Investment Evaluation Summary (IES)

Project Details:

Project Name:	Replace 220 kV Sprechur and Schuh HPF live tank circuit breakers
Project ID:	01671
Business Segment:	Transmission
Thread:	Transmission Substations
CAPEX/OPEX:	CAPEX
Service Classification:	Prescribed
Scope Type:	A
Work Category Code:	RENSB
Work Category Description:	Substations
Preferred Option Description:	Replace 220 kV Sprecher and Schuh HPF live tank circuit breakers in the 2019-24 regulatory period
Preferred Option Estimate (Dollars $2016/2017):	$6,519,037

	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29
Unit ($)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Volume	0.00	0.13	0.60	0.27	0.00	0.00	0.00	0.00	0.00	0.00
Estimate ($)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total ($)	$0	$847,475	$3,911,422	$1,760,140	$0	$0	$0	$0	$0	$0

Governance:

Works Initiator:	Michael Verrier	Date:	10/11/2018
Team Leader Endorsed:	Darryl Munro	Date:	15/11/2018
Leader Endorsed:	Nicole Eastoe	Date:	20/11/2018
General Manager Approved:	Wayne Tucker	Date:	22/11/2018

Related Documents:

Description	URL
S and S HPF 220 kV NPV analysis	http://reclink /R0001198175#NPV_V3_S_and_S_220_kV_breakers.xlsm
Sprecher and Schuh HPF 110 kV CB AMP (reference only until 220kV versioncompleted)	http://reclink/R0000241127
Estimate L1	http://reclink/R0000681123
EHV Circuit Breaker AMP	http://reclink/R0000040413
EHV circuit breaker replacement program-D11 6850	http://reclink/R0000743337
Risk analysis tool (EHV-CB Module)	http://reclink/R0000743375
TasNetworks Risk management Framework	http://Reclink/R0000238142
TasNetworks Transformation Roadmap 2025	http://Reclink/R0000764285
TasNetworks Corporate Plan - Planning period: 2017-18	http://reclink/R0000745475
National Electricity Rules (NER)	http://www.aemc.gov.au/Energy-Rules/National-electricity-rules/Current-Rules
TasNetworks Business Plan 2017-18	http://reclink/R0000779008

Section 1 (Gated Investment Step 1)

1. Overview

1.1 Background

There are six 220 kV Sprechur and Schuh HPF live tank circuit breakers currently installed at TasNetworks transmission Substations. These circuit breakers are installed on critical transmission circuits.

The circuit breakers are outside oil-insulated, some coupled and some phase-segregated, 220 kV units manufactured by Sprechur and Schuh in 1975.

These units have not been refurbished, predominately due to lack of manufacture spare parts, or relocated since their original installation. Inspection and minor maintenance works have been completed across the life of the assets.

TasNetworks strategy is to utilise dead tank circuit breakers for new or replacement circuit breaker installations, with the exception of installations that require the use of single-pole auto-reclose functionality where single pole live tank units can be considered. Single-pole auto-reclose functionality is typically required on 220 kV transmission line applications. The strategy has been developed based on life-cycle cost analysis and is consistent with industry practice.

It was detailed and supported in a circuit breaker replacement program document presented to the Transend board of management in 2011 that the Sprechur and Schuh units would be scheduled for replacement in 2023.(Note that Transend subsequently merged with Aurora Energy in 2014 to form TasNetworks.)

As detailed in TasNetworks EHV Circuit Breaker Asset Management Plan a extra high voltage (EHV) circuit breaker replacement program commenced in 1993, with its primary objective being to address compliance (safety, environmental and technical capability), performance and life-cycle management issues. The program has generally been implemented on a prioritised basis with bulk oil and air blast circuit breaker designs attributed the highest priority. The detailed sequence of the circuit breaker replacements has largely been determined by the criticality of the asset to sustaining the security and reliability of the transmission network, with consideration of the efficiencies that could be realised through coordinating the circuit breaker replacements with other planned works where appropriate. The 220 kV component of the original identified EHV circuit breaker replacement program was completed in 2004 and the replacement of the original identified 110 kV air blast and bulk oil circuit breaker components of the program was completed in 2003 and 2004 respectively.

The remainder of the EHV circuit breaker replacement program comprised the replacement of Sprecher and Schuh type HPF, Reyrolle type 110/OS and Siemens type H800 small oil volume circuit breakers. The Reyrolle type 110/OS (with exception of PM-P152 which is targeted for replacement over 2017/18) and Siemens type H800 have been completed with the Sprecher and Schuh type HPF being the objective of this project.

1.2 Investment Need

Sprechur and Schuh HPF live tank circuit breakers have been experiencing some failures; all which are complicated by the lack of manufacturer support and spares availability. The circuit breakers also utilise oil as an insulating and arc extinguishing medium, which requires more frequent maintenance intervals compared to modern equivalent assets. TasNetworks has standardised on SF6 insulation for new EHV circuit breakers.

Sprechur and Schuh HPF circuit breakers are costly to maintain when compared with units of dead tank design.

Replacement of these circuit breakers aligns with TasNetworks EHV Circuit Breaker asset management plan, which details that EHV circuit breakers have an average service life of 45 years which aligns with the Sinclair Knight Mertz “Asset Valuation for Financial Reporting Purposes” report prepared in May 2012 (D12/36181)

Renewal drivers

1.2.1 Design

The circuit breakers are outside oil-insulated, live tank units manufactured by Sprechur and Schuh HPF in 1975.

These units have not been refurbished or relocated since their original installation. Inspection and minor maintenance works have been completed across the life of the assets.

The external operating linkages and rotating post insulators on this type of circuit breaker are poorly designed. This poor design is why refurbishment is not recommended as it is unlikely to address the recurring physical conditions. Also there is no manufacture support with spare parts. Units of similar design that operated at 110 kV were prone to failure. The 110 kV units of similar design have already been replaced from TasNetworks system.

The circuit breakers will be 45 years old at time of recommended replacement having reached the end of their economic life based on Sinclair Knight Mertz “Asset Valuation for Financial Reporting Purposes” report which specifies that the economic life of a circuit breaker is 45 years.

1.2.2 Condition

A condition assessment report has been prepared for these Sprechur and schuh HPF live tank circuit breakers. The report has identified that the Sprecher and Schuh HPF 220 kV circuit breakers:

- Are 42 years of age;
- Are maintenance intensive and costly to maintain when compared with modern equivalent units;
- Have inherent design deficiencies;
- Have minor environmental issues regarding the use of insulating oil, however oil is PCB free;
- Have minor safety issues due to the use of insulating oil and potential of sharp projectiles during catastrophic failure due to porcelain bushings;
- Are in acceptable electrical condition;
- Have recurring physical condition issues;
- Have had no major failures, but have had a number of minor issues since commissioning;
- Have no significant oil leaks noted in the most recent switchyard inspections;
- The manufacturer or the manufacturer's agent no longer hold any spare parts;
- Require frequent maintenance and repair, leading to high life-cycle asset management costs and increased transmission circuit unavailability when compared to modern equivalent units; and
- Require skilled resources that are experienced in maintaining and repairing assets that are obsolete technology.

It is noted in the CIGRE technical bulletin "Final report of the 2004-2007 International enquiry on reliability of High Voltage Equipment, Part 2 - reliability of High Voltge circuit breakers" the most frequenct cause for minor or major failure is due to wear and ageing.

1.2.3 Defects records

With reference to TasNetworks defects register, there have been 8 recorded defects for Sprechur and Schuh HPF 220 kV circuit breakers between 2002-2017.

Majority of defects related to corrosion and leaking gaskets. Typical repairs involve:

- re-grouting seals;
- replacing damaged porcelain on post insulators units;
- repairing leaks on dash pots and refilling oil; and
- renewal works due to overall unit corrosion including to free up rusted linkages.

1.2.4 Condition Based Risk Management (CBRM)

Risk analysis for EHV circuit breakers was conducted in 2015 with the in-house development of a EHV Circuit Breaker risk analysis tool. This analysis resulted in the Sprechur and Schuh HPF 220 kV circuit breakers being grouped in the "High" health index network risk category (only three ratings applicable Low, Medium or High).

1.3 Customer Needs or Impact

TasNetworks continues to undertake consumer engagement as part of business as usual and through the voice of the customer program. This engagement seeks in depth feedback on specific issues relating to:

- How it prices impact on its services.
- Current and future consumer energy use.
- Outage experiences (frequency and duration) and expectations.
- Communication expectations.
- STPIS expectations (reliability standards and incentive payments).
- Increasing understanding of the electricity industry and TasNetworks.

Consumers have identified safety, restoration of faults/emergencies and supply reliability as the highest performing services offered by TasNetworks.

Consumers also identified that into the future they believe that affordability, green, communicative, innovative, efficient and reliable services must be provided by TasNetworks.

This project specifically addresses the requirements of consumers in the area of supply reliability and safety.

1.4 Regulatory Considerations

This project is required to achieve the following capital expenditure objectives in alignment with NER 6A.6.7 (Transmission) as outlined in table 1.

Table 1 Capital expenditure objectives relevant to this project.

This project is required to achieve the following capital expenditure objectives:	Yes/No
• Meet or manage the expected demand for prescribed services.	Yes
• Comply with all applicable regulatory obligations associated with the provision of prescribed services.	Yes
• Maintain the quality, reliability and security of supply of prescribed services.	Yes
• Maintain the reliability and security of the system through the supply of prescribed services.	Yes

• Maintain the safety of the system through the supply of prescribed services.	Yes

2. Project Objectives

The objective of this project is to replace the fleet of Sprechur and Schuh HPF 220 kV live tank circuit breakers to:

- Contribute to the achievement of the capital expenditure objectives identified in the NER;
- Provide a safe, secure and reliable electricity supply to customers connected through transmission substations by replacing obsolete assets;
- Achieve life-cycle cost savings due to reduced operations and maintenance requirements;
- Align with TasNetworks circuit breaker standard; and
- Align with strategic asset management plans.

3. Strategic Alignment

3.1 Business Objectives

Strategic and operational performance objectives relevant to this project are derived from TasNetworks 2017-18 Corporate Plan, approved by the Board in 2017.

This project is relevant to the following areas of the corporate plan:

- We understand our customers by making them central to all we do;
- We enable our people to deliver value; and
- We manage our assets to deliver safe and reliable services while transforming our business.

3.2 Business Initiatives

The business initiatives reflected in TasNetworks Transformation Roadmap 2025 publication (June 2017) for transition to the future that have synergy with this project are as follows:

- Network and operations productivity: We'll improve how we deliver the field works program, continue to seek cost savings and use productivity targets to drive our business;
- Electricity and telecoms network capability: To meet your energy needs and ensure power system security, we'll invest in the network to make sure it stays in good condition, even while the system grows more complex;
- Predictable and sustainable pricing: To deliver the lowest sustainable prices, we'll transition our pricing to better reflect the way you produce and use electricity; and
- Enabling and harnessing new technologies and services: By investing in technology and customer service, we'll be better able to host the technologies you're embracing.

4. Current Risk Evaluation

The qualitative risk evaluation summarised in section 4.1 below shows the untreated risk associated with a do nothing option. It equates to a worst case scenario of inherent risk associated with a particular asset. A lower

level of likelihood and / or consequence may be applied as part of the sensitivity analysis when calculating the total risk cost as part of the quantitative options analysis.

4.1 5x5 Risk Matrix

TasNetworks' business risks are analysed utilising the 5x5 corporate risk matrix, as outlined in TasNetworks Risk Management Framework.

Relevant strategic business risk factors that apply are as follows:

Risk Category	Risk	Likelihood	Consequence	Risk Rating
Customer	Material supply interuption to many customers.	Unlikely	Moderate	Medium
Environment and Community	Environmental remediation work. No impact beyond Tasnetworks area.	Unlikely	Negligible	Low
Financial	Moderate financial impact. Assets has been identified in deteriorating condition and if fail in service will result in un-intended costs to the business in excess of what would be expected for a controlled CAPEX spend	Unlikely	Moderate	Medium
Network Performance	Potential impact on major industrials due to NCSPS with loss of GO line.	Unlikely	Moderate	Medium
Regulatory Compliance	Potential breach of relationship with regulator, poor management of assets.	Unlikely	Moderate	Medium
Reputation	Some local media attention. Potential to spread wider.	Unlikely	Moderate	Medium
Safety and People	Risk of injury dependant on asset failure mode and potential industrial action for not adequately maintaining asset. Existing aged assets exhibiting external signs of degradation which introduces risk of failure.	Rare	Severe	Medium

Section 2 (Gated Investment Step 2)

5. Preferred Option:

The preferred option is to replace the existing aged and poor condition Sprechur and schuh 220 kV HPF live tank circuit breakers in the 2019-24 regulatory period.

5.1 Scope

Replace fleet of 220 kV Sprechur and schuh HPF live tank circuit breakers at Palmerston and Gordon substations.

- PM-A152; and
- GO-A152, GO-B152, GO-A752, GO-C752, GO-S752.

Addition scope of work to be considered for inclusion (and confirmed at time of project initiation to ensure network reliability, security of supply and maintenance flexibility are not compromised):

- phase segregated DTCBs for GO-A152 and GO-B152;
- mechanically coupled DTCBs for GO-A752, GO-C752, GO-S752; and
- replacement of disconnectors GO-A129D and GO-B129D.

5.2 Expected outcomes and benefits

The expected outcomes and benefits of the preferred option include:

- security, availabilty and reliability of supply maintained in various supply areas;
- reduction of safety risk;
- alignment with strategic asset management plans; and
- remove fleet of aged assets.

5.3 Regulatory Test

Although this project has a capital value which exceeds the threshold for triggering a regulatory investment test, as it comprises works at more than one substation and/or one transmission circuit, TasNetworks deems that a regulatory investment test is not required based on the current understanding of the applicable national electricity rule.

6. Options Analysis

Completion of options analysis has been undertaken using a modified Net Present Value (NPV) tool, to include Risk Cost. Risk Cost represents the expected annual cost of risk events ($ million) associated with the failure of asset. The business as usual case (BAU) base case definition applied in the options analysis is aligned to Australian Energy Regulator (AER) repex planning guideline. The NPV outcomes for all options considered, is relative to the BAU base case. The NPV tool has also been modified to include a Basis of Preparation. This enables increased transparency of the methodology and analysis undertaken, outlining methodology, key

inputs, key assumptions. The Risk Cost methodology is represented as below:

Annual asset risk cost = Probability of Asset Failure (PoF) * Asset units (No) * Likelihood of Consequence of Failure (LoC) * Cost of Consequence (CoC).

The analysis of all options is aligned with the Australian Energy Regulators application note for asset replacement planning, to ensure alignment of our approach. The risk cost categories, likelihood and consequence ratings are aligned with TasNetworks Corporate Risk Framework. The categories can also be mapped to the AER's repex planning guideline

AON, TasNetworks corporate insurer provided Cost of Consequence (CoC) and Likelihood of Consequence (LoC) data. We have also analysed our assets and sought additional benchmarked data to develop Likelihood of Failure, Likelihood of Consequence and Cost of Consequence when it can be obtained.

The replacement of the remaining fleet of 220KV Sprechur and Schuh HPF live tank circuit breakers (6 in total) in 2019-24 regulatory period, option 1, is the preferred option. This is the most cost-effective solution to address the project requirements and removes a safety concern in a more timely manner than other options and is the most positive NPV economically.

It is noted that the AER/ARUP preliminary proposal has highlight that a partial replacement may be justified with some work in 2019-24 regulatory period and remainder in the 2024-29 period. The fleet only comprises six units and a better supply price will be provided with a single project to replace all instead of staggering over different regulatory periods. It is also noted that five of the units are located at Gordon Substation with one at Palmerston Substation. Providing prudent project management and allocation of resources to complete the work would drive the need for it to be complete as a single work package. The NPV analysis shows that completion of the proposed works in the 2019-24 regulatory period is the preferred option.

The holding of removed units as spares is not the preferred asset management practice with these old, poor condition units as the spares themselves will not provide reliable service. The cost penalty for reactive replacement works with the inherent risk of supply security and increased cost would negatively impact TasNetworks and their customers (including potentially constraining generation and the resultant negative financial impact on TasNetworks) as opposed to a planned capital replacement in a controlled proactive manner. A NPV analysis for this staggered approach and holding of removed units as spares until the following regulatory period has not been completed as the low volume of replacement units does not warrant such a review.

The AER has commented that no unserved energy costs have been included with the NPV analysis. This is the case with transmission circuits impacted by this proposed project. These transmission circuits provide a redundant system where firm supply is provided for, ie. N-1 configuration. To allow for this there is a parallel supply path associated with each of the identified circuit breakers and as such failure of any one would not have any unserved energy costs associated. Although there is the possibility of impact on constrained generation. This has been included with the revised NPV along with an updated risk analysis costing. The example used in the NPV analysis was for the Gordon Power Station generation export noting that for loss of one 220 kV transmission line due to a circuit breaker failure the remaining transmission line will be constrained to 144 MW effectively negatively impacting on the national generation market with resultant financial penalties.

The preferred option is to undertake the proposed works as one project in the 2019-24 regulatory period.

Note that the NPV analysis undertaken for this project is based on capital and operational costs including risk based costs. The project has been deemed to be justified on the grounds that it is:

1. a safety related replacement project based on a need to satisfy a zero harm business requirement;
2. a safety related replacement project based on a strategy; and
3. a replacement project for assets that have a finite life or condition based identified during inspection or

condition test reports and failure can be assured or predicted. Replacement in a controlled manner is strongly recommended over an unplanned response which also aligns with good asset management practice.

6.1 Option Summary

Option description	
Option 0	Do nothing and replace on failure
Option 1 (preferred)	Replace 220 kV Sprecher and Schuh HPF live tank circuit breakers in the 2019-24 regulatory period
Option 2	Replace 220 kV Sprecher and Schuh HPF live tank circuit breakers in the 2024-29 regulatory period
Option 3	Staggered replacement of 220KV S&S HPF circuit breakers in the 2019-24 and 2024-29 regulatory periods.

6.2 Summary of Drivers

Option	
Option 0	Do nothing and replace on failure Retain exisiting fleet of 220 kV Sprechur and Schuh HPF live tank circuit breakers (6 in total). Scope The proposed scope for this option includes: • maintaining fleet of 220 kV Sprechur and Schuh HPF live tank circuit breakers (6 in total) and run to failure. Benefits The benefits for this option are no capital expenditure. Drawbacks The drawbacks for this option are: • higher operational costs; • increased likelihood of CB failure; • increased mainteanance cost; and • reactive replacement at higher cost.
Option 1 (preferred)	Replace 220 kV Sprecher and Schuh HPF live tank circuit breakers in the 2019-24 regulatory period

	Scope The proposed scope for this option includes: • replace fleet of 220 kV Sprechur and Schuh HPF live tank circuit breakers (6 in total). Benefits The benefits for this option are: • Most positive economical outcome from NPV analysis including monetised risk; • Maintain current level of supply reliability; • Controlled replacement of assets; and • Appropriate spend of capital expenditure. Drawbacks The drawbacks for this option is the high capital expenditure.
Option 2	Defer replacement of 220 kV Sprecher and Schuh HPF live tank circuit breakers until the 2024-29 regulatory period Scope The proposed scope for this option includes: • Replace fleet of 220 kV Sprechur and Schuh HPF live tank circuit breakers (6 in total). Benefits The benefits for this option are: • controlled replacement of assets; and • appropriate spend of capital expenditure. Drawbacks The drawbacks for this option are: • level of supply reliability decreases; • potential higher operational expenditure due to delayed replacement; and • deferment for another 5 years introducing risk of adverse supply reliability and safety consequences due to increased likelihood for asset failure.
Option 3	Staggered replacement of 220KV S&S HPF circuit breakers in the 2019-24 and 2024-29 regulatory periods. This option includes the replacement of the existing 220KV S&S HPF circuit breakers. This option addresses all the condition issues associated with this type of circuit breaker.

	Scope The proposed scope for this option includes: • Replacement of EHV breaker at Palmerston Substation in 2019-2024 revenue reset period • Replacement of EHV breakers at Gordon Substation in 2024-2029 revenue reset period Benefits The benefits for this option are: • Deferred some capital expenditure on replacement of EHV circuit breakers in declining condition. Drawbacks The drawbacks for this option are: • Higher capital cost; • Inefficient use of project resources; • Increased maintenance cost for remaining units; and • Continue with higher risk of failure as opposed to replacing out all units.

6.3 Summary of Costs

Option	Total Cost ($)
Option 0	$0
Option 1 (preferred)	$6,519,037
Option 2	$6,519,037
Option 3	$7,019,037

6.4 Summary of Risk

Option 0: Do nothing and replace on failure

Identified risks predominately to customers, financial, network performance, regulatory compliance, reputation and safety increase further over time as the asset condition deteriorates further.

Option 1: Replace 220KV Sprecher and Schuh HPF live tank circuit breakers in the 2019-24 regulatory period

Reliability of supply maintained for the long term. Risks to customers, network performance, regulatory compliance and reputation reduced with safety consequence reduced substantially.

Option 2: Defer replacement of 220KV Sprecher and Schuh HPF live tank circuit breakers until the 2025-29 regulatory period

The deferment of the replacement would result in an increased exposure to a failure.

With the asset failure likelihood increasing due to condition degradation, the risks to customers, financial, network performance, regulatory compliance, reputation and safety continue as per do nothing option for greater period of time.

Option 3: Staggered replacement of 220KV Sprecher and Schuh HPF live tank circuit breakers in the 2019-24 and 2024-29 regulatory periods.

The deferment of replacement of half the fleet would result in continued increased exposure to a failure on remaining units.

With the asset failure likelihood increasing due to condition degradation, the risks to customers, financial, network performance, regulatory compliance, reputation and safety continue as per do nothing option for greater period of time.

6.5 Economic analysis

Option	Description	NPV
Option 0	Do nothing and replace on failure	-$7,944,601
Option 1 (preferred)	Replace 220 kV Sprecher and Schuh HPF live tank circuit breakers in the 2019-24 regulatory period	$993,972
Option 2	Replace 220 kV Sprecher and Schuh HPF live tank circuit breakers in the 2024-29 regulatory period	-$1,295,973
Option 3	Staggered replacement of 220KV S&S HPF circuit breakers in the 2019-24 and 2024-29 regulatory periods.	-$735,912

6.5.1 Quantitative Risk Analysis

A quantitative risk analysis has been completed including the cost of risk as described in section 6 above. The most positive option has been selected as the preferred option.

A CBRM assessment has been completed, which indicates these assets are in the high risk category and require works to manage this risk.

6.5.2 Benchmarking

TasNetworks participates in various formal benchmarking forums with the aim to benchmark asset management practices against international and national transmission companies. Key benchmarking forums include:

- International Transmission Operations & Maintenance Study (ITOMS); and
- Transmission survey, which provides information to the Electricity Supply Association of Australia (ESAA) for its annual Electricity Gas Australia report.

In addition, TasNetworks works closely with transmission companies in other key industry forums, such as CIGRE (International Council on Large Electric Systems), to compare asset management practices and performance.

ITOMS provides a means to benchmark asset class averages (maintenance cost and service levels) between

related utilities from around the world. There is a strong need to ensure capital expenditure, maintenance processes and procedures are continually reviewed to ensure optimum financial and service benefits and minimal fault outages.

The completion of this project is expected to ensure TasNetworks continues to meet its benchmarking obligations and any improvement initiatives related to those benchmarking results.

6.5.3 Expert findings

Not applicable.

6.5.4 Assumptions

Assets require replacement due to two main issues:

1. Aged assets past financial life; and
2. Aged assets approaching end of technical life (replace before failures / defects eventuate).

It is also assumed that when GO-A152 and GO-B152 are replaced, that the corresponding "bypass bus" disconnectors CO-A129D and GO-B129D will also be replaced as part of this project. This will see the removal from the network of the last of the fleet of Stanger type TTRV disconnectors. These disconnectors were manufactured in 1958 making them 59 years of age.

Operating costs, unserved energy and/or network penalties used in NPV.

1. Operating costs based on either continued maintenance regime of aged assets, or new maintenance practice due to replaced assets. Maintenance schedules based on details listed in EHV circuit breaker asset management plan.
2. Use energy through line or transformer.
3. Apply failure rate, typically for EHV assets assume to be a certain per cent for aged (eg. 0.48 per cent) and a tenth of that (eg. 0.048 per cent) for new. An example of figures to use for penalty applied for impact on generation:
    a. Historical total MWh generated in a year which for example for Wilmot, 137GWh
    b. Use probability of CB fail, disconnector, CT or VT failure
    c. Use generation rescheduling cost of $20-30/MWh
    d. Loss generation cost Annual MWh x probability x $20 = 137,000 x 2 per cent x $20 = $54,800.
4. Noted that no <0.1 or >1.0 system minute loss for last few years and that for each project, EHV CB's, CT's and CVT's that failure of asset will typically not result in unserved energy due to N-1 arrangement. Only if breaker fail occurs and then bus trip will unserved energy be possible. If system minutes loss would result in ~$300K for each >0.1 and >1.0 loss of supply events.
5. Market Impact Congestion - Transmission (MICT) is an important consideration, Transmission congestion occurs when the transmission network has insufficient capacity to support the optimal generator dispatch based upon a bidding generator in the National Electricity Market (NEM). As current year performance impacts two years future target and next year performance, a value of $10,000 per hour (12 Dispatch Intervals) can be used as lost opportunity cost for the use in NPV analysis. An example from 30 May 2017 when 97 dispatch intervals were binding during a forced outage on the HA–GT No 1 220 kV required due to an oil leak on current transformer HA-Q196. The HA–GT No 1 transmission circuit was out of service for 36 hours (or 432 DI). Penalty cost $360,000.