Hobart-West area strategic plan
System capacity planning project
Aurora Energy

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Contents

Executive summary

The long term plan for Hobart-West recommends the continuation of the existing zone substation strategy, with the exception that 33 kV switchgear be planned for certain substations to minimise the future 33 kV cable requirements in the city. Terminal substation establishment has only been recommended at Creek Rd, where an existing site and 110 kV source is available in an ideal location. New 33 kV injection points at Bridgewater and McRobies Gully and zone substations at Austin's Ferry, Brighton, West Moonah, the Hobart CBD and Mount Nelson are proposed to address the forecast load growth in the area.

The ten year plan for Hobart-West recommends the establishment of a 33 kV injection point at Bridgewater and a new zone substation at Austin's Ferry, in order to deload Bridgewater and Claremont substations and provide future flexibility of supply to Brighton. The plan also recommends the replacement of ageing transformers at Derwent Park and Claremont zone substations to meet capacity requirements.

The five year plan for Hobart West examines the distribution networks of the nine existing 11 kV substations and the impact of the proposed zone substation at Austin's Ferry. Proposed distribution feeder works in the area include load transfers and a new feeder tie at Chapel St, load transfers from East Hobart to West Hobart, splitting of the feeder ring from Sandy Bay to the university and the establishment of a new feeder into the Sandy Bay residential area. The plan also recommends that capacitor banks be investigated for voltage control at Chapel St and North Hobart substations.

The five year plan also reviews the subtransmission networks from Creek Rd and Risdon substations, recommending that the possibility of uprating the 33 kV feeders to Sandy Bay, East Hobart and West Hobart be investigated.

The planning philosophy recommends that Aurora review the ratings of 33 kV cables and 33/11 kV transformers with a view to implementing cyclic, emergency and short-time ratings. This would result in higher capacity from existing and future plant, increase the flexibility of the system and defer system limitations. The planning philosophy also recommends that Aurora investigate the use of 11 kV capacitor banks at zone substations, and where appropriate, establish new capacitor banks to defer transformer upgrades and reduce system losses.

This report is part of a series covering the eleven planning areas in the state of Tasmania. References are made in this report to others in the series which cover adjacent planning areas. An overarching summary document was compiled to highlight the important outcomes and recommendations from each area in the study.

Report reference	Planning area
0	System capacity planning project summary
1	Tamar area strategic plan
2	North Coast area strategic plan
3	North West area strategic plan
4	**Hobart West area strategic plan**
5	Hobart East area strategic plan
6	South area strategic plan
7	Sorell area strategic plan
8	East Coast area strategic plan
9	North East area strategic plan

10	Central area strategic plan
11	West Coast area strategic plan

1. Introduction

Aurora Energy (Aurora) engaged Aurecon (formerly Connell Wagner) to undertake a network system capacity planning study covering the eleven planning areas in the state of Tasmania. A report will be produced for each of the eleven planning areas and will include a long term strategic plan, a ten year plan and a five year plan.

Each area report contains a summary of the planning area, describing the geographical region encompassed, the existing electrical infrastructure and the local council plans as well as Aurora and Transend's committed and proposed works for the area. A load forecast is then presented, with a discussion of the magnitude and location of expected load growth, followed by a discussion of the resulting limitations at each substation. The long term strategic plan, ten year plan and five year plan are then presented.

1.1 Background

Aurora is the distribution network service provider of mainland Tasmania, supplying more than 1 GW peak load through its high voltage network in 2008. Transend is the transmission network service provider of Tasmania.

The Aurora HV distribution system consists mainly of 22 and 11 kV feeders, with the connection point generally on the load side of the feeder circuit breakers at Transend's terminal substations. Aurora also owns several 33/11 kV zone substations and 33 kV feeders, which are supplied by Transend's 110/33 kV substations.

This report has been prepared for Aurora and its intent is to review Aurora's short and long term network requirements, however it is understood that Transend is impacted by the recommendations contained within. Therefore all efforts have been made to perform the study in consultation with Transend, and consideration has been given to Transend's future vision and network security standards.

1.2 Methodology

The methodology used to carry out the planning study is outlined below.

To begin with, data was reviewed for each of the planning areas including:

- Annual planning reports from Transend and Aurora
- Known developments and constraints
- The existing network configuration (using Webmap)
- Load models and load transfer capacity
- Transformer refurbishment program (Aurora)
- Schematics of Aurora and Transend substations
- Joint planning studies and regulatory test reports
- Council plans and residential strategies for all of the Tasmanian councils (where available)

The load model for each planning area was then refined into smaller growth areas, with each area allocated medium or high growth based on land availability, council plans for the area and information from Aurora on growth hot spots and point loads. This process resulted in a load forecast for each planning area which fell between the medium and high growth forecasts provided by Aurora, with load growth biased towards those areas (and hence substations) where high growth is expected. This forecast is considered the high growth forecast for this study, with the medium and low forecasts being those provided by Aurora.

For the purposes of the long term strategic plan and ten year plan it was decided to use the high growth forecast to determine the timing of limitations. This conservative approach was taken to ensure that Aurora is prepared should a higher than expected forecast eventuate. The five year plan is intended to be used by Aurora for its short-term planning, including regulatory submission for relevant projects, and therefore needs to be as accurate as possible. As a result, the five year plan uses the medium growth forecast to determine the timing of limitations.

The long term strategic plan was produced by projecting the high growth load forecast out to the year 2050 and performing a high level review of the resulting limitations. Substation capacity and condition were the primary limitations considered at this stage, as distribution network limitations are difficult to forecast and can largely be addressed independently of major substation projects. The introduction of new voltage levels and phasing out of non-standard voltage levels were examined at this time. The recommendations considered to address the resulting limitations included load transfers, transformer refurbishment or replacement to increase capacity, installation of additional transformers and switchgear and the establishment of new substations.

The recommended projects which fell within the period from 2012 to 2022 were then examined in greater detail in the ten year plan. An options analysis was undertaken by comparing the technical and financial implications of the recommended option against several other feasible options. The project drivers were also examined in greater detail, with distribution network limitations such as feeder loading and reliability considered at this stage.

The five year plan focused on the distribution works required within the period from 2012 to 2017. An analysis of each of the existing and new substations was completed to determine feeder limitations in the five year period. The medium growth substation forecast provided by Aurora was combined with historical feeder loading data from 2009 to produce a five year forecast for all distribution feeders in the Aurora network. A number of projects were proposed which included works as part of the substation projects identified in the ten year plan and new projects based on the analysis of feeder loading. A brief justification for the new feeder projects has been included and DINIS studies were completed as applicable. A section has been included to discuss the ultimate configuration of the substation areas and the impact on the ultimate plan by any works completed in the five year period.

For each area, a report was compiled including the long term strategic plan, ten year plan and five year plan. An overarching summary document was compiled to highlight the important outcomes and recommendations from each area in the study.

1.3 Assumptions

A list of some of the general assumptions made for the study is outlined below.

- Direct connected customers were not included in the original load models. However, where the direct connected load affects the substation, an estimated block load has been incorporated into the substation load to determine the capacity limitation.
- The UES 2008 forecast has been used for all load models. The high and medium growth rates for smaller areas in the substation supply areas have been assumed based on existing feeder configuration, land availability, council plans for the area and information from Aurora on growth hot spots and point loads.
- Draft historical feeder loadings were used for the long term strategic and ten year plans. Revised feeder loadings were provided prior to the commencement of the five year plan and the new figures were incorporated to ensure feeder limitations were accurately determined.
- All committed proposed projects up to 2012 are assumed to be completed for this study
- The assumed substation limitation is load above firm capacity
- Transformer asset life as advised by Aurora is 40 years for zone substations and 45 years for terminal substations. For the purpose of this report, it is assumed that actual transformer life is extended by approximately five years due to the regular condition assessments and transformer loading under normal conditions.

- The four-hour emergency ratings for transformers is based on 1.2 x normal capacity. It has been assumed that remote switching can be completed within four hours.
- Substation general arrangements were not available during the study and it has been assumed that there is space for the proposed upgrades outlined in the long term strategic plan
- The long term strategy does not take into account individual distribution feeder capacity or voltage drop. This has been further reviewed in the five year plan.
- ESI regulations have been taken into consideration where applicable
- Basic costing was provided by Aurora and Transend and any additional assumptions made are shown in Appendix A
- An NPV analysis has been completed for each of the ten year proposed projects. It should be noted that a cost benefit analysis has not been undertaken
- Demand side initiatives have not been considered in this study. Any feasible demand side initiatives that are identified as part of a separate review will in some cases defer or alleviate identified capital expenditure. The focus of this review is to identify network constraints and determine appropriate network solutions.

2. Area background

The Hobart-West planning area consists of the area west of the Derwent River, from Lower Taroona in the South to Bagdad in the North, including the Hobart CBD and the city of Glenorchy.

Figure 2-1 provides a geographic view of the area under study.

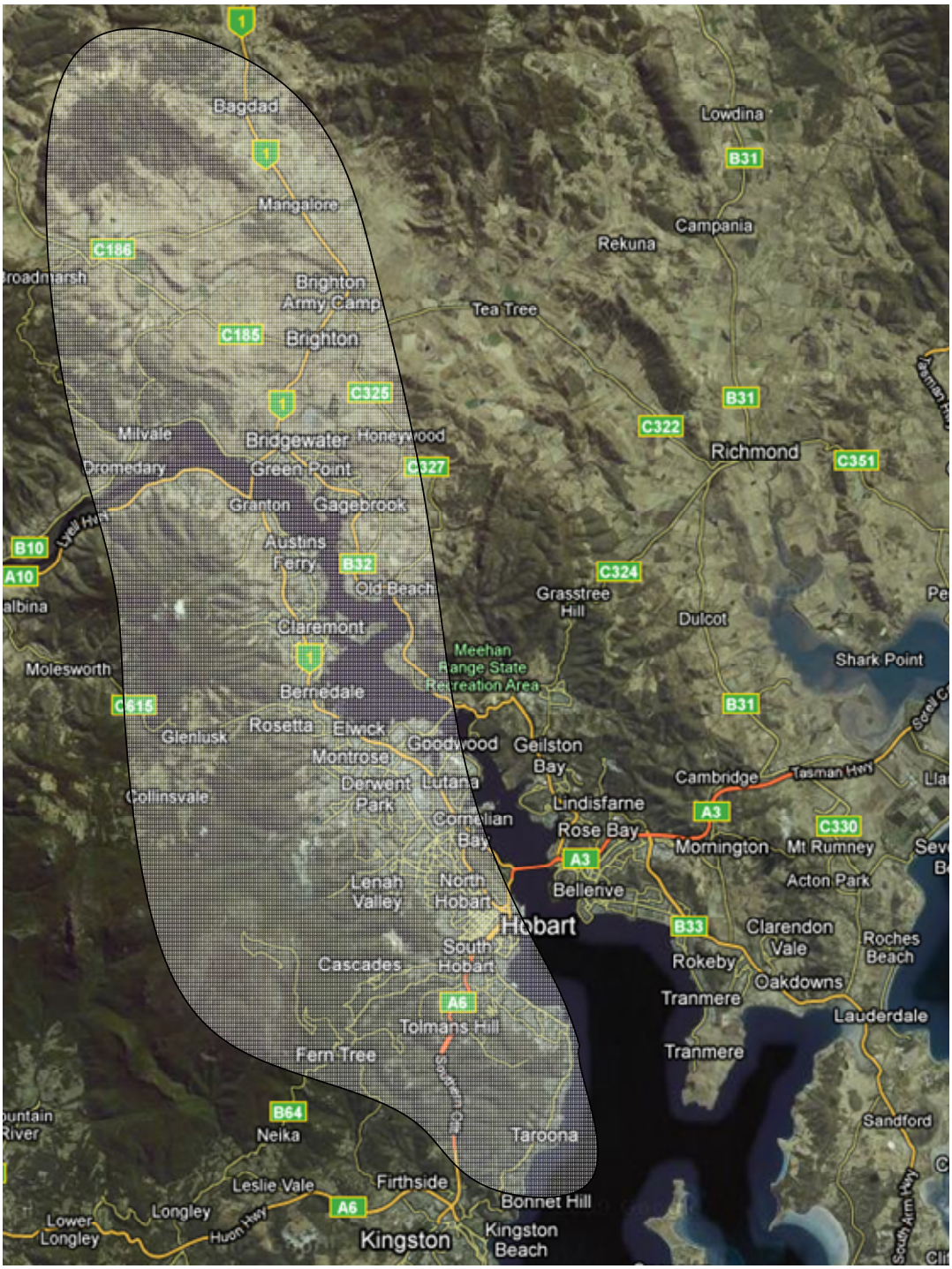


Figure 2-1 Hobart-West planning area geographical view

Hobart-West is considered a medium growth area, recording a growth rate of 2-3% pa in 2008. The area contains a mixture of commercial, industrial and urban residential load.

Growth in the Hobart-West area is naturally constrained by Mount Wellington to the west, and the Derwent River to the east. As a result the bulk of load growth is due to consolidation of existing areas rather than development of new areas.

2.1 Existing infrastructure

The substations within the Hobart-West planning area are listed in Table 2-1 and Table 2-2.

Table 2-1 Terminal substations in the Hobart-West planning area

Substation	Number of Transformers	Transformer MVA	Transformer Primary Voltage	Transformer Secondary Voltage	Number of Feeders
Bridgewater	2	35 MVA	110 kV	11 kV	10 distribution
Chapel St	2	60 MVA	110 kV	11 kV	16 distribution
Creek Rd	3	60 MVA	110 kV	33 kV	8 subtransmission
North Hobart	2	60 MVA	110 kV	11 kV	21 distribution
Risdon	3	50 MVA	110 kV	33 kV	7 subtransmission

Table 2-2 Zone substations in the Hobart-West planning area

Substation	Number of Transformers	Transformer MVA	Transformer Primary Voltage	Transformer Secondary Voltage	Number of Feeders
Claremont	2	22.5 MVA	33 kV	11 kV	9 distribution
Derwent Park	2	22.5 MVA	33 kV	11 kV	10 distribution
East Hobart	3	30 MVA	33 kV	11 kV	11 distribution
New Town	2	22.5 MVA	33 kV	11 kV	7 distribution
Sandy Bay	3	30 MVA	33 kV	11 kV	13 distribution
West Hobart	3	30 MVA	33 kV	11 kV	14 distribution

As outlined above, distribution within this planning area is at 11 kV, and subtransmission is at 33 kV.

2.2 Council areas and restrictions

The Hobart-West planning area encompasses the Hobart, Glenorchy and Brighton councils.

Hobart City Council

The Hobart City Council (HCC) covers the Hobart CBD and from New Town in the north, to Sandy Bay in the south.

The Hobart City Council has adopted a 2025 Strategic Framework which outlines the vision and future direction for the Hobart local government area. The council has also adopted a strategic plan for 2008 - 2013 to identify the priority actions that will work towards the 2025 community vision for Hobart.

The proposed future direction of the HCC are identified in the following statements:

- Offers opportunities for all ages and a city for life
- Is recognised for its natural beauty and quality of environment
- Is well governed at a regional and community level
- Achieves good quality development and urban management
- Is highly accessible through efficient transport options
- Builds strong and healthy communities through diversity, participation and empathy
- Is dynamic, vibrant and culturally expressive

The HCC has also released a 2009 planning scheme. This document divides the Hobart local government area into a number of zones and defines the type of development allowed in each zone (eg residential, industrial, mixed use).

Glenorchy City Council

The Glenorchy City Council has adopted a strategic plan for 2009-2014 which outlines the values and mission of the council. It has also released a planning scheme which defines the type of development allowed in the local government area, as well as proposed future areas of urban development.

Brighton Council

The Brighton Council intends to establish residential growth within existing settlement areas. Growth is proposed to be via infill within the existing townships and suburbs to take advantage of existing infrastructure. Green field development will be limited to Tivoli Green, Old Beach and Brighton.

The council intends to promote Brighton as the region's primary industrial location.

2.3 Approved and proposed works

Distribution feeder works

- During 2010-2012, Loop Automation to be installed at several substations to improve reliability
- Improved transfer capability of Royal Hobart Hospital from North Hobart to East Hobart
- Reconfiguration of 11 kV network from North Hobart substation to Calvary Hospital
- Establishment of two new 11 kV feeders from West Hobart substation to the western end of Hobart in 2009/10
- 11 kV reinforcement to the Salamanca and wharf area from East Hobart and West Hobart zone substations in 2010/11
- Project to deload the constrained Chapel St 11 kV feeders in 2009/10

Creek Road terminal substation upgrade

Establish an 110/11 kV substation along side Creek Road 110/33 kV substation in 2015 to deload Chapel Street and North Hobart. This project is discussed in the Aurora Annual Planning Report, however given the proposed date of 2015 this is not considered a committed project.

Brighton Transport Hub

To provide electrical supply to the Brighton Transport Hub, this project proposes an additional 11 kV feeder from Bridgewater terminal substation, created by splitting existing feeder 191. This feeder is to be designed at 33 kV, but energised at 11 kV until such time as a zone substation in the Brighton area is required. The project is proposed to be completed in 2009/10.

3. Load forecast

The Hobart-West planning area has experienced growth from 2-3% per year for the past two years and sustained growth in this area is expected.

The long term medium growth rate from the Aurora forecast is approximately 1.5% for the Hobart-West planning area. Blanket load growth above this rate is considered unlikely, as the load is the Hobart city area is generally mature, and constrained by mountains to the west and the river to the East. However higher growth is likely in certain areas.

The following regions are considered to have potential for particularly high growth:

- Works are ongoing by the Department of Transport to establish Brighton as a transport hub. This will involve the termination of cargo train lines at Brighton, with cargo to be carried by road to the river at Bridgewater, and will likely see the connection of heavy machinery and associated loads at Brighton. A related project will also establish a dual carriageway bypass of Brighton, and is expected to encourage development in the valley around Brighton.
- The wharf area of Hobart is expected to experience significant load growth following the establishment of the Brighton Transport Hub. The cargo trains which currently unload at the wharf are expected to be phased out, with preference being to unload trains at Brighton and truck cargo to ship loaders at Bridgewater. This would free up a significant tract of land in the Hobart CBD for development.

As a result, to produce a conservative load forecast high growth has been applied to these areas, with medium growth applied to the remainder of the planning area. A point load of 4.5 MVA has also been added in the Brighton area to allow for industrial development at the Brighton Transport Hub prior to the beginning of the study in 2012.

For the purposes of this study the planning area has been split into two groups of substations, with each group having significant transfer capacity amongst other substations of that group. The northern substations of Claremont, Derwent Park, New Town and Chapel St compose one group, and the southern substations of East, West and North Hobart and Sandy Bay the other. It is assumed that a capacity limitation occurs when the group load exceeds the sum of the firm capacities.

The resulting 38 year load forecast and firm ratings for substations of the Hobart-West planning area are provided in Figure 3-1 and Figure 3-2 below. It should be noted that Figure 3-3 includes only those terminal substations not included in the group load forecast in Figure 3-4.

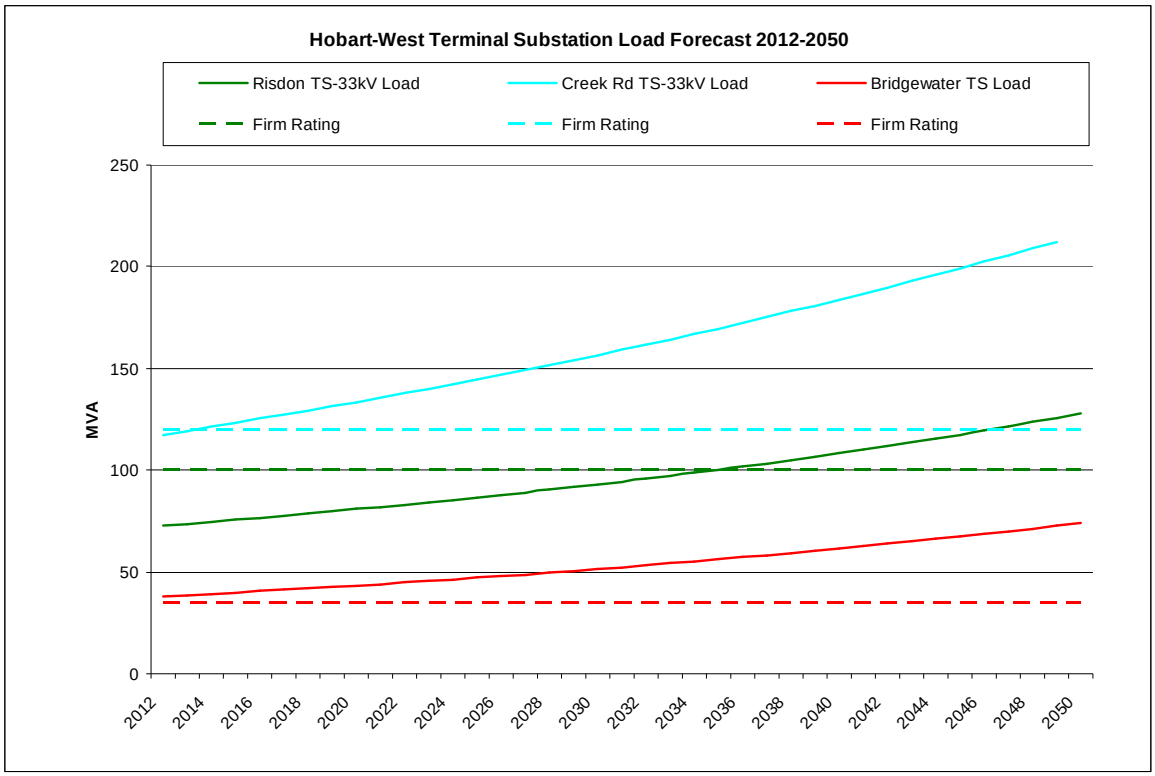


Figure 3-5 Hobart-West existing terminal substation load forecast 2012-2050

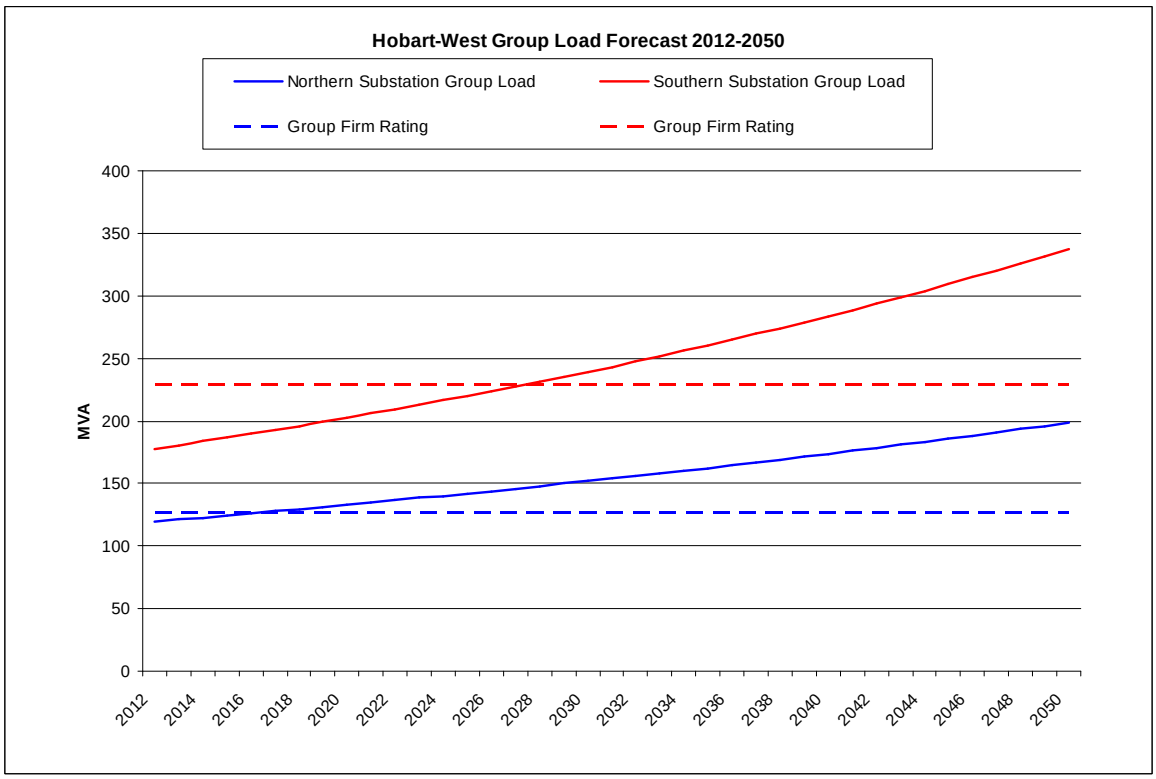


Figure 3-6 Hobart-West existing group load forecast 2012-2050

Figure 3-7 provides a geographic view of the resulting load distribution in 2012 and 2050. The areas in which high growth has been applied are indicated with red borders.

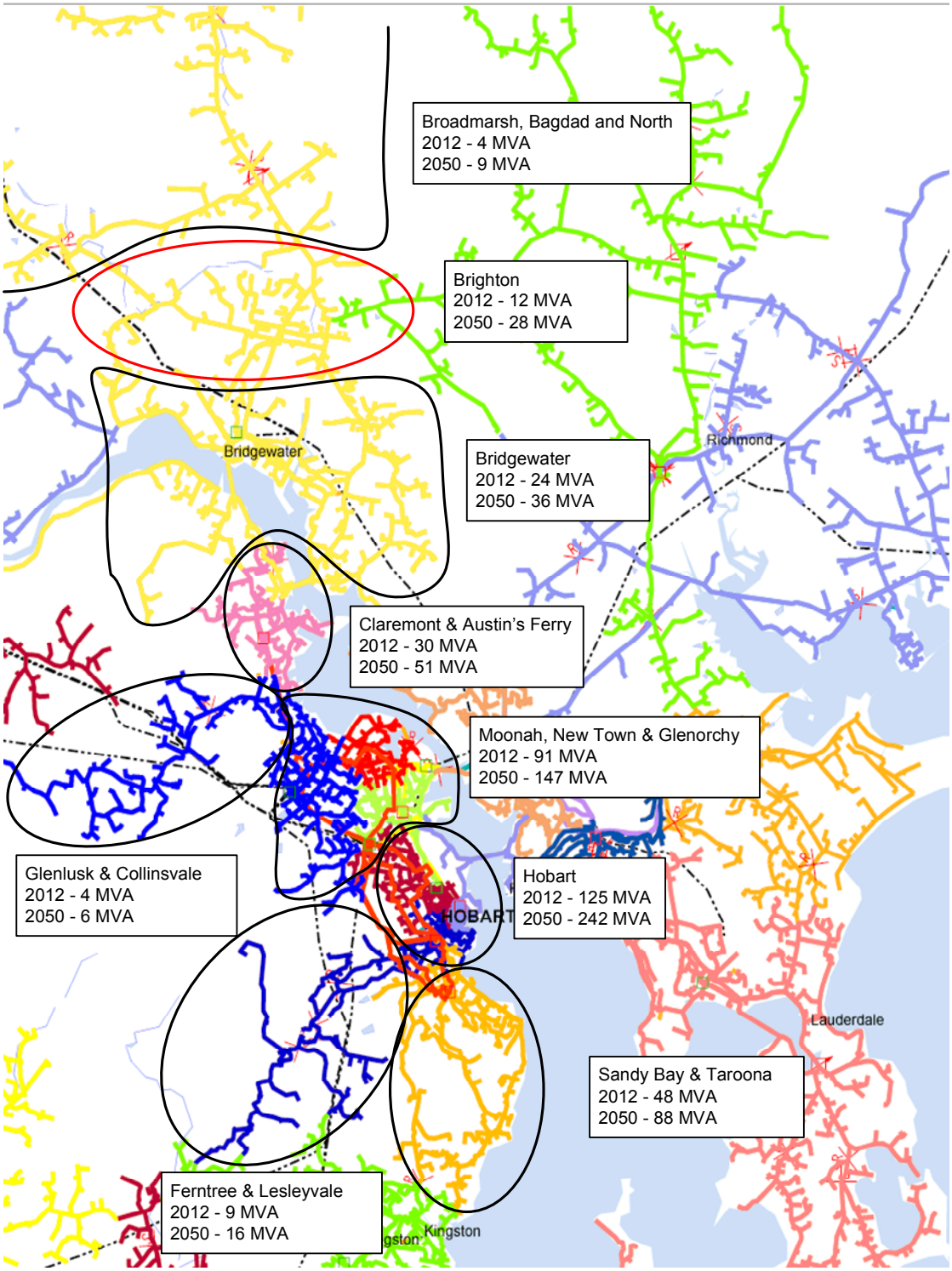


Figure 3-7 Hobart-West geographic load forecast 2012-2050

4. Limitations

4.1 Bridgewater terminal substation

Bridgewater terminal substation is equipped with 2 x 35 MVA transformers, providing a firm capacity of 35 MVA. The transformers at Bridgewater were installed in 1980.

Load at Bridgewater is forecast to exceed firm capacity in 2012.

4.2 Creek Rd terminal substation

Creek Rd terminal substation is equipped with 3 x 60 MVA 110/33 kV transformers, providing a firm capacity of 120 MVA. The transformers at Creek Rd were installed in 2001 and 2002.

Creek Rd provides 33 kV supply to Sandy Bay, West Hobart and Claremont zone substations.

The load at Creek Rd terminal substation is forecast to exceed substation firm capacity in 2015.

4.3 West Hobart zone substation

West Hobart zone substation is equipped with 3 x 30 MVA 33/11 kV transformers, providing a firm capacity of 60 MVA. However the subtransmission feeders from Creek Rd are only rated to 28.2 MVA, limiting the firm capacity of the substation to 56.4 MVA. The transformers at West Hobart are not expected to reach end of life within the scope of this study.

The load at West Hobart zone substation is forecast to exceed substation firm capacity in 2023.

4.4 Sandy Bay zone substation

Sandy Bay zone substation is equipped with 3 x 30 MVA 33/11 kV transformers, providing a firm capacity of 60 MVA. However the subtransmission feeders from Creek Rd are rated at only 28.2 MVA, limiting the firm capacity of the substation to 56.4 MVA. The transformers at Sandy Bay are not expected to reach end of life within the scope of this study.

The load at Sandy Bay zone substation is forecast to exceed substation firm capacity in 2029.

4.5 Claremont zone substation

Claremont zone substation is equipped with 2 x 22.5 MVA 33/11 kV transformers, providing a firm capacity of 22.5 MVA. The transformers at Claremont have been recommended for replacement by 2019/20.

The load at Claremont zone substation is forecast to exceed substation firm capacity in 2009. It is assumed that this limitation can be deferred by load transfers to adjacent substations, since group load does not exceed firm capacity until 2017.

4.6 Risdon terminal substation

Risdon terminal substation is equipped with 3 x 50 MVA 110/33 kV transformers, providing a firm capacity of 100 MVA. The transformers at Risdon were installed in 2006 and 2007.

Risdon provides 33 kV supply to East Hobart, New Town and Derwent Park zone substations.

The load at Risdon terminal substation is forecast to exceed substation firm capacity in 2042.

4.7 East Hobart zone substation

East Hobart zone substation is equipped with 3 x 30 MVA 33/11 kV transformers, providing a firm capacity of 60 MVA. However the subtransmission feeders from Risdon are rated at only 28.2 MVA, limiting the firm capacity of the substation to 56.4 MVA. The transformers at East Hobart are not expected to reach end of life within the scope of this study.

The load at East Hobart zone substation is forecast to exceed substation firm capacity in 2046.

4.8 New Town zone substation

New Town zone substation is equipped with 2 x 22.5 MVA 33/22/11 kV transformers, providing a firm capacity of 22.5 MVA. The transformers at New Town are not expected to reach end of life within the scope of this study.

The load at New Town zone substation is forecast to exceed substation firm capacity in 2016.

4.9 Derwent Park zone substation

Derwent Park zone substation is equipped with 2 x 22.5 MVA 33/11 kV transformers, providing a firm capacity of 22.5 MVA. The transformers at Derwent Park have been recommended for replacement by 2014/15.

The load at Derwent Park zone substation is forecast to exceed substation firm capacity in 2012, but this is expected to be addressed by the transformer upgrade in 2014/15.

4.10 Chapel St terminal substation

Chapel St terminal substation is equipped with 2 x 60 MVA 110/11 kV transformers, providing a firm capacity of 60 MVA. The transformers at Chapel St were installed in 1984.

The load at Chapel St terminal substation is forecast to exceed substation firm capacity in 2024.

4.11 North Hobart terminal substation

North Hobart terminal substation is equipped with 2 x 60 MVA 110/11 kV transformers, providing a firm capacity of 60 MVA. The transformers at North Hobart were installed in 1977.

The load at North Hobart terminal substation is forecast to exceed substation firm capacity in 2014. It is assumed that this limitation can be deferred by load transfers to adjacent substations, since group load does not exceed firm capacity until 2026.

5. Planning philosophy

For the purposes of this study the planning area has been split into two groups of substations, with each group having significant transfer capacity amongst other substations of that group. The northern substations of Claremont, Derwent Park, New Town and Chapel St compose one group, and the southern substations of East, West and North Hobart and Sandy Bay the other. It is assumed that a capacity limitation occurs when the group load exceeds the sum of the firm capacities.

Hobart-West already contains a significant 33 kV subtransmission network, with two 33 kV injection points and six zone substations. Therefore it is prudent to continue with strategy of using 33 kV subtransmission and zone substations, as opposed to a 110/11 kV solution. This is the preferred strategy of Aurora and Transend because it allows the flexibility to establish zone substations as dictated by load growth, without the expense and level of approvals involved with 110 kV network augmentation. This arrangement also simplifies distribution works since Aurora own the 11 kV CBs, so do not need to consult with Transend for a simple 11 kV project.

The zone substations in Hobart-West are all transformer-ended and radially supplied from the 33 kV injection points, meaning that a dedicated 33 kV feeder is required for each zone substation transformer. This results in a system with more 33 kV feeder capacity than is required for N-1 redundancy – in fact it is capable of withstanding a 33 kV feeder fault at every zone substation simultaneously at peak load. This network arrangement also requires long runs of 33 kV cable from the 33 kV injection point to the zone substation, and can result in cable congestion and a shortage of CBs at the 33 kV injection point.

Under this network configuration it is not possible to transfer load between 33 kV injection points, which brings forward the requirement for 33 kV augmentation in the form of new injection points or 110/33 kV transformer installation or replacement.

An approach to network development that enables excess feeder capacity to be efficiently utilised, is to install 33 kV switchgear at zone substations and to establish meshed 33 kV networks with tie feeders between zone substations. With a small amount of 33 kV feeder augmentation this enables a single 33 kV feeder to be used to normally supply one zone substation, while providing backup supply to an adjacent zone substation. If the zone substations are supplied from different 33 kV injection points, this configuration also allows load to be transferred between 33 kV injection points. It also allows zone substations to be supplied fully from other zone substations, resulting in shorter 33 kV cable requirements. Such a meshed system still provides full redundancy for a single 33 kV feeder fault and is significantly lower cost than the alternative.

With regards to the Hobart-West network, there is little to be gained in simply installing 33 kV switchgear at existing zone substations. The approach undertaken in this study is to recommend the installation of 33 kV switchgear at strategic locations which enable the existing 33 kV network to be utilised to the fullest extent, while still providing N-1 security. Terminal substation establishment has only been recommended where an existing site was available in an ideal location (e.g. Creek Road).

An example of the 33 kV strategy recommended in this study is the Derwent Park upgrade project in 2029. To defer capacity limitations at Creek Rd and Risdon 110/33 kV substations and increase zone substation firm capacity in 2029, it is recommended to install a 33 kV switchboard and third transformer at Derwent Park zone substation, and a tie to Creek Rd-Claremont 33 kV feeder 10026 which runs past Derwent Park. This provides transfer capacity between Risdon and Creek Rd, deferring the establishment of a new 33 kV injection point by 5 years, and increases the zone substation firm capacity by 22.5 MVA at the cost of only 500m of 33 kV cable, a 33/11 kV transformer and a 33 kV switchboard. A geographical arrangement of the proposed configuration is given in Figure 5-1.

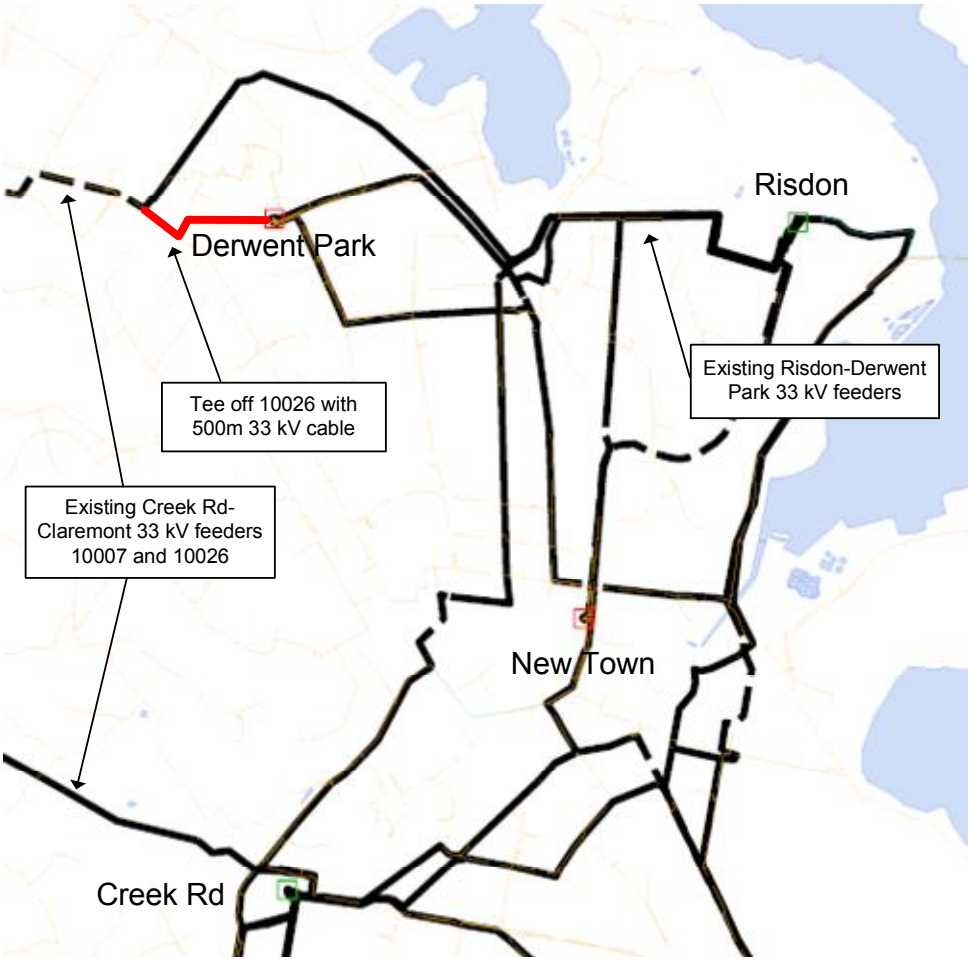


Figure 5-1 Geographic arrangement following Derwent Park upgrade in 2029

It should be noted that Aurora's 33 kV feeder network is predominantly overhead, so the feeder short-term emergency capacity is generally the same as normal capacity. Therefore, in situations like the above where 33 kV feeders will be normally loaded at close to capacity (with a normally open backup feeder), a feeder fault would cause the remaining feeder(s) to exceed emergency capacity. The resulting load being above emergency capacity means there is insufficient time for an operator to respond to overloads and an automated scheme is necessary.

In these cases, a logic scheme could be established at the substation to automatically switch in the backup feeder for the loss of a primary feeder. Alternatively, if such a scheme is not possible a logic scheme could be implemented to reduce load on the remaining feeder(s) to emergency capacity through selective shedding of 11 kV feeders, with load to be restored by operators once the backup feeder has been switched in. Uprating or reconductoring the existing feeders or installation of a new 33 kV feeder could mitigate this issue, however the marginal benefit would need to be weighed against the increase in cost.

The design of 33 kV cables should be carefully considered with regard to the ultimate load to be supplied. XLPE cables generally have a short-time rating far in excess of the normal capacity (depending on cable installation and prior loading conditions). For example, an XLPE cable that is loaded at half its normal capacity can have a short-time rating of double its normal capacity. The time used in the short time rating would be chosen to allow operators and line crews sufficient time to respond, either by 33 kV switching or 11 kV load transfers to reduce load below the normal rating, and is typically several hours. This allows the 33 kV cables to be loaded well above their normal N-1 rating without risking any loss of load, provided that there is transfer capacity available to reduce load within the nominated short-time rating period following a feeder fault. In the case of multiple 33 kV circuits in

a common trench, the cable rating with an adjacent circuit out of service can also be evaluated. This higher rating reduces the quantity of load that needs to be transferred after a feeder fault.

A similar approach can be taken with the rating of transformers. Aurora currently use transformer continuous ratings as the driver for capacity limitations, whereas the cyclical nature of substation load, particularly in predominantly domestic areas, means that significantly higher peak loads can usually be safely accommodated. It is also common practice to define a transformer emergency rating, a slightly higher load at which accelerated ageing of the transformer is possible but is considered an acceptable risk during contingencies. Balancing the accelerated ageing under contingency loading with the reduced ageing rate under normal loading will ensure that the expected service life of the transformer is achieved. As discussed above for 33 kV feeders, short-time transformer ratings may also be employed for transformers to allow time to implement load transfers during contingencies.

While capacitor banks have not been proposed in any particular project in this study, it is generally recommended that the installation of 11 kV capacitor banks at Aurora zone substations be investigated. This would defer substation capacity limitations, while reducing losses in the upstream network and improving the power factor at the substation.

6. Long term strategy

The bulk of the near term limitations in Hobart-West occur towards the north of the planning area, with Derwent Park and Claremont transformers requiring replacement by 2020, and the group loading of the northern substations exceeding group firm capacity in 2017.

The southern substations are generally newer and of higher capacity, with the group load forecast for East, West and North Hobart and Sandy Bay zone substations not forecast to exceed group firm rating until 2028. This is largely due to the low loading of Hobart East zone substation.

It should be noted that the projects proposed in this section will require further detailed analysis to confirm their economic and technical feasibility. A regulatory investment test will also be required for those projects where the augmentation component exceeds $1 million (RIT-D) or $5 million (RIT-T).

6.1 Proposed projects

6.1.1 Upgrade Derwent Park zone substation

Derwent Park zone substation transformers have been deemed to be end of life by 2015. Therefore it is proposed that the 2 x 22.5 MVA transformers be replaced by 25 MVA units in 2015.

This project increases the group firm capacity of the northern substations, deferring the group capacity limitation until 2021.

6.1.2 Establish Bridgewater 33 kV injection point and zone substation at Austin's Ferry

Bridgewater terminal substation is forecast to exceed firm capacity in 2012, however it is assumed that this can be deferred or mitigated until 2016 by load transfers to Derwent Park, Claremont and New Norfolk zone substations. Creek Rd is forecast to exceed firm capacity in 2015, however it is expected that this limitation can be deferred by load transfers from West Hobart to East Hobart. The northern substation group is forecast to exceed firm capacity in 2017.

Therefore it is recommended that 2 x 110/33 kV 60 MVA transformers and 110 kV and 33 kV switchgear be installed at the existing Bridgewater site in 2016 and that a new zone substation at Austin's Ferry be established and supplied from Bridgewater.

Completion of this project in 2016 defers the firm capacity limitation on Creek Rd and Bridgewater until 2020 and 2025 respectively.

An alternative to the Austin's Ferry establishment would be to install a third transformer and 33 kV switchgear at Claremont, and supply via 2 x 33 kV cables from Bridgewater. It is expected that the additional length of 33 kV cable and 33 kV switchgear required in this option will make Austin's Ferry zone substation the preferred option. This option is discussed in more detail in the ten year plan.

6.1.3 Upgrade Claremont zone substation

Claremont zone substation transformers have been deemed to be end of life by 2020. Therefore it is proposed that the 2 x 22.5 MVA transformers be replaced by 25 MVA units in 2020. However, should it be determined that the transformers are in good condition beyond 2020, the replacement may be deferred until justified on condition basis.

6.1.4 Establish Brighton zone substation

Bridgewater terminal substation will again exceed firm capacity in 2025. The load in Brighton and to the north is forecast to exceed 20 MVA at this time, which is likely to be difficult to supply via the existing 11 kV feeders. To address these limitations it is recommended that a new zone substation be established in Brighton. Note that the timing of this project is dependent on the load growth in the Brighton area. Should the high growth not eventuate, the Brighton zone substation may be deferred until justified by capacity or feeder limitations at Bridgewater. Conversely, 11 kV feeder limitations may justify the project at an earlier date.

Brighton zone substation will have 2 x 25 MVA 33/11 kV transformers, and will be supplied from 33 kV cables from Bridgewater installed as part of the Brighton Transport Hub project.

6.1.5 Establish 110/11 kV substation at Creek Rd

Following the establishment of Austin's Ferry zone substation, the northern substation group is extended to include Austin's Ferry zone substation. The northern substation group subsequently exceeds firm capacity in 2026. The southern substation group is also forecast to exceed firm capacity in 2028.

The combined load of Risdon and Creek Rd 33 kV substations is forecast to exceed firm capacity by 2026 (up to this time it is assumed that load can be balanced between Creek Rd and Risdon through 11 kV load transfers between East Hobart and West Hobart).

Creek Rd is situated equidistant from the Chapel St and North Hobart terminal substations, both of which are forecast to be loaded above firm capacity by this time.

Therefore it is proposed that 2 x 110/11 kV 60 MVA transformers be installed at the existing Creek Rd site in 2026. This substation would deload the Chapel St, North Hobart and New Town zone substations. In doing so it would allow North Hobart to focus towards the CBD, deloading West Hobart and consequently deloading Creek Rd.

This project would defer the limitations at Creek Rd and Risdon 33 kV substations by approximately five years.

An alternative to this project would be to establish Creek Rd as a zone substation instead of a terminal substation, however it is expected that the cost in advancing other works to deload Creek Rd 33 kV would outweight the savings and other benefits of a zone substation. This option is discussed in more detail in Appendix D.

It should be noted that the timing of this project is based on the northern and southern substation group firm capacity limitations, and assumes that individual substation and feeder limitations will be addressed by load transfers or feeder works. If such works are not possible, or are expected to be more expensive than justified by deferral of the Creek Rd project, the project requirement date may need to be brought forward.

6.1.6 Upgrade North Hobart 110/11 kV transformers

The North Hobart 110/11 kV transformers are predicted to reach end of life around 2027. Therefore it is proposed that the 2 x 60 MVA transformers be replaced like for like in 2027. However, should it be determined that the transformers are in good condition beyond 2027, the replacement may be deferred until justified on condition basis.

6.1.7 Upgrade Derwent Park zone substation and install 33 kV tie to Creek Rd

Risdon and Creek Rd 33 kV substations are again forecast to exceed firm capacity by 2031, with the northern substation group to follow in 2033. The most cost effective way to address both limitations at this time would be the installation of an additional 33/11 kV transformer and 33 kV switchgear at an existing zone substation. A new 33 kV feeder can then be installed to the zone substation from an adjacent 110/33 kV substation. This would increase the firm capacity of the northern substation group, while providing transfer capacity between adjacent 110/33 kV substations.

The most suitable candidate for a third 33/11 kV transformer would be Derwent Park zone substation, due to its proximity to the Creek Rd-Claremont feeder 10026, thus minimising the length of 33 kV cable required. New Town zone substation would also be a suitable candidate and is even closer to feeder 10026, however the fact that it is supplied from an overhead and an underground cable make it unsuitable for a 33 kV switchboard due to uneven load sharing. It is also considered an inferior location for 11 kV injection due to its proximity to expected 11 kV injection at Creek Rd.

It is proposed that a new 25 MVA 33/11 kV transformer be installed at Derwent Park in 2031, as well as three sections of 33 kV switchgear with sufficient CBs to terminate the existing and new feeders and transformers. A new section of 33 kV cable is to be installed to tee off feeder 10026 (approximately 500m) and be terminated at a normally open CB at Derwent Park. The existing Risdon-Derwent Park feeders would need to be uprated to 31 MVA to enable half of Claremont load to be transferred to Risdon.

As a result Derwent Park substation would have a firm capacity of 50 MVA and would deload Chapel St, North Hobart and New Town. It would also provide transfer capacity between the Risdon and Creek Rd 33 kV substations.

It should be noted that for the loss of one of the Risdon-Derwent Park 33 kV feeders, load on the remaining feeder would be above its emergency rating during peak load. To address this, it is recommended that an ACO scheme be implemented to perform switching at Claremont and Derwent Park such that the backup feeder supplies a single transformer and 11 kV bus at Derwent Park. The remaining Risdon-Derwent Park feeder would supply two transformers and two 11 kV buses, while Claremont would be supplied by a single feeder and transformer.

A discussion of some alternative options for the 33 kV configuration at Derwent Park are given in Appendix C.

A possible alternative to this stage of works would be to establish a new zone substation between Chapel St, Derwent Park and Claremont substation supplied from the existing Creek Rd to Claremont 33 kV feeders. Claremont would then be supplied from Bridgwater via a new 33 kV double circuit from Austin's Ferry, with 33 kV switchgear installed at Austin's Ferry and Claremont. These works would be more expensive than the proposed option, however it may be a competitive option if significant 11 kV feeder works would otherwise be required into the area. This should be evaluated in more detail closer to the date.

6.1.8 Upgrade Bridgewater terminal substation

The Bridgewater 110/11 kV transformers were installed in 1980 and are predicted to reach end of life around 2030. Therefore it is proposed that these transformers be replaced by 60 MVA units in 2030. Should it be determined that the existing 110/11 kV transformers are still in good condition beyond 2030, the transformer upgrade may be deferred until dictated by capacity requirements.

An alternative option would be to establish a new Bridgewater zone substation on a nearby block, allowing space on the existing site for the installation of the third 110/33 kV transformer. This option also has the benefit that Aurora would have control over the 11 kV injection at Bridgewater, simplifying the operation of the network and the establishment of future 11 kV feeders. However this option has not been recommended for the following reasons:

- It would bring forward the installation of the third 110/33 kV transformer at Bridgewater
- Replacing the existing 35 MVA transformers at Bridgewater with 25 MVA units would result in a deficit in firm capacity, which would require an additional zone substation establishment or upgrade to address
- It is likely to be a more costly option than a simple transformer replacement

6.1.9 Upgrade Chapel St 110/11 kV transformers

The Chapel St 110/11 kV transformers are predicted to reach end of life around 2034, so a like for like replacement may be timed to occur with the above works at Chapel St. However, should it be determined that the transformers are in good condition beyond 2034, the replacement may be deferred until justified on condition basis.

6.1.10 Establish 33 kV injection point at McRobies Gully to supply Sandy Bay

The combined load of Risdon and Creek Rd is forecast to exceed firm capacity again in 2034 (taking into account the transfer capacity between the two). The northern and southern substation groups follow soon after. Thus it is expected that new zone substations will be required in the northern and southern areas, with no spare capacity at the existing 33 kV substations. Therefore it is expected that a new 33 kV injection point will be required in Hobart around this time.

It is proposed that a new 110/33 kV substation be established in the McRobies Gully area as a block of land in the area is already owned by Transend and it is in the vicinity of the 110 kV transmission lines to the Kingston area. This location is also conveniently located to cut in to the Creek Rd-Sandy Bay feeders as well as to supply to a future zone substation at Mount Nelson. The substation will consist of 2 x 60 MVA 110/33 kV transformers with two sections of 33 kV switchgear.

It is proposed that McRobies Gully supply Sandy Bay via two new 33 kV feeders teed off the existing 10008 and 10022 from Creek Rd to Sandy Bay (approximately 1.5 km). A new 33 kV switchboard will also be required at Sandy Bay, with the three feeders (two from McRobies Gully and one from Creek Rd) and three transformers terminated. Feeders 10008 and 10022 will be normally open at Creek Rd. These feeders could potentially be used to supply a future zone substation between McRobies Gully and Creek Rd, however such a substation is not required in the scope of this study. Alternatively, the feeders could be disconnected at Creek Rd, with the spare CBs used for the West Moonah zone substation discussed below.

The rating of the new 33 kV feeders would be chosen based on the requirement to transfer load from Creek Rd to McRobies Gully. Transfer capacity is not expected to be required from Creek Rd to McRobies Gully for the scope of this study, and thus the feeder ratings only need to match the existing Creek Rd-Sandy Bay feeders i.e. 28.2 MVA (with consideration given to uprating to achieve 30 MVA in order to match the transformer ratings at Sandy Bay). However if it is determined closer to the date that transfer capacity is needed, the new feeders would need to be rated 35-40 MVA to allow one of the West Hobart transformers to be transferred to McRobies Gully via Sandy Bay. The sections of 33 kV overhead feeders from the tee to Sandy Bay would also need to be uprated or reconductored to achieve this rating.

This project will deload Creek Rd by approximately 55 MVA in 2034, but it does not address the firm capacity limitations on the northern and southern substation groups in the following years. These are addressed in separate projects below.

6.1.11 Establish Mt Nelson zone substation

In order to address the firm capacity limitation on the southern substation group in 2036, it is proposed that a new zone substation be established in the Mount Nelson area.

The Mt Nelson zone substation will consist of 2 x 25 MVA 33/11 kV transformers and will be supplied by 2 x 33 kV feeders from McRobies Gully (approximately 4 km). This substation will deload Sandy Bay by approximately 15 MVA.

Supply of the Mt Nelson substation from Kingston 33 kV injection point was considered as a way to defer the McRobies Gully injection point discussed above, however it is expected that the long 33 kV double circuit feeder run required (approximately 10 km) would negate the benefits derived from deferring McRobies Gully by only a few years.

6.1.12 Establish CBD zone substation

The group load of the North, East and West Hobart, Sandy Bay and Mount Nelson substations is forecast to exceed firm capacity in 2042.

To address this limitation it is proposed that a new 33/11 kV substation be established in the Hobart CBD in 2042. This substation should be located equidistant from the existing Hobart substations and in the vicinity of 33 kV feeder 10024, and would consist of 2 x 25 MVA 33/11 kV transformers (30 MVA units could be considered for consistency with the other CBD zone substations). The substation would cut in to the existing 33 kV Creek Rd-Sandy Bay feeder 10024 and be supplied as transformer-ended feeders.

This project would also require that a 33 kV switchboard be installed at West Hobart substation, with feeder 10024 cut outside the substation and terminated to two new CBs. In this way the new zone substation would be supplied from a transformer-ended feeder from Creek Rd and a transformer-ended feeder from West Hobart, with a normally open tie from West Hobart to Sandy Bay allowing transfer capacity between Creek Rd and McRobies Gully. When the third transformer is required in 2047, a new feeder can be installed to the CBD substation from Creek Rd.

Alternatively, the substation could be supplied from two new 33 kV feeders from Creek Rd, however this would not provide the required transfer capacity between Creek Rd and McRobies Gully, and would be more expensive due to cabling costs through the CBD.

Another alternative would be to establish the CBD substation as a 110 kV substation supplied by new 110 kV cables from North Hobart. This would require a 110 kV indoor switchboard be installed at North Hobart. If space for the 110 kV switchgear is not available at North Hobart, the switchboard could be installed at the new CBD substation, however this would require 4 x 110 kV cables to North Hobart and cable joint bays in the vicinity of North Hobart. It is expected that the 110 kV option will be more expensive than a 33 kV solution. The existing Creek Rd-North Hobart cables are rated 108 MVA, limiting the firm capacity of North Hobart and the new CBD substation.

This project would deload the North, East and West Hobart and Sandy Bay substations.

6.1.13 Establish West Moonah zone substation

In order to address the firm capacity limitation on the northern substation group in 2046, it is proposed that a new zone substation be established in the West Moonah area.

The West Moonah zone substation will consist of 2 x 25 MVA 33/11 kV transformers and will be supplied by two new 33 kV feeders from Creek Rd (approximately 2 km). This substation will deload New Town, Derwent Park and Chapel St substations.

This project would require the installation of 2 x 33 kV CBs at Creek Rd, or the normally open 33 kV feeders to Sandy Bay could be disconnected and these CBs reused for the West Moonah feeders.

An alternative to this project would be to extend the 33 kV network from Austin's Ferry to Claremont, thus supplying Claremont normally from Bridgewater 33 kV substation. This would allow the existing Creek Rd to Claremont 33 kV feeders to supply a new zone substation in the Montrose area. This option would likely be slightly more expensive than the West Moonah option due to the requirement for 33 kV switchgear at each zone substation, however it would deload Creek Rd 33 kV substation and would bypass potential issues with getting new 33 kV cables out of Creek Rd. It would also address potential 11 kV feeder loading issues in the area between the Chapel St and Claremont substation.

6.2 Summary of proposed works

A summary of the proposed works from 2012 to 2050 in the Hobart-West planning area is outlined in Table 6-1.

Table 6-1 Hobart-West project summary

Year	Proposed Project	Proposed Outcomes
2015	Upgrade Derwent Park zone substation	Replace ageing 33/11 kV transformers and increase firm capacity at Derwent Park
2016	Establish Bridgewater 33 kV injection point and zone substation at Austin's Ferry	Deload Claremont zone substation and Creek Rd 33 kV substation
2020	Upgrade Claremont zone substation	Replace ageing 33/11 kV transformers and increase firm capacity at Claremont
2025	Establish Brighton zone substation	Deload Bridgewater and relieve Brighton and North 11 kV feeders
2026	Establish 110/11 kV substation at Creek Rd	Deload Creek Rd and Risdon 33 kV substations and northern and southern substation groups
2027	Upgrade North Hobart 110/11 kV transformers	Replace ageing 110/11 kV transformers
2030	Upgrade Bridgewater terminal substation	Replace ageing 110/11 kV transformers and increase firm capacity at Bridgewater
2031	Upgrade Derwent Park zone substation and install 33 kV tie to Creek Rd	Deload northern substation group and provide transfer capacity between Creek Rd and Risdon
2034	Upgrade Chapel St 110/11 kV transformers	Replace ageing 110/11 kV transformers
2034	Establish 33 kV injection point at McRobies Gully to supply Sandy Bay	Deload Creek Rd substation
2036	Establish Mt Nelson zone substation	Deload southern substation group
2042	Establish CBD zone substation	Deload southern substation group
2046	Establish West Moonah zone substation	Deload northern substation group and Risdon substation

The resulting load forecast curves are given in Figure 6-1 and Figure 6-2.

It should be noted that the group load forecast in Figure 6-2 includes the establishment of Austin's Ferry, Creek Rd and West Moonah substations into the northern substation group, and Mount Nelson and the CBD zone substation into the southern substation group.

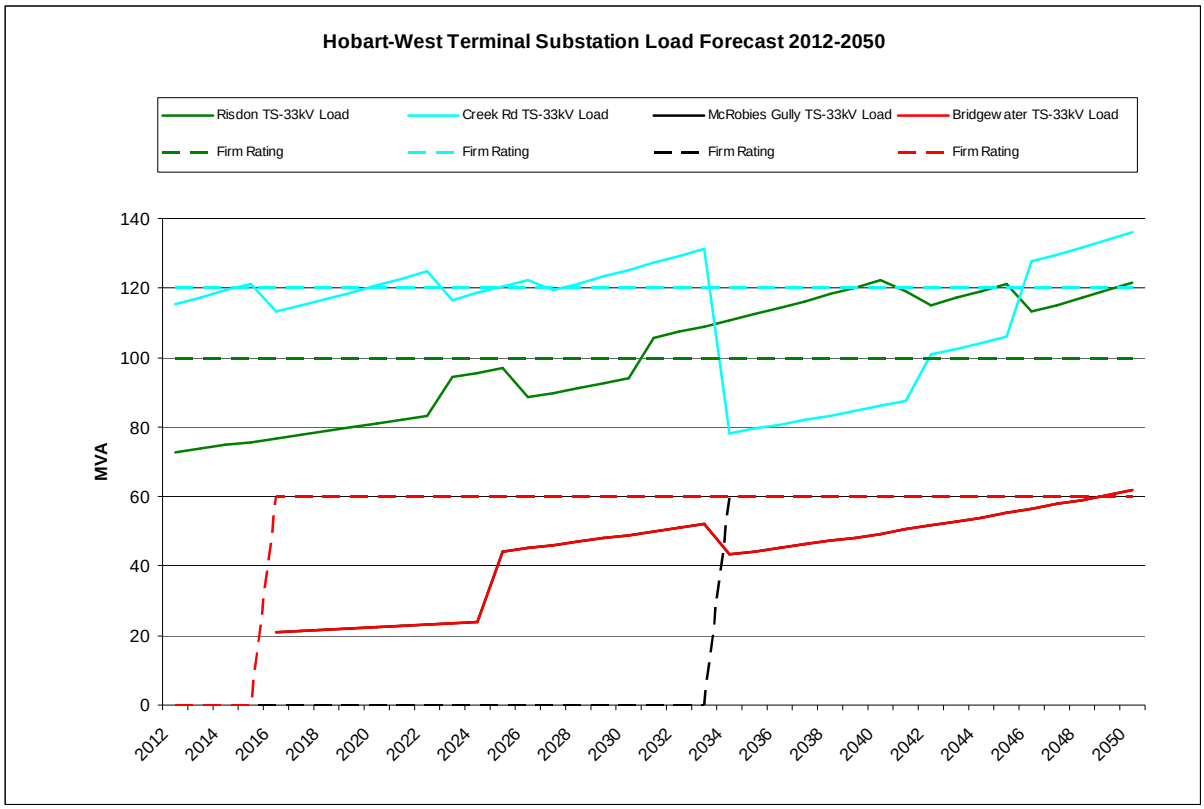


Figure 6-1 Hobart-West proposed terminal substation load forecast 2012-2050

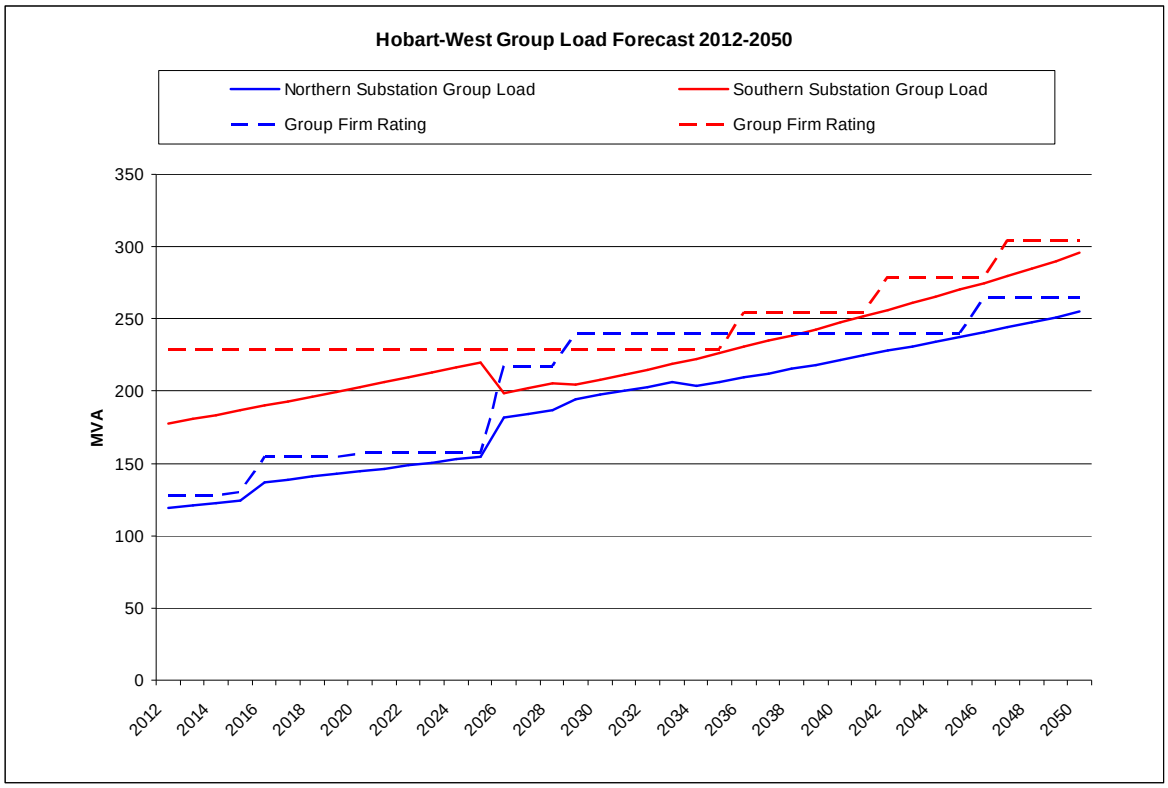


Figure 6-2 Hobart-West proposed group load forecast 2012-2050

Schematic and geographic diagrams of the resulting 33 kV configuration are given in Figure 6-3 and Figure 6-4.

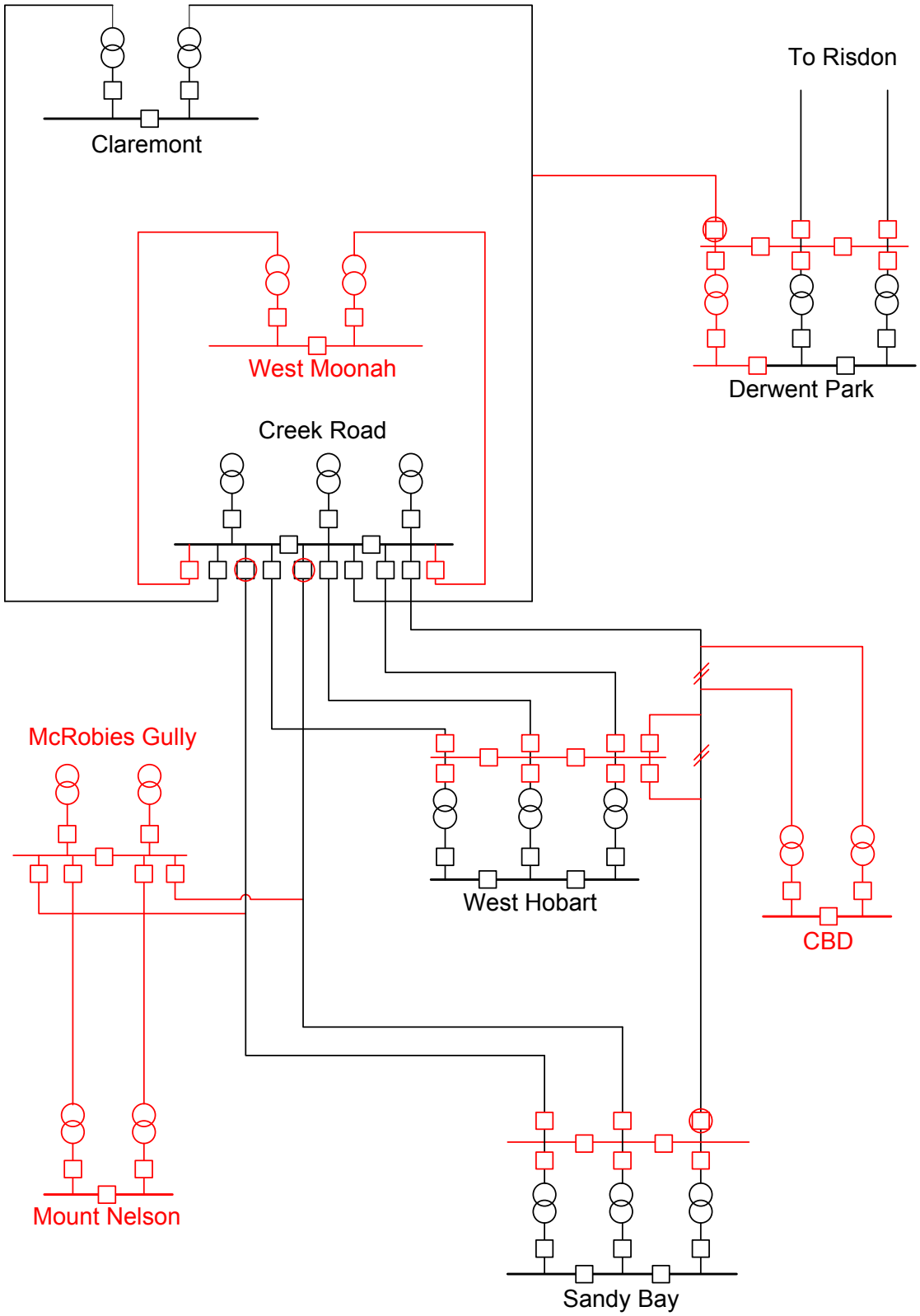


Figure 6-3 Hobart-West proposed 33 kV schematic

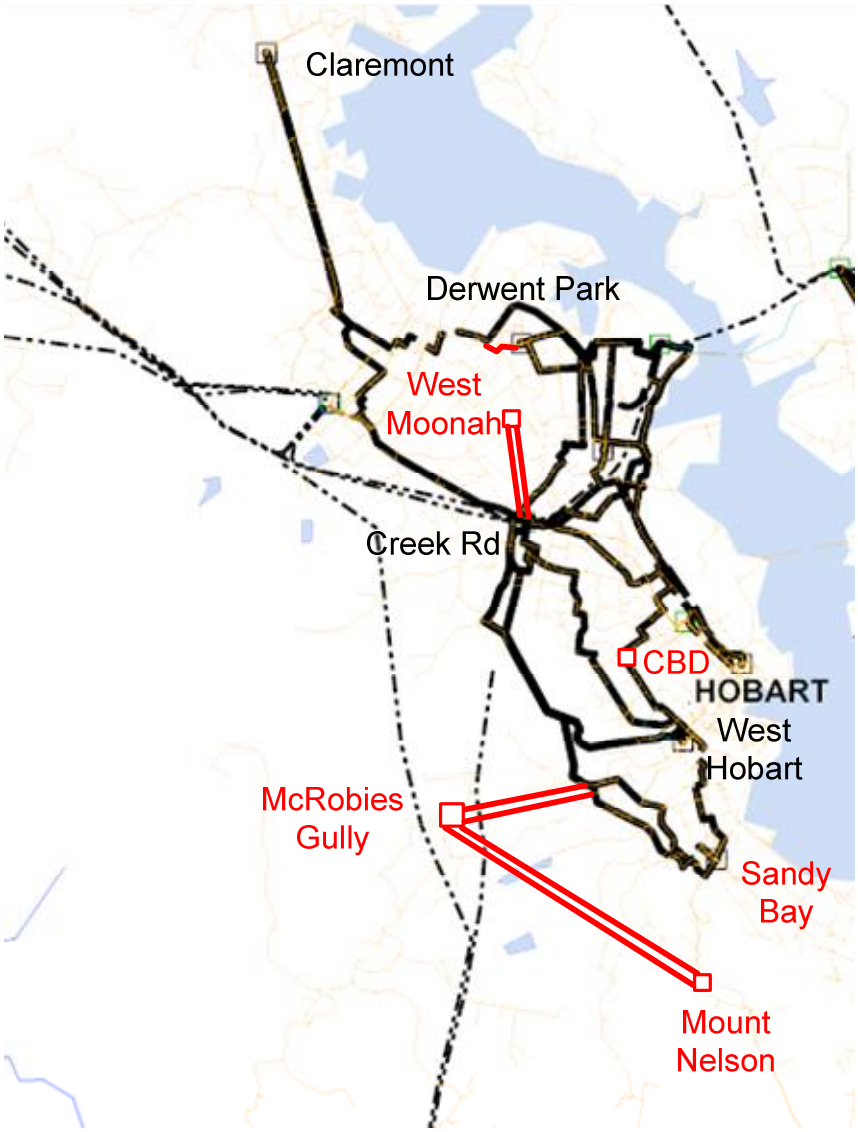


Figure 6-4 Hobart-West proposed 33 kV geographic

7. Ten year plan

The ten year plan for Hobart-City recommends the establishment of a 33 kV injection point at Bridgewater and a new zone substation at Austin's Ferry, in order to deload Bridgewater and Claremont substations and provide future flexibility of supply to Brighton. The plan also recommends the replacement of ageing transformers at Derwent Park and Claremont zone substations.

It should be noted that while each proposed project has undergone a thorough high level analysis, these projects will require further detailed analysis to confirm their economic and technical feasibility. A regulatory investment test will also be required for those projects where the augmentation component exceeds $1 million (RIT-D) or $5 million (RIT-T).

7.1 Proposed projects

7.1.1 Upgrade Derwent Park zone substation

Limitations

The Derwent Park 2 x 22.5 MVA 33/11 kV transformers have been deemed to be end of life by 2015.

Option 1 (recommended option) – Upgrade Derwent Park zone substation

To address the above limitations, it is proposed that the existing 33/11 kV transformers be replaced with new 25 MVA units in 2015.

As this project is justified on condition grounds and proposes a like-for-like replacement, for regulatory purposes it is considered a refurbishment project rather than an augmentation project. As such, a Regulatory Investment Test (RIT) is not required for this project.

Option 2 – Non-network option

No non-network alternatives have been considered.

Option 3 – Do nothing option

The do nothing option is not considered a feasible option as the Derwent Park transformers are expected to be end of life by 2015. However should it be determined that the transformers are in good condition beyond 2015, the upgrade may be deferred until justified on condition basis.

Recommended option

The scope of works includes:

- Replacement of the existing transformers with two 33/11 kV 25 MVA transformers

The estimated cost for the upgrade is $4 million.

7.1.2 Establish Bridgewater 33 kV injection point and zone substation at Austin's Ferry

Limitations

The ten year load forecast for Bridgewater and Creek Rd terminal substations, as well as the substation group containing Claremont, New Town, Derwent Park and Chapel St is outlined in Figure 7-1.

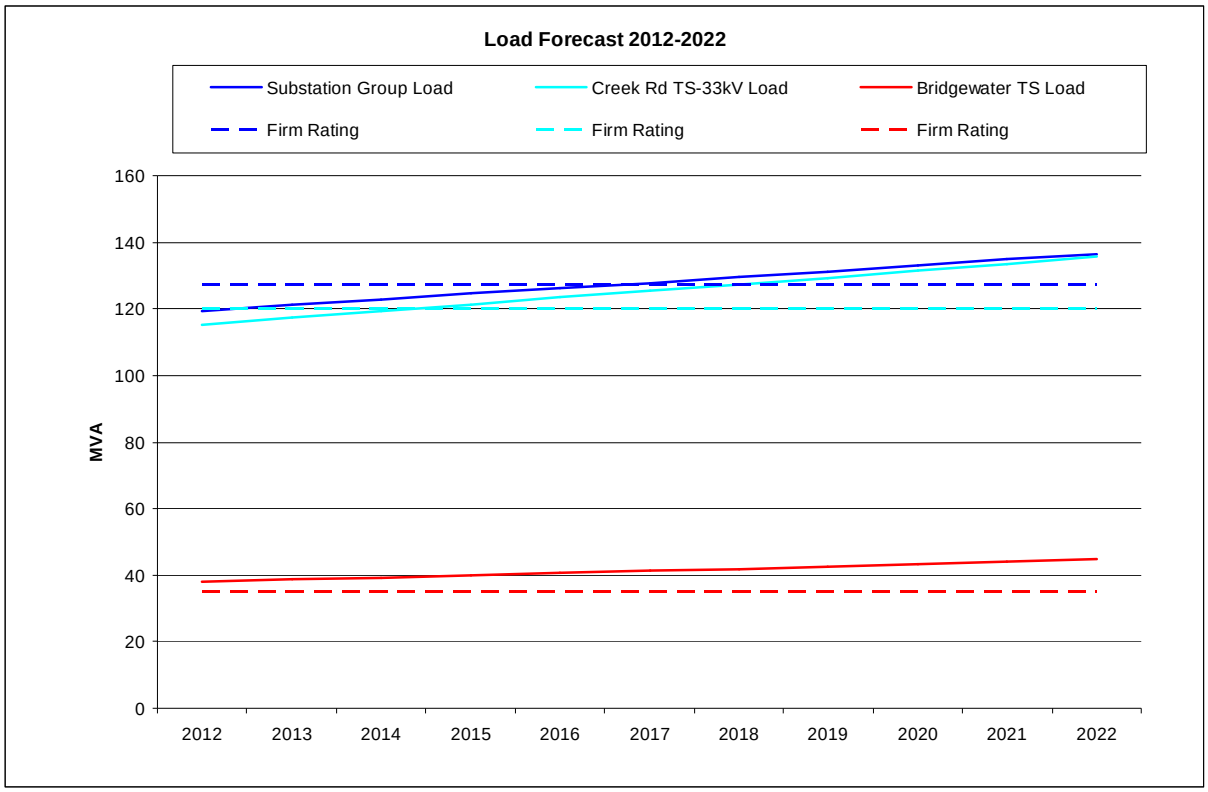


Figure 7-1 Hobart West existing load forecast 2012-2022

As outlined above, the load at Bridgewater is forecast to exceed firm capacity by approximately 3 MVA in 2012. Load transfers from Bridgewater to New Norfolk, Derwent Park and Claremont are expected to be able to defer or mitigate this limitation until 2016.

The group load forecast of Claremont, Derwent Park, New Town and Chapel St is forecast to exceed group firm capacity in 2017, with Claremont itself forecast to exceed firm capacity by approximately 4 MVA.

The load on Creek Rd substation is forecast to exceed firm capacity in 2015. It is expected that load transfers from West Hobart to East Hobart will be able to defer this limitation beyond 2016.

There are currently ten distribution feeders emanating from Bridgewater, with an additional feeder proposed as part of the Brighton Transportation Hub prior to 2012. Assuming an average loading of 3.75 MVA per distribution feeder, the maximum load able to be supplied by the 11 kV network is 41.25 MVA. This load will be exceeded at Bridgewater in 2017.

The three feeders from Bridgewater supplying to the Austin's Ferry area – 48180, 48182 and 48185 - are forecast to have a combined load of 13 MVA in 2012, increasing to 14.5 MVA by 2022. The Claremont feeders supplying to the North towards Austin's Ferry – 21082, 21085 and 21089 – are forecast to have a combined load of 9 MVA in 2012, increasing to 10 MVA in 2022. Therefore it is clear that the feeder network in the area is heavily loaded and will require attention in the near-term. A geographical diagram of the 11 kV feeders is given in Figure 7-2.

Figure 7-2 Existing geographic diagram of Claremont and Bridgewater 11 kV feeders

Option 1 (recommended option) – Establish Bridgewater 33 kV injection point and zone substation at Austin's Ferry

This option involves the establishment of a 33 kV injection point at the existing Bridgewater terminal substation site and the establishment of a new zone substation at Austin's Ferry supplied from 2 x 33 kV cables from Bridgewater in 2016.

Bridgewater 33 kV substation will consist of 2 x 60 MVA 110/33 kV transformers and two sections of 33 kV switchgear. The new 110/33 kV transformers will be connected to the existing 110 kV buses via isolators.

Austin's Ferry zone substation will consist of 2 x 25 MVA 33/11 kV transformers and two sections of 11 kV switchgear. The substation will be supplied transformer-ended from 33 kV cables from Bridgewater (approximately 5 km). The 33 kV cables will be required to cross the Derwent River – ideally the cables would be installed under the new bridge at Bridgewater (assuming the bridge is completed in time), otherwise submarine cables would be required.

An alternative option would be to establish the zone substation in the Old Beach area on the East bank of the river. This would avoid the requirement for 33 kV submarine cables, however an Old Beach substation would require longer 33 kV feeders and additional 11 kV feeder crossings to deload Claremont. Additionally, although both areas have undeveloped land and are expected to experience significant load growth, Austin's Ferry is considered a superior location for a substation due to the magnitude of existing load in the area.

Option 2 – Establish Bridgewater 33 kV injection point and upgrade Claremont zone substation

This option is the same as option 1 except that instead of a new zone substation at Austin's Ferry, the cables from Bridgewater are run further south to Claremont zone substation (approximately 8 km).

An additional 33/11 kV transformer is installed at Claremont under this option, supplied as a transformer-ended feeder from Bridgewater. The 11 kV bus would be split, with one bus supplied by the new transformer and two buses supplied by the existing two transformers.

This option also requires augmentation of the 11 kV network to the north of Claremont in order to deload Bridgewater terminal substation and reduce loading of the 11 kV feeders from Claremont and Bridgewater into the Austin's Ferry area.

Option 3 – Upgrade Bridgewater terminal substation and reinforce 11 kV network

This option involves the replacement of the existing 2 x 35 MVA 110/11 kV transformers at Bridgewater with 60 MVA units in 2017.

This option also requires augmentation of the 11 kV network into the Austin's Ferry area, including additional 11 kV river crossings, in order to deload Claremont zone substation and reduce 11 kV feeder loading,

Option 4 – Establish Bridgewater 33 kV injection point and zone substations at Bridgewater and Austin's Ferry

This option is identical to option 1, except that the 110/11 kV terminal substation at Bridgewater is also replaced by a new zone substation. The benefit of this option is the reduction in 110 kV costs at Bridgewater, since the new 110/33 kV transformers can connect to the existing transformer bays.

Technical comparison

Table 7-1 Technical comparison of options

Option	Description	Advantages	Disadvantages
1	Establish Bridgewater 33 kV injection point and zone substation at Austin's Ferry	Deloads Bridgewater, Claremont and Creek Rd substations 33 kV injection point provides flexibility for future supply in the area Shorter 33 kV cable run than option 2 Increases firm capacity of northern substation group by 25 MVA Results in shorter 11 kV feeders than options 2 and 3, and hence increases reliability and defers future 11 kV augmentation	Requires purchase and establishment of a new site at Austin's Ferry

Option	Description	Advantages	Disadvantages
2	Establish Bridgewater 33 kV injection point and upgrade Claremont zone substation	Deloads Bridgewater and Creek Rd substations 33 kV injection point provides flexibility for future supply in the area Increases firm capacity of northern substation group by 25 MVA	Longer 33 kV cable run than option 1 Requires additional 11 kV feeders out of Claremont substation to split existing feeders and transfer load from Bridgewater Requires the 11 kV bus to be split to avoid paralleling 33 kV injection points
3	Upgrade Bridgewater terminal substation and reinforce 11 kV network	Deloads Claremont and Creek Rd substations Increases firm capacity of Bridgewater substation by 25 MVA	Requires additional 11 kV feeders out of Bridgewater substation (including river crossings) to split existing feeders and transfer load from Claremont
4	Establish Bridgewater 33 kV injection point and zone substations at Bridgewater and Austin's Ferry	Minimal 110 kV works required at Bridgewater Deloads Claremont and Creek Rd substations 33 kV injection point provides flexibility for future supply in the area Shorter 33 kV cable run than option 2 Increases firm capacity of northern substation group by 25 MVA Results in shorter 11 kV feeders than options 2 and 3, and hence increases reliability and defers future 11 kV augmentation	Non-standard zone substation transformers to maintain 35 MVA firm capacity Requires purchase and establishment of two new zone substation sites

The above technical comparison of options indicates that option 1 provides the best technical solution.

Cost comparison

Table 7-2 Cost comparison of options

Option	Initial Capital Cost	Total Capital Cost	Net Present Value
1	27.5	44.0	23.2
2	26.7	47.5	24.3
3	19.6	49.3	23.8
4	34.5	45.0	26.0

The above cost comparison of options indicates that option 1 provides the lowest cost solution. Details of the NPV analysis are given in appendix B.

Recommended option

Based on the technical and cost comparison, option 1 is considered the preferred option to address the forecast limitations.

The scope of works for Transend includes:

- Installation of 2 x 60 MVA 110/33 kV transformers and connection to existing 110 kV double bus and new 33 kV switchboard at Bridgewater terminal substation
- Installation of two sections of 33 kV switchgear, with two transformer CBs, six feeder CBs and a bus section CB inside a new switchgear building at Bridgewater
- Termination of 33 kV feeders at feeder CBs

The scope of works for Aurora includes:

- Establishment of new zone substation site at Austin's Ferry
- Installation of 2 x 25 MVA 33/11 kV transformers
- Installation of two sections of 11 kV switchgear, with two transformer CBs, twelve feeder CBs and a bus section CB inside a new switchgear building.
- Installation of an underground 33 kV double circuit from Bridgewater to Austin's Ferry (approximately 5 km) including a river crossing
- 11 kV feeder tails to cut into existing Bridgewater and Claremont feeders

The resulting load forecast is given in Figure 7-3.

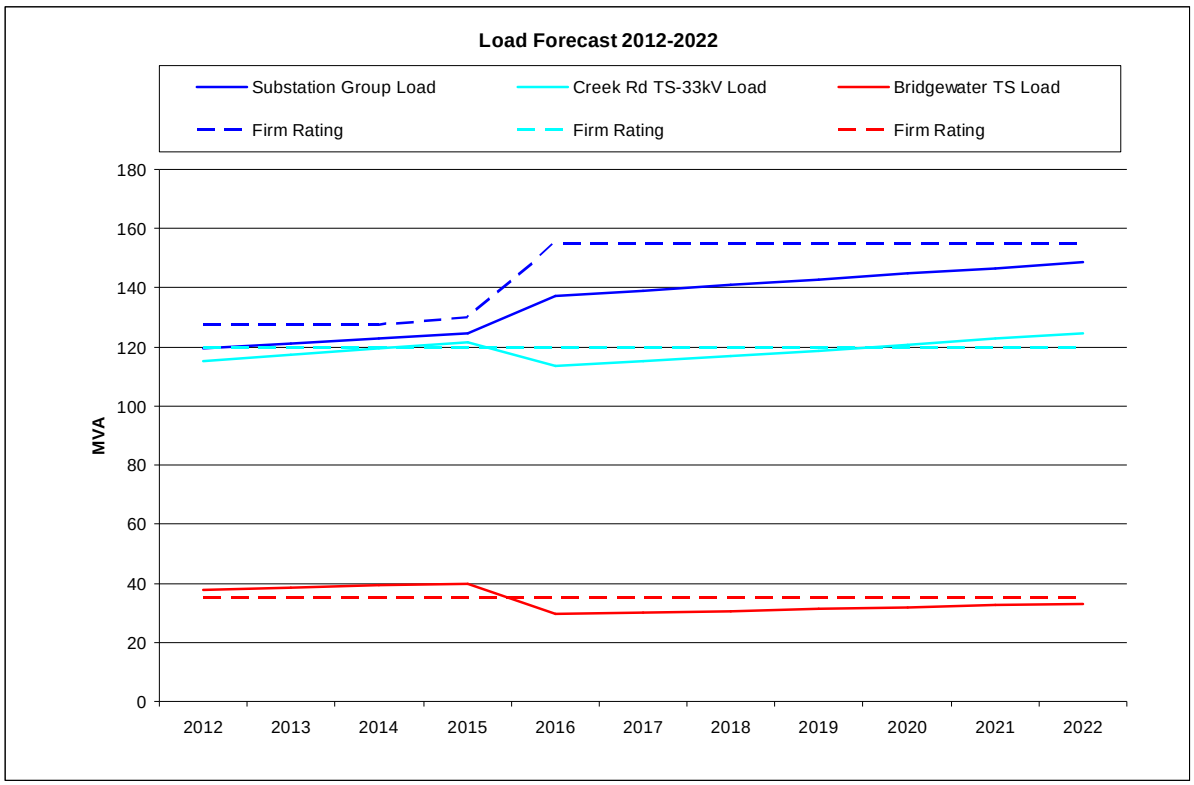


Figure 7-3 Hobart West proposed load forecast

As outlined above, the proposed works deload the substation group and Bridgewater substation below firm capacity for the period of study. Creek Rd 33 kV load is forecast to exceed firm capacity again in 2020, however it is expected that this limitation will be deferred by load transfers from West Hobart to East Hobart.

Geographic and schematic diagrams of the proposed works are shown in Figure 7-4 and Figure 7-5.

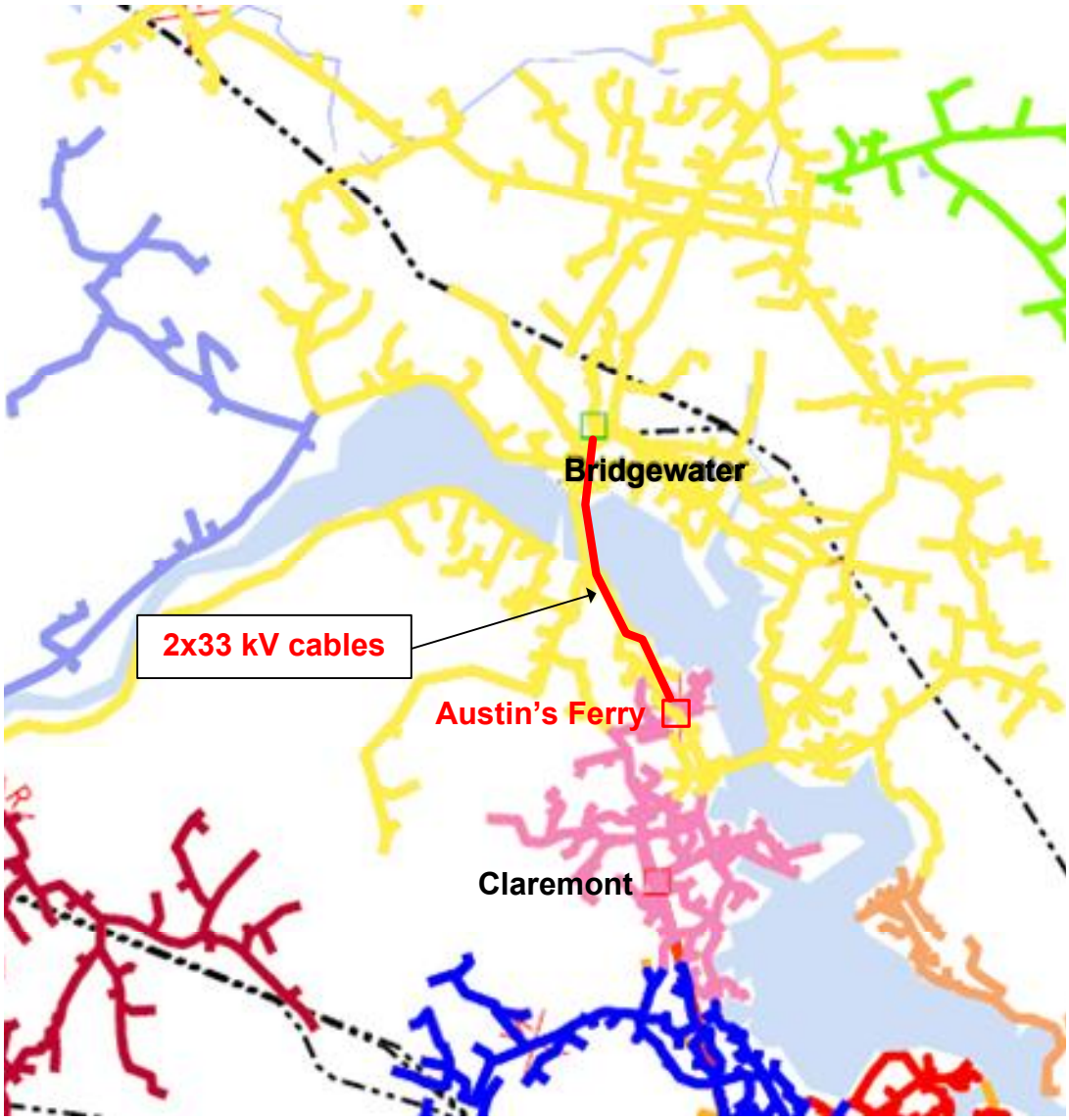


Figure 7-4 Proposed geographic network diagram

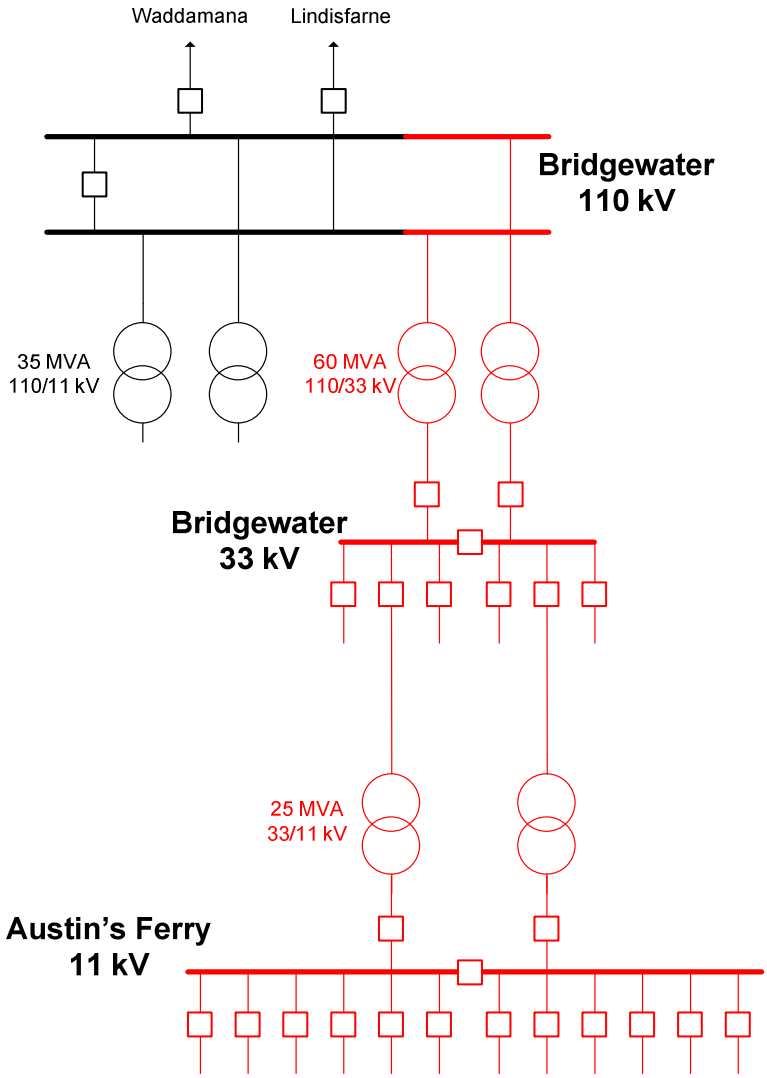


Figure 7-5 Proposed schematic network diagram

7.1.3 Upgrade Claremont zone substation

Limitations

The Claremont 2 x 22.5 MVA 33/11 kV transformers have been deemed to be end of life by 2020.

Option 1 (recommended option) – Upgrade Claremont zone substation

To address the above limitations, it is proposed that the existing 33/11 kV transformers be replaced with new 25 MVA units in 2020.

As this project is justified on condition grounds and proposes a like-for-like replacement, for regulatory purposes it is considered a refurbishment project rather than an augmentation project. As such, a Regulatory Investment Test (RIT) is not required for this project.

Option 2 – Non-network option

No non-network alternatives have been considered.

Option 3 – Do nothing option

The do nothing option is not considered a feasible option as the Claremont transformers are expected to be end of life by 2020. However should it be determined that the transformers are in good condition beyond 2020, the upgrade may be deferred until justified on condition basis.

Recommended option

The scope of works includes:

- Replacement of the existing transformers with two 33/11 kV 25 MVA transformers

The estimated cost for the upgrade is $4 million.

7.2 Summary of proposed works

The proposed works from 2012 to 2022 in the Hobart-West planning area are listed in Table 7-3.

Table 7-3 Hobart-West project summary

Year	Proposed Project	Proposed Outcomes
2015	Upgrade Derwent Park zone substation	Replace ageing 33/11 kV transformers and increase firm capacity at Derwent Park
2016	Establish Bridgewater 33 kV injection point and zone substation at Austin's Ferry	Deload Claremont zone substation and Creek Rd 33 kV substation
2020	Upgrade Claremont zone substation	Replace ageing 33/11 kV transformers and increase firm capacity at Claremont

8. Five year plan

A five year plan for each of the substations (including proposed new substations) in the Hobart-West area is outlined below.

It should be noted that while each proposed project has undergone a thorough high level analysis, these projects will require further detailed analysis to confirm their economic and technical feasibility. A regulatory investment test will also be required for those projects where the augmentation component exceeds $1 M (RIT-D) or $5 M (RIT-T).

8.1 Bridgewater substation

Bridgewater terminal substation supplies the towns of Bridgewater, Brighton and north to Bagdad, as well as the northern Hobart suburbs of Old Beach and Granton and parts of Claremont.

8.1.1 Limitations

Using the medium growth forecast, the Bridgewater substation load is forecast to grow from 37.5 MVA in 2012 to 40.0 MVA in 2017, including a block load of approximately 3 MVA prior to 2012 to account for developments as part of the Brighton Transport Hub. The resulting load forecast is given in Figure 8-1.

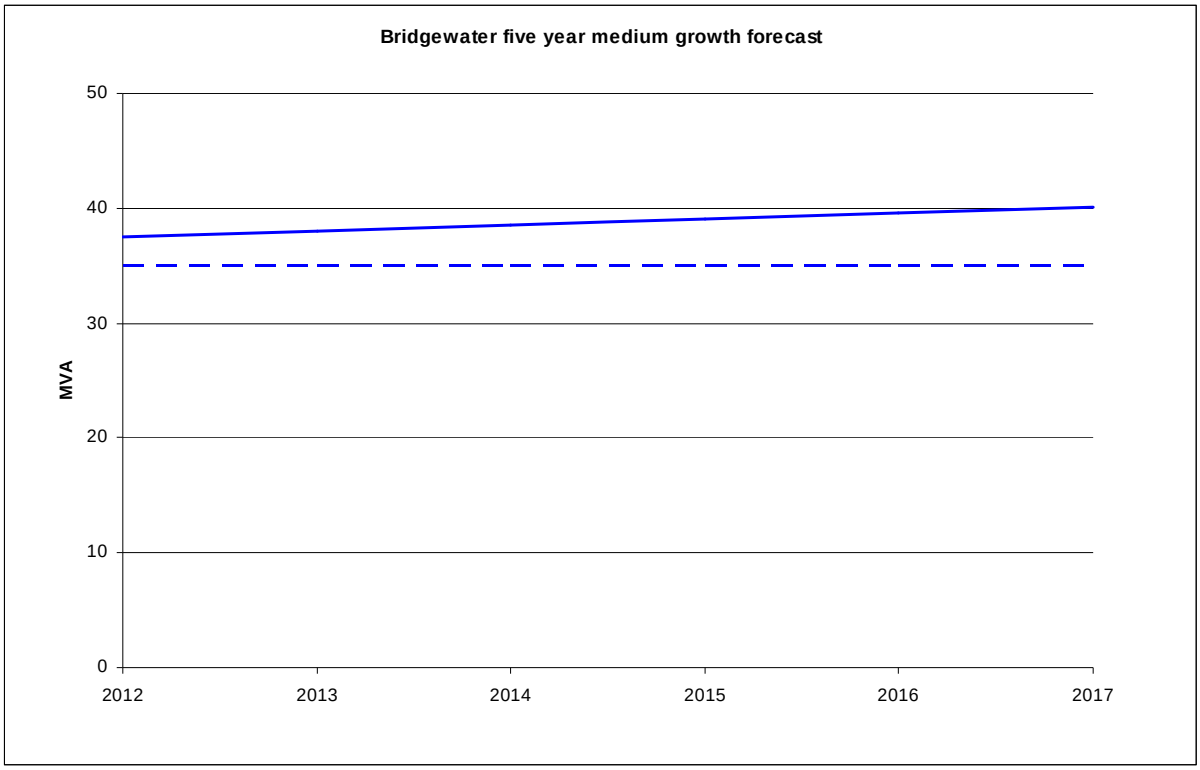


Figure 8-1 Bridgewater five year medium growth forecast

The 11 kV network from Bridgewater consists of ten distribution feeders, with a new feeder planned from the last remaining spare circuit breaker to relieve feeder congestion to the north in the Brighton area. The Bridgewater supply area and individual feeders are shown in Figure 8-2 and Figure 8-3 below.

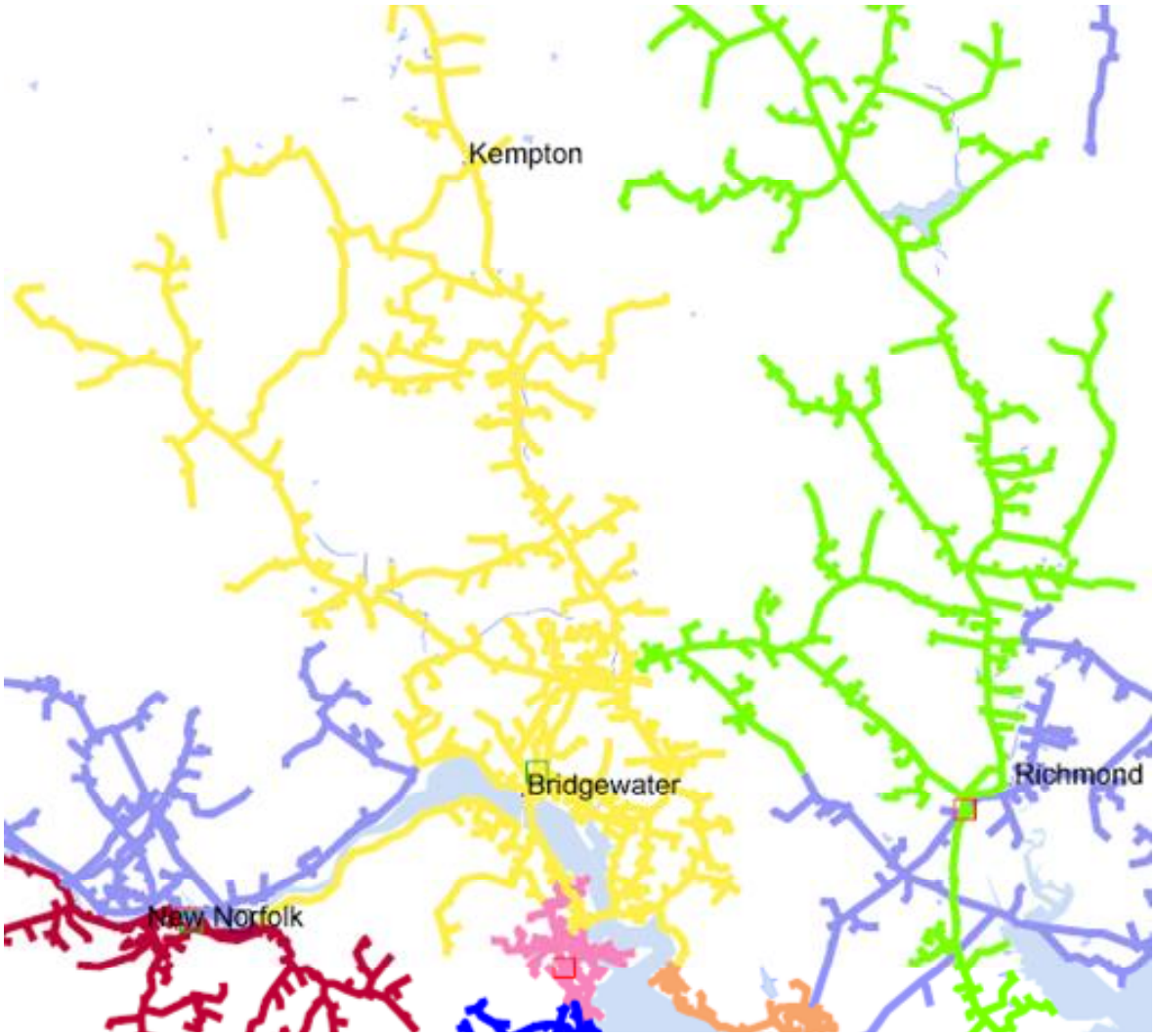


Figure 8-2 Bridgewater 11 kV supply area

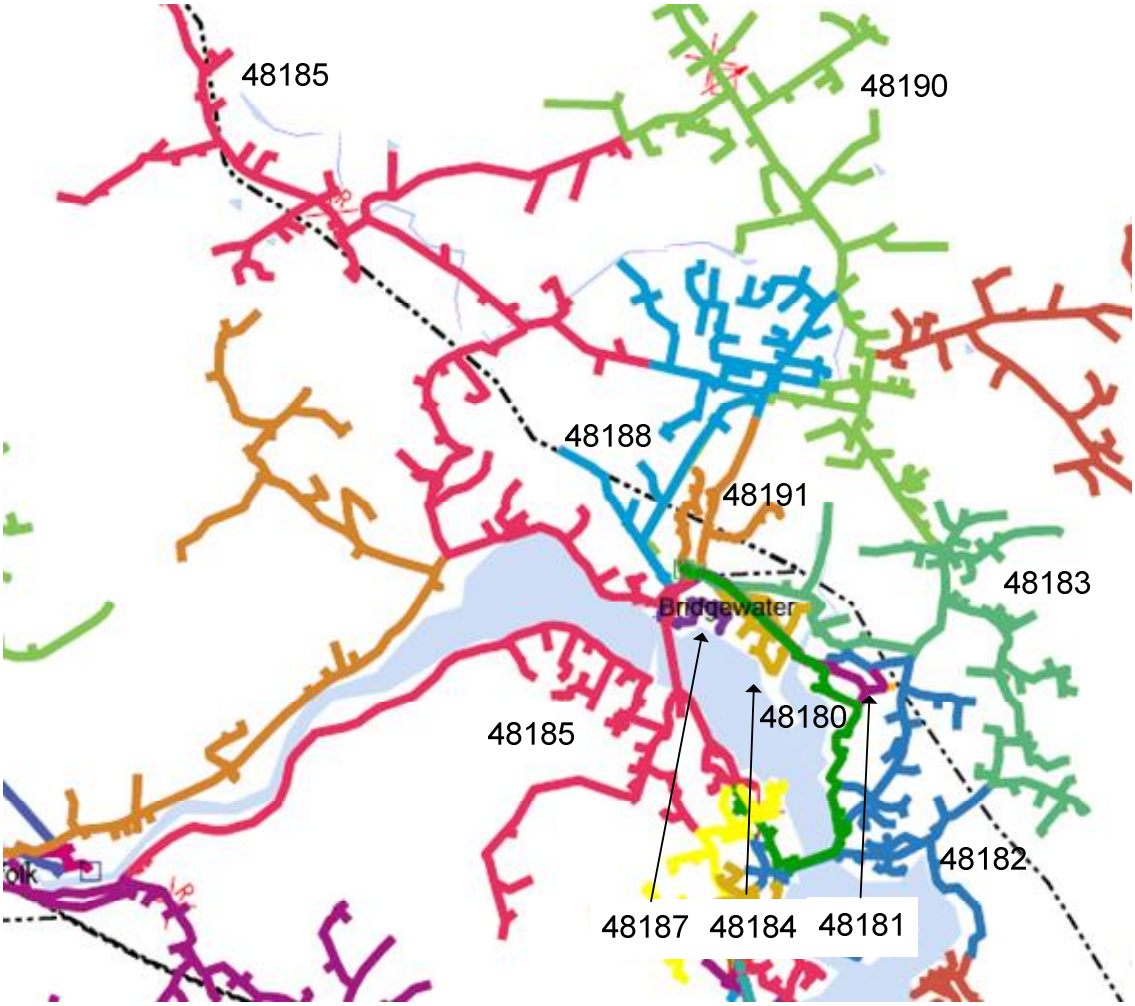


Figure 8-3 Bridgewater 11 kV feeders

A five year feeder forecast has been developed by applying the substation medium growth rate to the feeder peak loads. The feeder forecast is outlined in Table 8-1.

Table 8-1 Bridgewater substation feeder forecast

Area	Feeder/s	2012 load (MVA)	2013 load (MVA)	2014 load (MVA)	2015 load (MVA)	2016 load (MVA)	2017 load (MVA)
Bridgewater	48181	1.2	1.3	1.3	1.3	1.3	1.3
	48184	4.4	4.4	4.5	4.5	4.6	4.6
	48187	2.2	2.2	2.2	2.3	2.3	2.3
Brighton	48188	5.2	5.2	5.3	5.3	5.4	5.5
	48190	5.5	5.7	5.8	6.0	6.1	6.2
	48191	5.0	5.1	5.1	5.2	5.2	5.3
Broadmarsh	48185	3.2	3.3	3.3	3.3	3.4	3.4
Old Beach	48180	4.0	4.1	4.1	4.2	4.2	4.3
	48182	5.6	5.7	5.7	5.8	5.9	5.9
	48183	2.4	2.4	2.4	2.5	2.5	2.5

As outlined above, feeders 48188, 48190 and 48191 to Brighton and north are forecast to exceed the 5 MVA planning rating from 2012. A 3 MVA block load in the Brighton area has been assumed prior to 2012 to allow for Brighton transportation hub works, and this load has been shared across the three feeders. It is expected that the project to establish a new feeder and switching station in the Brighton area will address this limitation for the scope of the study.The proposal to convert the Kempton and Melton-Mowbray 11 kV network to 22 kV is also expected to deload 48190 prior to 2012.

Feeder 48182 to the Old Beach and Austin's Ferry area also exceeds the 5 MVA planning rating from 2012. This limitation is addressed in 2016 by the establishment of Austin's Ferry zone substation, but could be mitigated in the meantime by a small load transfer from 48182 to 48183.

The remainder of Bridgewater 11 kV feeders are within their planning ratings for the scope of the study.

The available transfer capacity from Bridgewater substation to the Claremont, Richmond and Geilston Bay substations is outlined in Table 8-2.

Table 8-2 Bridgewater substation transfer capability

Substation	Feeder	2012 transfer (MVA)	2013 transfer (MVA)	2014 transfer (MVA)	2015 transfer (MVA)	2016 transfer (MVA)	2017 transfer (MVA)
Claremont	21081	3.1	3.1	3.1	3.0	3.0	3.0
	21085	2.1	2.0	2.0	2.0	2.0	1.9
	21089	0.7	0.7	0.7	0.6	0.6	0.5
Geilston Bay	26161	0.8	0.8	0.7	0.7	0.6	0.6
Total transfers	-	6.7	6.6	6.5	6.3	6.2	6.0

As outlined above, there is sufficient transfer capacity to reduce the load at Bridgewater below firm capacity for the period of study.

8.1.2 Proposed projects

Austin's Ferry zone substation

Austin's Ferry zone substation is proposed to be installed in 2016 and will address the firm capacity limitations at Claremont and Bridgewater substations, as well as deloading the 11 kV networks north from Claremont and south from Bridgewater. For information on the options analysis for this project please refer to the ten year plan in Section 7.1.2. For information on the distribution network details please refer to the five year plan in Section 8.2.

The resulting Bridgewater five year load forecast is shown in Figure 8-4.

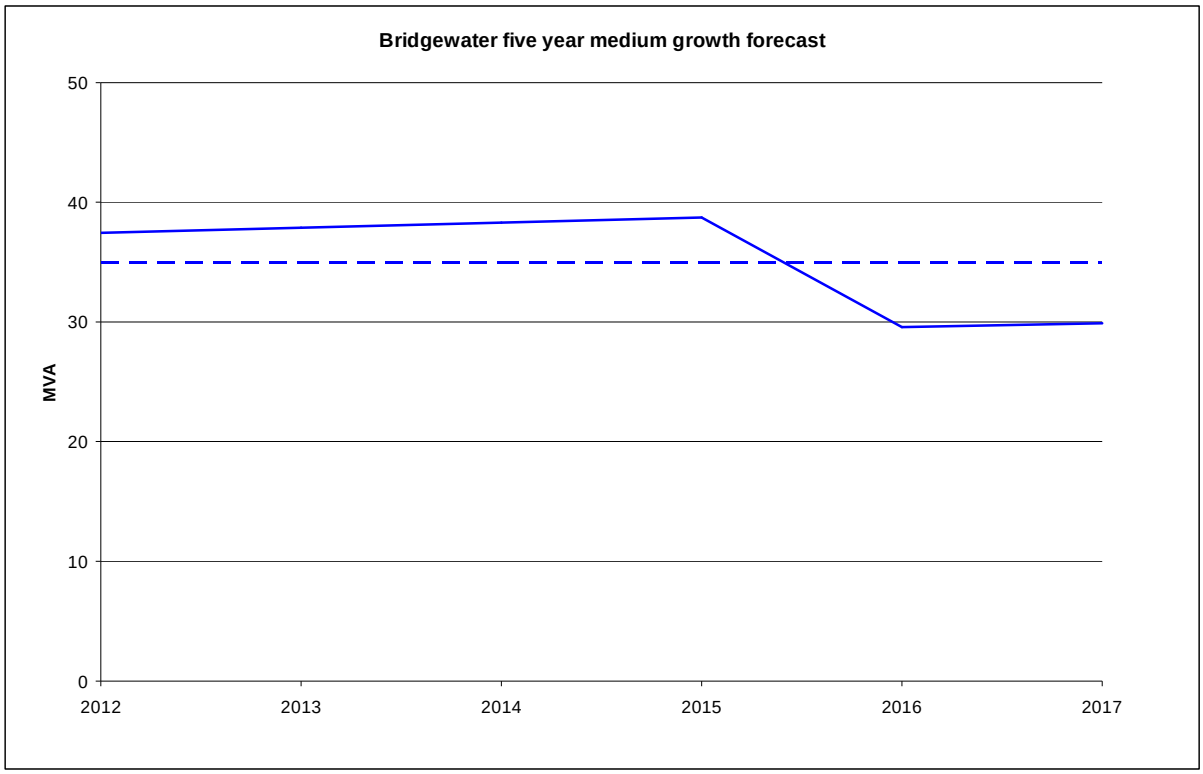


Figure 8-4 Bridgewater proposed five year medium growth forecast

As outlined above, Bridgewater load is reduced below firm capacity in 2016.

The resulting Bridgewater feeder loads are shown in Table 8-3

Table 8-3 Bridgewater substation proposed feeder forecast

Area	Feeder/s	2012 load (MVA)	2013 load (MVA)	2014 load (MVA)	2015 load (MVA)	2016 load (MVA)	2017 load (MVA)
Broadmarsh	48185	3.2	3.3	3.3	3.3	2.0	2.0
Old Beach	48180	4.0	4.1	4.1	4.2	0.9	0.9
	48182	5.6	5.7	5.7	5.8	0.8	0.8
	48183	2.4	2.4	2.4	2.5	2.3	2.4

As outlined above, feeders 48180, 48182, 48183 and 48185 are deloaded by the establishment of Austin's Ferry zone substation.

New feeder projects

Based on the medium growth forecast all feeder overloads are addressed by existing projects within the period of study. The only potential feeder project identified would be to transfer a small amount of load from 48182 to 48183 to reduce load below 5 MVA prior to the Austin's Ferry project.

8.1.3 Ultimate configuration

Substation

Bridgewater is expected to remain a two (110/11 kV) transformer substation up to 2050, though the existing 110/11 KV 35 MVA transformers were installed in 1980 so are expected to reach end of life around 2030. It is expected that the transformers will be replaced with 60 MVA units at this time. The 11 kV switchboard may also need to be replaced or extended at this time to enable additional 11 kV feeders to be established.

It is expected that the two 110/33 kV transformers to be installed at Bridgewater will be sufficient to supply the Austin's Ferry and Brighton zone substations up to 2050. Should their be a requirement for a zone substation between Claremont and Chapel St, supplied from Creek Rd via the existing Claremont 33 kV feeders, Claremont may ultimately be normally supplied from Brigdewater via Austin's Ferry. In this case an additional 110/33 kV transformer would still not be required, as transfer capacity would be established with Creek Rd at the same time.

Feeders

With the establishment of substations in Austin's Ferry to the south and Brighton to the north of Bridgewater, and the mountainous terrain to the west of the substation, any future feeders from Bridgewater are likely to be towards the east to the townships of Bridgewater, Gagebrook and Old Beach.

As noted above, there are no spare circuit breakers at Bridgewater substation. Additional feeders would not be possible without replacing or extending the switchgear, which may be undertaken with the transformer age replacement in 2030. The establishment of Austin's Ferry and Brighton zone substations will significantly deload the existing feeders into Gagebrook and Old Beach, which suggests that feeder reinforcement from Bridgewater will not be required prior to this time.

8.2 Austin's Ferry substation

Austin's Ferry zone substation is proposed to be installed in 2016 to address firm capacity limitations at Claremont, Bridgewater and Creek Rd substations and to address 11 kV feeder limitations from Bridgewater and Claremont. For information on the options analysis and justification for this project please refer to the ten year plan in section 7.1.2. This section of the report will focus on the scope of work for Aurora and the impact on the distribution network.

An approximate site location has been assumed and the proposed Austin's Ferry feeder configuration is shown in Figure 8-5 below.

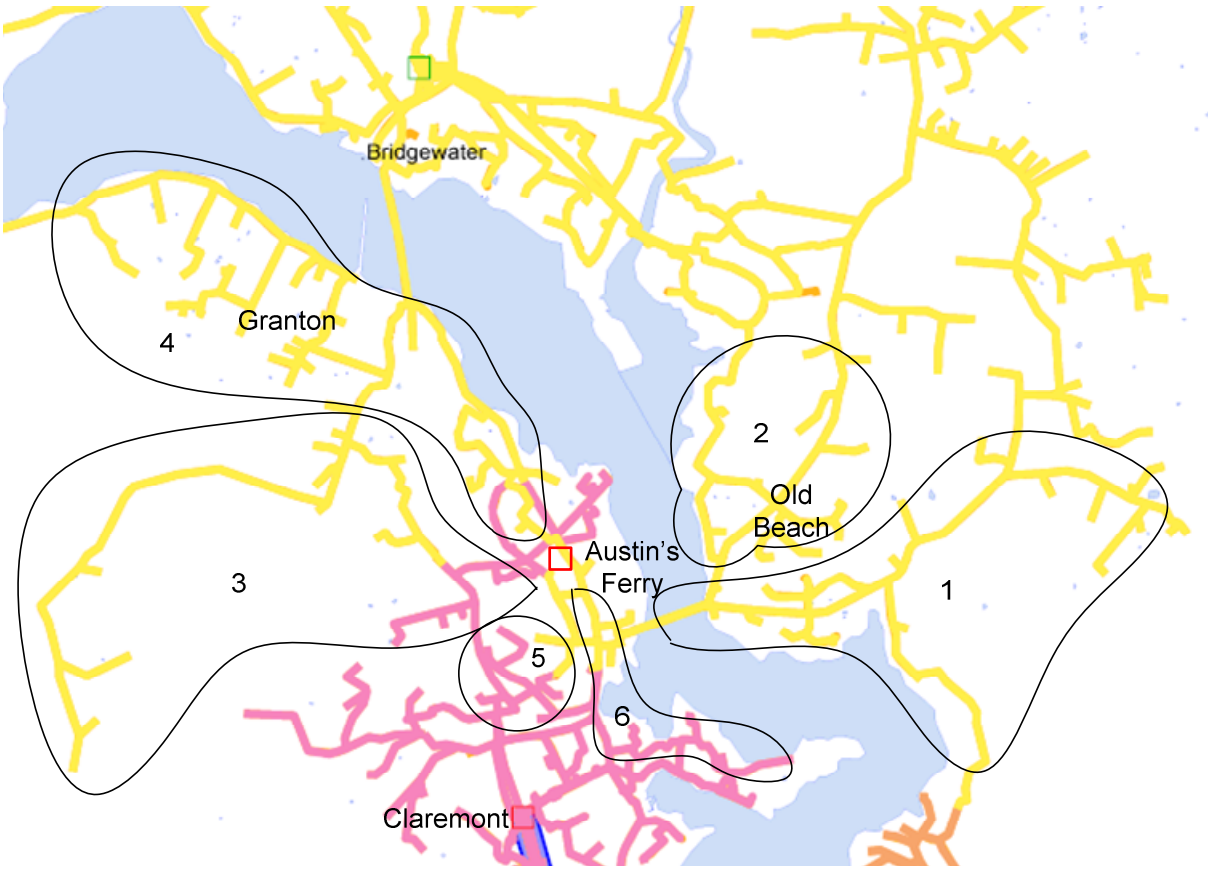


Figure 8-5 Austin's Ferry proposed feeder configuration

Feeder loads have been determined using DINIS and a five year feeder forecast has been developed by applying the substation medium growth rate to the feeder peak loads. The feeder forecast is outlined in Table 8-5.

Table 8-4 Austin's Ferry substation feeder forecast

Area	Feeder/s	2016 load (MVA)	2017 load (MVA)	2018 load (MVA)	2019 load (MVA)	2020 load (MVA)	2021 load (MVA)
Old Beach	1	3.6	3.7	3.7	3.8	3.8	3.9
	2	4.2	4.2	4.3	4.4	4.4	4.5
Austin's Ferry	3	2.9	3.0	3.0	3.1	3.1	3.2
Granton	4	1.8	1.8	1.9	1.9	1.9	2.0
Claremont	5	1.9	2.0	2.0	2.0	2.0	2.1
	6	3.2	3.2	3.3	3.3	3.4	3.4

As outlined above there are no forecast feeder limitations in the five years following the establishment of Austin's Ferry substation, based on the feeder planning rating of 5 MVA.

8.2.1 Proposed projects

No projects are proposed in the five year plan for the Austin's Ferry supply area.

8.2.2 Ultimate configuration

Substation

Austin's Ferry is expected to remain a two transformer substation up to 2050. As discussed in the long term plan there is the potential for the installation of 33 kV switchgear at the site, with a new 33 kV double circuit from Austin's Ferry to supply Claremont. However this is not expected to be required in the near future.

Feeders

The requirement for future feeders will be dependent on the development of land in the area. There is significant undeveloped land in the areas around Austin's Ferry and Granton, so ultimately new feeders may be required in all directions.

Although the feeders to the Old Beach area are forecast to be quite heavily loaded in 2017, the configuration is expected to be adequate up to 2025. At this time the establishment of a zone substation at Brighton is expected to deload the Bridgewater feeders in the area, allowing them to provide support to Old Beach.

8.3 Claremont substation

Claremont zone substation supplies to the far northern suburbs of Hobart including Claremont, Austin's Ferry and Berriedale.

8.3.1 Limitations

Using the medium growth forecast, Claremont substation load is forecast to grow from 24.8 MVA in 2012 to 26.9 MVA in 2017, which is well in excess of the substation firm capacity of 22.5 MVA. The five year load forecast for Claremont substation is given in Figure 8-6.

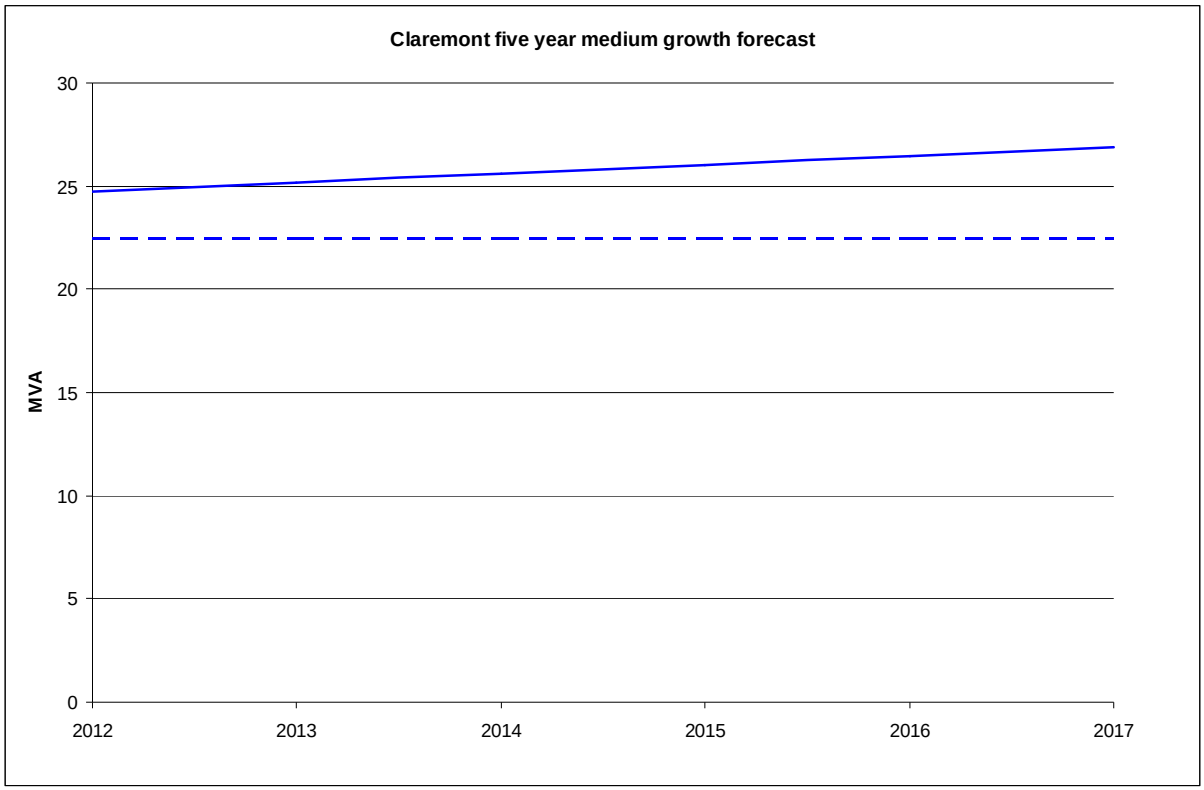


Figure 8-6 Claremont five year medium growth forecast

The 11 kV network from Claremont consists of nine distribution feeders and there are three spare feeder circuit breakers available. The Claremont supply area and individual feeders are shown in Figure 8-7 and Figure 8-8 below.

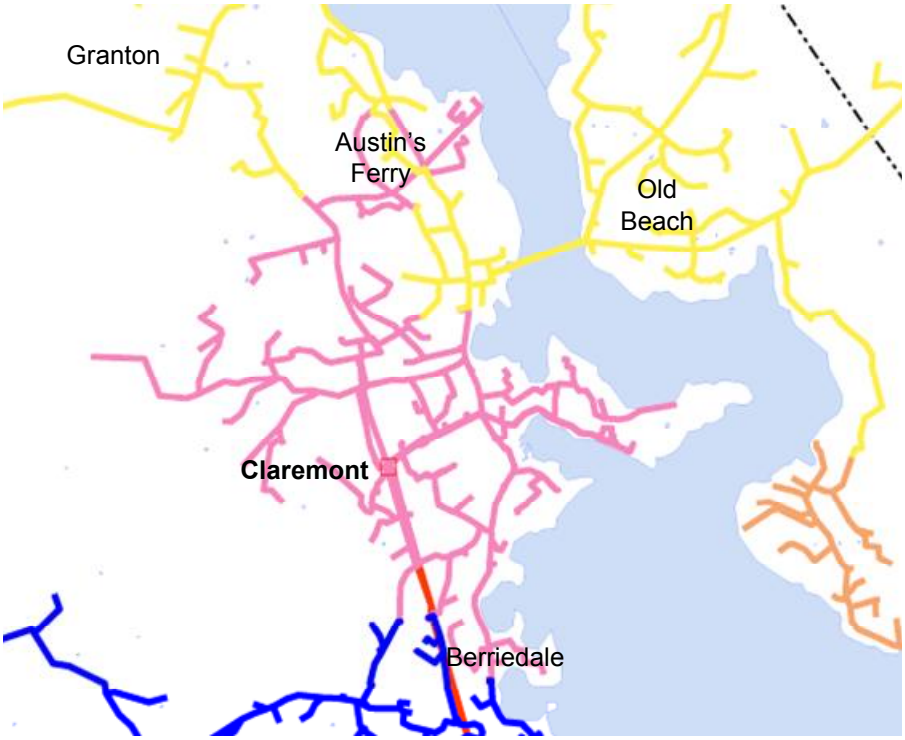


Figure 8-7 Claremont 11 kV supply area

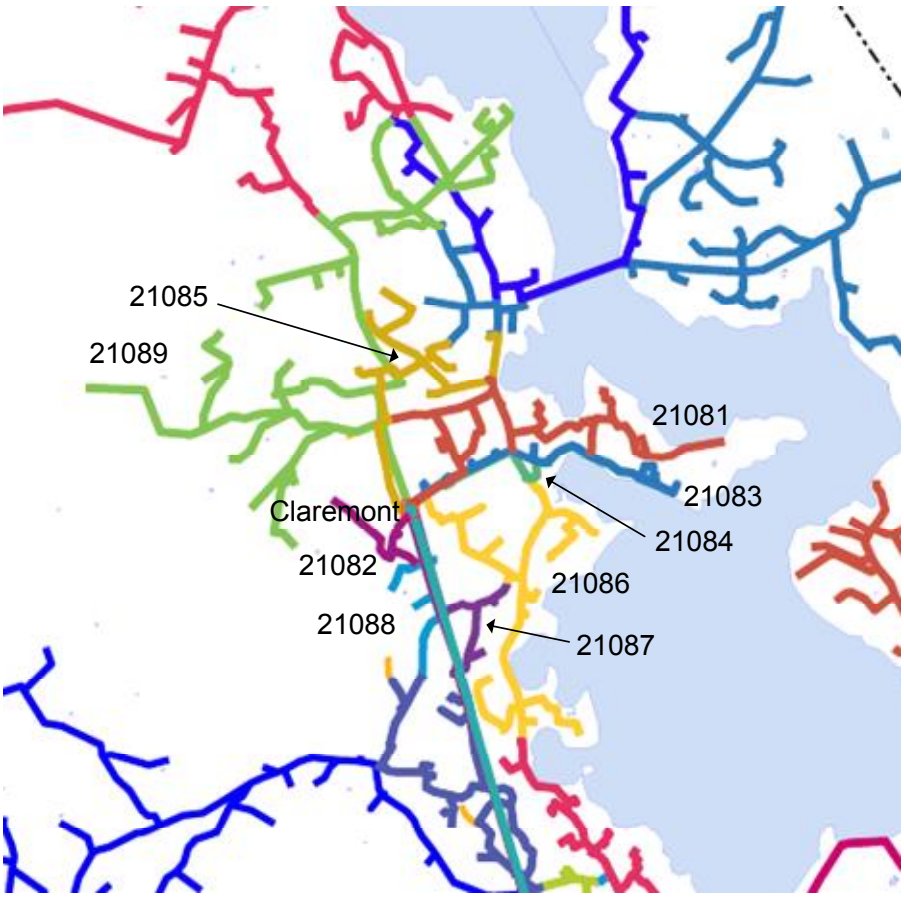


Figure 8-8 Claremont 11 kV feeders

A five year feeder forecast has been developed by applying the substation medium growth rate to the feeder peak loads. The feeder forecast is outlined in Table 8-5.

Table 8-5 Claremont substation feeder forecast

Area	Feeder/s	2012 load (MVA)	2013 load (MVA)	2014 load (MVA)	2015 load (MVA)	2016 load (MVA)	2017 load (MVA)
Claremont	20181	3.2	3.2	3.3	3.3	3.4	3.4
	21082	0.9	1.0	1.0	1.0	1.0	1.0
	21083	3.7	3.8	3.8	3.9	4.0	4.0
	21084	2.8	2.9	2.9	3.0	3.0	3.1
	21085	3.7	3.8	3.8	3.9	4.0	4.0
	21087	1.3	1.3	1.3	1.3	1.4	1.4
	21088	1.3	1.3	1.3	1.3	1.4	1.4
Berriedale	21086	4.0	4.1	4.2	4.2	4.3	4.4
Austin's Ferry	21089	4.1	4.2	4.3	4.3	4.4	4.5

As outlined above there are no forecast feeder limitations in the period of study, based on the feeder planning rating of 5 MVA.

Aurora has advised the potential for an additional 2 MVA block load at Moorilla, currently supplied from feeder 21086. Should this load eventuate it will increase the load on 21086 above the planning rating. It is expected that this could be addressed by rebalancing load between the three feeders in the area – 21086, 21087 and 21088 – with additional transfers to 21084 if necessary.

The available transfer capacity from Claremont substation to the Bridgewater and Chapel St substations is outlined in Table 8-6.

Table 8-6 Claremont substation transfer capability

Substation	Feeder	2012 transfer (MVA)	2013 transfer (MVA)	2014 transfer (MVA)	2015 transfer (MVA)	2016 transfer (MVA)	2017 transfer (MVA)
Bridgewater	48180	1.3	1.2	1.2	1.1	1.1	1.0
	48182	0.0	0.0	0.0	0.0	0.0	0.0
	48185	0.0	0.0	0.0	0.0	0.0	0.0
Chapel St	20541	1.5	1.4	1.3	1.3	1.2	1.1
	20549	2.3	2.3	2.2	2.2	2.1	2.0
Total transfers	-	5.1	4.9	4.7	4.6	4.4	4.1

As outlined above, there is sufficient transfer capacity to reduce the load at Claremont below firm capacity for the period of study.

8.3.2 Proposed projects

Austin's Ferry zone substation

Austin's Ferry zone substation is proposed to be installed in 2016 and will address the firm capacity limitations at Claremont and Bridgewater substations, as well as deloading the 11 kV networks north from Claremont and south from Bridgewater. For information on the options analysis for this project please refer to the ten year plan in Section 7.1.2. For information on the distribution network details please refer to the five year plan in Section 8.2.

The resulting Claremont five year load forecast is shown in Figure 8-9.

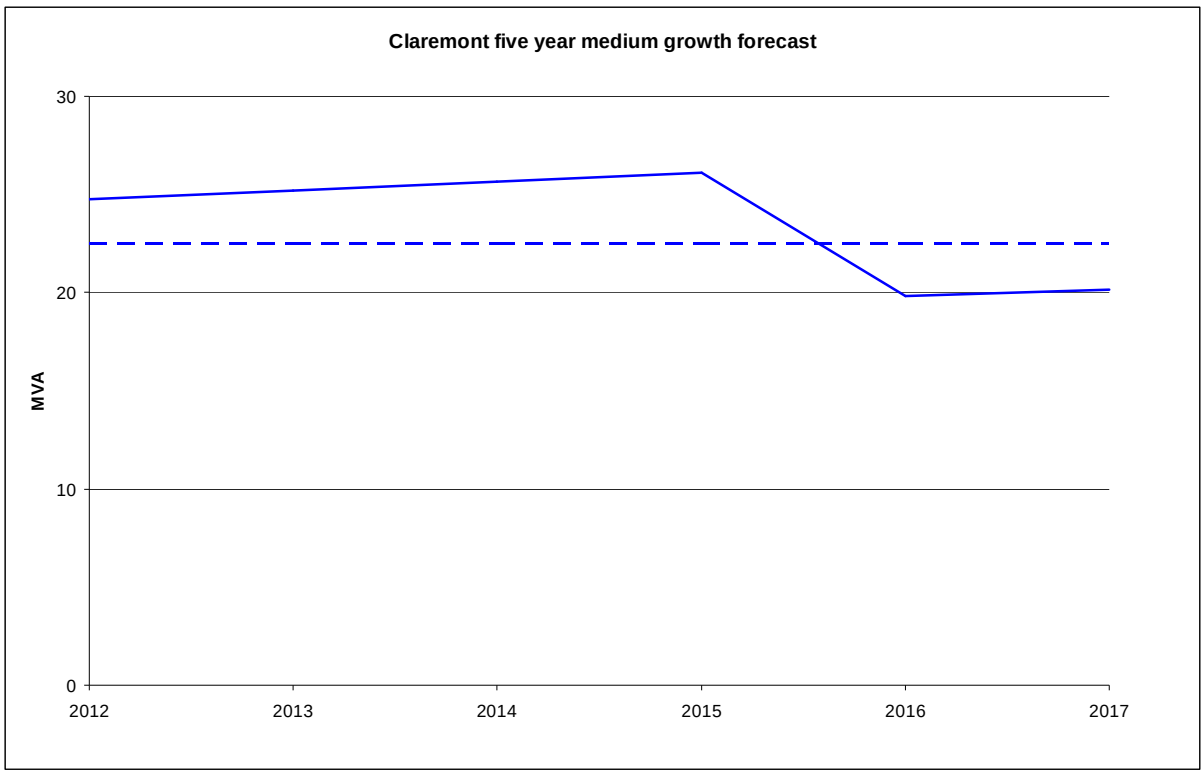


Figure 8-9 Claremont proposed five year medium growth forecast

As outlined above, Claremont load is reduced below firm capacity in 2016.

The resulting Claremont feeder loads are shown in Table 8-7

Table 8-7 Claremont substation proposed feeder forecast

Area	Feeder/s	2012 load (MVA)	2013 load (MVA)	2014 load (MVA)	2015 load (MVA)	2016 load (MVA)	2017 load (MVA)
Claremont	20181	3.2	3.2	3.3	3.3	0.8	0.8
	21085	3.7	3.8	3.8	3.9	1.5	1.5
Austin's Ferry	21089	4.1	4.2	4.3	4.3	1.7	1.7

As outlined above, feeders 21081, 21085 and 21089 are deloaded by the establishment of Austin's Ferry zone substation.

New feeder projects

Based on the medium growth forecast there are no feeder overloads within the period of study. Therefore no feeder projects have been proposed for Claremont substation.

8.3.3 Ultimate configuration

Substation

Claremont is expected to remain a two transformer substation up to 2050. As discussed in the long term plan there is the potential for the installation of 33 kV switchgear at the site, with supply taken from Bridgewater via Austin's Ferry, however this is not expected to be required in the near future.

Feeders

With Austin's Ferry to the north and mountains restricting growth to the west, it is expected that the majority of future feeders required from Claremont will be to the south and east. The establishment of Austin's Ferry will likely defer the requirement for new feeders, since existing deloaded feeders can be redirected as needed.

As noted above there are three spare circuit breakers at Claremont substation.

8.4 Chapel Street substation

Chapel Street terminal substation supplies to the northern suburbs of Hobart including Glenorchy, West Moonah, Montrose and Lenah Valley.

8.4.1 Limitations

Using the medium growth forecast, Chapel St substation load is forecast to grow from 50.3 MVA in 2012 to 54.4 MVA in 2017, which is below the substation firm capacity of 60 MVA. The five year load forecast for Chapel St substation is given in Figure 8-10.

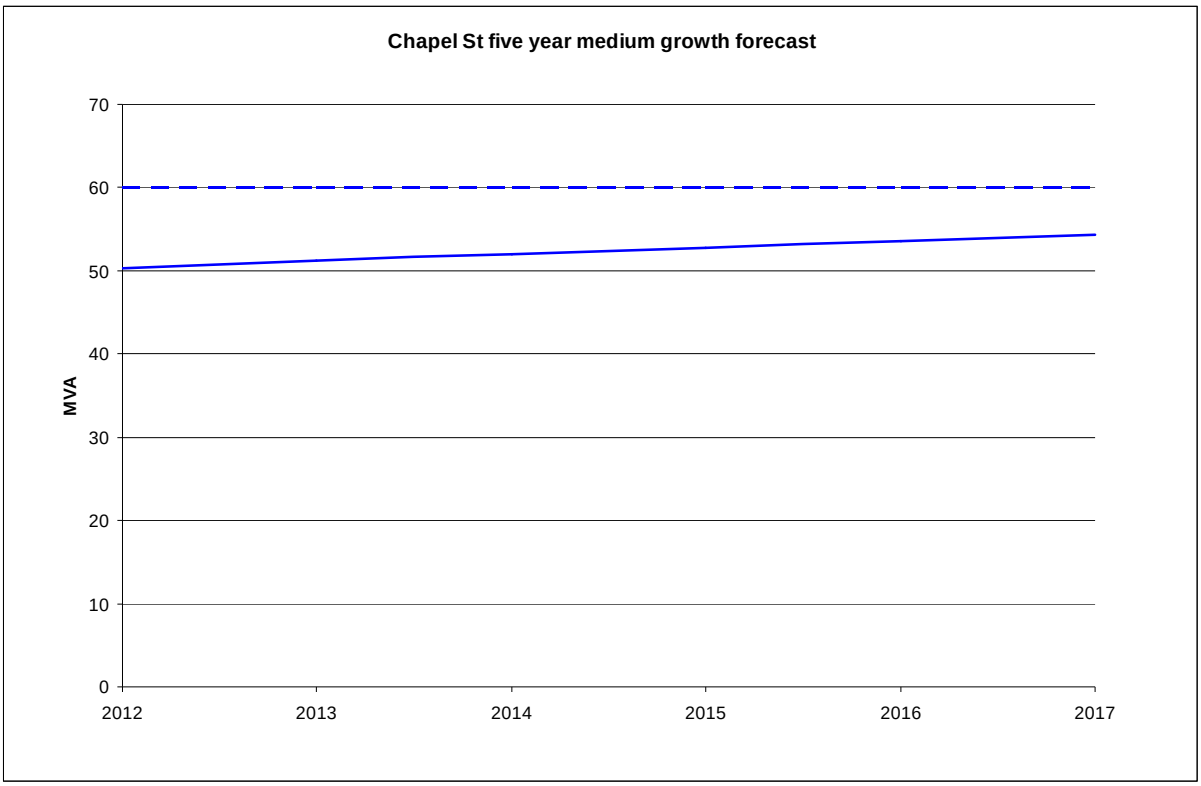


Figure 8-10 Chapel St five year medium growth forecast

The 11 kV network from Chapel Street consists of 16 distribution feeders and there are four spare feeder circuit breakers available.

North Hobart and Chapel Street terminal substations are the only two substations in the state with 110/11 kV transformers with dual secondary windings. This type of transformer is used in order to minimise the 11 kV fault levels. To accomplish the fault level reduction, the secondary windings from a transformer must not be operated in parallel. A schematic of the resulting configuration is shown in Figure 8-22 in the North Hobart section.

The Chapel Street supply area and individual feeders are shown in Figure 8-11 and Figure 8-12 below.

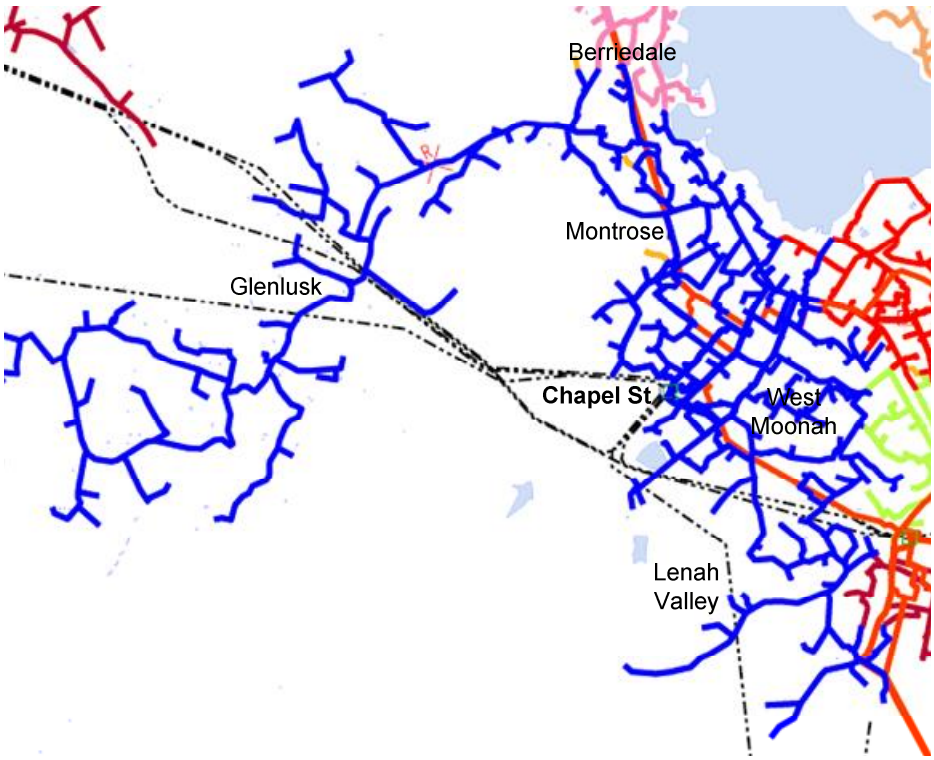


Figure 8-11 Chapel Street 11 kV supply area

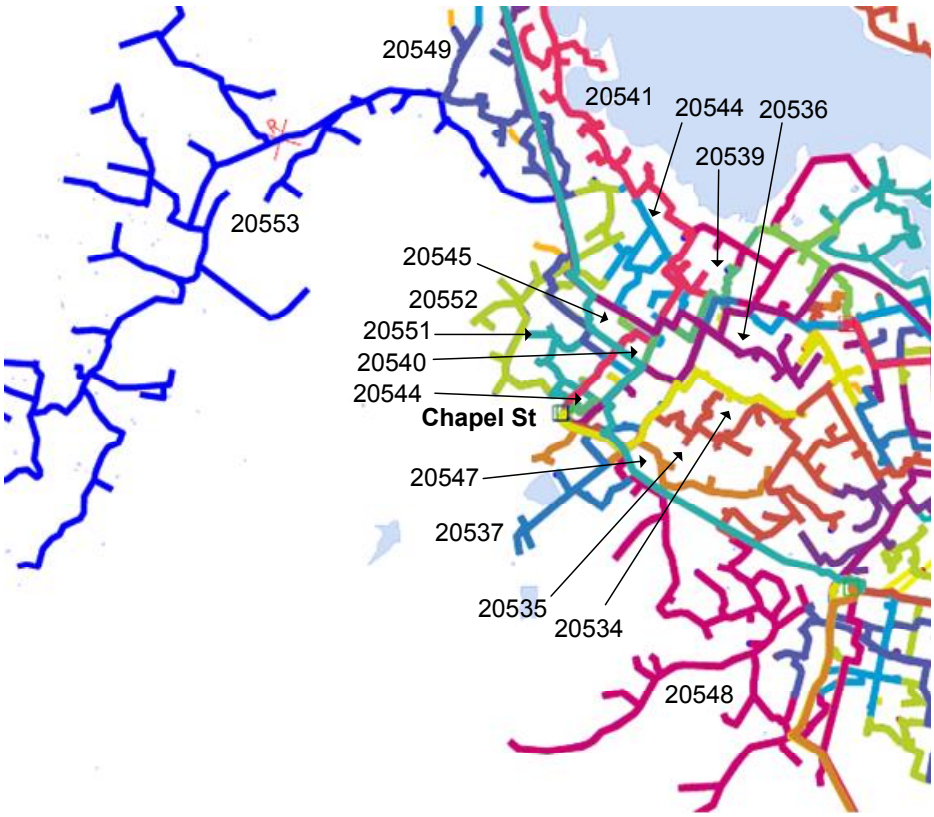


Figure 8-12 Chapel St 11 kV feeders

A five year feeder forecast has been developed by applying the substation medium growth rate to the feeder peak loads. The feeder forecast is outlined in Table 8-8.

Table 8-8 Chapel St substation feeder forecast

Feeder/s	2012 load (MVA)	2013 load (MVA)	2014 load (MVA)	2015 load (MVA)	2016 load (MVA)	2017 load (MVA)
20534	0.5	0.5	0.5	0.6	0.6	0.6
20535	5.5	5.6	5.6	5.7	5.8	5.9
20536	2.9	3.0	3.0	3.1	3.1	3.2
20537	2.9	2.9	3.0	3.0	3.1	3.1
20539	0.4	0.4	0.4	0.4	0.4	0.5
20540	3.2	3.2	3.3	3.3	3.4	3.4
20541	5.0	5.1	5.1	5.2	5.3	5.4
20544	2.9	2.9	3.0	3.0	3.1	3.1
20545	0.9	0.9	0.9	1.0	1.0	1.0
20547	6.4	6.5	6.6	6.7	6.8	6.9
20548	4.6	4.7	4.8	4.9	4.9	5.0
20549	4.0	4.1	4.2	4.2	4.3	4.4
20551	1.2	1.2	1.2	1.2	1.2	1.2
20552	5.1	5.1	5.2	5.3	5.4	5.5
20553	2.8	2.9	2.9	3.0	3.0	3.1
20554	3.2	3.2	3.3	3.3	3.4	3.4

As outlined above, there are several feeders that exceed the feeder planning rating of 5 MVA within the period of study.

The overloads on feeders 20547 and 20548 have already been recognised by Aurora and projects are scheduled to address these limitations. There are no projects scheduled to address the limitations on feeders 20535, 20541 and 20552.

The available transfer capacity from Chapel St substation to the Claremont, New Town and Derwent Park substations is outlined in Table 8-9.

Table 8-9 Chapel St substation transfer capability

Substation	Feeder	2012 transfer (MVA)	2013 transfer (MVA)	2014 transfer (MVA)	2015 transfer (MVA)	2016 transfer (MVA)	2017 transfer (MVA)
Claremont	21088	3.3	3.3	3.3	3.3	3.3	3.3
	21087	6.4	6.4	6.3	6.3	6.3	6.3
	21086	2.8	2.8	2.7	2.7	2.7	2.6
Derwent Park	17100	2.3	2.3	2.2	2.2	2.2	2.1
	17101	3.5	3.4	3.4	3.4	3.4	3.3
	17103	2.3	2.3	2.3	2.2	2.2	2.2
	17107	2.8	2.8	2.7	2.7	2.7	2.6

Substation	Feeder	2012 transfer (MVA)	2013 transfer (MVA)	2014 transfer (MVA)	2015 transfer (MVA)	2016 transfer (MVA)	2017 transfer (MVA)
New Town	16091	2.7	2.6	2.6	2.6	2.5	2.5
Total transfers	-	26.1	25.9	25.5	25.4	25.3	24.9

As outlined above, there is significant transfer capacity away from Chapel St for the period of study.

8.4.2 Proposed projects

Install capacitor banks for voltage control

As per the North Hobart proposed project in section 8.9.2, it is recommended that the installation capacitor banks be investigated in order to balance the voltages on the 11 kV buses at Chapel St.

Transfer load from New Town to Chapel St

Chapel St has the most available capacity of the substations in the northern part of the Hobart West planning area, while the surrounding substations at Derwent Park, New Town and Claremont are all approaching or exceeding firm capacity. While Claremont is expected to be addressed by the Austin's Ferry project in 2016, and Derwent Park transformers are proposed to be upgraded in 2014/15, there are no projects proposed to deload New Town.

Thus it is proposed that load transfers from New Town to Chapel St be identified and implemented as New Town load increases above firm capacity.

Transfer load from 20535 to 20534

As discussed above, feeder 20535 is forecast to exceed the 5 MVA planning rating in 2013. A simple project to deload 20535 would be to transfer load to the adjacent feeder 20534 which has a load forecast of less than 1 MVA.

DINIS load flows show that load transfer of approximately 3 MVA can be achieved in 2012 simply by opening the air-break switch C010278 and closing the link C010282. This would address the limitation of 20535 for the five year period of study.

Transfer load from 20541 to 21086, 21087 or 21088

As discussed above, feeder 20541 currently exceeds the 5 MVA planning rating. It is expected that this limitation can be addressed by load transfers to Claremont feeder 21086, 21087 or 21088 which are currently loaded at 3.9 MVA, 1.2 MVA and 1.2 MVA respectively.

Transfer load from 20552 to 20551

As discussed above, feeder 20552 currently exceeds the 5 MVA planning rating. To address this limitation it is proposed to build a 500 m tie to feeder 20551 which is currently loaded at 1.1 MVA and split 20552. These works could be deferred by initially transferring load to 20544 which is currently loaded at 3 MVA, however this would only be a temporary solution.

8.4.3 Ultimate configuration

Substation

Chapel St is expected to remain a two transformer substation up to 2050. The transformers at Chapel St were installed in 1984, which implies that they will require replacement in 2034.

Feeders

As discussed above, it is expected that feeder limitations at Chapel St up to 2017 can be addressed by load transfers between existing feeders.

It is likely that the Chapel St 11 kV network to the south and east will be significantly deloaded with the establishment of 11 kV injection at Creek Rd proposed for 2025. Therefore it is proposed that new feeders and significant feeder works to these areas be deferred where possible, with Chapel St focused on supplying future load to the north.

As noted above there are four spare feeder circuit breakers at Chapel St substation.

8.5 Derwent Park substation

Derwent Park zone substation supplies to the northern suburbs of Hobart including Derwent Park, Goodwood and Glenorchy.

8.5.1 Limitations

Using the medium growth forecast, Derwent Park substation load is forecast to grow from 22.6 MVA in 2012 to 23.8 MVA in 2017, which is below the substation firm capacity of 25 MVA (following the proposed transformer replacement in 2014/15). The five year load forecast for Derwent Park substation is given in Figure 8-13.

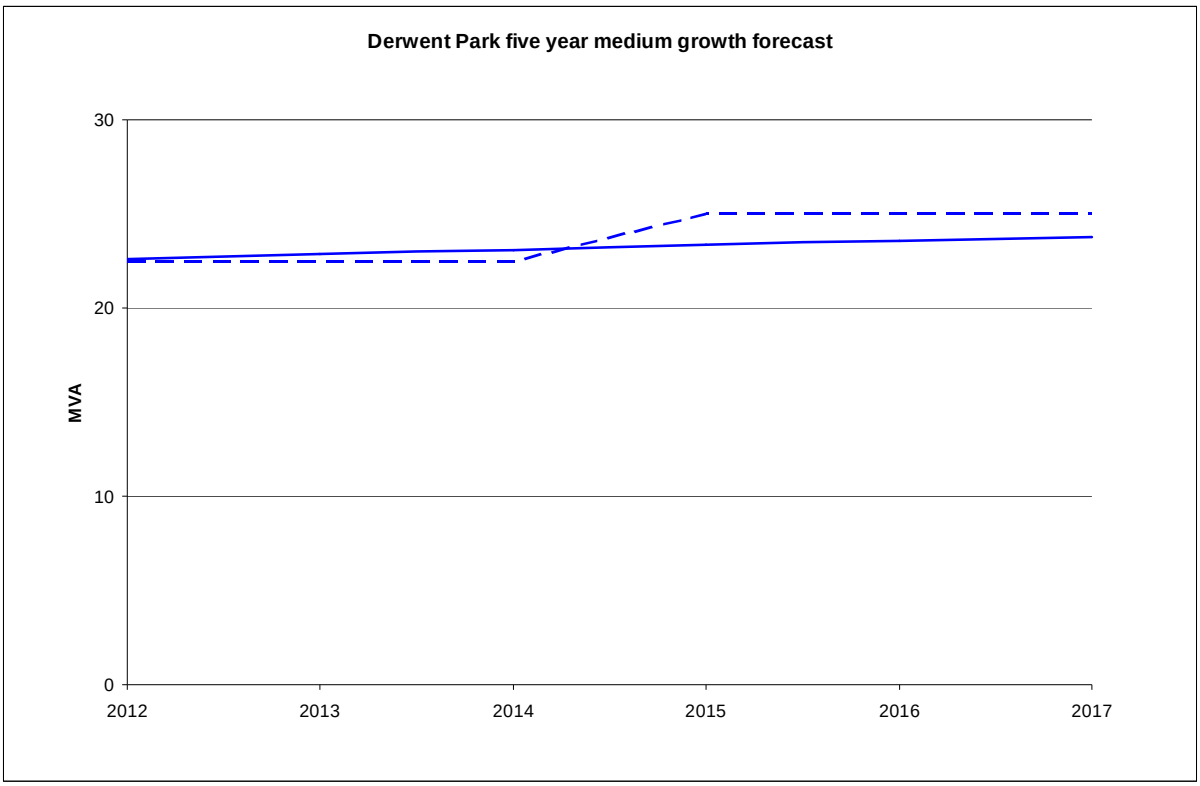


Figure 8-13 Derwent Park five year medium growth forecast

The 11 kV network from Derwent Park consists of ten distribution feeders and there are no spare feeder circuit breakers available. The Derwent Park supply area and individual feeders are shown in Figure 8-14 and Figure 8-15 below.

Figure 8-14 Derwent Park 11 kV supply area

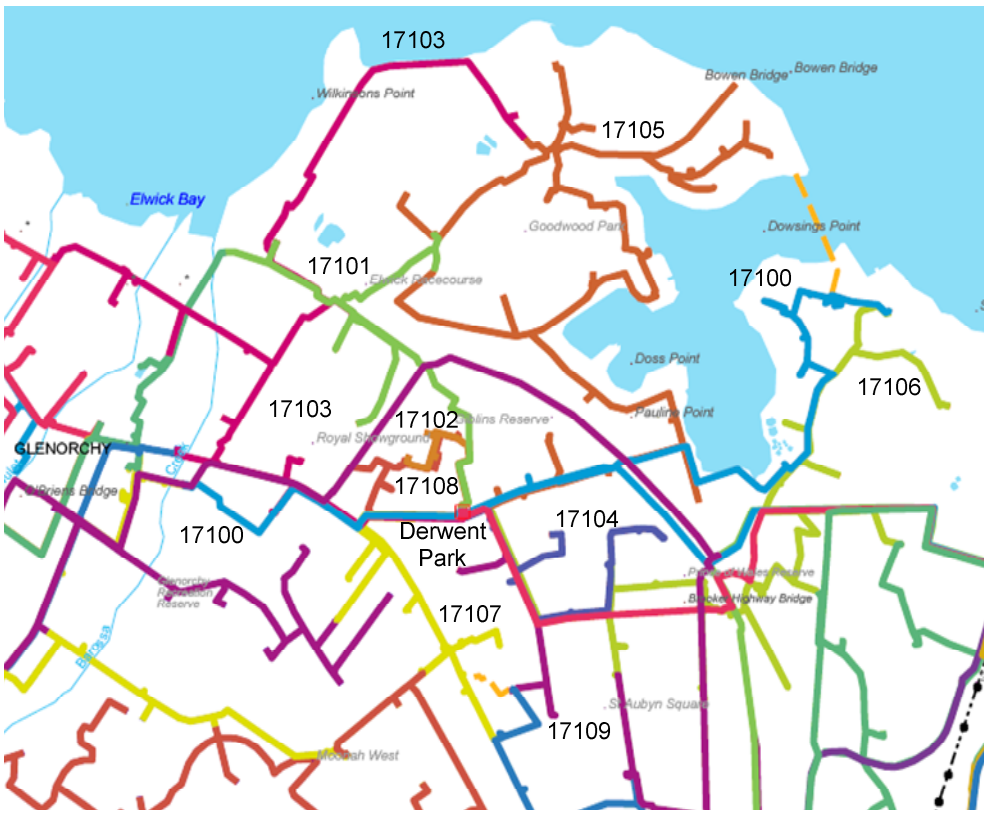


Figure 8-15 Derwent Park 11 kV feeders

A five year feeder forecast has been developed by applying the substation medium growth rate to the feeder peak loads. The feeder forecast is outlined in Table 8-10.

Table 8-10 Derwent Park substation feeder forecast

Feeder/s	2012 Load (MVA)	2013 Load (MVA)	2014 Load (MVA)	2015 Load (MVA)	2016 Load (MVA)	2017 Load (MVA)
17100	3.5	3.6	3.6	3.6	3.7	3.7
17101	2.7	2.8	2.8	2.8	2.8	2.9
17102	0.4	0.4	0.4	0.4	0.4	0.4
17103	3.4	3.4	3.5	3.5	3.5	3.6
17104	2.6	2.6	2.7	2.7	2.7	2.7
17105	3.4	3.4	3.5	3.5	3.5	3.6
17106	4.2	4.2	4.3	4.3	4.4	4.4
17107	2.8	2.8	2.9	2.9	2.9	3.0
17108	1.6	1.6	1.6	1.6	1.7	1.7
17109	1.3	1.4	1.4	1.4	1.4	1.4

As outlined above, there are no feeders that exceed the feeder planning rating of 5 MVA within the period of study.

The available transfer capacity from Derwent Park substation to the Chapel St and New Town substations is outlined in Table 8-11.

Table 8-11 Derwent Park substation transfer capability

Substation	Feeder	2012 Transfer (MVA)	2013 Transfer (MVA)	2014 Transfer (MVA)	2015 Transfer (MVA)	2016 Transfer (MVA)	2017 Transfer (MVA)
New Town	16091	2.7	2.6	2.6	2.6	2.5	2.5
	16092	3.7	3.6	3.6	3.6	3.6	3.6
	16093	0.0	0.0	0.0	0.0	0.0	0.0
	16094	3.2	3.2	3.1	3.1	3.0	3.0
Chapel St	20536	2.8	2.7	2.7	2.6	2.6	2.5
	20537	2.7	2.7	2.7	2.6	2.6	2.5
	20539	5.4	5.3	5.3	5.3	5.3	5.3
	20541	0.0	0.0	0.0	0.0	0.0	0.0
	20554	2.6	2.6	2.5	2.5	2.4	2.4
Total transfers	-	23.1	22.7	22.5	22.3	22.0	21.8

As outlined above, there is significant transfer capacity away from Derwent Park for the period of study.

8.5.2 Proposed projects

No projects are proposed in the five year plan for the Derwent Park supply area.

8.5.3 Ultimate configuration

Substation

The existing 33/11 kV transformers are proposed to be replaced with 25 MVA units in 2014/15. The installation of a third transformer and 33 kV switchgear has been proposed in the long term plan for Derwent Park zone substation in 2031.

Feeders

There are no feeder circuit breakers available at Derwent Park, however the existing Derwent Park feeders are relatively lightly loaded and new feeders are not expected to be required in the near future. The highest loaded feeders are toward the north and east, and it is likely that existing feeders 17102 and 17108 can be extended to deload these feeders initially.

The installation of a third transformer, as proposed in the long term plan, will make several feeder circuit breakers available in 2031.

8.6 New Town substation

New Town zone substation supplies to the northern suburbs of Hobart including Moonah, New Town, Lutana and Cornelian Bay.

8.6.1 Limitations

Using the medium growth forecast, New Town substation load is forecast to grow from 21.7 MVA in 2012 to 22.8 MVA in 2017, exceeding the substation firm capacity of 22.5 MVA in 2016. The five year load forecast for New Town substation is given in Figure 8-16.

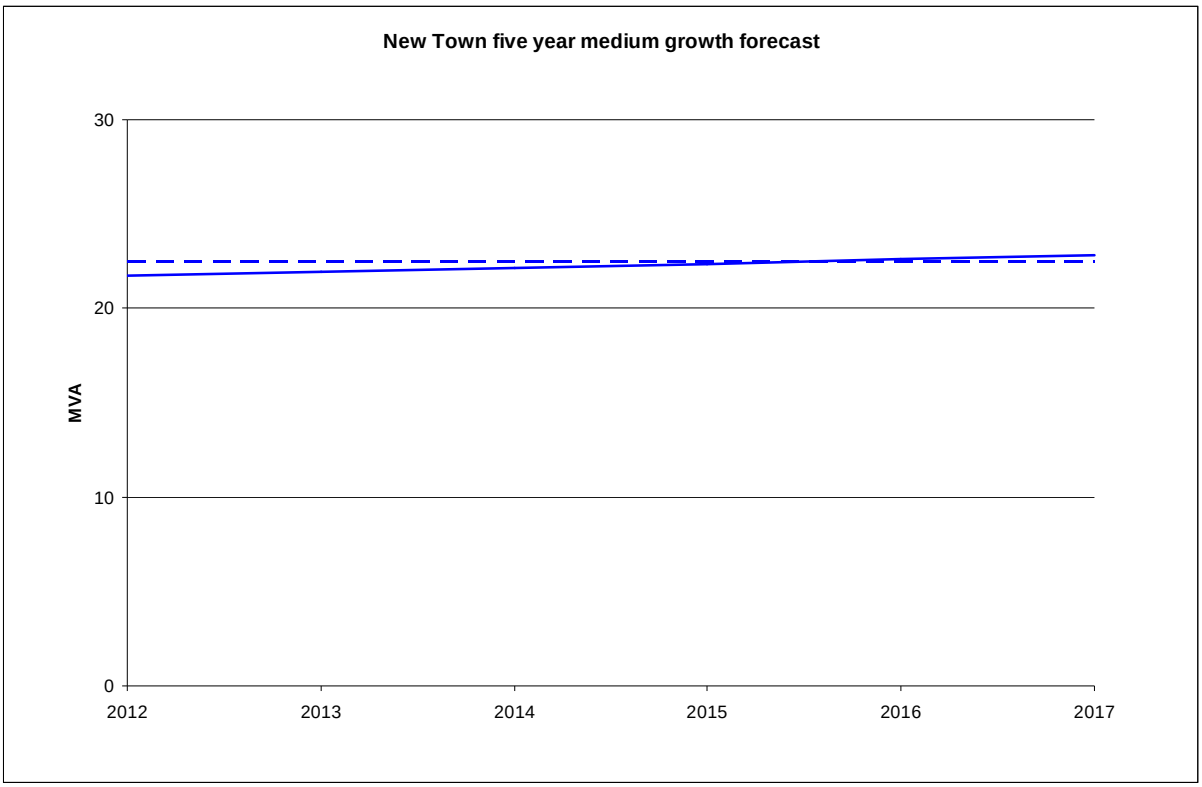


Figure 8-16 New Town five year medium growth forecast

The 11 kV network from New Town consists of seven distribution feeders and there is a single spare feeder circuit breaker available. The New Town supply area and individual feeders are shown in Figure 8-17 and Figure 8-18 below.

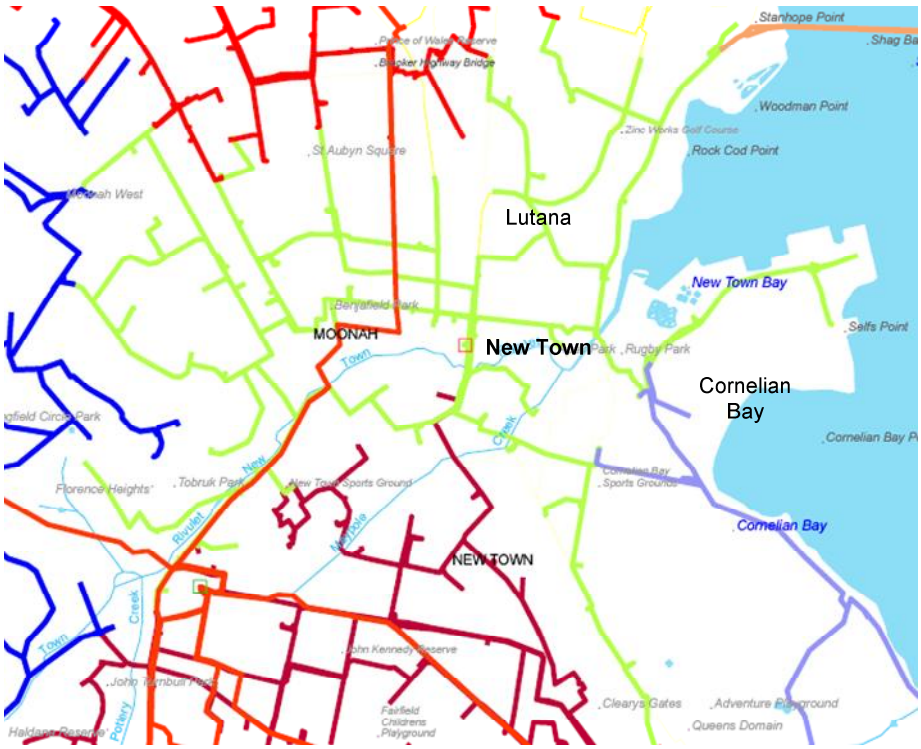


Figure 8-17 New Town 11 kV supply area

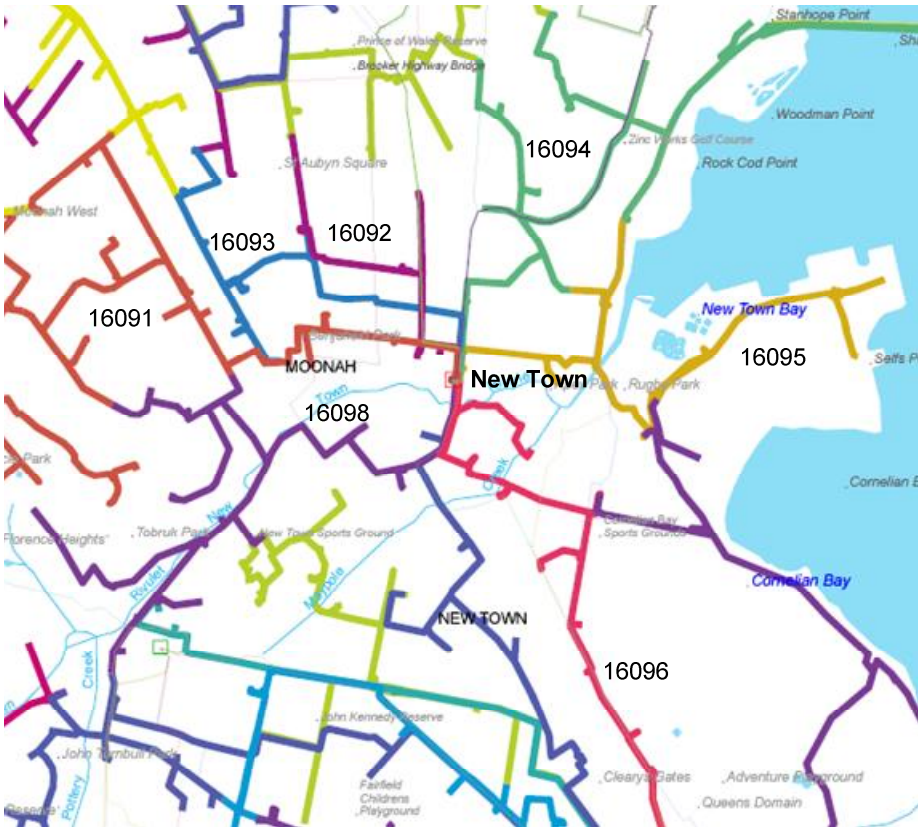


Figure 8-18 New Town 11 kV feeders

A five year feeder forecast has been developed by applying the substation medium growth rate to the feeder peak loads. The feeder forecast is outlined in Table 8-12.

Table 8-12 New Town substation feeder forecast

Feeder/s	2012 Load (MVA)	2013 Load (MVA)	2014 Load (MVA)	2015 Load (MVA)	2016 Load (MVA)	2017 Load (MVA)
16091	4.0	4.1	4.1	4.1	4.2	4.2
16092	1.7	1.8	1.8	1.8	1.8	1.8
16093	3.4	3.5	3.5	3.5	3.6	3.6
16094	4.2	4.3	4.3	4.4	4.4	4.5
16095	2.3	2.3	2.3	2.4	2.4	2.4
16096	4.1	4.2	4.2	4.3	4.3	4.4
16097	0.0	0.0	0.0	0.0	0.0	0.0
16098	3.4	3.4	3.5	3.5	3.5	3.6

As outlined above, there are no feeders that exceed the feeder planning rating of 5 MVA within the period of study.

The available transfer capacity from New Town substation to the Derwent Park, Chapel St and North Hobart substations is outlined in Table 8-13.

Table 8-13 New Town substation transfer capability

Substation	Feeder	2012 transfer (MVA)	2013 transfer (MVA)	2014 transfer (MVA)	2015 transfer (MVA)	2016 transfer (MVA)	2017 transfer (MVA)
North Hobart	18135A	4.1	4.1	4.1	4.1	4.1	4.1
	18145A	3.3	3.3	3.3	3.3	3.3	3.3
Chapel St	20534	4.7	4.7	4.7	4.7	4.6	4.6
Derwent Park	17106	3.1	3.1	3.0	3.0	3.0	3.0
	17107	1.2	1.1	1.1	1.0	1.0	1.0
Geilston Bay	26164	3.7	3.7	3.6	3.6	3.5	3.4
Total transfers	-	20.1	20.0	19.8	19.7	19.5	19.4

As outlined above, there is sufficient transfer capacity to reduce the load at New Town below firm capacity for the period of study.

8.6.2 Proposed projects

No projects are proposed in the five year plan for the New Town supply area.

8.6.3 Ultimate configuration

Substation

New Town is expected to remain a two transformer zone substation without 33 kV switchgear for the scope of the study. There is the potential to establish a third transformer and switchgear at New Town instead of Derwent Park, as proposed in the long term plan for 2031. However considering that 11 kV injection is likely to occur at Creek Rd prior to 2031, Derwent Park is considered a superior location for subsequent 11 kV injection.

Feeders

There is only a single spare feeder circuit breaker available at New Town, however the existing feeders are well within planning ratings and new feeders are not expected to be required in the scope of the five year plan.

The installation of a new feeder from the final remaining circuit breaker is expected to be sufficient for New Town up to the proposed establishment of 11 kV injection at Creek Rd in 2025.

Due to the lack of spare CBs at North Hobart, support from New Town may be required prior 2025 to deload the North Hobart northern 11 kV feeders. Derwent Park could then support New Town from the north - the enlarged Derwent Park supply area would tie-in with the proposal to establish a third transformer in 2031.

Alternatively, the Creek Rd 11 kV injection could be brought forward to defer additional feeder works, however the cost of bringing forward such a large project is expected to outweigh the feeder costs.

8.7 Creek Rd substation

Creek Rd substation is the 33 kV injection point which supplies the Claremont, West Hobart and Sandy Bay zone substations.

8.7.1 Limitations

Using the medium growth forecast, Creek Rd substation load is forecast to grow from 115.3 MVA in 2012 to 125.4 MVA in 2017, exceeding the substation firm capacity of 120 MVA in 2015. The five year load forecast for Creek Rd substation is given in Figure 8-19.

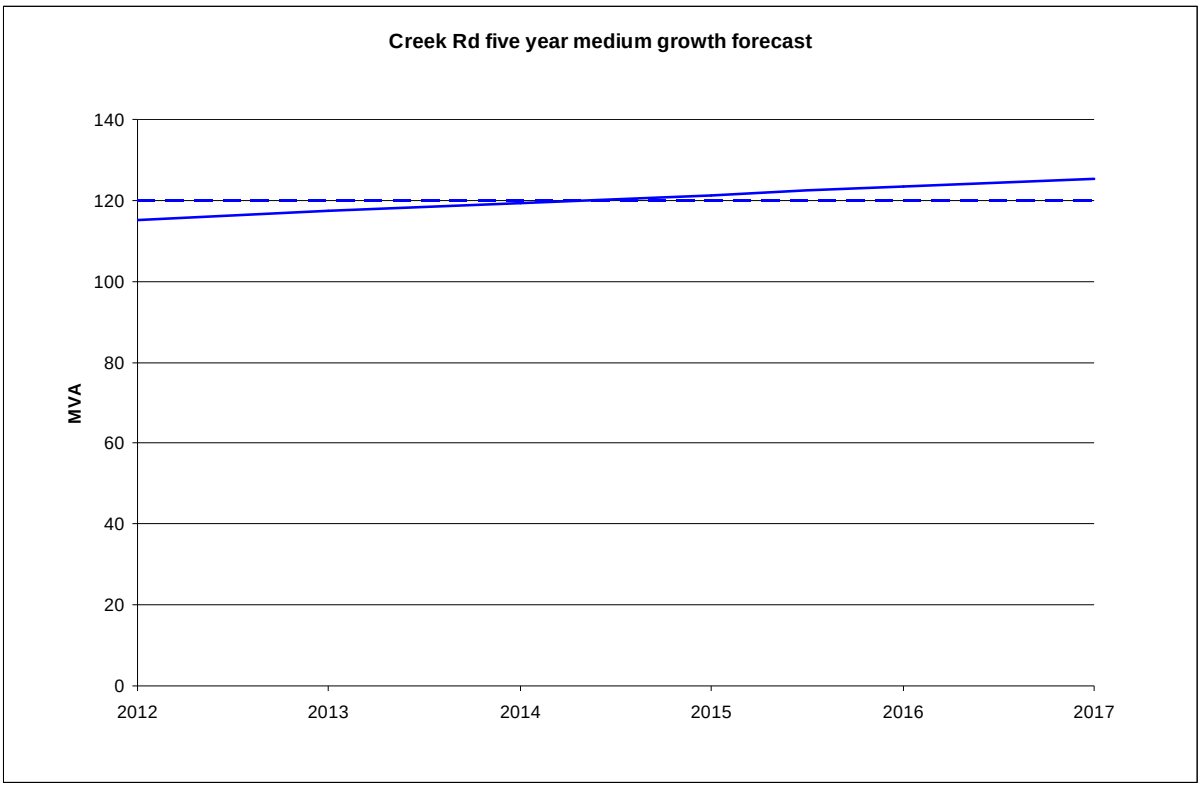


Figure 8-19 Creek Rd five year medium growth forecast

The 33 kV network from Creek Rd consists of eight 33 kV feeders and there is a single spare feeder circuit breaker available, as well as space for the installation of four additional circuit breakers.

Table 8-14 below shows the ratings of the 33 kV feeders from Creek Rd to the various zone substations, as well as the ratings of the zone substation transformer supplied by that feeder. The table also shows an approximate load on the feeder for the loss of an adjacent feeder in 2017.

Table 8-14 Creek Rd 33 kV feeder loads and ratings

Substation	Feeder no.	Transformer Rating	SD Rating (MVA)	WD Rating (MVA)	SD N-1 Load 2017 (MVA)	WD N-1 Load 2017 (MVA)
Claremont	10007	22.5	22.1	28.2	10	17
	10026	22.5	22.1	28.2	10	17
West Hobart	10001	30	22.1	28.2	14	26
	10002	30	22.1	28.2	14	26
	10003	30	22.1	28.2	14	26
Sandy Bay	10008	30	22.1	28.2	10	23
	10022	30	22.1	28.2	10	23
	10006	30	22.1	28.2	10	23

As outlined above, all of the 33 kV feeders are forecast to be loaded within their ratings beyond 2017 for an N-1 condition. The table also shows that the feeders to West Hobart and Sandy Bay limit the N-1 capacity of the substation, since they are rated lower than the transformers which they supply.

8.7.2 Proposed projects

Transfer load from Creek Rd to Risdon

It is proposed that load be transferred permanently from Creek Rd to Risdon in order to defer the capacity limitation at Creek Rd. The simplest way of achieving this would be to implement 11 kV load transfers from West Hobart to East Hobart, since East Hobart is currently very lightly loaded compared with West Hobart. This project is discussed in more detail in the East Hobart section.

Uprate Sandy Bay and West Hobart 33 kV feeders

As outlined in Table 8-14, the 33 kV feeders from Creek Rd to Sandy Bay and West Hobart have ratings lower than the transformers which they supply. As a result, the N-1 ratings of Sandy Bay and West Hobart substations are limited by the 33 kV feeder ratings to 56.4 MVA. These feeders are primarily overhead 19/.128 AA and 19/.101 Cu conductor, and depending on clearances with sub-circuits are expected to be able to carry in excess of 30 MVA.

Therefore it is proposed that the feeders be uprated to at least 30 MVA. The works may be deferred until the load at Sandy Bay or West Hobart is forecast to increase such that the feeder load exceeds 28.2 MVA during a feeder contingency.

8.7.3 Ultimate configuration

Substation

Creek Rd is expected to remain a three transformer substation for the scope of the study. A fourth transformer at Creek Rd would likely cause excessive fault levels, or a split 33 kV bus resulting in operational difficulties.

Replacing the existing transformers with larger unit may be an option at Creek Rd, however the transformers are not expected to reach end of life until 2051 and the long term plan proposes the establishment of transfer capacity with adjacent 33 kV injection points as a more cost effective alternative prior to this time.

Two new feeders have been proposed from Creek Rd in the long term plan to supply a new West Moonah zone substation in 2046. A new feeder circuit breaker would be required at Creek Rd at this time.

The long term plan also proposes the establishment of 11 kV injection at Creek Rd in 2025 in the form of two 110/11 kV 60 MVA transformers and 11 kV switchgear.

Feeders

The only 33 kV feeders proposed for Creek Rd are the two new circuits to a new West Moonah zone substation in 2046.

Following the establishment of 11 kV injection at Creek Rd (proposed for 2025), new 11 kV feeder tails would be required in all directions, particularly to the northwest and south east to deload Chapel St and North Hobart substations respectively.

8.8 Risdon substation

Risdon substation is the 33 kV injection point which supplies the Derwent Park, New Town and East Hobart zone substations.

8.8.1 Limitations

Using the medium growth forecast, Risdon substation load is forecast to grow from 72 MVA in 2012 to 76 MVA in 2017, well below the substation firm capacity of 100 MVA. The five year load forecast for Risdon substation is given in Figure 8-20.

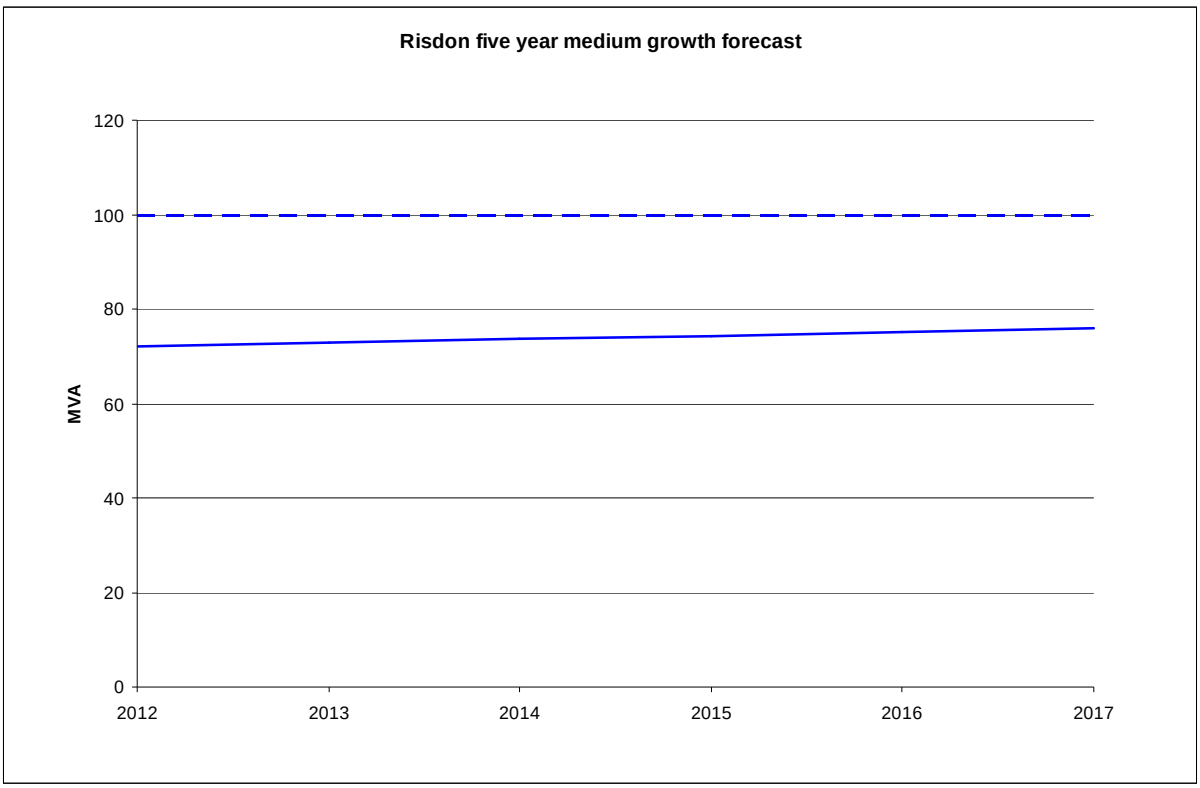


Figure 8-20 Risdon five year medium growth forecast

The 33 kV network from Risdon consists of seven 33 kV feeders and there are no spare feeder circuit breakers available.

Table 8-15 below shows the ratings of the 33 kV feeders from Risdon to the various zone substations, as well as the ratings of the zone substation transformer supplied by that feeder. The table also shows an approximate load on the feeder for the loss of an adjacent feeder in 2017.

Table 8-15 Risdon 33 kV feeder loads and ratings

Substation	Feeder no.	Transformer rating	SD rating (MVA)	WD rating (MVA)	SD N-1 load 2017 (MVA)	WD N-1 load 2017 (MVA)
Derwent Park	11021	22.5	22.1	28.2	16	24
	11025	22.5	22.1	28.2	16	24
New Town	11023	22.5	36.0	36.0	13	23
	11027	22.5	22.1	28.2	13	23
East Hobart	11004	30	22.1	28.2	11	15
	11005	30	22.1	28.2	11	15
	11006	30	22.1	28.2	11	15

As outlined above, all of the 33 kV feeders are forecast to be loaded within their ratings beyond 2017 for an N-1 condition. The table also shows that the feeders to East Hobart limit the N-1 capacity of the substation, since they are rated lower than the transformers which they supply.

8.8.2 Proposed projects

Transfer load from Creek Rd to Risdon

As discussed in the Creek Rd section, it is proposed that load be transferred permanently from Creek Rd to Risdon in order to defer the capacity limitation at Creek Rd. This project is discussed in more detail in the East Hobart section.

Uprate East Hobart 33 kV feeders

As outlined in Table 8-15, the 33 kV feeders from Risdon to East Hobart have ratings lower than the transformers which they supply. As a result, the N-1 rating of East Hobart substation is limited by the 33 kV feeder ratings to 56.4 MVA. These feeders are primarily overhead 19/.128 AA and 19/.101 Cu conductor, and depending on clearances with sub-circuits are expected to be able to carry in excess of 30 MVA.

Therefore it is proposed that the feeders be uprated to at least 30 MVA. The works may be deferred until the load at East Hobart is forecast to increase such that the feeder load exceeds 28.2 MVA during a feeder contingency.

8.8.3 Ultimate configuration

Substation

Risdon is expected to remain a three transformer substation for the scope of the study. A fourth transformer at Risdon would likely cause excessive fault levels, or a split 33 kV bus resulting in operational difficulties.

Replacing the existing transformers with larger units may be an option at Risdon, however the transformers are not expected to reach end of life until 2056 and the long term plan proposes the establishment of transfer capacity with adjacent 33 kV injection points as a more cost effective alternative prior to this time.

A single new 33 kV feeder has been proposed from Risdon in the long term plan to supply a new transformer at Derwent Park in 2031. A new feeder circuit breaker would be required at Risdon at this time.

Feeders

The only new 33 kV feeder proposed for Risdon is the new circuit to Derwent Park zone substation in 2031.

8.9 North Hobart substation

North Hobart terminal substation supplies to the Hobart CBD as well as north to North Hobart, New Town and Mt Stuart.

8.9.1 Limitations

Using the medium growth forecast, North Hobart substation load is forecast to grow from 58 MVA in 2012 to 63 MVA in 2017, exceeding the substation firm capacity of 60 MVA in 2014. The five year load forecast for North Hobart substation is given in Figure 8-21.

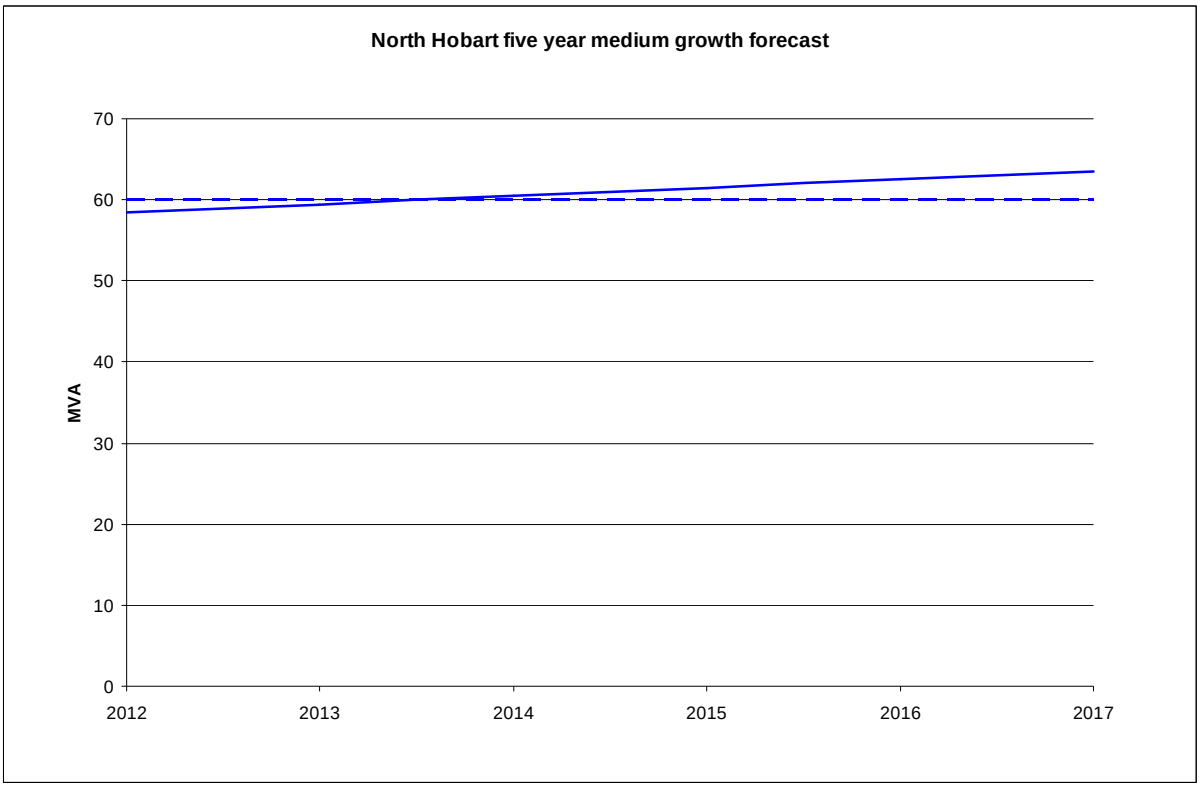


Figure 8-21 North Hobart five year medium growth forecast

The 11 kV network from North Hobart consists of 21 distribution feeders and there are no spare feeder circuit breakers available, although there is a single leg of a single circuit breaker available for a future feeder. The existing feeder circuit breakers already supply two feeders per breaker.

North Hobart feeders 18132B and 18133A are dedicated to supplying the Royal Hobart Hospital and associated loads.

North Hobart and Chapel St terminal substations are the only two substations in the state with 110/11 kV transformers with dual secondary windings. This type of transformer is used in order to minimise the 11 kV fault levels. To accomplish the fault level reduction, the secondary windings from a transformer must not be operated in parallel. A schematic of the resulting configuration is shown in Figure 8-21.

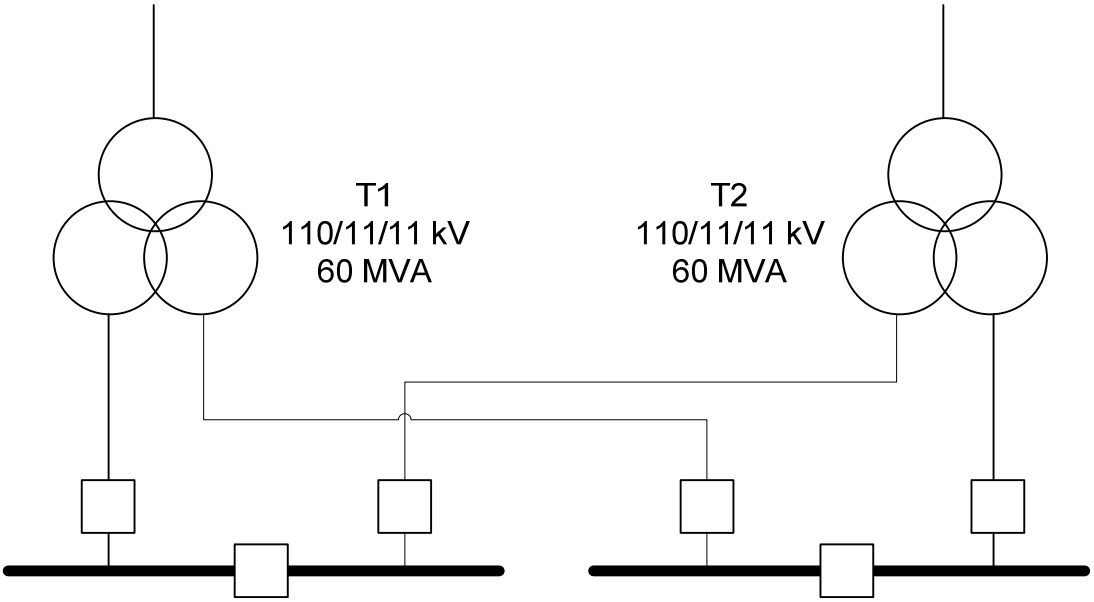


Figure 8-22 North Hobart dual secondary transformer schematic

Under the above configuration it is impossible to control the voltage on the isolated buses independently, as the tap-changers are installed on the transformer HV winding so tap change operations affect both buses. This issue is currently managed by balancing the load on the isolated bus sections as accurately as possible, with Aurora investing significant capital in feeder projects to enable load to be shifted between the buses.

The North Hobart supply area is shown in Figure 8-23. The individual feeders are shown in Figure 8-24 and Figure 8-25 for the northern and southern feeders respectively.

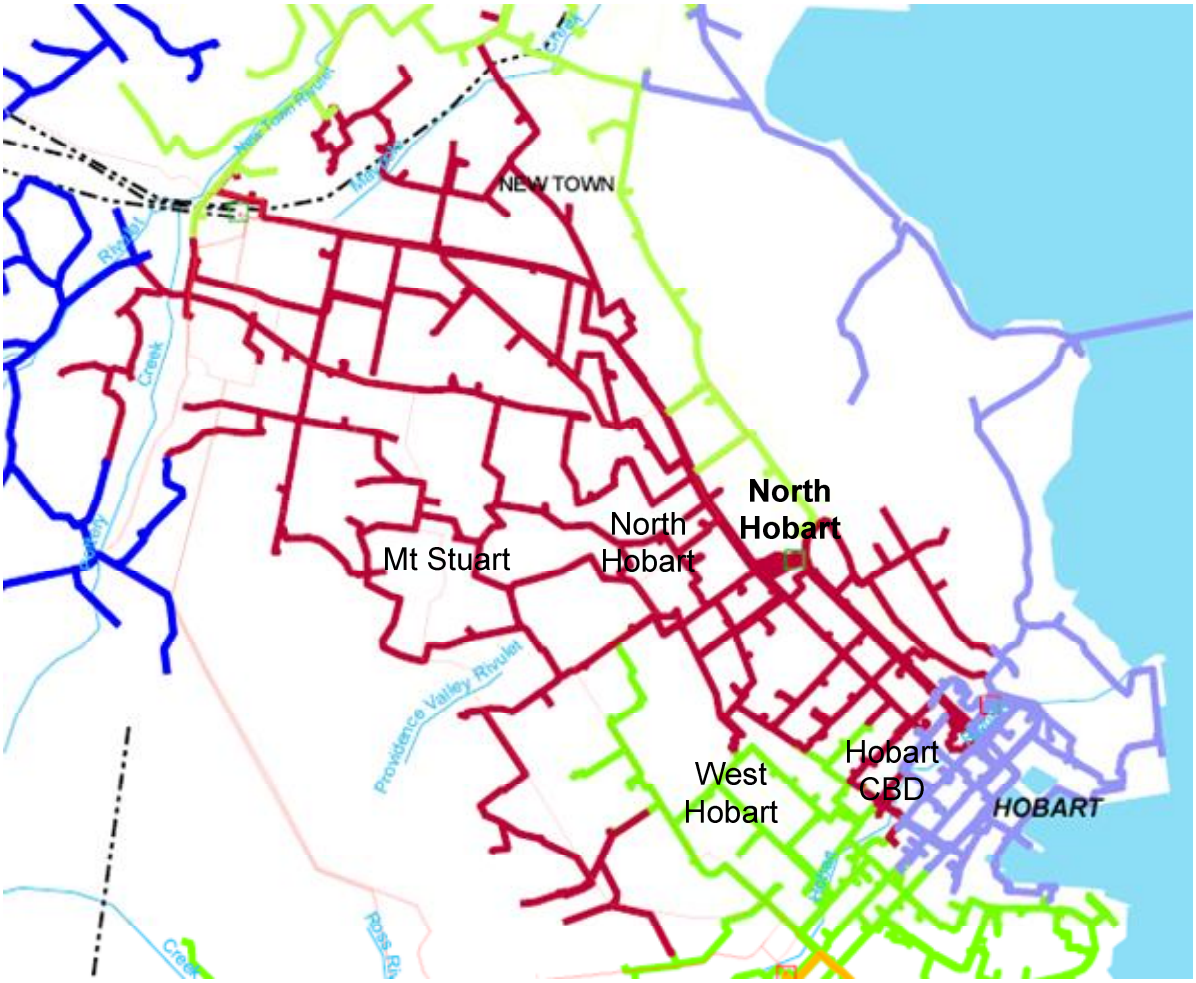


Figure 8-23 North Hobart 11 kV supply area

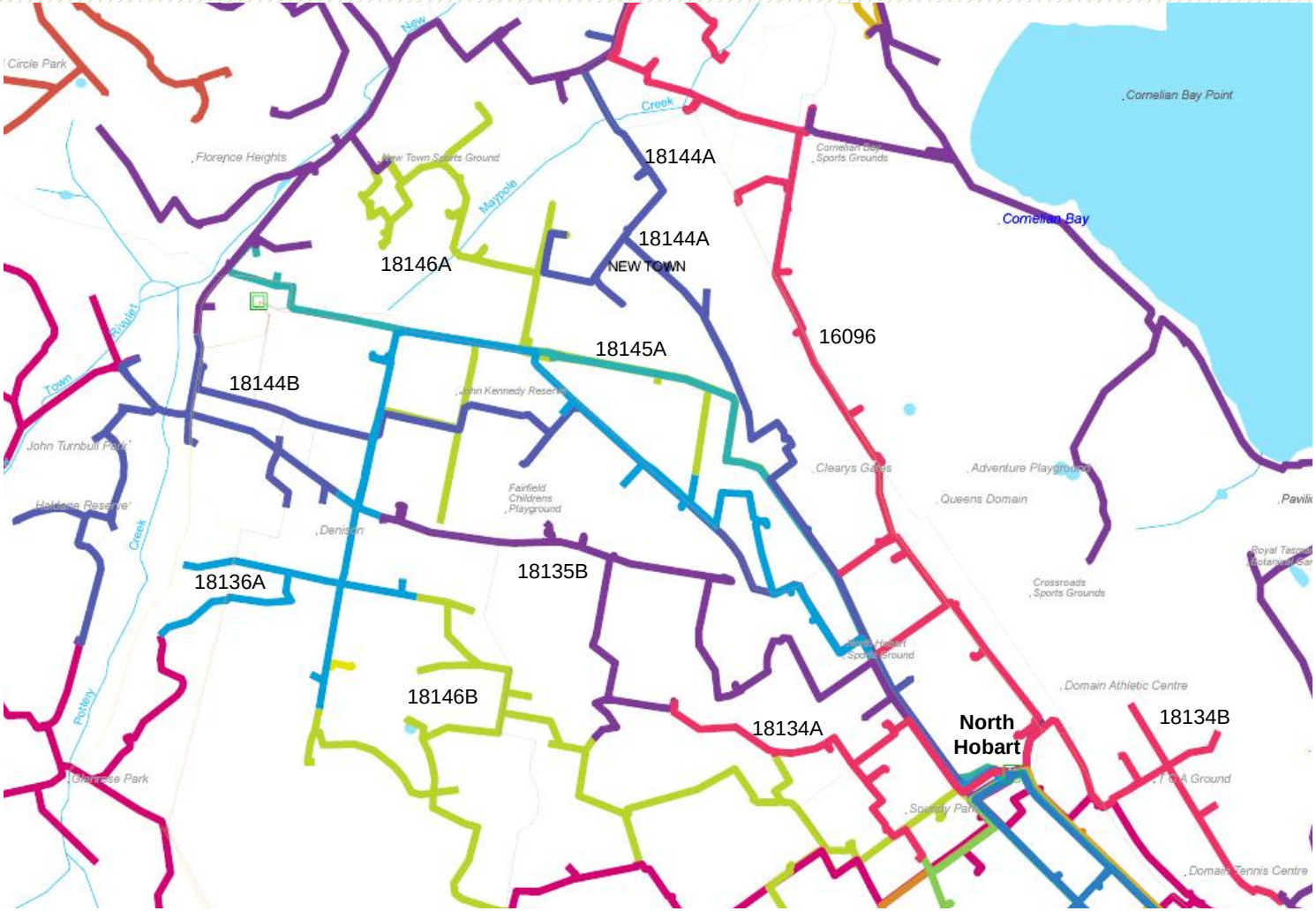


Figure 8-24 North Hobart northern 11 kV feeders

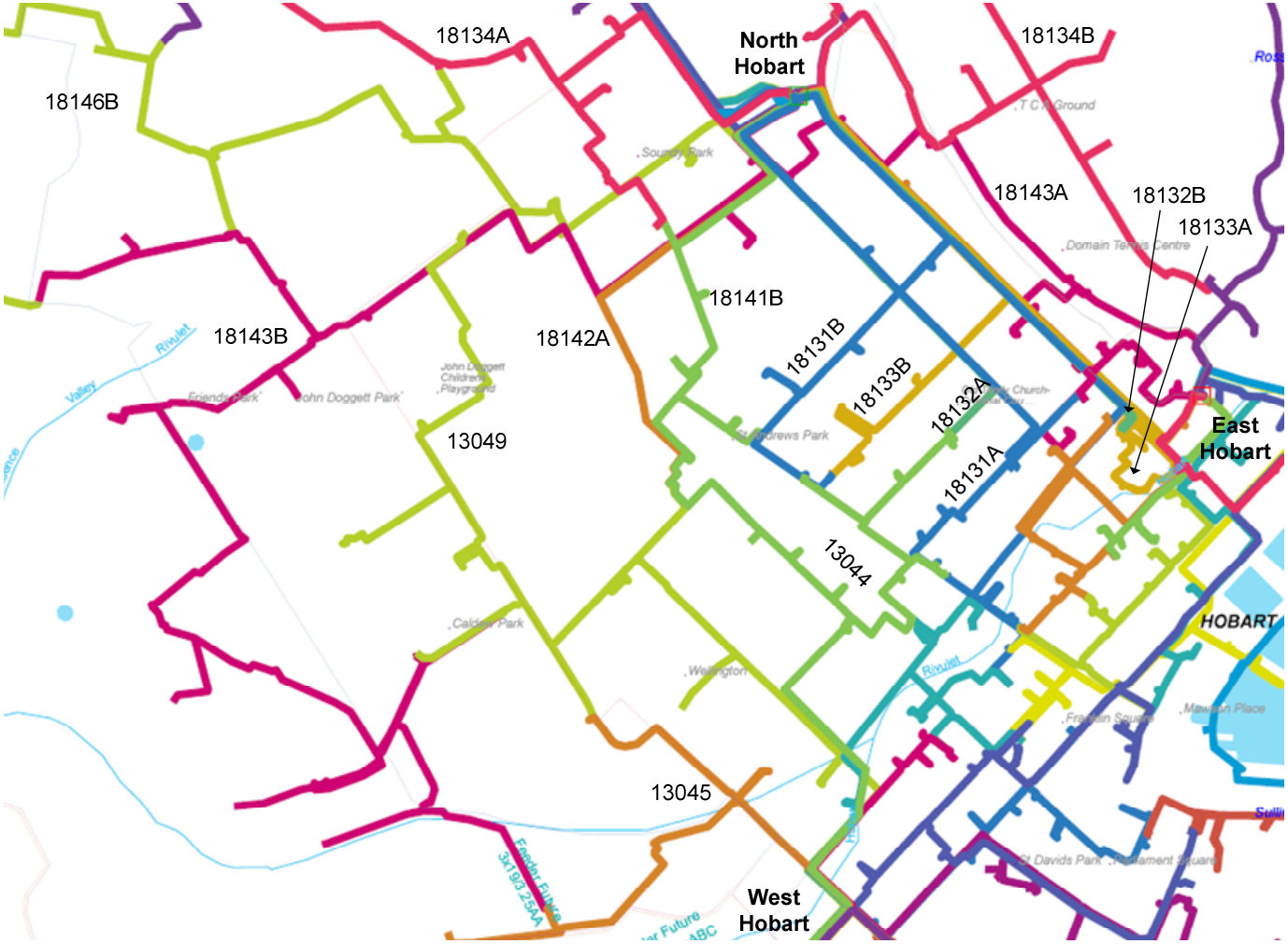


Figure 8-25 North Hobart southern 11 kV feeders

A five year feeder forecast has been developed by applying the substation medium growth rate to the feeder peak loads. The feeder forecast is outlined in Table 8-16.

Table 8-16 North Hobart substation feeder forecast

Feeder/s	2012 load (MVA)	2013 load (MVA)	2014 load (MVA)	2015 load (MVA)	2016 load (MVA)	2017 load (MVA)
18131A	3.7	3.8	3.8	3.9	4.0	4.0
18131B	5.7	5.8	5.9	6.0	6.1	6.2
18132A	0.5	0.5	0.5	0.5	0.5	0.5
18132B	3.1	3.2	3.3	3.4	3.5	3.6
18133A	2.8	2.9	3.0	3.1	3.1	3.2
18133B	1.5	1.6	1.6	1.6	1.6	1.7
18134A	2.5	2.6	2.6	2.7	2.7	2.7
18134B	2.0	2.0	2.1	2.1	2.2	2.2
18135A	0.1	0.1	0.1	0.1	0.1	0.1
18135B	4.2	4.2	4.3	4.4	4.4	4.5
18136A	4.5	4.6	4.7	4.7	4.8	4.9
18136B	0.0	0.0	0.0	0.0	0.0	0.0
18141A	0.0	0.0	0.0	0.0	0.0	0.0
18141B	1.8	1.9	1.9	2.0	2.0	2.1
18142A	0.7	0.7	0.8	0.8	0.8	0.8
18142B	0.8	0.8	0.8	0.8	0.9	0.9
18143A	2.9	3.0	3.0	3.1	3.1	3.2
18143B	5.0	5.1	5.2	5.3	5.4	5.4
18144A	3.5	3.5	3.6	3.6	3.7	3.8
18144B	3.6	3.7	3.7	3.8	3.9	3.9
18145A	1.0	1.0	1.0	1.0	1.0	1.1
18145B	0.0	0.0	0.0	0.0	0.0	0.0
18146A	4.3	4.4	4.5	4.6	4.6	4.7
18146B	4.2	4.3	4.3	4.4	4.5	4.6

As outlined above, there are several feeders that currently exceed the feeder planning rating of 5 MVA. It is expected that the limitation on 18143B will be addressed by the Aurora project to establish two new feeders from West Hobart zone substation to the west side of the CBD.

No projects have been proposed by Aurora to address the limitation on 18131B.

The available transfer capacity from North Hobart substation to the New Town, Chapel St, East Hobart and West Hobart substations is outlined in Table 8-17.

Table 8-17 North Hobart substation transfer capability

Substation	Feeder	2012 transfer (MVA)	2013 transfer (MVA)	2014 transfer (MVA)	2015 transfer (MVA)	2016 transfer (MVA)	2017 transfer (MVA)
New Town	16096	0.1	0.1	0.1	0.1	0.1	0.1
	16097	3.5	3.6	3.6	3.6	3.7	3.7
	16098	3.0	3.0	2.9	2.9	2.9	2.8
Chapel St	20548	0.2	0.1	0.0	0.0	0.0	0.0
East Hobart	14060	1.7	1.7	1.6	1.6	1.6	1.5
	14061	0.1	0.1	0.1	0.0	0.0	0.0
	14063	3.0	3.1	3.1	3.1	3.2	3.2
	14066	3.9	3.9	3.9	3.8	3.8	3.8
	14069	1.5	1.4	1.4	1.4	1.3	1.3
	14070	1.7	1.7	1.7	1.6	1.6	1.5
West Hobart	13044	3.4	3.4	3.3	3.2	3.2	3.1
	13048	3.5	3.4	3.4	3.3	3.3	3.2
	13049	3.4	3.3	3.3	3.2	3.2	3.1
Total transfers	**-**	**29.0**	**28.8**	**28.4**	**27.8**	**27.9**	**27.3**

As outlined above, there is sufficient transfer capacity to reduce the load at North Hobart below firm capacity for the period of study.

8.9.2 Proposed projects

Install capacitor banks for voltage control

As discussed above, the split secondary windings of the North Hobart 110/11/11 kV transformers result in difficulties in controlling the 11 kV bus voltages, with voltages currently controlled by load transfers between the isolated bus sections.

A more flexible method of voltage control would be to use capacitor banks to trim the voltages between the isolated buses. For example, if bus 1 is loaded more heavily than bus 2 resulting in a voltage imbalance between the two, capacitors on bus 1 would be switched in to increase the bus voltage without affecting the voltage on bus 2. Alternatively capacitors on bus 2 could be switched out and the transformer taps raised to achieve the same result.

This would require that the existing AVR (Automatic Voltage Regulation) functionality at North Hobart be modified to include capacitor switching.

The three-phase fault level at North Hobart is relatively low at approximately 100 MVA. Assuming an AVR bandwidth of 2.5% the maximum capacitor step size would be approximately 2.5 MVAr, however finer voltage control could be achieved with smaller step sizes.

Due to the lack of spare circuit breakers at North Hobart, consideration may be given to the installation of RMUs from the circuit breaker legs currently supplying the station transformers, thus supplying a feeder, station transformer and capacitor bank from a single circuit breaker. The CB rating of 800 A is expected to be sufficient to supply up to 10 MVAr of capacitance (although cable sizing may be an issue) as well as the 7.5 MVA feeder emergency rating. A schematic diagram of this arrangement is given in Figure 8-26.

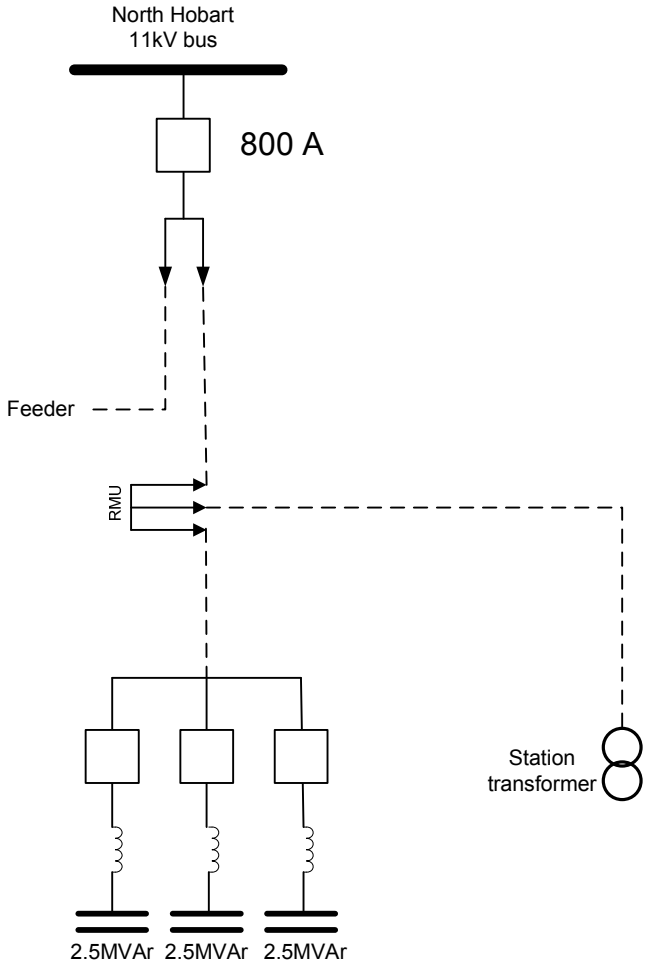


Figure 8-26 North Hobart possible RMU configuration schematic

There are many options with regard to the capacitor bank control and protection. The entire bank may be protected by a single circuit breaker with contactors on each stage for switching, or each stage can have a dedicated circuit breaker. It should be noted that the feeder circuit breaker may not be rated for capacitive switching. If this is the case, feeder protection would need to be modified to trip the capacitor bank prior to tripping the feeder circuit breaker.

Binary switched capacitor banks are also an option as a way of increasing the capacitance while minimising the step size. This configuration involves the installation of capacitors of different sizes, which are switched in a coordinated way to achieve the desired step size. For example, a 1.5 MVAr, 3 MVAr and 6 MVAr staged capacitor bank can be switched in stages of 1.5 MVAr while achieving a maximum capacitance of 10.5 MVAr.

Transfer load from 18131B to 18133B

As discussed above, feeder 18131B currently exceeds the 5 MVA planning rating. A simple project to deload 18131B would be to transfer load to the adjacent feeder 18133B which has a load forecast of 1.7 MVA in 2017. This would keep the load on both feeders below 5 MVA for the scope of the study.

8.9.3 Ultimate configuration

Substation

North Hobart is expected to remain a two transformer substation up to 2050. The transformers at North Hobart were installed in 1977, which means it is predicted that they will require replacement around 2027.

Transend drawings indicated that there is space for the existing switchgear to be extended by six circuit breakers, however space required for interfacing with the old switchgear may reduce this number. As the substation is already loaded near capacity, it is not expected that significantly more feeder circuit breakers will be required.

The long term plan discusses the possibility of a future 110/11 kV substation in the CBD, fed by an underground double circuit from a new 110 kV switchboard at North Hobart. While this not the preferred option for development it should be taken into consideration when planning works for North Hobart.

Feeders

As discussed above, it is expected that feeder limitations at North Hobart up to 2017 will be addressed by existing Aurora projects or load transfers between existing feeders.

It is likely that the North Hobart 11 kV network to the north and west will be significantly deloaded with the establishment of 11 kV injection at Creek Rd proposed for 2025, however this part of the network is forecast to become quite heavily loaded prior to this. Since there is only a single leg of a circuit breaker available at North Hobart (without extending the existing switchgear), support may be required from New Town prior to 2025. The network to the south and west of North Hobart will need to be supported from East Hobart and West Hobart substations.

8.10 East Hobart substation

East Hobart zone substation supplies to the Hobart CBD, with a single feeder which supplies parts of Rosny, Rose Bay and Cornelian Bay.

8.10.1 Limitations

Using the medium growth forecast, East Hobart substation load is forecast to grow from 28 MVA in 2012 to 29 MVA in 2017, well below the substation firm capacity of 56.4 MVA (limited by the 33 kV feeders). The five year load forecast for East Hobart substation is given in Figure 8-27.

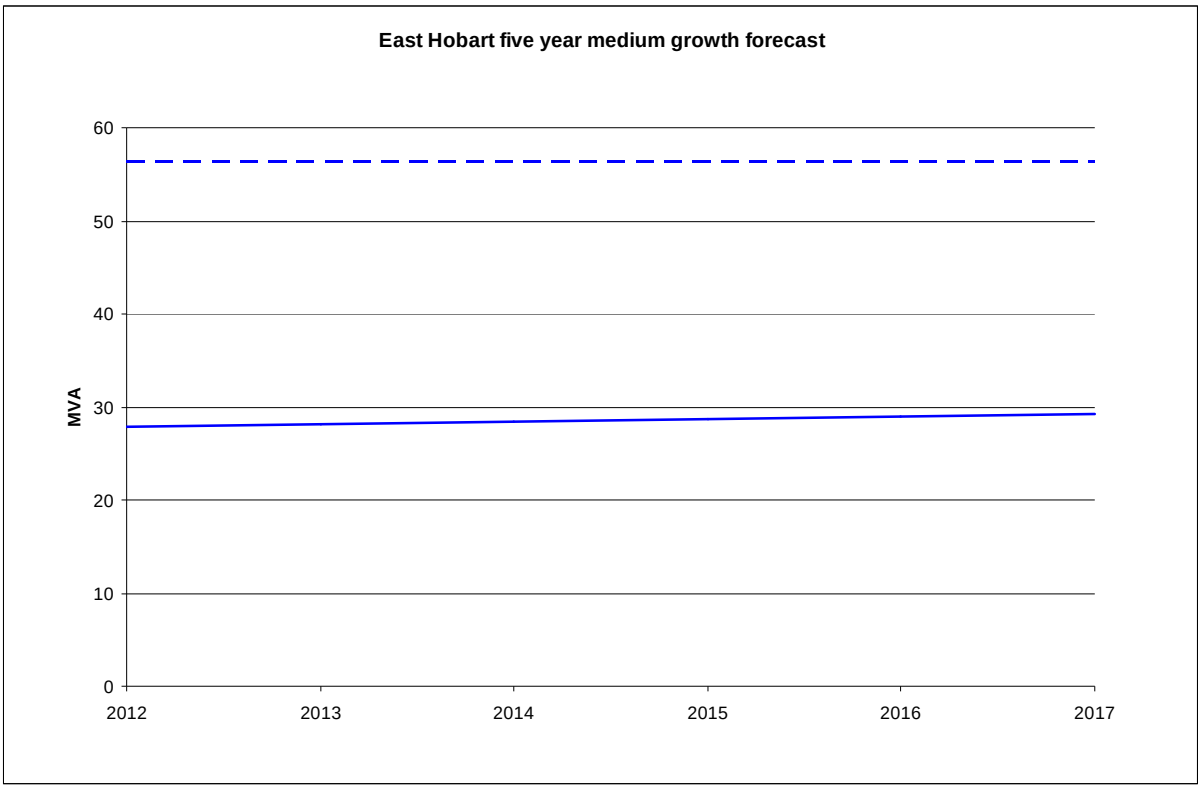


Figure 8-27 East Hobart five year medium growth forecast

The 11 kV network from East Hobart consists of eleven distribution feeders and there are two spare circuit breakers available for future feeders.

Feeder 14063 is a normally open back supply to North Hobart feeder 18143A which supplies the police headquarters, ambulance centre and other CBD loads. Feeder 14060 provides backup supply to the Royal Hobart Hospital, which is normally supplied from North Hobart feeders 18132B and 18133A.

The East Hobart supply area and individual feeders are shown in Figure 8-28 and Figure 8-29 below.

Figure 8-28 East Hobart 11 kV supply area

Figure 8-29 East Hobart 11 kV feeders

A five year feeder forecast has been developed by applying the substation medium growth rate to the feeder peak loads. The feeder forecast is outlined in Table 8-18.

Table 8-18 East Hobart substation feeder forecast

Feeder/s	2012 load (MVA)	2013 load (MVA)	2014 load (MVA)	2015 load (MVA)	2016 load (MVA)	2017 load (MVA)
14060	2.7	2.7	2.8	2.8	2.8	2.9
14061	4.0	4.0	4.1	4.1	4.2	4.2
14062	2.3	2.4	2.4	2.4	2.4	2.5
14063	0.0	0.0	0.0	0.0	0.0	0.0
14064	2.8	2.8	2.9	2.9	2.9	3.0
14065	3.1	3.1	3.1	3.2	3.2	3.2
14066	2.1	2.1	2.1	2.2	2.2	2.2
14067	4.5	4.5	4.6	4.6	4.7	4.7
14068	4.9	4.9	5.0	5.0	5.1	5.1
14069	3.8	3.8	3.9	3.9	3.9	4.0
14070	4.0	4.0	4.1	4.1	4.2	4.2

As outlined above, feeder 14068 is forecast to exceed the planning rating of 5 MVA in 2014. It is expected that the limitation on this feeder will be addressed by the proposed reinforcement to the Salamanca and wharf areas by Aurora in 2010/11.

The available transfer capacity from East Hobart substation to the West Hobart and North Hobart, substations is outlined in Table 8-19.

Table 8-19 East Hobart substation transfer capability

Substation	Feeder	2012 transfer (MVA)	2013 transfer (MVA)	2014 transfer (MVA)	2015 transfer (MVA)	2016 transfer (MVA)	2017 transfer (MVA)
North Hobart	18131A	2.0	1.9	1.9	1.9	1.8	1.8
	18131B	0.5	0.4	0.4	0.3	0.2	0.2
	18134B	3.3	3.2	3.2	3.2	3.2	3.1
	18142B	4.9	4.9	4.9	4.9	4.8	4.8
West Hobart	13047	4.1	4.1	4.0	4.0	4.0	3.9
	13052	2.5	2.4	2.4	2.3	2.2	2.1
	13054	3.0	2.9	2.9	2.8	2.7	2.7
Geilston Bay	26163	3.5	3.5	3.4	3.4	3.3	3.3
	26169	0.6	0.6	0.7	0.7	0.8	0.8
Total transfers	**-**	**24.4**	**23.9**	**23.8**	**23.5**	**23.0**	**22.7**

As outlined above, there is significant transfer capacity away from East Hobart for the period of study.

8.10.2 Proposed projects

Transfer load from West Hobart to East Hobart

Refer to the West Hobart proposed projects in Section 8.11.2 for information on this project.

8.10.3 Ultimate configuration

Substation

East Hobart is expected to remain a three transformer substation up to 2050. The transformers at East Hobart are not predicted to reach end of life within the scope of this study.

No works are proposed for East Hobart substation in the long term plan.

Feeders

As discussed above, it is expected that feeder limitations at East Hobart up to 2017 will be addressed by existing Aurora projects.

Considering the significant spare capacity at East Hobart substation, and its proximity to the Royal Hobart Hospital, it would be prudent to ultimately transfer the hospital from North Hobart to East Hobart. This would also deload the heavily loaded North Hobart network in the area.

It is also suggested that the lightly loaded feeders to the north and west (14065 and 14066), and the backup feeder 14063 be utilised to push back the reach of North Hobart so that the East Hobart supply area extends further to the north and west. Feeder 14061 which extends to the eastern shore should also be pushed back by Rosny or Geilston Bay substations, allowing it to assist in deloading North Hobart.

Future feeders will be required beyond 2017 to support the 11 kV network in the CBD, particularly towards the Salamanca and wharf area where the existing feeders are already quite heavily loaded. The establishment of a CBD substation, proposed in the long term plan for 2042, would significantly deload the East Hobart CBD feeders.

8.11 West Hobart substation

West Hobart zone substation supplies to the Hobart CBD, West Hobart, South Hobart and Cascades and with two long feeders supplying the rural area towards Fern Tree and Neika.

8.11.1 Limitations

Using the medium growth forecast, West Hobart substation load is forecast to grow from 48 MVA in 2012 to 52 MVA in 2017, below the substation firm capacity of 56.4 MVA (limited by the 33 kV feeders). The five year load forecast for West Hobart substation is given in Figure 8-30.

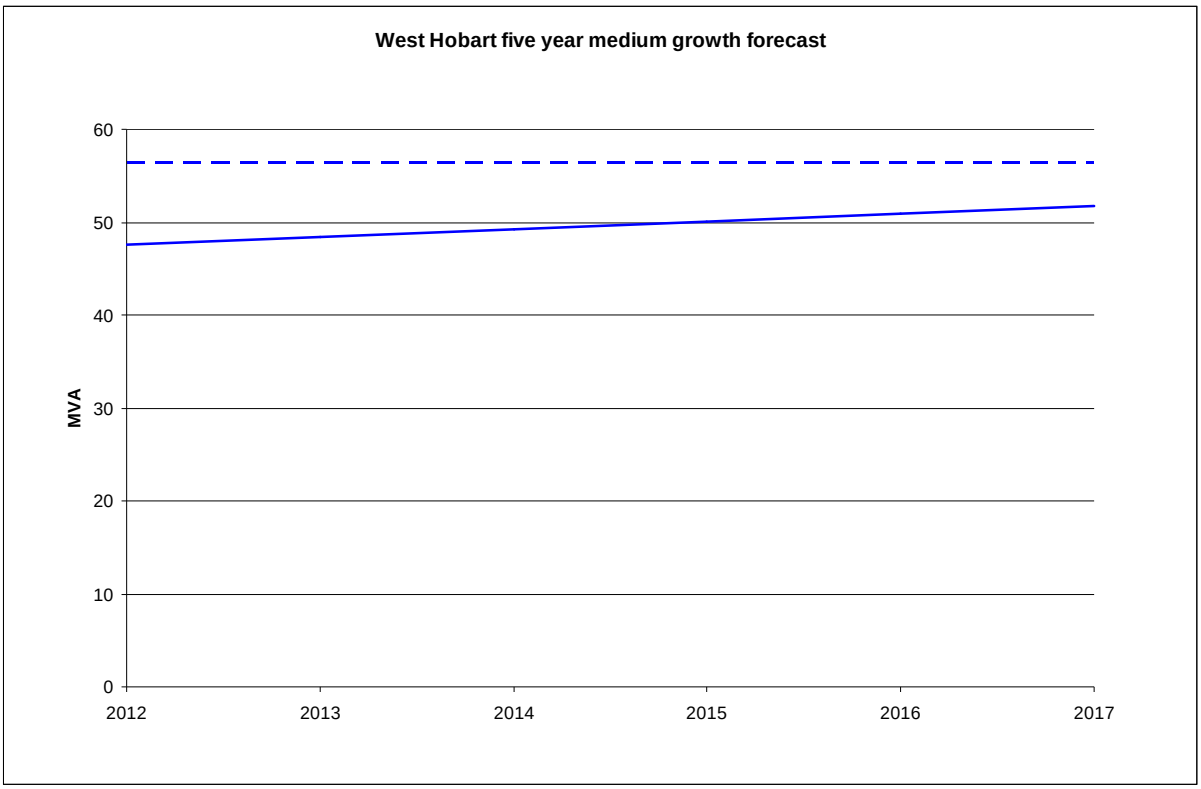


Figure 8-30 West Hobart five year medium growth forecast

The 11 kV network from West Hobart consists of fifteen distribution feeders and there are no spare circuit breakers available for future feeders as the last spare breakers are being used for two new feeders in 2010.

The West Hobart supply area is shown in Figure 8-31 and the urban and rural feeders are shown in Figure 8-32 and Figure 8-33 respectively.

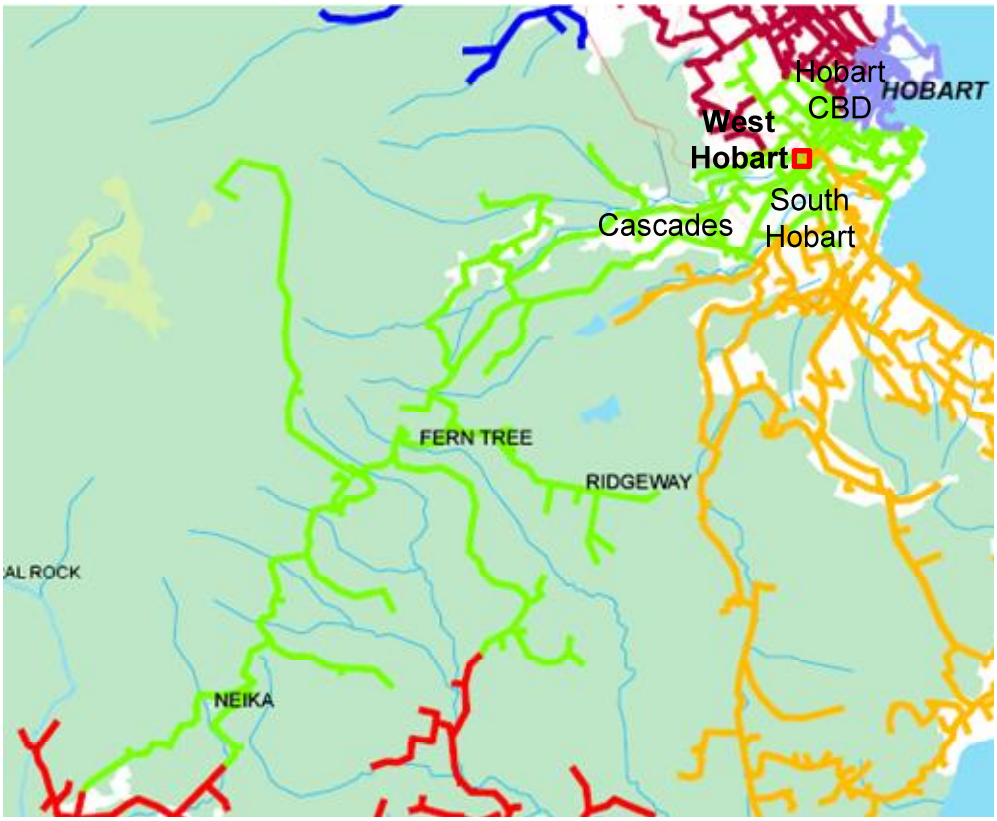


Figure 8-31 West Hobart 11 kV supply area

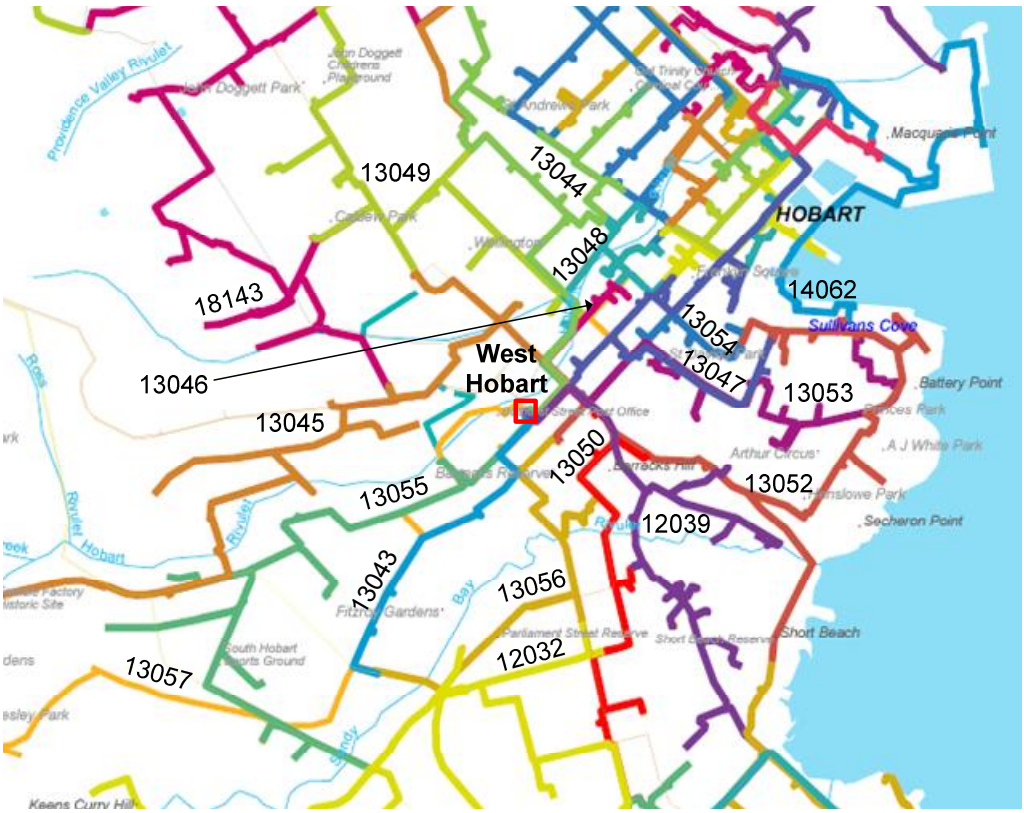


Figure 8-32 West Hobart 11 kV feeders (urban)

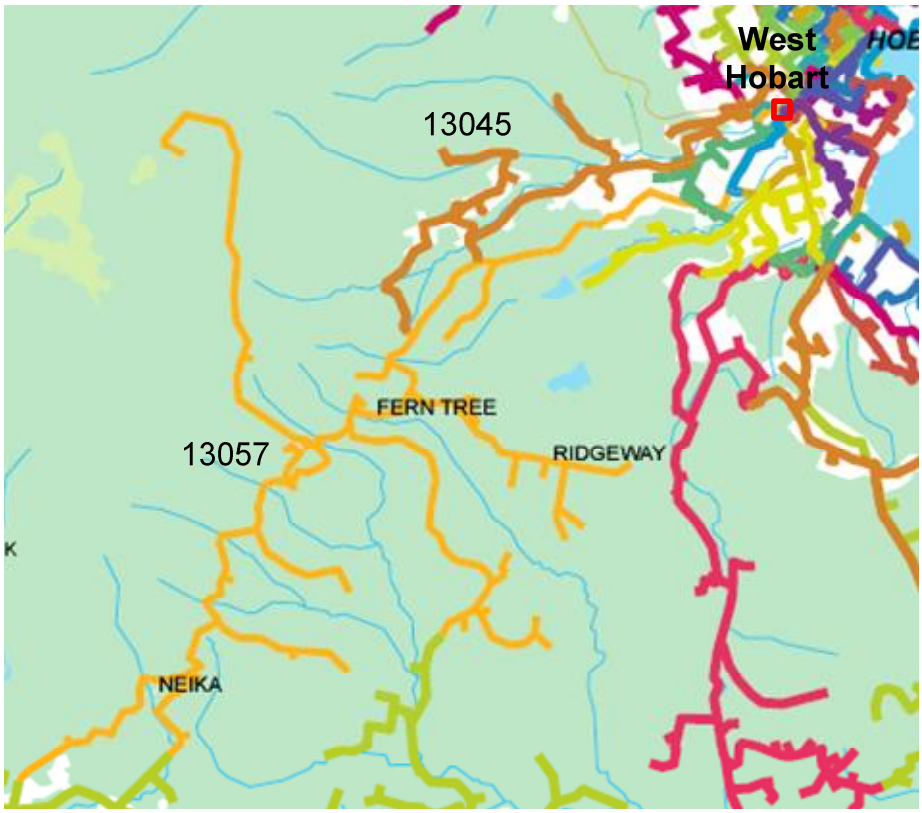


Figure 8-33 West Hobart 11 kV feeders (rural)

A five year feeder forecast has been developed by applying the substation medium growth rate to the feeder peak loads. The feeder forecast is outlined in Table 8-20.

Table 8-20 West Hobart substation feeder forecast

Feeder/s	2012 load (MVA)	2013 load (MVA)	2014 load (MVA)	2015 load (MVA)	2016 load (MVA)	2017 load (MVA)
13043	2.6	2.7	2.7	2.8	2.8	2.9
13044	3.3	3.4	3.4	3.5	3.5	3.6
13045	4.9	5.0	5.1	5.2	5.3	5.4
13046	4.4	4.5	4.6	4.7	4.8	4.8
13047	2.1	2.1	2.1	2.2	2.2	2.2
13048	4.3	4.3	4.4	4.5	4.6	4.6
13049	3.6	3.6	3.7	3.8	3.8	3.9
13050	1.6	1.7	1.7	1.7	1.8	1.8
13051	0.0	0.0	0.0	0.0	0.0	0.0
13052	4.0	4.1	4.1	4.2	4.3	4.3
13053	3.6	3.6	3.7	3.8	3.8	3.9
13054	3.5	3.6	3.7	3.7	3.8	3.8
13055	4.7	4.8	4.9	5.0	5.1	5.2
13056	1.4	1.5	1.5	1.5	1.5	1.6
13057	3.2	3.2	3.3	3.3	3.4	3.4

As outlined above, there are several feeders which are forecast to exceed the planning rating of 5 MVA prior to 2017. There are no projects in the Aurora program of works that will address these feeder limitations.

Feeder 13051 is a normally open backup supply to Sandy Bay feeder 12039, which supplies the commercial area of Sandy Bay.

The available transfer capacity from West Hobart substation to the East Hobart, North Hobart, Sandy Bay and Kingston substations is outlined in Table 8-21.

Table 8-21 West Hobart substation transfer capability

Substation	Feeder	2012 transfer (MVA)	2013 transfer (MVA)	2014 transfer (MVA)	2015 transfer (MVA)	2016 transfer (MVA)	2017 transfer (MVA)
East Hobart	14062	5.3	5.3	5.2	5.2	5.2	5.2
	14067	0.1	0.1	0.0	0.0	0.0	0.0
	14070	1.7	1.7	1.7	1.6	1.6	1.5
North Hobart	18133	1.0	1.0	0.9	0.9	0.8	0.7
	18141	1.2	1.2	1.1	1.0	1.0	0.9
	18142	2.7	2.7	2.7	2.7	2.6	2.6
Sandy Bay	12032	2.6	2.5	2.5	2.4	2.4	2.3
	12036	0.6	0.6	0.5	0.4	0.3	0.2
	12037	3.8	3.7	3.7	3.6	3.5	3.5
	12039	0.7	0.6	0.6	0.5	0.4	0.3
Kingston	34261	0.7	0.6	0.4	0.3	0.1	0.0
Total transfers	**-**	**20.4**	**20.0**	**19.3**	**18.6**	**17.9**	**17.2**

As outlined above, there is significant transfer capacity away from West Hobart for the period of study.

8.11.2 Proposed projects

Transfer load from West Hobart to East Hobart

As discussed above, the load at West Hobart is approaching firm capacity, while the load at East Hobart is well below firm capacity. Similarly, load at Creek Rd (which supplies West Hobart) is approaching firm capacity, while load at Risdon substation (which supplies East Hobart) is well below firm capacity. Therefore it is proposed that load transfers be implemented from West Hobart to East Hobart.

Of the existing East Hobart feeders with ties to West Hobart feeders, only 14062 and 14065 have any real capacity to accept load from West Hobart, so to achieve any significant load transfer it is expected that reconfiguration of the network (e.g. double shuffle load via North Hobart) and possibly new feeders from East Hobart would be required.

Transfer load from 13045 and 13055 to 13043 and 13056

As discussed above feeders 13045 and 13055 are forecast to exceed the 5 MVA planning ratings in 2013 and 2016 respectively. To address this limitation it is proposed to transfer load to adjacent

feeders 13043 and 13056 which have load forecasts of 2.9 MVA and 1.5 MVA in 2017 respectively. These works may require the construction of a short feeder tie in order to implement the transfers.

8.11.3 Ultimate configuration

Substation

West Hobart is expected to remain a three transformer substation up to 2050. The transformers at West Hobart are not predicted to reach end of life within the scope of this study.

The long term plan proposes the establishment of a 33 kV switchboard at West Hobart in 2042. This should be taken into account when future works are proposed for the substation, or if adjacent land becomes available.

Feeders

As discussed above, it is expected that feeder limitations at West Hobart up to 2017 will be addressed by the proposed projects.

The establishment of Browns Rd substation in 2012 is expected to allow the reconfiguration of the Kingston 11 kV network to shorten the reach of feeder 13057, which currently supplies all the way west to Neika. Similarly, the establishment of a Mount Nelson zone substation, proposed in the long term plan for 2036, is expected to provide an opportunity to split this long feeder.

The Mount Nelson substation would also allow Sandy Bay to focus further north, which would relieve some of the future limitations on the relatively heavily-loaded West Hobart feeders to the south.

The establishment of a CBD substation, proposed in the long term plan for 2042, would significantly deload the West Hobart CBD feeders.

8.12 Sandy Bay substation

Sandy Bay zone substation supplies to the southern Hobart suburbs of Sandy Bay, Dynnyrne, Mount Nelson and Taroona.

8.12.1 Limitations

Using the medium growth forecast, Sandy Bay substation load is forecast to grow from 43 MVA in 2012 to 47 MVA in 2017 (assuming a 5 MVA load transfer to Browns Rd in 2012), below the substation firm capacity of 56.4 MVA (limited by the 33 kV feeders). The five year load forecast for Sandy Bay substation is given in Figure 8-34.

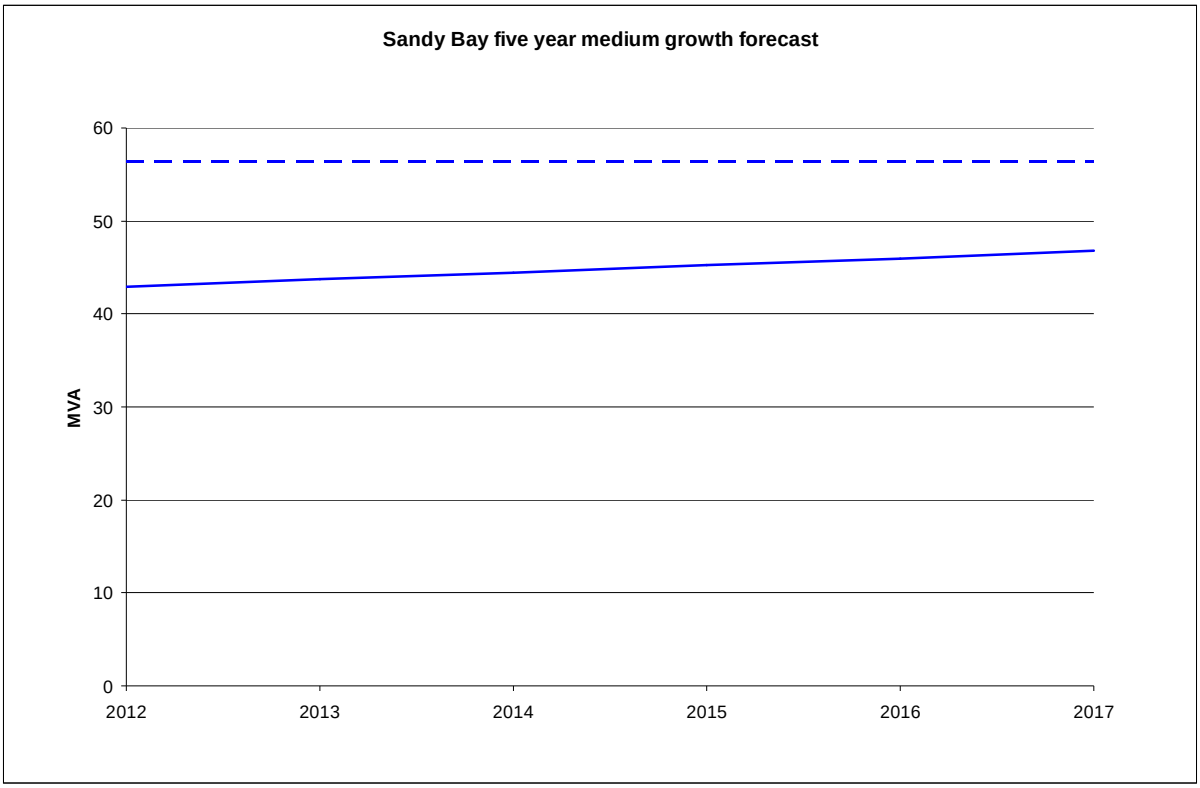


Figure 8-34 Sandy Bay five year medium growth forecast

The 11 kV network from Sandy Bay consists of thirteen distribution feeders and there are no spare circuit breakers available for future feeders.

The Sandy Bay supply area is shown in Figure 8-35 and the northern and southern feeders are shown in Figure 8-36 and Figure 8-37 respectively.

Figure 8-35 Sandy Bay 11 kV supply area

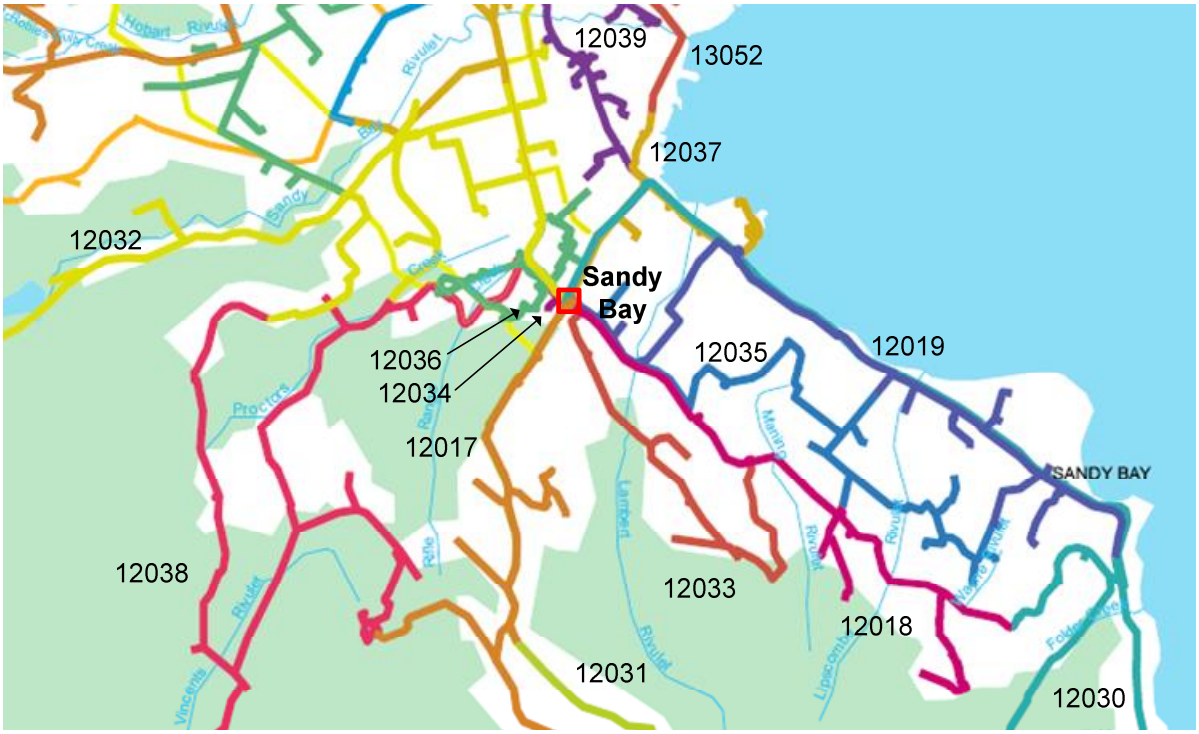


Figure 8-36 Sandy Bay northern 11 kV feeders

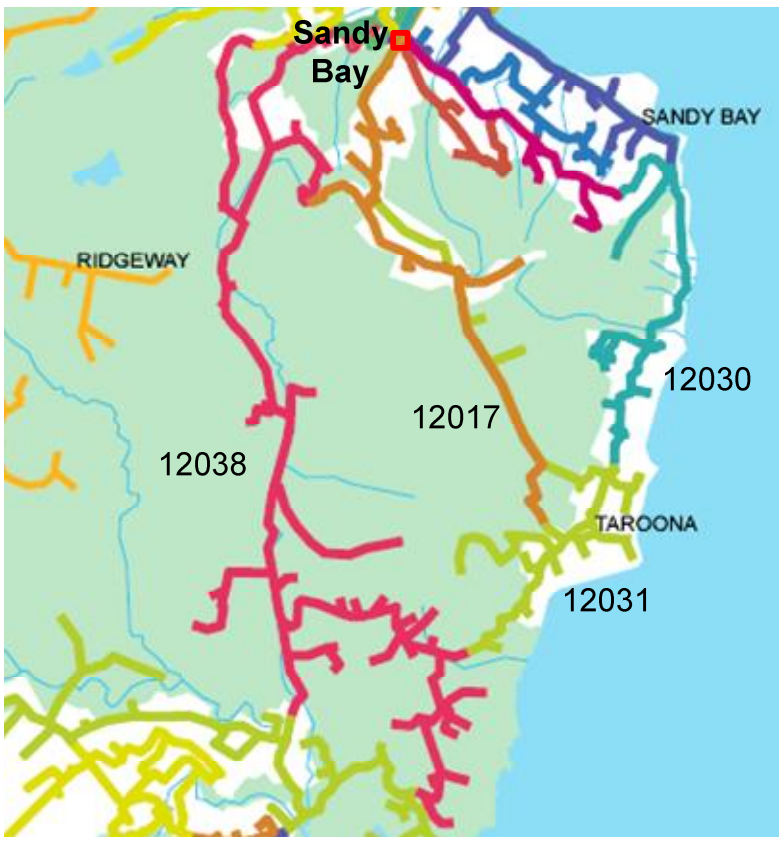


Figure 8-37 Sandy Bay southern 11 kV feeders

A five year feeder forecast has been developed by applying the substation medium growth rate to the feeder peak loads. The feeder forecast is outlined in Table 8-22.

Table 8-22 Sandy Bay substation feeder forecast

Feeder/s	2012 load (MVA)	2013 load (MVA)	2014 load (MVA)	2015 load (MVA)	2016 load (MVA)	2017 load (MVA)
12017	3.9	4.0	4.1	4.1	4.2	4.3
12018	4.8	4.8	4.9	5.0	5.1	5.2
12019	4.9	5.0	5.1	5.2	5.3	5.3
12030	3.9	4.0	4.1	4.1	4.2	4.3
12031	4.4	4.5	4.6	4.7	4.7	4.8
12032	3.2	3.3	3.4	3.4	3.5	3.5
12033	1.4	1.5	1.5	1.5	1.5	1.6
12034	0.1	0.1	0.1	0.1	0.1	0.1
12035	3.8	3.9	4.0	4.0	4.1	4.2
12036	5.2	5.3	5.4	5.5	5.6	5.6
12037	3.7	3.7	3.8	3.9	3.9	4.0
12038	2.9	3.0	3.0	3.1	3.1	3.2
12039	4.4	4.5	4.6	4.7	4.8	4.8

As outlined above, there are several feeders which are forecast to exceed the planning rating of 5 MVA prior to 2017. There are no projects in the Aurora program of works that will address these feeder limitations.

Feeder 12036 is a dedicated feeder to the university and supplies an HV feeder ring.

Feeder 12034 is a dedicated feeder which supplies the University boiler. The boiler is only run sporadically when the university heating fails, and was last run in 2006. The boiler is supplied by a 11/22 kV step-up transformer at Sandy Bay, and a 22/11 kV step down transformer at the boiler substation.

Feeder 12039 supplies to commercial area of Sandy Bay and has a dedicated backup feeder 13051 from West Hobart which currently supplies no load. It is expected that load could be transferred from 12039 to 13051 to address the capacity limitation on 12039 which is expected beyond 2017.

The available transfer capacity from Sandy Bay substation to the West Hobart and Kingston substations is outlined in Table 8-23.

Table 8-23 Sandy Bay substation transfer capability

Substation	Feeder	2012 transfer (MVA)	2013 transfer (MVA)	2014 transfer (MVA)	2015 transfer (MVA)	2016 transfer (MVA)	2017 transfer (MVA)
West Hobart	13050	5.3	5.2	5.2	5.2	5.1	5.1
	13051	4.6	4.7	4.8	4.8	4.9	5.0
	13052	0.2	0.1	0.1	0.0	0.0	0.0
	13056	3.2	3.2	3.2	3.2	3.1	3.1
Kingston	34261	0.3	0.1	0.0	0.0	0.0	0.0
Total transfers	**-**	**13.6**	**13.3**	**13.3**	**13.2**	**13.1**	**13.2**

As outlined above, there is significant transfer capacity away from Sandy Bay for the period of study. This is expected to increase with the establishment of the Browns Rd zone substation in 2012.

8.12.2 Proposed projects

Split University HV ring

As discussed above, feeder 12036 supplies the university HV ring and currently exceeds the 5 MVA planning rating. To address this limitation it is proposed to extend feeder 12034, which currently supplies the university boiler, to cut into and split the university HV ring.

This would require approximately 50m 11 kV double circuit from the boiler switchboard to cut into the HV ring, as well as the cut and re-joint of the ring in another location to form two rings. Figure 8-38 shows a possible arrangement.

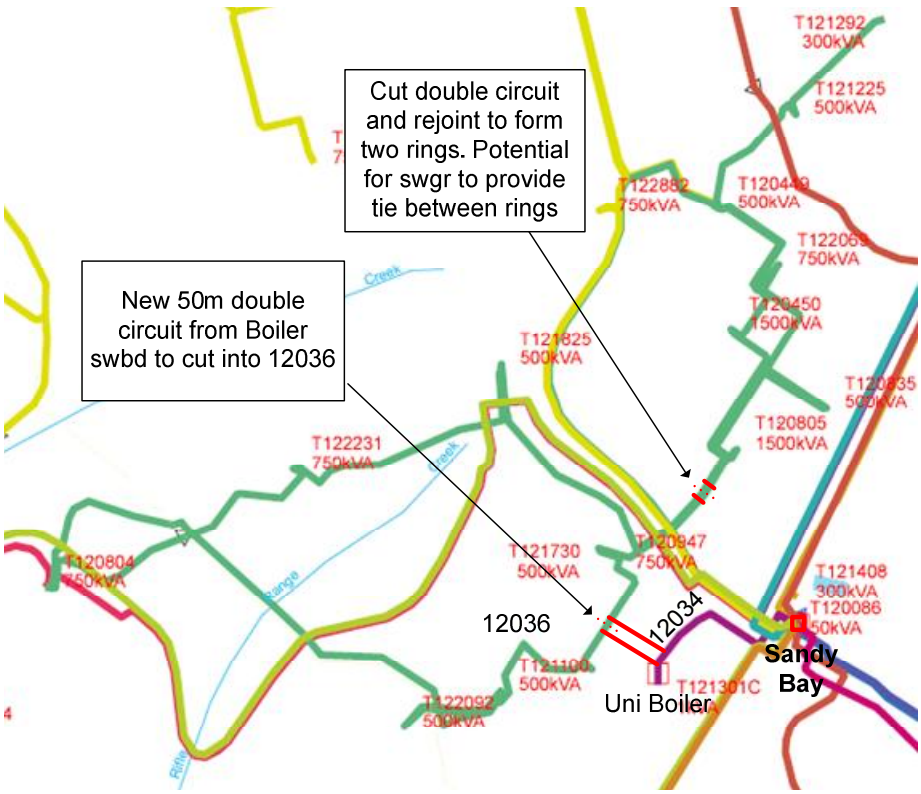


Figure 8-38 Proposed university HV ring geographic configuration

The above arrangement results in two rings with approximately the same installed load on each.

There are several other possibilities in a similar vein, such as the installation of switchgear to provide transfer capacity between the rings, or the parallel of the two feeders into a single ring. This should be evaluated in more detail as part of the project planning.

This project would also require the decommissioning of the 11/22 kV transformer at Sandy Bay, and the 22/11 kV transformer at the boiler substation. The 22 kV feeder and 22 kV boiler switchboard would then be energised at 11 kV, with the boiler and the new 11 kV double circuit connected directly to this switchboard. A schematic diagram of this proposal is shown in Figure 8-39.

It should be noted that an 11/11 kV isolation transformer may be required at the university boiler connection to ensure adequate earth fault protection. It may be possible to relocate the existing unused 11/11 kV transformer installed at Cadbury's to avoid purchasing a new unit.

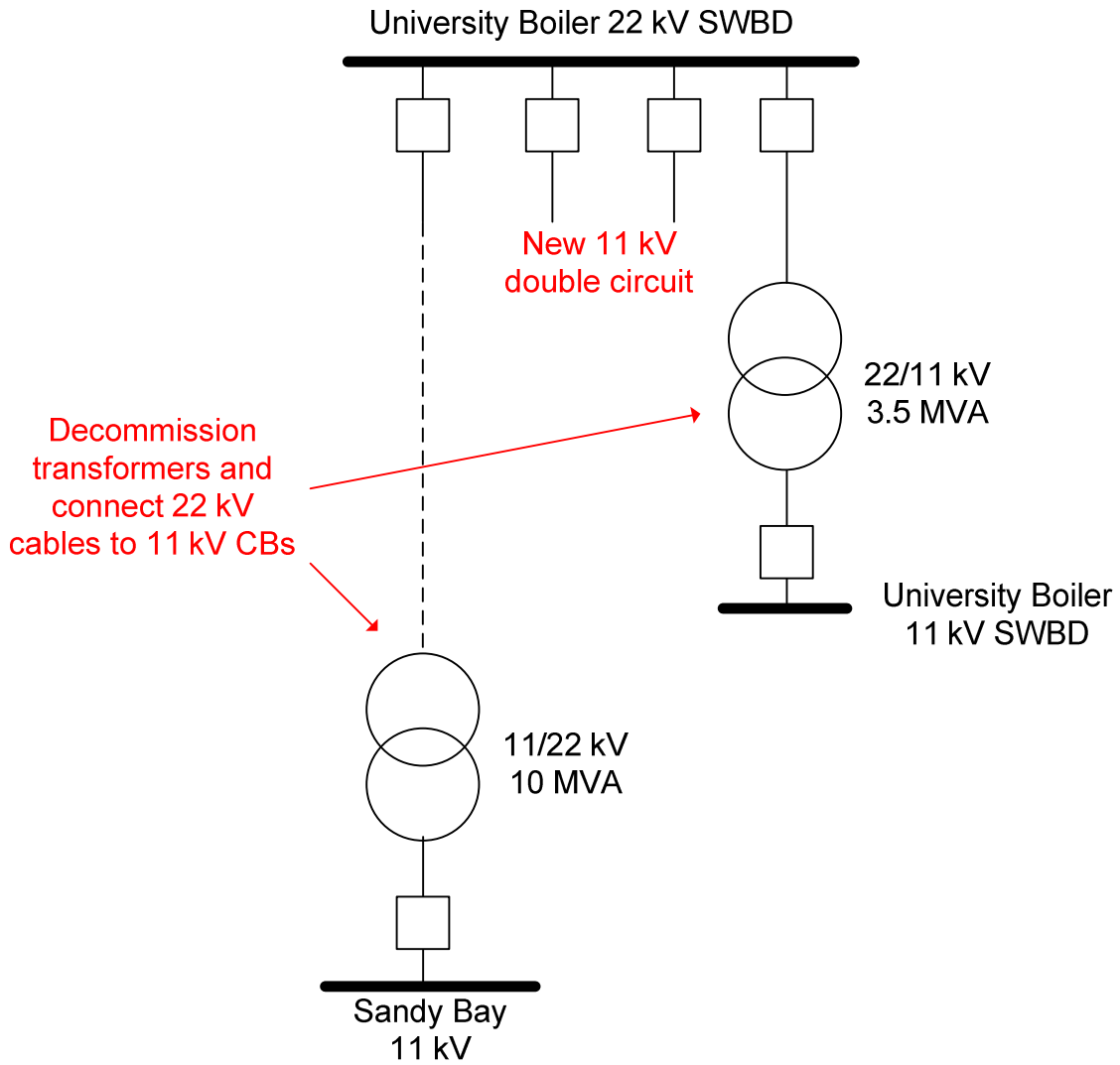


Figure 8-39 Proposed university HV ring schematic configuration

An alternative to this project would be to transfer part of the university load to the adjacent Sandy Bay feeder 12038 via the existing tie. However this feeder does not have capacity to take half of the ring, so splitting the ring into two rings as described above would not be possible without running long cables to split the ring in a different location. This is expected to be similar in cost to the preferred

option but the solution would not last as long due to the existing load on 12038, and would not be as reliable due to the long overhead sections of 12038.

A third option would be to transfer part of the existing ring to 12038 by a simple load transfer, without any additional feeder works, however this is not expected to be acceptable since it would involve splitting the university ring and a consequent loss of reliability.

There are no other feeders in the vicinity of the university that have spare capacity to deload the university ring, and there are no spare circuit breakers at Sandy Bay to establish new feeders, so reusing the boiler feeder is considered the best option to address the existing feeder limitation. This option also provides Aurora with the opportunity to remove old 22 kV infrastructure from the area, while maintaining an emergency supply to the university boiler.

Extend Sandy Bay 11 kV switchboard and establish new feeder to Sandy Bay residential area

As discussed above, feeders 12018 and 12019 to the Sandy Bay residential area are forecast to exceed the planning rating of 5 MVA in 2015 and 2014 respectively. This limitation may be addressed by load transfers to 12030 (after being deloaded by Browns Rd zone substation in 2012) and 12033 in the short term, however with the majority of feeders into this area being heavily loaded it is expected that reinforcement will be required by 2017 or shortly thereafter.

Therefore it is proposed that a new feeder be established from Sandy Bay substation to split the existing network in the Sandy Bay residential area. Depending on the load growth in the area, and the amount of load able to be supplied from the new Brown's Rd zone substation, it may be practical to install a double circuit at this time. If not, conduits should be installed to simplify the establishment of future feeders into the area.

As there are no spare circuit breakers at Sandy Bay, the 11 kV bus would need to be extended with additional circuit breakers at this time. This may require the extension of the existing switchroom, or the establishment of a small 11 kV switchroom. The current arrangement of the 11 kV switchgear at Sandy Bay has two buses of 5 feeder circuit breakers and a third bus of three feeder circuit breakers. This project would provide an opportunity to address this unusual arrangement by replacing the small bus with a standard 5 circuit breaker bus.

There are no adjacent substations capable of providing alternate supply to the Sandy Bay residential area, with only West Hobart and Browns Rd (after 2012) geographically neighbouring Sandy Bay zone substation. Neither of these substations are suitable to provide supply into the area – West Hobart substation is on the opposite side of Sandy Bay substation to the load and the only West Hobart feeder in the area is already loaded near its planning rating. Browns Rd will be located approximately 10 km away from the load so it is considered unlikely to be able provide any significant assistance. Therefore a new feeder from Sandy Bay is considered the best option.

8.12.3 Ultimate configuration

Substation

Sandy Bay is expected to remain a three transformer substation up to 2050. The transformers at Sandy Bay are not predicted to reach end of life within the scope of this study.

The existing 11 kV switchboard has only 13 feeder circuit breakers, which is unlikely to be sufficient to supply the substation firm capacity of 60 MVA. This is proposed to be addressed by the extension of the existing 11 kV switchgear in 2017, in order to supply the proposed feeder to the Sandy Bay residential area.

The long term plan proposes the establishment of a 33 kV switchboard at Sandy Bay in 2034 to enable it to take supply from the proposed McRobies Gully 33 kV injection point. This should be taken into account when future works are proposed for the substation, or if adjacent land becomes available.

Feeders

As discussed above, it is expected that feeder limitations at Sandy Bay up to 2017 will be addressed by the proposed projects.

The establishment of Browns Rd substation in 2012 is expected to allow the reconfiguration of the Kingston 11 kV network to shorten the reach of feeders 12017, 12030, 12031 and 12038, which currently supply south to the Taroona and Taronga areas. Similarly, the establishment of a Mount Nelson zone substation, proposed in the long term plan for 2036, is expected to shorten these feeders further, as well as to provide the opportunity for feeder reinforcement into the Sandy Bay residential area.

The Mount Nelson substation would also allow Sandy Bay to focus further north, which would relieve some of the future limitations on the relatively heavily-loaded West Hobart feeders to the north of Sandy Bay.

Appendix A
Estimating data

Appendix A

The following tables list the standard feeder and substation costs used for this report.

Voltage	Feeder Type	Cost ($k/km)			Source
		Rural	Urban	High density Urban	
110 kV	Overhead single circuit	450	-	-	Transend (advised $400-500k)
110 kV	Over head single circuit (double circuit construction)	500	-	-	Transend (advised $400-500)
110 kV	Overhead double circuit	550	-	-	Transend (advised $500-600k)
66 kV	Overhead single circuit	250	-	-	Aurora
66 kV	Overhead double circuit	330	-	-	Aurecon assumption
66 kV	Overbuild of existing 22 kV	180	290	360	Aurecon assumption
33 kV	Underground single circuit	250	300	500	Aurora
33 kV	Underground double circuit	420	500	750	Aurora
33 kV	Overhead single circuit	150	200	300	Aurora
22 kV	Overhead single circuit	100	150	200	Aurora
22 kV	Underground single circuit	220	270	470	Aurora
22 kV	Underground double circuit	360	440	690	Aurora
11 kV	Overhead single circuit	100	150	200	Aurora
11 kV	Underground single circuit	220	270	470	Aurora
11 kV	Underground double circuit	360	440	690	Aurora

Component	Cost ($k)	Source
110/22/11 kV terminal substation	17,500	Transend (advised $15-20M)
110/22/11 kV terminal substation (single 25 MVA transformer)	9,000	Transend (advised $8-10M)
Install 3rd 110/22/11 kV transformer at existing site	7,000	Transend (advised $6-8M)
Install 3rd 33/11 kV transformer at existing site	3,000	Aurecon assumption
Replace 2 x 110/22/11 kV 60 MVA transformers	6,000	Aurecon assumption based Transend projects in APR
Replace 2 x 110/22/11 kV 25 MVA transformers	5,000	Aurecon assumption based Transend projects in APR
Establish 110/33 kV substation at existing site	13,500	Transend (advised $12-15M)
Establish 110/66 kV substation at existing site	14,000	Aurecon assumption
66/22 kV zone substation	9,000	Aurora
33/11 kV zone substation	7,000	Aurora
33 kV switchboard (5 CBs in existing building)	500	Aurecon assumption
11 kV switchboard (8 CBs in existing building)	300	Aurecon assumption

Appendix B
NPV analysis

Appendix B

The following table lists the NPV analyses attached in this section of the report.

NPV	Project	Section reference
1	Bridgewater 33 kV injection and Austin's Ferry	7.1.2

Bridgewater and Austin's Ferry NPV analysis (Hobart-West area)

Base Year
2010

OPTION 1
Establish Bridgewater 33 kV injection point and zone substation at Austin's Ferry

Development Year			System Limitation	Description of Works		Medium Growth Net Present Value in $ M			High Growth Net Present Value in $ M			Low Growth Net Present Value in $ M		
Medium	High	Low			Cost $k	5.64%	6.64%	7.64%	5.64%	6.64%	7.64%	5.64%	6.64%	7.64%
2017	2016	2018	Firm capacity and 11 kV feeder limitations at Bridgewater Firm capacity on northern substation group Firm capacity at Creek Rd	Establish 33 kV injection point at Bridgewater: - 2 x 60 MVA 110/33 kV transformers - 2 sections of 33 kV switchgear	$13,100	$8.92	$8.35	$7.82	$9.43	$8.91	$8.42	$8.45	$7.83	$7.27
2017	2016	2018	As above	Establish Austin's Ferry zone substation: - Site purchase and establishment -4.5 km 33 kV underground double circuit - 2 x 25 MVA 33/11 kV transformers - 2 sections of 11 kV switchgear - 11 kV feeders to cut in to existing network	$14,350	$9.77	$9.15	$8.57	$10.32	$9.76	$9.23	$9.25	$8.58	$7.96
2025	2020	2030	Firm capacity and 11 kV feeder limitations at Bridgewater	Establish Brighton zone substation: - Site purchase and establishment - 2 km 33 kV underground double circuit (assumed 3km already installed) - 2 x 25 MVA 33/11 kV transformers - 2 sections of 11 kV switchgear - 11 kV feeders to cut in to existing network	$10,500	$4.61	$4.00	$3.48	$6.07	$5.52	$5.03	$3.50	$2.90	$2.41
2030	2025	2035	Bridgewater transformer end of life	Upgrade Bridgewater substation: - Replace 35 MVA 110/11 kV transformers with 60 MVA	$6,000	$2.00	$1.66	$1.38	$2.63	$2.29	$1.99	$1.52	$1.20	$0.95
					Total	**$25.31**	**$23.16**	**$21.25**	**$28.45**	**$26.47**	**$24.67**	**$22.72**	**$20.52**	**$18.59**

OPTION 2
Establish Bridgewater 33 kV injection point and upgrade Claremont zone substation

Development Year			System Limitation	Description of Works		Medium Growth Net Present Value in $ M			High Growth Net Present Value in $ M			Low Growth Net Present Value in $ M		
Medium	High	Low			Cost $k	5.64%	6.64%	7.64%	5.64%	6.64%	7.64%	5.64%	6.64%	7.64%
2017	2016	2018	Firm capacity and 11 kV feeder limitations at Bridgewater Firm capacity on northern substation group Firm capacity at Creek Rd	Establish 33 kV injection point at Bridgewater: - 2 x 60 MVA 110/33 kV transformers - 2 sections of 33 kV switchgear	$13,100	$8.92	$8.35	$7.82	$9.43	$8.91	$8.42	$8.45	$7.83	$7.27
2017	2016	2018	As above	Upgrade Claremont zone substation: - 6.5 km 33 kV underground single circuit - 1 x 25 MVA 33/11 kV transformer - 1 section of 11 kV switchgear - 11 kV feeders to cut in to existing network	$13,550	$9.23	$8.64	$8.09	$9.75	$9.21	$8.71	$8.74	$8.10	$7.52
2025	2020	2030	Claremont 11 kV feeder limitations	Reinforce 11 kV network north of Claremont: - 1 x 3 km SCCT HD UG from Claremont - 1 x 3km SCCT UG from Bridgewater & river crossing	$4,320	$1.90	$1.65	$1.43	$2.50	$2.27	$2.07	$1.44	$1.19	$0.99
2025	2020	2030	Firm capacity and 11 kV feeder limitations at Bridgewater	Establish Brighton zone substation: - Site purchase and establishment - 2 km 33 kV underground double circuit (assumed 3km already installed) - 2 x 25 MVA 33/11 kV transformers - 2 sections of 11 kV switchgear - 11 kV feeders to cut in to existing network	$10,500	$4.61	$4.00	$3.48	$6.07	$5.52	$5.03	$3.50	$2.90	$2.41
2030	2025	2035	Bridgewater transformer end of life	Upgrade Bridgewater substation: - Replace 35 MVA 110/11 kV transformers with 60 MVA	$6,000	$2.00	$1.66	$1.38	$2.63	$2.29	$1.99	$1.52	$1.20	$0.95
					Total	**$26.66**	**$24.30**	**$22.21**	**$30.37**	**$28.20**	**$26.22**	**$23.65**	**$21.23**	**$19.14**

Base Year
2010

OPTION 3
Upgrade Bridgewater terminal substation and reinforce 11 kV network

Development Year			System Limitation	Description of Works		Medium Growth Net Present Value in $ M			High Growth Net Present Value in $ M			Low Growth Net Present Value in $ M		
Medium	High	Low			Cost $k	5.64%	6.64%	7.64%	5.64%	6.64%	7.64%	5.64%	6.64%	7.64%
2017	2016	2018	Firm capacity and 11 kV feeder limitations at Bridgewater Firm capacity on northern substation group Firm capacity at Creek Rd	Upgrade Bridgewater substation: - Replace 35 MVA 110/11 kV transformers with 60 MVA - Replace 11 kV switchgear (or install additional 4 x CBs) - 11 kV reinforcement to deload Claremont	$19,600	$13.35	$12.50	$11.71	$14.10	$13.33	$12.60	$12.64	$11.72	$10.88
2025	2020	2030	Claremont 11 kV feeder limitations	Reinforce 11 kV network north of Claremont: - 1 x 3 km SCCT HD UG from Claremont - 1 x 3km SCCT UG from Bridgewater & river crossing	$4,320	$1.90	$1.65	$1.43	$2.50	$2.27	$2.07	$1.44	$1.19	$0.99
2025	2020	2030	Bridgewater exceeds firm capacity	Establish Brighton terminal substation: - 8km 110 kV DCCT from BW - Extend 110 kV bus at BW - 2 x 25 MVA transformer - Two sections of 11 kV swtichgear - 11 kV feeders to cut in to existing network	$25,400	$11.15	$9.68	$8.42	$14.67	$13.35	$12.16	$8.48	$7.02	$5.83
					Total	**$26.40**	**$23.83**	**$21.56**	**$31.27**	**$28.95**	**$26.83**	**$22.56**	**$19.93**	**$17.69**

OPTION 4
Establish Bridgewater 33 kV injection point and zone substations at Bridgewater and Austin's Ferry

Development Year			System Limitation	Description of Works		Medium Growth Net Present Value in $ M			High Growth Net Present Value in $ M			Low Growth Net Present Value in $ M		
Medium	High	Low			Cost $k	5.64%	6.64%	7.64%	5.64%	6.64%	7.64%	5.64%	6.64%	7.64%
2017	2016	2018	Firm capacity and 11 kV feeder limitations at Bridgewater Firm capacity on northern substation group Firm capacity at Creek Rd	Establish 33 kV injection point at Bridgewater: - 2 x 60 MVA 110/33 kV transformers - 2 sections of 33 kV switchgear	$11,100	$7.56	$7.08	$6.63	$7.99	$7.55	$7.14	$7.16	$6.64	$6.16
2017	2016	2018	As above	Establish Bridgewater zone substation: - Site purchase and establishment - 2 x 35 MVA 33/11 kV transformers - 2 sections of 11 kV switchgear - 11 kV feeders to cut in to existing network	$9,000	$6.13	$5.74	$5.38	$6.48	$6.12	$5.79	$5.80	$5.38	$4.99
2017	2016	2018	As above	Establish Austin's Ferry zone substation: - Site purchase and establishment -4.5 km 33 kV underground double circuit - 2 x 25 MVA 33/11 kV transformers - 2 sections of 11 kV switchgear - 11 kV feeders to cut in to existing network	$14,350	$9.77	$9.15	$8.57	$10.32	$9.76	$9.23	$9.25	$8.58	$7.96
2025	2020	2030	Firm capacity and 11 kV feeder limitations at Bridgewater	Establish Brighton zone substation: - Site purchase and establishment - 2 km 33 kV underground double circuit (assumed 3km already installed) - 2 x 25 MVA 33/11 kV transformers - 2 sections of 11 kV switchgear - 11 kV feeders to cut in to existing network	$10,500	$4.61	$4.00	$3.48	$6.07	$5.52	$5.03	$3.50	$2.90	$2.41
					Total	**$28.07**	**$25.97**	**$24.06**	**$30.85**	**$28.95**	**$27.18**	**$25.72**	**$23.50**	**$21.52**

Appendix C
Alternative 33 kV options at Derwent Park

Appendix C

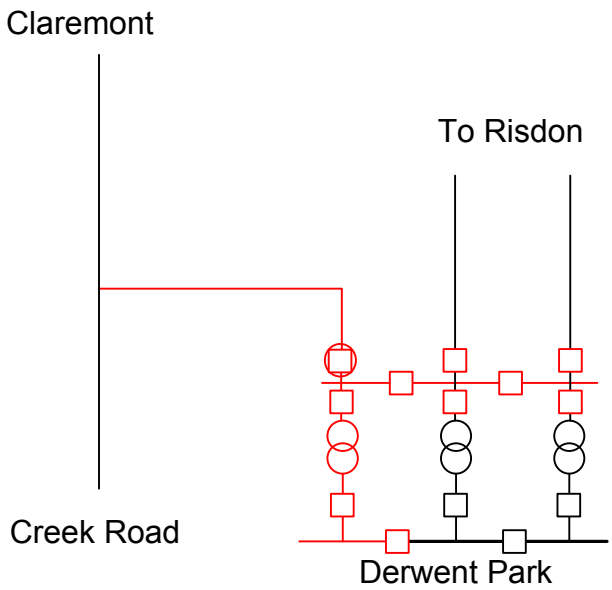
The option to install a 33 kV switchboard at Derwent Park is considered the lowest cost option to increase the firm capacity of the northern substation group of Hobart-West, while providing transfer capacity between Risdon and Creek Rd substations. However there are alternative options that provide a similar outcome with differing levels of complexity and risk.

Option 1

Option 1 involves the installation of a 33 kV switchboard with 8 CBs, and a short section of 33 kV cable to tee of the existing Creek Rd-Claremont feeder. This results in a three-ended 33 kV feeder and would require a three-ended protection scheme. It also requires an auto-changeover scheme to supply a Derwent Park transformer in the event of a fault on one of the Risdon-Derwent Park feeders.

The Risdon-Derwent Park 33 kV feeders are rated 28.2 MVA, so assuming Derwent Park is loaded to its firm capacity of 50 MVA, only an additional 6.4 MVA could be taken transferred from Claremont without further uprating or reconductoring. These feeders would need to be uprated to around 31 MVA to be able to supply all of Derwent Park load (firm capacity of 50 MVA) and half of Claremont load (22.5 MVA firm capacity).

The resulting Derwent Park schematic is given below.



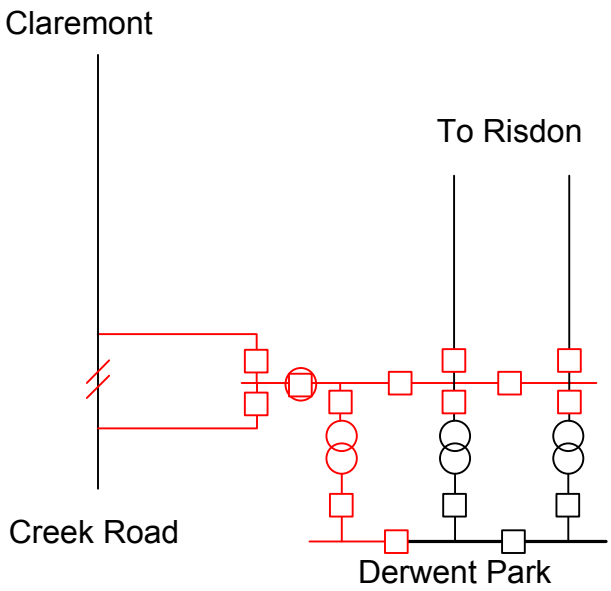
Ignoring the transformer and 11 kV costs since these are common to all options, the estimated cost for option 1 is as follows:

- Uprate existing 33 kV feeders to 31 MVA - $0.25 M
- 33 kV switchboard with 8 CBs in new switchgear building - $1 M
- 500m 33 kV underground cable - $0.25 M
- Total - $1.5 M

Option 2

Option 2 is similar to option 1, except that instead of teeing off the Creek Rd-Claremont 33 kV feeder, two new sections of 33 kV cable cut into the feeder. This option also requires an additional two 33 kV CBs, but removes the three-ended feeder resulting in a simplified protection scheme. Since Claremont is fed from Derwent Park under this option, the auto-changeover scheme is simplified (switching only needs to be performed at Derwent Park).

The resulting Derwent Park schematic is given below.



Ignoring the transformer and 11 kV costs since these are common to all options, the estimated cost for option 2 is as follows:

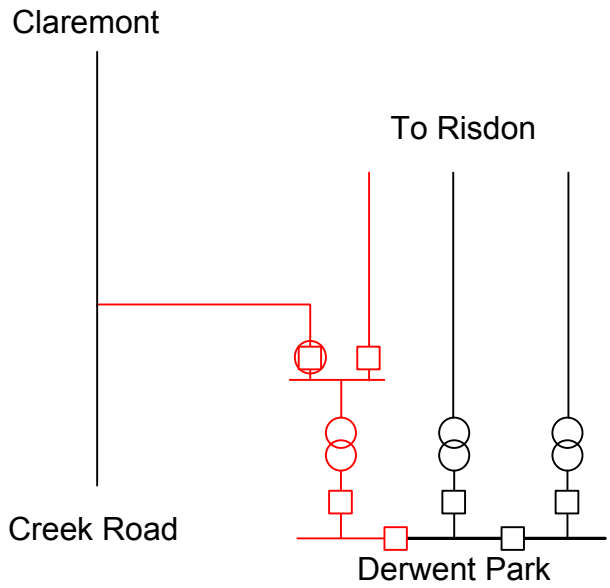
- Uprate existing 33 kV feeders to 31 MVA - $0.25 M
- 33 kV switchboard with 10 CBs in new switchgear building - $1.2 M
- 1000m 33 kV underground cable - $0.5 M
- Total - $1.95 M

Option 3

Option 3 involves the installation of a new 33 kV feeder from Risdon to Derwent Park and a new 33 kV RMU at Derwent Park. This option also installs the 33 kV cable to tee off the Creek Rd-Claremont 33 kV feeder as per option 1. The benefit of this option is that no auto-changeover scheme is required. This option is also familiar to Aurora, since a similar scheme has been proposed for Bellerive zone substation.

The new 33 kV feeder would allow the full load at Claremont to be transferred from Creek Rd to Risdon in the event of a contingency at Creek Rd.

The resulting Derwent Park schematic is given below.



Ignoring the transformer and 11 kV costs since these are common to all options, the estimated cost for option 3 is as follows:

- 33 kV RMU with two 33 kV CBs - $0.3 M
- 2.5 km 33 kV underground cable - $1.25 M
- New 33 kV CB at Risdon - $0.2 M
- Total - $1.75 M

The table below discusses the advantages and disadvantages of the three options.

Option	Advantages	Disadvantages
1	• Lowest cost option	• Requires three-ended protection scheme on the 33 kV teed feeder • Requires an auto-changeover scheme to perform switching at Derwent Park and Claremont
2	• Simpler protection scheme than other options since there is no three-ended feeder • Simpler auto-changeover scheme than option 1 since only local CBs need to be switched	• Requires two more 33 kV CBs than option 1 • Highest cost option
3	• Auto-changeover scheme is not required • Provides more transfer capacity than other options	• Requires three-ended protection scheme on the 33 kV teed feeder

Option 1 is the recommended development to address the system limitations identified in the long term strategic plan. While option 3 provides more transfer capacity than the other options, this does not defer any subsequent works (i.e. the new 33 kV injection point at McRobies Gully) in the long term plan since this augmentation is required shortly afterwards to address other limitations. However option 1 relies on the uprating of 33 kV feeders, the feasibility of which needs to be investigated in more detail. Thus these options should be re-examined closer to the requirement date.

Appendix D
Alternative options at Creek Rd

Appendix D

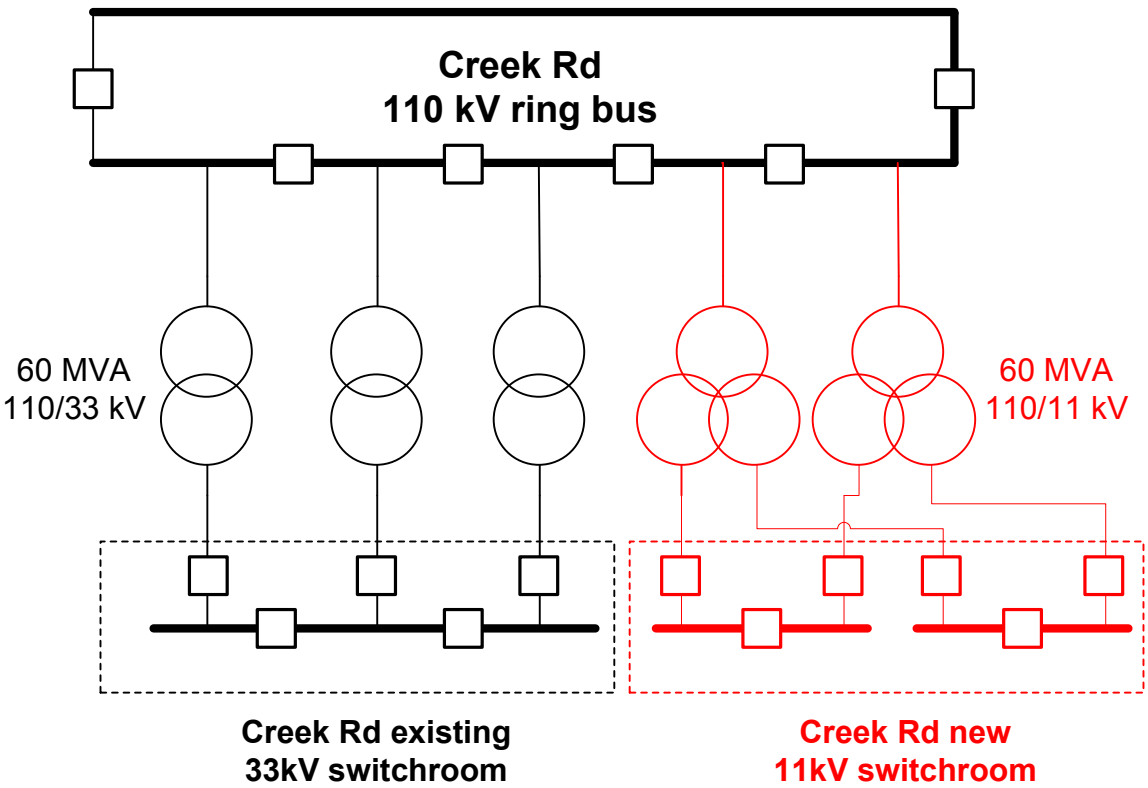
The option to establish Creek Rd as an 11 kV injection point is considered the best option to increase the firm capacity of the northern substation group. This is due to its ideal location equidistant from the heavily loaded Chapel St and North Hobart substations, its proximity to dense urban load, as well as the space on the existing substation site for development.

There are three alternative options to achieve 11 kV injection at the site.

Option 1

Option 1 involves the establishment of 110/11 kV transformers and a new 11 kV switchroom at the existing Creek Rd site. This option would require significant 110 kV works to establish the two new transformer bays, however it is expected that there is sufficient space on the site.

The resulting Creek Rd schematic is given below.



The estimated cost for option 1 is as follows:

- 110 kV bus reconfiguration to make space for new transformers - $3 M
- Two 110/11/11 kV transformers $8 M
- Two sections of 11 kV switchgear (18 CBs) in a new building $2 M
- **Total - $13 M**

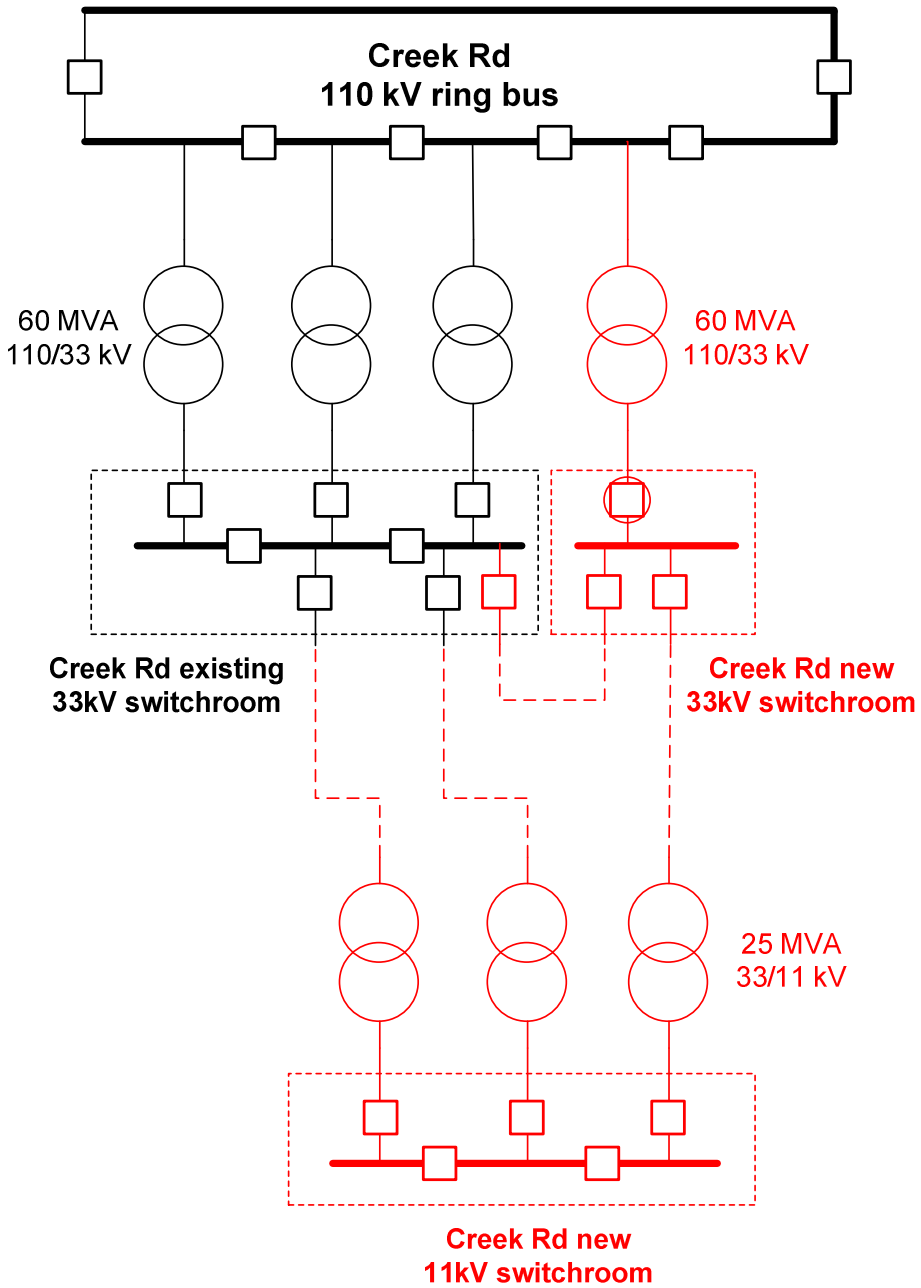
It should be noted that distribution feeder works have not been included as these are common to all options.

Option 2

Option 2 involves the establishment of a new zone substation at the existing Creek Rd site, as well as the installation of an additional 110/33 kV transformer to address the resulting load increase on the Creek Rd 110/33 kV transformers.

It is expected that the new transformer would need to be operated on hot standby to avoid increasing the 33 kV system fault level. An alternative would be to split Creek Rd 33 kV into two separate systems, however this causes problems at the three-transformer zone substations, since they would need to either have two feeders from a single 33 kV bus (loss of redundancy), or feeders from the both 33 kV systems (increased fault level or split 11 kV bus).

The resulting Creek Rd schematic is given below.



The estimated cost for option 2 is as follows:

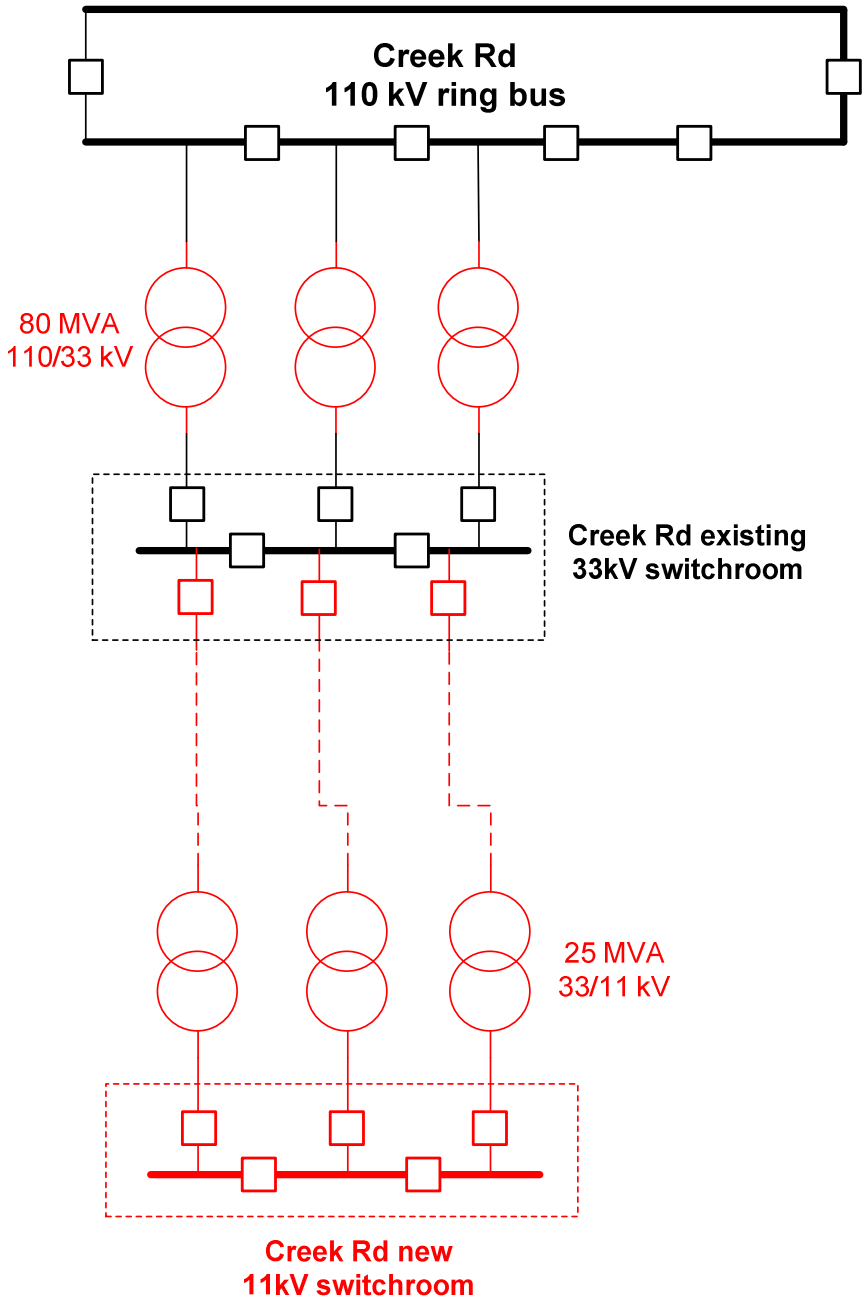
- 110 kV bus reconfiguration to make space for new transformer - $1 M
- One 110/33 kV transformer $4 M
- One 33 kV switchboard (6 CBs) in new switchgear building $1 M
- Extend existing 33 kV switchboard with bus section CB and bus tie cable $0.2 M
- 33 kV feeders cut over to the new bus to free up CBs for 33/11 kV transformers $0.4 M
- Three 33/11 kV transformers $6 M
- One section of 11 kV switchgear (17 CBs) in a new building $1.5 M
- **Total - $14.1 M**

It should be noted that distribution feeder works have not been included as these are common to both options.

Option 3

Option 3 also involves the establishment of a new zone substation at the existing Creek Rd site, with the replacement of the existing 60 MVA 110/33 kV transformers with 80 MVA units to address the resulting 33 kV load increase at Creek Rd.

The resulting Creek Rd schematic is given below.



The estimated cost for option 3 is as follows:

- Three 110/33 kV transformer $10 M
- Extend existing 33 kV switchboard with 3 x 33 kV CBs $0.2
- 33 kV feeders cut over to the new CBs to free up CBs for 33/11 kV transformers $0.3 M

- Three 33/11 kV transformers $6 M
- One section of 11 kV switchgear (17 CBs) in a new building $1.5 M
- **Total - $18 M**

It should be noted that distribution feeder works have not been included as these are common to both options.

The table below discusses the advantages and disadvantages of the options.

Option	Advantages	Disadvantages
1	• Lowest cost option • System not reliant on auto-changeover	• Transend have control of 11 kV circuit breakers (unless agreement can be reached for Aurora to own the 11 kV switchroom) • Uses an additional 110 kV bay than the other options
2	• In keeping with the Aurora strategy of 33/11 kV zone substations • Zone substation may be on an alternative site if space not available at Creek Rd • Flexibility to stage the installation of 3rd 33/11 kV transformer	• Results in a non-standard 33 kV configuration • 110/33 kV transformer needs to be on hot standby to reduce fault levels, and auto-changeover scheme required to bring transformer into service • New 33 kV switchboard and building required, and 33 kV feeder cutovers to balance feeders across the buses.
3	• No 110 kV works required • In keeping with the Aurora strategy of 33/11 kV zone substations • Zone substation may be on an alternative site if space not available at Creek Rd • Flexibility to stage the installation of 3rd 33/11 kV transformer	• Requires non-standard 80 MVA units (may require additional unit for spares) • Lower firm capacity than option 2

Option 1 is the recommended development to address the system limitations identified in the long term strategic plan. This is expected to be the lowest cost option and provide the most robust and secure solution. The 33/11 kV options have the flexibility to reduce initial costs by establishing a two transformer substation initially, however it is considered likely that the extra capacity would be required shortly after commissioning.

In terms of the long term plan, the options are roughly interchangeable – the 110/11 kV option does not impact the Creek Rd 33 kV load, while the 33/11 kV options increases both the ultimate 33 kV load and 33 kV firm capacity at Creek Rd.

It should be noted that the cost estimate above is indicative only and a more detailed analysis should be performed closer to the project requirement date. In particular the 110 kV costs need to be understood in greater detail. It is also worth noting that if control of the feeder circuit breakers is a strong project driver, Aurora should consider negotiating with Transend for ownership of the 11 kV switchgear. This could either be on the existing Transend site, or the switchgear could be installed on an adjacent block owned by Aurora.

Appendix E
Glossary

Appendix E – Glossary of terms

AAC – All Aluminium Conductor

AAAC – All Aluminium Alloy Conductor

ACO – Auto Change-Over

APR – Annual Planning Report

AVR – Automatic Voltage Regulation

CB – Circuit Breaker

CBD – Central Business District

DCCT – Double Circuit

DINIS – Power systems software package used by Aurora for load flow studies.

ESI regulations – Electricity Supply Industry regulations, transmission network performance standards specified by the Tasmanian Department of Energy

ECC – Emergency Cyclic Capacity

FLRS – Feeder Load Reporting System, Aurora database of historical distribution feeder loading.

HV – High Voltage

NCC – Normal Cyclic Capacity

NPV – Net Present Value

PMR – Pole-Mounted Recloser

RIT – Regulatory Investment Test

RMU – Ring Main Unit

SCCT – Single Circuit

TRIP – Targeted Reliability Improvement Project

WACC – Weighted Average Cost of Capital

Webmap – Software package used by Aurora to maintain geographical information about installed assets.

XLPE – Cross Linked Poly Ethylene