# Investment Evaluation Summary (IES)

## Project Details:

| | |
|---|---|
| Project Name: | Dynamic Reactive Power Device for George Town Substation |
| Project ID: | 01523 |
| Business Segment: | Transmission |
| Thread: | Transmission Development |
| CAPEX/OPEX: | CAPEX |
| Service Classification: | Prescribed |
| Scope Type: | A |
| Work Category Code: | AUGMP |
| Work Category Description: | Major Projects |
| Preferred Option Description: | Install ±50 MVAr STATCOM at George Town Substation |
| Preferred Option Estimate (Dollars $2016/2017): | $15,068,456 |

| | 19/20 | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | 25/26 | 26/27 | 27/28 | 28/29 |
|---|---|---|---|---|---|---|---|---|---|---|
| Unit ($) | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Volume | 0.07 | 0.72 | 0.21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Estimate ($) | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Total ($) | $1,054,792 | $10,849,288 | $3,164,376 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |

## Governance:

| | | | |
|---|---|---|---|
| Works Initiator: | Herath Samarakoon | Date: | 12/10/2017 |
| Team Leader Endorsed: | Ewan Sherman | Date: | 01/11/2017 |
| Leader Endorsed: | Stephen Jarvis | Date: | 01/11/2017 |
| General Manager Approved: | Wayne Tucker | Date: | 01/11/2017 |

## Related Documents:

| Description | URL |
|---|---|
| [1] George Town Reactive Support Requirements | http://reclink/R559534 |
| [2] Tasmania Reactive Power Plan (2013) | http://viewdoc/D13/15477 |
| [3] George Town Dynamic Reactive Support - Cost Estimate | http://reclink/R681164 |
| [4] George Town Dynamic Reactive Support - Economic Analysis spreadsheet | http://reclink/R848757 |
| [5] Requirements for Negative Phase Sequence Compensation at George Town | http://reclink/R246419 |
| [6] Economic benefits of Geogre Town proposed dynamic reactive support | http://reclink/R819820 |
| [7] Electricity Network Transformation Roadmap, ENA and CSIRO, 2017 | http://www.energynetworks.com.au/electricity-network-transformation-roadmap |
| [8] NTNDP 2016 Generation and Transmission outlooks, AEMO | https://www.aemo.com.au/ |
| [9] TasNetworks Transformation Roadmap 2025 | http://reclink/R764285 |
| [10] TasNetworks Corporate Plan 2017 | http://reclink/R745475 |
| [11] National Transmission Network Development Plan 2016, AEMO | https://www.aemo.com.au/ |
| [12] Final determination, Cost thresholds review for the regulatory investment rest, AER 2015 | https://www.aer.gov.au/ |

Section 1 (Gated Investment Step 1)

# 1. Overview

## 1.1 Background

TasNetworks is acutely aware of the impacts that a changing generation mix is having on power system security and reliability. The change in generation technologies has altered the operational dynamics of the power system and our need for system services to keep it secure.

It is in this context, as well as continued load growth at George Town substation, that TasNetworks has identified investment needs in northern Tasmania which are to be pursued through this project.

George Town Substation (GTS) is a critical part of the Tasmanian Power System. It is the connection point for the Basslink High Voltage Direct Current (HVDC) interconnector which facilitates Tasmania's participation in the National Electricity Market (NEM).

Tamar Valley Power Station (TVPS), having a total capacity of 386 MW connects to GTS. The gas turbines at TVPS contribute significantly to the fault levels at GTS and assist with stabilising voltages during network disturbances with their large reactive power capability supporting both steady state and dynamic voltage stability.

The November 2016 update of the Electricity Statement of Opportunities (ESOO), projects that in the absence of any market response, the recent closure of Hazelwood power station in 2017 may lead to breaches of the reliability standard by the summer of 2017-18, and maintaining the export capability from Tasmania will positively contribute toward the ongoing reliability of the NEM, and reduce the probability of unserved energy particularly in the Victorian and South Australian regions.

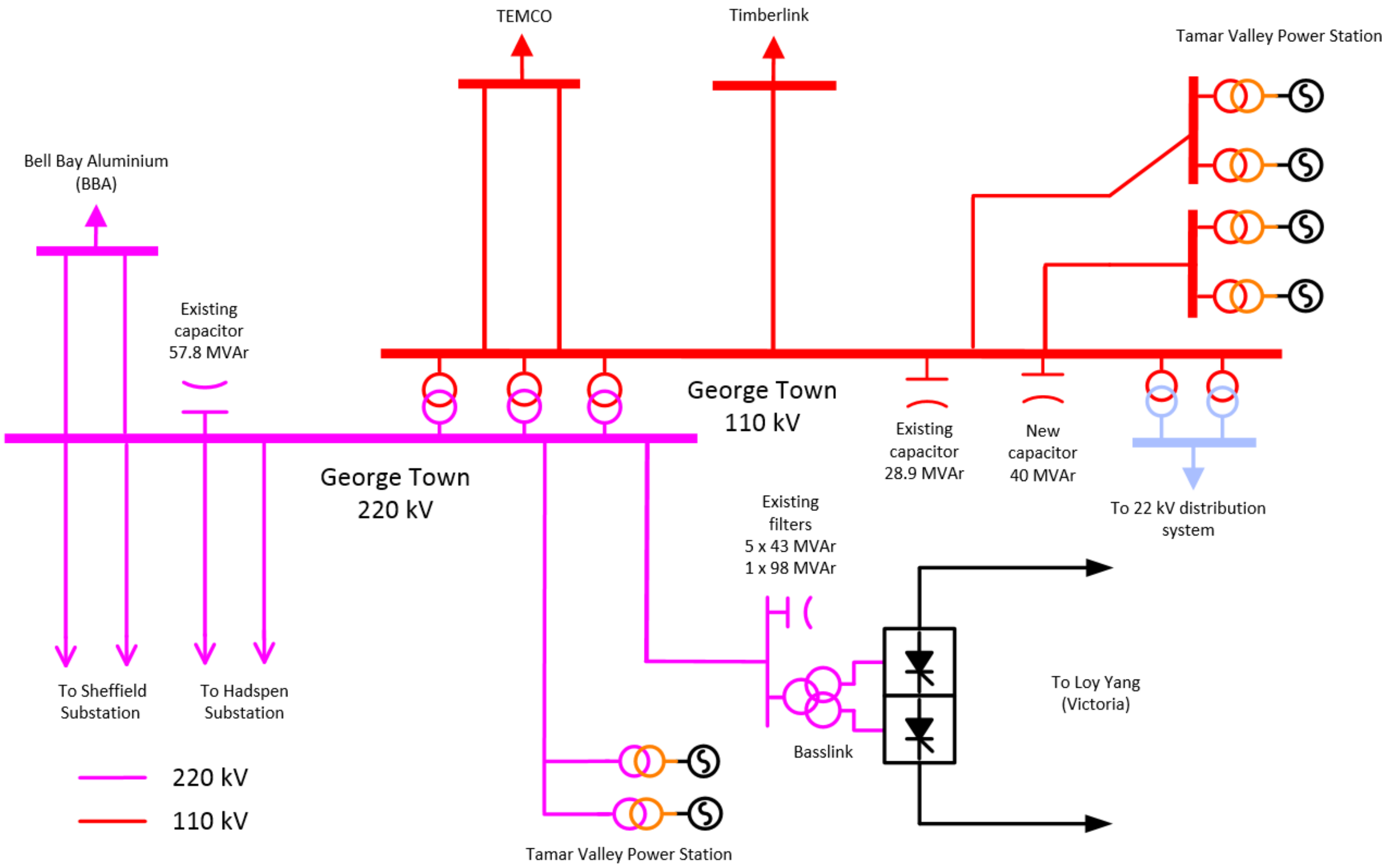
The GTS also supplies significant local load, 467 MW in 2016 (excluding Basslink exports), predominantly to two major industrial customers. During 2017/18 the load connected to GTS is expected to increase by approximately 22 MW, which without any other action would result in an increase in periods where Basslink export will be constrained.

As an initial step in resolving the voltage control issues at GTS, TasNetworks is currently installing a 40 MVAr 110 kV capacitor bank at GTS to provide additional static reactive reserves to reduce the amount of time that Basslink export is constrained. The installation of an additional capacitor bank represents Stage 1 of a strategic initiative to provide adequate voltage control and reactive margin at GTS. This capacitor bank will complement the two installed capacitor banks already located at GTS and in concert with the proposed Static Synchronous Compensator (STATCOM), will provide the required dynamic voltage stability.

This project will assist with the broader question of how to efficiently increase the networks ability to host intermittent asynchronous renewable energy systems without negatively impacting on power system security and reliability standards. TasNetworks is currently progressing in excess of 1400 MW of proposed large scale renewable generator connection enquiries and applications.

The George Town transmission network is shown in Figure 1 below:

Figure 1: Transmission Network in the George Town area.




## 1.2 Investment Need

Since mid-2014, the GTS area has seen very little generation dispatched from the TVPS combined cycle gas turbine (CCGT). This is predominantly due to the sustained increase in the cost of gas generation, which has impacted both Tasmanian and mainland generation profiles. In the Tasmanian context, this has meant that the GTS load (plus Basslink export) is now generally supplied from remote hydro and wind generating units, a situation that will be further exacerbated by future wind developments. The further generation is from GTS the lower is the fault level of the GTS 220 kV bus bar, and the more challenging is voltage control.

The non-availability of TVPS has increased the periods of low fault level at GTS and increased the difficulties in managing post contingency Temporary Overvoltages (TOV) and voltage instability issues at GTS. Similarly the increased intervals of low fault level will increase the periods where phase voltage unbalance is likely to be an issue.

TasNetworks in its role as the Transmission Network Service Provider (TNSP) must maintain voltages within prescribed operating limits and ensure that voltage stability can be maintained. Both criteria are described within the System Standards of the National Electricity Rules (Rules) and are technical requirements that TasNetworks to manage as part of its overall system security obligations.

Negative Phase Sequence

Significant levels of Negative Phase Sequence (NPS) voltage have been measured at GTS indicating unacceptable voltage phase unbalance. The likelihood of the phase unbalance being unacceptable increases the lower, the fault level at the George Town buses [5].

The NPS levels observed at GTS are non-compliant in respect to the voltage unbalance as detailed in S5.1a.7 of the Rules, and are expected to be further exacerbated by increased periods of low fault levels. The non-compliance can be addressed by correcting breaches with Table S5.1a.1, column 2 (Reduce negative phase sequence 30 minute average voltage at GTS 110 kV bus to within the planning levels of 0.5%).

Voltage Control

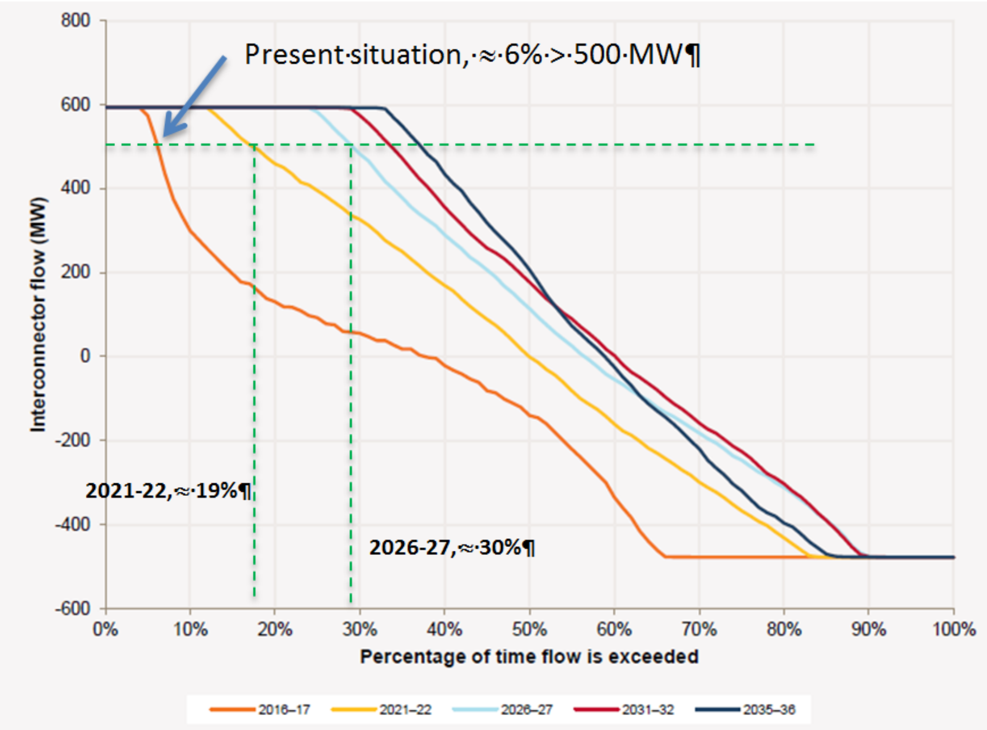
The 2016 NTNDP prepared by AEMO forecasts that the generation mix on mainland Australia will change significantly in the coming years, with large-scale wind and solar developments progressively displacing existing coal generation.

TasNetworks has seen significant amounts of wind and photovoltaic (PV) developers wishing to connect to the Tasmanian network.

AEMO has predicted that the Tasmanian–Victoria interconnector is projected to experience an increase in flows in both direction (ie north and south), often to the interconnector's limit.

Northward flow is mainly due to forecast increases of renewable energy in Tasmania and coal retirements on the mainland [11]. These forecasts show an increasing reliance on high Basslink export in future years, as shown in Figure 2.

Figure 2: Extract from 2016 NTNDP - projected Basslink utilisation (page 45)




## 1.3 Customer Needs or Impact

The existing levels of Negative Phase Sequence observed at GTS are non-compliant with the *Rules*, and will be further exacerbated as periods of low fault level at GTS become more frequent due to the non-availability of the TVPS and displacement of closer hydro generation with more remote wind and PV generators.

Voltage stability and TOV issues are currently managed by introducing constraint equations into the National Electricity Market Dispatch Engine (NEMDE). The current practice is to reduce the impact of these constraints by operating existing Tasmanian hydro generators in synchronous condenser mode, introducing additional cost to the energy market, and ultimately customers.

Basslink export constraints can limit available low cost energy from offsetting higher cost energy in Victoria.

## 1.4 Regulatory Considerations

The National Electricity Rules section 6A.6.7(a) gives the capital expenditure objectives that must be met as part of a revenue proposal.

The below table describes the regulatory requirement in relation to the initial capability block of the dynamic reactive support at George Town Substation (i.e., the first ±25 MVAr STATCOM). The installation of an additional ±25 MVAr STATCOM (i.e., the second stage, increase the capacity to ±50 MVAr) is based on the market benefits.

| Capital expenditure objectives | | Yes / No |
|---|---|---|
| 1. | Meet or manage the expected demand for prescribed transmission services over that period | No |
| 2. | Comply with all applicable regulatory obligations or requirements associated with the provision of prescribed transmission services | Yes |
| 3. | To the extent that there is no applicable regulatory obligation or requirement in relation to: | |
| (i) | the quality, reliability or security of supply of prescribed transmission services; or | |
| (ii) | the reliability or security of the transmission system through the supply of prescribed transmission services<br><br>to the relevant extent: | |
| (iii) | Maintain the quality, reliability and security of supply of prescribed transmission services | No |
| (iv) | Maintain the reliability and security of the transmission system through the supply of prescribed transmission services | No |
| 4. | Maintain the safety of the transmission system through the supply of prescribed transmission services | No |

# 2. Project Objectives

The primary objective of the project is to address the non-compliance issue observed at George Town Substation.

The secondary objective is to provide net positive market benefit by releasing Basslink export constraints, where Basslink exports are to be constrained more with the forecasted export increases, and further integration of large scale wind and PV generators in Tasmania.

# 3. Strategic Alignment

## 3.1 Business Objectives

Strategic and operational performance objectives relevant to this project are derived from the TasNetworks Corporate Plan 2017 [10]. This project supports the four pillars to the strategy, included in the corporate plan:

- we care for our customers and make their experience easier
- we keep safe, build trusting relationships, and enable our people to deliver value
- we manage our assets to deliver safe and reliable services, while transforming our business
- we operate our business to deliver sustainable shareholder outcomes

The proposed project aligns with the strategic initiative to integrate large scale renewables and strategic measure of maintaining network service performance. Releasing the export constraints provides more opportunities for the renewable energy generators to access the Victorian energy market. Addressing non-compliance of NPS at George Town helps maintain network service performance at George Town Substation.

## 3.2 Business Initiatives

Our TasNetworks Transformation Roadmap 2025 [9] identifies business-wide programs that we need to focus on to achieve our strategic goals. This project supports the following transformation programs as set out below:

- Voice of the customer: we anticipate and respond to changing needs of customers and market conditions
- 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 customer 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
- Enabling and harnessing new technologies and services: by investing in technology and customer service, we'll be better able to host the technologies customers are embracing

This project will release the constraint in exporting energy from Tasmania to Victoria, and support the integration of large scale renewable generators in Tasmania.

# 4. Current Risk Evaluation

The following risk assessment indicates the current level of risk associated with the area the proposed project is to be implemented.

## 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 |
|---|---|---|---|---|
| Network Performance | Non-compliance with NPS and TOV is a substantial quality of supply issue | Likely | Moderate | High |
| Regulatory Compliance | Difficulty in managing non-compliance with NPS limits and TOV is a minor systemic breach of the Rules | Likely | Moderate | High |
| Reputation | Unlikely damage to reputation due to constrain the export | Unlikely | Moderate | Medium |

## 5. Preferred Option:

The preferred option is to install a ±50 MVAr dynamic reactive support (STATCOM) at George Town Substation 110kV Busbar.

A STATCOM responds very quickly in the critical post-contingency voltage recovery period, that helps to manage TOV and voltage instability issues. Similarly STATCOM reduces the level of NPS voltage and installing ±25 MVAr will help to reduce if any future NPS issues arise.

An additional ±25 MVAr will provide net positive market benefits by reducing Basslink export constraints.

### 5.1 Scope

The scope of the project includes the installation of the following equipment:

- An 110 kV bay for the proposed dynamic reactive support (selected such that there is no single point of failure which can lead to loss the proposed dynamic reactive support and a transmission crcuit or transformer which can cause the issues to be addressed by the proposed installation);
- Step down transformer of 100 MVA and MV switchgear for the transformer and the dynamic reactive support;
- ±50 MVAr STATCOM and associated secondary equipment; and
- Voltage control scheme for integrated control of all reactive power devices at George Town Substation.

### 5.2 Expected outcomes and benefits

The main benefits of the project are to maintain power quality at GTS and provide net positive market benefit. The proposed solution will address power quality non-compliance issues associated with NSP at GTS. Similarly the proposed solution will maximize the net market benefits by releasing the TOV and voltage instability constraint on Basslink exports. This will help to export more energy from Tasmania to Victoria.

A number of other benefits, which are not quantified in the justification of the investment, are in this project. The risk of system black due to a double circuit failure (single asset failure) on either the Sheffield – George Town or Hadspen - George Town 220 kV transmission lines will be minimised by the proposed project [2]. Similarly this provides an opportunity to establish an active power support device using new technologies. This will give a benefit by releasing the operational constraints on generators and Basslink.

### 5.3 Regulatory Test

The regulatory investment test for transmission (RIT-T) will apply to this project as the most expensive option identified will cost more than $6 million [12]. The following table represents the proposed schedule for implementing the RIT-T.

RIT-T proposed schedule

| Milestone | Proposed date |
|---|---|
| Publish Project Specification Consultation Report (PSCR) | 1 July 2019 |
| PSCR consultation period starts | 1 July 2019 |
| PSCR consultation period finishes | 1 October 2019 |
| Prepare Project Assessment Draft Report (PADR) | Exempt under NER 5.15.3(b)(5) (cost under $41m) |
| Publish Project Assessment Conclusions Report (PACR) | 1 February 2020 |
| Begin implementation of preferred option | 1 July 2020 |

## 6. Options Analysis

Two issues at George Town Substation were identified: non-compliance with NPS limits, and constraint energy export from Tasmania to Victoria. Only one technically and economically feasible solution was identified to address the NPS issue (i.e., installation of ±25 MVAr STATCOM). The previous study on NPS identified that 17 MVAr dynamic reactive support is required to address the existing issue [5]. This has been approximated to 25 MVAr with the consideration of uncertainties in operations and practical limitations.

Two technically and economically feasible solutions were identified to address the constraining energy export limitation: continuation of current practice (i.e., operating generators on synchronous mode to release the constraints or constrain the export if no sufficient generators to run on synchronous mode), and installation of additional ±25 MVAr dynamic reactive support (i.e., total of ±50 MVAr STATCOM). This is the capacity recommended in the previous study on George Town reactive support requirements [1].

Three options were developed for the option analysis with the consideration of the above feasible solutions: Option 0 (business as usual), Option 1 (install ±25 MVAr STATCOM to address NPS issue and operating the generators as synchronous condensors to manage the export constraints), Option 2 (install ±50 MVAr STATCOM to address NPS issue and release the export constraints further). Option 2 can be described as a two stage development in which the first stage is ±25 MVAr STATCOM (i.e., Option 1), and the second stage is an addition dynamic reactive power capacity of ±25 MVAr.

Option 0 is rejected as it does not address NPS non-compliance issue. However, Option 1 (or the first stage of Option 2) has market benefits over Option 0 due to release the export constraints with the provision of votlage control services from the STATCOM. Option 2 has additional market benefits due to release the export constraints further (i.e., from the second stage). Both these stages were analysed in order to visualise the economics behind these.

The implementation of ±25 MVAr STATCOM (i.e., the first stage) has market benefits due to the reduction of voltage instability and TOV constraints. Alternative option to address the market constraint issues is to operate generators on synchronous mode or constrain Basslink export if no sufficient generators are available to run on synchronous mode (i.e., Option 0). Avoiding the alternative option is considered as a benefit of the proposed solution. Figure 2 shows the comparison of additional annual cost and benefits under AEMO Basslink flow forecasts for 2021/22 and 2026/27. In 2021/22, the expected benefits are equivalent to $496,000, which is $113,000 lower than the annualised cost of the first stage. The expected benefit of $763,000 will result a net market benefit of $154,000 in 2026/27. These benefits are quite significant and sufficient to recover the total cost by 2023/24 based on linear interpolation. It is assumed that the base capital cost of the first ±25 MVAr STATCOM would be around $10 million (i.e., equivalent to $609,000 annualised cost) with the consideration of additional equipment needed with the first installation such as transformer, connection bay etc. The cost of the ±25 MVAr STATCOM was calculated based on the cost estimate for ±50 MVAr STATCOM [3].

Figure 2: Benefits and additional cost of the first stage of dynamic reactive support at George Town Substation


The second stage is to address voltage instability and TOV issues further. Similar to the first stage, alternative is to to operate generators on synchronous mode or constrain Basslink export if no sufficient generators are available to run on synchronous mode. The incremental cost of increasing STATCOM capacity from ±25MVAr to ±50MVAr is compared against the alternative. The incremental cost to increase STATCOM capacity is about $5 million, which is equivalent to $302,000 annualised cost. Figure 3 shows the comparison of the additional annual cost of the STATCOM and the benefits in 2021/22 and 2026/27. In 2021/22, the expected benefit is $333,000 which is $31,000 (or 10%) higher than the annualised cost. That is a 10$ net benefit to the energy market. The benefits will reach to 190% of the cost under 2026/27 Basslink flow profile (i.e., 90% net benefit).

Figure 2: Benefits and additional cost of the second stage of dynamic reactive support at George Town Substation


The details of the cost benefit analysis are given in the document, Economic benefits of George Town proposed dynamic reactive support [6].

The total net present value of costs and benefits are given in Section 6.5. It shows Option 2 has the lowest NPV cost. Furthermore, the sensitivity of the results was tested against time of commissioning (advanced by a year to delayed by 3 years), real discount rate (3% to 8%), change of capital cost (reduced by 10% to increased by 30% of the base cost), change of operation and maintenance cost (reduced by 20% to increased by 100% of the base cost). All these sensitivity scenarios show that Option 2 gives maximum benefit to the energy market than Option 1 except when real discount rate is above 7.8% (i.e., more than double the base discount rate used in the analysis). Accordingly Option 2 is the most economical option. Further details of the economic analysis are available in the economic analysis spreadsheet [4].

## 6.1 Option Summary

| Option description | |
|---|---|
| Option 0 | Base Option: continue current operating practices |
| Option 1 | Install ±25 MVAr STATCOM at George Town Substation |
| Option 2 (preferred) | Install ±50 MVAr STATCOM at George Town Substation |

## 6.2 Summary of Drivers

| Option | |
|---|---|
| Option 0 | This option is rejected as this is not address the non-compliance issue of NPS at George Town Substation. Furthermore, this option has the highest negative NPV among the three options considered (i.e., other two options have net positive market benefits with respect to this option). |
| Option 1 | This option is rejected as this is not the most economic option. The existing Negative Phase Sequence issue will be managed by the installation of the ±25 MVAr STATCOM. Similarly chances of constraining energy exports in this option are higher than Option 2, which has higher capacity of dynamic reactive support at George Town Substation. |
| Option 2 (preferred) | This option has the highest net positive present value with respect to Option 0 (i.e, NPV of this option is the least negative value). Sensitivity analysis is also suggested Option 2 is better than Option 1. This option solves the existing NPS non-compliance issue and the voltage instability and TOV issues. It has extra capacity if NPS issue arises in future. |

## 6.3 Summary of Costs

| Option | Total Cost ($) |
|---|---|
| Option 0 | $0 |
| Option 1 | $10,123,896 |
| Option 2 (preferred) | $15,068,456 |

## 6.4 Summary of Risk

The implementation of the proposed project helps to reduce the risk identified in Section 4.1 in regards to network performance and regulatory compliance to low rating by addressing non-compliance issues of NPS and TOV. Similarly the project helps to reduce the unlikely risk associated with reputation of the TasNeworks and shareholders due to energy export constraints.

## 6.5 Economic analysis

| Option | Description | NPV |
|---|---|---|
| Option 0 | Base Option: continue current operating practices | -$14,312,252 |
| Option 1 | Install ±25 MVAr STATCOM at George Town Substation | -$13,585,024 |
| Option 2 (preferred) | Install ±50 MVAr STATCOM at George Town Substation | -$11,539,851 |

### 6.5.1 Quantitative Risk Analysis

Note applicable

### 6.5.2 Benchmarking

Note applicable

### 6.5.3 Expert findings

Note applicable

### 6.5.4 Assumptions

Theassumptions used in the economic analysis are as follows:

- The benefits beyond 2027 are considered as constant assuming that the existing Basslink would not be sufficient if further renewable development is taken place in Tasmania and there is no load growth;
- The real discount rate is considered as 3.59% and tested the sensitivity 3% to 8%; and
- 0.5% of the capital cost is assumed as incremental operations and maintenance cost and tested the sensitivity of -20% to 100% of the base operation and maintenance cost.
- The analysis was extended to identify the benefits over a study period. The capital, operation and maintenance cost of these options were analysed against the identified benefits for 20 year study period.
- These benefits were evaluated based on Basslink flow profiles forecasted by AEMO [11]. These Basslink flow profiles were analysed with the consideration of three historic operation pattern of the Tasmanian system (i.e., 2014, 2015 and 2016/17). It is assumed that historic data gives better operating pattern than a market simulation study.
- The details of the analysis are given in Economic benefits of George Town proposed dynamic reactive support report [6].