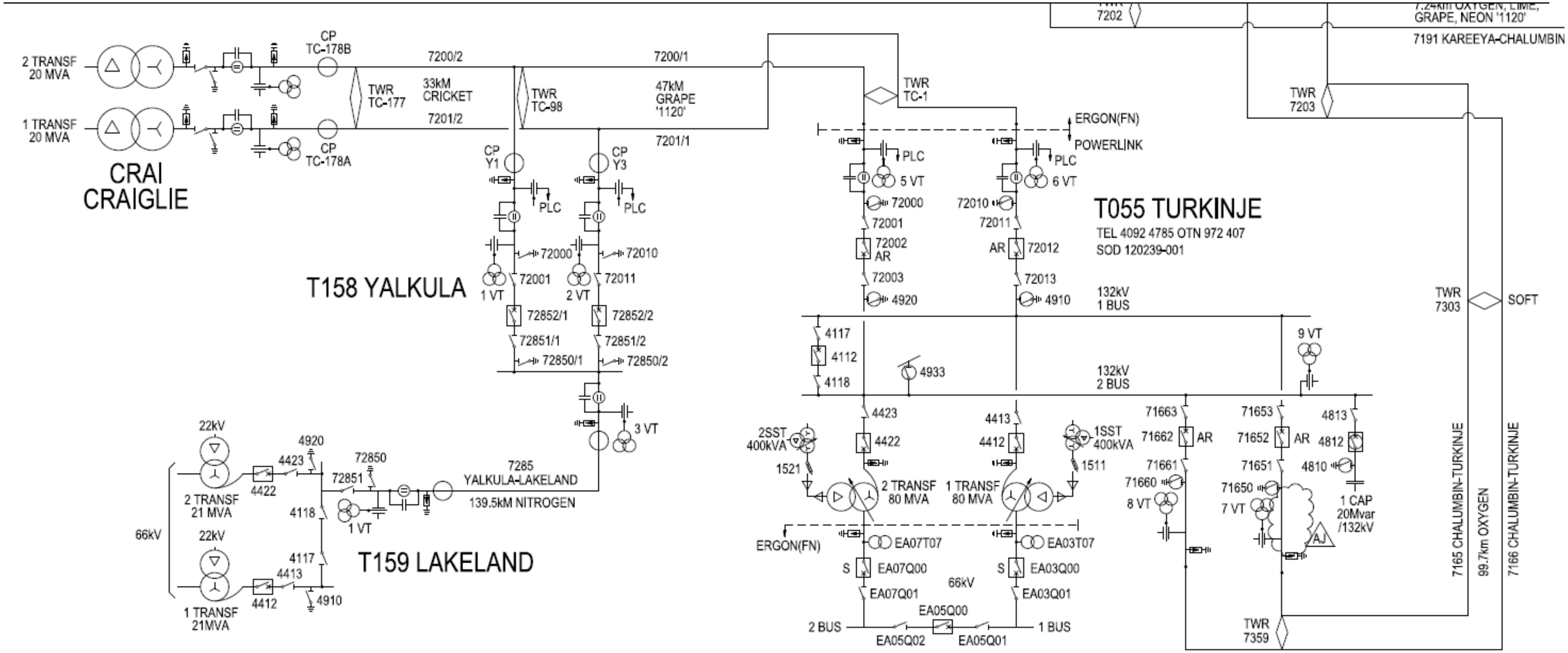



Figure A20: Electrical Schematic 132 kV TURK network

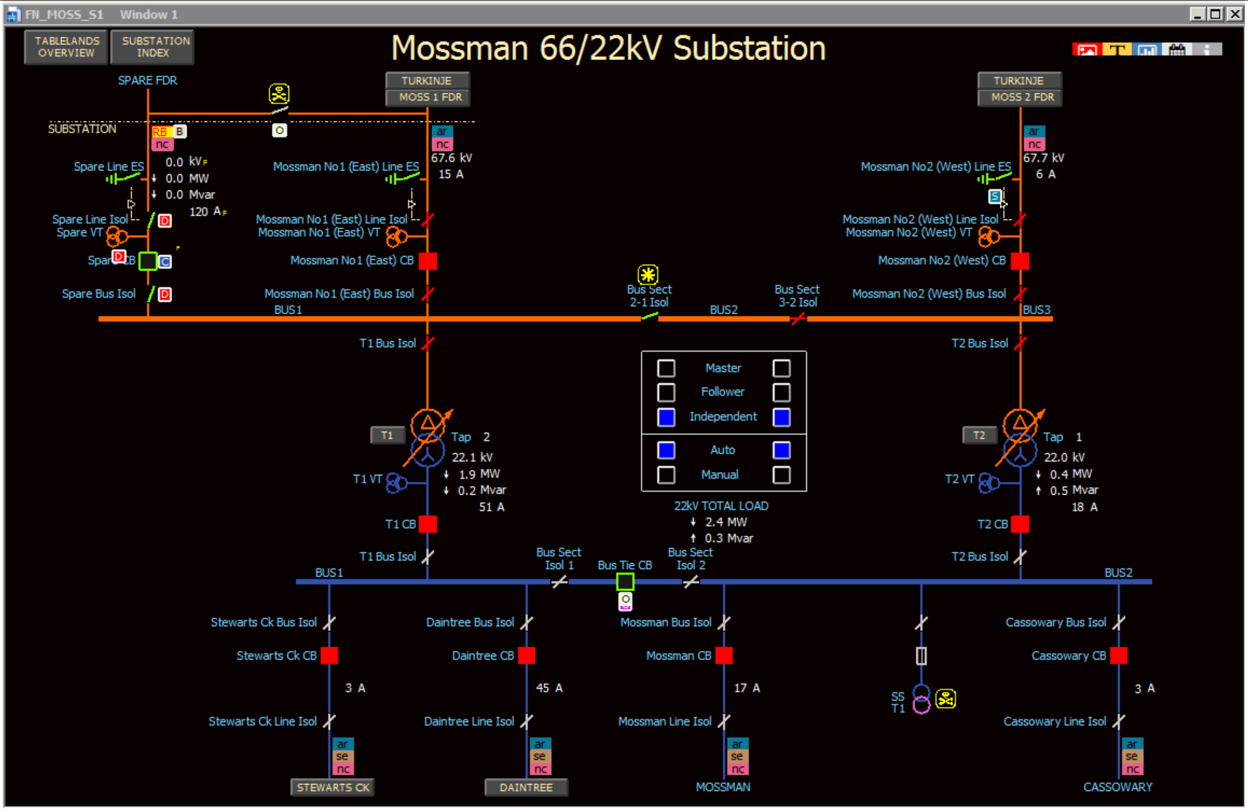



**Figure A21: MOSS: 66/22 kV Zone Substation (Ergon Mossman substation)**

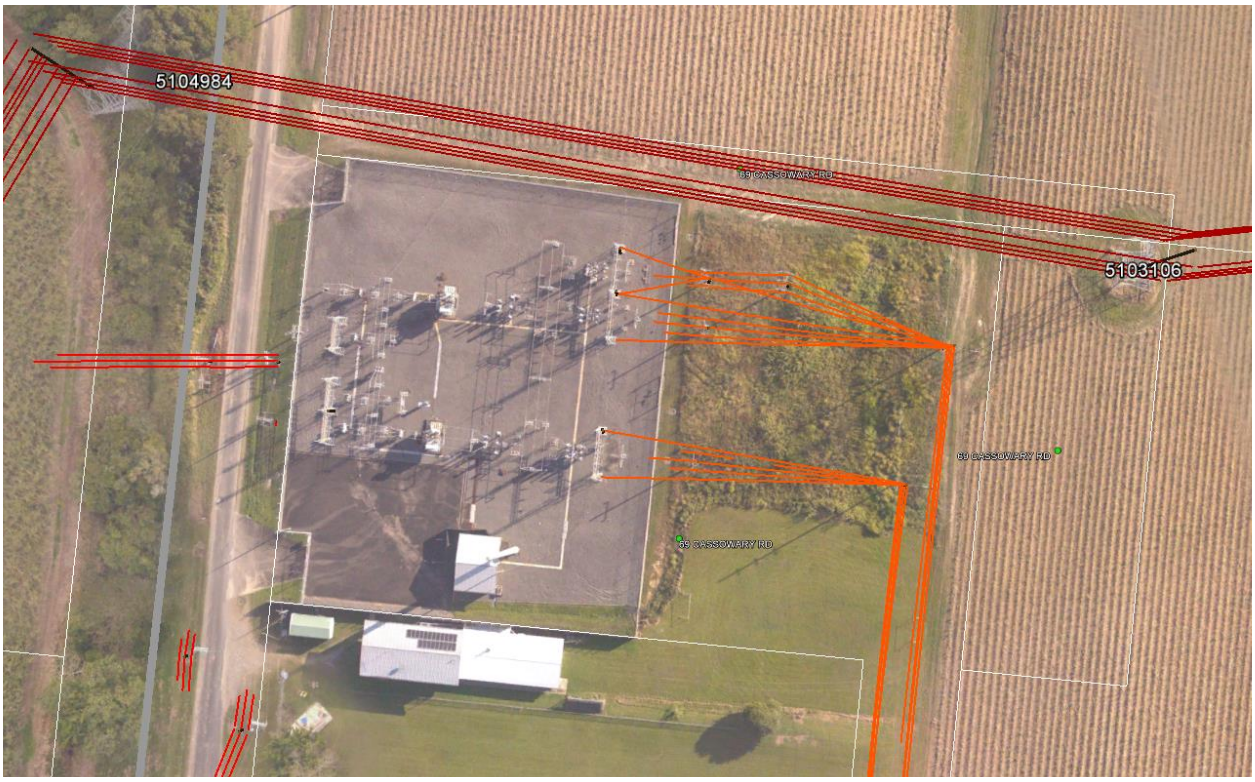



**Figure A22: MOSS: 66/22 kV Zone Substation (Geographical)**

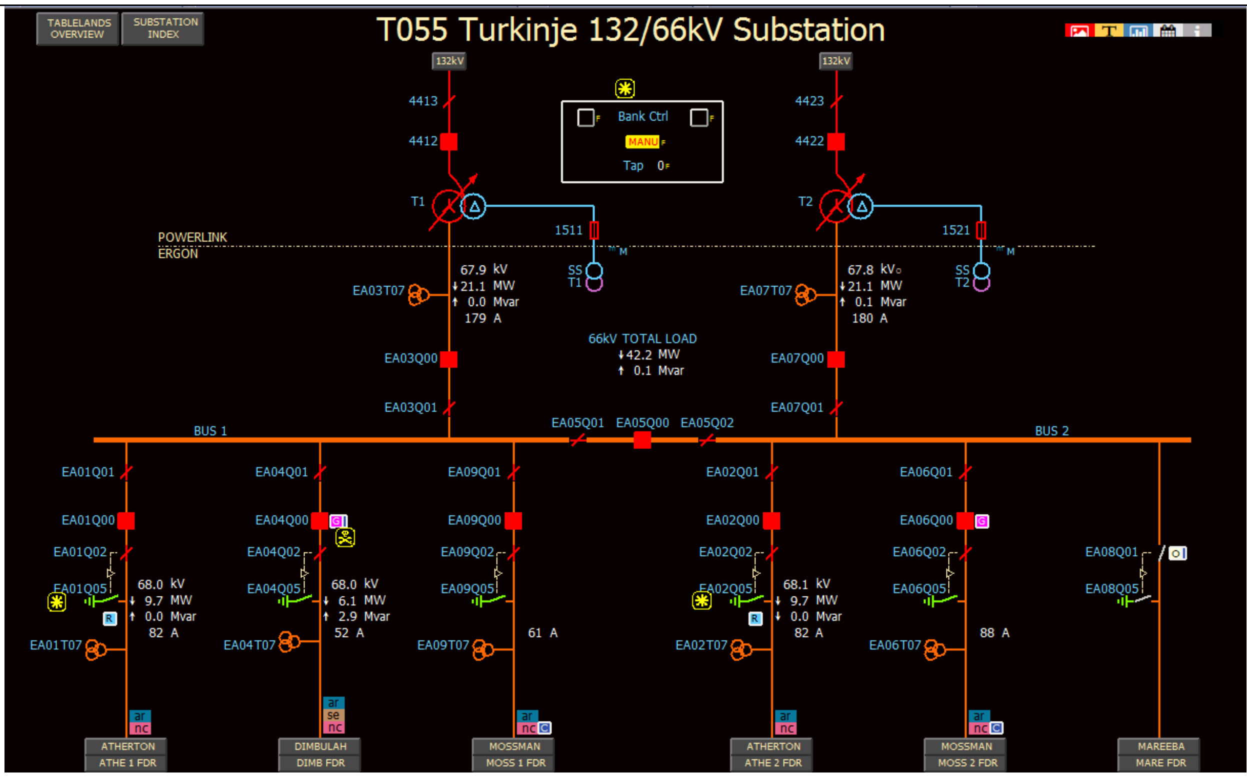



**Figure A23: TURK:132/66 Substation - Ergon Connection Points (132 & 66kV) with Powerlink**

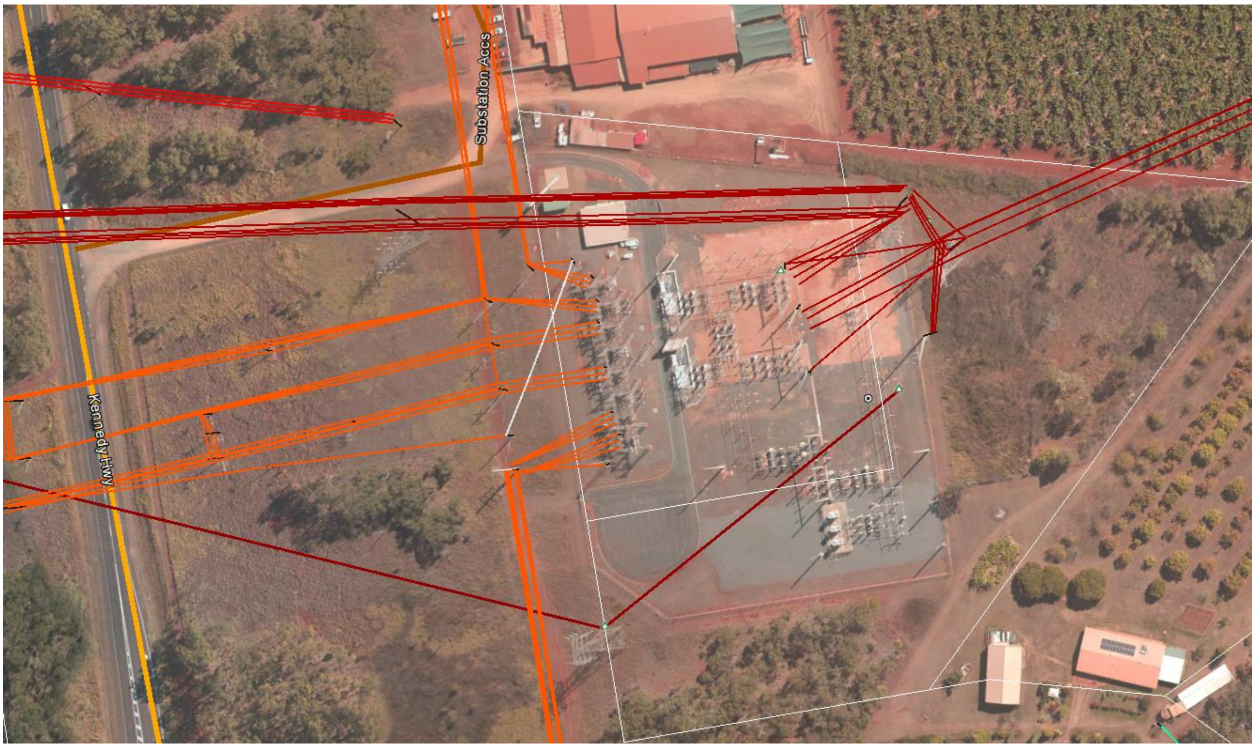



**Figure A24: TURK:132/66 Substation (Turkinje)- Ergon and Powerlink (132 & 66kV)**

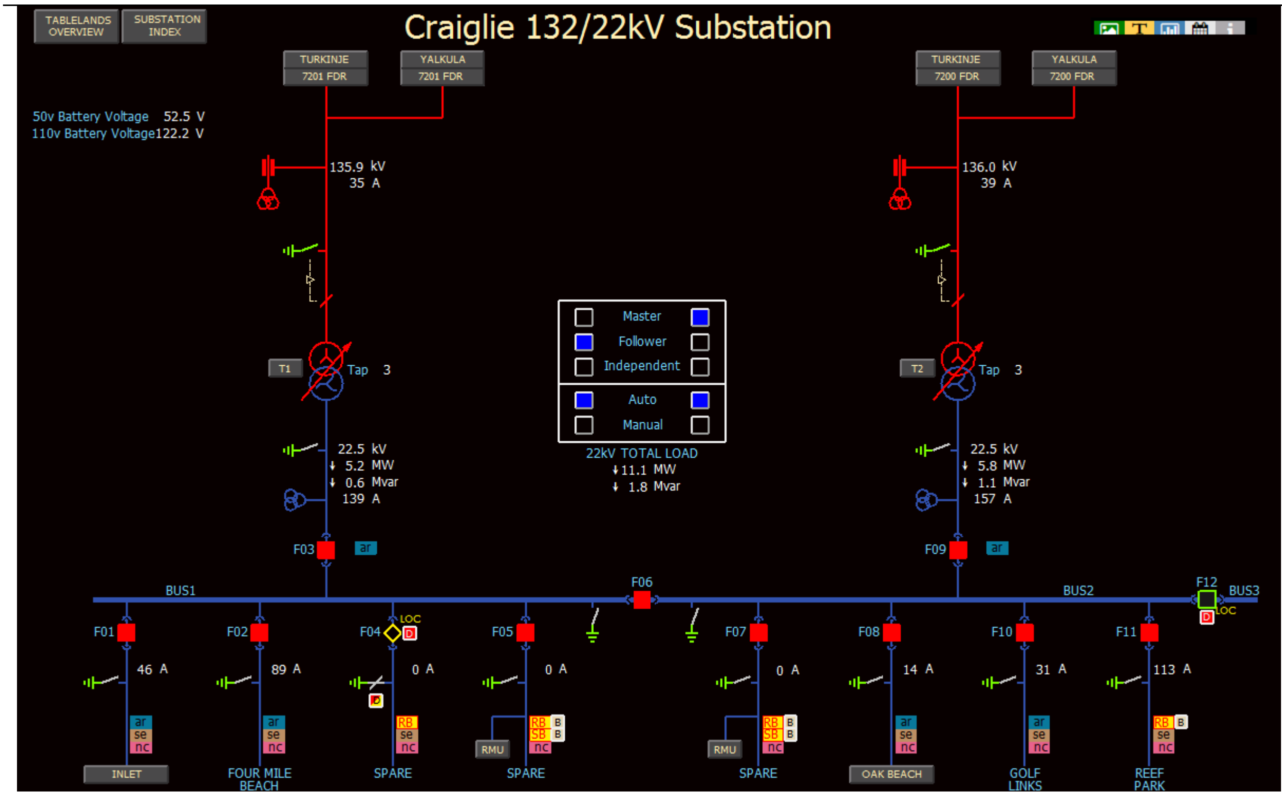



**Figure A25: CRAI: 132/22 kV Zone Substation (Ergon Craiglie substation)**

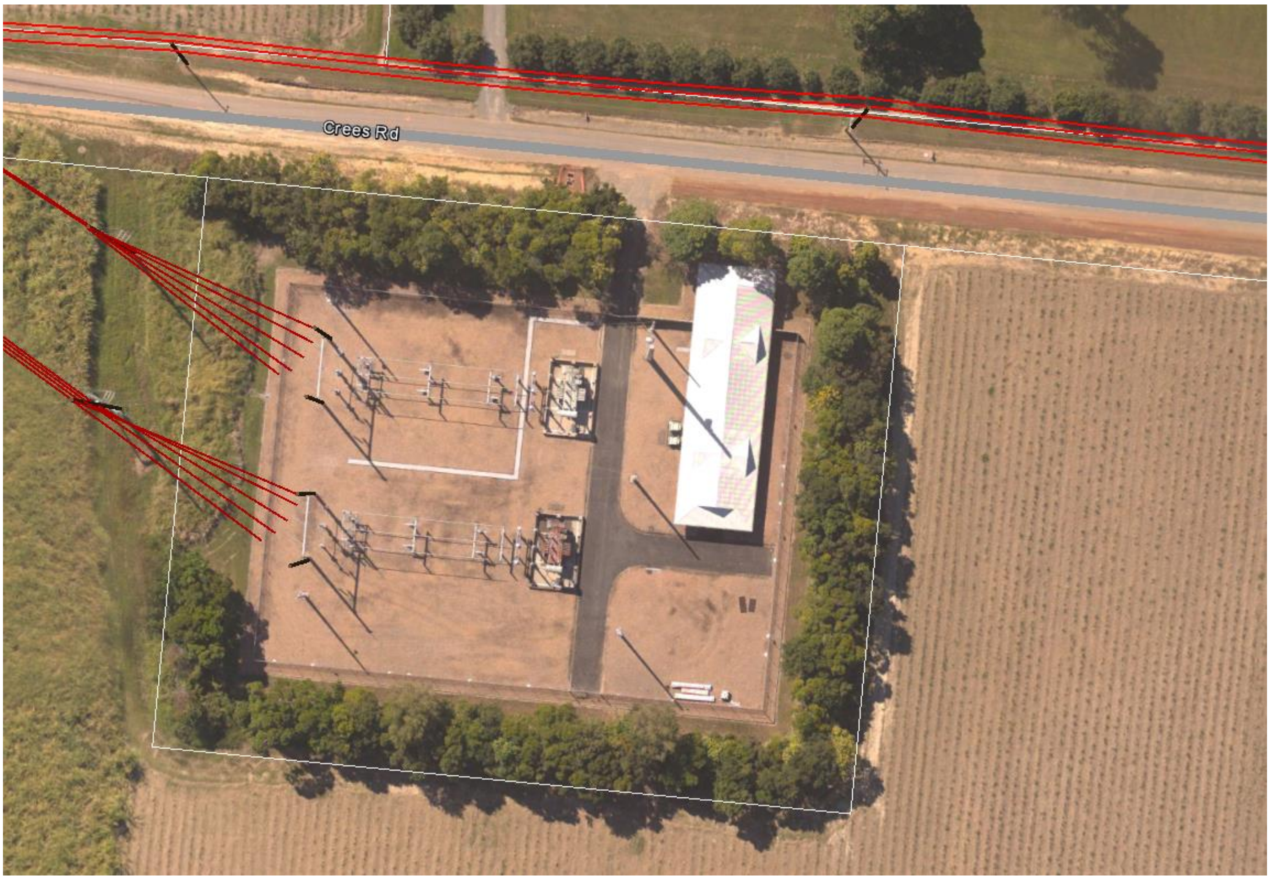



**Figure A26: CRAI: 132/22 kV Zone Substation (Geographical)**

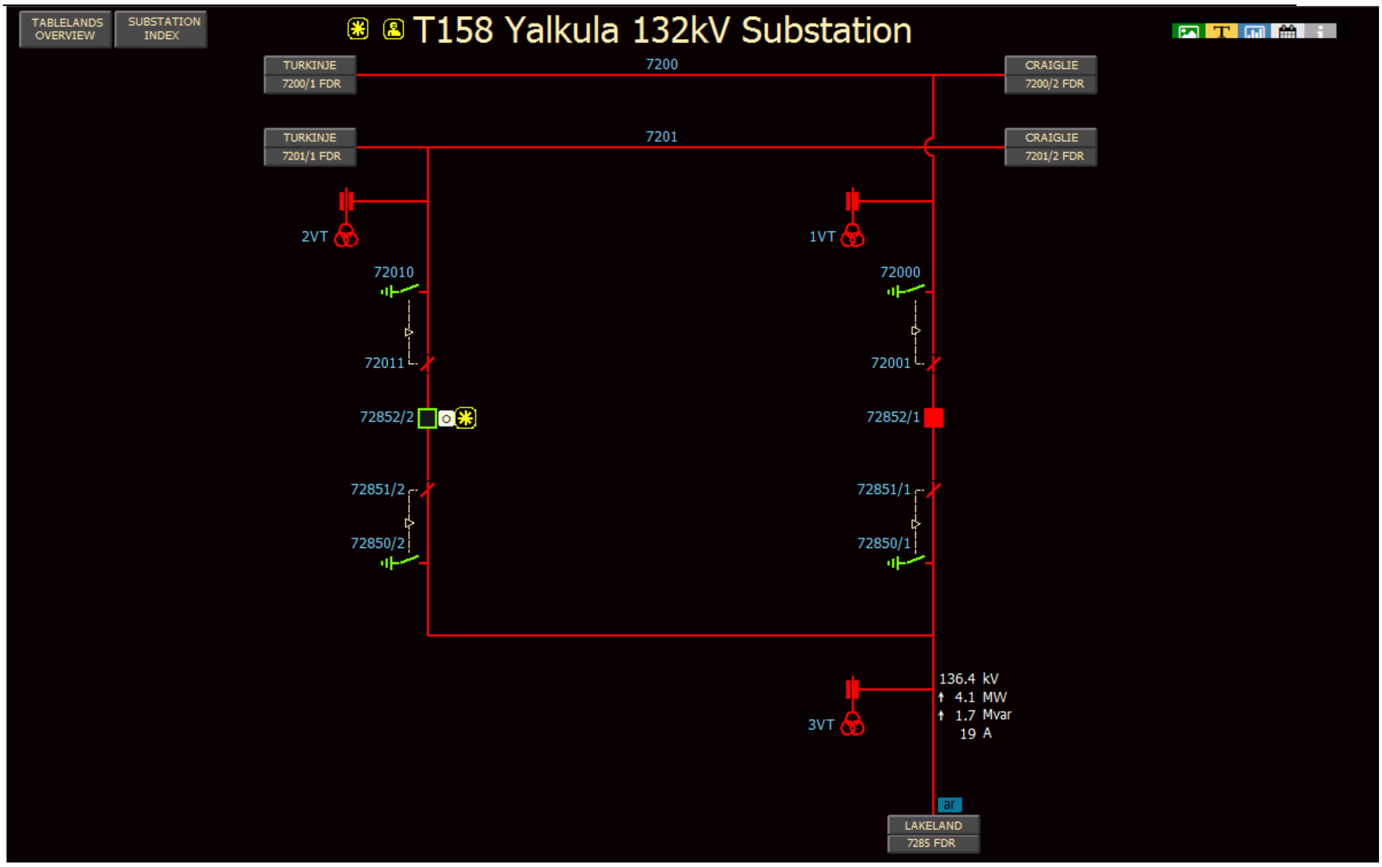


Figure A27: YALK: 132 kV Switching Substation (Ergon Yalkula substation)

Figure A28: YALK: 132 kV Switching Substation (geographical)

# 11. APPENDIX B: VCR VALUE ANALYSIS

| Feeder | Domestic | Commercial/Industrial | Total Customers |
|---|---|---|---|
| **Mossman 66/22 kV zone substation, 22 kV feeders** | | | |
| **2MOS** | 946 | 251 | 1197 |
| **2SCK** | 77 | 24 | 101 |
| **2CAS** | 88 | 9 | 97 |
| **2DAI** | 1723 | 130 | 1853 |
| **TOTAL** | **2834** | **414** | **3248** |
| | | | |
| **Feeder** | **Domestic** | **Commercial/Industrial** | **Total Customers** |
| **Craiglie 132/22 kV zone substation, 22 kV feeders** | | | |
| **2REE** | 691 | 230 | 921 |
| **2INL** | 567 | 77 | 644 |
| **2FOM** | 1154 | 174 | 1328 |
| **2OAB** | 401 | 133 | 534 |
| **2GLK** | 825 | 32 | 857 |
| **TOTAL** | **3638** | **646** | **4284** |

**Table B1: Customer Number Breakdown (NETDASH)**

| Sector | $/kWh | VCR ($/MWh) |
|---|---|---|
| Domestic | $25 | $25,420 |
| Commercial | $45 | $44,720 |
| Industrial | $44 | $44,060 |
| Rural | $48 | $47,670 |

**Table B2: AEMO VCR Values (AEMO VCR FACT SHEET)**

$$VCR = \frac{(Domestic\ No.of\ Customers\ x\ VCR\ value) + (Industrial\ No.of\ Customers\ x\ VCR\ value)}{Total\ number\ of\ Customers}$$

$$VCR\ (CRAI) =\approx \$28/kWh$$

$$VCR\ (CRAI) = \frac{(646\ x\ 44) + (3638\ x\ 25)}{4284}$$

$$VCR\ (MOSS) =\approx \$27/kWh$$

$$VCR\ (CRAI) = \frac{(414\ x\ 44) + (2834\ x\ 25)}{3248}$$

CRAI: Total Customers of 4284

- 3638 domestic customers;
- 646 industrial/commercial customers; and
- $28/kWh.

MOSS: Total Customers of 3248

- 2834 domestic customers;
- 414 industrial/commercial customers; and
- $27/kWh.

# 12. APPENDIX C: FINANCIAL ANALYSIS

The NPV below were calculated on the past capital and maintenance costs, estimated replacement costs and options estimates.

| $ Millions | Base Case | Option A | Option B | Option C |
|---|---|---|---|---|
| Capex | (11.10) | (11.77) | (12.99) | (12.16) |
| Opex | (3.48) | (1.80) | (2.01) | (1.62) |
| Direct Benefits | 0.00 | 0.00 | 0.00 | 0.00 |
| **Commercial NPV** | **(14.58)** | **(13.57)** | **(15.01)** | **(13.79)** |
| *Ranking* | *3* | *1* | *4* | *2* |
| | | | | |
| Indirect/Risk | 0.00 | 0.00 | 0.00 | 0.00 |
| **Commercial + Risk** | **(14.58)** | **(13.57)** | **(15.01)** | **(13.79)** |
| *Ranking* | *3* | *1* | *4* | *2* |

**Table C1: NPV of Options (15 yr C3 cycle for BAU but excluding potential generator connection savings in 2021/22)**

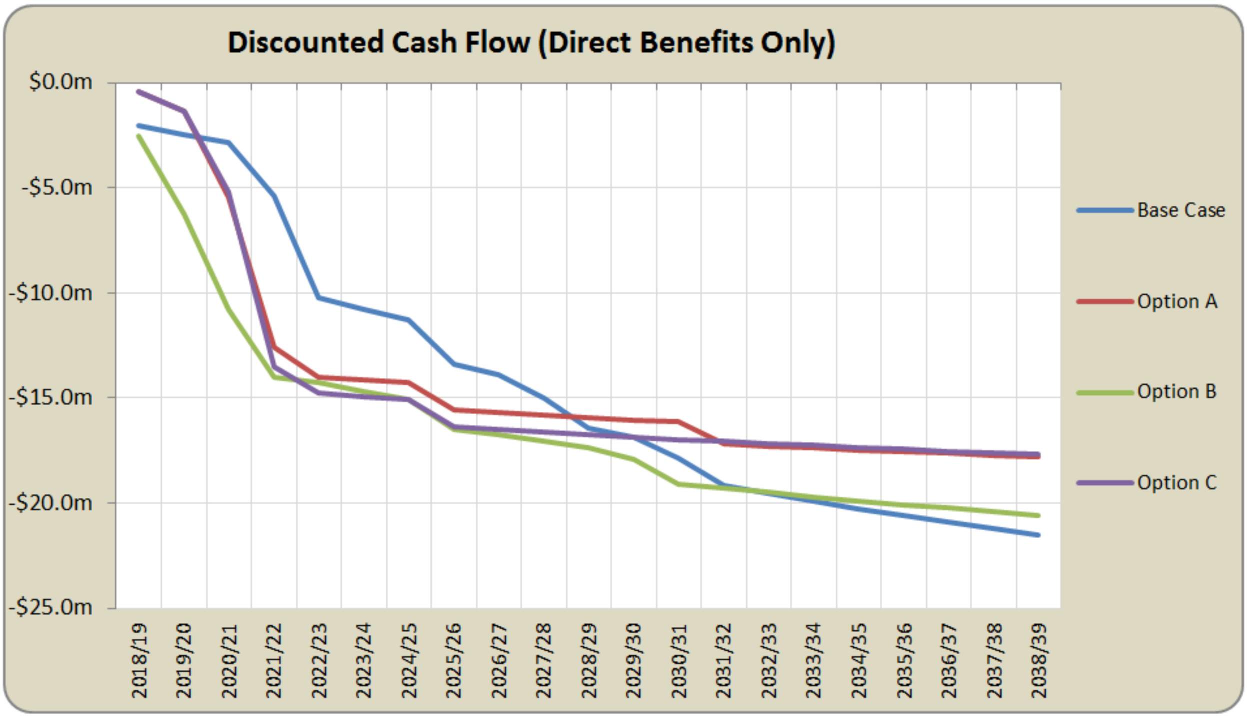



**Figure C2 – Discounted Cash Flow (Direct Benefits Only) for all Assessed Options with a 15 yr C3 Cycle for BAU but Excluding Potential Generator Connection Savings in 2021/22**

| $ Millions | Base Case | Option A | Option B | Option C |
|---|---|---|---|---|
| Capex | (12.21) | (11.77) | (12.99) | (12.16) |
| Opex | (3.48) | (1.80) | (2.01) | (1.62) |
| Direct Benefits | 0.00 | 0.00 | 0.00 | 0.00 |
| **Commercial NPV** | **(15.70)** | **(13.57)** | **(15.01)** | **(13.79)** |
| *Ranking* | *4* | *1* | *3* | *2* |
| | | | | |
| Indirect/Risk | 0.00 | 0.00 | 0.00 | 0.00 |
| **Commercial + Risk** | **(15.70)** | **(13.57)** | **(15.01)** | **(13.79)** |
| *Ranking* | *4* | *1* | *3* | *2* |

**Table C3: NPV of Options including a BAU 10 yr C3 replacement cycle (no generator connection savings)**

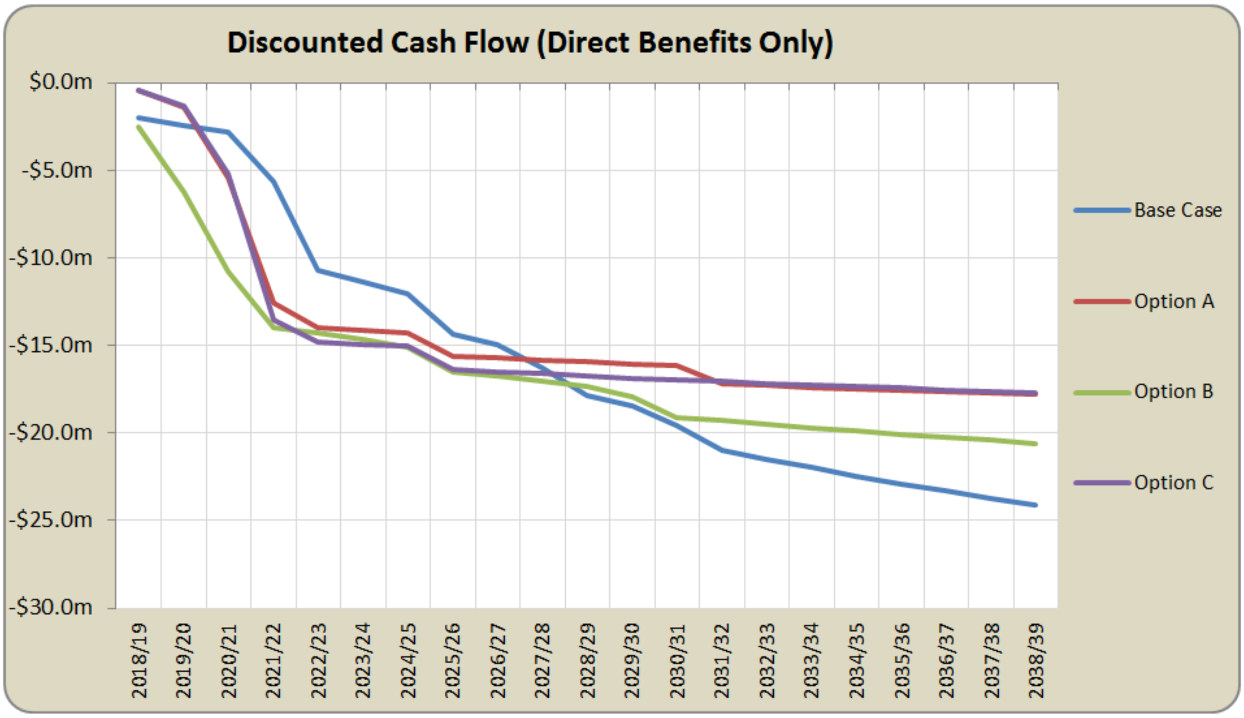



**Figure C4 – Discounted Cash Flow (Direct Benefits Only) for all Assessed Options with a 10 yr C3 Cycle for BAU but Excluding Potential Generator Connection Savings in 2021/22**

| $ Millions | Base Case | Option A | Option B | Option C |
|---|---|---|---|---|
| Capex | (11.10) | (10.92) | (12.99) | (12.16) |
| Opex | (3.48) | (1.80) | (2.01) | (1.62) |
| Direct Benefits | 0.00 | 0.00 | 0.00 | 0.00 |
| **Commercial NPV** | **(14.58)** | **(12.72)** | **(15.01)** | **(13.79)** |
| *Ranking* | *3* | *1* | *4* | *2* |
| | | | | |
| Indirect/Risk | 0.00 | 0.00 | 0.00 | 0.00 |
| **Commercial + Risk** | **(14.58)** | **(12.72)** | **(15.01)** | **(13.79)** |
| *Ranking* | *3* | *1* | *4* | *2* |

**Table C5: NPV of Options including a savings of $1.182M in 2021/22 from proposed generator connection works which results in an Option A NPV of $12.72 M (but retaining a 15 yr C3 cycle for BAU)**

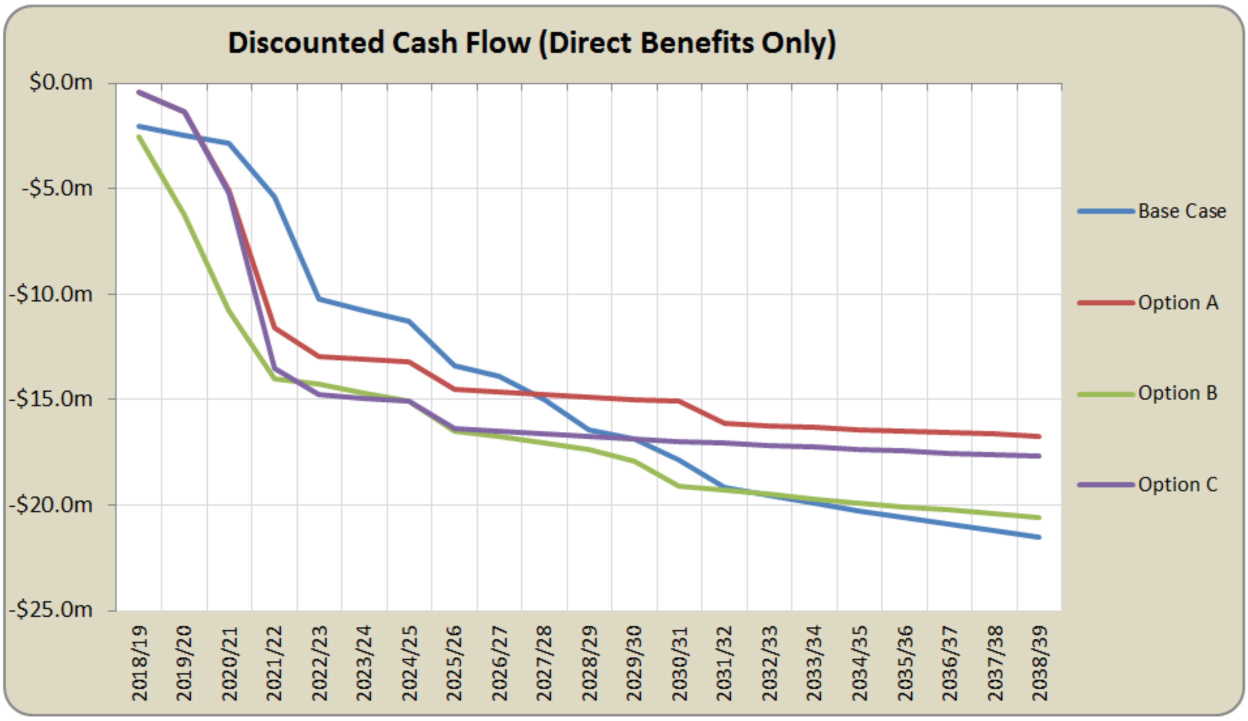



**Figure C6 – Discounted Cash Flow (Direct Benefits Only) for all Assessed Options with a 15 yr C3 Cycle for BAU and Including Potential Generator Connection Savings in 2021/22**

For full NPV Analysis and breakdown of the BCCT see Section 8.0

# 13. APPENDIX D: NETWORK ULTIMATE STATE INCLUDING RENEWABLE GENERATORS AT LAKELAND

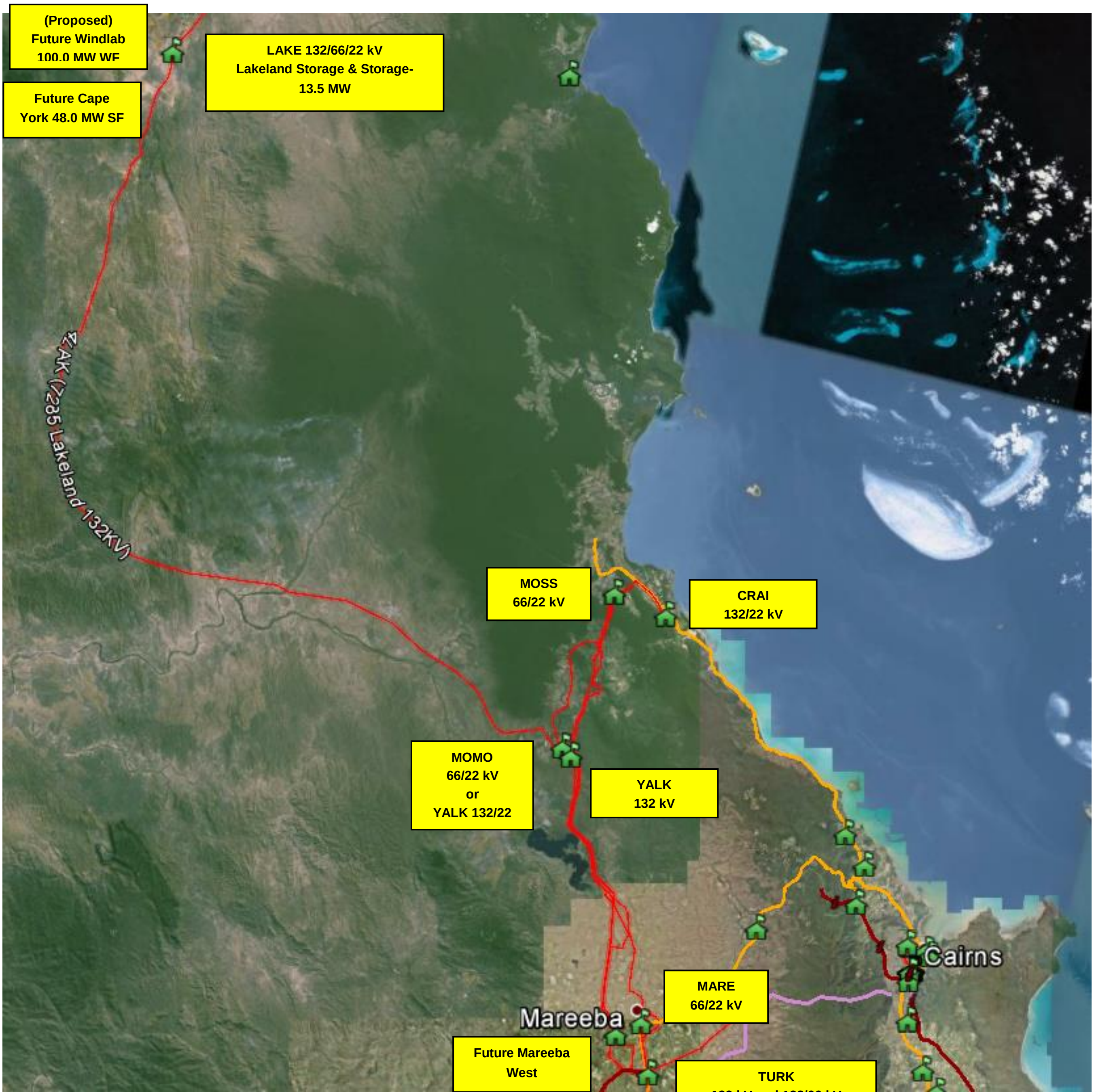



**Figure D1: Geographical Future State (132 & 66 kV lines and subs ... ajor renewable generators)**

**Ultimate Development: Northern Tablelands 132 kV and 66 kV network**
132 kV network development Northern Tablelands (TURK to YALK to LAKE/MOSS/CRAI)

As part of the proposed Cape York 48 MW solar farm project (i.e. WR1138785).

- Cape York work at Lakeland:
  - LAKE:
    - 132 kV protection works;
  - Solar Farm site:
    - 132 kV switching station approx. 4 km from LAKE;
    - 132 kV switching stn is adjacent 132/33 kV substation at solar farm.

Potential work as part of the proposed Windlab 100 MW wind farm project (i.e. WR926741). Similar work will be required for other generator connections if Windlab does not proceed.

- YALK (i.e. upstream augmentation):
  - double 132 kV closed tee;
  - 132 kV bus section bay;
  - 132/22 kV 50/63 MVA OLTC (note that the size of the transformer relates to system standard spares and enables the 22 kV to operate as a PCC to the distribution network);
  - 22 kV switchboard and building;
  - +/- 15 MVAr STATCOM comprising 4 OFF +/- 4MVAr modules

- Windlab work at Lakeland:
  - LAKE:
    - 132 kV incoming C/B bay
    - 132 kV outgoing connection point bay;
  - Wind farm:
    - 132 kV line to wind farm site;
    - 132/33 kV substation at wind farm.

- TURK (part of AER2020-25 submission): WR1339630
    - Replacement of all aged 66 kV assets.

Rationalisation
The future state 132 kV development of the Northern Tablelands enables rationalisation of the 66 kV substations and lines to Mount Molloy and Mossman including the 66 kV bus at Mareeba.

As can be seen from the single line diagrams below, the supply of MOSS substation from the 132 kV triggers wider rationalisation of the upstream 66 kV towards TURK including MARE and MOMO.

Ultimately, removing MOSS from the 66 kV enables:

- Phase 1 (immediate upon completion of this project):
  - Retirement of the aged 66 kV substation plant at MOSS;
  - Removal of 31 km of wood pole 66 kV line across the Rex Range back towards (MOMO);
- Phase 2 (upon completion of Phase 1 and proposed TURK 66 kV bus works WR1339630):
  - Retirement of the 66 kV line, older Mossman No. 2 – West circuit between MARE to MOMO initially (reconfigure newer Mossman No. 1 or East circuit 1975 66 kV line to supply MOMO);
  - Retirement of the 66 kV circuit breakers (i.e. x2) at MARE to become transformer ended feeders from TURK;
- Phase 3 (upon completion of Phase 2 and the proposed Windlab project (or alternative generator connection))
  - Mount Molloy 22 kV distribution supply from MOMO 66/22 kV and ultimately adjacent YALK 132/22 kV 50/63 MVA OLTC;
  - Retirement of the 66 kV line, Mossman No. 1 – East circuit between TURK to MOMO ultimately pending supply from YALK 132/22 kV 50/63 MVA OLTC and Safety Net criteria.

The redevelopment of the 66 kV bus at TURK will account for the proposed phasing and ultimate development.

**Electrical Future State (132 kV lines, substations and renewable generation projects)**

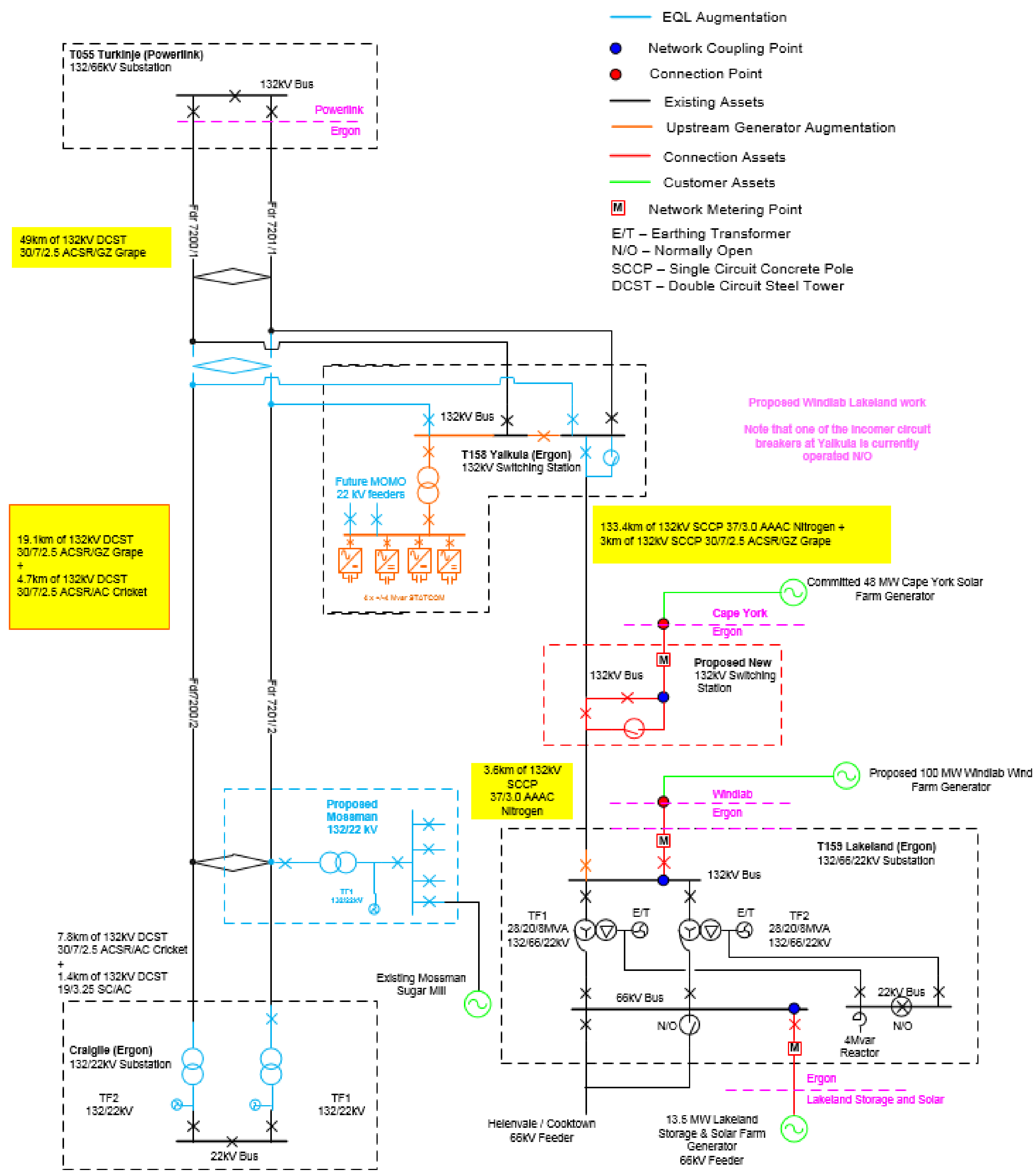
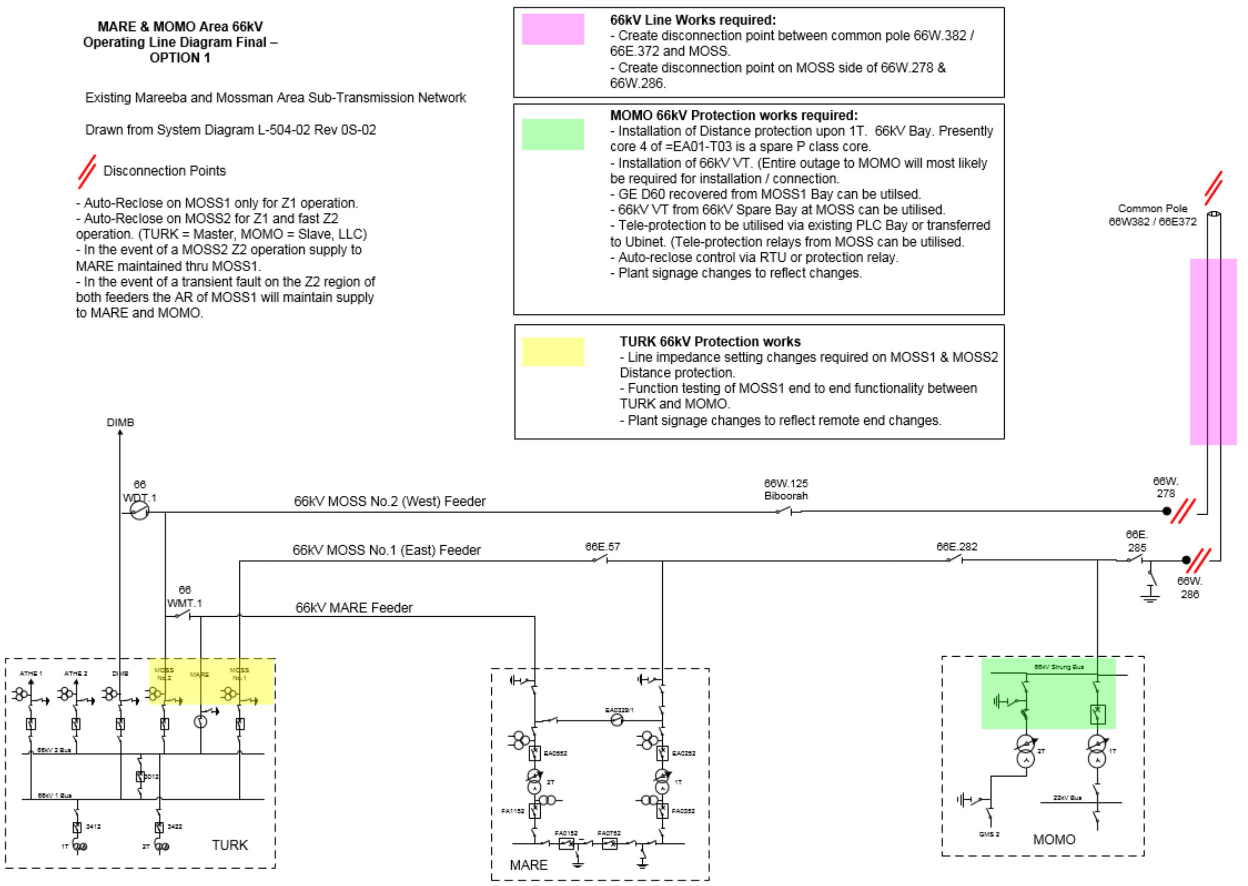
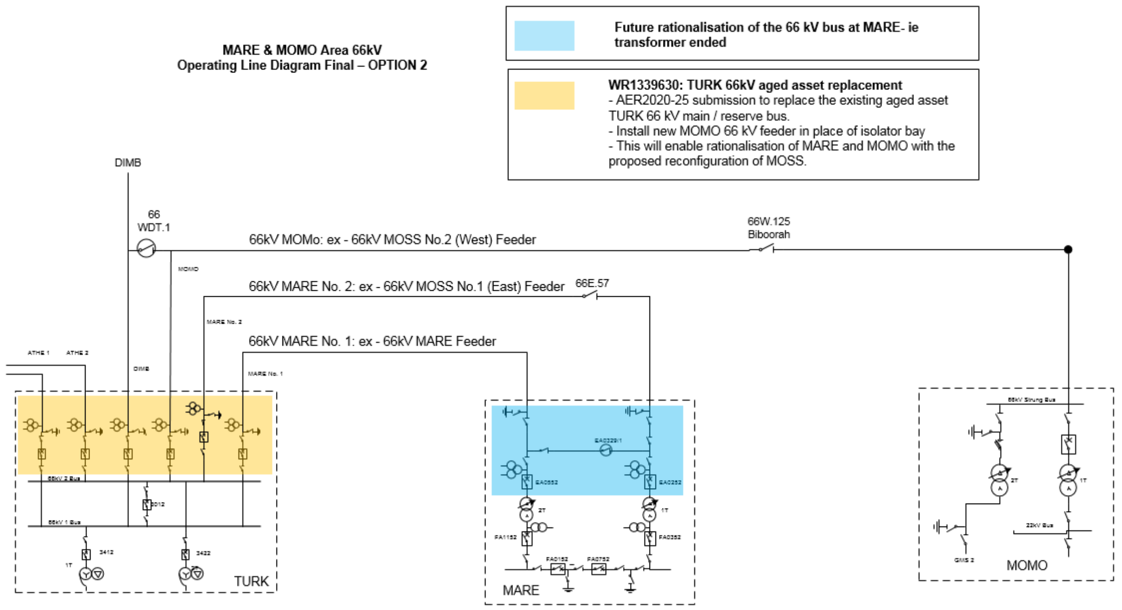



**Figure D2: Single Line Diagram of Mossman c/w single 132/22 kV OLTC and 132 kV tee, switched 132 kV at Yalkula, upgrade of CRAI TF1/TF2 and renewable generation proposals at Lakeland including STATCOM development at YALK 132/22 kV which is part of the Windlab development proposal**




## Figure D3: Electrical Post MOSS State (66 kV lines and Substations)




## Figure D4: Electrical Post TURK & MOSS State (66 kV lines and Substations)

# 14. APPENDIX E: BASE CASE (BAU)

Base Case:

- CAPEX to the end of the AER period 2024/25: $8.408M (all costs are DCV)
- Complete replacement through aged asset replacement and RTS projects;
- Continue Maintenance on the substation and 66 kV line; and
- Includes replacements of assets according to CBRM dates.

**Base Case** Return to Process Page **Non-Escalated DIRECT COSTS (DCV) to be used for all budget inputs**

| | |
|---|---|
| Base Case Title: | Replacement of Plant through Aged asset replacement and RTS |
| Base Case Short Description: | Replacement of Plant through Aged asset replacement and RTS and Continued Maintenance of 66kV line with an increase for MOMO to MOSS section |

*Note: Font in red indicates costs are outside of the evaluation period (From 'Inputs & Assumptions' tab)

| Description | Assumptions | Asset Life (yrs) | 2018/19 | 2019/20 | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | 2025/26 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Capex** | | | | | | | | | | |
| 1074599 Mossman 66kV CT and VT Replacement | | 40 | 570,000 | | | | | | | |
| 1171858 Mossman TX Protection Upgrade | | 20 | 329,000 | | | | | | | |
| MOSS 1 66 kV 35km conductor replace (start age 65 yr age) | initially 25km MOSS to MOMO | 40 | | | | | 2,506,000 | | | |
| Capital Lines Works | for post 2021 cycle due to C3 poles | 40 | 98,750 | 98,750 | 98,750 | 575,733 | 431,800 | 431,800 | 431,800 | 431,800 |
| Capital Substation works | | 40 | 17,732 | 17,732 | 17,732 | 17,732 | 8,866 | 8,866 | 8,866 | 8,866 |
| 66kV plant replace (C/B, CT, VT, isolators) | MOSS & MARE (5 isolators) | 40 | 429,000 | | | | | | | 582,000 |
| Relay Replacement | coming to end of life | 20 | | | | | 554,000 | | | |
| 1xMOSS 20, 2xCRAI+ET 25/32-CRAI DC & 132 kV prot. | years as per Aged asset replacment, | 40 | | | | 1,553,500 | 513,000 | | | 1,561,000 |
| replacement | | 40 | | | | | 312,500 | | | |
| 22kV CB & SB replacement, 22 kV security work | CB & CTs, regs/recl./gas switches | 40 | 255,000 | | | 368,000 | 1,018,000 | | | |
| **TOTAL IMPLEMENTATION COSTS (real)** | | | **1,699,482** | **116,482** | **116,482** | **2,514,965** | **5,344,166** | **440,666** | **440,666** | **2,583,666** |
| **TOTAL IMPLEMENTATION COSTS (nominal)** | | | **1,699,482** | **119,394** | **122,379** | **2,708,342** | **5,898,959** | **498,573** | **511,037** | **3,071,167** |
| **TOTAL IMPLEMENTATION COSTS (discounted)** | | | **1,699,482** | **112,065** | **107,816** | **2,239,574** | **4,578,515** | **363,216** | **349,443** | **1,971,127** |

| Opex | | | 2018/19 | 2019/20 | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | 2025/26 |
|---|---|---|---|---|---|---|---|---|---|---|
| 66kV Line Maintenance | calculated off the last 10 years + C3 | | 154,375 | 154,375 | 154,375 | 154,375 | 154,375 | 154,375 | 154,375 | 154,375 |
| Substation Maintenance (calculated off the last 5 years) | MOSS ZS | | 171,055 | 171,055 | 171,055 | 171,055 | 171,055 | 42,764 | 42,764 | 42,764 |
| | | | | | | | | | | |

**Figure E1: BAU Direct Cost NPV**



Ergon Energy Corporation Limited ABN 50 087 646 062
Energy Queensland Limited ABN 96 612 535 583
Energex Limited ABN 40 078 849 055

| WR Number | WR Name | Description | AP Budget | Funding Source | PIA | RBD |
|---|---|---|---|---|---|---|
| **1165865** | FN MOSSZS Building Roof Investigation | Concrete cancer assessment, replacement of concrete roof. | Approx. $250,000 | CA - Capital | 20160923 | 20170630 |
| **1074599** | Mossman Sub Refurb | 06-CBRM-PP-Portfolio CT & VT Replacement | $911,279 | CA - Capital | 20151214 | 20180531 |
| **1171858** | MOSS Protection Upgrade | Install TF Diff and 66 kV Bus Zone Relays | $526,024 | CA - Capital | 20161014 | 20191229 |
| **2 x 66 kV replace** | ARP CBRM FN MOSS Replace 1 C/B | 06-CBRM-PP-Portfolio-C/B Replacement (WR1216596) | $342,907* say $200k | CA - Capital | 20170216 | 20200630 |
| | ARP CBRM FN MOSS Replace 1 C/B | 06-CBRM-PP-Portfolio-C/B Replacement | $342,907* say $200k | CA - Capital | | |

*(With OH rate of 60% applied)

**Table E1: WR projects in program**

| Item | ZS | Description | Estimate No. | Estimate Description | Unit DC Price ($ M) | Quantity | Year of Spend | DC Cost ($ M) | Comments |
|---|---|---|---|---|---|---|---|---|---|
| | | **DCV costs** | | | | | | | |
| | | **MOSS,CRAI & MARE costs** | | | | | | | |
| **1** | MOSS | 22 kV switchgear replacement | S_33CB_RLC | SUB 33KV CB | 109843 | 1 | 2018/19 | 0.110 | VBF c/b -Equiv. 22 kV est. |
| **2** | " | 22 kV switchgear replacement | S_33CT_RLC | SUB 33KV CT | 144869 | 1 | " | 0.145 | VBF c/b -Equiv. 22 kV est. |
| **3** | " | 20 MVA 66/22 kV OLTC | S_TXM1_INS | INSTALL 33/11kV POWER TX 20MVA | 1111000 | 1 | 2021/22 | 1.111 | Both txers YOM 1963 |
| **4** | " | Bund | S_OCBD_TX_M | INSTALL OIL CONTAINMENT & BUND MEDIUM | 442500 | 1 | " | 0.4425 | No bunds presently exist |
| **5** | " | 22 kV security whilst TF1 / TF2 replacement | MIP1002 + MIP1019 | Closed delta regs and automated recloser/sectionaliser | 368101 | 1 | " | 0.368 | Risk during TF1 / TF2 replacement |
| **6** | CRAI | CRAI DC 132 kV prot. - NER | S_PTRLY_SUB | REPLACE PROTECTION RELAY | 92281 | 4 | 2022/23 | 0.369 | |
| **7** | " | CRAI DC duplicate supply - 132 kV NER | S_DC110_UPG | REPLACE PROTECTION RELAY | 144275 | 1 | " | 0.144 | |
| **8** | MOSS | Building replacement | Mossman building assessment | Mossman building assessment | 312500 | 1 | " | 0.313 | See report (AP, 70% overhead & risk) |
| **9** | " | 22 kV switchgear replacement | S_33CB_RLC | SUB 33KV CB REPLACE | 109843 | 4 | " | 0.439 | Equivalent 22 kV est. |
| **10** | " | 22 kV switchgear replacement | S_33CT_RLC | SUB 33KV CT REPLACE | 144869 | 4 | " | 0.579 | Equivalent 22 kV est. |
| **11** | " | MOSS Protection Relays | S_PTRLY_SUB | REPLACE PROTECTION RELAY | 92281 | 6 | " | 0.554 | Exclude adjcent ex-Daintree 66 kV bay |
| **12** | " | MOSS 1 reconductor (MOMO to MOSS) | MIP1046 | Urban recond dist | 100251 | 25 | " | 2.506 | MOSS 1 7/0.104 recond.- 1958 vintage (do MOMO - MOSS 25km section first) |
| **13** | CRAI | Replace CRAI TF1 | S_TXM2_INS | INSTALL 66/11kV POWER TX 32MVA | 1279000 | 1 | 2025/26 | 1.279 | Replace CRAI TF1 YOM 1963- equivalent 132/22 kV |
| **14** | " | Add 22 kV earthing transformer | 0003671 stock code | Zn 8kA/30s | 282000 | 1 | " | 0.282 | Earthing transformer- ZN |
| **15** | " | 66 kV isolator replacement | S_66ISOL_RLC | Isolator replacement | 116454 | 5 | " | 0.582 | 66 kV bay-B/S, incomers |
| **16** | " | MOSS 1 reconductor (MOMO - TURK) | MIP1046 | Urban recond dist | 100251 | 10 | 2027/28 | 1.003 | MOSS 1 7/0.104 recond.- 1958 vintage (remaining 10km towards TURK) |
| **17** | MOSS | 66 kV isolator replacement | S_66ISOL_RLC | Isolator replacement | 116454 | 8 | 2028/29 | 0.932 | YOM 1963, 65 yr old isolator structures but not including VT/CT/CBs |
| **18** | " | 66 kV and 22 kV bus structure replacement | Steel lattice structure | x 6 22 kV structures, x 6 66 kV structures x 5 landing spans | 31250 | 17 | " | 0.531 | YOM 1963, 65 yr old steel lattice structures but not including VT/CT/CBs |
| **19** | " | per MOSS Replace 1 CB x 2 (66 kV) | per WR1216596 | MOSS Replace 1 CB | 214317 | 2 | 2030/31 | 0.429 | AP value less 70% overheads and risk |
| **20** | MOSS | MOSS replace 22 kV C/B | S_33CB_RLC, S_33CT_RLC | MOSS Replace 1 CB | 254712 | 2 | " | 0.509 | Equivalent 22 kV est. |
| **21** | CRAI | Replace CRAI TF2 | S_TXM2_INS | INSTALL 66/11kV POWER TX 32MVA | 1279000 | 1 | 2031/32 | 1.279 | Replace CRAI TF2 YOM 1963- equivalent 132/22 kV 25/32 cost |
| **22** | " | Add 22 kV earthing transformer | 0003671 stock code | Zn 8kA/30s | 282000 | 1 | " | 0.282 | Earthing transformer- ZN |
| | | **Projects - detailed** | | | | | | | |
| **1** | MOSS | 1074599 Mossman 66kV CT and VT Replacement | WR1074599 | 1074599 Mossman 66kV CT and VT | 569549 | 1 | 2018/19 | 0.570 | AP value less 70% overheads and risk |
| **2** | " | 1171858 Mossman TX Protection Upgrade | WR1171858 | 1171858 Mossman TX Protection Upgrade | 328765 | 1 | " | 0.329 | AP value less 70% overheads and risk |
| **3** | " | MOSS Replace 1 CB x 2 (66 kV) | WR1216596 | MOSS Replace 1 CB | 214317 | 2 | " | 0.429 | AP value less 70% overheads and risk |
| | | **YALK switching stn costs** | | | | | | | |
| **1** | YALK | No change | | | | | | 0.000 | |
| **Total** | | BAU: Estimated Cost | | | | | | **15.516** | |

**Table E2: CAPEX estimated cost of works (direct costs)**

# 15. APPENDIX F: OPTION A – SINGLE 132/22 KV OLTC AT MOSS, YALK 132 KV SWITCHED (C/W B/S C/B)

Option A is the recommended solution which is anticipated to provide a strategic network development benefit (refer to Appendix D) including resolving the Mossman 66/22 kV substation and 66 kV lines asset and maintenance issues. Significant work is involved in the staging plan.

Option A:

- CAPEX to the end of the AER period 2024/25: $13.390M (all costs are DCV)
- Strategic development of Northern Tablelands and Douglas Shire area transmission and sub-transmission lines and substations;
- Re-develop MOSS into a 132/22 kV site, recover 66 kV plant from MOSS, develop YALK - switched 132 kV bus; and
- Recover problematic section of 66 kV lines between MOMO and MOSS.

**Option A** Return to Process Page **Non-Escalated DIRECT COSTS (DCV) to be used for all budget inputs**

| | |
|---|---|
| Option Title: | Conversion of Mossman to single 132/22kV Substation; Yalkula 132 kV fully switched, remove 66 kV lines |
| Option Short Description: | Mossman to single 132/22kV Substation; Yalkula 132 kV fully switched; CRAI augmentation, remove 66 kV lines |

*Note: Font in red indicates costs are outside of the evaluation period (From 'Inputs & Assumptions' tab)

| Description | Assumptions | Asset Life (yrs) | 2018/19 | 2019/20 | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | 2025/26 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Capex** | | | | | | | | | | |
| Install 1 x 132/22kV TF @ MOSS, Full 132 kV @ YALK | & MOMO-MOSS 66 kV line | 40 | | 536,000 | 3,971,000 | 7,375,000 | 1,362,000 | | | |
| TF1 132 kV c/b only | Remove risk of aged TF1 outages | 40 | | | | 146,000 | | | | |
| | | | | | | | | | | |
| Capital Lines Works | calc. off the last 5 yrs - escalated for post 2021 cycle due to C3 | 40 | 98,750 | 98,750 | 98,750 | 116,200 | 116,200 | 116,200 | 116,200 | 116,200 |
| Capital Substation works | | 40 | 17,732 | 17,732 | 8,866 | 8,866 | 8,866 | 8,866 | 8,866 | 8,866 |
| | | 40 | | | | | | | | |
| TF2 - 1 x CRAI | 25/32 MVA OLTC + earthing tfer | 40 | | | | | | | | |
| TF1 - 1 x CRAI | 25/32 MVA OLTC + earthing tfer | 40 | | | | | | | | 1,561,000 |
| | | 40 | | | | | | | | |
| 22 kV security whilst in construction | 22 kV dist. network | 40 | | | | | | | | |
| **TOTAL IMPLEMENTATION COSTS (real)** | | | 116,482 | 652,482 | 4,078,616 | 7,646,066 | 1,487,066 | 125,066 | 125,066 | 1,686,066 |
| **TOTAL IMPLEMENTATION COSTS (nominal)** | | | 116,482 | 668,794 | 4,285,096 | 8,233,977 | 1,641,443 | 141,501 | 145,038 | 2,004,203 |
| **TOTAL IMPLEMENTATION COSTS (discounted)** | | | 116,482 | 627,740 | 3,775,158 | 6,808,816 | 1,274,016 | 103,085 | 99,176 | 1,286,331 |
| | | | | | | | | | | |
| **Opex** | | | 2018/19 | 2019/20 | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | 2025/26 |
| 66kV Line Maintenance | calc. off the last 5 yrs | | 154,375 | 154,375 | 154,375 | 154,375 | 38,594 | 38,594 | 38,594 | 38,594 |
| Substation Maintenance (calculated off the last 5 years) | MOSS ZS | | 171,055 | 171,055 | 171,055 | 171,055 | 171,055 | | | |

**Figure F1: Option A Direct Cost NPV**

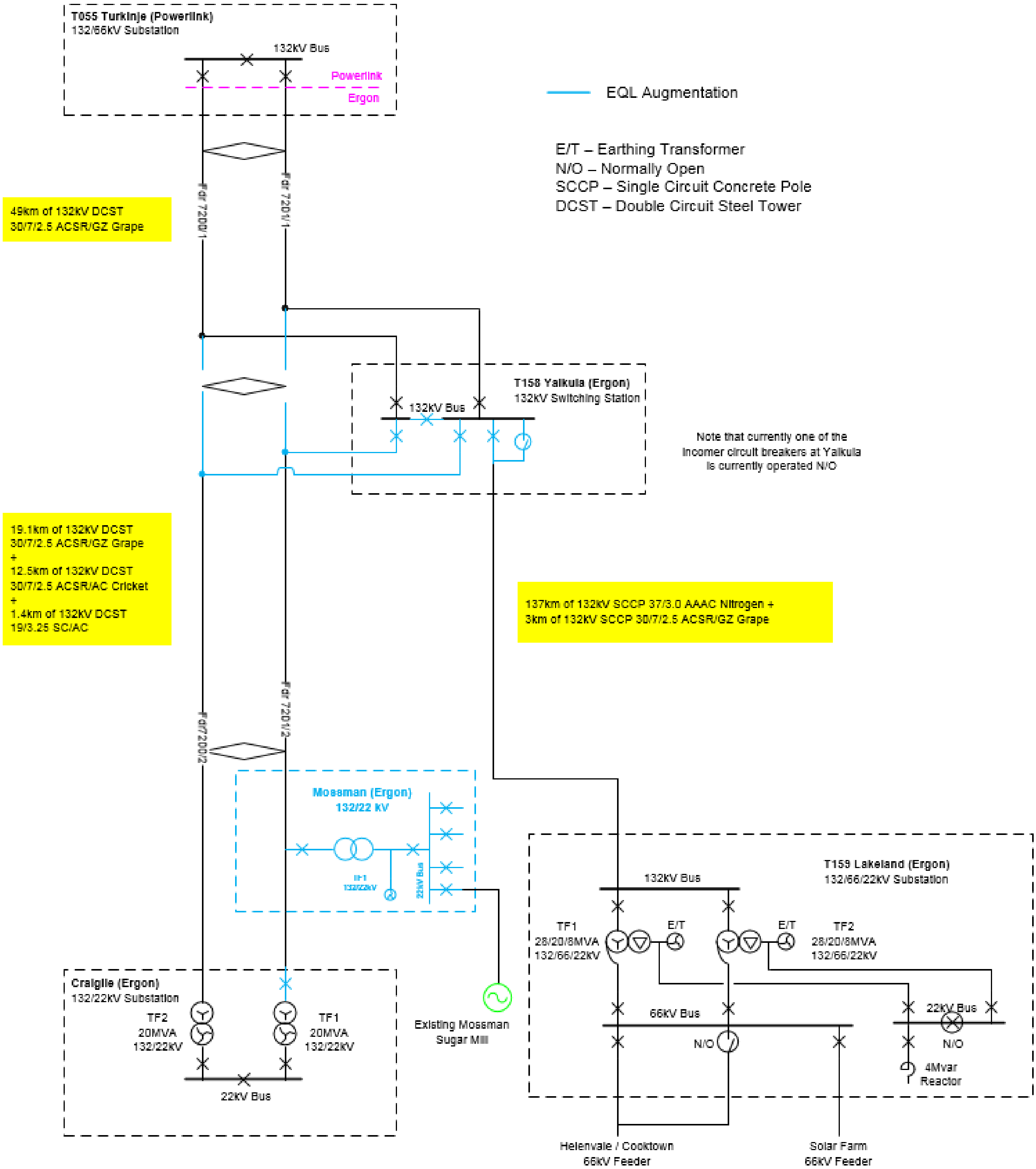



**Figure F2: Single Line Diagram of single 132 kV tee at Mossman c/w single 132/22 kV OLTC and switched 132 kV at Yalkula**

DCV costs

| Item | ZS | Description | Estimate No. | Estimate Description | Unit DC Price ($ M) | Quantity | Year of Spend | DC Cost ($ M) | Comments |
|---|---|---|---|---|---|---|---|---|---|
| | | **MOSS, CRAI & MARE costs** | | | | | | | |
| 1 | MOSS/YALK | Upgrade MOSS & YALK, retire MOSS and 66 kV MOSS 1&2 to MOMO | Base estimate for WR1273666 | Est. no. 193247 | 12713000 | 1 | 2019/20 to 22/23 | 12.713 | |
| 2 | CRAI | 132 kV TF1 c/b at CRAI | 132_CB_I | part 132 kV bay | 146140 | 1 | 2021/22 | 0.146 | CRAI bay built c/w CT/VT |
| 3 | " | CRAI DC 132 kV prot.- NER | S_PTRLY_SUB | REPLACE PROTECTION RELAY SCHEME | 92281 | 0 | " | 0.000 | included in main YALK/MOSS?CRAI works |
| 4 | " | CRAI DC duplicate supply - 132 kV NER | S_DC110_UPG | REPLACE PROTECTION RELAY SCHEME | 144275 | 0 | " | 0.000 | included in main YALK/MOSS?CRAI works |
| 5 | CRAI | Replace CRAI TF2 | S_TXM2_INS | INSTALL 66/11kV POWER TX 32MVA | 1279000 | 1 | 2025/26 | 1.279 | Replace CRAI TF2- equivalent 132/22 kV 25/32 |
| 6 | " | Add 22 kV earthing transformer | 0003671 stock code | Zn 8kA/30s | 282000 | 1 | " | 0.282 | Earthing transformer- ZN |
| 7 | CRAI | Replace CRAI TF1 | S_TXM2_INS | INSTALL 66/11kV POWER TX 32MVA | 1279000 | 1 | 2031/32 | 1.279 | Replace CRAI TF1- equivalent 132/22 kV 25/32 |
| 8 | " | Add 22 kV earthing transformer | 0003671 stock code | Zn 8kA/30s | 282000 | 1 | " | 0.282 | Earthing transformer- ZN |
| | | | | | | | | | |
| | | | | | | | | | |
| | | **YALK switching stn costs** | | | | | | | |
| 1 | YALK | YALK- add 3 x 132 kV bays | see base estimate above | 2 x 132 kV feeder bays, 1 bus section bay | 0 | 0 | 2019/20 to 22/23 | 0.000 | Included in est. 193247 above |
| 2 | " | YALK- add 1 part 7285 LAKE 132 kV bays (add C/B, CT, VT | S_132CB_INS, S_132CT_INS, S_132ISL_INS | Unit installs | 411800 | 1 | " | 0.412 | |
| 3 | " | Yalk 132 kV- bypass for LAKE 132 kV fder | S_132ISL_INS | | 119915 | 1 | " | 0.120 | |
| | | | | | | | | 0 | |
| | | | | | | | | | |
| | | | | | | | | | |
| **Total** | | **Estimated Cost: YALK & MOSS** | | | | | | **16.513** | |

**Table F1: CAPEX estimated cost of works (direct costs)**

### 15.1. Staging

- Stage 1 – 22 kV line works and removal of clouded assets including 66 kV TF1;
- Stage 2a – Installation of MOSS 132/22 kV yard
- Stage 2b – Installation of a switched 132 kV (excluding B/S C/B) yard at YALK
- Stage 3 – Removal of 66 kV TF2 and Mossman 2 Bay
- Stage 4 – Removal of 66 kV Mossman Feeders

### 15.2. Scope of Works

Install the single transformer 132/22 kV and associated 22 kV indoor switchgear at Mossman Substation. Remove the existing aged 66 and 22 kV substation plant.

## 15.3. Stage 1: Removal of Clouded Assets

**Substation works**

Removal of Assets:

- 1 x 66/22 kV TF1;
- 2 x 66 kV feeder bay;
- 66 kV Bus section;
- 2 x 22 kV Feeder Bay;
- 22 kV Bus Section.

**Lines works**

22 kV Lines Works:

- Contingency 22 kV supply augmentation from CRAI, installation of:
  - 2 remote controlled 22 kV ABS (Sectionalises);
  - 22 kV recloser on 2MOS;
  - 200A closed-delta regulator for voltage support from 2INL;
- 66 kV Lines Work;
- Add in temporary 66 kV feeder tie between MOSS No. 1 and MOSS No. 2.

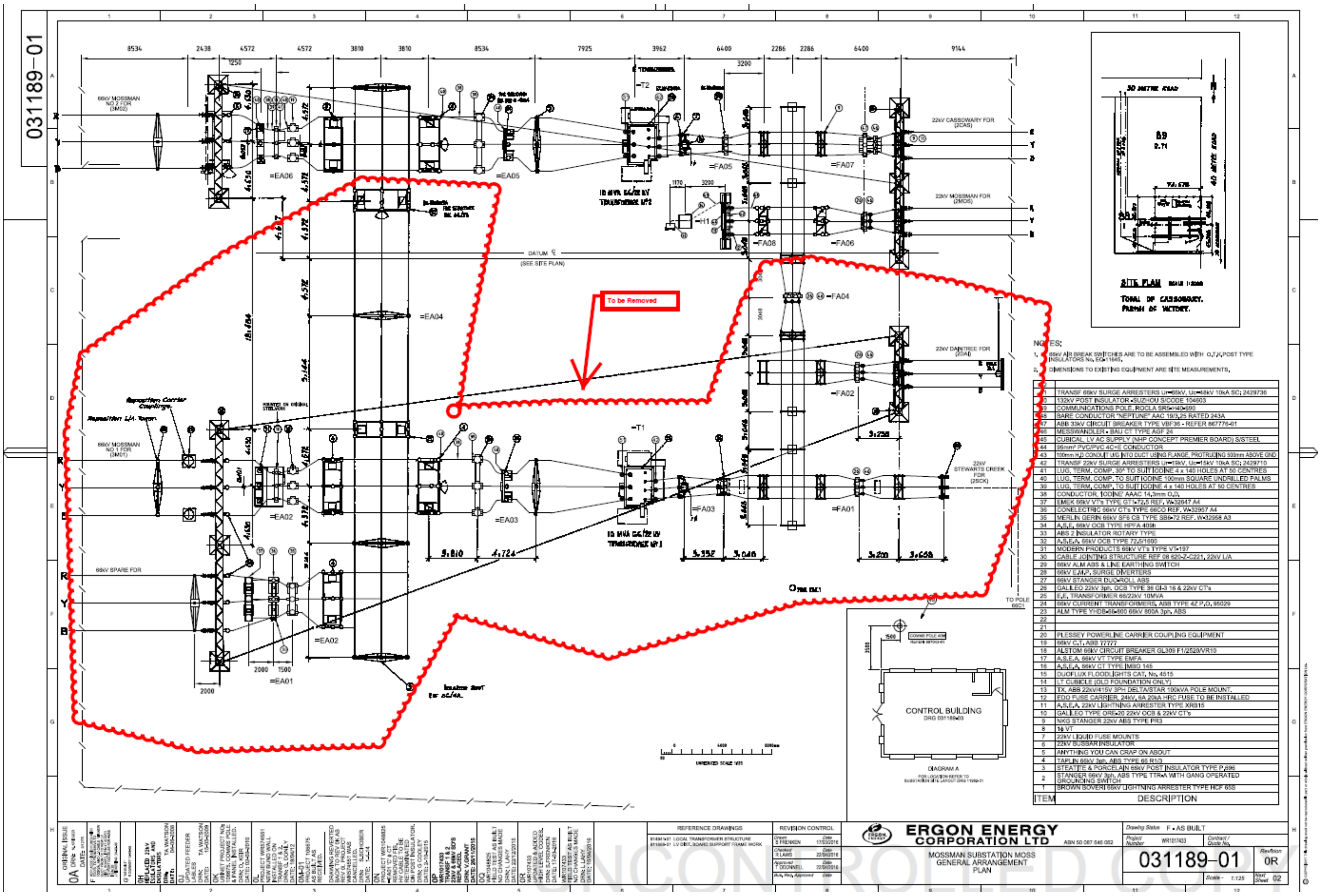



**Figure F3: Stage 1 - General Arrangement with current equipment and proposed asset removal clouded**

## 15.4. Stage 2a: Installation of 132/22 kV Yard at MOSS

**Substation works**

Installation of:

- 132/22 kV OLTC, vector grouping YNd11;
- 1 x earthling transformer ZN;
- 1 x 132 kV landing span;
- 132 kV Bays:
  - Part 132 kV bus bay;
  - 1 x TF1 bay;
- 2 x 14m Modular control building including:
  - Building 1:
    - Ultimate 22 kV S/B with sufficient room for 11 C/Bs (two TFer, 1 bus section and 4 feeders per Bus);
      - 4 x feeder C/B per bus section (Stock code 3031);
      - 2 x TF C/B (Stock code 3031);
      - 1 x Bus Section C/B (Stock code 3031);
    - Initial 22 kV S/B layout (one TFer, 1 bus section and 2 feeders per Bus);
      - 2 x feeder C/B per bus section (Stock code 3031);
      - 1 x TF C/B (Stock code 3031);
      - 1 x Bus Section C/B (Stock code 3031);
      - Future spares can be feeder/capacitor banks
    - Toilet and amenities room;
    - Battery Room;
  - Building 2: (consolidate into Building 1)
    - Communication Panels;
    - Protection Panels;
- 1 x RMUs;
- 1 x SS TFER 22/433 kV 50 KVA;
- 22 kV U/G Cables for :
  - 4 feeders exits to outside substation term poles;
  - TF1 LV cables:
    - 400A/phase rating
- Protection Work:
  - YALK, MOSS & CRAI, 3 ended communicating distance protection scheme; and
  - DC supplies and 132 kV protection works for NER.

**Lines works**

- 22 kV Termination of exit cables on term poles and connection onto outgoing feeders

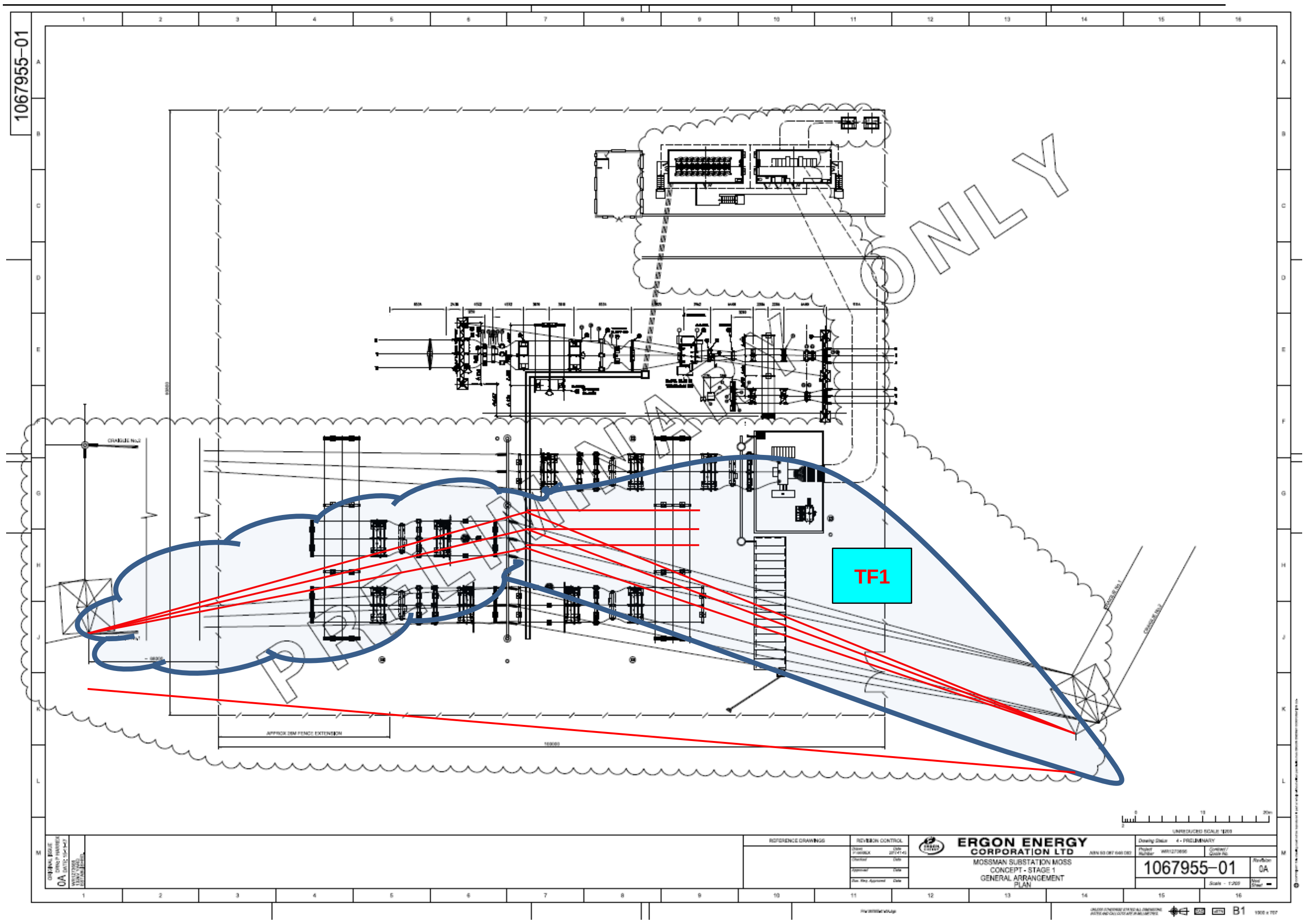



**Figure F4: Stage 2a: General Arrangement with Proposed 132 kV Substation Overlay to be modified to include only a single landing span from re-directed 7201/2 and 132 kV bus tee to TF1 132/22 kV OLTC.**

## 15.5. Stage 2b: Installation of a Switched 132 kV Substation at YALK

**Substation works**

Installation of:

- 2 x 132 kV landings spans;
- 3 x 132 kV Bays:
  - 2 x feeder bays;
  - 1 part feeder bay (i.e. 7285).

-

**Lines works**

Installation of:

- 132 kV under-crossing at tower;
- New 400m SCCP 132 kV line from tower to YALK to enable the switched in/out 132 kV at YALK:
  - Circuit 7200 to YALK;
  - Circuit 7201 to YALK;
  - 8 SC poles;
  - 1 DCST tower.


**Figure G5: Existing double tee to YALK**

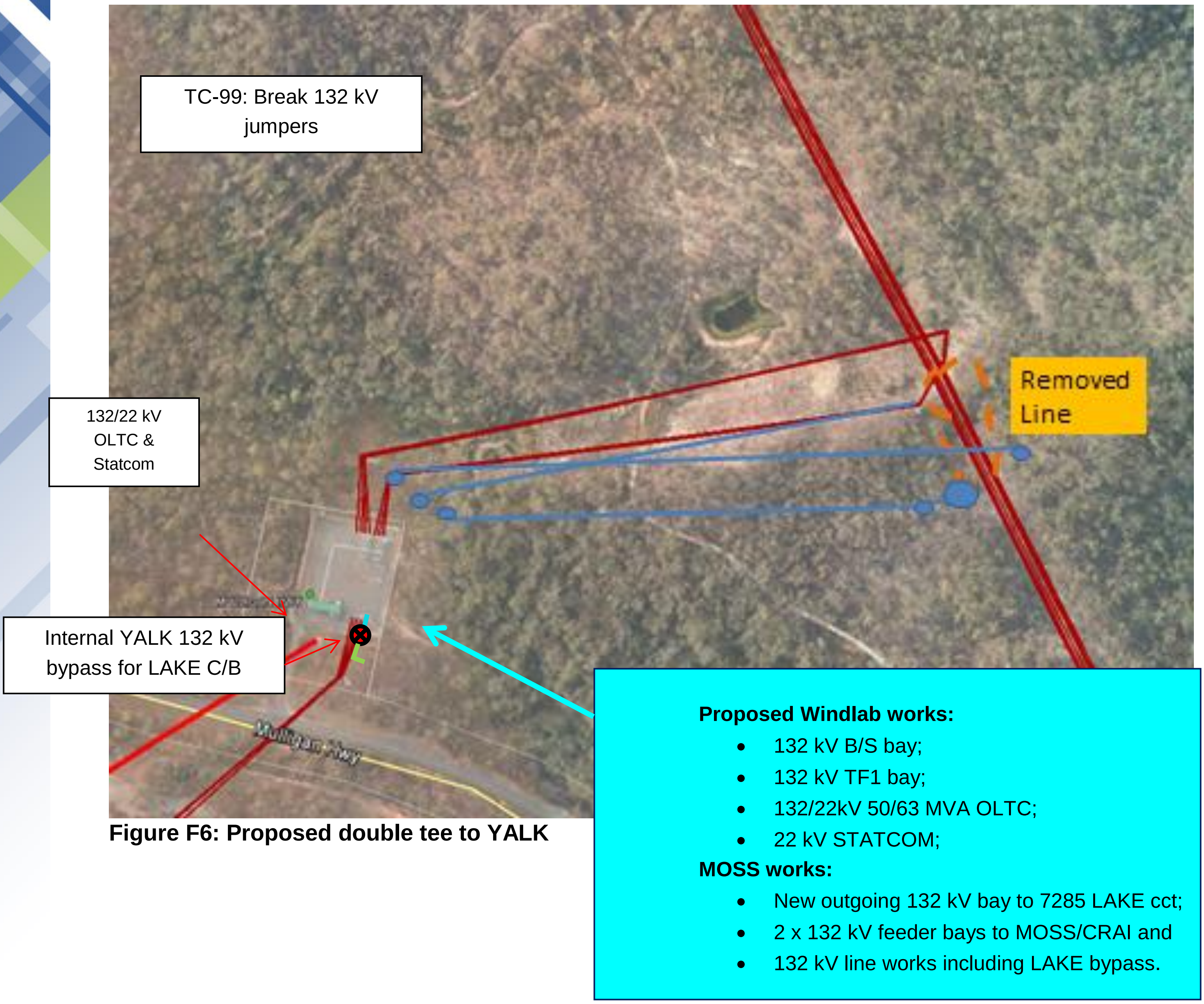



**Figure F6: Proposed double tee to YALK**


**Figure F7: Expand existing yard to North and include additional 3 x 132 kV bays (i.e. 2 x feeder bays, 1 x bus section bay) and a bypass 132 kV bay adjacent 7285 (LAKE).**

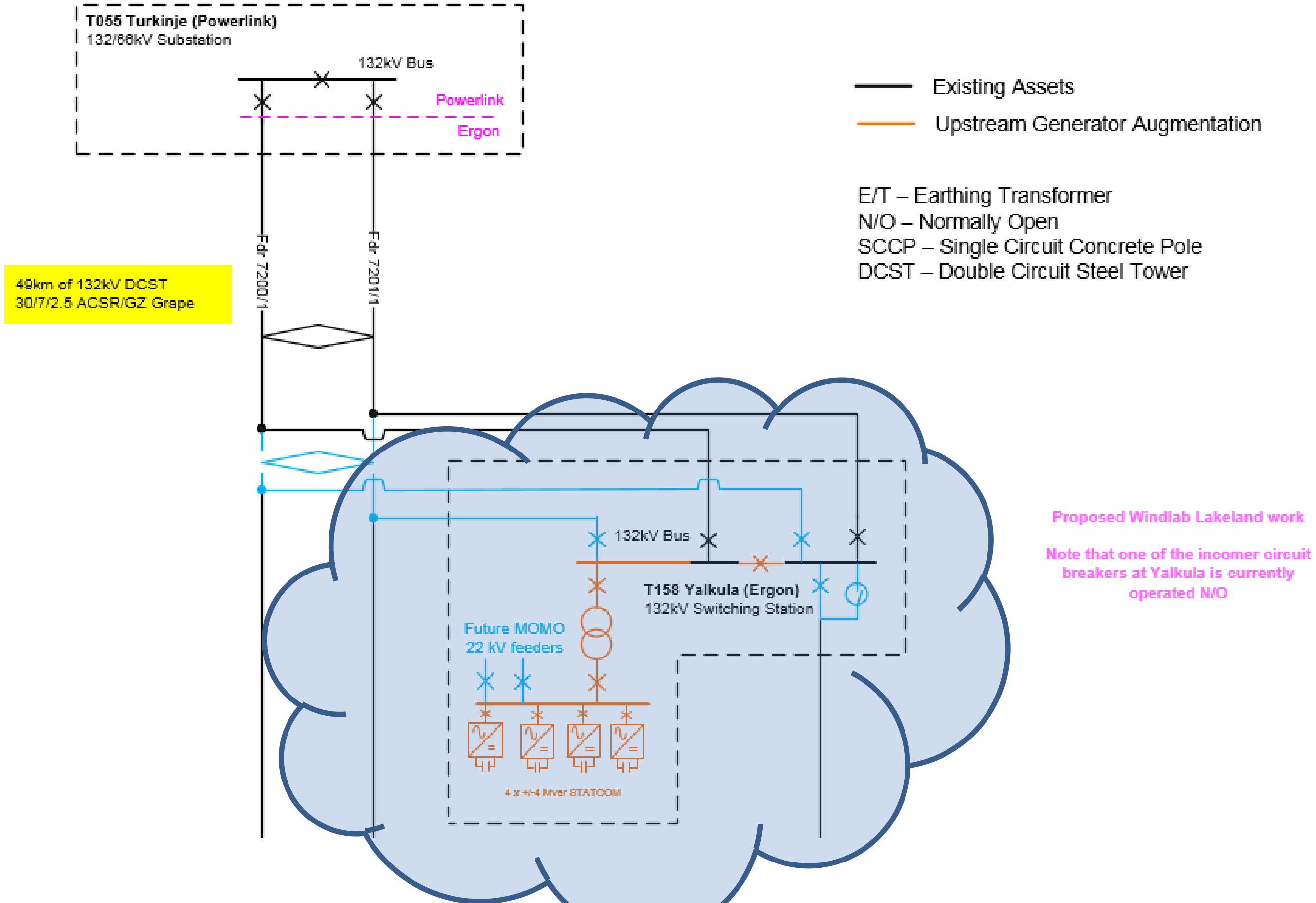



**Figure F8: Ultimate design including Cape York and proposed Windlab**

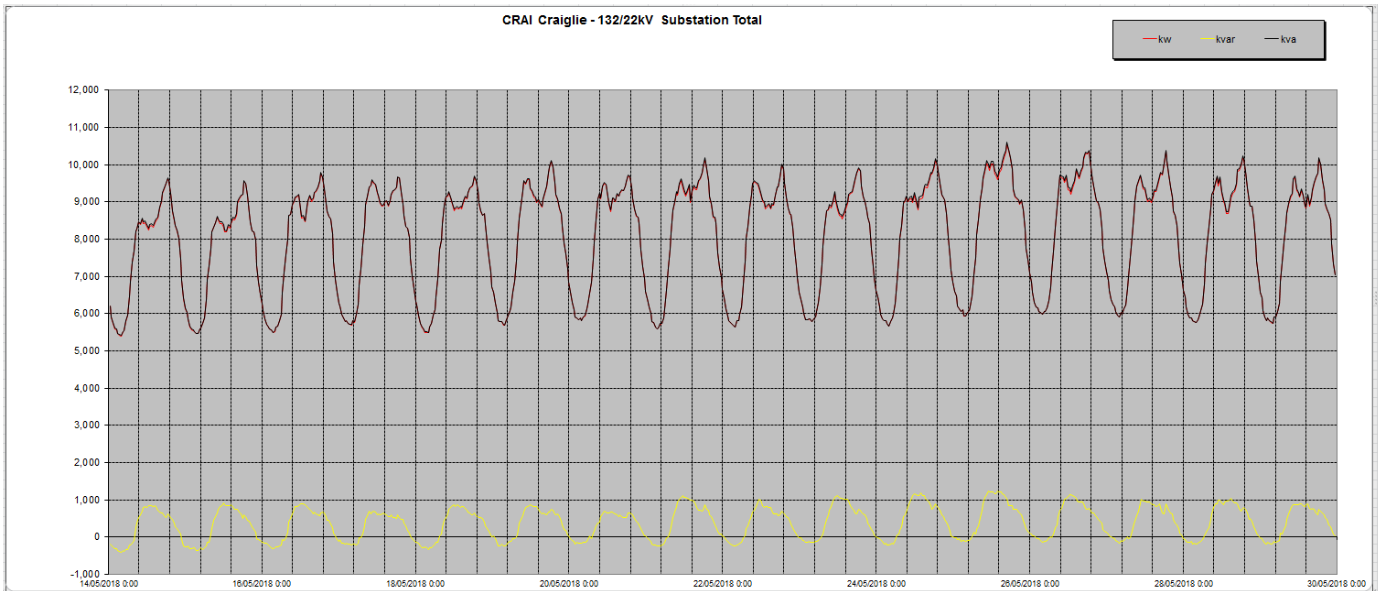



**Figure F9: YALK cut in/out period to minimise outages: CRAI transfer of load to MOSS**

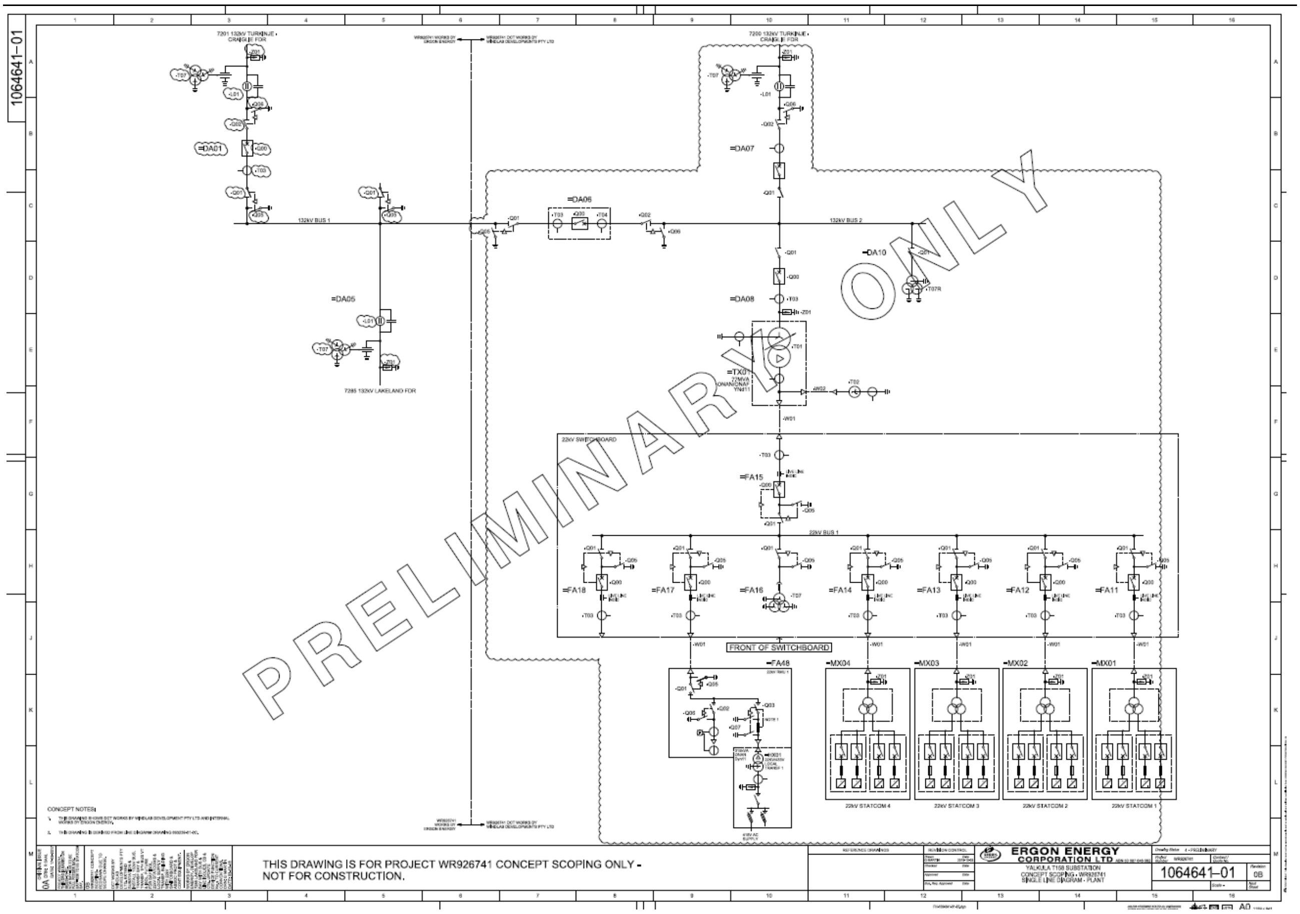



**Figure F10: Proposed Windlab works at YALK**

FN-1064641-01-0Bconceptv3.pdf

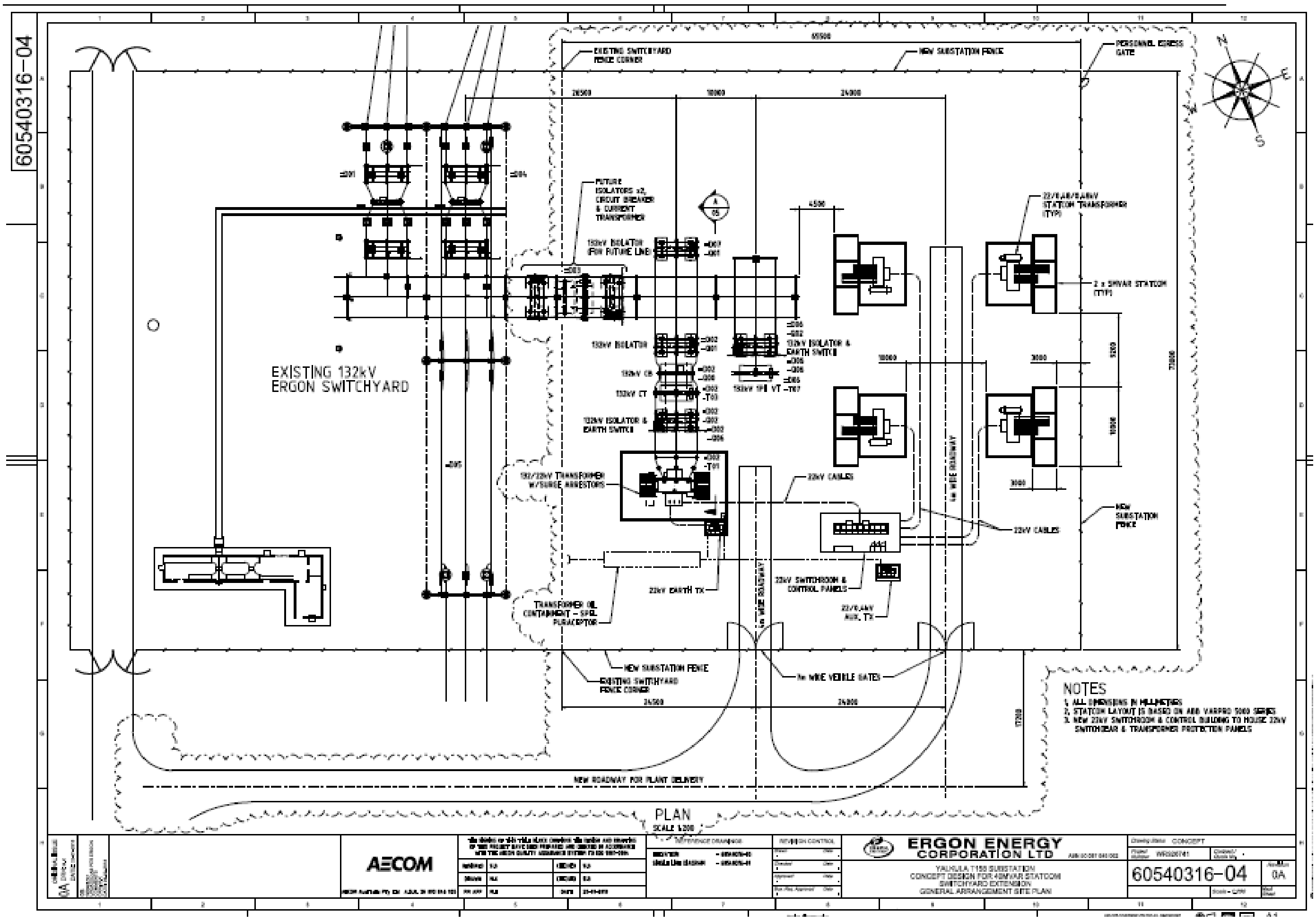



**Figure F11: Proposed Windlab general arrangement works at YALK**

Yalkula 132kV
extension concept pa

## 15.6. Stage 3: Lines Work

**Substation works**

**Nil**

**Lines works**

- Removal of 66 kV Mossman No. 1 Line
- Removal of 66 kV Mossman No. 2 Line

**Stage 3 – Lines Work Removals**

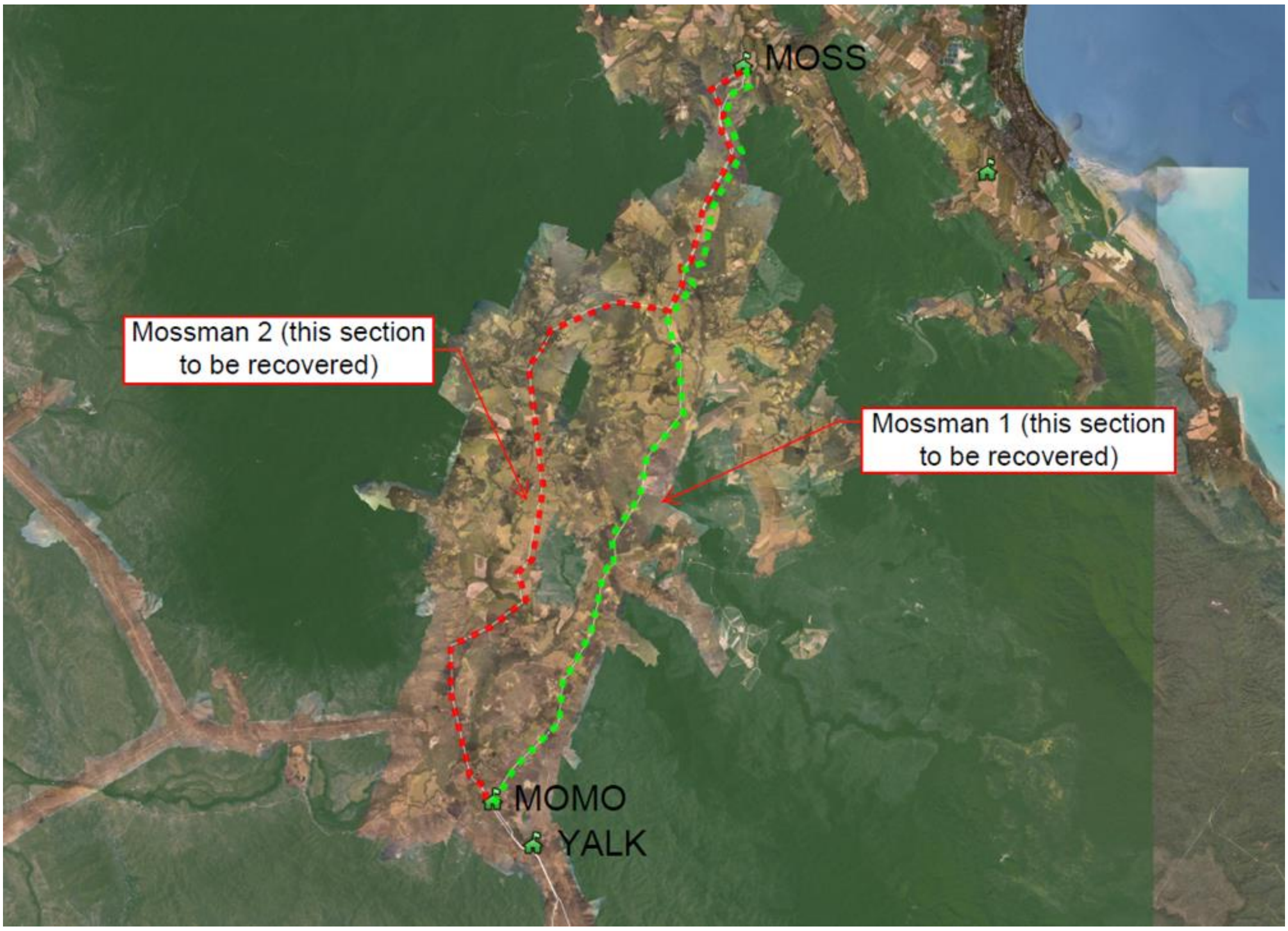



**Figure F12: Stage 3 Lines Work Removals of Mossman No.1 and Mossman No. 2 66 kV**

## 15.7. Stage 4: Removal of 66 kV TF2 and Mossman 2 Bay

### Substation works

Removal of all redundant 66 kV gear

- Feeder bay
- 66/22 kV TFER
- 22 kV outdoor bays

### Exclusions

- All substation works to be completed inside the existing Mossman Substation
- **Installation of second 132/22 kV transformer and bay to be allocated for but not included**

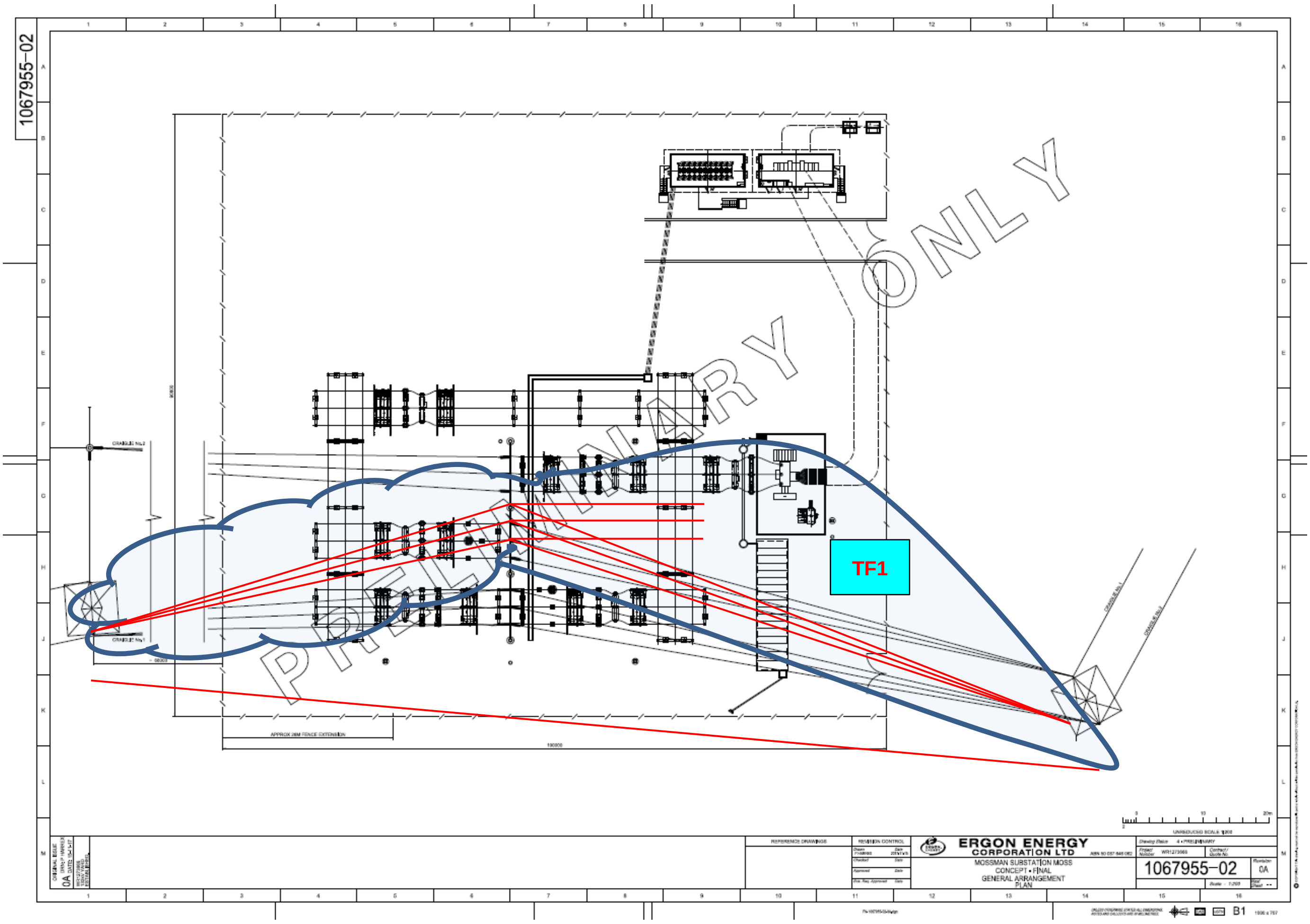



**Figure F13: Stage 4 Final General Arrangement of 132/22 kV Substation with Proposed 132 kV Substation Overlay to be modified to include only a single landing span and 132 kV bus tee to TF1 132/22 kV OLTC.**

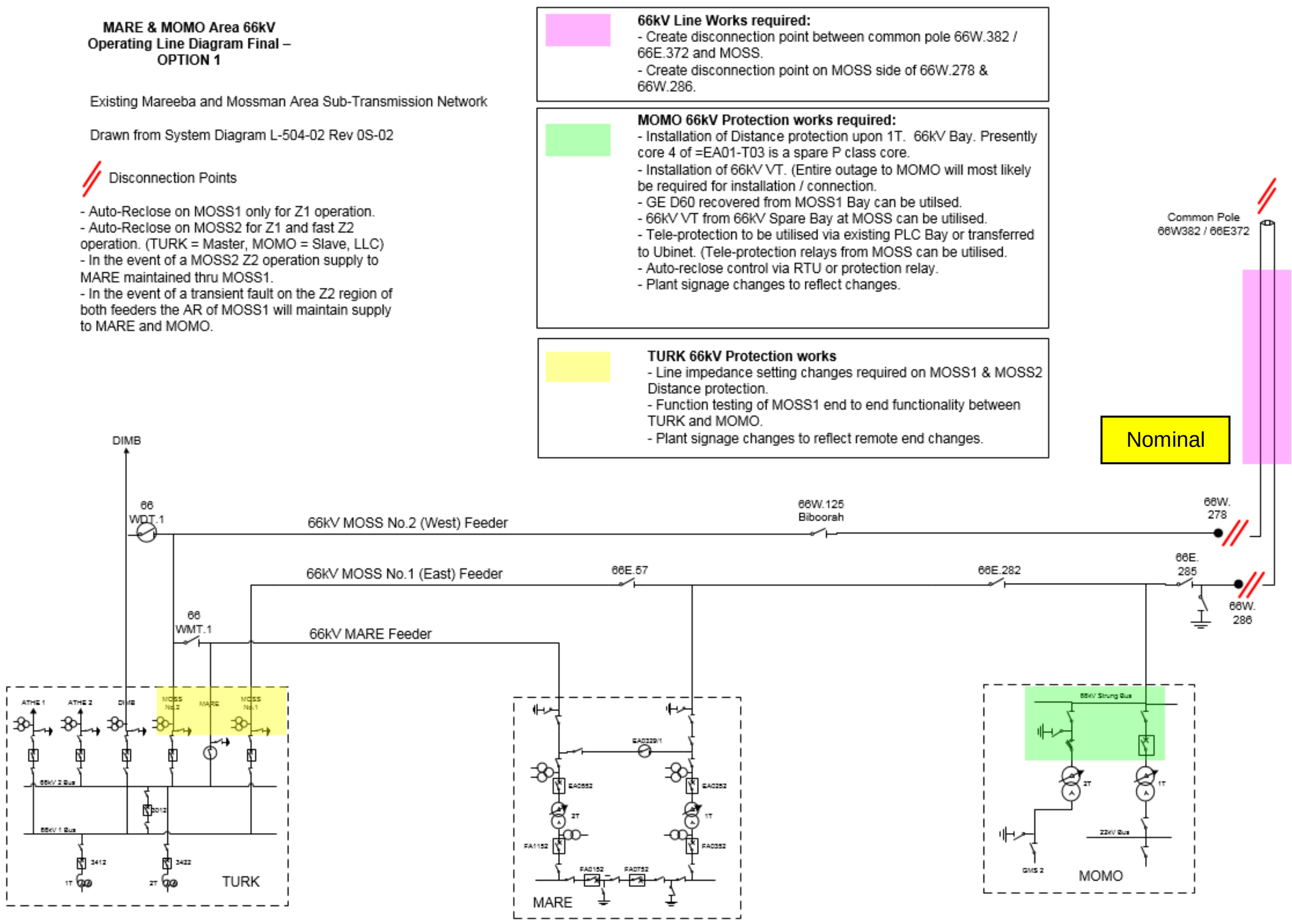



**Figure F14: Turkinje to Mount Molloy 66 kV line re-configuration**

# 16. APPENDIX G: OPTION B – BASE CASE WITH 66 KV LINE REPLACEMENT WHEN HI = 7.5

Option B:

- CAPEX to the end of the AER period 2024/25: $13.458M (all costs are DCV)

This option involves:

- Replacement of 66 kV Feeders Mossman 1 and 2 at HI = 7.5; and
- ADHOC replacement of aged plant through RTS projects

CBRM Mossman Summary v1.0_Final.:

-

**Option B** Return to Process Page **Non-Escalated DIRECT COSTS (DCV) to be used for all budget inputs**

| | |
|---|---|
| Option Title: | Replace/Refurbish 66kV Line, along with substations assets at HI 7.5 |
| Option Short Description: | Replace/Refurbish 66kV Line at $15mil over 3 years 2019-2021, along with replacement of SS assets at HI 7.5 |

*Note: Font in red indicates costs are outside of the evaluation period (From 'Inputs & Assumptions' tab)

| Description | Assumptions | Asset Life (yrs) | 2018/19 | 2019/20 | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | 2025/26 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Capex** | | | | | | | | | | |
| 1074599 Mossman 66kV CT and VT Replacement | | 40 | 569,549 | | | | | | | |
| 1171858 Mossman TX Protection Upgrade | | 20 | 328,765 | | | | | | | |
| 66kV Line replacement/refurbishment | Sitting 2019-2022 ($15Mil) | 40 | | 2,500,000 | 4,375,000 | 2,500,000 | | | | |
| Capital Lines Works | calc. off the last 5 yrs - escalated | 40 | 98,750 | 98,750 | 98,750 | 232,400 | 232,400 | 232,400 | 232,400 | 232,400 |
| Capital Substation works | | 40 | 17,732 | 17,732 | 17,732 | 17,732 | 8,866 | 8,866 | 8,866 | 8,866 |
| | | | | | | | | | | |
| MOSS Asset Replacement Due to 7.5 HI | | 40 | 1,198,438 | 937,500 | 93,938 | 308,750 | | 166,875 | 166,875 | |
| Install new 132/22kV TFers @ CRAI, YALK- no change | 25/32 MVA TFERs at CRAI | 40 | | | | | | | | 1,561,000 |
| Building replacement | | 40 | | | | 312,500 | | | | |
| | | | | | | | | | | |
| **TOTAL IMPLEMENTATION COSTS (real)** | | | **2,213,234** | **3,553,982** | **4,585,420** | **3,371,382** | **241,266** | **408,141** | **408,141** | **1,802,266** |
| **TOTAL IMPLEMENTATION COSTS (nominal)** | | | **2,213,234** | **3,642,832** | **4,817,557** | **3,630,610** | **266,313** | **461,774** | **473,319** | **2,142,328** |
| **TOTAL IMPLEMENTATION COSTS (discounted)** | | | **2,213,234** | **3,419,215** | **4,244,255** | **3,002,213** | **206,700** | **336,408** | **323,651** | **1,374,982** |

| **Opex** | | | 2018/19 | 2019/20 | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | 2025/26 |
|---|---|---|---|---|---|---|---|---|---|---|
| 66kV Line Maintenance | calculated off the last 10 years + C3 | | 154,375 | 154,375 | 154,375 | 38,594 | 38,594 | 38,594 | 38,594 | 38,594 |
| Substation Maintenance (calculated off the last 5 years) | MOSS ZS | | 171,055 | 171,055 | 171,055 | 171,055 | 42,764 | 42,764 | 42,764 | 42,764 |

**Figure G1: Option B Direct Cost NPV**

## 17. APPENDIX H: OPTION C – UPGRADE A CRAI 132/22 KV TRANSFORMER IN 2021/22, UNDERGROUND 22 KV FDERS TOWARDS MOSS ALONG CAPTAIN COOK H'WAY SUPPLIED FROM CRAI 22 KV S/B, NIL WORK AT YALK

Option C is not the recommended solution –Whilst it does locate the 132/22 kV transformers at the Port Douglas load centre, development options of the Mossman Sugar Mill & north of the Daintree is limited once MOSS is retired and YALK is not strategically developed (refer to Appendix D).

Option C:

- CAPEX to the end of the AER period 2024/25: $14.53M (all costs are DCV);
- Poor strategic development of Northern Tablelands and Douglas Shire area transmission and sub-transmission lines and substations;
- Re-develop supply to MOSS via underground feeders to Killaloe area;
- Retire MOSS and recover problematic section of 66 kV lines between MOMO and MOSS; and
- Nil work at YALK.

**Option C** Return to Process Page **Non-Escalated DIRECT COSTS (DCV) to be used for all budget inputs**

| | |
|---|---|
| Option Title: | Install new 132/22 kV 25/32 MVA tfers at CRAI, U/G feeders to 2MOS, 2DAI, 2SCK/2CAS + regs/reclosers |
| Option Short Description: | Retire MOSS, supply from CRAI |

*Note: Font in red indicates costs are outside of the evaluation period (From 'Inputs & Assumptions' tab)

| Description | Assumptions | Asset Life (yrs) | 2018/19 | 2019/20 | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | 2025/26 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Capex** | | | | | | | | | | |
| Install new 132/22kV TF @ CRAI, YALK- no change | 25/32 MVA TFERs at CRAI | 40 | | | | 1,561,000 | | | | 1,561,000 |
| 3 x 22 kV feeders to 2DAI, 2MOS, 2SCK/2CAS | 630AI. / 185AI. u/g cable feeders | 40 | | 504,000 | 3,735,000 | 6,936,000 | 1,281,000 | | | |
| | MOSS and MOSS 1 & 2 66 kV line | | | | | | | | | |
| Capital Lines Works | calc. off the last 5 yrs - escalated | 40 | 98,750 | 98,750 | 98,750 | 116,200 | 116,200 | 116,200 | 116,200 | 116,200 |
| Capital Substation works | | 40 | 17,732 | 17,732 | 17,732 | 8,866 | 8,866 | 8,866 | 8,866 | 8,866 |
| CRAI DC supply & 132 kV prot. | NER requirements | 20 | | | | 513,000 | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| **TOTAL IMPLEMENTATION COSTS (real)** | | | **116,482** | **620,482** | **3,851,482** | **9,135,066** | **1,406,066** | **125,066** | **125,066** | **1,686,066** |
| **TOTAL IMPLEMENTATION COSTS (nominal)** | | | **116,482** | **635,994** | **4,046,464** | **9,837,467** | **1,552,034** | **141,501** | **145,038** | **2,004,203** |
| **TOTAL IMPLEMENTATION COSTS (discounted)** | | | **116,482** | **596,954** | **3,564,924** | **8,134,769** | **1,204,621** | **103,085** | **99,176** | **1,286,331** |

| **Opex** | | | **2018/19** | **2019/20** | **2020/21** | **2021/22** | **2022/23** | **2023/24** | **2024/25** | **2025/26** |
|---|---|---|---|---|---|---|---|---|---|---|
| 66kV Line Maintenance | calc. off the last 5 yrs | | 154,375 | 154,375 | 154,375 | 38,594 | 38,594 | 38,594 | 38,594 | 38,594 |
| Substation Maintenance (calculated off the last 5 years) | MOSS ZS | | 171,055 | 171,055 | 171,055 | 171,055 | | | | |
| Losses (vs Option A) | | | | | | | 6,950 | 6,950 | 6,950 | 6,950 |
| | | | | | | | | | | |

**Figure H1: Option C Direct Cost NPV**



Ergon Energy Corporation Limited ABN 50 087 646 062
Energy Queensland Limited ABN 96 612 535 583
Energex Limited ABN 40 078 849 055

**DCV costs**

| Item | ZS | Description | Estimate No. | Estimate Description | Unit DC Price ($ M) | Quantity | Year of Spend | DC Cost ($ M) | Comments |
|---|---|---|---|---|---|---|---|---|---|
| | | **MOSS, CRAI & MARE costs** | | | | | | | |
| 1 | CRAI | CRAI DC 132 kV prot. - NER | S_PTRLY_SUB | REPLACE PROTECTION RELAY | 92281 | 4 | 2021/22 | 0.369 | |
| 2 | " | CRAI DC duplicate supply - 132 kV NER | S_DC110_UPG | REPLACE PROTECTION RELAY | 144275 | 1 | " | 0.144 | |
| 3 | " | Add retrofit relays for S/B- 22 kV C/Bs | S_PTRLY_SUB | REPLACE PROTECTION RELAY | 92281 | 2 | 2019/20 to 22/23 | 0.185 | 2 new feeder c/b relays |
| 4 | " | Base trench from CRAI to Tollentini Rd (2MOS) | MIP1024 | 400Al cable est. - new trench+ spares | 672275 | 10.5 | " | 7.059 | 630Al. to 2MOS adjacent Tollentini Rd Killaloe |
| 5 | " | 2SCK/2CAS new feeder in spare conduit from new trench | MIP1044 | 185Al. to Searanch | 119903 | 4.5 | " | 0.540 | New 185Al. To Searanch to join to U/G for 2DAI |
| 6 | " | 2DAI new feeder in spare conduit from new trench | MIP1045 | 630Al. To Tollentini Rd | 288607 | 10.5 | " | 3.030 | 630Al. to 2SCK/2CAS adjacent Tollentini Rd Killaloe |
| 7 | " | Add 2 reclosers end of 630Al. Cables | MIP1019 | reclosers end of 11km cable run | 49573 | 2 | " | 0.099 | 2 new 630Al. Feeders cable to 2MOS_2SCK/2CAS adjacent Tollentino Rd Killaoe |
| 8 | " | Add new regs. + recloser on 2DAI ex-2INL U/G 185Al. | MIP1002 & MIP1019 | Regs/reclosers | 369315 | 1 | " | 0.369 | Supply 2CAS, 2SCK from 2INL tail end |
| 9 | MOSS | Recover MOSS -MOMO 66 kV lines (MOSS 1 & 2) | MIP0371 | MOSS 1 & 2 to MOMO | 867500 | 1 | " | 0.868 | Recover MOSS ot MOMO 66 kV lines |
| 10 | " | Recover MOSS substation | MIP0263 | Structure, CBs,VTS, CTs, isolators, building, tfers etc | 306500 | 1 | " | 0.307 | Recover MOSS substation |
| 11 | " | Add 132/22 kV OLTC- CRAI | S_TXM2_INS | INSTALL 66/11kV POWER TX 32MVA | 1279000 | 1 | 2021/22 | 1.279 | " |
| 12 | " | Add 22 kV earthing transformer | 0003671 stock code | Zn 8kA/30s | 282000 | 1 | " | 0.282 | " |
| 13 | " | Add 132/22 kV OLTC- CRAI | S_TXM2_INS | INSTALL 66/11kV POWER TX 32MVA | 1279000 | 1 | 2031/32 | 1.279 | " |
| 14 | " | Add 22 kV earthing transformer | 0003671 stock code | Zn 8kA/30s | 282000 | 1 | " | 0.282 | " |
| | | **YALK switching stn costs** | | | | | | | |
| 1 | | No change | | | | | | 0.000 | |
| | | | | | | | | 0 | |
| | | | | | | | | 0 | |
| | | | | | | | | 0 | |
| **Total** | | **Estimated Cost: YALK & MOSS** | | | | | | **16.091** | |

**Table H1: CAPEX estimated cost of works (direct costs):**

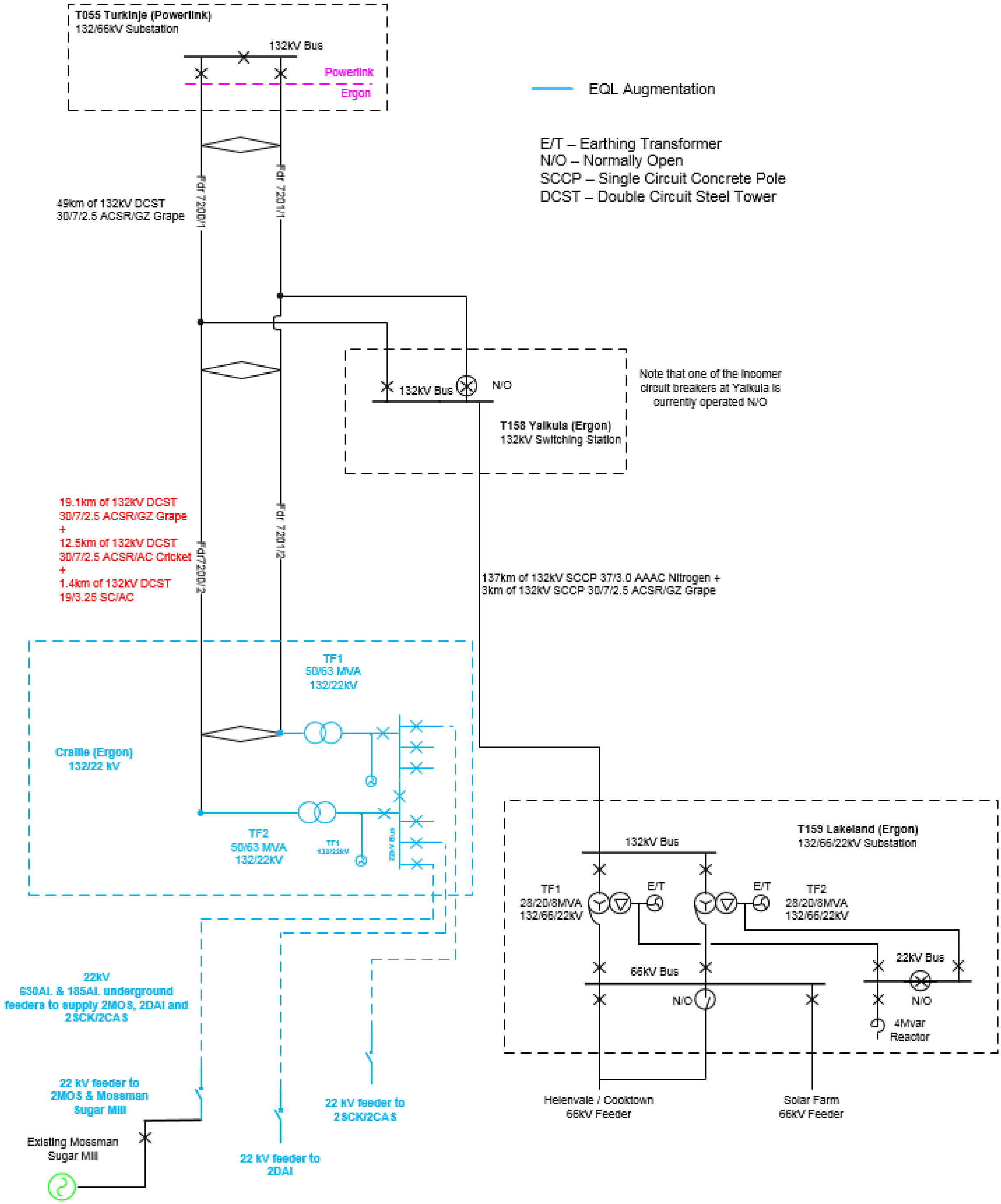



**Figure H2: Single Line Diagram of CRAI 2 x 132/22 kV OLTC c/w u/g 22 kV fders towards MOSS along Captain Cook H'way. No 132 kV works at Yalkula**

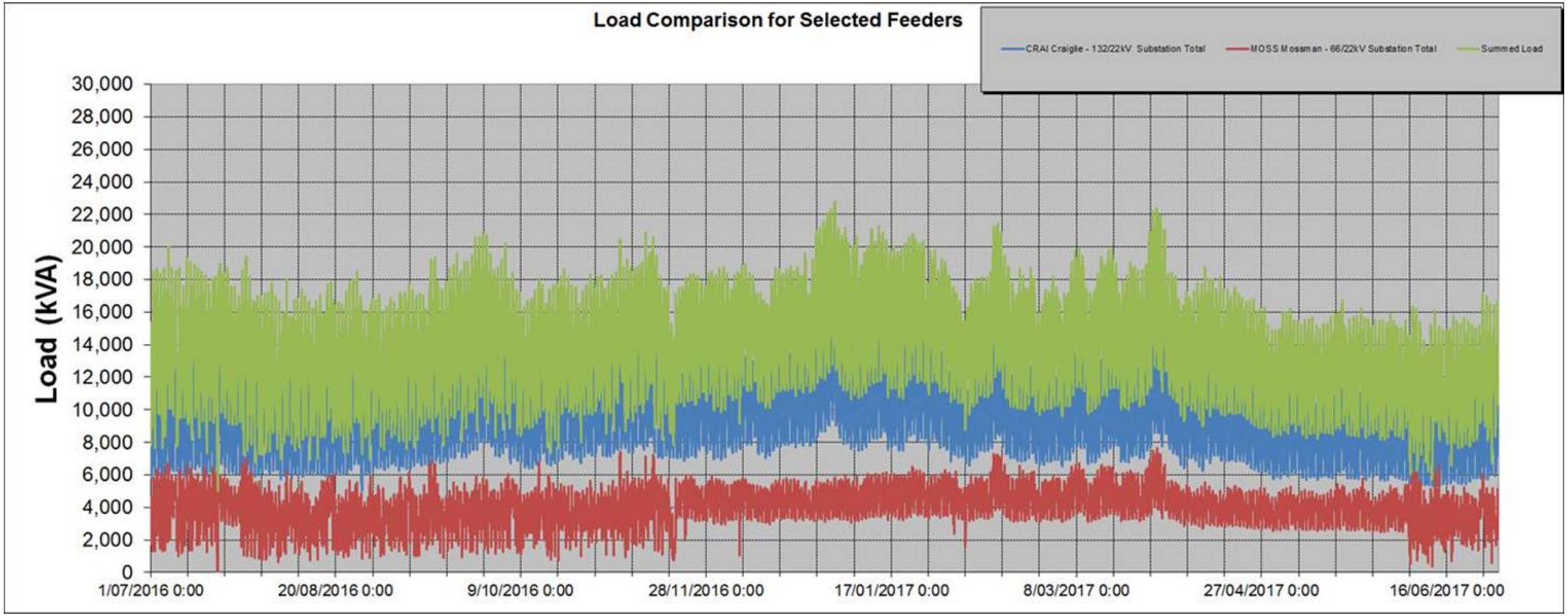



**Figure H3: The existing 15/20 MVA OLTCs at CRAI will require upgrading to a minimum 25/32 or 50/63 MVA units.**

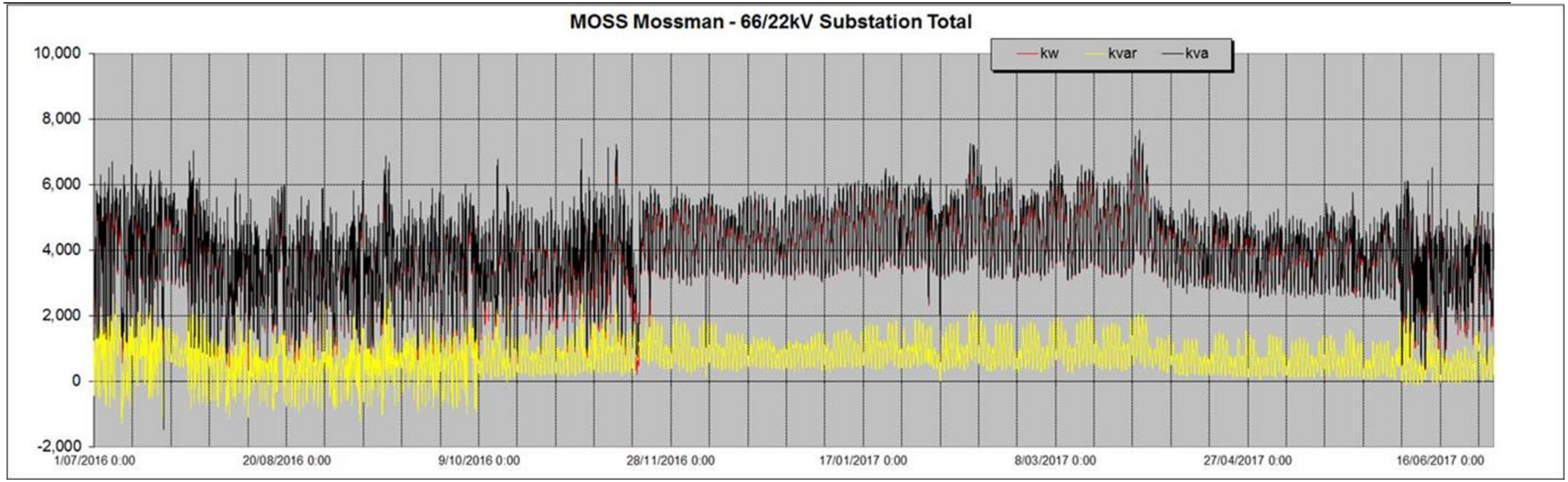



**Figure H4: Load forecast is 7.8 MVA**

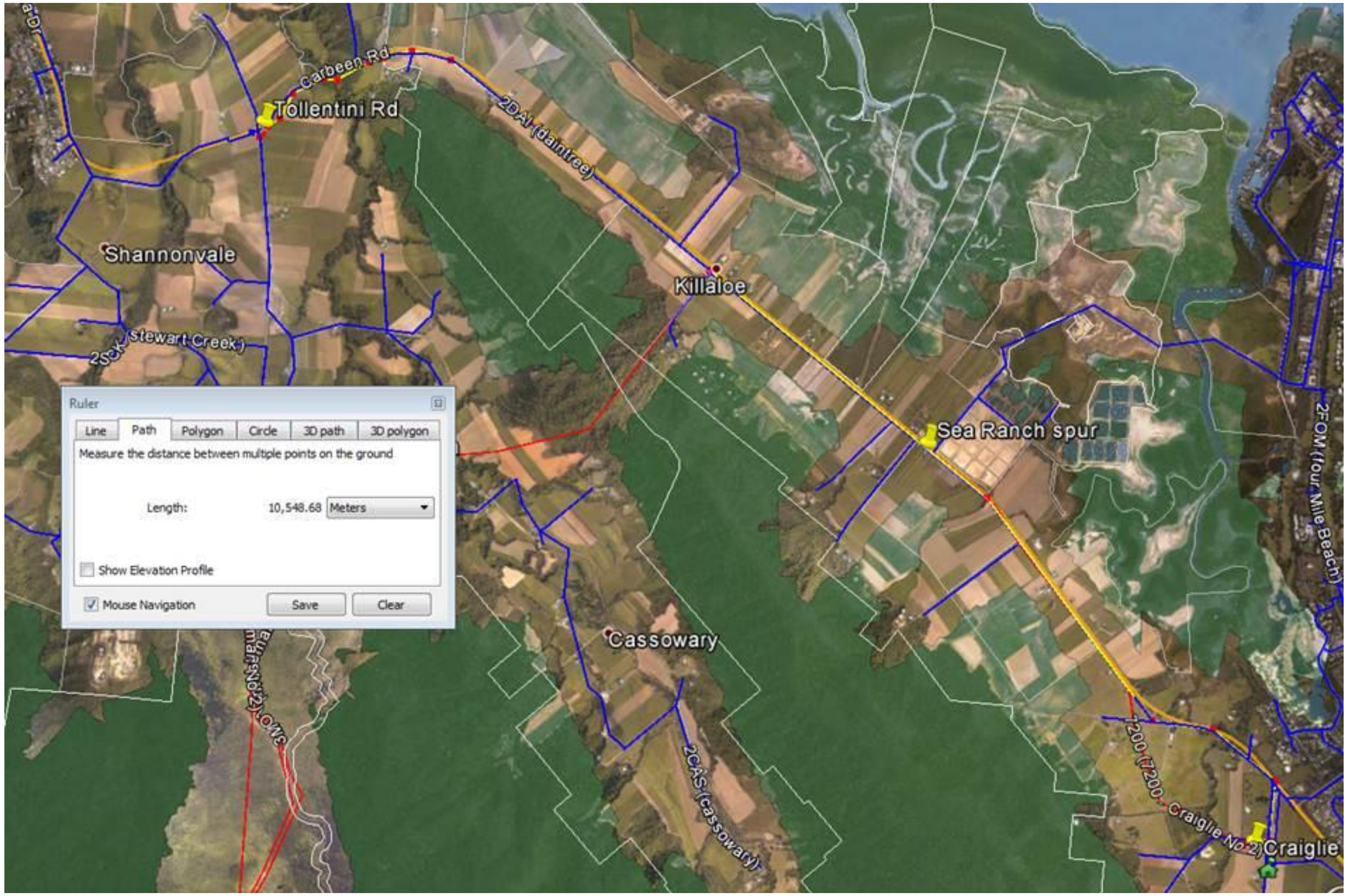



**Figure H5: Proposed 22 kV underground cable route (CRAI to 2MOS, 2SCK/2CAS at Tollenteni Rd)**

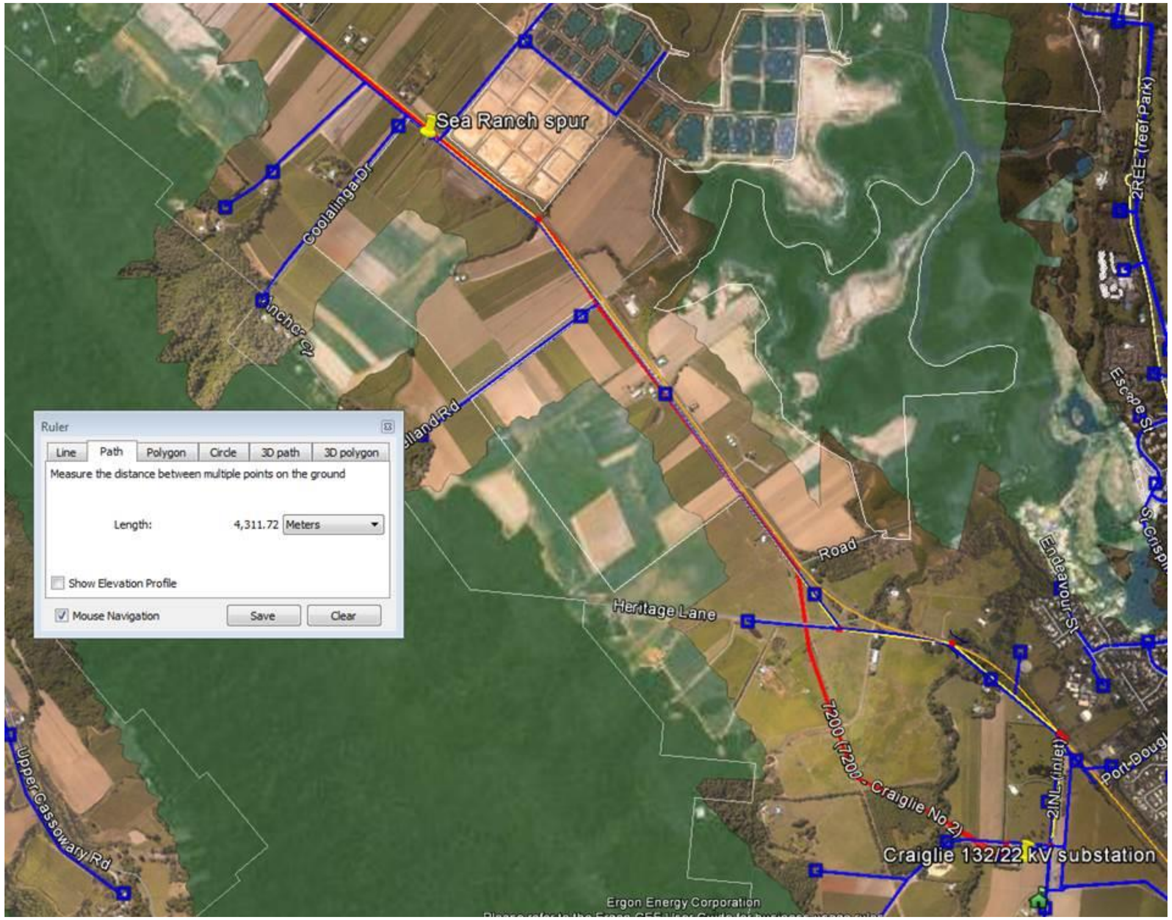



**Figure H6: Proposed 22 kV underground cable route (CRAI to 2DAI via ex-2INL backend just past Sea Ranch spur)**

## Planning Proposal


**Figure H7: Geographical of Proposed Option C (MOSS 22 kV distribution network via CRAI)**

# 18. APPENDIX I: ALTERNATE OPTIONS (MOSS & CRAI)

Two additional options were considered:

1. 2 x 132/22 kV OLTC at MOSS, 2 x 22 kV interconnectors to CRAI via existing 132kV circuits, convert CRAI into a switching stn with dedicated unit protected interconnectors and no YALK works; and
2. 1 x 132/22 kV OLTC at MOSS, 1 x 132/22 kV at CRAI, 1 x 22 kV unit protected interconnector between CRAI and MOSS via ex-132kV as a 22 kV interconnector and no YALK works.

Neither option provides strategic development at YALK which becomes a major 132 kV hub under preferred Option A.

Alternative 1 above was not considered further as the load centre is at CRAI (i.e. 17.0MVA), voltage regulation at CRAI 22 kV and the ex-132 kV as a 22 kV interconnector capacity becomes problematic,YALK is not developed as a major 132 kV hub and the cost to develop MOSS into a two transformer substation whilst retiring 132 kV from CRAI is more expensive than other options:

- 22 kV voltage management
  - switched shunt capacitors required at CRAI to support the CRAI 22 kV during an outage of one of the interconnectors or 22 kV bus at either MOSS or CRAI;
- 22 kV line capacity:
  - Cricket (30/7/2.50 ACSR/AC) and 19/3.25 SC/AC are SD rated at approx. 395 A (15.1 MVA) and 379 A (14.5 MVA at 22 kV) respectively which is below the present forecast demand at CRAI (i.e. approx. 446 A or 17.0 MVA at 22 kV); and
  - CRAI past demands have been as high as 19.4 MVA (i.e. 509 A at 22 kV in 2008-11) during peak tourism periods;
- Significant additional capital cost is required to develop MOSS into a two transformer substation; and
- YALK is not a strategically developed hub as proposed in Option A.

Alternative 2 above was not considered further as the load centre is at CRAI (i.e. 17.0MVA), voltage regulation at CRAI 22kV bus and the ex-132 kV as a 22 kV interconnector capacity becomes problematic,YALK is not developed as major 132 kV hub and the estimated cost to develop MOSS/CRAI into single transformer substations is as significant as other detailed options:

- 22 kV voltage management
  - switched shunt capacitors required at CRAI to support the CRAI 22 kV during an outage of 132 kV plant (i.e. transformer) to and at CRAI;
  - complex voltage management due to severely unbalanced power flows should only Cape York solar farm proceed as a result of the split 132 kV bus at YALK;
- 22 kV line capacity:
  - Cricket (30/7/2.50 ACSR/AC) and 19/3.25 SC/AC are SD rated at approx. 395 A (15.1 MVA) and 379 A (14.5 MVA at 22 kV) respectively which is below the present forecast demand at CRAI (i.e. approx. 446 A or 17.0 MVA at 22 kV); and
  - CRAI past demands have been as high as 19.4 MVA (i.e. 509 A at 22 kV in 2008-11) during peak tourism periods; and
- Significant additional capital cost is required to develop MOSS into single transformer substation and secure supply at CRAI (i.e. via the ex-132 kV line as a 22kV interconnector); and
- YALK is not a strategically developed hub as proposed in Option A.

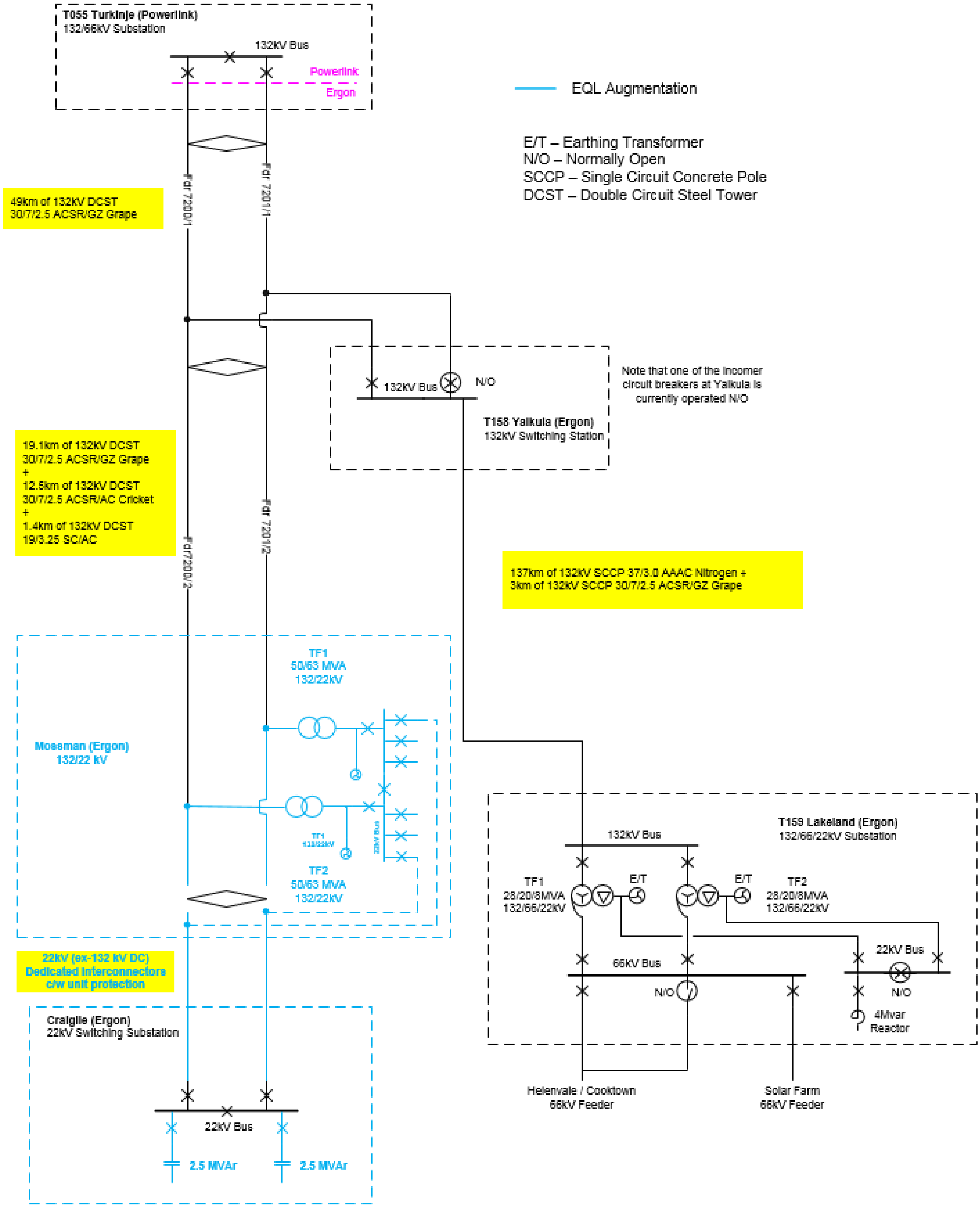



**Figure I1: Alternative 1 Single Line Diagram of Transformer ended 132 kV at Mossman c/w 22 kV interconnector comprising ex-132 kV circuit 7201/2 between Mossman and Craiglie. Remove 132 kV at Yalkula**

## 19. APPENDIX J: GLOSSARY OF TERMS

| Abbreviation | Term |
|---|---|
| **A** | Amps |
| **ACS** | Alternate Control Services |
| **AD** | Authorised Demand |
| **AER** | Australian Energy Regulator |
| **AFLC** | Audio Frequency Load Control |
| **AP** | Approved Plan |
| **AS** | Australian Standard |
| **AVR** | Automated Voltage Regulator |
| **CAPEX** | Capital Expenditure |
| **CARE** | Cyclone Area Reliability Enhancements |
| **CAW** | Contract Awarded |
| **CICW** | Customer Initiated Customer Works |
| **C/B** | Circuit Breaker |
| **CP** | Connection Point |
| **CT** | Current Transformer |
| **CVT** | Capacitor Type Voltage Transformer |
| **CCM** | Construction Commenced |
| **DNP** | Distributed Network Protocol |
| **EECL** | Ergon Energy Corporation Limited |
| **DNAP** | Distribution Network Augmentation Plan |
| **FCA** | First Capacity Available |
| **FACTS** | Flexible AC Transmission System |
| **GSM** | Global System for Mobile Communications |
| **HV** | High Voltage |
| **IP** | Internet Protocol |
| **IED** | Intelligent Electronic Device |
| **IDR** | Implementation Design Released |
| **IRC** | Investment Review Committee |
| **kA** | Kilo Amp |
| **kV** | Kilo Volt |
| **kVArh** | Kilo Volt Amps Reactive Hours |
| **kW** | Kilo Watt |
| **kWh** | Kilo Watt Hour |
| **LCF** | Local Control Facility |
| **LED** | Light Emitting Diode |
| **LMVP** | Type of VACUUM Type C/B |
| **LTEC** | Long Term Emergency Cyclic |
| **MEGU** | Micro Embedded Generating Unit |
| **MDP** | Meter Data Provider |

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|---|---|
| **MiCOM** | Type of Brand/Model For Protection Relays |
| **MSP** | Message Switching Protocol |
| **MW** | Mega Watt |
| **NATA** | National Association of Testing Authorities |
| **NCR** | Normal Cyclic Rating |
| **NIRC** | Network Investment Review Committee |
| **OPEX** | Operating Expenditure |
| **OEM** | Original Equipment Manufacturer |
| **OTD** | Operational Technology Deployment |
| **OLTC** | Online Tap Changer |
| **OCN** | Operational Communications Network |
| **OES** | Operational Engineering Service |
| **OPGW** | Optical Ground Wire |
| **PDH** | Plesiosynchronous Digital Hierarchy |
| **PoP** | Plant Overload Protection |
| **PIA** | Project Initiation Advice |
| **PSS** | Project Scope Statement |
| **PCO** | Project Close Out |
| **PDA** | Protection Design Advice |
| **RWR** | Recommended Works Report |
| **RAM** | Regional Asset Management |
| **RDAS** | Remote Data Acquisition Server |
| **RWH** | Recommended Works Handover |
| **RMS** | Root Means Square |
| **RTU** | Remote Terminal Unit |
| **RUG** | Releasable User Guide |
| **SDH** | Synchronous Digital Hierarchy |
| **SEL** | Schweitzer Engineering Laboratories |
| **SME** | Subject Matter Experts |
| **SCR** | Short Circuit Ratio |
| **SCS** | Shared Control Services |
| **SFU** | Static Frequency Unit |
| **SP** | Service Provider |
| **SCADA** | Supervisory Control & Data Acquisition |
| **SCCP** | Single Circuit Concrete Pole |
| **SCR** | Short Circuit Ratio |
| **SVC** | Static Var Compensator |
| **SWER** | Single Wire Earth Return |
| **SNAP** | Sub transmission Network Augmentation Plan |
| **SYN-CON** | Synchronous Condenser |
| **TAPS** | Transmission & Project Services |
| **TSR** | Technical Specification Released |



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|---|---|
| **TCR** | Thyristor Controlled Reactor |
| **V** | Volt |
| **VT** | Voltage Transformer |
| **WE** | Works Enablement |
| **WCO** | Warranty Close Out |
| **ZSS** | Zone Substation Standard |