Hobart East Area Strategic Plan
System Capacity Planning Project
Aurora Energy

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Contents

Executive summary

The long term plan for Hobart East recommends the continuation of the existing zone substation strategy. The existing 33 kV injection point at Lindisfarne and future injection point at Mornington are expected to provide sufficient capacity to the area's zone substations for the scope of the study (after the installation of third transformers at each). Upgrades to the existing zone substations to increase firm capacity and address transformers age limitations are recommended and two new zone substations are proposed at Sandford and in the Risdon Vale area.

The ten year plan for Hobart East recommends the establishment of a new zone substation in the Sandford area in order to deload Rokeby substation and address feeder limitations to the peninsula. The plan also recommends the upgrade of Richmond zone substation to 33/11 kV and the replacement of ageing transformers at Lindisfarne and Geilston Bay substations to meet capacity requirements.

The five year plan for Hobart East examines the distribution networks of the six existing (including the Howrah and Rosny) zone substations and the impact of the proposed zone substation at Sandford. The only proposed feeder works in the five year plan is the establishment of a new feeder north from Geilston Bay zone substation. The five year plan also reviews the subtransmission networks from Lindisfarne and Mornington substations, recommending that Bellerive be transferred from Mornington to Lindisfarne after the establishment of Sandford zone substation in 2017.

The planning philosophy section proposes 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-East planning area consists of the area east of the Derwent River, from South Arm in the south to Bridgewater in the North.

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

Figure 2-1 Hobart-East planning area geographical view

Hobart-East 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 residential load.

There is significant rural-residential load in the Eastern and Southern regions of the planning area, with the commercial, industrial and urban-residential concentrated along the East bank of the Derwent River.

2.1 Existing infrastructure

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

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

Substation	Number of Transformers	Transformer MVA	Transformer Primary Voltage	Transformer Secondary Voltage	Number of Feeders
Lindisfarne	2	45 MVA	110 kV	33 kV	6 subtransmission
Rokeby	2	35 MVA	110 kV	11 kV	10 distribution

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

Substation	Number of transformers	Transformer MVA	Transformer primary voltage	Transformer secondary voltage	Number of Feeders
Bellerive	2	22.5 MVA	33 kV	11 kV	8 distribution
Cambridge	2	20 MVA	33 kV	11 kV	10 distribution
Geilston Bay	2	22.5 MVA	33 kV	11 kV	8 distribution
Richmond	2	2.5 MVA	22 kV	11 kV	3 distribution

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

This differs from the neighbouring Central and Sorell areas whose distribution voltage is 22 kV, limiting the available load transfers between substations of these areas.

2.2 Council areas and restrictions

The Hobart-East planning area encompasses the Clarence city council.

Clarence City Council

The Clarence City Council has indicated that the majority of future settlement in this region will be infill in existing urban areas, or growth on the fringes of the existing urban areas. As such, the primary source of future settlement is expected to be in and around the suburbs of Lauderdale, Howrah, Tranmere, Rokeby and Clarendon Vale.

2.3 Approved and proposed works

The following approved and proposed projects have been identified in the Aurora program of works. For the purpose of this report is assumed that these projects will be commissioned by 2012.

Hobart Eastern Shore Region

A joint planning study between Aurora and Transend has identified limitations within the Hobart Eastern Shore region transmission and distribution networks. The study recommends the establishment of a new Mornington terminal substation in 2011, as well as Howrah and Rosny zone substations in 2011 and 2012 respectively. There will also be a new 33 kV switching station installed at Bellerive zone substation, which allows the transfer of Bellerive between Mornington and Lindisfarne substations. Normal supply to Bellerive will be from Mornington substation.

The proposed works will deload the Rokeby and Lindisfarne terminal substations, and the Bellerive and Geilston Bay zone substations.

The study also proposes the replacement of the existing 2 x 45 MVA 110/33 kV transformers with 60 MVA units at Lindisfarne terminal substation in 2014, and the establishment of a Lauderdale zone substation in 2015. This option will be analysed as part of this report.

Richmond zone substation upgrade

Richmond zone substation is currently experiencing capacity and reliability issues. To address this, Aurora is considering replacement of the existing 22/11 kV transformers with 33/11 kV units, and reinforcing an existing 22 kV feeder to become a 33 kV subtransmission line from Lindisfarne terminal substation.

At the time of writing, Aurora are planning to replace the two 22/11 kV transformers with a single 10 MVA 33/22/11 kV transformer in 2012 and retaining supply at 22 kV.

3. Load forecast

The Hobart-East planning area has experienced growth from 2-3% per year for the past two years and sustained growth in this area is expected. Hobart-East is considered one of the growth hotspots in the state.

The long term medium growth rate from the Aurora forecast is approximately 2.7% for the Hobart-East planning area. Blanket load growth above this rate is considered unlikely, however higher growth is likely in certain areas.

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

- The area to the west of Hobart airport and east of Mt Rumney is considered a likely area for future significant commercial growth, with Cambridge a potential future commercial centre of the Eastern Shore. There is also the potential for long term residential subdivision in the surrounding area, with a significant amount of undeveloped land, flat terrain and access to the Tasman Highway.
- Subdivisions in the Lauderdale and Tranmere areas are expected to increase, with this area having the potential for reticulated water supply from the Rokeby treatment plant, and land corridors have been set aside by the Clarence council 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.

For the purposes of this study the planning area has been combined into a group of substations, with members of the group having significant transfer capacity amongst each other. The substations within the group are Cambridge, Geilston Bay, Bellerive, Howrah, Rosny and Rokeby. It is assumed that a capacity limitation occurs when the group load exceeds the sum of the firm capacities. Richmond substation has been considered separately, since it has limited load transfer capacity to adjacent substations.

Figure 3-1 and Figure 3-2 show the resulting 38 year load forecast and firm ratings for substations of the Hobart-East planning area are provided below.

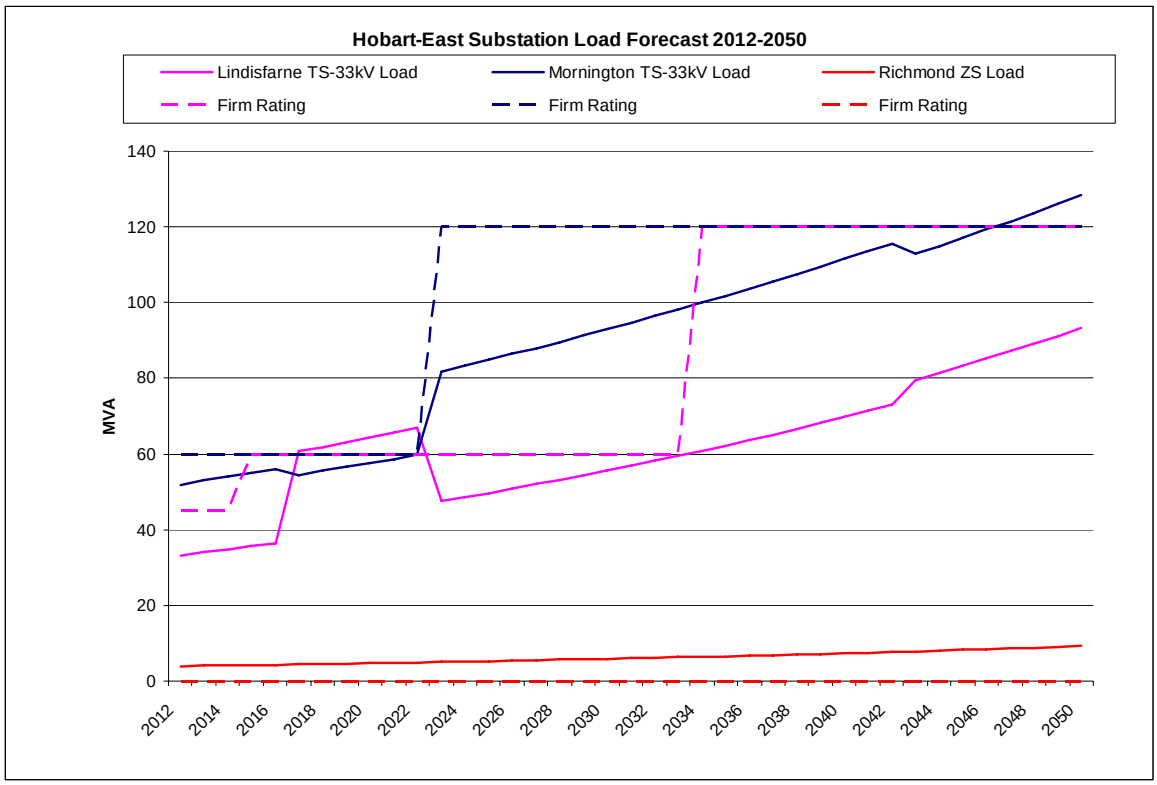

Figure 3-1 Hobart-East existing substation load forecast 2012-2050

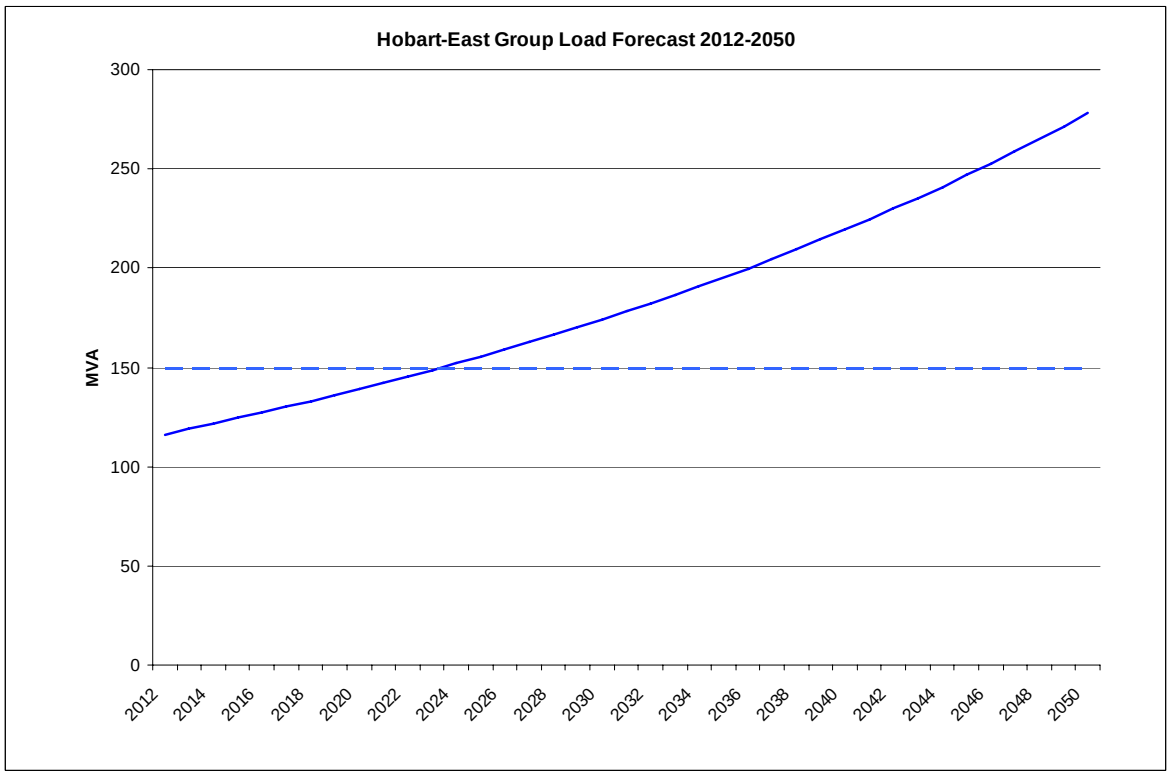

Figure 3-2 Hobart-East existing group load forecast 2012-2050

Figure 3-3 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.

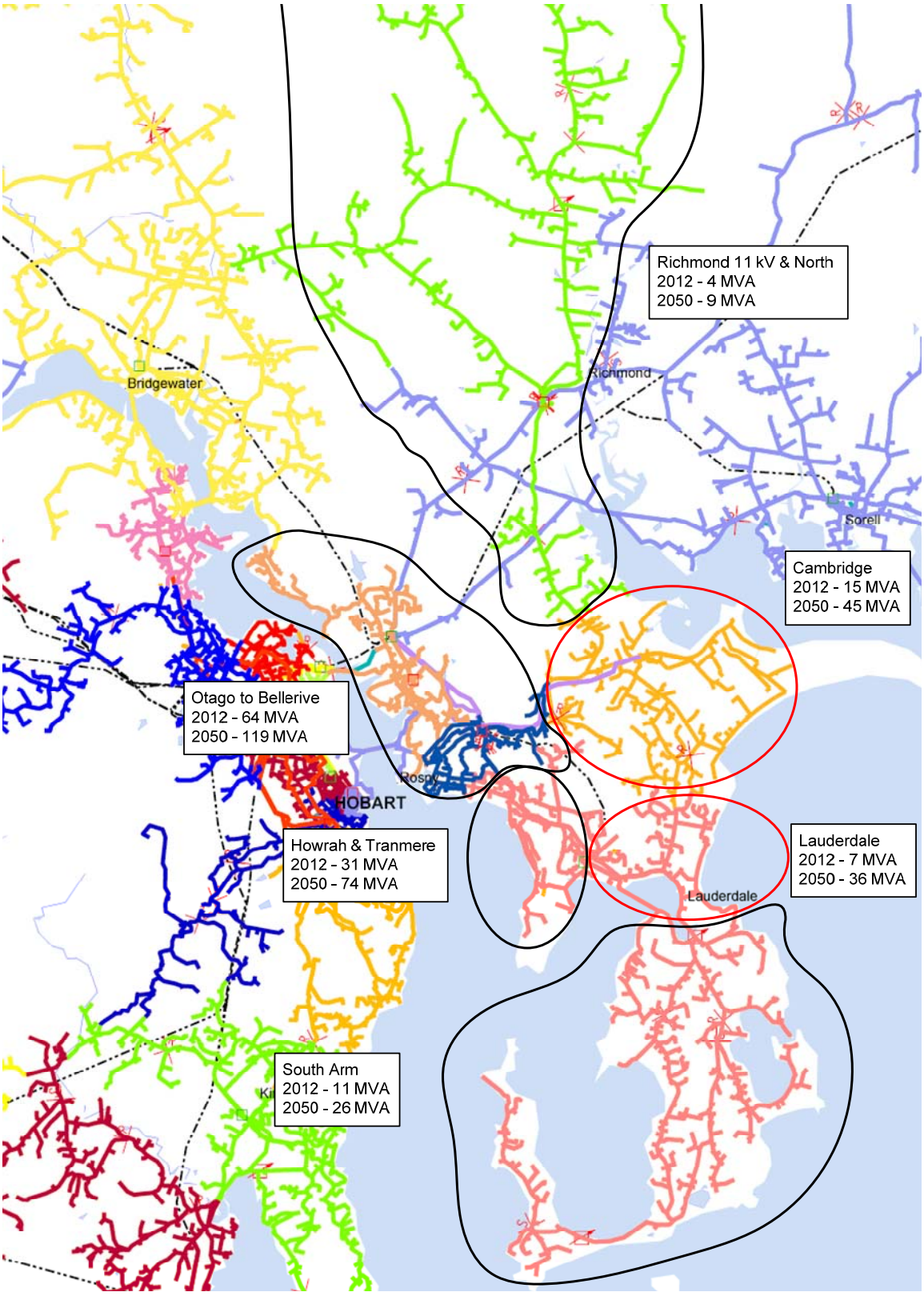

Figure 3-3 Hobart-East geographic load forecast 2012-2050

4. Limitations

4.1 Lindisfarne terminal substation

Lindisfarne terminal substation is equipped with 2 x 45 MVA 110/33 kV transformers, providing a firm capacity of 45 MVA. The transformers at Lindisfarne were installed in 1965.

Lindisfarne currently provides supply to the Bellerive, Geilston Bay and Cambridge zone substations and is loaded well in excess of its firm capacity. After Mornington 33 kV injection point is established in 2011, Bellerive will be supplied from Mornington substation with a normally open tie to Lindisfarne substation. Subsequently, Lindisfarne substation is forecast to exceed firm capacity in 2026.

4.2 Cambridge zone substation

Cambridge zone substation is equipped with 2 x 20 MVA 33/11 kV transformers, providing a firm capacity of 20 MVA. The transformers at Cambridge were installed in 2009.

The load at Cambridge is forecast to exceed firm capacity in 2023.

4.3 Geilston Bay zone substation

Geilston Bay 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 Geilston Bay have been deemed to be end of life in 2014/15.

The load at Geilston Bay substation is currently well in excess of firm capacity. Load transfers to Rosny zone substation in 2012 deload Geilston Bay by 11 MVA, with load subsequently forecast to exceed firm capacity again by 2025.

4.4 Bellerive zone substation

Bellerive 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 Bellerive substation have been deemed to be end of life in 2020/21.

The load at Bellerive substation is reduced in 2011 by load transfers to Howrah zone substation and is subsequently forecast to exceed firm capacity in 2028.

4.5 Mornington terminal substation

Mornington terminal substation will be equipped with 2 x 60 MVA 110/33 kV transformers, providing a firm capacity of 60 MVA.

Based on the load forecast provided by Aurora, load at Mornington substation is forecast to exceed firm capacity in 2020. However, in the event of a transformer contingency at Mornington, load may be reduced through the transfer of Bellerive substation to Lindisfarne and hence there is scope to use the emergency capacity of the transformer. The four hour emergency capacity of Mornington is 72 MVA. Load at Mornington substation is forecast to exceed emergency capacity in 2030.

4.6 Howrah zone substation

Howrah zone substation will be equipped with 2 x 25 MVA transformers, providing a firm capacity of 25 MVA.

Based on the load forecast provided by Aurora, load at Howrah is forecast to exceed firm capacity in 2025.

4.7 Rosny zone substation

Rosny zone substation will be equipped with 2 x 25 MVA transformers, providing a firm capacity of 25 MVA.

Based on the load forecast provided by Aurora, load at Rosny is forecast to exceed firm capacity in 2040.

4.8 Rokeby terminal substation

Rokeby terminal substation is equipped with 2 x 35 MVA transformers, providing a firm capacity of 35 MVA. The transformers at Rokeby were installed in 1982.

Load at Rokeby currently exceeds firm capacity. Load transfers to Howrah and Rosny zone substations in 2011 and 2012 respectively, defer this limitation until 2017.

There are two 11 kV feeders to Lauderdale and South Arm which currently exceed planning ratings. An additional feeder to South Arm is 1 MVA below its planning rating.

4.9 Richmond zone substation

Richmond zone substation is equipped with 2 x 2.5 MVA transformers, providing a firm capacity of 2.5 MVA. The transformers at Richmond have been recommended for replacement in 2010/11. These transformers are in poor condition and in the event of a transformer contingency it is difficult to transfer load to adjacent substations. The 11 kV network from Richmond does not phase out with the adjacent 11 kV network, so any load transfers would also need to be done break-before-make, resulting in customer outages.

The 11 kV network around Richmond overlaps with the 22 kV network from Sorell resulting in an undesirable mix of voltage levels at Richmond.

Load at Richmond currently exceeds firm capacity.

4.10 Lindisfarne-Mornington-Rokeby 110 kV transmission line

The establishment of Mornington terminal substation, supplying the Howrah, Rosny and Bellerive zone substations is forecast to increase the load on the Lindisfarne-Mornington-Rokeby 110 kV transmission line to approximately 82.5 MVA by 2012. This is well below the feeder firm capacity of 150 MVA for the Lindisfarne-Mornington section of the line.

The ESI rules stipulate that a single transmission asset failure must not result in unserved load in excess of 3000 MWh over a 48 hour period. A single tower failure on the Lindisfarne-Rokeby line would result in the loss of both lines, which implies that the total load supplied by the double circuit line should be limited to 62.5 MW.

However the installation of 33 kV switchgear at Bellerive zone substation allows load to be immediately transferred from Mornington to Lindisfarne in the event of such a contingency, which defers this limitation until approximately 2023.

5. Planning philosophy

For the purposes of this study the planning area has been combined into a group of substations, with members of the group having significant transfer capacity amongst each other. The substations within the group are Cambridge, Geilston Bay, Bellerive, Howrah, Rosny and Rokeby. It is assumed that a capacity limitation occurs when the group load exceeds the sum of the firm capacities. Richmond substation has been considered separately, since it has limited load transfer capacity to adjacent substations.

Hobart-East currently contains a significant 33 kV subtransmission network with three 33/11 kV zone substations supplied from a single 33 kV injection point at Lindisfarne. A new 33 kV injection point and two new zone substations are planned to be installed by 2012. Aurora are also planning to install a 33 kV switching station at Bellerive zone substation by 2012, which would enable the transfer of Bellerive between the Lindisfarne and Mornington 33 kV injection points and thus deferring capacity limitations at these substations.

As discussed in the Hobart-West report, the strategy of using 33 kV subtransmission and zone substations has many advantages and is the preferred strategy of Aurora and Transend for high density load areas. This strategy has been continued in the long term planning for Hobart-East.

The strategy of using 33 kV switchgear and meshed networks as described in the Hobart-West report was investigated with regard to Hobart-East, however the existing 33 kV injection points provide sufficient capacity for the scope of the study (after installation of a third transformer at each) and the location of future zone substations does not lend itself well to reuse of the existing 33 kV network, so this strategy was generally not pursued. The exception to this is the potential to reuse the Lindisfarne to Bellerive 33 kV circuits to supply a new zone substation between Geilston Bay and Bellerive in order to defer the third transformer installation at Lindisfarne. This is discussed further in the Lindisfarne upgrade project below.

Richmond zone substation is one of the few remaining 22/11 kV substations in the network, and Aurora are taking steps to convert Richmond to 33/11 kV by replacing the existing 22/11 kV transformers with a single 33/22/11 kV unit in 2012. Consideration has been given to rationalising the distribution voltages in the areas around Richmond zone substation where the 22 and 11 kV networks overlap. It is considered prudent to convert those sections of the 22 kV network from Sorell which supply west of the Coal River to 11 kV. This would provide transfer capacity between Richmond and Geilston Bay substations while improving security to those customers on those isolated sections of 22 kV feeder. The Coal River would then provide a natural barrier between the Hobart 11 kV network and the 22 kV network from Sorell.

Conversion of the Richmond 11 kV network to 22 kV was examined as an alternative to a 33/11 kV substation at Richmond. However the transfer capacity that is achieved between Richmond, Bridgewater, Geilston Bay and Cambridge substations is a strong driver for an 11 kV network in the area. Although this results in a boundary between the voltage levels at Richmond, this is considered a superior option to having multiple boundaries at the other substations.

The 11 kV network in the Colebrook area supplied from Richmond is currently experiencing power quality issues due to the starting of irrigation pumps. It is proposed that the 11 kV network in this area be converted to 22 kV and a new tie be built to Sorell in order to address the power quality issues. This would result in a second supply from Sorell into Oatlands which would relieve the reliability stress being experienced in that area.

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 Hobart Eastern Shore Region project addresses the bulk of the near-term limitations in the Hobart-East area, with the replacement of ageing transformers being the primary project driver in the near term. The exception to this is the requirement for a new zone substation in the Sandford area in 2017, and the consequent upgrade of the Mornington 33 kV injection point.

These works are sufficient to supply the Hobart-East load for the subsequent 15 years, around which time Rokeby and Lindisfarne exceed firm capacity and are upgraded accordingly. The remaining 20 years of the study require the installation of a new zone substation in Risdon Vale, and the upgrade of two existing zone substations to meet the forecast load.

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 Geilston Bay zone substation

The Geilston Bay transformers have been deemed end of life in 2014.

Therefore it is proposed that the existing 2 x 22.5 MVA transformers be replaced with 25 MVA units in 2014. The subtransmission feeders to Geilston Bay are rated 28.5 MVA, so the firm capacity at Geilston Bay will increase to 25 MVA. Should it be determined that the transformers are in good condition beyond 2014, the upgrade may be deferred until justified on condition basis.

6.1.2 Upgrade Lindisfarne terminal substation

The upgrade of Richmond zone substation to 33/11 kV and supplying from Lindisfarne would bring forward the capacity limitation on Lindisfarne substation from 2025 to 2021. However, Lindisfarne will reach its nominal 50 year lifespan in 2015, so upgrade in this timeframe is likely to be required anyway.

Therefore it is proposed that the existing two 45 MVA transformers be replaced with two 60 MVA units in 2015.

If it is determined that the existing 110/33 kV transformers are still in good condition beyond 2015, the transformer upgrade could be deferred by several years, depending on whether Lindisfarne is supplying Richmond by this time.

Alternatively, if the transformers still have plenty of life it may be better to keep the existing two 45 MVA transformers and install a single 60 MVA transformer with new 33 kV and 110 kV switchgear. The 45 MVA transformers would then be replaced with 60 MVA units as dictated by regular condition assessments. Ultimately, three 60 MVA transformers are required at Lindisfarne by 2034 to address capacity limitations.

This project is discussed in more detail in the five and ten year plans.

6.1.3 Upgrade Richmond zone substation to 33/11 kV

Aurora have indicated that to address the age and capacity limitations on the Richmond 22/11 kV transformers the existing transformers will be replaced by a single 10 MVA 33/22/11 kV transformer in 2012, with the substation continuing to take supply from Sorell 22 kV feeder 41512.

It is proposed that Richmond 22/11 kV substation be converted to 33/11 kV in 2017, with the 22 kV network to the south and west of Richmond re-energised at 11 kV and distribution transformers replaced with 11/0.433 kV units. Richmond would be supplied by re-insulating sections of 22 kV feeder to 33 kV and terminating on a new CB at Lindisfarne substation, resulting in a dedicated 33 kV feeder between Lindisfarne and Richmond.

The timing of the upgrade to 33 kV is driven by the ability to back up the Richmond 11 kV network via load transfers to adjacent substations, capacity/reliability constraints on the Sorell 22 kV feeders and Aurora resource availability (Aurora have indicated that 2017 is a reasonable target date).

This project would increase load on Lindisfarne substation, however the transformers at Lindisfarne are nominally end of life in 2015 so upgrade at Lindisfarne at this time is required anyway.

It is recommended that the 22 kV network be converted to 11 kV west of the Coal River running through Richmond, as this would serve as a natural barrier between the voltage levels and would provide increased 11 kV transfer capacity between Richmond, Bridgewater, Geilston Bay and Cambridge substations.

Aurora have indicated that the 11 kV network north of Colebrook is ultimately desired to be converted to 22 kV to address voltage drop issues and allow the starting of irrigation pumps in the area. It is recommended that this conversion be extended south towards Richmond as far as practical (ie north of Lowdina, where there is little load). Sorell feeder 41512 could then be extended north from Richmond to this point (10-15 km). This would provide a second feeder from Sorell into the Oatlands area, relieving the reliability issues which are expected in the area. These works could be completed with the Richmond conversion, or staged to happen as justified by reliability issues on feeder 41516 from Sorell into Oatlands.

Consideration should be given to the installation of a pad-mounted 22/11 kV transformer at strategic locations in order to allow transfer capacity between the Sorell and Richmond substations.

This project is discussed in more detail in the five and ten year plans.

6.1.4 Establish Sandford zone substation

Rokeby terminal substation is forecast to exceed firm capacity from 2017. It would be possible to address this limitation by upgrading Rokeby to 2 x 60 MVA transformers in 2017, however this would not address the 11 kV feeders to Lauderdale and the peninsula which currently exceed their planning ratings. The Rokeby transformers have an estimated end of life in 2032, so this solution also does not efficiently utilise existing assets.

Therefore it is proposed that a new zone substation with 2 x 25 MVA transformers be established in Sandford in 2017. The zone substation will be supplied from Mornington terminal substation via 2 x 33 kV underground feeders (approximately 10 km), and supply to the Lauderdale, Sandford and South Arm areas.

The establishment of Sandford zone substation will increase load at Mornington terminal substation above emergency capacity, so it is proposed that Bellerive zone substation be transferred to Lindisfarne at this time.

Considering that the group load does not exceed firm capacity until 2021 it may be possible to defer this project and address the Rokeby capacity constraint by 11 kV load transfers. However any significant deferral is considered unlikely as it is expected that the 11 kV feeder limitations to Lauderdale and the peninsula will drive the project. An alternative would be to install the 33 kV cables initially and energise at 11 kV, deferring the zone substation establishment until the subsequent feeder or firm capacity limitation.

This project is discussed in more detail in the five and ten year plans.

6.1.5 Upgrade Bellerive zone substation

The Bellerive transformers have been deemed end of life in 2020.

Therefore it is proposed that the existing 2 x 22.5 MVA transformers be replaced with 25 MVA units in 2020. The subtransmission feeders to Bellerive are rated 22.3 MVA, so these would be the limitation in the event of a feeder contingency. However there is a 33 kV switching station to allow Bellerive to be transferred to Lindisfarne in such a contingency, so for the purposes of this study the firm rating at Bellerive is considered to be the transformer rating.

Should it be determined that the transformers are in good condition beyond 2020, the upgrade may be deferred until justified on condition basis.

6.1.6 Upgrade Mornington terminal substation

The load at Mornington terminal substation is forecast to exceed firm capacity in 2023 and the load at Lindisfarne terminal substation is forecast to exceed firm capacity in 2034 (after the transfer of Bellerive zone substation to Mornington during contingencies).

Therefore it is proposed that a third 60 MVA transformer be installed at Mornington substation in 2023, with the associated 33 and 110 kV switchgear. It is also proposed that Bellerive zone substation be normally supplied from Mornington at this time in order to deload Lindisfarne below firm capacity.

6.1.7 Establish 3rd Lindisfarne-Mornington 110 kV transmission line

The load on the Lindisfarne-Mornington 110 kV transmission line is forecast to exceed the ESI limit of 62.5 MVA in 2023 after all 33 kV load transfers away from Mornington.

Therefore it is proposed that a new 110 kV transmission line be installed between Lindisfarne and Mornington (approximately 7 km) in 2023.

6.1.8 Upgrade Rokeby terminal substation

The substation group load forecast exceeds firm capacity in 2033. The transformers at Rokeby substation are predicted to reach end of life in approximately 2032.

Therefore it is recommended that the existing Rokeby transformers be replaced with 60 MVA units in 2032 to address the capacity and predicted age limitations.

6.1.9 Upgrade Lindisfarne terminal substation

The load at Lindisfarne terminal substation is forecast to exceed firm capacity in 2034.

Therefore it is proposed that a third 60 MVA transformer be installed at Lindisfarne substation in 2034, with the associated 33 and 110 kV switchgear.

An alternative option at this stage would be to establish a zone substation to the south of Geilston Bay, utilising the existing Lindisfarne to Bellerive 33 kV circuits. This would actually increase the load at Lindisfarne substation depending on how much load is transferred from Bellerive and Rosny zone substations, however it would also provide transfer capacity away from Lindisfarne for a transformer contingency. This would defer the third transformer at Lindisfarne by five to ten years while potentially superseding one of the zone substation projects discussed below.

A third option at this stage would be to run a short 33 kV double circuit from Mornington substation to cut into the existing Lindisfarne to Cambridge 33 kV circuits, thus supplying Cambridge from Mornington. The Lindisfarne end of the circuits could then be used to supply a new zone substation at an appropriate location.

The option chosen at this point is highly dependent on load growth. If the growth is in the Cambridge or Risdon Vale areas, then the Lindisfarne substation upgrade is probably the superior option. However if a zone substation is justified between Geilston Bay and Bellerive it is better to defer the Lindisfarne upgrade by establishing new 11 kV injection and taking advantage of the existing 33 kV feeder capacity and 110/33 kV transformer capacity at Mornington.

6.1.10 Upgrade Cambridge zone substation

The group firm capacity of the Hobart-East substations is exceeded again in 2039, with the Cambridge area having a forecast load of 31 MVA at this time according to the high growth forecast. Being relatively remote from the remainder of the Hobart-East substations, it is unlikely that a significant amount of load can be transferred to adjacent substations.

Therefore it is recommended that a third transformer be installed at Cambridge substation at this time, supplied from a third 33 kV feeder from Mornington.

It should be noted that this project is heavily dependent on the load growth in the Cambridge area. It may be that the project can be deferred, or interchanged with the Risdon Vale or Howrah/Rosny projects below, or the upgrade of a more suitable zone substation, depending on the location and magnitude of load growth. Another option would be the establishment of a new zone substation in the vicinity of Acton Park, should the load in the Lauderdale area require additional support from the north.

6.1.11 Establish Risdon Vale zone substation

The group firm capacity of the Hobart-East substations is exceeded again in 2045. To address this limitation it is proposed that a new zone substation be established in the Risdon Vale area in 2045.

The substation will be 2 x 25 MVA transformers, supplied from 2 x 33 kV underground feeders from Lindisfarne (approximately 2 km).

It should be noted that the location of the new zone substation is highly dependent on load development, and it may be that a better development at this stage would be to install a third transformer at Bellerive, or establish a new zone substation between Geilston Bay and Bellerive utilising the existing Lindisfarne to Bellerive 33 kV circuits. This should be evaluated closer to the date.

6.1.12 Upgrade Howrah/Rosny zone substation

The group firm capacity of the Hobart-East substations is exceeded again in 2049. In particular, Howrah and Rosny zone substations are forecast to be well above firm capacity. The lowest cost way to address this limitation would be to install a third 33/11 kV transformer be installed at Howrah or Rosny, supplied from a new 33 kV feeder from Mornington (approximately 3 km). However should the 11 kV feeder network between the two substations also require significant augmentation, a new zone substation between the two may be the better solution. This should be evaluated closer to the date.

6.2 Summary of proposed works

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

Table 6-1 Hobart-East project summary

Year	Proposed Project	Proposed Outcomes
2014	Upgrade Geilston Bay zone substation	Replace ageing 33/11 kV transformers and increase firm capacity at Geilston Bay
2015	Upgrade Lindisfarne terminal substation	Replace ageing 110/33 kV transformers and increase firm capacity at Lindisfarne

Year	Proposed Project	Proposed Outcomes
2017	Upgrade Richmond zone substation to 33/11 kV	Convert sections of 22 kV encroaching on Hobart-East to 11 kV and establish a 33 kV feeder from Lindisfarne
2017	Establish Sandford zone substation	Deload Rokeby and relieve Lauderdale and South Arm 11 kV feeders
2020	Extend 22 kV feeder 41512 to Oatlands and convert Colebrook to 22 kV	Address power quality issues on the Richmond northern 11 kV network and reliability issues in the Oatlands area
2020	Upgrade Bellerive zone substation	Replace ageing 33/11 kV transformers and increase firm capacity at Bellerive
2023	Upgrade Mornington terminal substation	Increase firm capacity at Mornington
2023	Establish 3rd Lindisfarne-Mornington 110 kV transmission line	Address ESI 62.5 MW limitation on Lindisfarne-Mornington double circuit 110 kV line
2032	Upgrade Rokeby terminal substation	Replace ageing 110/11 kV transformers and increase firm capacity at Rokeby
2034	Upgrade Lindisfarne terminal substation	Increase firm capacity at Lindisfarne
2039	Upgrade Cambridge zone substation	Increase firm capacity at Cambridge and address group firm capacity limitation
2045	Establish Risdon Vale zone substation	Address group firm capacity limitation
2049	Upgrade Howrah/Rosny zone substation	Address group firm capacity limitation

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

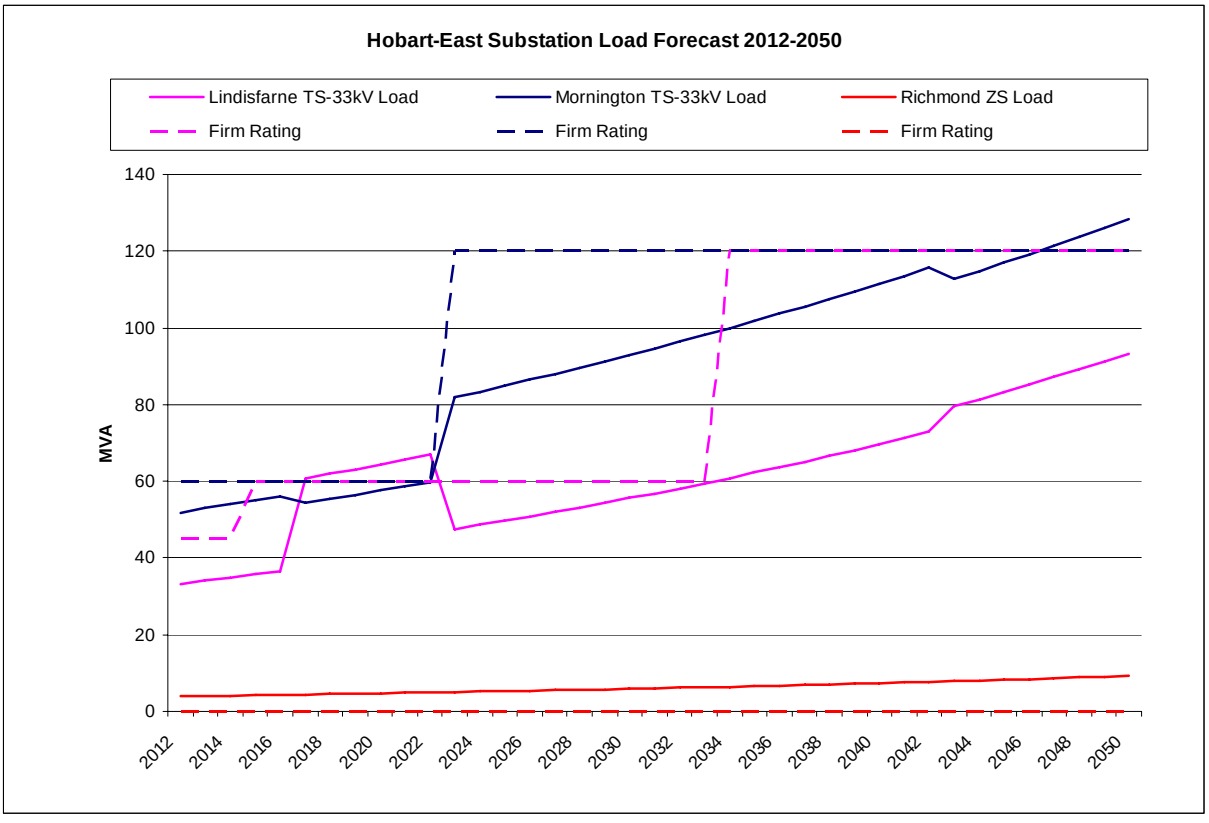

Figure 6-1 Hobart-East proposed substation load forecast 2012-2050

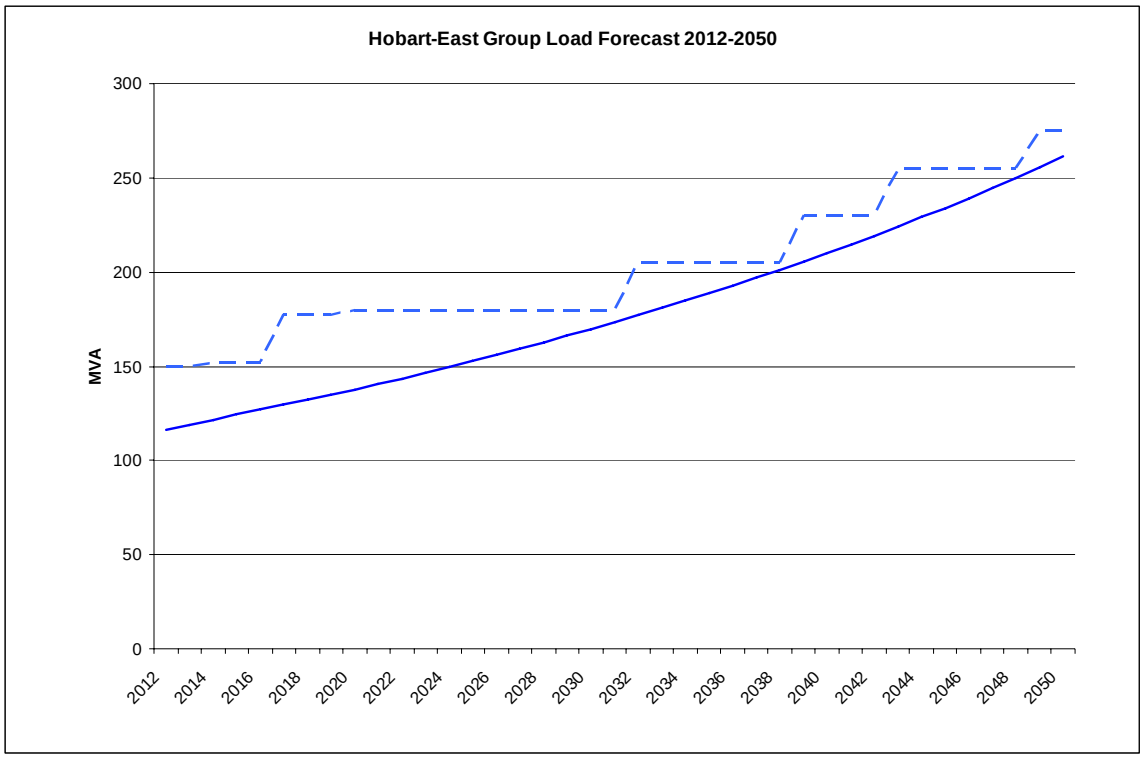

Figure 6-2 Hobart-East proposed group load forecast 2012-2050

7. Ten year plan

The ten year plan for Hobart-East recommends the establishment of a new zone substation at Sandford in order to deload Rokeby terminal substation and address 11 kV feeder capacity and reliability issues in the Lauderdale and peninsula areas. The plan also recommends the replacement of ageing transformers at Lindisfarne, Geilston Bay and Bellerive substations.

In addition, a project is proposed to convert the 22 kV network to the south and west of Richmond zone substation to 11 kV, and Richmond zone substation is proposed to be supplied at 33 kV from Lindisfarne.

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 Geilston Bay zone substation

Limitations

The Geilston Bay 2 x 22.5 MVA 33/11 kV transformers have been deemed to be end of life by 2014.

Option 1 (recommended option) – Upgrade Geilston Bay 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 2014.

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 a feasible option as the Geilston Bay transformers are expected to be end of life by 2014. However should it be determined that the transformers are in good condition beyond 2014, 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 Upgrade Lindisfarne terminal substation

Limitations

The Lindisfarne 2 x 45 MVA 110/33 kV transformers are ageing and have been recommended for replacement by Transend in 2015.

Option 1 (recommended option) – Upgrade Lindisfarne zone substation

To address the above limitations, it is proposed that the existing 110/33 kV transformers be replaced with new 60 MVA units in 2015.

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 Lindisfarne transformers are predicted to reach an age limitation around 2015.

Recommended option

The scope of works includes:

- Replacement of the existing transformers with two 110/33 kV 60 MVA transformers

The estimated cost for the upgrade is $7 million.

7.1.3 Convert Richmond zone substation to 33/11 kV

Limitations

Richmond zone substation is currently equipped with 2 x 2.5 MVA transformers, providing a firm capacity of 2.5 MVA. The transformers at Richmond have been recommended for replacement and Aurora has indicated that they will likely be replaced in 2012 with a 10 MVA 33/11 kV unit, with an off-load tap changer installed to provide a 22 kV tap. Richmond would initially retain its supply from Sorell 22 kV feeder 41512.

The star-star connection of the new transformer would remove the phase shift that currently exists between Richmond and the adjacent 11 kV networks.

A geographical network diagram of the Richmond area is shown in Figure 7-1.

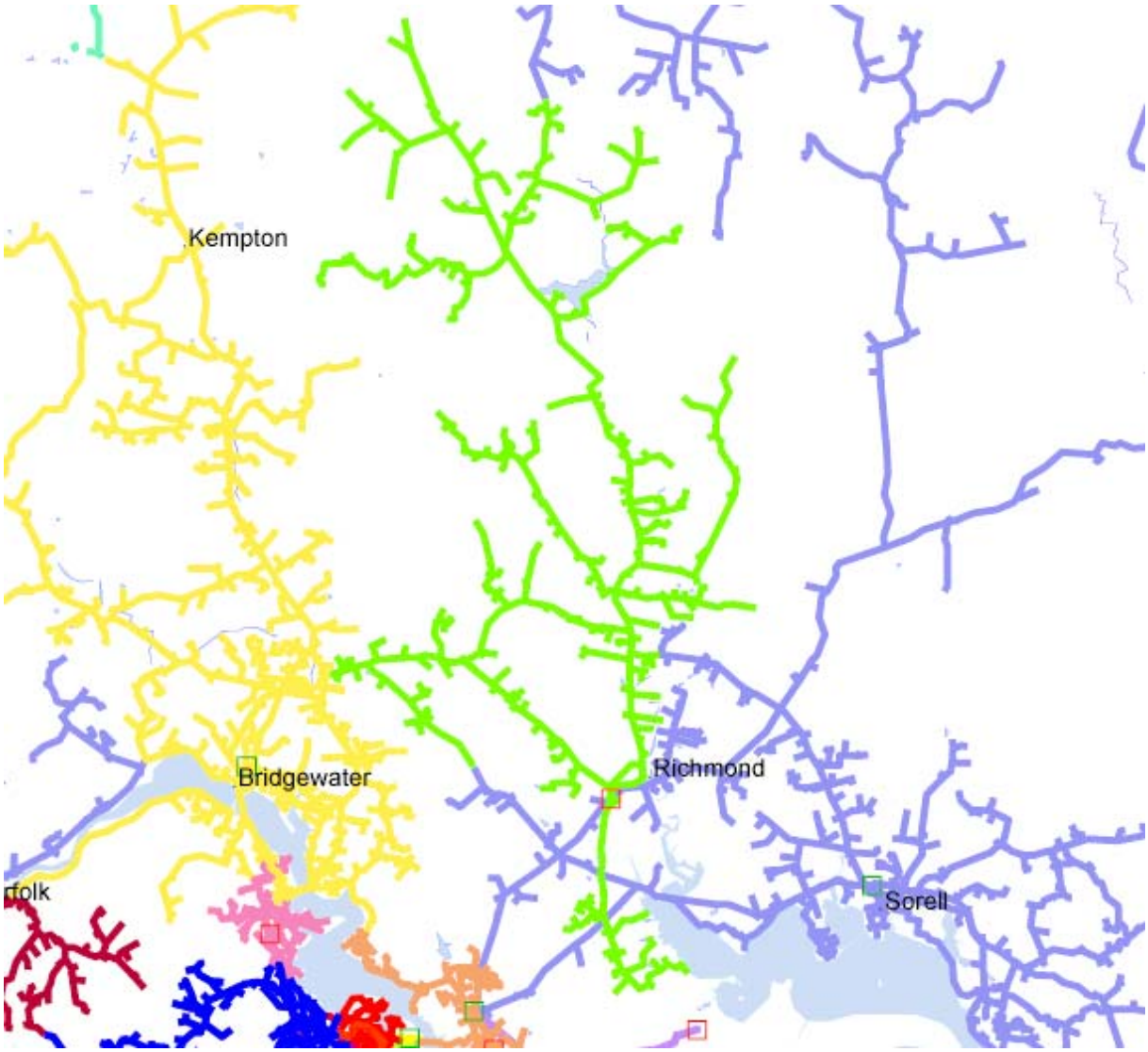

Figure 7-1 Richmond zone substation existing geographic network diagram

As shown above, the 11 kV network to the south of Richmond overlaps with the 22 kV network from Sorell, resulting in an undesirable mix of voltage levels and limiting the transfer capacity between Richmond and the surrounding 11 kV network.

The ten year load forecast for Richmond zone substation is outlined in Figure 7-2.

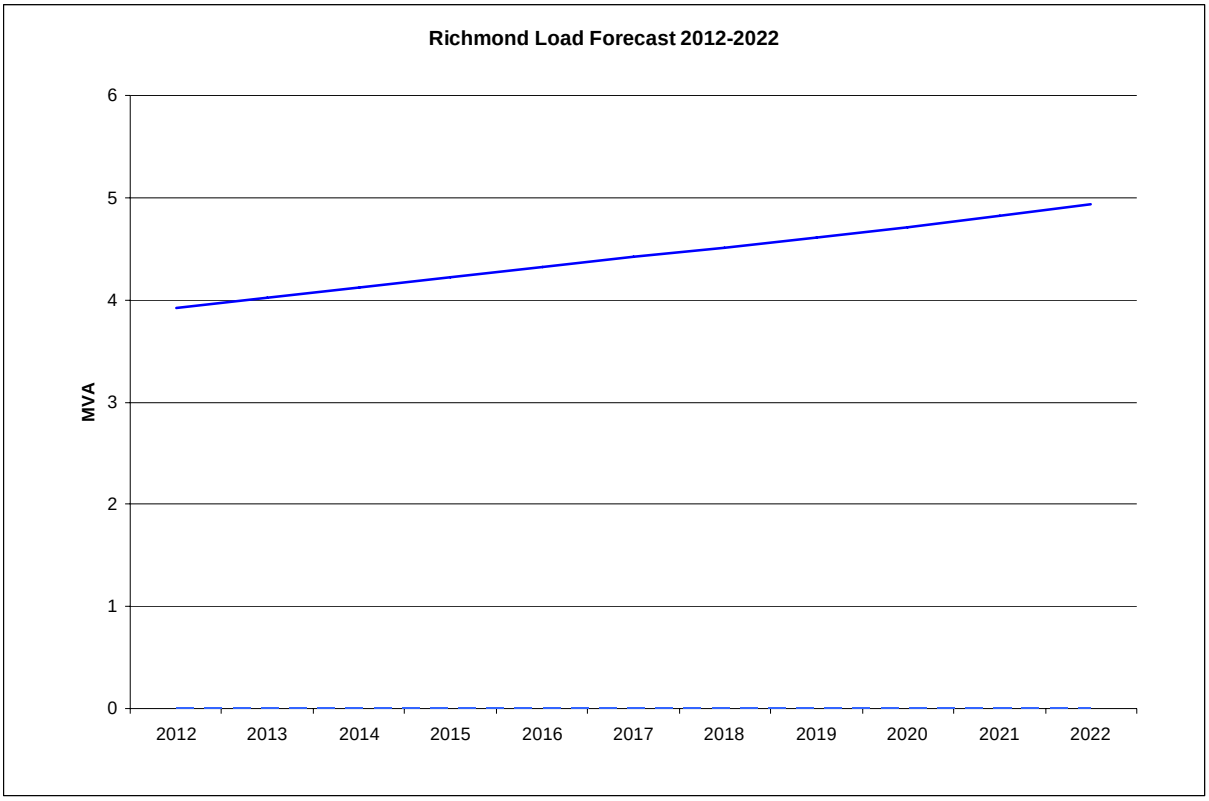

Figure 7-2 Richmond zone substation load forecast 2012-2022

As outlined above, the load at Richmond is forecast to exceed firm capacity by approximately 4 MVA in 2012, however 11 kV load transfers to Cambridge and Bridgewater can deload Richmond for the scope of the study.

Option 1 (recommended option) – Convert Richmond zone substation to 33/11 kV

This option involves the conversion of the existing 22 kV network to the south and west of Richmond to 11 kV and the establishment of a new 33 kV feeder from Lindisfarne to Richmond. All of Sorell feeder 41512 to the west of the Coal River running through Richmond would be re-energised at 11 kV, with distribution transformers replaced with new 11/0.415 kV units (approximately 80).

A 9 km section of the southern-most section of 22 kV line would be reinsulated to 33 kV and underbuilt with 11 kV line. A new 33 kV overhead line would then be established for the remaining 4 km run to Richmond zone substation.

Richmond would thus be supplied from Lindisfarne at 33 kV, and the newly converted 11 kV network would be supplied from Richmond and Geilston Bay substations.

Aurora has indicated that revenue and resources would be available to complete these works in 2017.

As the estimated cost of works is less than $5M a Regulatory Investment Test (RIT) is not required for this project.

This project deloads Sorell feeder 41512 by approximately 4.5 MVA in 2017, which allows load to be transferred from 41516 to 41512, thus addressing reliability issues on feeder 41516. This is discussed in the Sorell section of the report, however it is a benefit of option 1 that is not addressed by the other options.

Option 2 – Install second 33/22/11 kV transformer at Richmond

This option involves the installation of a second 33/22/11 kV transformer at Richmond, supplied from Sorell feeder 41512. This would address the lack of firm capacity at Richmond, however additional works would be required to address the reliability issues on 22 kV feeder 41516.

This option would ultimately require conversion of the 22 kV network to the South and west of Richmond to 11 kV as per option 1, since load growth in the area will eventually drive the requirement for transfer capacity, however it is assumed this may be delayed by five years

Technical comparison

Table 7-1 Technical comparison of options

Option	Description	Advantages	Disadvantages
1	Convert Richmond zone substation to 33/11 kV	• Reliability improvement since Richmond has a dedicated source of supply • Decreases load on Sorell substation and Sorell 22 kV feeder 41512 • Increases transfer capacity between Richmond and surrounding substations • Removes non-standard 22/11 kV zone substation from network • Deloads 41512, allowing it to be used to support 41516	• Increases load on Lindisfarne
2	Install second 33/22/11 kV transformer at Richmond	• Provides firm capacity at Richmond substation	• Non-standard 22/11 kV zone substation remains in network • No transfer capacity between Sorell feeder 41512 and adjacent 11 kV feeders

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	4.0	4.1	2.6
2	1.0	5.5	2.7

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 Aurora scope of works includes:

- Replacement of approximately 80 x 22/0.415 kV distribution transformers with 11/0.415 kV units
- Re-insulation of 9 km of existing 22 kV line to 33 kV, and underbuild with 11 kV
- Establish 4 km of single circuit 33 kV from Richmond substation to join the re-insulated sections

The Transend scope of works includes:

- Installation of 33 kV feeder circuit breaker at Lindisfarne and termination of new feeder tail

A geographic diagram of the proposed works is shown in Figure 7-3.

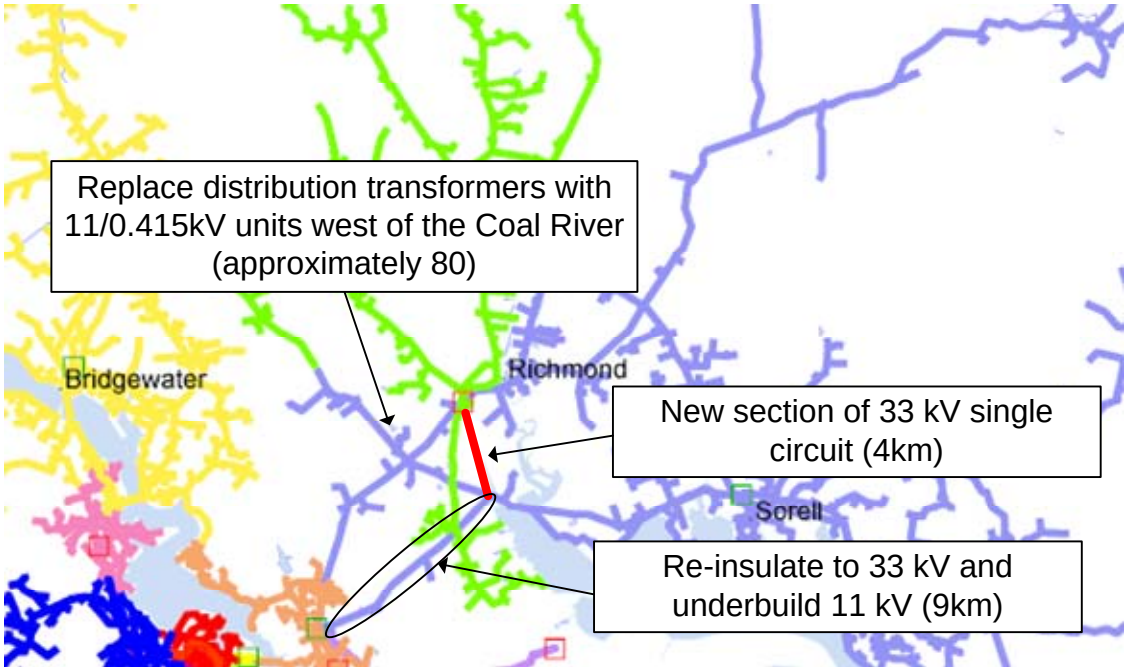

Figure 7-3 Proposed geographic network diagram

7.1.4 Establish Sandford zone substation

Limitations

Rokeby terminal substation is equipped with 2 x 35 MVA 110/11 kV transformers providing a firm capacity of 35 MVA. The transformers at Rokeby were installed in 1982 which implies a nominal end of life in 2032.

A geographical network diagram (following the Hobart Eastern shore upgrade in 2011 and 2012) of the Rokeby supply area is shown in Figure 7-1.

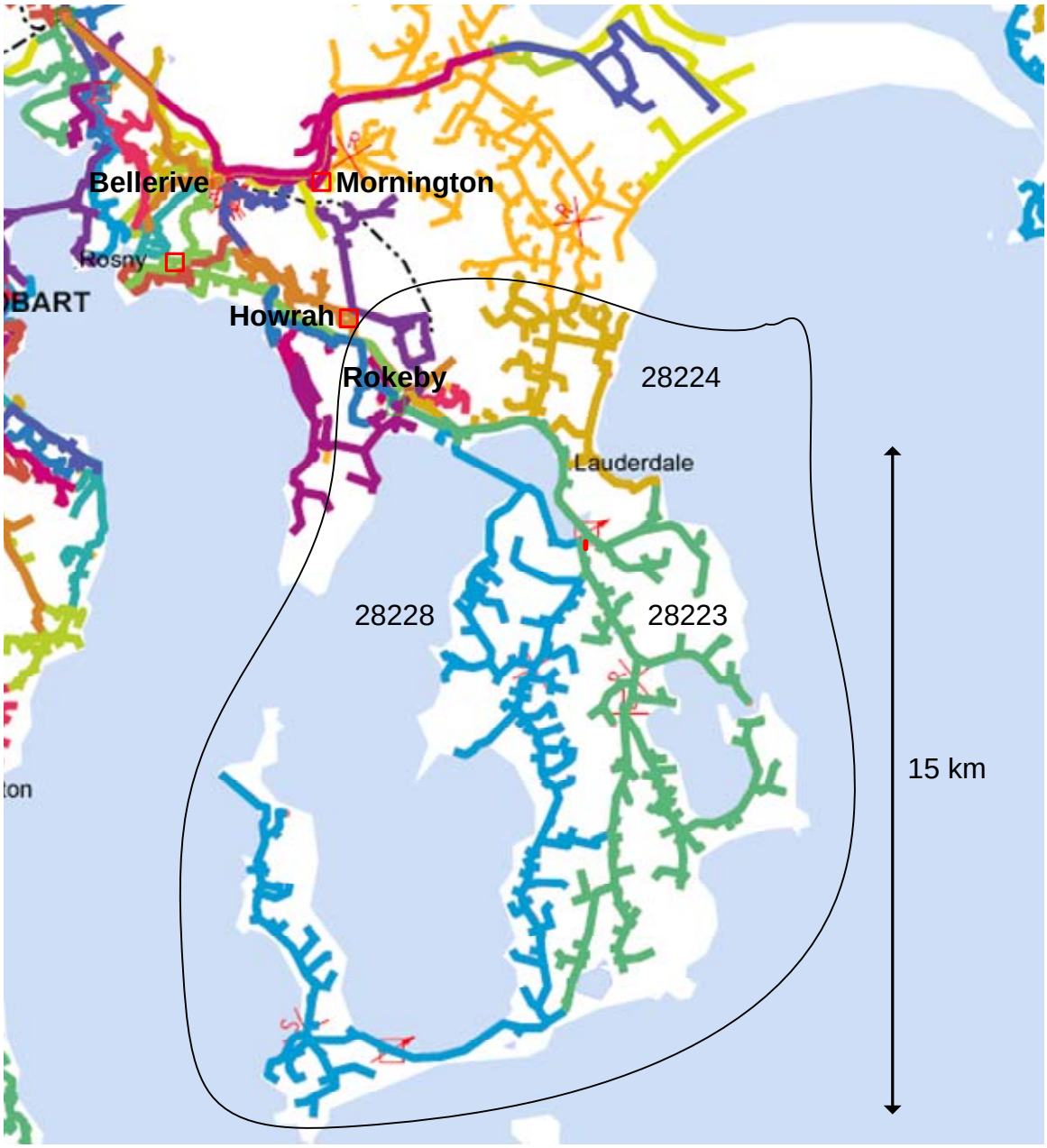

Figure 7-4 Rokeby substation existing geographic network diagram

As outlined above, 11 kV feeders 28223 and 28228 which supply to the peninsula from Rokeby are greater than 15 km long. The combined load on these feeders is forecast to exceed their combined planning rating of 10 MVA in 2015, increasing to 12 MVA in 2022. Feeder 28224 is also forecast to be heavily loaded, increasing from 3.7 MVA to 4.7 MVA between 2012 and 2022.

The ten year load forecast for Rokeby and Mornington terminal substations the Hobart East substation group is outlined in Figure 7-5.

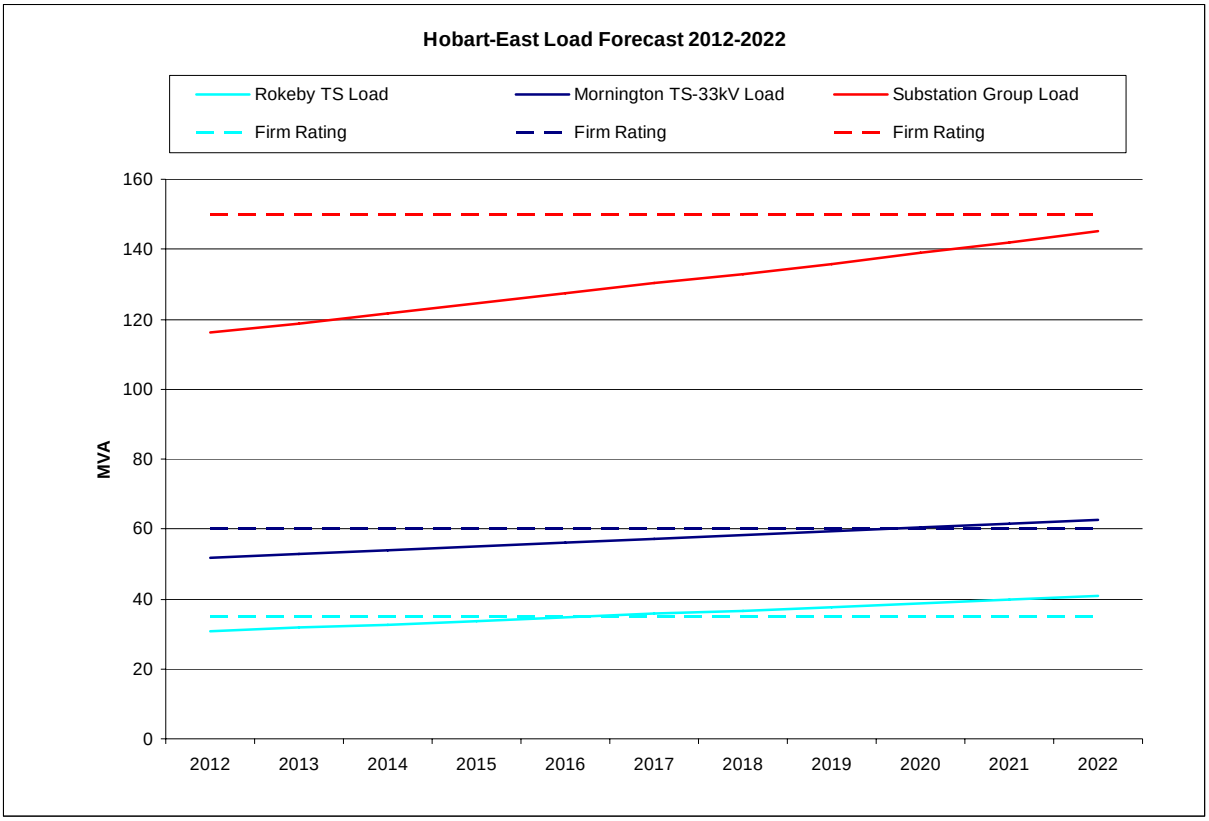

Figure 7-5 Hobart East existing load forecast 2012-2022

As outlined above, the load at Rokeby is forecast to exceed firm capacity in 2017. It is possible that this limitation could be deferred by load transfers to adjacent substations. However the substation group load is also forecast to exceed firm capacity in 2021, which implies that additional firm capacity will be required in the area. There are currently ten distribution feeders emanating from Rokeby. Assuming an average loading of 3.75 MVA per distribution feeder, the maximum load able to be supplied by the existing Rokeby 11 kV network is 37.5 MVA. This load will be exceeded at Rokeby in 2019 (taking into account the establishment of Howrah and Rosny prior to 2012).

As also outlined above, the load on Mornington terminal substation is forecast to exceed firm capacity in 2020.

Option 1 (recommended option) – Establish Sandford zone substation

This option involves the establishment of a new zone substation in the Sandford area supplied by 2 x 33 kV cables from Mornington terminal substation in 2017.

Sandford 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 Mornington (approximately 14 km).

The 11 kV network would be reconfigured with minimal augmentation such that the existing three 11 kV feeders to the peninsula would be used to support the Lauderdale and Rokeby areas from Sandford. The two long feeders to the south would be split into five feeders initially, with future feeders established as required.

To defer the firm capacity limitation at Mornington, it is also proposed that Bellerive zone substation be normally supplied from Lindisfarne following the establishment of Sandford zone substation.

Option 2 – Establish Lauderdale zone substation

This option is identical to option 1, except that the zone substation is established in the Lauderdale area rather than on the peninsula.

This option would require a shorter 33 kV feeder run initially, but would require significantly more 11 kV reinforcement both initially and ultimately. The forecast 2050 load on the peninsula is approximately 26 MVA, so the entire Lauderdale substation would be dedicated to supplying to the south and many additional 11 kV feeders would ultimately be required across the narrow isthmus to the peninsula.

Option 3 – Upgrade Rokeby terminal substation

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

This option would require significant 11 kV reinforcement the peninsula and Lauderdale areas to address feeder capacity and reliability issues. Aurora have advised that feeder routes along South Arm Rd between Rokeby and Lauderdale are difficult to obtain. Thus it is assumed that the second round of feeder reinforcement from Rokeby to the peninsula would need to be via sub-marine cables.

Technical comparison

Table 7-3 Technical comparison of options

Option	Description	Advantages	Disadvantages
1	Establish Sandford zone substation	• Increases group firm capacity by 25 MVA • Results in shortest 11 kV feeders and hence best reliability of all options • Optimally utilises existing assets	• Requires a longer 33 kV cable run than option 2 • Increases load on Mornington substation and advances firm capacity limitation • Requires purchase and establishment of a new site
2	Establish Lauderdale zone substation	• Increases group firm capacity by 25 MVA • Requires a shorter 33 kV cable run than option 1	• Requires significant 11 kV reinforcement to the peninsula • Increases load on Mornington substation and advances firm capacity limitation • Substation location not ideal to supply ultimate load • Requires purchase and establishment of a new site

Option	Description	Advantages	Disadvantages
3	Upgrade Rokeby terminal substation	• Increases group firm capacity by 25 MVA • Defers the Mornington firm capacity limitation • Utilises existing site	• Fails to fully utilise existing Rokeby transformers (15 years life remaining) • Requires significant 11 kV reinforcement to the peninsula • Difficulty getting additional 11 kV feeders out of Rokeby and onto the peninsula due to congestion

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

Cost comparison

Table 7-4 Cost comparison of options

Option	Initial Capital Cost	Total Capital Cost	Net Present Value
1	14.2	27.2	13.5
2	15.5	28.5	14.4
3	15.5	30.8	13.7

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 Aurora scope of works includes:

- Establishment of new zone substation site at Sandford
- Installation of 2 x 25 MVA 33/11 kV transformers
- Installation of two sections of 11 kV switchgear, with two transformer CBs, eight feeder CBs and a bus section CB inside a new switchgear building
- Installation of an underground 33 kV double circuit from Mornington (approximately 14 km)
- 11 kV feeder works to split existing feeders 28223 and 28228 into five feeders. Minor additional 11 kV works could also be undertaken to split the feeders further to provide support to Rokeby, although this could likely be deferred until justified by feeder constraints. This is examined in more detail in the five year plan in Section 8.9.

It is also proposed to perform switching at Bellerive zone substation such than Bellerive is normally supplied from Lindisfarne rather than Mornington.

It should be noted that if the load at Rokeby does not eventuate as per the forecast, it may possible to defer the substation establishment by reinforcing the distribution network from Rokeby initially. This reinforcement could be built at 33 kV in order to simplify the future establishment of a zone substation in the Sandford area.

The resulting load forecast is given in Figure 7-6.

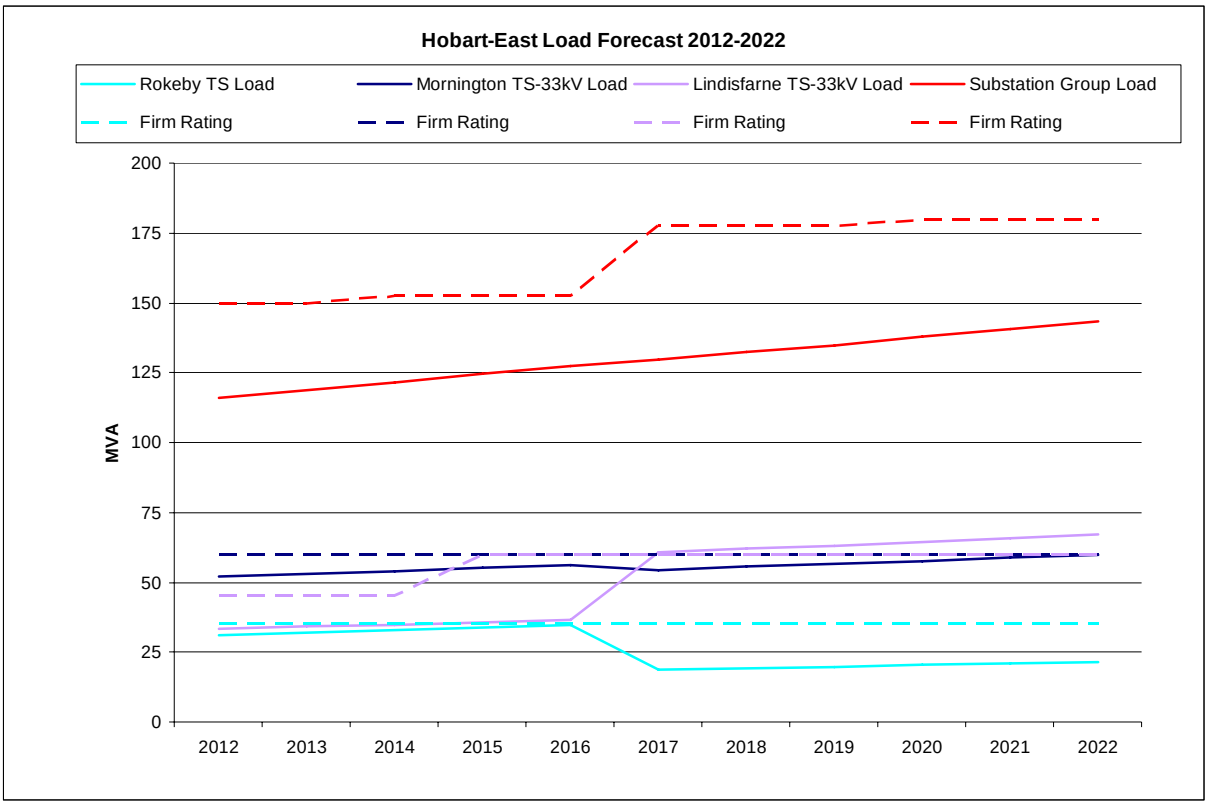

Figure 7-6 Hobart East proposed load forecast 2012-2022

As outlined above, the proposed works deload Rokeby substation by approximately 15 MVA, and increase load on Mornington substation by the same amount, however this is offset by the transfer of Bellerive to Lindisfarne. The load at Lindisfarne is further increased in 2017 by the establishment of Richmond as a 33/11 kV substation, supplied from Lindisfarne.

As a result, the load at Lindisfarne is forecast to exceed firm capacity in 2017, however load is within the emergency capacity of the substation and the transfer of Bellerive back to Mornington can reduce load to below normal capacity for the scope of this study.

Geographic and schematic diagrams of the proposed works are shown in Figure 7-7 and Figure 7-8.

Figure 7-7 Proposed geographic network diagram

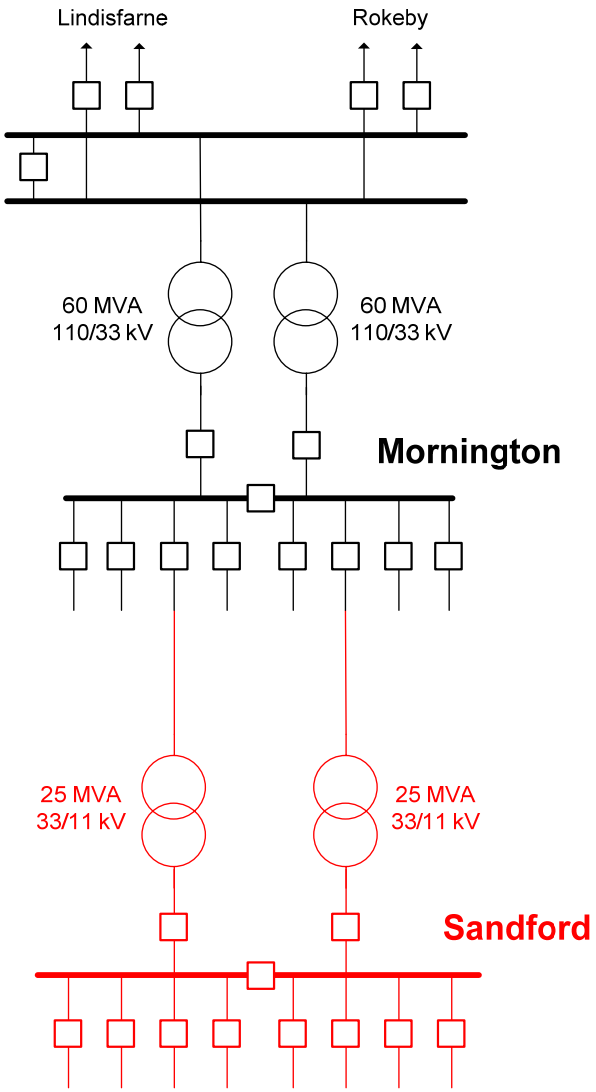

Figure 7-8 Proposed schematic network diagram

7.1.5 Upgrade Bellerive zone substation

Limitations

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

Option 1 (recommended option) – Upgrade Bellerive 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 a feasible option as the Bellerive transformers are expected to be end of life by 2020. However should it be determined that the transformers are in good condition beyond 2014, 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.

7.1.6 Extend 22 kV feeder 41512 to Oatlands and convert Colebrook to 22 kV

Limitations

Sorell 22 kV feeder 41516 currently supplies into the Oatlands (2.3 MVA), Richmond (1.2 MVA) and Sorell (0.7 MVA) areas. Aurora have indicated that the Oatlands area is currently experiencing reliability issues, with the current round of reliability works in the area expected to relieve these limitations until approximately 2020. There are 22 kV feeders from Meadowbank and Avoca which have ties to 41512, however each of these feeders is over 80 km in length to Oatlands and both are experiencing reliability issues themselves.

Sorell 22 kV feeder 41512 currently supplies Richmond 22/11 kV substation as well as some 22 kV distribution load in Sorell, Midway point and between Richmond and Lindisfarne. This feeder is expected to be deloaded significantly in 2017, when Richmond is converted to 33/11 kV and much of the 22 kV network between Richmond and Lindisfarne is converted to 11 kV.

Aurora have indicated that the 11 kV network in the Colebrook area, to the South of Oatlands, is currently experiencing power quality issues such as voltage drop during the starting of electric irrigation pumps. This area is currently supplied from the Richmond zone substation via 30 km 11 kV feeder 40002.

A geographic diagram of the area under study is given in Figure 7-9.

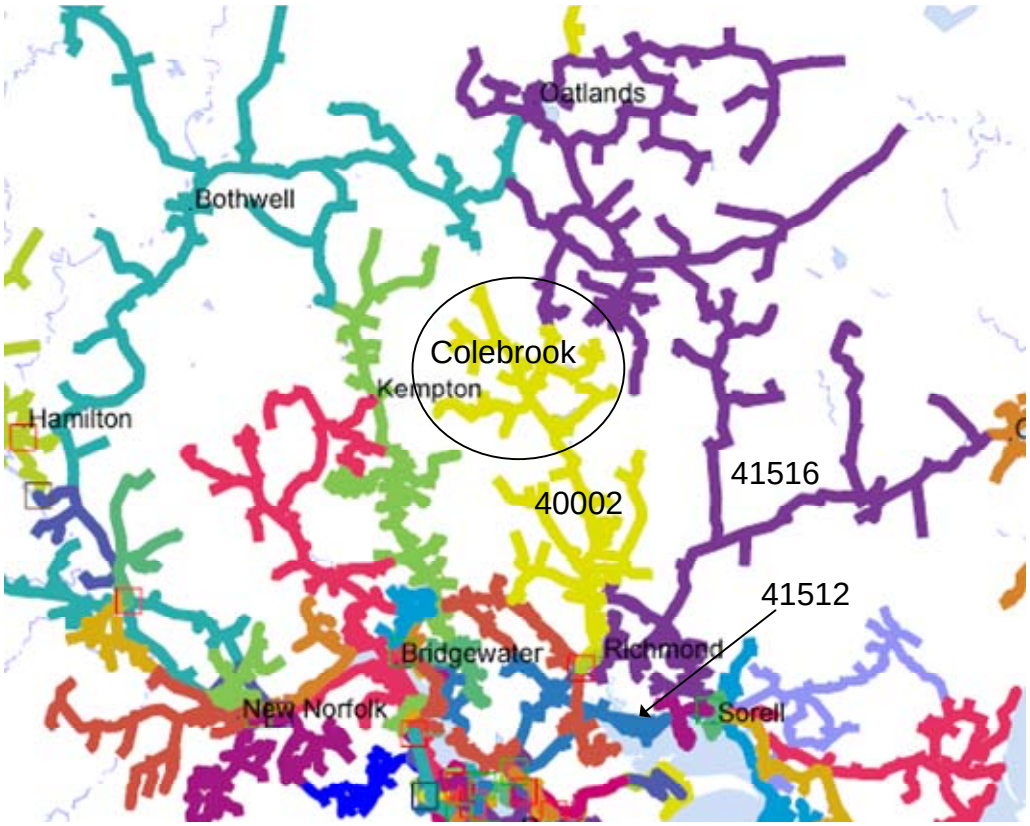

Figure 7-9 Sorell feeders 41512 and 41516 and Richmond feeder 40002 existing geographic diagram

Option 1 (recommended option) – Extend Sorell feeder 41512 and convert Colebrook 11 kV network to 22 kV

This option involves the conversion of the 11 kV network in the Colebrook area to 22 kV in 2020, as well as the extension of Sorell feeder 41512 north from Richmond to supply the Colebrook area and part of Oatlands. The resulting feeder would be limited by 7/3.00 Cu for much of its length, providing a feeder winter day rating of 7.8 MVA.

Option 2 – Establish Bothwell terminal substation and convert Colebrook 11 kV network to 22 kV

This option also proposes the conversion of the Colebrook 11 kV network to 22 kV in 2020, however it is proposed that the reliability limitations be addressed by the establishment of a new single transformer 110/22 kV substation at Bothwell.

Technical comparison

Table 7-5 Technical comparison of options

Option	Description	Advantages	Disadvantages
1	Extend Sorell feeder 41512 and convert Colebrook 11 kV network to 22 kV	• Utilises spare capacity at Sorell substation and on feeder 41512	• Broadens boundary of 22 and 11 kV in Richmond
2	Establish Bothwell terminal substation and convert Colebrook 11 kV network to 22 kV	• Provides shorter 22 kV feeder than option 1	• Substation site is not ideal location to supply future load

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

Cost comparison

Table 7-6 Cost comparison of options

Option	Initial Capital Cost ($M)	Total Capital Cost ($M)	Net Present Value ($M)
1	1.8	28.6	3.8
2	9.0	35.8	6.2

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 includes:

- Establish a new 1.5 km section of 22 kV 19/3.25 AAC feeder to create a tie between 41512 and 41516. This stage of works allows the Richmond 22 kV load to be transferred from 41516 to 41512 (approximately 1.2 MVA).
- Convert Colebrook area 11 kV network to 22 kV, supplied from Sorell feeder 41516
- Convert sections of the Richmond 11 kV network (approximately 15 km reinsulated to 22 kV and 50 distribution transformers replaced) east of the Coal River to 22 kV, and use as backbone for extended 41512
- Establish a new 5 km tie from converted Colebrook 22 kV network to extended Sorell feeder 41512

These works would result in a second Sorell feeder into Oatlands which is expected to relieve the reliability limitations in the area up to the establishment of a substation in Ross proposed for 2045.

It should be noted that the first stage above may be sufficient to address the 41516 reliability issues at a very low cost for a number of years. The Colebrook conversion and the extension of 41512 could then be deferred until justified by further reliability limitations at Oatlands or by the power quality issues at Colebrook.

The quantity of load transfers and any requirement for voltage regulators would be determined in a more detailed study closer to the requirement date.

The resulting geographic diagram is given in Figure 7-10.

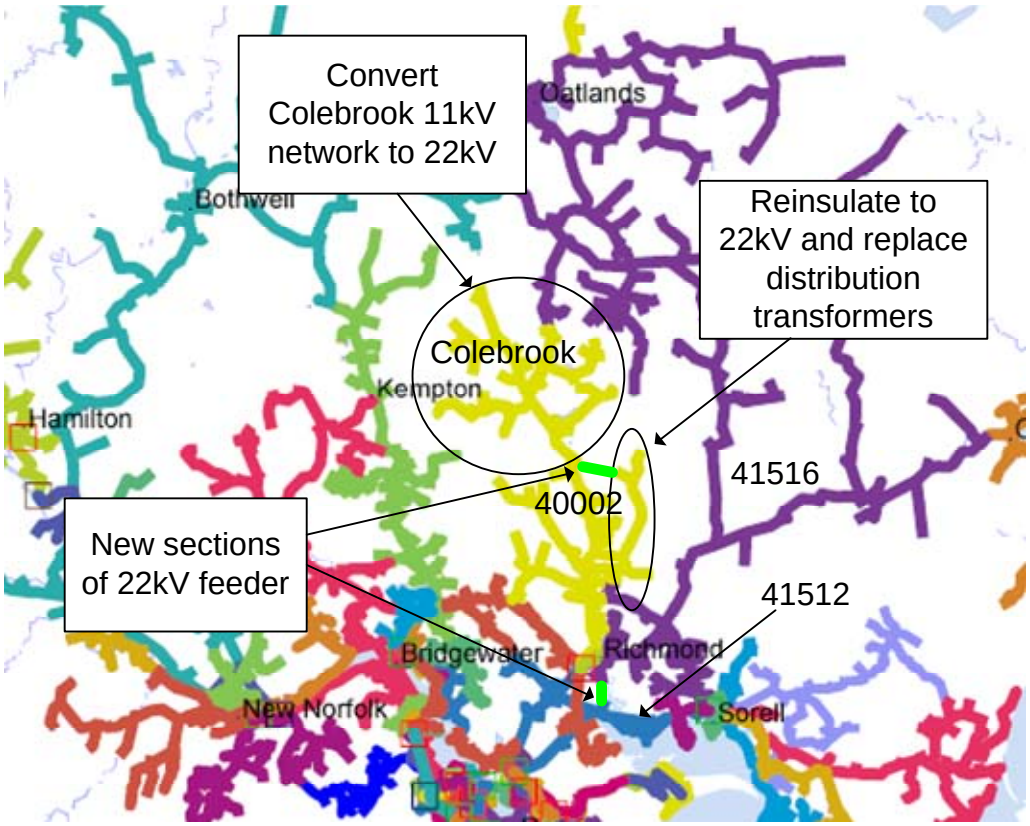

Figure 7-10 Sorell feeder 41512 extension proposed geographic diagram

7.2 Summary of proposed works

The proposed works from 2012 to 2022 in the Hobart-East planning area are listed in Table 6-1.

Table 7-7 Hobart-East project summary

Year	Proposed Project	Proposed Outcomes
2014	Upgrade Geilston Bay zone substation	Replace ageing 33/11 kV transformers and increase firm capacity at Geilston Bay
2015	Upgrade Lindisfarne terminal substation	Replace ageing 110/33 kV transformers and increase firm capacity at Lindisfarne
2017	Convert Richmond zone substation to 33/11 kV	Convert sections of 22 kV encroaching on Hobart-East to 11 kV, and establish 33 kV feeder from Lindisfarne to Richmond
2017	Establish Sandford zone substation	Deload Rokeby and relieve Lauderdale and South Arm 11 kV feeders
2020	Upgrade Bellerive zone substation	Replace ageing 33/11 kV transformers and increase firm capacity at Bellerive
2020	Extend 22 kV feeder 41512 to Oatlands and convert Colebrook to 22 kV	Address power quality issues on the Richmond northern 11 kV network and reliability issues in the Oatlands area

8. Five year plan

A five year plan for each of the substations (including proposed new substations) in the Hobart-East 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 million (RIT-D) or $5 million (RIT-T).

8.1 Richmond substation

Richmond zone substation supplies the townships of Richmond, north to Colebrook, south to Dulcot and west to Tea Tree.

8.1.1 Limitations

Using the medium growth forecast, the Richmond substation load is forecast to grow from 3.9 MVA in 2012 to 4.4 MVA in 2017. The existing 2 x 2.5 MVA 22/11 kV transformers are expected to be replaced with a single 10 MVA unit in 2012, providing no firm capacity. The resulting load forecast is given in Figure 8-1.

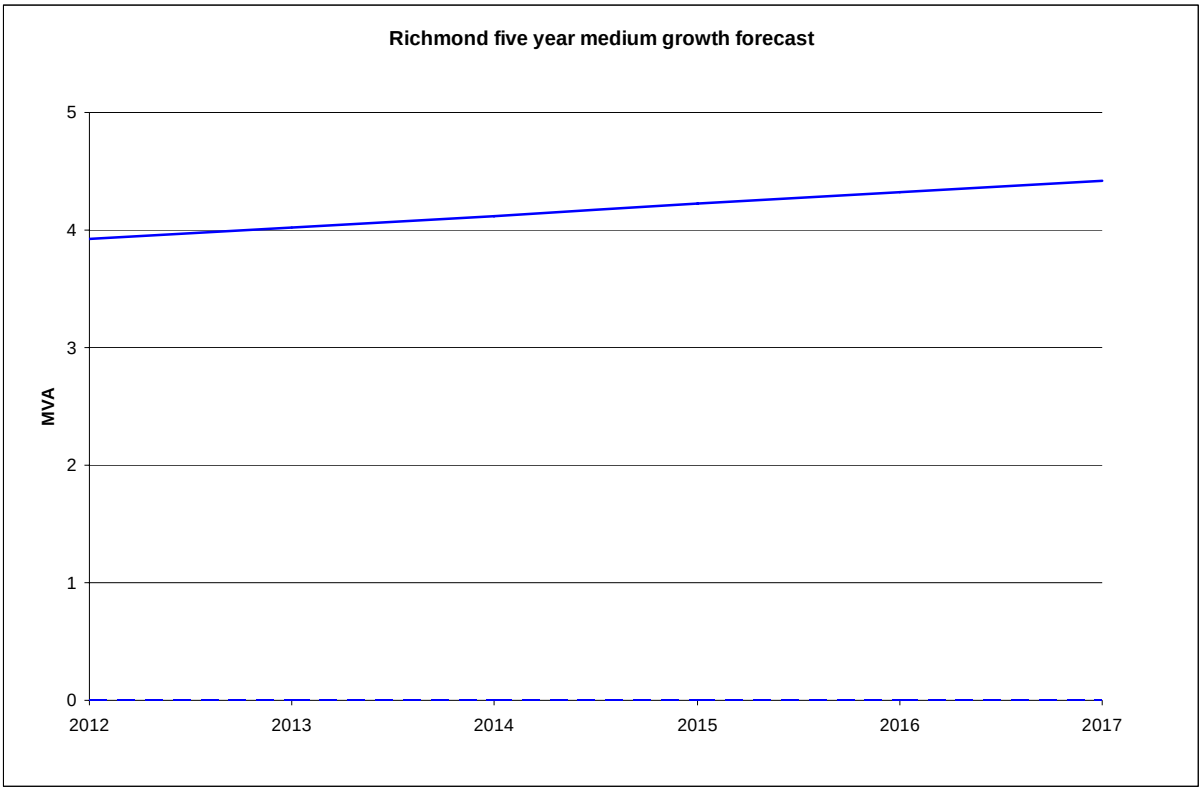

Figure 8-1 Richmond five year medium growth forecast

The 11 kV network from Richmond consists of three distribution feeders and there are no spare feeder circuit breakers available. The Richmond supply area and individual feeders are shown in Figure 8-2 and Figure 8-3 below.

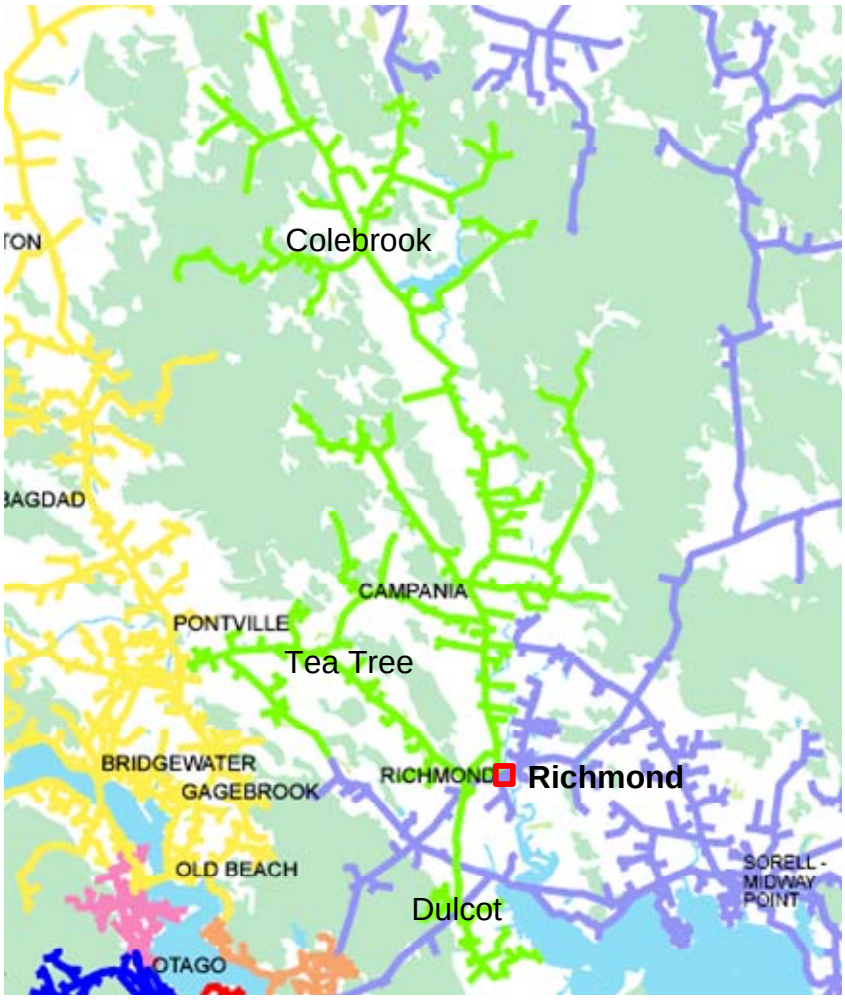

Figure 8-2 Richmond 11 kV supply area

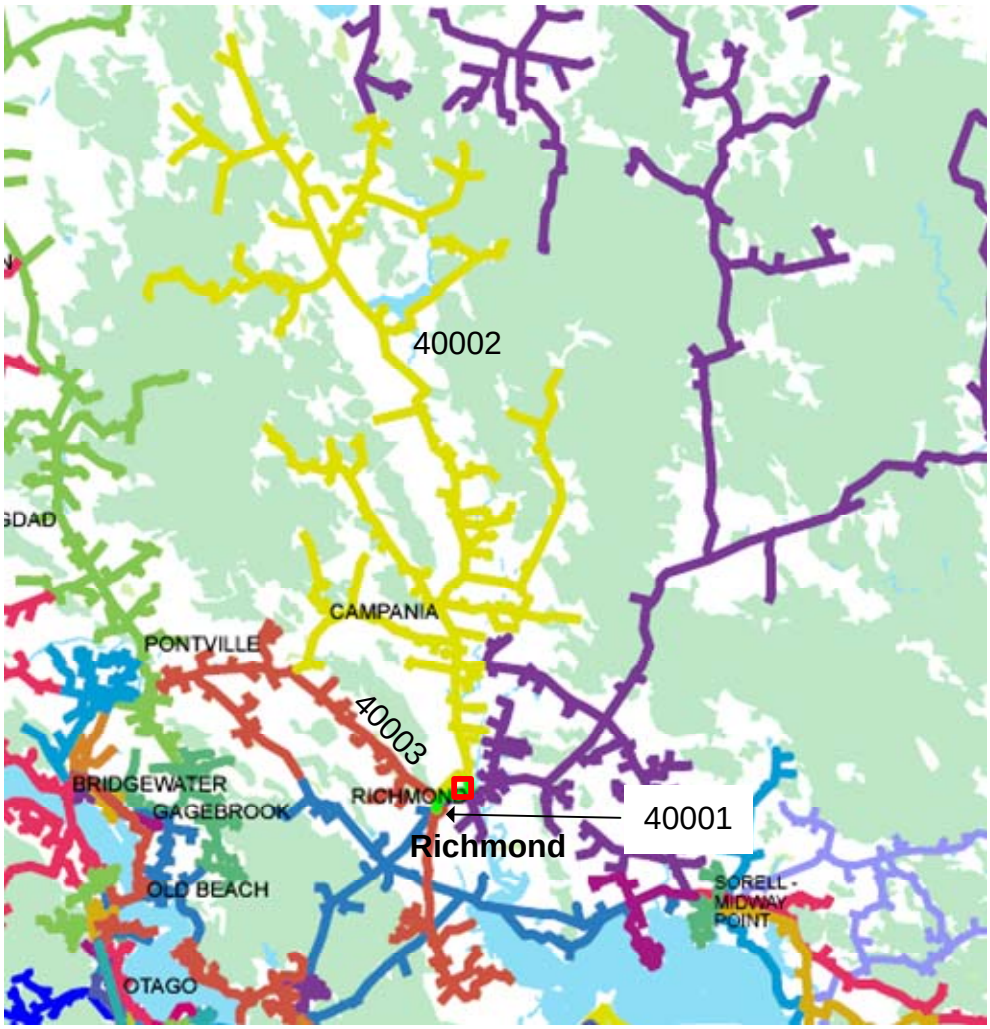

Figure 8-3 Richmond 11 kV feeders

A five year feeder forecast has been developed by applying the substation medium growth rate to the 2009 historical feeder peak loads. The feeder forecast is outlined in Table 8-1.

Table 8-1 Richmond substation feeder forecast

Feeder/s	2012 Load (MVA)	2013 Load (MVA)	2014 Load (MVA)	2015 Load (MVA)	2016 Load (MVA)	2017 Load (MVA)
40001	1.3	1.3	1.4	1.4	1.4	1.5
40002	1.8	1.9	1.9	2.0	2.0	2.1
40003	0.8	0.8	0.8	0.8	0.8	0.9

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

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

Table 8-2 Richmond substation transfer capability

Substation	Feeder	2012 Transfer (MVA)	2013 Transfer (MVA)	2014 Transfer (MVA)	2015 Transfer (MVA)	2016 Transfer (MVA)	2017 Transfer (MVA)
Cambridge	29488	1.1	1.1	1.0	1.0	0.9	0.9
Total transfers	**-**	**1.1**	**1.1**	**1.0**	**1.0**	**0.9**	**0.9**

As outlined above, there is not sufficient transfer capacity to supply Richmond from 11 kV transfers for a transformer contingency. This is expected to be addressed by the project to convert Richmond to 33/11 kV.

8.1.2 Proposed projects

Convert Richmond zone substation to 33/11 kV

Richmond zone substation is proposed to be converted to 33/11 kV and supplied from Lindisfarne substation in 2017. This involves the conversion of the existing Sorell 22 kV network to the south and west of Richmond to 11 kV and the establishment of a new 33 kV feeder from Lindisfarne to Richmond.

For information on the options analysis and justification for this project please refer to the ten year plan in section 7.1.3. This section of the report will focus on the scope of work for Aurora and the impact on the distribution network.

It is proposed that the newly converted 11 kV network be supplied from Richmond feeder 40003 and Geilston Bay feeder 26167. The resulting feeder forecast is outlined in Table 8-3.

Table 8-3 Richmond substation feeder forecast

Feeder/s	2012 Load (MVA)	2013 Load (MVA)	2014 Load (MVA)	2015 Load (MVA)	2016 Load (MVA)	2017 Load (MVA)
40001	1.3	1.3	1.4	1.4	1.4	1.5
40002	1.8	1.9	1.9	2.0	2.0	2.1
40003	0.8	0.8	0.8	0.8	0.8	1.9

As outlined above, this results in approximately 1 MVA additional load on Richmond feeder 40003 in 2017.

The impact on Sorell feeder 41512 is discussed in the Sorell strategic plan.

8.1.3 Ultimate configuration

Substation

A second transformer and second 33 kV feeder from Lindisfarne will ultimately be required at Richmond substation, with the timing dependent on the ability to backup the 11 kV network from adjacent substations. An 11 kV switchboard would also be installed at this time to provide adequate protection for the transformers, and to enable the feeder network to be split without relying on PMRs.

Feeders

The feeder network from Richmond is not expected to require augmentation in the short term, being lightly loaded already and with low growth forecast for the area. The long term plan for Richmond proposes the conversion of feeder 40002 in the Colebrook area to 22 kV, supplied from Sorell, which would deload feeder 40003 to the north. The long term plan also proposes the establishment of a zone substation in Brighton in 2025, which is expected to push back and deload feeder 40002.

Ultimately it is proposed that the Coal river form a boundary between the 22 kV and 11 kV voltage levels.

8.2 Lindisfarne substation

Lindisfarne substation is the 33 kV injection point which currently supplies the Bellerive, Geilston Bay and Cambridge zone substations. Bellerive will be supplied from Mornington substation following its establishment in 2011.

8.2.1 Limitations

Using the medium growth forecast, Lindisfarne substation load is forecast to grow from 33 MVA in 2012 to 37 MVA in 2017, below the substation firm capacity of 60 MVA (Transend are proposing to replace the existing 45 MVA 110/33 kV transformers with 60 MVA units in 2015). The resulting five year load forecast for Lindisfarne substation is given in Figure 8-4.

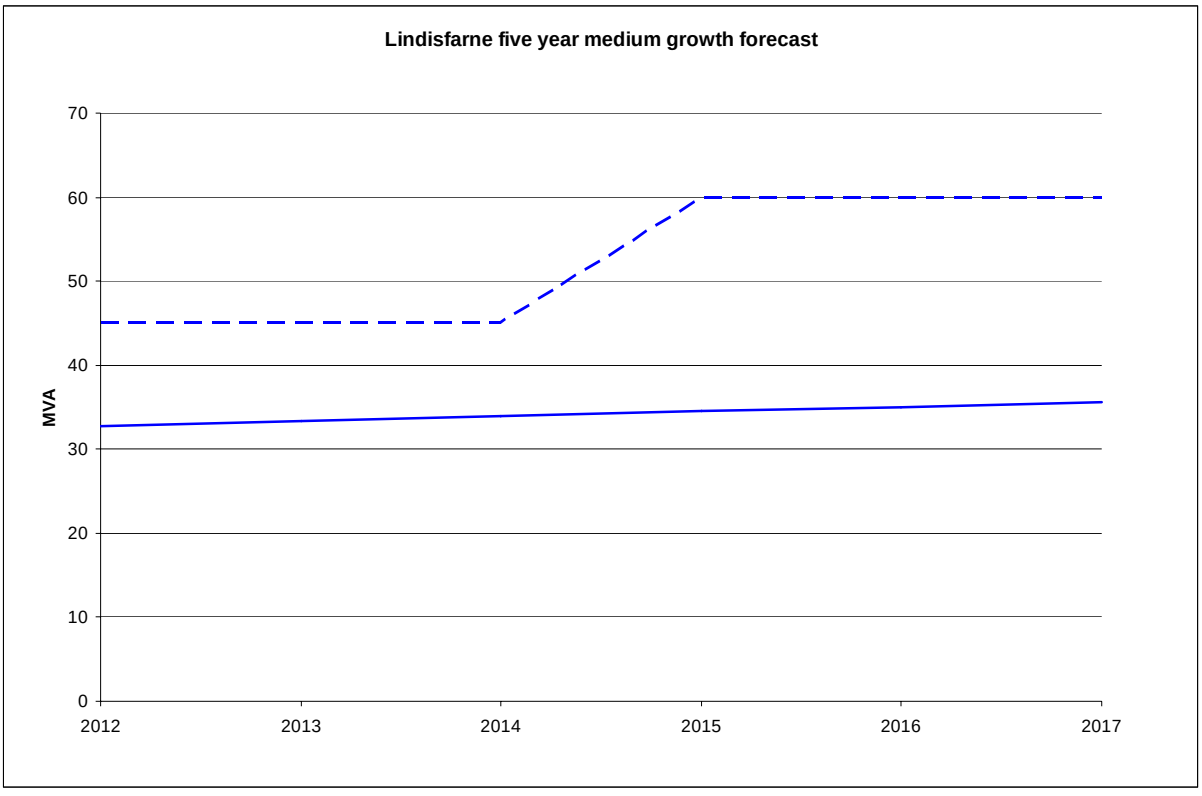

Figure 8-4 Lindisfarne five year medium growth forecast

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

Table 8-4 below shows the ratings of the 33 kV feeders from Lindisfarne 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 8-4 Lindisfarne 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)
Cambridge	25306	20	20	20	9	17
	25309	20	20	20	9	17
Geilston Bay	25307	25	22.1	28.2	8	20
	25308	25	22.1	28.2	8	20
Bellerive	25305	22.5	20	22.3	10	19
	25310	22.5	21.1	22.3	10	19

As outlined above, all of the 33 kV feeders are forecast to be loaded within their ratings beyond 2017 for an N-1 condition. It should be noted that once the Bellerive transformers are upgraded to 25 MVA units in 2020, the subtransmission feeders will limit the N-1 capacity of the substation.

8.2.2 Proposed projects

Replace Lindisfarne 110/33 kV transformers

This project is discussed in more detail in the long term and ten year plans.

Supply Richmond and Bellerive from Lindisfarne

The long term plan proposes that Richmond and Bellerive zone substations be supplied from Lindisfarne in 2017. The resulting five year load forecast for Lindisfarne substation is given in Figure 8-5.

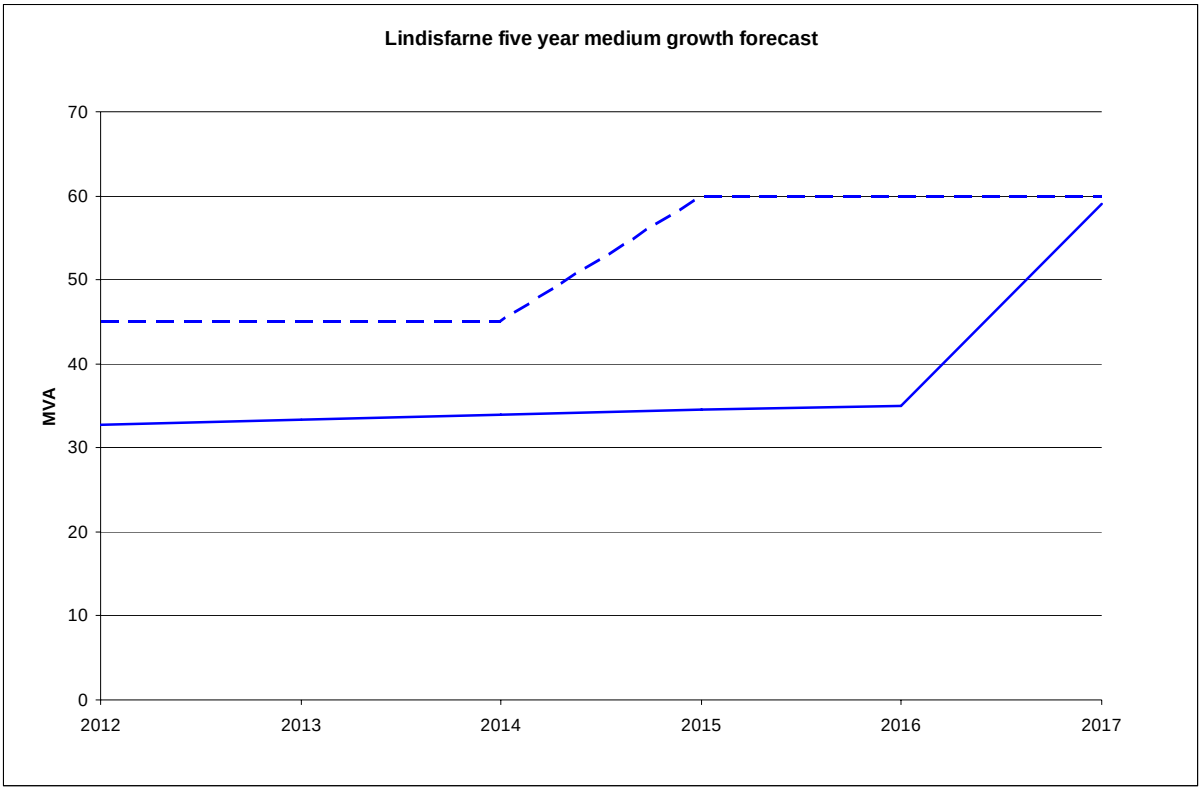

Figure 8-5 Lindisfarne five year medium growth forecast

As outlined above, the load at Lindisfarne remains below firm capacity up to 2017. However, even if load does increase above firm capacity, this is not considered a limitation as long as load remains below the emergency capacity of 72 MVA, since there is the ability to quickly transfer Bellerive back to Mornington in the event of a transformer contingency. These projects are discussed in more detail in the ten year plan.

8.2.3 Ultimate configuration

Substation

A third transformer and the associated 33 kV switchgear has been proposed in the long term plan for Lindisfarne in 2034, however the plan also discusses some options that may defer this requirement by several years by providing additional transfer capacity to Mornington or by cutting Cambridge over to Mornington.

Feeders

Due to the proximity of Cambridge to Mornington compared with Lindisfarne, it makes sense to ultimately aim to supply Cambridge from Mornington substation. This would particularly be the case if the third transformer is required at Cambridge.

This would ultimately leave Lindisfarne supplying to Geilston Bay, Richmond, Risdon Vale, and potentially an additional zone substation between Geilston Bay and Bellerive using the existing Bellerive 33 kV feeders.

8.3 Geilston Bay substation

Geilston Bay zone substation supplies to the Hobart eastern shore suburbs of Geilston Bay, Risdon Vale, Otago, Risdon, Lindisfarne and Rose Bay.

8.3.1 Limitations

Using the medium growth forecast, Geilston Bay substation load is forecast to grow from 18 MVA in 2012 to 20 MVA in 2017 (assuming establishment of Rosny and Howrah zone substations by 2012), which is well below the substation firm capacity of 25 MVA (after the transformer replacement in 2014). The five year load forecast for Geilston Bay substation is given in Figure 8-6.

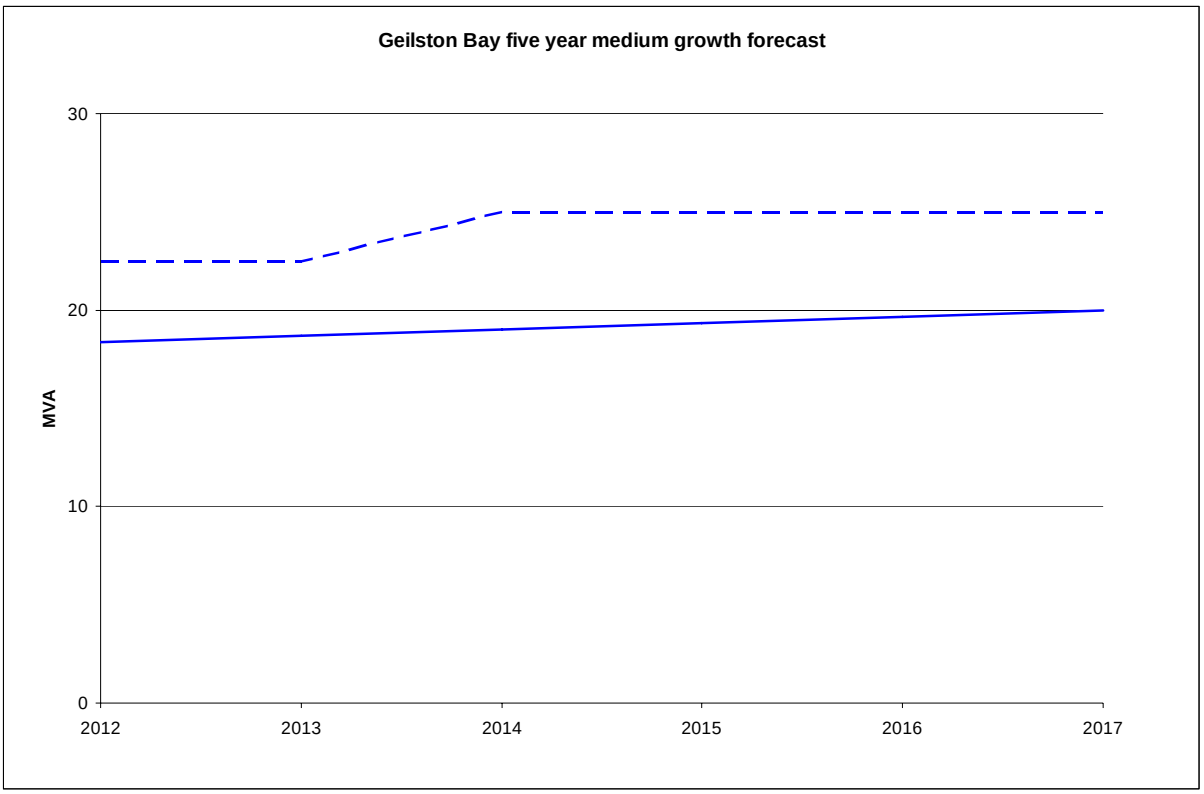

Figure 8-6 Geilston Bay five year medium growth forecast

The 11 kV network from Geilston Bay consists of eight distribution feeders and there are two spare circuit breakers available for future feeders (one shared with the station services transformer). It is expected that there is space for the installation of at least two additional feeder circuit breakers.

The Geilston Bay supply area and individual feeders are shown in Figure 8-7 and Figure 8-8 below. It should be noted that these figures represent the current arrangement and do not show the impact of the future Howrah and Rosny zone substations.

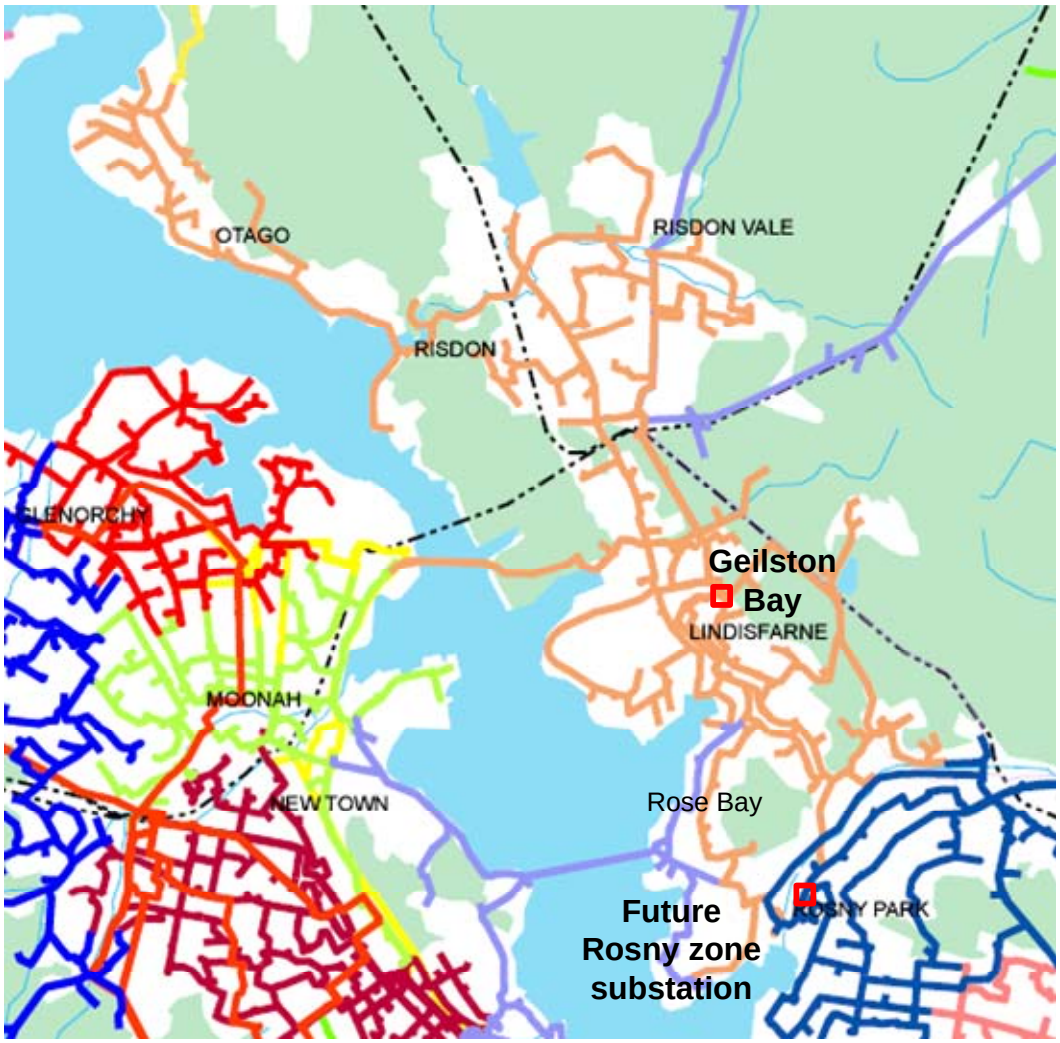

Figure 8-7 Geilston Bay 11 kV supply area

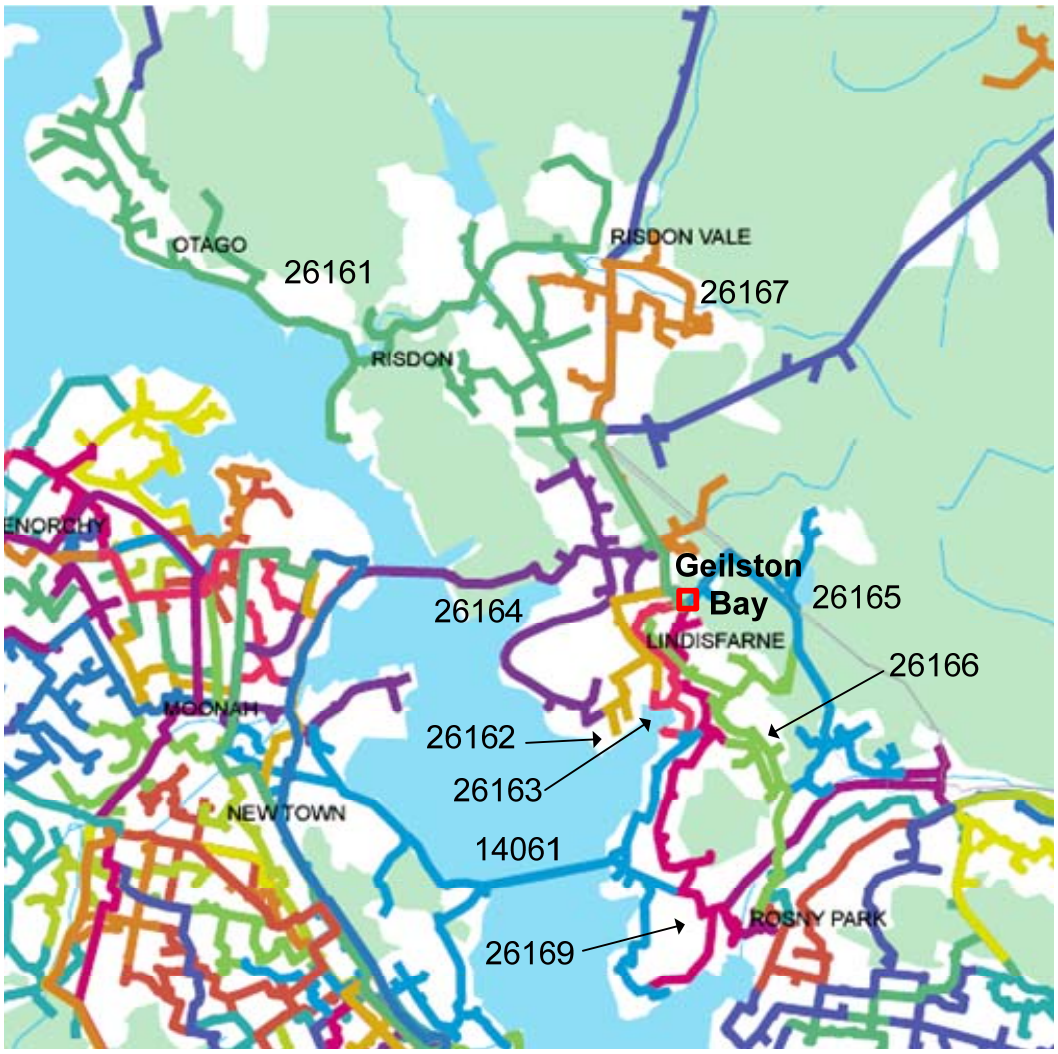

Figure 8-8 Geilston Bay 11 kV feeders

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. As above, these loads do not take into account the establishment of the Rosny and Howrah zone substations.

Table 8-5 Geilston Bay substation feeder forecast

Feeder/s	2012 Load (MVA)	2013 Load (MVA)	2014 Load (MVA)	2015 Load (MVA)	2016 Load (MVA)	2017 Load (MVA)
26161	2.1	2.1	2.2	2.2	2.2	2.3
26162	4.6	4.7	4.8	4.9	5.0	5.1
26163	1.9	1.9	2.0	2.0	2.0	2.1
26164	2.7	2.7	2.8	2.8	2.8	2.9
26165	3.5	3.5	3.6	3.7	3.7	3.8
26166	4.5	4.6	4.7	4.7	4.8	4.9
26167	5.8	5.9	6.0	6.1	6.2	6.3
26169	4.4	4.5	4.6	4.7	4.7	4.8

As outlined above, feeder 26162 to the south of Geilston Bay is forecast to exceed the planning rating of 5 MVA in 2016. It is expected that the establishment of Rosny zone substation in 2012 will address this feeder limitation as well as deload the other feeders south from Geilston Bay.

Feeder 26167 to Risdon Vale currently exceeds the planning rating of 5 MVA. No projects have been proposed by Aurora to address this limitation.

The available transfer capacity from Geilston Bay substation to the Rosny and New Town substations is outlined in Table 8-6.

Table 8-6 Geilston Bay substation transfer capability

Substation	Feeder	2012 Transfer (MVA)	2013 Transfer (MVA)	2014 Transfer (MVA)	2015 Transfer (MVA)	2016 Transfer (MVA)	2017 Transfer (MVA)
Rosny	23348	5.3	5.3	5.2	5.2	5.1	5.1
	23354	1.6	1.6	1.5	1.4	1.4	1.3
New Town	16094	2.5	2.5	2.4	2.4	2.4	2.3
Total transfers	**-**	**9.4**	**9.4**	**9.1**	**9**	**8.9**	**8.7**

As outlined above, there is significant transfer capacity from Geilston Bay to adjacent substations.

8.3.2 Proposed projects

Establish new feeder to split 26167

As discussed above, the load on Geilston Bay feeder 26167 currently exceeds the planning rating of 5 MVA. It is expected that this limitation can be addressed initially by load transfers to the adjacent feeder 26161, which has a forecast load of 2.3 MVA in 2017, particularly if some load in the Otago area can be taken off this feeder after the extension of feeder 17105 across the Bowen Bridge from Derwent Park in 2010. The establishment of Austin's Ferry zone substation in 2016 may also allow a small amount of load to be transferred from 26161.

However the conversion of the 22 kV network between Richmond and Geilston Bay to 11 kV is proposed to proceed in 2017 and additional load will be transferred to the Geilston Bay network in the area at this time. Feeder 17105 and the Austin's Ferry feeder are expected to be quite heavily loaded, and thus not expected to be able to significantly deload 26161.

Therefore it is proposed to establish a new feeder from Geilston Bay to split 26167 and supply part of the newly converted 22 kV network in 2017.

A suggested way to achieve this is by running a new feeder tail to existing feeder 26164, and using the northern spur of this feeder to establish a third feeder into the Risdon Vale area. A tie between the Risdon Vale network and the newly converted 11 kV would then allow load to be transferred to this feeder. A geographical diagram of this proposal is shown in Figure 8-9.

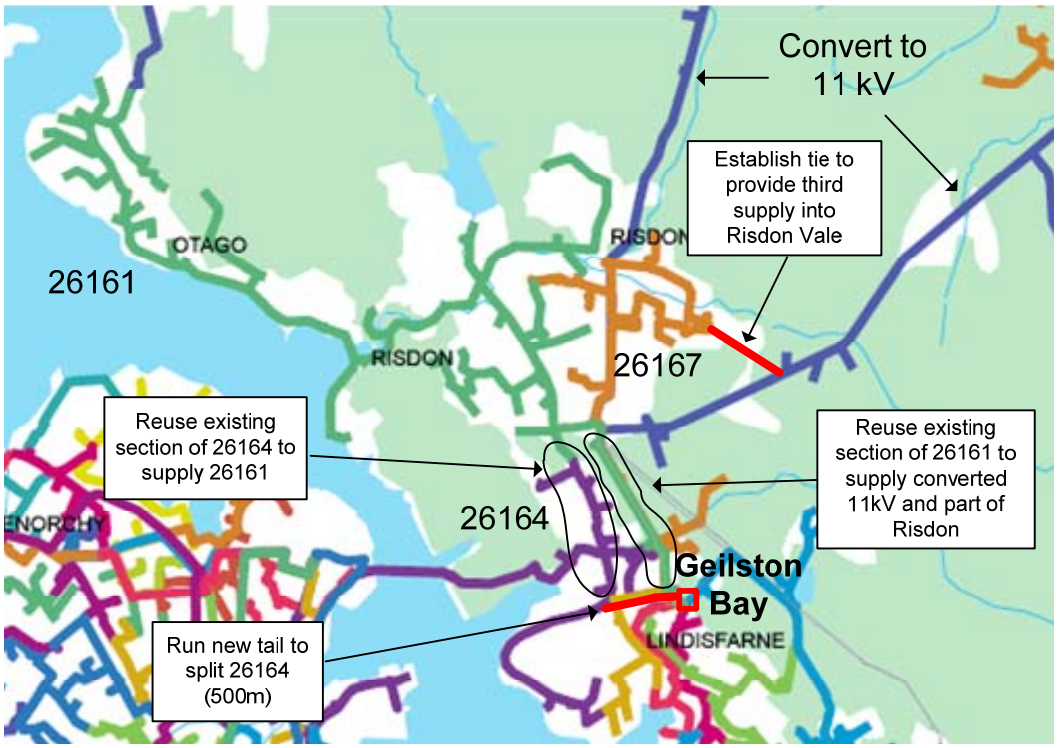

Figure 8-9 Geographical diagram of proposed project to split 26167

An alternative to this project would be to supply part of the Risdon Vale area load from Richmond following the conversion of the 22 kV network in the area to 11 kV in 2017. This is not expected to be an adequate solution as it would significantly increase the load at Richmond, which has no firm capacity. It would also require Richmond substation to supply a significant load at the end of a long overhead feeder (approximately 10 km), reducing reliability in the area and infringing on the Geilston Bay supply area.

8.3.3 Ultimate configuration

Substation

Geilston Bay is expected to remain a two transformer substation up to 2050. Following the transformer replacement in 2014, no further works are proposed for Geilston Bay substation in the long term plan.

Feeders

As discussed above, it is expected that feeder limitations at Geilston Bay up to 2017 will be addressed by existing Aurora projects and the proposed project above.

The establishment of Rosny zone substation to the south of Geilston Bay in 2012 will significantly deload the Geilston Bay 11 kV network in the area. Consequently, it is not expected that new feeders will be required from Geilston Bay to the south.

The long term plan proposes a new zone substation in Risdon Vale in 2045, which would deload the Geilston Bay 11 kV network to the north. Additional support from Geilston Bay may be required to the area prior to this time, depending on load growth in the Otago, Old Beach and Risdon Vale areas.

8.4 Bellerive substation

Bellerive zone substation supplies to the Hobart eastern shore suburbs of Bellerive, Rosny Park, Warrane and Mornington.

8.4.1 Limitations

Using the medium growth forecast, Bellerive substation load is forecast to grow from 17 MVA in 2012 to 19 MVA in 2017 (assuming establishment of Rosny and Howrah zone substations by 2012), which is below the substation firm capacity of 22.5 MVA. The five year load forecast for Bellerive substation is given in Figure 8-10.

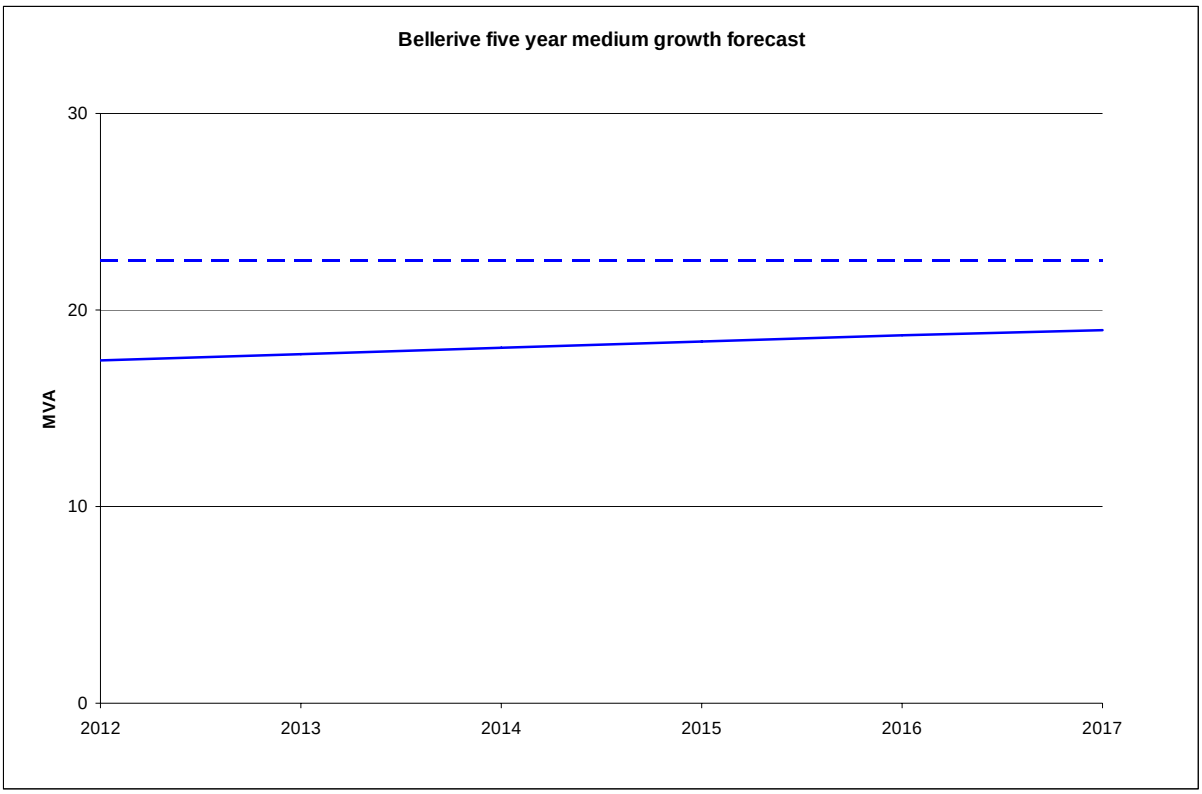

Figure 8-10 Bellerive five year medium growth forecast

The 11 kV network from Bellerive consists of eight distribution feeders and there are no spare circuit breakers available for future feeders. It is expected that there is space for the installation of at least two additional feeder circuit breakers.

The Bellerive supply area and individual feeders are shown in Figure 8-11 and Figure 8-12 below. It should be noted that these figures represent the current arrangement and do not show the impact of the future Howrah and Rosny zone substations.

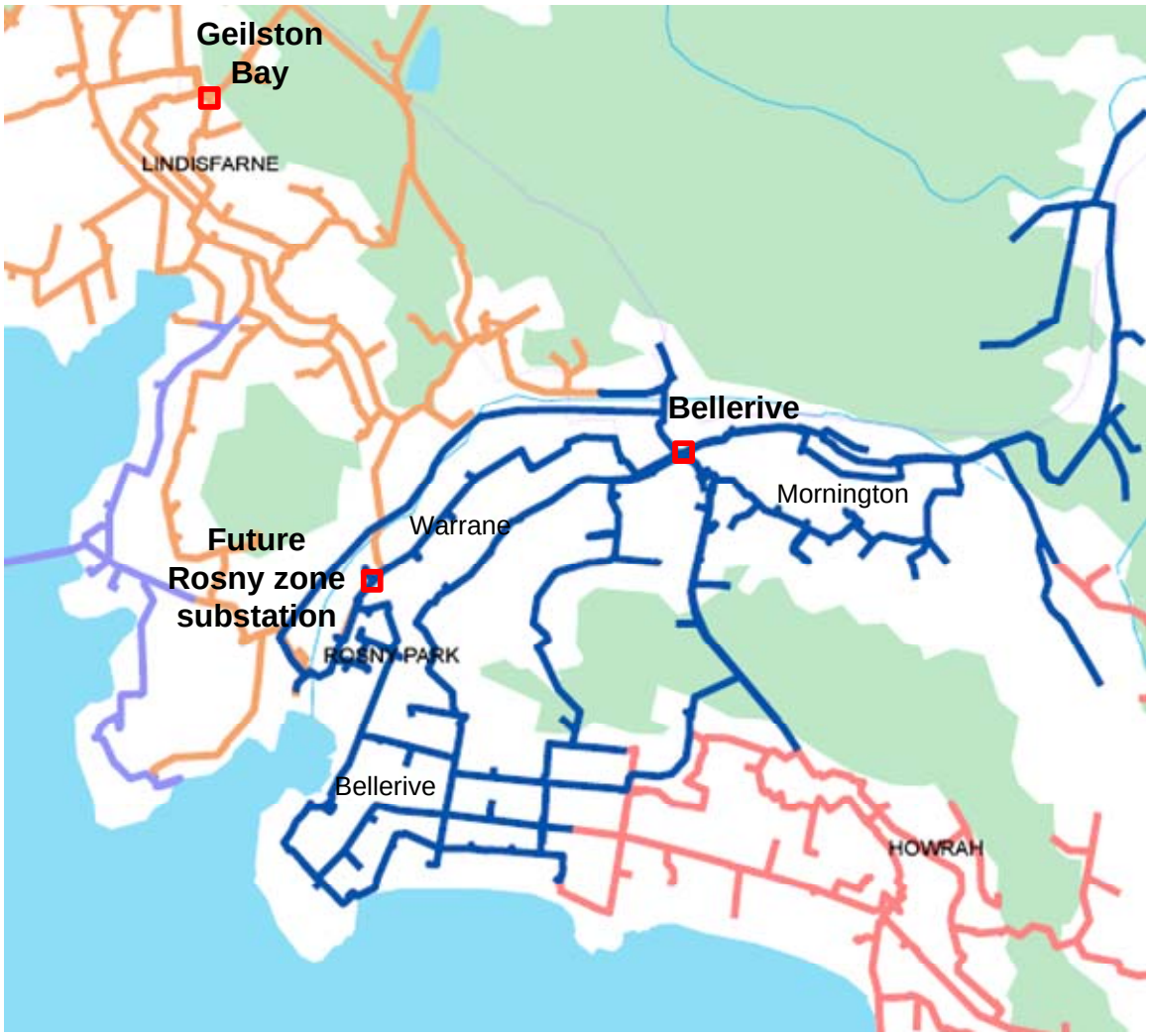

Figure 8-11 Bellerive 11 kV supply area

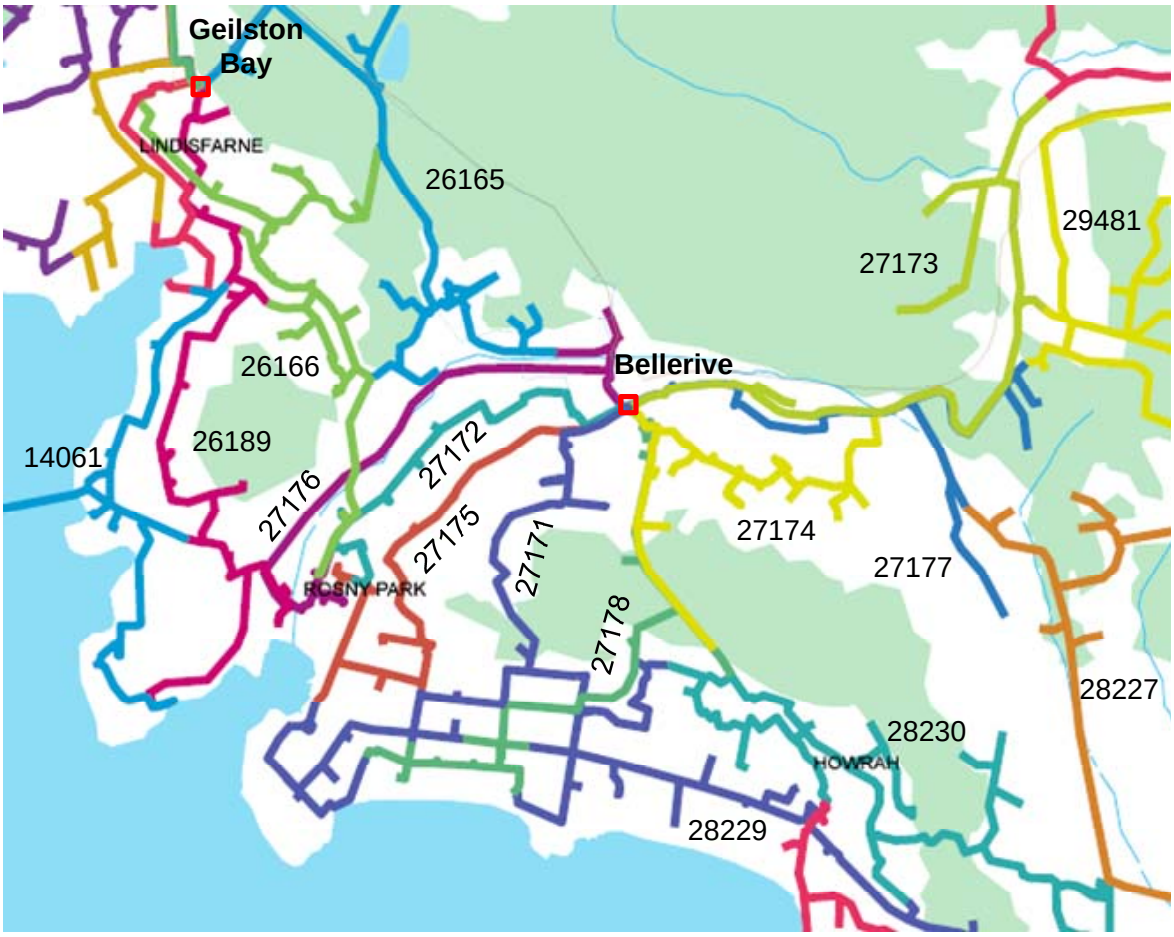

Figure 8-12 Bellerive 11 kV feeders

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 8-7. As above, these loads do not take into account the establishment of the Rosny and Howrah zone substations.

Table 8-7 Bellerive substation feeder forecast

Feeder/s	2012 Load (MVA)	2013 Load (MVA)	2014 Load (MVA)	2015 Load (MVA)	2016 Load (MVA)	2017 Load (MVA)
27171	4.5	4.6	4.7	4.8	4.8	4.9
27172	3.4	3.4	3.5	3.6	3.6	3.7
27173	0.3	0.3	0.3	0.3	0.3	0.3
27174	1.7	1.8	1.8	1.8	1.9	1.9
27175	5.1	5.2	5.3	5.4	5.4	5.5
27176	3.4	3.5	3.5	3.6	3.6	3.7
27177	1.2	1.2	1.3	1.3	1.3	1.3
27178	5.6	5.7	5.8	5.9	6.0	6.1

As outlined above, feeders 27175 and 27178 are forecast to exceed the planning rating of 5 MVA prior to 2012. It is expected that the limitation on these feeders will be addressed by the establishment of Rosny and Howrah zone substations by 2012. Feeder 27171, which is approaching 5 MVA in 2017, is also expected to be deloaded by these projects.

The available transfer capacity from Bellerive substation to the Cambridge, Howrah and Rosny substations is outlined in Table 8-8.

Table 8-8 Bellerive substation transfer capability

Substation	Feeder	2012 Transfer (MVA)	2013 Transfer (MVA)	2014 Transfer (MVA)	2015 Transfer (MVA)	2016 Transfer (MVA)	2017 Transfer (MVA)
Cambridge	29481	2.8	2.8	2.8	2.8	2.8	2.8
	29488	2.1	2.2	2.2	2.3	2.3	2.4
Howrah	22320	4.6	4.6	4.6	4.6	4.6	4.6
	22322	4.2	4.1	4	4	3.9	3.8
	22330	4.6	4.5	4.4	4.4	4.3	4.2
Rosny	23347	1.6	1.7	1.7	1.7	1.8	1.8
	23350	1.1	1.1	1	1	0.9	0.9
	23354	2.8	2.7	2.6	2.6	2.5	2.5
	23355	4	4.1	4.2	4.3	4.4	4.5
	23356	4.4	4.3	4.3	4.2	4.1	4.1
Total transfers	**-**	**32.2**	**32.1**	**31.8**	**31.9**	**31.6**	**31.6**

As outlined above, there is significant transfer capacity from Bellerive to the adjacent substations for the scope of the study.

8.4.2 Proposed projects

There are no projects proposed in the Bellerive supply area in the five year plan.

8.4.3 Ultimate configuration

Substation

Bellerive is expected to remain a two transformer substation up to 2050. Following the transformer replacement in 2020, no further works are proposed for Bellerive substation in the long term plan.

Feeders

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

Following the establishment of Rosny and Howrah zone substations, the Bellerive 11 kV network will be quite lightly loaded, and additional feeder projects are not expected to be required in the short term. There are no spare circuit breakers at Bellerive, so any future feeders would require a switchboard extension. The transformer replacement in 2020 may present an opportunity to replace the 11 kV switchgear and provide additional circuit breakers.

8.5 Mornington substation

Mornington substation is a 33 kV injection point which is to be established by Transend in 2011. Mornington will supply the new Rosny and Howrah zone substations, as well as the existing Bellerive zone substation.

8.5.1 Limitations

Using the medium growth forecast, Mornington substation load is forecast to grow from 52 MVA in 2012 to 57 MVA in 2017, below the substation firm capacity of 60 MVA. The resulting five year load forecast for Mornington substation is given in Figure 8-13.

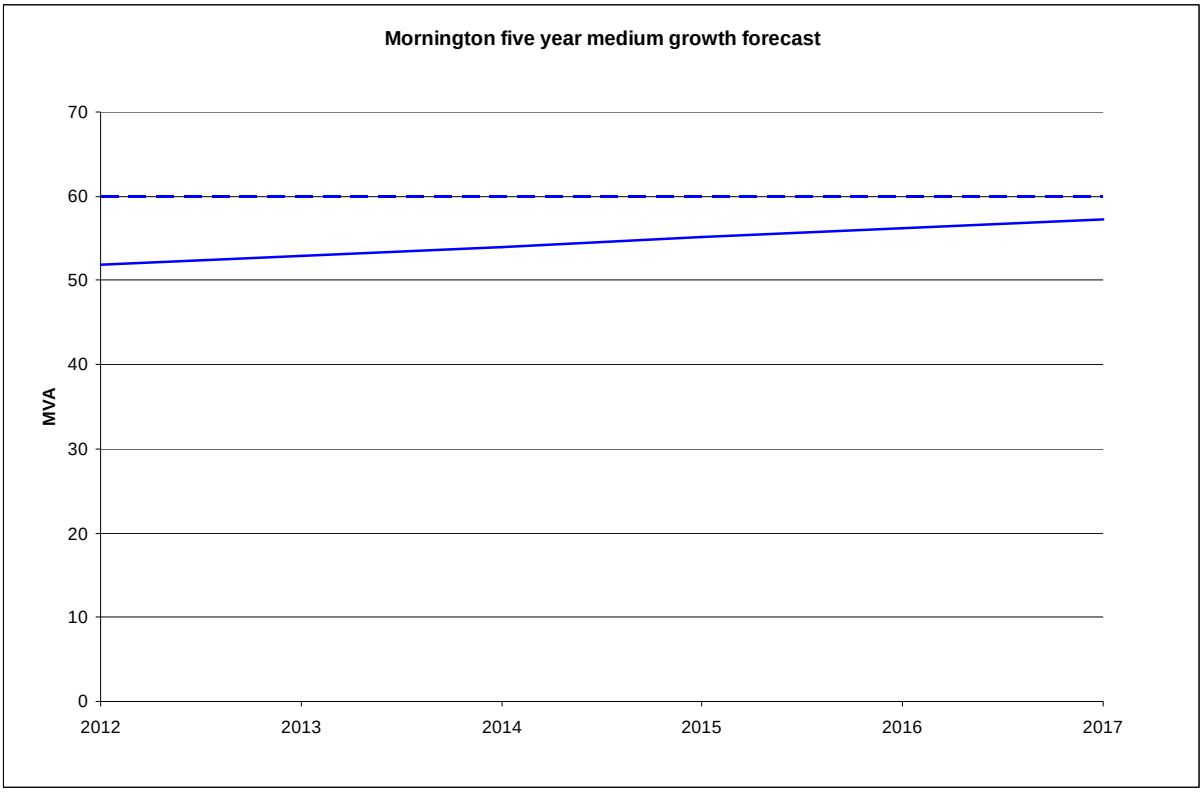

Figure 8-13 Mornington five year medium growth forecast

The 33 kV network from Mornington will consist of six 33 kV feeders and there will be two spare feeder circuit breakers available.

Table 8-9 below shows the ratings of the 33 kV feeders from Mornington 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 8-9 Mornington 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)
Bellerive	-	22.5	-	27.1*	10	19
	-	22.5	-	27.1*	10	19
Rosny	-	25	-	27.1*	9	17
	-	25	-	27.1*	9	17

Substation	Feeder no.	Transformer Rating	SD Rating (MVA)	WD Rating (MVA)	SD N-1 Load 2017 (MVA)	WD N-1 Load 2017 (MVA)
Howrah	-	25	-	27.1*	10	21
	-	25	-	27.1*	10	21

** Rating given is Aurora standard rating – actual rating is not yet known*

As outlined above, all of the 33 kV feeders are forecast to be loaded within their ratings beyond 2017 for an N-1 condition.

8.5.2 Proposed projects

Establish Sandford zone substation

Sandford zone substation is proposed to be established in 2017 and be supplied from Mornington substation via two new 33 kV feeders. To avoid overloading Mornington substation, it is also proposed that Bellerive be normally supplied from Lindisfarne substation at this time.

For information on the options analysis for this project please refer to the ten year plan in Section 7.1.4. For information on the proposed Sandford distribution network details please refer to the five year plan in Section 8.9.

The resulting Mornington five year load forecast is shown in Figure 8-25.

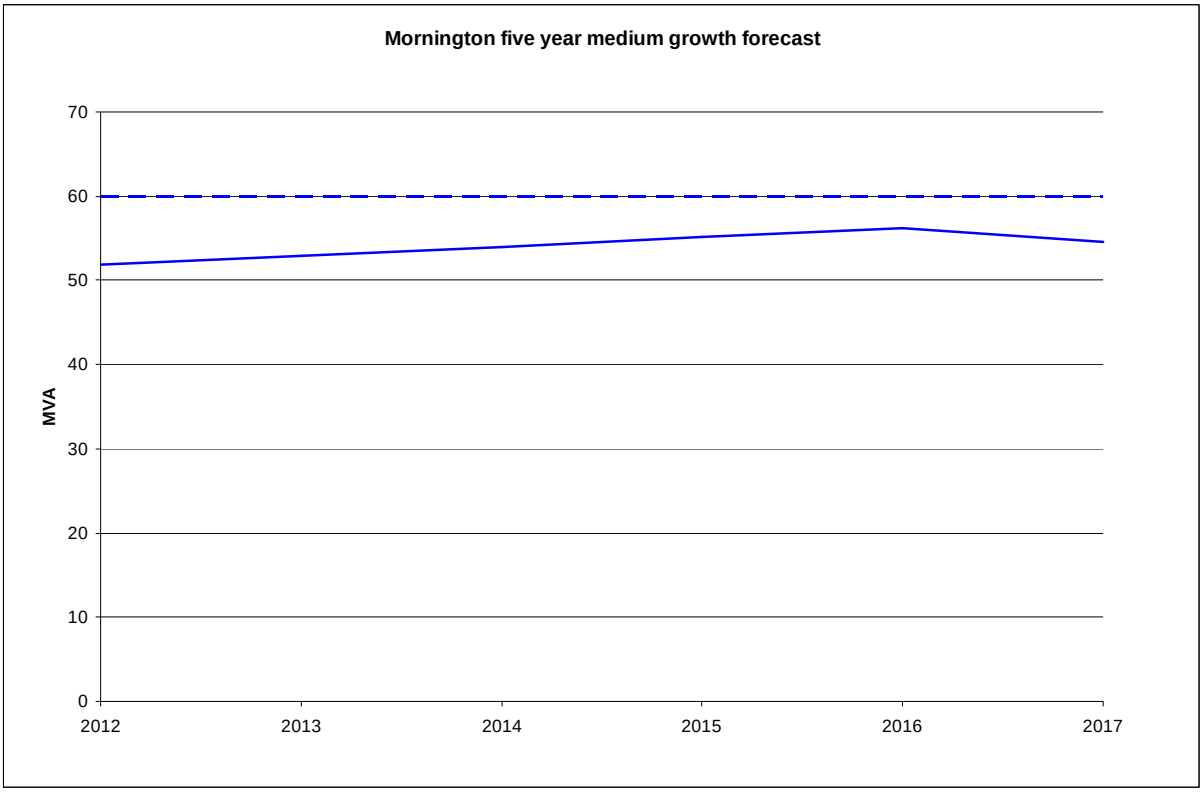

Figure 8-14 Mornington proposed five year medium growth forecast

As outlined above, Mornington load is below firm capacity beyond 2017.

8.5.3 Ultimate configuration

Substation

A third transformer and the associated 33 kV switchgear has been proposed in the long term plan for 2023 at Mornington substation.

Feeders

Due to the proximity of Cambridge to Mornington compared with Lindisfarne, it makes sense to ultimately aim to supply Cambridge from Mornington substation. This would particularly be the case if the third transformer is required at Cambridge.

This would ultimately result in Mornington supplying to Cambridge, Sandford, Rosny, Howrah and Bellerive substations. The firm capacities of these zone substations would total 140 MVA, in excess of the ultimate firm capacity at Mornington of 120 MVA. However the ability to transfer Bellerive back to Lindisfarne during contingencies results in an effective firm capacity of 144 MVA at Mornington (the four hour emergency capacity). The diversity of zone substation load is also likely to mitigate this further - e.g. the commercial area around Cambridge, the rural areas around Sandford and the high density urban areas around Bellerive are expected to have different load curves, resulting in a diversity factor less than unity at Mornington substation.

8.6 Rosny substation

Rosny zone substation is to be established by Aurora by 2012. Rosny will deload the existing Bellerive, Geilston Bay and Rokeby substations, supplying the Hobart eastern shore suburbs of Rosny, Bellerive, Warrane and Flagstaff Gully.

8.6.1 Limitations

Using the medium growth forecast, Rosny substation load is forecast to grow from 16 MVA in 2012 to 17 MVA in 2017, below the substation firm capacity of 25 MVA. The five year load forecast for Rosny substation is given in Figure 8-15.

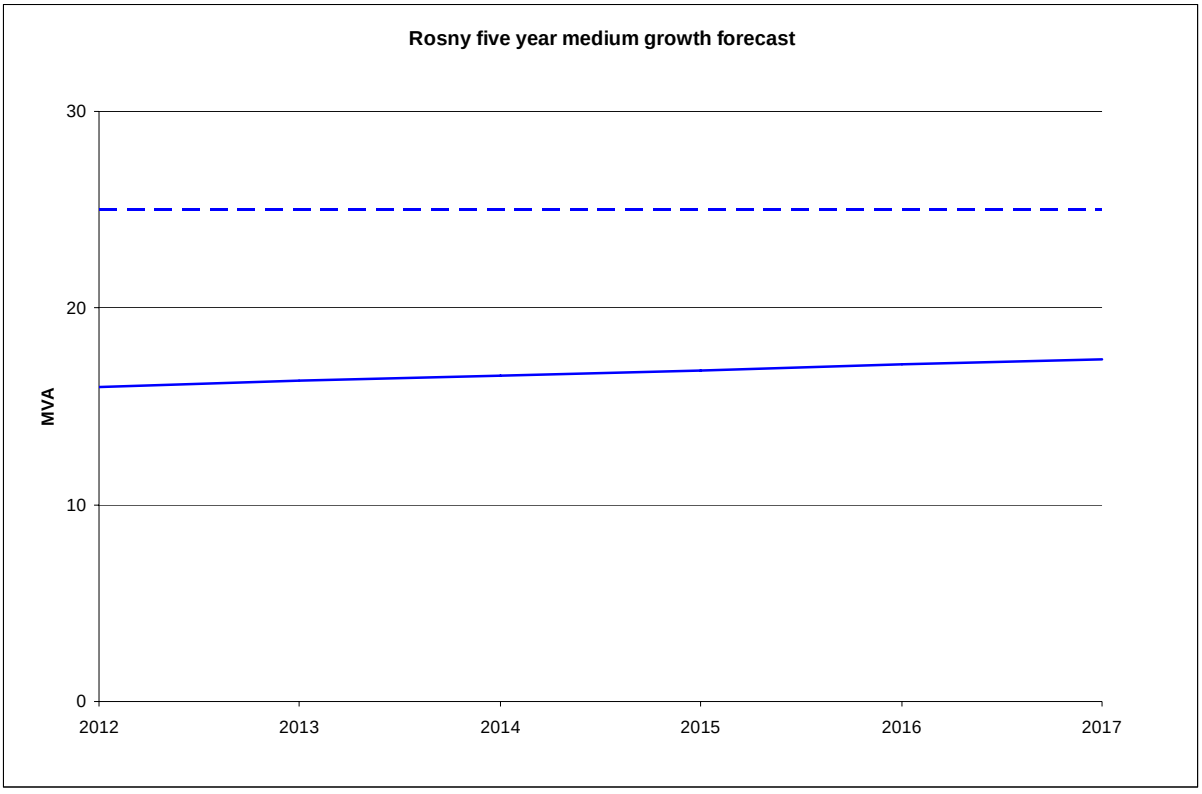

Figure 8-15 Rosny five year medium growth forecast

The 11 kV network from Rosny is expected to consist of ten distribution feeders, with two spare circuit breakers available for future feeders.

The expected Rosny supply area and individual feeders are shown in Figure 8-16 and Figure 8-17 below.

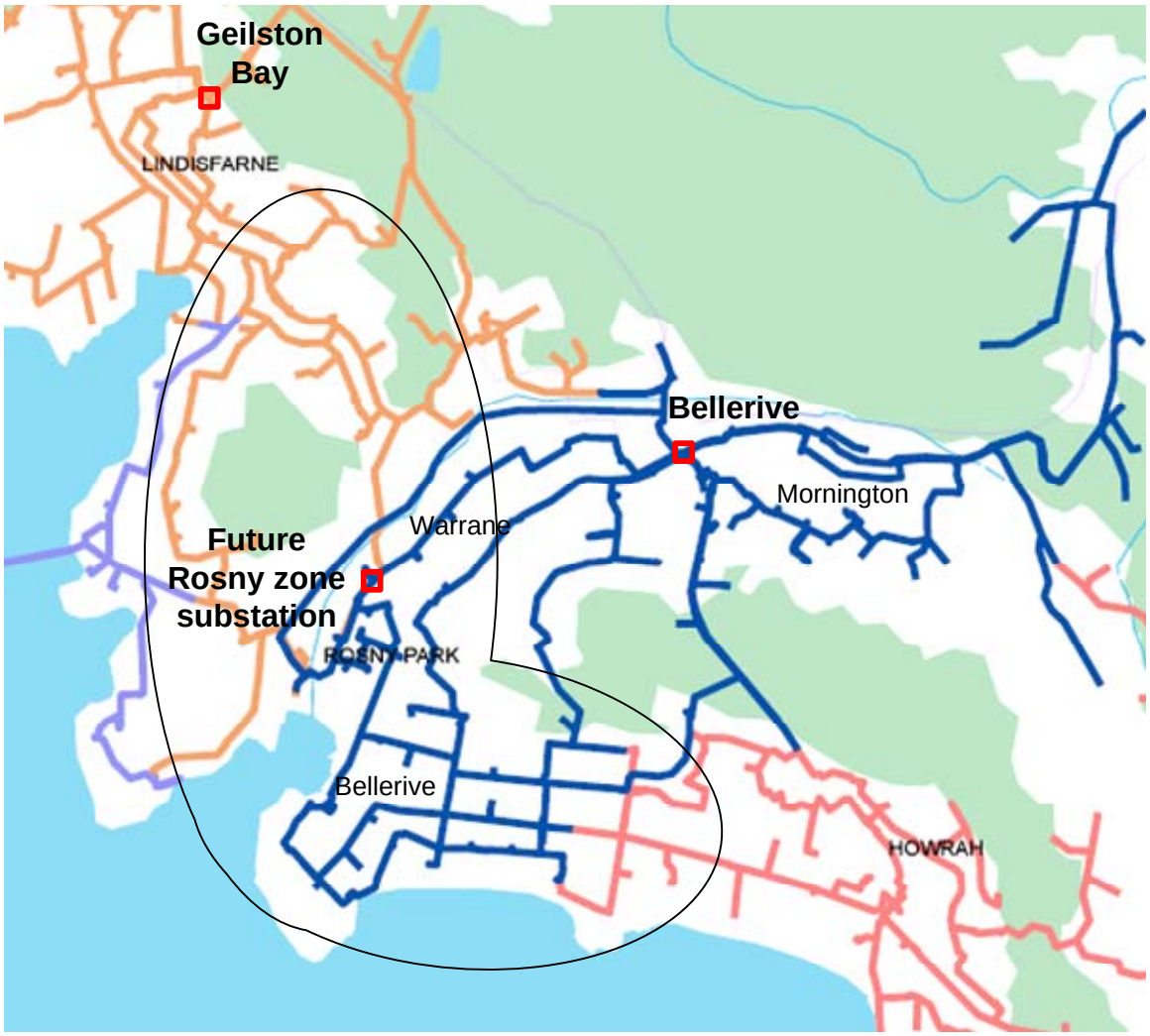

Figure 8-16 Rosny 11 kV supply area

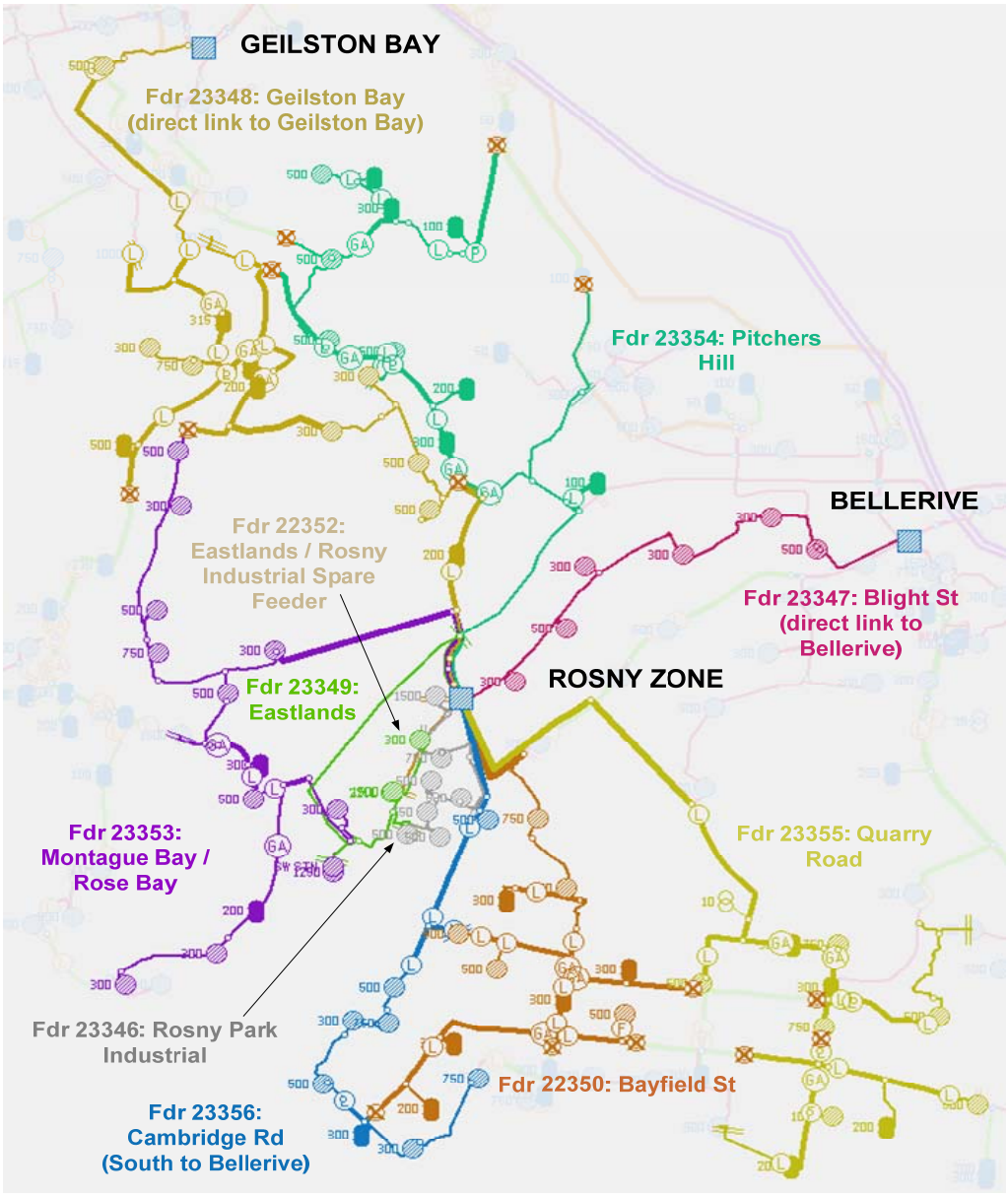

Figure 8-17 Rosny 11 kV feeders

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

Table 8-10 Rosny substation feeder forecast

Feeder/s	2012 Load (MVA)	2013 Load (MVA)	2014 Load (MVA)	2015 Load (MVA)	2016 Load (MVA)	2017 Load (MVA)
23346	3.7	3.7	3.8	3.9	3.9	4.0
23347	1.6	1.7	1.7	1.7	1.7	1.8
23348	3.1	3.1	3.2	3.2	3.3	3.3
23349	2.9	2.9	3.0	3.0	3.1	3.1
23350	3.5	3.5	3.6	3.6	3.7	3.8
23353	3.5	3.5	3.6	3.6	3.7	3.8
23354	2.8	2.8	2.8	2.9	2.9	3.0
23355	3.9	3.9	4.0	4.1	4.1	4.2
23356	2.1	2.2	2.2	2.3	2.3	2.3

As outlined above, no feeders are forecast to exceed the planning rating of 5 MVA prior to 2017.

The expected transfer capacity from Rosny substation to the Bellerive and Geilston Bay substations is outlined in Table 8-11.

Table 8-11 Rosny substation transfer capability

Substation	Feeder	2012 Transfer (MVA)	2013 Transfer (MVA)	2014 Transfer (MVA)	2015 Transfer (MVA)	2016 Transfer (MVA)	2017 Transfer (MVA)
Bellerive	27175	5.1	5.1	5.1	5.1	5	5
	27176	2.6	2.5	2.5	2.4	2.3	2.3
	27178	1.5	1.4	1.3	1.2	1	0.9
Geilston Bay	26165	2.7	2.6	2.6	2.6	2.6	2.6
	26169	6.2	6.2	6.2	6.2	6.2	6.2
Total transfers	-	18.1	17.8	17.7	17.5	17.1	17

As outlined above, there is expected to be significant transfer capacity from Rosny to the adjacent substations for the scope of the study.

8.6.2 Proposed projects

There are no projects proposed in the Rosny supply area in the five year plan.

8.6.3 Ultimate configuration

Substation

Rosny is expected to remain a two transformer substation up to 2050, however the long term plan discusses the possibility of a third transformer at around this time to relieve firm capacity limitations at Rosny and Howrah. The installation of 33 kV switchgear has not been proposed for Rosny in the long term plan.

Feeders

There area no new feeders expected to be required from Rosny in the short term. It is proposed that the Rosny supply area ultimately push back the Hobart East feeder 14601 to the west side of the Derwent River.

The most heavily loaded feeders are those supplying south and east of the substation to the dense urban area of Bellerive. The feeders west from Howrah to the same area are also expected to be relatively heavily loaded. Therefore it is expected that feeder reinforcement from both substations to this area will be required in the future.

8.7 Howrah substation

Howrah zone substation is to be established by Aurora 2011. Howrah will deload the existing Bellerive and Rokeby substations, supplying the Hobart eastern shore suburbs of Howrah, Tranmere and Bellerive.

8.7.1 Limitations

Using the medium growth forecast, Howrah substation load is forecast to grow from 18 MVA in 2012 to 21 MVA in 2017, below the substation firm capacity of 25 MVA. The five year load forecast for Howrah substation is given in Figure 8-18.

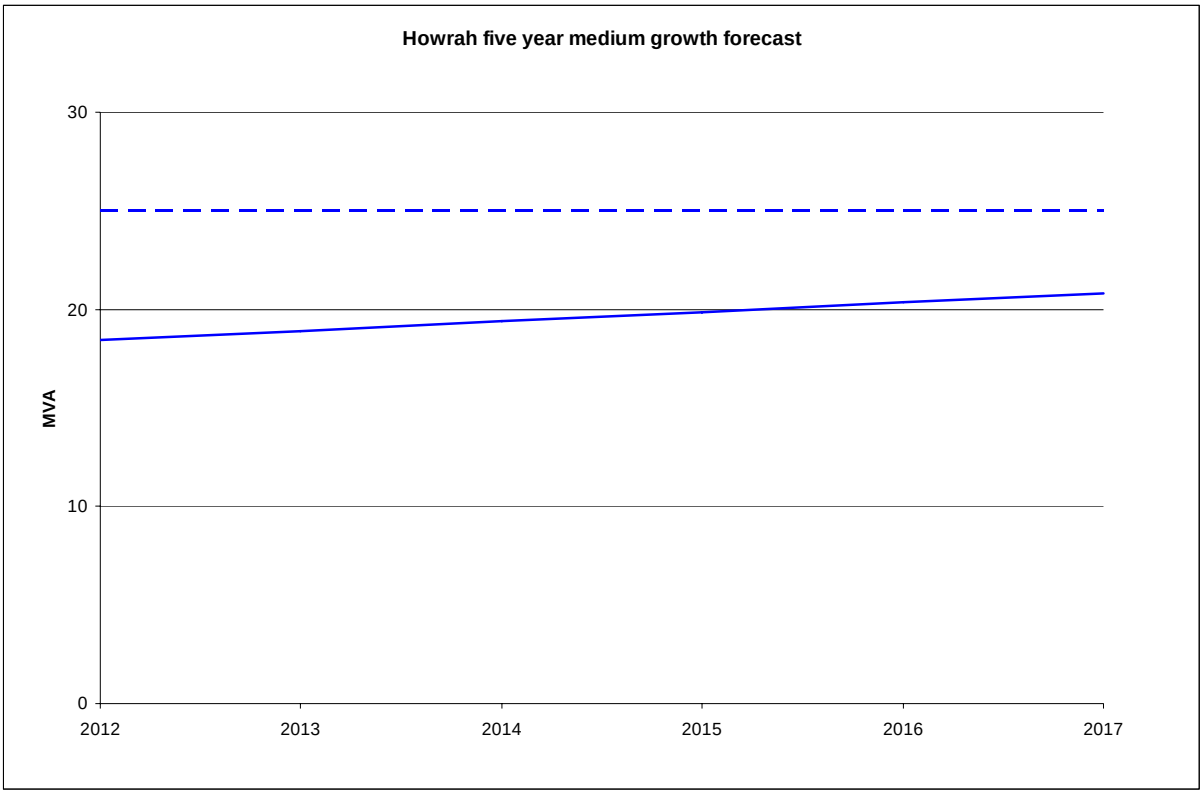

Figure 8-18 Howrah five year medium growth forecast

The 11 kV network from Howrah is expected to consist of nine distribution feeders, with three spare circuit breakers available for future feeders.

The expected Howrah supply area and individual feeders are shown in Figure 8-19 and Figure 8-20 below.

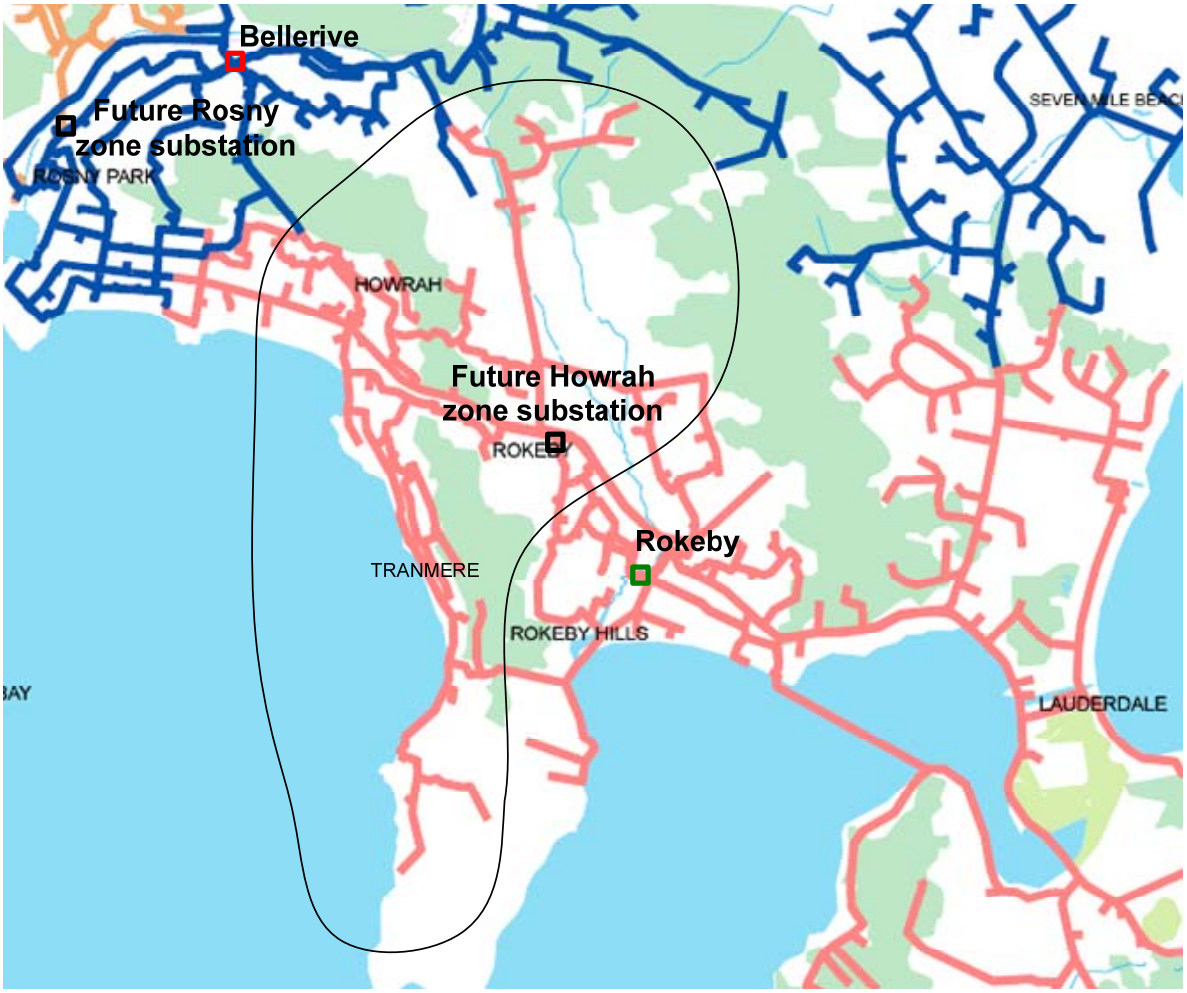

Figure 8-19 Howrah 11 kV supply area

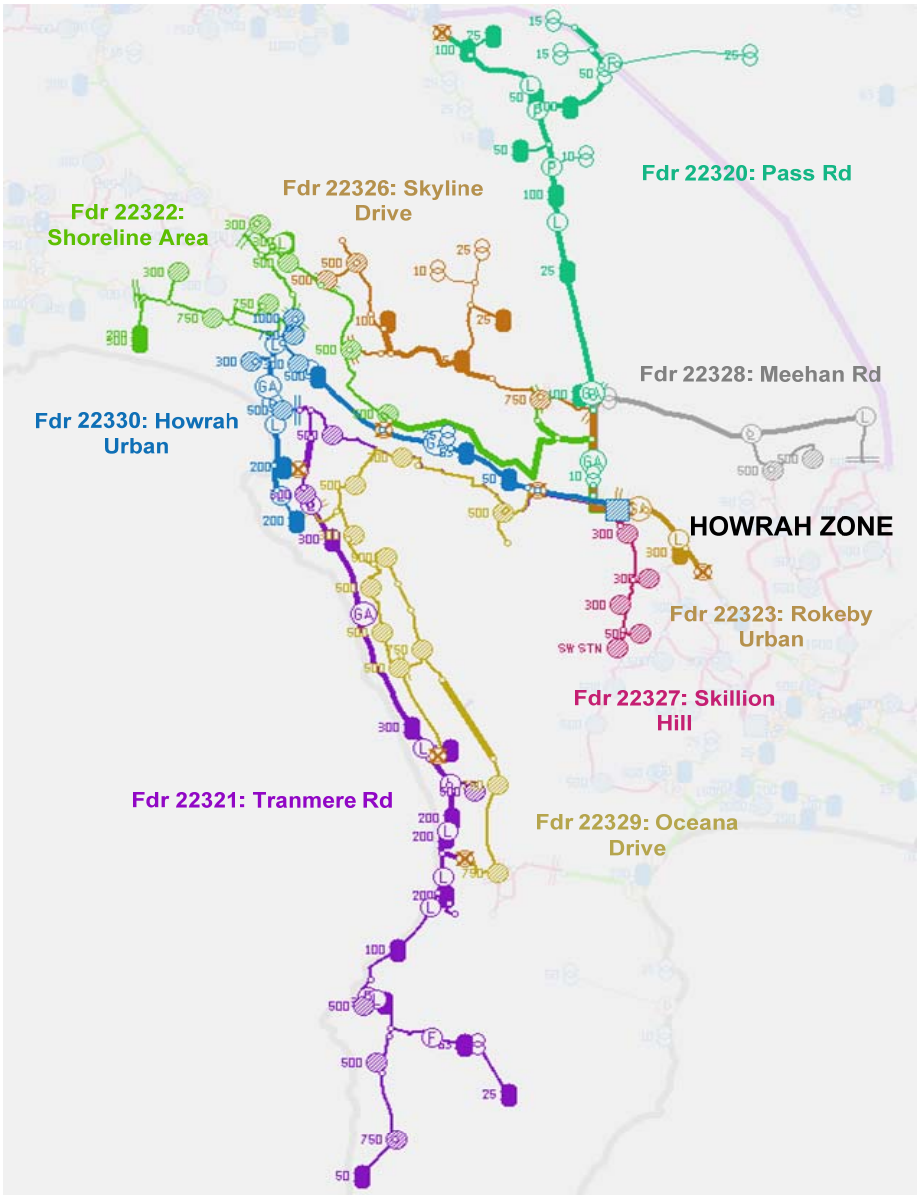

Figure 8-20 Howrah 11 kV feeders

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

Table 8-12 Howrah substation feeder forecast

Feeder/s	2012 Load (MVA)	2013 Load (MVA)	2014 Load (MVA)	2015 Load (MVA)	2016 Load (MVA)	2017 Load (MVA)
22320	0.3	0.3	0.3	0.3	0.3	0.4
22321	2.7	2.8	2.9	3.0	3.0	3.1
22322	3.3	3.4	3.4	3.5	3.6	3.7
22323	0.2	0.2	0.2	0.2	0.2	0.2
22326	1.5	1.5	1.6	1.6	1.6	1.7
22327	1.3	1.3	1.3	1.4	1.4	1.4
22328	0.5	0.5	0.6	0.6	0.6	0.6
22329	3.6	3.7	3.8	3.9	4.0	4.0
22330	3.3	3.4	3.4	3.5	3.6	3.7

As outlined above, no feeders are forecast to exceed the planning rating of 5 MVA prior to 2017.

The expected transfer capacity from Howrah substation to the Bellerive and Rokeby substations is outlined in Table 8-13.

Table 8-13 Howrah substation transfer capability

Substation	Feeder	2012 Transfer (MVA)	2013 Transfer (MVA)	2014 Transfer (MVA)	2015 Transfer (MVA)	2016 Transfer (MVA)	2017 Transfer (MVA)
Bellerive	27171	2.5	2.4	2.4	2.3	2.3	2.2
	27177	3.2	3.2	3.2	3.1	3.1	3.1
	27178	1.9	1.8	1.6	1.5	1.4	1.3
Rokeby	28221	5.2	5.1	5.1	5.1	5	4.9
	28222	1.3	1.2	1.2	1.1	1.1	1.1
	28229	4.8	4.9	5	5.2	5.3	5.4
	28230	5.3	5.2	5.2	5.2	5.2	5.2
Total transfers	**-**	**24.2**	**23.8**	**23.7**	**23.5**	**23.4**	**23.2**

As outlined above, there is expected to be significant transfer capacity from Howrah to the adjacent substations for the scope of the study.

8.7.2 Proposed projects

There are no projects proposed in the Howrah supply area in the five year plan.

8.7.3 Ultimate configuration

Substation

Howrah is expected to remain a two transformer substation up to 2050, however the long term plan discusses the possibility of a third transformer at around this time to relieve firm capacity limitations at Rosny and Howrah. The installation of 33 kV switchgear has not been proposed for Howrah in the long term plan.

Feeders

There are no new feeders expected to be required from Howrah in the short term. Due to the proximity of Rokeby substation to the east of Howrah, it is considered unlikely that future feeders will be required east from Howrah.

The most heavily loaded feeders are those supplying west of the substation to the dense urban areas of Bellerive and Howrah. The feeders south and east from Rosny to the same area are also expected to be relatively heavily loaded. Therefore it is expected that feeder reinforcement from both substations to this area will be required in the future.

8.8 Rokeby substation

Rokeby terminal substation supplies to the Hobart eastern shore suburbs of Rokeby, Howrah, Tranmere, Lauderdale and South Arm.

8.8.1 Limitations

Using the medium growth forecast, Rokeby substation load is forecast to grow from 30 MVA in 2012 to 34 MVA in 2017 (assuming establishment of Rosny and Howrah zone substations by 2012), which is below the substation firm capacity of 35 MVA. The five year load forecast for Rokeby substation is given in Figure 8-21.

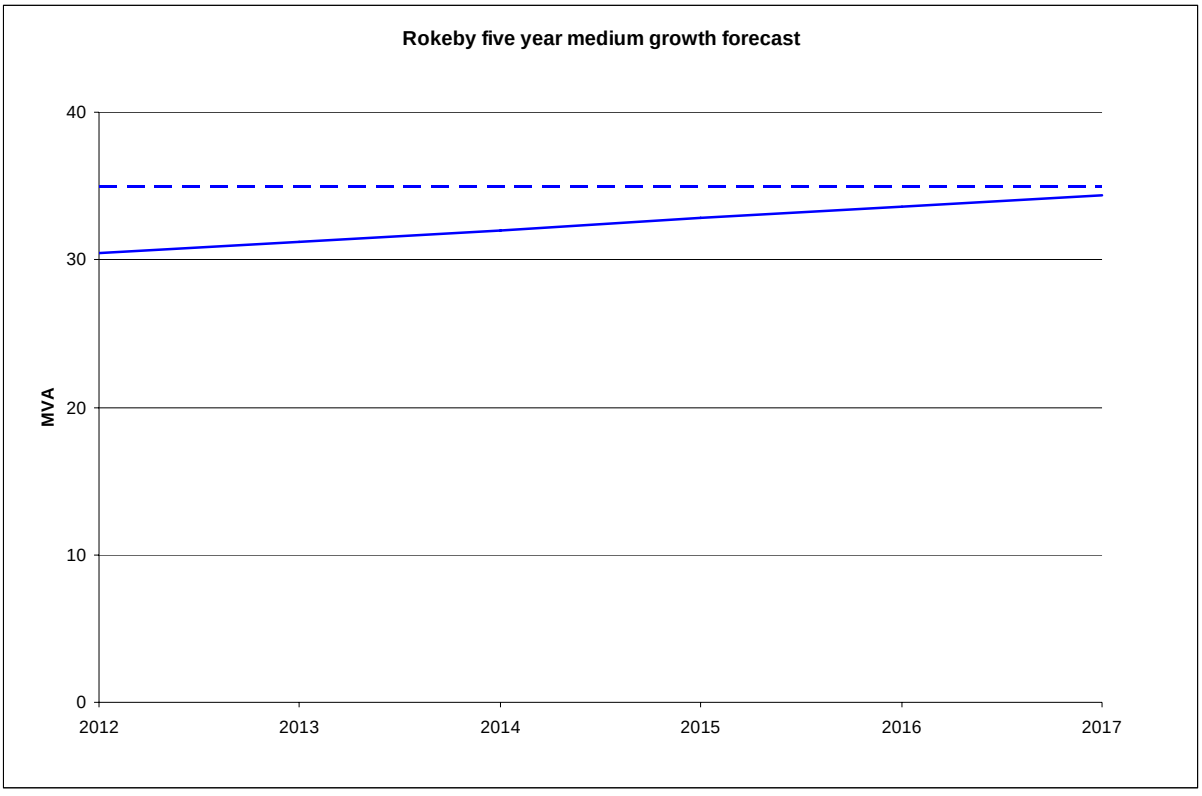

Figure 8-21 Rokeby five year medium growth forecast

The 11 kV network from Rokeby consists of ten distribution feeders and there are two spare circuit breakers available for future feeders. It is expected that there is space for the installation of at least two additional feeder circuit breakers.

The Rokeby supply area is shown in Figure 8-22. The Rokeby individual feeders are shown in Figure 8-23 and Figure 8-24 for the northern and southern feeders respectively. It should be noted that these figures represent the current arrangement and do not show the impact of the future Howrah and Rosny zone substations.

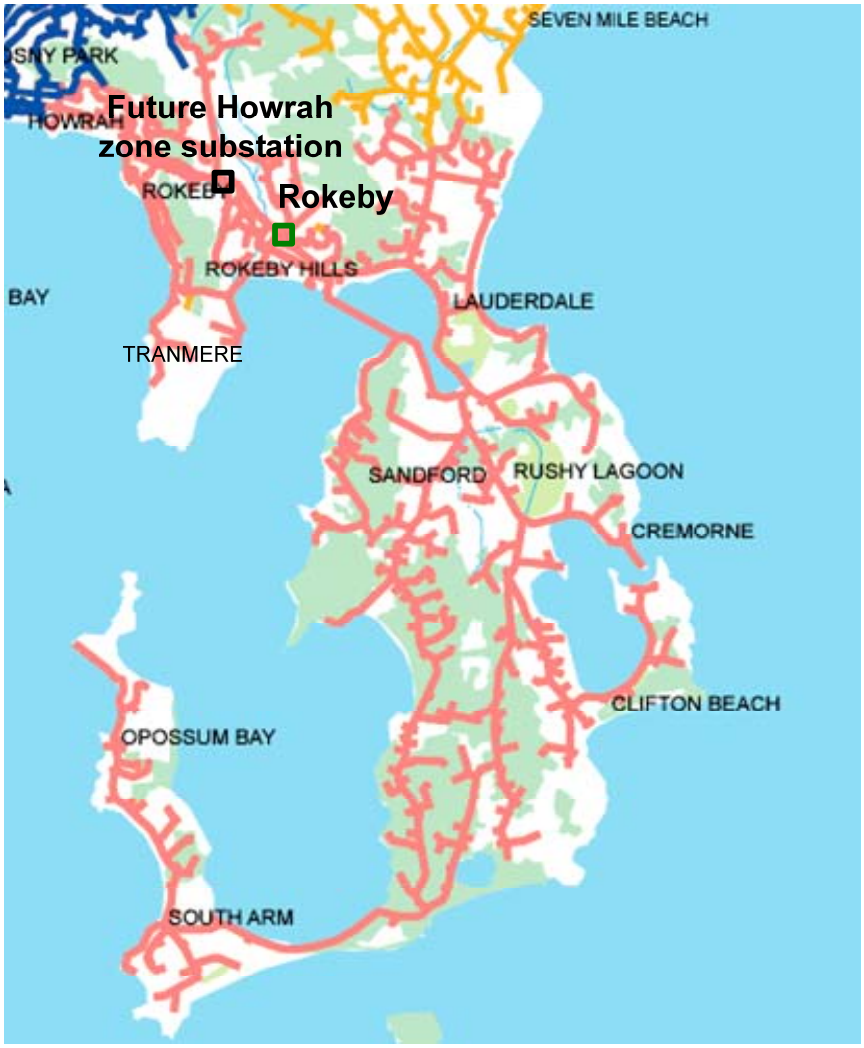

Figure 8-22 Rokeby 11 kV supply area

Figure 8-23 Rokeby northern 11 kV feeders

Figure 8-24 Rokeby 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 8-14. As above, these loads do not take into account the establishment of the Rosny and Howrah zone substations.

Table 8-14 Rokeby substation feeder forecast

Feeder/s	2012 Load (MVA)	2013 Load (MVA)	2014 Load (MVA)	2015 Load (MVA)	2016 Load (MVA)	2017 Load (MVA)
28221	5.4	5.6	5.7	5.8	6.0	6.1
28222	4.5	4.6	4.7	4.8	4.9	5.1
28223	5.0	5.1	5.2	5.4	5.5	5.6
28224	3.7	3.8	3.9	4.0	4.1	4.2
28225	1.4	1.5	1.5	1.6	1.6	1.6
28227	2.4	2.5	2.5	2.6	2.7	2.7
28228	3.7	3.8	3.9	4.0	4.1	4.2
28229	5.0	5.1	5.2	5.4	5.5	5.6
28230	5.5	5.6	5.8	5.9	6.1	6.2
28231	2.8	2.9	3.0	3.1	3.1	3.2

As outlined above, feeders 28221, 28222, 28223, 28229 and 28230 are forecast to exceed the 5 MVA planning rating by 2017.

It is expected that the limitation on 28221, 28222, 28229 and 28230 will be addressed by the establishment of Howrah zone substation in 2011. No projects have been proposed by Aurora to address the limitation on feeder 28223.

The available transfer capacity from Rokeby substation to the Howrah and Cambridge substations is outlined in Table 8-15.

Table 8-15 Rokeby substation transfer capability

Substation	Feeder	2012 Transfer (MVA)	2013 Transfer (MVA)	2014 Transfer (MVA)	2015 Transfer (MVA)	2016 Transfer (MVA)	2017 Transfer (MVA)
Cambridge	29483	1.7	1.6	1.6	1.6	1.6	1.6
Howrah	22323	3.7	3.7	3.7	3.7	3.7	3.7
	22324	1.3	1.3	1.3	1.4	1.4	1.4
	22327	2	2	2	2	1.9	1.9
	22328	1.7	1.7	1.7	1.7	1.7	1.7
	22329	1.7	1.7	1.6	1.5	1.4	1.3
Total transfers	**-**	**12.1**	**12**	**11.9**	**11.9**	**11.7**	**11.6**

As outlined above, there is significant transfer capacity from Rokeby to adjacent substations for the scope of the study.

8.8.2 Proposed projects

Establish Sandford zone substation

Sandford zone substation is proposed to be established in 2017 to address the firm capacity limitations at Rokeby substation, as well as deloading the 11 kV network to the south and east of Rokeby. For information on the options analysis for this project please refer to the ten year plan in Section 7.1.4. For information on the proposed Sandford distribution network details please refer to the five year plan in Section 8.9.

The resulting Rokeby five year load forecast is shown in Figure 8-25.

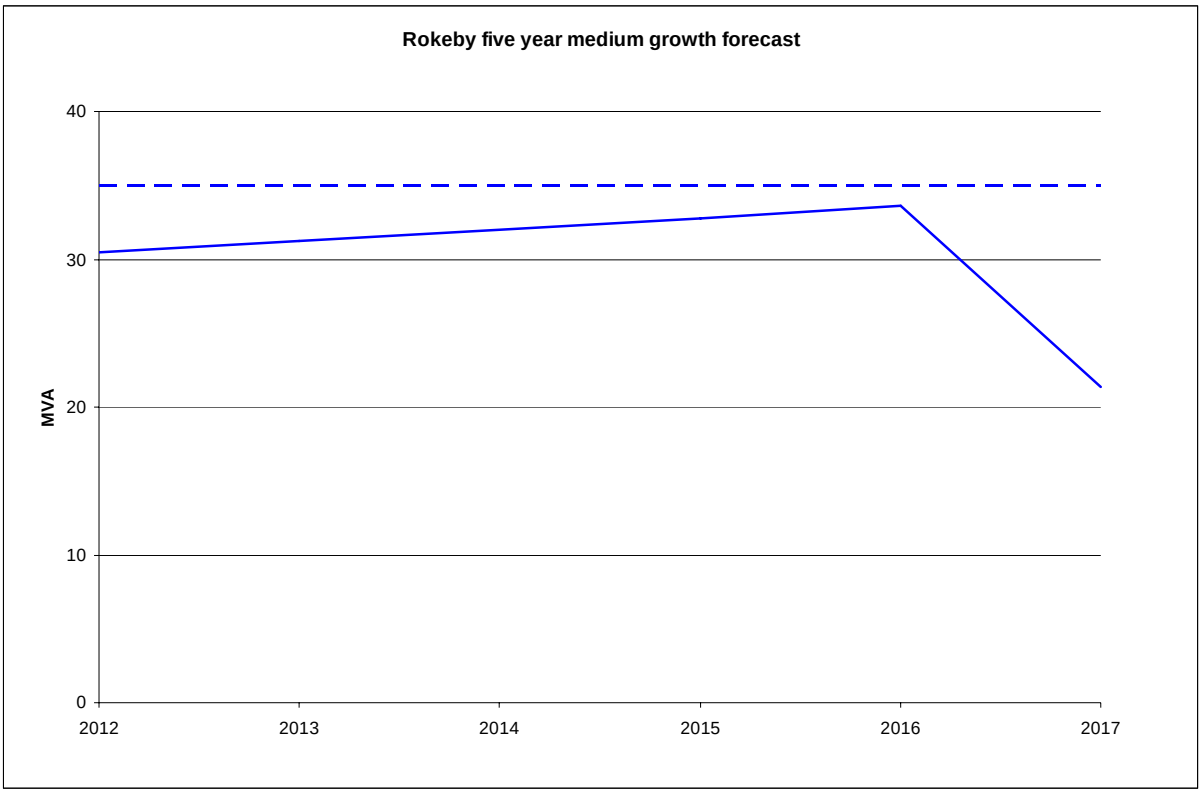

Figure 8-25 Rokeby proposed five year medium growth forecast

As outlined above, Rokeby load is reduced below firm capacity in 2017.

New feeder projects

All feeder limitations within the period of study are addressed by the Howrah and Sandford projects. Therefore no feeder projects have been proposed for Rokeby substation.

8.8.3 Ultimate configuration

Substation

Rokeby is expected to remain a two transformer substation up to 2050, though the existing 110/11 KV 35 MVA transformers were installed in 1982 so are predicted to be end of life around 2032. 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 provide sufficient circuit breakers to enable the full capacity of the transformers to be utilised.

Beyond 2050, it is conceivable that Rokeby could be the site of a new 33 kV injection point, since it is well located to cut into the Sandford 33 kV cables and close to Howrah, and Mornington is forecast to reach firm capacity around this time. A new 110 kV feeder to Rokeby would also be required at that time to address the ESI 3000 MWh rule on the existing overhead lines.

Feeders

As discussed above, it is expected that feeder limitations at Rokeby up to 2017 will be addressed by existing Aurora projects as well as the proposed Sandford project.

Following the establishment of Howrah zone substation, the Rokeby 11 kV network to the north and west will be quite lightly loaded. Considering the proximity of Howrah, it is considered unlikely that new feeders will be required from Rokeby in this direction.

Similarly, the establishment of Sandford zone substation is expected to significantly deload the Rokeby 11 kV network to the south and east, allowing Rokeby substation to focus on the supply of the suburbs of Rokeby, Clarendon Vale, Oakdowns with support to Tranmere and Lauderdale. An additional feeder may ultimately be required from Rokeby to the Lauderdale/Roches Beach area. A new feeder over the hills separating Clarendon Vale and Roches Beach would be ideal, as this would provide an additional source at the approximate midpoint of the Cambridge and Sandford substations.

It is expected that load in the high growth area around Lauderdale area can be adequately supplied from the Sandford, Rokeby and Cambridge substations up to 2050.

8.9 Sandford substation

Sandford zone substation is proposed to be installed in 2017 to address the firm capacity limitation at Rokeby substation and to address 11 kV feeder limitations from Rokeby to Lauderdale and the peninsula. For information on the options analysis and justification for this project please refer to the ten year plan in Section 7.1.4. 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 Sandford feeder configuration is shown in Figure 8-26 below.

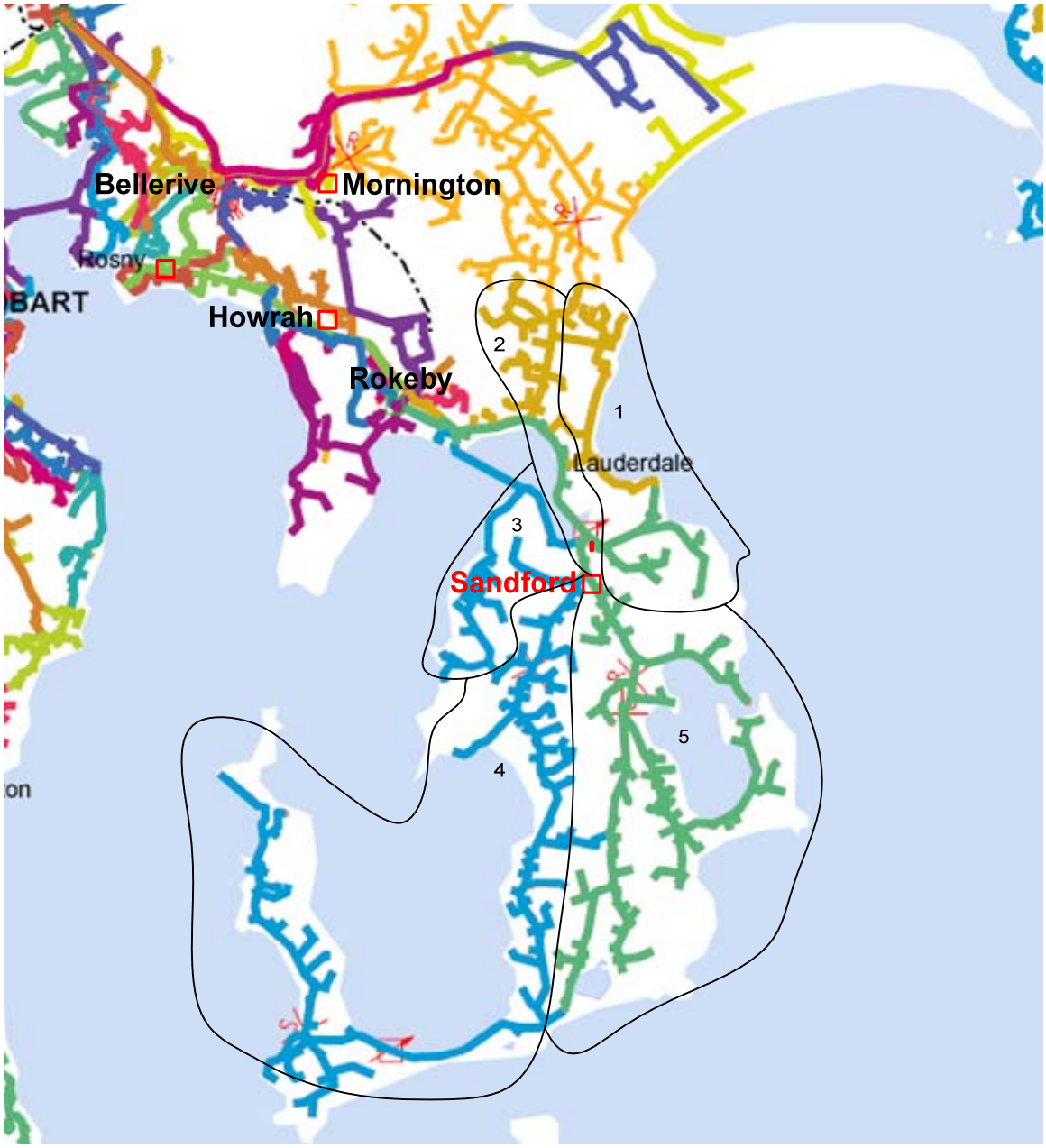

Figure 8-26 Sandford proposed feeder configuration

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 8-16.

Table 8-16 Sandford substation feeder forecast

Feeder/s	2017 Load (MVA)	2018 Load (MVA)	2019 Load (MVA)	2020 Load (MVA)	2021 Load (MVA)	2022 Load (MVA)
1	2.5	2.5	2.6	2.7	2.7	2.8
2	2.4	2.4	2.5	2.5	2.6	2.7
3	1.0	1.0	1.1	1.1	1.1	1.1
4	3.3	3.4	3.4	3.5	3.6	3.7
5	4.1	4.2	4.3	4.4	4.5	4.6

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

8.9.1 Proposed projects

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

8.9.2 Ultimate configuration

Substation

Sandford is expected to remain a two transformer substation up to 2050. There is no plan to install 33 kV switchgear at the substation.

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 Lauderdale and high growth has been forecast for this area, so future feeders from Sandford are considered most likely to be to the north. However the Sandford feeders in this direction are forecast to be quite lightly loaded, and there is also support from Rokeby to the area, so new feeders in this direction are not expected to be required in the near term.

The feeder to the south east (feeder 5) is forecast to be the heaviest loaded of the Sandford feeders, however a simple project to defer limitations on this feeder would be to run a new tail to split the feeder (approximately 4 km).

The proposed feeder to South Arm and Opossum bay is expected to provide adequate supply to this area in the short term, with further feeder augmentation such as running a new tail to split feeder 5, expected to be able to defer limitations in the area further. If justified by load growth, or if a second source of supply is required to improve security, a second overhead circuit could be run down the narrow isthmus along the South Arm highway. An alternative option would be a sub-marine cable from the Tranmere peninsula supplied from Rokeby, however this is likely to be a more expensive option and would only be considered should a second circuit along the isthmus be unfeasible.

8.10 Cambridge substation

Cambridge zone substation supplies to the Hobart eastern shore suburbs of Cambridge, Acton Park, Warrane and Mornington.

8.10.1 Limitations

Using the medium growth forecast, Cambridge substation load is forecast to grow from 14 MVA in 2012 to 16 MVA in 2017, below the substation firm capacity of 20 MVA. The five year load forecast for Cambridge substation is given in Figure 8-27.

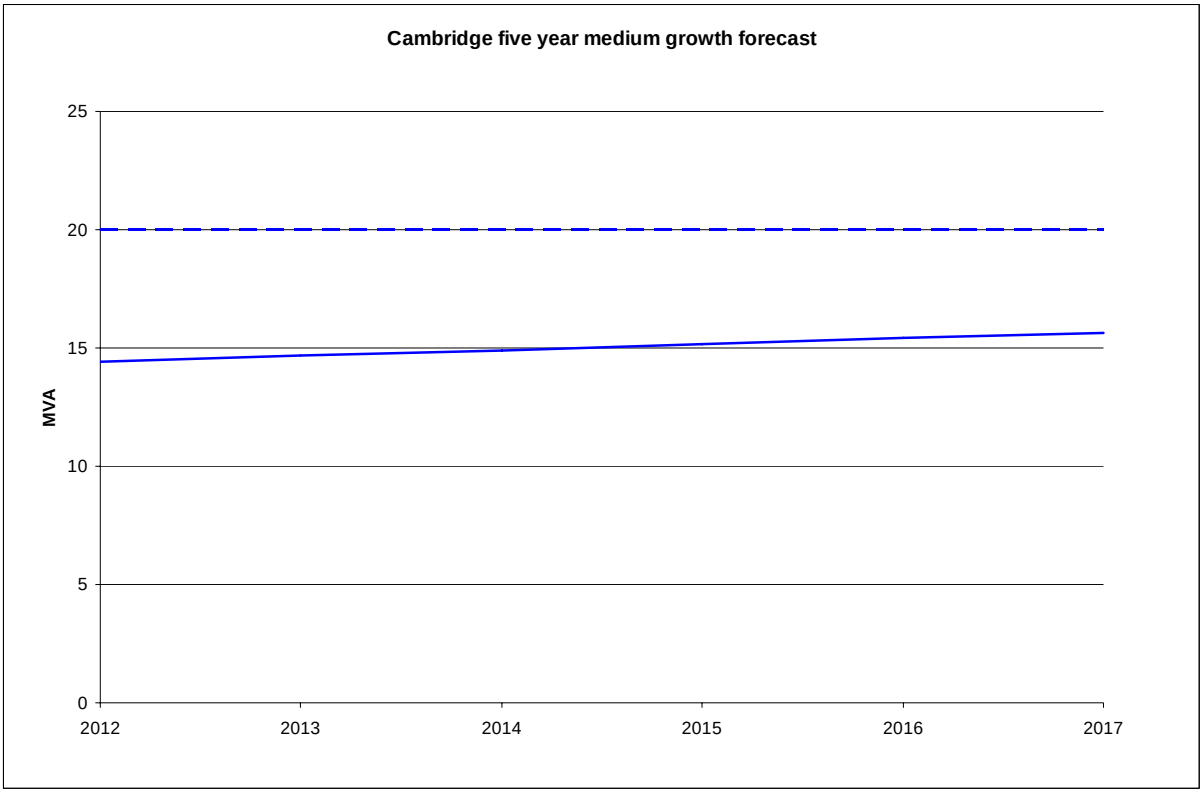

Figure 8-27 Cambridge five year medium growth forecast

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

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

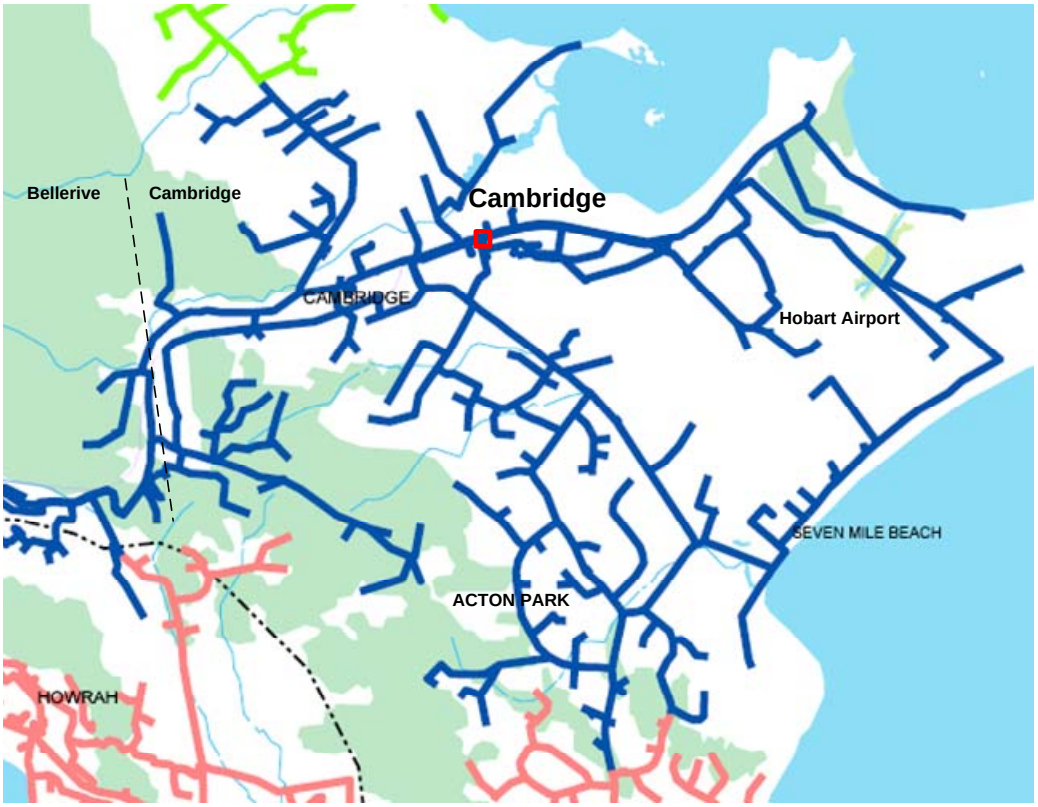

Figure 8-28 Cambridge 11 kV supply area

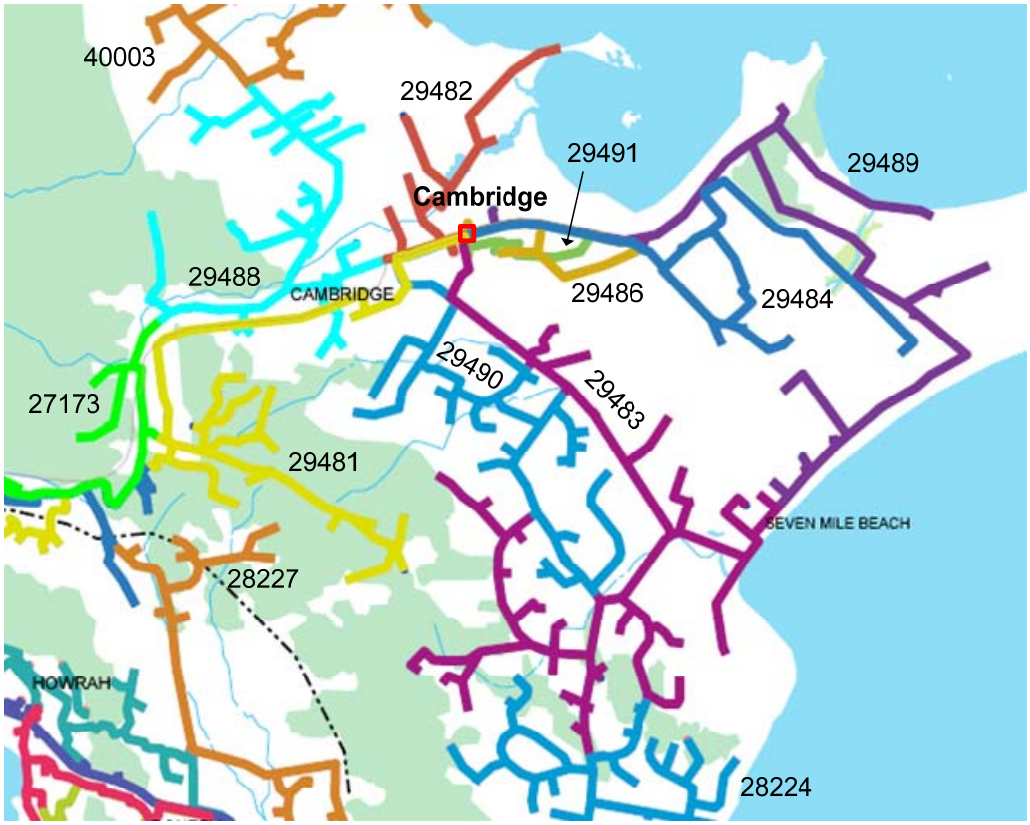

Figure 8-29 Cambridge 11 kV feeders

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 8-17. As above, these loads do not take into account the establishment of the Rosny and Howrah zone substations.

Table 8-17 Cambridge substation feeder forecast

Feeder/s	2012 Load (MVA)	2013 Load (MVA)	2014 Load (MVA)	2015 Load (MVA)	2016 Load (MVA)	2017 Load (MVA)
29481	0.7	0.7	0.7	0.7	0.7	0.7
29482	0.7	0.7	0.7	0.7	0.7	0.7
29483	2.5	2.6	2.6	2.7	2.7	2.8
29484	1.3	1.4	1.4	1.4	1.4	1.5
29485	0.0	0.0	0.0	0.0	0.0	0.0
29486	0.7	0.7	0.7	0.7	0.7	0.7
29488	2.8	2.8	2.9	2.9	3.0	3.0
29489	1.1	1.1	1.1	1.2	1.2	1.2
29490	2.0	2.1	2.1	2.1	2.2	2.2
29491	2.1	2.1	2.2	2.2	2.3	2.3

As outlined above, no feeders are forecast to exceed the planning rating of 5 MVA prior to 2017. Feeder 29485 is a backup feeder into the airport switching station and currently does not carry any load.

The available transfer capacity from Cambridge substation to the Bellerive and Rokeby substations is outlined in Table 8-18.

Table 8-18 Cambridge substation transfer capability

Substation	Feeder	2012 Transfer (MVA)	2013 Transfer (MVA)	2014 Transfer (MVA)	2015 Transfer (MVA)	2016 Transfer (MVA)	2017 Transfer (MVA)
Bellerive	27173	3.1	3.1	3.1	3	3	3
	27177	3.7	3.7	3.6	3.6	3.6	3.5
Rokeby	28224	1.1	1.0	0.9	0.8	0.7	0.6
Total transfers	**-**	**7.9**	**7.8**	**7.6**	**7.4**	**7.3**	**7.1**

As outlined above, there is significant transfer capacity from Cambridge to adjacent substations for the scope of the study.

8.10.2 Proposed projects

There are no projects proposed in the Cambridge supply area in the five year plan.

8.10.3 Ultimate configuration

Substation

The installation of a third 33/11 kV transformer has been proposed in the long term plan for 2039, with the caveat that such a project is heavily dependent on whether the forecast high load growth in the area eventuates.

The transformer would be supplied by a new feeder from Mornington substation. This may require the 11 kV bus to be operated normally open, depending on whether Cambridge retains supply from Lindisfarne or is cut over to Mornington.

No 33 kV switchgear is expected to be required at Cambridge substation.

Feeders

As discussed above, there are no forecast feeder limitations up to 2017 – in fact the existing feeders are forecast to be very lightly loaded at this time. As such it is difficult to determine the probable directions of future feeders.

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 $400-500 k)
110 kV	Over head single circuit (double circuit construction)	500	-	-	Transend (advised $400-500 k)
110 kV	Overhead double circuit	550	-	-	Transend (advised $500-600 k)
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 $15-20 million)
110/22/11 kV terminal substation (single 25 MVA transformer)	9,000	Transend (advised $8-10 million)
Install 3rd 110/22/11 kV transformer at existing site	7,000	Transend (advised $6-8M million
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 $12-15 million)
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	Richmond substation conversion	7.1.3
2	Establish Sandford zone substation	7.1.4
3	Extend 22 kV feeder 41512 to Oatlands and convert Colebrook to 22 kV	7.1.6

Richmond substation conversion NPV analysis (Hobart-East area)

Base Year
2010

OPTION 1
Convert Richmond zone substation to 33/11 kV

Development Year			System Limitation	Description of Works	Cost $k	Medium Growth Net Present Value in $ M			High Growth Net Present Value in $ M			Low Growth Net Present Value in $ M		
Medium	High	Low				5.64%	6.64%	7.64%	5.64%	6.64%	7.64%	5.64%	6.64%	7.64%
2017	2016	2018	Remove mixed voltage levels Increase transfer capacity away from Richmond to address ESI limitation for loss of transformer	Convert 41512 to 11 kV west of river and overbuild new 33 kV circuit: - Convert 22 to 11 kV ~ 80 transformers - Reinsulate to 33 kV and underbuild 11 kV 9 km - New 33 kV SCCT 4 km	$4,000	$2.72	$2.55	$2.39	$2.88	$2.72	$2.57	$2.58	$2.39	$2.22
2020	2019	2021	Address 41516 reliability	Split 41516 using deloaded 41512: - 1 km 22 kV overhead to tie 41516 and 41512	$100	$0.06	$0.05	$0.05	$0.06	$0.06	$0.05	$0.05	$0.05	$0.04
					Total	**$2.78**	**$2.60**	**$2.44**	**$2.94**	**$2.78**	**$2.62**	**$2.63**	**$2.44**	**$2.26**

OPTION 2
Install second 33/22/11 kV transformer at Richmond

Development Year			System Limitation	Description of Works	Cost $k	Medium Growth Net Present Value in $ M			High Growth Net Present Value in $ M			Low Growth Net Present Value in $ M		
Medium	High	Low				5.64%	6.64%	7.64%	5.64%	6.64%	7.64%	5.64%	6.64%	7.64%
2017	2016	2018	Address ESI limitation for loss of transformer	Install additional 33/22/11 kV transformer - 1 x 10 MVA 33/22/11 kV transformers	$1,000	$0.68	$0.64	$0.60	$0.72	$0.68	$0.64	$0.64	$0.60	$0.55
2020	2019	2021	Address 41516 reliability	New feeder from Sorell to deload 41516: - extend 22 kV bus with 1 x CB - 3km sections of 22 kV OH (feeder tail and 1km tie)	$450	$0.26	$0.24	$0.22	$0.27	$0.25	$0.23	$0.25	$0.22	$0.20
2027	2026	2028	Remove mixed voltage levels	Convert 41512 to 11 kV west of river and overbuild new 33 kV circuit: - Convert 22 to 11 kV ~ 80 transformers - Reinsulate to 33 kV and underbuild 11 kV 9 km - New 33 kV SCCT 4 km	$4,000	$1.57	$1.34	$1.14	$1.66	$1.43	$1.23	$1.49	$1.26	$1.06
					Total	**$2.51**	**$2.22**	**$1.96**	**$2.66**	**$2.36**	**$2.11**	**$2.38**	**$2.08**	**$1.82**

Establish Sandford zone substation NPV analysis (Hobart-East area)

Base Year
2010

OPTION 1
Establish Sandford zone substation

Development Year			System Limitation	Description of Works	Cost $k	Medium Growth Net Present Value in $ M			High Growth Net Present Value in $ M			Low Growth Net Present Value in $ M		
Medium	High	Low				5.64%	6.64%	7.64%	5.64%	6.64%	7.64%	5.64%	6.64%	7.64%
2017	2016	2018	Rokeby substation exceeds firm capacity South arm feeder reliability/capacity	Establish Sandford zone substation: - 33 kV UG DCCT 14 km from Mornington - zone substation on new block - 11 kV feeder ties 4 km UG 1 km OH	$14,150	$9.64	$9.02	$8.45	$10.18	$9.62	$9.10	$9.12	$8.46	$7.85
2023	2022	2024	Mornington substation exceeds firm capacity (after Bellerive transfer)	Install 3rd transformer at Mornington - 1 x 60 MVA 110/33 kV transformer - 1 x 33 kV switchboard - 2 x 110 kV CBs	$7,000	$3.43	$3.03	$2.69	$3.62	$3.24	$2.89	$3.25	$2.85	$2.50
2032	2031	2033	Rokeby transformer end of life	Replace 110/11 kV transformers	$6,000	$1.79	$1.46	$1.19	$1.90	$1.56	$1.28	$1.70	$1.37	$1.10
					Total	**$14.86**	**$13.52**	**$12.33**	**$15.70**	**$14.41**	**$13.27**	**$14.07**	**$12.67**	**$11.45**

OPTION 2
Establish Lauderdale zone substation

Development Year			System Limitation	Description of Works	Cost $k	Medium Growth Net Present Value in $ M			High Growth Net Present Value in $ M			Low Growth Net Present Value in $ M		
Medium	High	Low				5.64%	6.64%	7.64%	5.64%	6.64%	7.64%	5.64%	6.64%	7.64%
2017	2016	2018	Rokeby substation exceeds firm capacity South arm feeder reliability/capacity	Establish Lauderdale zone substation: - 33 kV UG DCCT 12 km from Mornington - zone substation on new block - 2x11 kV super feeder 7 km UG to split south arm - 11 kV feeder ties 3 km UG to split lauderdale	$15,495	$10.55	$9.88	$9.25	$11.15	$10.54	$9.96	$9.99	$9.26	$8.60
2023	2022	2024	Mornington substation exceeds firm capacity (after Bellerive transfer)	Install 3rd transformer at Mornington - 1 x 60 MVA 110/33 kV transformer - 1 x 33 kV switchboard - 2 x 110 kV CBs	$7,000	$3.43	$3.03	$2.69	$3.62	$3.24	$2.89	$3.25	$2.85	$2.50
2032	2031	2033	Rokeby transformer end of life	Replace 110/11 kV transformers	$6,000	$1.79	$1.46	$1.19	$1.90	$1.56	$1.28	$1.70	$1.37	$1.10
					Total	**$15.78**	**$14.37**	**$13.13**	**$16.67**	**$15.33**	**$14.13**	**$14.94**	**$13.48**	**$12.20**

OPTION 3
Upgrade Rokeby terminal substation

Development Year			System Limitation	Description of Works	Cost $k	Medium Growth Net Present Value in $ M			High Growth Net Present Value in $ M			Low Growth Net Present Value in $ M		
Medium	High	Low				5.64%	6.64%	7.64%	5.64%	6.64%	7.64%	5.64%	6.64%	7.64%
2017	2016	2018	Rokeby substation exceeds firm capacity South arm feeder reliability/capacity	Upgrade Rokeby substation - 2 x 60 MVA 110/11 kV transformers - Replace 11 kV switchboard - 2x11 kV super feeder 11 km UG (9km DCCT) to split South Arm - 11 kV super feeder 4km UG to split Lauderdale	$15,480	$10.54	$9.87	$9.25	$11.14	$10.53	$9.95	$9.98	$9.26	$8.59
2027	2026	2028	South Arm feeder reliability/capacity	2x11 kV super feeder 8 km UG (6km DCCT) to split South Arm (2 river crossings)	$8,300	$3.27	$2.78	$2.37	$3.45	$2.97	$2.56	$3.09	$2.61	$2.21
2039	2038	2040	Mornington substation exceeds firm capacity (after Bellerive transfer)	Install 3rd transformer at Mornington - 1 x 60 MVA 110/33 kV transformer - 1 x 33 kV switchboard - 2 x 110 kV CBs	$7,000	$1.43	$1.08	$0.83	$1.51	$1.16	$0.89	$1.35	$1.02	$0.77
					Total	**$15.23**	**$13.74**	**$12.45**	**$16.09**	**$14.65**	**$13.40**	**$14.42**	**$12.88**	**$11.56**

Extend Sorell feeder 41512 to Oatlands and convert Colebrook to 22 kV

Base Year
2010

OPTION 1
Extend Sorell feeder 41512

Development Year			System Limitation	Description of Works	Cost $k	Medium Growth Net Present Value in $ M			High Growth Net Present Value in $ M			Low Growth Net Present Value in $ M		
Medium	High	Low				5.64%	6.64%	7.64%	5.64%	6.64%	7.64%	5.64%	6.64%	7.64%
2020	2019	2021	Address 41516 reliability	Split 41516 using deloaded 41512: - 1.5 km 22 kV overhead to tie 41516 and 41512 - Reinsulate 15 km 11 to 22 kV - Replace 50 distribution transformers - 5 km 22 kV overhead to tie new 41512 with 40002	$1,775	$1.03	$0.93	$0.85	$1.08	$1.00	$0.92	$0.97	$0.88	$0.79
2020	2019	2021	Colebrook conversion 11 to 22 kV	Common to both options		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
2045	2040	2050	Ross feeder reliability	Establish Ross 110/22 kV substation	$26,800	$3.93	$2.82	$2.04	$5.17	$3.90	$2.94	$2.99	$2.05	$1.41
					Total	**$4.95**	**$3.76**	**$2.89**	**$6.25**	**$4.89**	**$3.86**	**$3.96**	**$2.92**	**$2.20**

OPTION 2
Establish Bothwell substation

Development Year			System Limitation	Description of Works	Cost $k	Medium Growth Net Present Value in $ M			High Growth Net Present Value in $ M			Low Growth Net Present Value in $ M		
Medium	High	Low				5.64%	6.64%	7.64%	5.64%	6.64%	7.64%	5.64%	6.64%	7.64%
2020	2019	2021	Address 41516 reliability	Establish Bothwell substation - 1 x 10 MVA 110/22 kV transformer - 1 x 22 kV bus	$9,000	$5.20	$4.73	$4.31	$5.49	$5.05	$4.64	$4.92	$4.44	$4.00
2020	2019	2021	Colebrook conversion 11 to 22 kV	Common to both options		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
2055	2045	2065	Ross feeder reliability (assumed deferred by 10 years due to Bothwell substation)	Establish Ross 110/22 kV substation	$26,800	$2.27	$1.49	$0.98	$3.93	$2.82	$2.04	$1.31	$0.78	$0.47
					Total	**$7.47**	**$6.22**	**$5.29**	**$9.42**	**$7.87**	**$6.68**	**$6.23**	**$5.22**	**$4.47**

Appendix C
Glossary

Appendix C – 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

Adelaide 61 8 8237 9777
Auckland 64 9 520 6019
Bangkok 66 2 260 4560
Blenheim 64 3 520 6060
Brisbane 61 7 3173 8000
Cairns 61 7 4051 6266
Canberra 61 2 6112 0100
Christchurch 64 3 366 0821
Darwin 61 8 8919 9777
Geraldton 61 8 9964 2764
Gladstone 61 7 4962 0600
Gold Coast 61 7 5591 7775
Hamilton 64 7 834 1565
Hanoi 84 4976 1282
Ho Chi Minh City 84 8 3910 0288
Hong Kong 852 3664 6888
Jakarta 62 21 5140 2470
Karratha 61 8 9185 6344
Kuala Lumpur 60 3 2164 7301
Lithgow 61 2 6351 3750
Mackay 61 7 4951 3500
Maroochydore 61 7 5443 4055
Melbourne 61 3 8683 1333
Mildura 61 3 5022 2766
Morwell 61 3 5116 7205
Nelson 64 3 539 0190
Newcastle 61 2 4941 5415
Paraparaumu 64 4 296 1240
Parramatta 61 2 9890 4100
Perth 61 8 9223 1500
Phnom Penh 855 12 923 248
Port Augusta 61 8 8642 3197
Queenstown 64 3 441 0346
Rangiora 64 3 313 8776
Shanghai 86 21 3313 4750
Singapore 65 6256 6188
Sydney 61 2 9465 5599
Tauranga 64 7 578 6183
Toowoomba 61 7 4632 6249
Townsville 61 7 4772 2858
Traralgon 61 3 5176 0113
Wellington 64 4 472 9589
Whyalla 61 8 8645 5755
Wollongong 61 2 4224 7274

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