Beca

# Southland Murihiku Regional Energy Strategy 2022-2050

Prepared for **Great South**
by Beca Limited

**1 July 2023**

GREAT SOUTH
Southland Regional Development Agency

Murihiku Regeneration


Creative people together transforming our world

# Acknowledgement

We would like to expressly thank, and acknowledge, the commitment of the Southland Murihiku Regional Energy Strategy Advisory Group members. Their contributions to the process and development of the Strategy are greatly appreciated. (Refer to Appendix C for a full list of the Advisory Group members). We also wish to acknowledge the financial contributions from Great South, Community Trust South and from the Ministry of Business Innovation and Employment as part of the Beyond 2025 Southland Regional Long-Term Plan.

# Acronyms and Abbreviations

| | |
|---|---|
| AFOLU | Agriculture, Forestry, and Other Land Use |
| AMP | Asset Management Plan |
| BESS | Battery Energy Storage Systems |
| BEV | Battery Electric Vehicle |
| BfCC | Building for Climate Change |
| COP | Coefficient of Performance |
| EBD | Electricity Distribution Business |
| EIL | Electricity Invercargill |
| ERP | Emissions Reduction Plan |
| EV | Electric Vehicle |
| FCEV | Fuel Cell Electric Vehicle |
| GHG | Greenhouse Gas |
| GIDI | Government Investment in Decarbonising Industry Fund |
| GIS | Geographic Information System |
| GWP | Global Warming Potential |
| GXP | Grid Exit Point |
| HVDC | High Voltage Direct Current |
| IPPU | Industrial Processes and Products Uses |
| LNG | Liquified Natural Gas |
| LPG | Liquified Petroleum Gas |
| LRMC | Long Run Marginal Cost |
| MSI | Milford Sound Infrastructure Limited |
| NBE | Natural and Build Environment Plan |
| NZAS | New Zealand's Aluminium Smelter |
| NZBC | New Zealand Building Code |
| ONL | OtagoNet |
| PHES | Pumped Hydro Energy Storage |

| | |
|---|---|
| RETA | Regional Energy Transition Accelerator |
| RAPS | Remote Area Power Schemes |
| REC | Renewable Energy Industrial Clusters |
| REZ | Renewable Energy Zone |
| RMA | Resource Management Act |
| RSS | Regional Spatial Strategy |
| SE | Steam Exploded |
| SGH | Southern Green Hydrogen |
| SIESA | Stewart Island Electricity Supply Authority |
| TPCL | The Power Company |
| TPM | Transmission Pricing Methodologies |

# Glossary

| | |
|---|---|
| Active transport | Forms of transport that involve physical exercise – for example walking and cycling. For planning purposes, this is the most common term used to group pedestrians and cyclists. |
| Baseline | A starting point used for future comparisons. |
| Biogas | Gas (methane) derived from the fermentation of organic matter. |
| Biogenic | Produced or brought about by living organisms. |
| Biomass | Biomass is matter from recently living organisms which is used for bioenergy production. Examples include wood, wood residues, energy crops, agricultural residues, and organic waste from industry and households. |
| Black pellets | Made of biomass, refined to resemble hard coal. |
| $CO_2$ equivalent | the universal unit of measurement to indicate the global warming potential (GWP) of each greenhouse gas (GHG), expressed in terms of the GWP of one unit of carbon dioxide. It is used to evaluate the climate impact of releasing (or avoiding releasing) different GHGs on a common basis. |
| $tCO_2e$ | Tonnes of carbon dioxide equivalent |
| Decarbonisation | To remove or reduce the carbon dioxide emitted within in the Southland economy. |
| Fossil fuel | A fuel formed by natural processes of buried dead organisms of biological origin. |
| Net zero emissions | A state in which the greenhouse gases going into the atmosphere are balanced by removal out of the atmosphere. |
| Power factor | the ratio of working power, measured in kilowatts (kW), to apparent power, measured in kilovolt amperes (kVA). |

| | |
|---|---|
| Renewable | (of a natural resource or source of energy) not depleted when used. |
| rLPG | LPG-equivalent fuel sourced from renewable materials/organic materials. |
| Vehicle to Grid (V2G) | A system in which battery electric vehicles (BEV) sell demand response services to the grid. |
| Short term | 10-year horizon. |
| Medium term | 15-year horizon. |
| Long term | 30-year horizon. |
| Scenario 1: Baseline | NZAS closes at the end of 2024 and SGH does not proceed. |
| Scenario 2: Transition | There is a managed transition of load between NZAS closing and commissioning of the SGH plant in 2030 (date chosen to align with short term roadmap). |
| Scenario 3: Green Energy Growth | NZAS remains open long term (until 2050), production of SGH commences in 2030. |

# List of Technical Papers

| Report name | Report date | Author/Publisher | Comments |
|---|---|---|---|
| Vol 1 Assessment of wind resources | Jul -22 | Great South (GS) | |
| Vol 2 Assessment of solar resources | Nov-22 | GS | |
| Vol 3 Assessment of Hydro Electric Power Stations | Feb-23 | GS | |
| Net Zero Southland 2050 | Mar-21 | EY- GS Commission | |
| Southland Energy Strategy | 2011 | Venture Southland | |
| Potential additional power demand in Southland | Oct-22 | GS | |
| Southland Region Bioenergy Availability Assessment | May-22 | Ahika | Unpublished |
| Stewart Island DC Interconnect Converters, Cables and Installation | - | ELMG – GS Commission | Draft confidential |
| Stewart Island Hydro | Jul-16 | Envirolink | |
| Stewart Island Future Power Supply | Sep-16 | Power Business Limited | Confidential |
| Invercargill Decarbonisation Contestable Fund | Feb-22 | GS | |
| Southland Region March 2022 quarter update | May-22 | Infometrics - GS Commission | |
| Just Transition Clean Energy Work Stream | Jun-22 | Murihiku Regeneration | |
| Wood Fuelled Industrial and Commercial Heating Systems | Jun-15 | Wood Energy South -GS | |
| Transmission Pricing Methodology Review: 2019 issues Paper | Sep-19 | GS | |
| Southland's Power Demand Projections | Oct-22 | GS | |
| Southland Regional Carbon Footprint 2018 | Oct-19 | AECOM | |
| Regional Energy Transition Accelerator (RETA) | Oct-22 | EECA | |
| Hydro generation stack update for large-scale plant | Sep-20 | MBIE | |
| Southland Road Revenue & Expenditure Report 2010-2021 | Oct-21 | GS | |
| Southland EV and Hybrid Uptake Research | Jul-21 | Impact Consulting – GS Commission | |

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## Appendices

## Revision History

| Revision Nº | Prepared By | Description | Date |
|---|---|---|---|
| A | Beca Ltd. | Draft for client review | 10 Feb 2023 |
| B | Beca Ltd. | Issued for advisory group | 24 Feb 2023 |
| C | Beca Ltd. | Re-issue for advisory group | 8 Mar 2023 |
| D | Beca Ltd. | Updated with advisory group feedback | 31 Mar 2023 |
| E | | | |

## Document Acceptance

| Action | Name | Signed | Date |
|---|---|---|---|
| Prepared by | Elizabeth Timings, Tim Hopkins, Colin Pearson | | |
| Reviewed by | Mike Pond | | |
| Approved by | Jorge Martinez | | |
| on behalf of | Beca Limited | | |

# Executive Summary

Southland Regional Development Agency (Great South) in partnership with Murihiku Regeneration have engaged Beca Ltd (Beca) to develop the Southland Murihiku Regional Energy Strategy 2022 – 2050. This Strategy is the fourth to be carried out by Great South (and its predecessor Venture Southland) with previous energy strategies completed in 2003, 2005 and 2011. The vision for the strategy is: **"Energy in Southland Murihiku is clean, resilient and affordable supporting a thriving community"** The purpose of the strategy is to articulate the current and future demand and supply of energy in Southland Murihiku, considering the immediate and long-term challenges and opportunities the region faces.

The Southland Murihiku Regional Energy Strategy aligns with the renewable energy focus of the Clean Energy workstream within the Southland Just Transition Work Plan, which was released in January 2022. It will also be a key input into the long-term planning workstream of the Just Transition work plan, Beyond 2025 Southland.

One of the main objectives of this work was to collate the key findings from a range of recent work relating to the energy transition, and present it in a cohesive document that:

- Lays out the actionable activities
- Provides information to support the development of the Southland Murihiku spatial strategy


When considering a 100% renewable future, the following parts of the energy trilemma (*right*) must be considered:

- Energy security: keeping the lights on and minimising exposure to global swings in energy markets
- Energy equity: cost for consumers, enabling a just transition
- Environmental sustainability: protecting the local environment and taking positive climate change action to minimise the effects of climate change

The energy changes required to transition to a net zero economy by 2050 are a once in a generation investment. It is not only the scale of the change that is immense, but also the pace at which this change must happen, to limit global warming and meet New Zealand's Nationally Determined Contributions (NDCs) under the Paris Agreement[1]. This presents both risks and opportunities for Southland Murihiku. By developing a whole of region energy balance, this strategy aims to help illuminate risks and opportunities for Southland Murihiku and provide a plan for the development and efficient use of renewable energy in the region. This has been achieved by matching up the energy balance outputs in an interactive dashboard, linked to a map of the region to understand:

- Who are the current users of fossil fuels in the region
- Where are they located
- What are the fossil fuels used for and what practical renewable alternatives exist
- When is it feasible to transition to a renewable form of energy

[1] https://environment.govt.nz/what-government-is-doing/international-action/about-the-paris-agreement/

## Energy Strategy Scenarios and Implications

Three energy scenarios have shaped the energy transition modelling:

- **Scenario 1: *Baseline Scenario* –** New Zealand's Aluminium Smelter (NZAS) closes at the end of 2024 and Southern Green Hydrogen (SGH) does not proceed.
- **Scenario 2: *Transition Scenario* –** There is a managed transition of load between NZAS closing and commissioning of the Southern Green Hydrogen plant in 2030 (date chosen to align with short term roadmap).
- **Scenario 3: *Green Energy Growth Scenario*** – NZAS remains open long term (until 2050), production of Southern Green Hydrogen commences in 2030.

The future of NZAS and SGH will have a significant impact on the direction and subsequent actions required to meet Southland Murihiku's net zero vision. At the same time, there are many challenges that need to be addressed regardless of these decisions.

| NZAS closes in 2024 and SGH doesn't go ahead (Baseline Scenario) | NZAS stays open, SGH goes ahead or both operate simultaneously (Transition and Green Energy Growth scenarios) |
|---|---|
| Without a major load (such as NZAS or SGH), Southland Murihiku will have a net surplus of electricity generation, even taking into account decarbonisation of existing industry and known potential new industry | • If NZAS remains, SGH goes ahead or both operate simultaneously, there is insufficient generation currently in Southland Murihiku to meet the forecast demand<br>• Onshore wind is likely to make up the majority of new generation however if both NZAS and SGH are to operate simultaneously, offshore wind or new hydroelectric development should be considered |

| Findings independent of scenario |
|---|
| • The broader areas around Makarewa, Awarua, Mataura and Edendale will require infrastructure upgrades to enable decarbonisation of industry in these areas. The decarbonisation of the Edendale Dairy Factory will have a significant renewable energy demand for both electricity and biomass<br>• Whilst solar shouldn't be considered a major contributor to grid scale generation, embedded solar, close to electricity loads can make an important contribution to the overall grid<br>• Biomass will play an important role in phasing out coal however there is unlikely to be sufficient biomass supply locally to meet the demand.<br>• Biogas is a relatively underutilised resource in Southland Murihiku that could potentially replace the current LPG demand in the region |

## Recommendations

Due to the complexity and multi-sectorial implications of the energy transition, collaboration across organisations and industries will be critical to achieving favourable outcomes. We recommend the following key actions to support the energy strategy implementation. They have been grouped under three themes:

### Market Leadership and Engagement

- Establish a working group made up of the major coal users in the region to share resources, expertise and co-ordinate their efforts to develop specific plans to decarbonise their businesses.
- Encourage the public disclosure of non-residential building energy performance to encourage the improvement of the current building stock.
- Facilitate energy planning as an integral part of the proposed amendments to the NZ Building Code H1/AS1.

- Engage with the market to understand what financial mechanisms can be put in place to incentivise demand side load management.
- Create a community-wide education programme to foster meaningful community participation and raise awareness of the need for new renewable energy sources in the region.

### Policy and Process

- Establish a consenting taskforce that will provide technical and consent expertise to territorial local authorities. Building on the successful regional models such as the Wood Energy South and Carbon Neutral Advantage Advisory Groups, the taskforce should be expanded to include representation from Murihiku's four Papatipu Rūnaka and Te Ao Mārama Inc.
- Incorporate new energy investment opportunities into current and future planning frameworks and spatial plans to minimise risks and streamline the development of renewable generation and transmission infrastructure.
- Advocate for changes to how electricity network providers are regulated nationally, to allow fast tracking of electricity grid and network upgrades where they will enable decarbonisation to occur. This change will allow the electricity network providers to lead the way and upgrade ahead of demand, rather than demand being the trigger for upgrades. This will effectively allow the network service providers to 'build it and they will come', which should support more rapid decarbonisation.
- The colocation of complementary industries (and potentially energy generation) is an opportunity to realise numerous efficiencies. Consider ways to incentivise and co-ordinate this development.
- In collaboration with industry, investigate how to optimise the entire biomass value chain. The industry should also advocate for favourable government policies to increase wood processing in New Zealand and maximise forest floor recovery.
- The impacts of climate change to coastal margins and river systems must be considered. The geographic location and elevation of infrastructure and key energy assets should be incorporated into all planning and risk mitigation processes.

### New Energy

- Southland has an abundance of new renewable energy potential. Investigations referenced in this strategy have identified more than 100 onshore wind sites that may be suitable for new generation. It is possible that future energy demand can be met through new local renewable generation and storage investment.
- Locating generation close to demand is the most efficient use of infrastructure. For the mainland Southland Murihiku region to become neutral or a net exporter of renewable energy new generation is required, especially for the Green Energy Growth Scenario. Generation developers should first look to onshore wind, beginning in Waihōpai Invercargill/Awarua and environs and Mataura Valley, Eastern Southland and Edendale areas, followed by hydro generation in upper and lower Clutha areas. Grid scale solar north of Te Anau basin, Mossburn and possibly Fairlight areas offer potential and then finally offshore wind. The optimal magnitude of each will depend on which of the three scenarios prevails, and locations of new generation and loads.
- As a priority, Rakiura Stewart Island should start to decarbonise their energy supply. We recommend behind the meter solar to supplement wind generation and a battery or hydrogen storage solution to achieve net zero. Diesel should only be seen as a short-term solution. 2027 should be the carbon zero target for Rakiura/Stewart Island.
- For Piopiotahi Milford Sound, we recommend a comprehensive evaluation of energy needs and upgrading the current hydroelectrical power system with backup battery or hydrogen storage. 2027 should be the carbon zero target for Piopiotahi Milford Sound.
- Green hydrogen production, storage and use for generation within Southland Murihiku should be investigated regardless of SGH's development to support the decarbonisation of heavy transport.
- The Southern Green Hydrogen project would represent a major boost to the local economy so supporting this project's success is a big opportunity for the region as well as an opportunity to address carbon reduction, clean transport fuels and green fertiliser production.

- A more detailed investigation into the opportunity to capture biogas in Southland and determine the best use cases for it in the context of the region's broader decarbonisation goals.

# 1 Introduction

## 1.1 Background

The development of the strategy is a partnership between the Southland Regional Development Agency (Great South) and Murihiku Regeneration (a collaboration between the four Murihiku Papatipu Rūnanga who are working together to advance their collective aspirations). The strategy is being guided by Southland Murihuku Regional Energy Strategy Advisory Group (see Appendix C for the Advisory Group members).

The strategy supports the 'Beyond 2025 Southland' regional long-term plan and other regional spatial planning processes. The aim of the Southland Murihiku Regional Energy Strategy 2022 – 2050 is to provide a plan for the efficient use and delivery of reliable and affordable renewable energy to drive decarbonisation of Southland Murihiku industries, households and transport, as set out in the Net Zero Southland emissions abatement pathways report 2021.

The strategy focuses on a 'short term' (10-year horizon), 'medium term' (15-year horizon) and 'long term' (30-year horizon).

## 1.2 Scope

The geographic scope of this project is Southland Murihiku as defined by the three territorial local council areas (Gore District; Southland District and Invercargill City). However, it is recognised that some new generation opportunities and energy, such as biomass, may involve areas of Otago beyond the Southland regional boundary. This may be identified and considered within the scope of this strategy.

This strategy will focus on all forms of energy, including electricity, biomass, biogenic methane, transport fuels and alternative multi-mode transport options such as electricity-based transport and transport mode shift to low carbon or no carbon options. Energy efficiency, emissions reduction, decarbonisation, sequestration opportunities for existing industry, greenhouse gas capture and use, will all contribute to a credible regional climate change response.

Any new fossil fuel energy sources were out of scope for the development of this strategy, however, the implications of the transition from fossil fuels to clean energy sources needs to be considered and the impacts and timing of coal mine closures need to be considered from an energy perspective. The social and economic impacts of the transition from fossil fuels in mining communities such as Ohai and Nightcaps are addressed in separate reports as part of the Beyond 2025 Regional Planning Process.

## 1.3 Process

The development of the strategy has been managed by Great South with guidance from the Southland Regional Energy Strategy Project Advisory Group who have met regularly throughout the development of this process with Beca who have been contracted to complete the Strategy.

A draft version of this strategy was made available for the Advisory Group to consider in early March 2023. A public consultation period where the public were invited to complete submissions or attend one of three hui held around the region (Invercargill, Gore and Te Anau) was open from the end of March 2023.

## 1.4 Vision and Goals

As part of this work the following vision was developed for Southland Murihiku's energy future:

**"Energy in Southland Murihiku is clean, resilient and affordable supporting a thriving community"**

Cascading from this vision, the following aspirational goals have been developed in consultation with the Advisory Group and Great South to guide the strategy:

- All sectors and industries have committed to the establishment of emissions abatement pathways to meet the Net Zero Southland 2050 targets.
- That energy efficiency be the priority consideration in all energy use cases.
- Access to affordable and reliable energy for residents and industry alike.
- Everyone in Southland Murihiku has access to a warm, healthy home by 2030.
- Rakiura Stewart Island and Piopiotahi Milford Sound net zero emissions by 2027.
- Decarbonisation of commercial and industrial thermal heat by 2030.
- Continued roll-out of EV charging stations to accommodate growth in the use of EVs in Southland Murihiku.
- Energy infrastructure is resilient to the effects of climate change.
- All of society has access to affordable, clean transport.
- Encourage active modes of transport to increase the proportion from the current level of 7% to 14% by 2028 and 21% by 2048.
- 92% of light vehicles and 60% of heavy vehicles to be powered by renewable energy by 2050.
- Maximise the capture of biogenic methane for use as an energy source.
- Community awareness of the need for new renewable energy investment be a focus for all iwi and community engagement.

# 2 Current State

## 2.1 Context

Southland Murihiku's economy is highly export focused, producing 15% of all New Zealand's tradeable exports[2]. This makes up 70% of Southland Murihiku's $7.2b Gross Domestic Product (GDP)[3]. Given the criticality of affordable energy to industry, it is essential that energy costs remain globally competitive in a New Zealand setting.

The energy landscape in Southland Murihiku is dominated by New Zealand Aluminium Smelter (NZAS) which draws up to 610MW from the national grid. As New Zealand's largest electricity user, NZAS's future will have a significant influence on new electricity generation investment in the region (and further afield).

With the risk of NZAS closing in 2024, several projects have been initiated to look to take advantage of the electricity that would become available. The most energy intensive of these are Southern Green Hydrogen and the Datagrid 'hyperscale' data centre.

Subsequently, NZAS have announced that they are actively exploring options with electricity generators for a contract beyond 2024. If the electricity generation and transmission infrastructure was available, there is a possibility that all these sites (and others currently being considered) could co-exist. This presents an opportunity for Southland Murihiku to not only improve its resilience to the threat of NZAS closing but also grow GDP, exports and high value jobs in the region.

## 2.2 Southland Murihiku's Emissions

### 2.2.1 Emissions Scope Definition

Emission measurement in Southland Murihiku commenced in 2017/18 and was led by Southland Regional Development Agency (Great South) and its predecessor Venture Southland. This initial work was peer reviewed by Think Step and AECOM which ultimately resulted in the publishing of the first Regional Emissions Profile in 2018/19.

The Greenhouse Gas (GHG) emissions sources included in this inventory were identified with reference to ISO 14064-1:2018 standard, and the Greenhouse Gas Protocol 2004. The emissions sources are classified into the following scopes.

- Scope 1: Direct GHG emissions from sources that are owned or controlled by the company. For example, emissions from vehicles owned or controlled by the organisation.
- Scope 2: Indirect GHG emissions (in the form of electricity, heat or steam) from the generation of purchased energy that the organisation uses.
- Scope 3: Indirect GHG emissions that occur because of the company's activities but from sources not owned or controlled by the company (e.g., air travel).

[2] Impact Consulting (2021) Southland EV and Hybrid Uptake Research

[3] Infometrics (2022), Southland Region March 2022 quarter update

### 2.2.2 Carbon Footprint

Southland Murihiku is responsible for around 9.7% of New Zealand's total gross emissions (8,910,806 $tCO_2e$ gross emissions in 2018)[4], with the highest per capita greenhouse gas emissions by region[5]. This is primarily due to Southland Murihiku's highly productive industrial and agricultural sector compared with its population size.

| tCO2e | BASIC+ Other Scope 3 | Scope 1 | Scope 2 | Scope 3 |
|---|---|---|---|---|
| | Stationary | 711,805 | 764,876 | 57,948 |
| | Transportation | 501,031 | | 46,456 |
| | Waste | 44,030 | | |
| | IPPU | 657,588 | | |
| | AFOLU | 3,895,420 | | |
| | Other Scope 3 | | | |
| | TOTAL | 6,679,154 | | |

**Figure 2-1: Summary of Net Emissions (including forestry) for the Southland Murihiku Region (AECOM, 2019)**

The largest source of greenhouse gas emissions in Southland Murihiku are its agricultural emissions, primarily from dairy, beef and sheep farming (6,127,073 $tCO_2e$ gross emissions), but the net emissions from this sector decrease to 3,895,420 $tCO_2e$ after including forestry removals (listed under AFOLU in Figure 2-1).

After agriculture, two of the largest sources of greenhouse gas emissions are from stationary energy use and transportation: powering industry, providing transportation and heating homes and buildings. Stationary energy use represents 17% of Southland Murihiku's annual gross emissions (1,534,628 $tCO_2e$), with transportation energy representing a further 6% (547,487 $tCO_2e$).

[4] AECOM (2019) Southland Regional Carbon Footprint 2018

[5] Stats NZ (2022) Greenhouse gas emissions by region (industry and household): Year ended 2021. https://www.stats.govt.nz/information-releases/greenhouse-gas-emissions-by-region-industry-and-household-year-ended-2021. Accessed 08/02/2022

| Emission Source | Scope 1 | Scope2 | Scope 3 | Total $tCO_2e$ |
|---|---|---|---|---|
| Residential buildings | 2,383 | 32,984 | 2,499 | 37,866 |
| Commercial buildings and facilities | 45,856 | 25,191 | 1,908 | 72,955 |
| Manufacturing industries | 543,736 | 706, 701 | 53, 540 | 1,303,978 |
| Agriculture, forestry and fisheries | 4,330 | | | 4,330 |
| Fugitive emissions from coal | 115,499 | | | 115,499 |
| **TOTAL** | **711,805** | **764,876** | **57,948** | **1,534,628** |

**Figure 2-2: Summary of stationary energy emissions by source (AECOM, 2019)**

The largest single source of emissions reported in the above table (Figure 2-2) is consumption of grid-supplied electricity (Scope 2 emissions), and the associated transmission/distribution loss emissions (Scope 3 emissions). These emissions totals are derived using the Ministry for the Environment's grid-averaged emissions factor for electrical use, which accounts for emissions produced by thermal and geothermal electricity generation across the national electrical grid. This is the correct approach when reporting on carbon emissions at a regional level. However, since much of electrical use in Southland Murihiku (especially industrial electricity use at NZAS) is directly supplied by hydrogeneration, the actual physical emissions associated with electrical use in Southland Murihiku is likely lower that the accounting numbers presented above. New Zealand's current government has committed to converting the electrical grid to 100% (or close to 100%) renewable power by 2030, which will address emissions associated with electricity use at a national level.

Taking into consideration both the low emission electricity generation in Southland Murihiku and the New Zealand government's current commitment to a renewable grid, addressing emissions from electricity use in Southland Murihiku has not been recommended as a key focus area for this strategy.

Fugitive emissions from the extraction/mining of coal are another key point source of stationary energy emissions, with most remaining Scope 1 emissions from the burning of coal and other fossil fuels for residential, commercial, and industrial heat.

| | Emission Source | Scope 1 | Scope 2 | Scope 3 | Total $tCO_2e$ |
|---|---|---|---|---|---|
| On-Road | Passenger Vehicles | 238,371 | | | 238,371 |
| | Mobile LPG consumption | 1,741 | | | 1,741 |
| | Buses | 7,481 | | | 7,481 |
| | Heavy Vehicles | 195,496 | | | 195,496 |
| Shipping/ Marine | | | | 41,480 | 41,480 |
| Aviation | | | | 4,976 | 4,976 |
| Off-Road | | 57,943 | | | 57,943 |
| **TOTAL** | | **501,031** | **0** | **46,456** | **547,487** |

**Figure 2-3: Transportation Emissions by source (AECOM, 2019)**

Diesel and petrol use (Scope 1 emissions) for on and off-road transportation within the region are the dominant sources of Scope 1 emissions in the transportation sector.

Scope 1 emissions from transportation are almost equivalent to the total Scope 1 emissions from industrial fuel use, which is primarily from the consumption of coal for heat. Direct fossil fuel use in Southland Murihiku across Stationary Energy and Transportation accounts for over 13% of the region's gross emissions.

Based on this data, when considering an energy strategy, **the focus areas that will make the biggest difference to the region's emissions are transport fuels and stationary heat.**

### 2.2.3 Net Zero Trajectory

In March 2021, Great South commissioned the Net Zero Southland report which showed that Southland Murihiku was not on track to meet net zero emissions under the current trajectory[6]. However, the report also detailed that the region could achieve net zero emissions by 2050 from mitigation pathways with a positive net financial outcome, and that "80% of the abatement potential identified comes from mitigation options which provide a positive net financial outcome". This is shown in the marginal abatement cost curve in Figure 2-4. It should be noted that the Net Zero Southland Report contemplates the abatement of 611,384tCO2e of process emissions and electricity transmission and distribution emissions of 411,575tCO2e resulting from the potential closure of the Tiwai Aluminium Smelter. This being the case it is expected that if the smelter continues to operate that the smelter will continue its excellent track record of reducing its process and electricity related emissions.

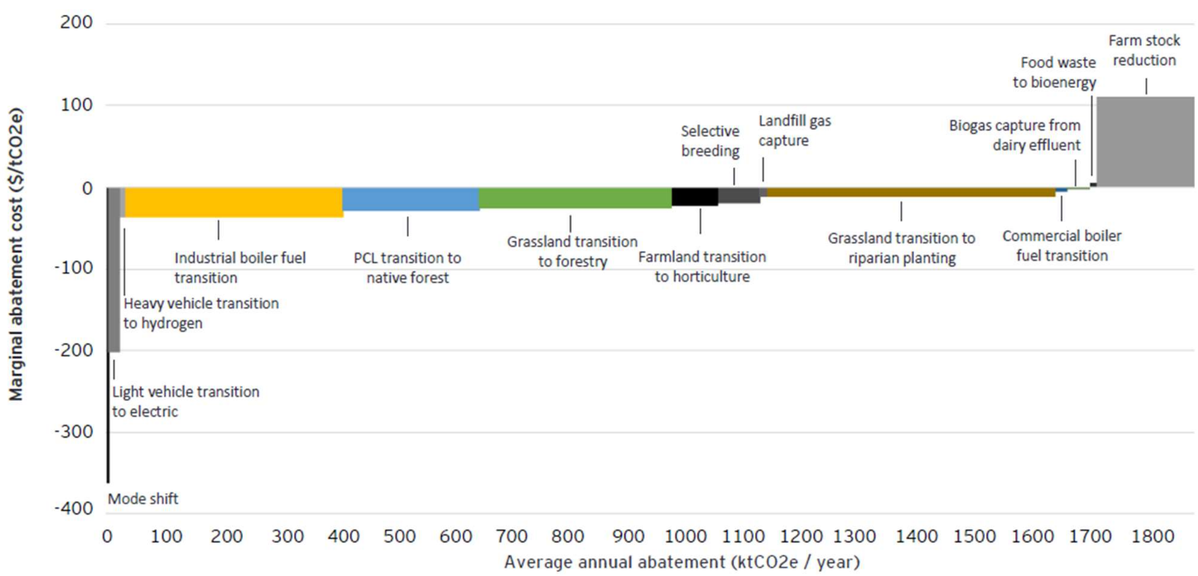



**Figure 2-4 - Marginal abatement cost curve of the modelled mitigation options (EY, 2021)**

### 2.2.4 Coal

When considering energy, the phase out of coal will be one of the biggest challenges for Southland Murihiku to reach net zero emissions. Coal is widely used for heating, particularly in industry in large part due to the lack of a reticulated gas network in the region. The government plans to phase out coal boilers for low to medium process heat by 2037 by requiring local authorities "to consider the effects of GHG emission on climate change in RMA (Resource Management Act) decision-making". Additionally, the cost of operating these assets will rise as carbon prices increase and the local supply of coal reduces over time. Organisations in Southland Murihiku need an economically viable energy alternative to coal to enable a just transition.

In terms of work already underway, Southland Murihiku is a leading region in the move away from fossil fuels, with a boiler conversion programme underway that has 83 of 186 large boilers either converted or in the

[6] EY (2021), Net Zero Southland, Economic Mitigation Pathways Analysis to Net Zero Emissions for Southland

process of converting to renewable energy. Note, after completing the modelling for this report, many current fossil fuel process heat users have indicated they aim to be decarbonised by 2030 based on economics, market-access and consumer preferences.

## 2.3 Existing Electricity Infrastructure and Upgrades in Progress

Energy is transported via the national transmission grid and the regional distribution networks. Transpower enables the national generation to reach the region and selected major users within the region. Electricity Invercargill (EIL), OtagoNet (ONL) and The Power Company (TPCL) manage networks to distribute generation and electricity flow within the region. Similarly, Stewart Island Electrical Supply Authority provides and manages the Rakiura Stewart Island network and Milford Sound Infrastructure Limited provides the Piopiotahi Milford Sound generation and network.

The transmission grid and distribution networks are built to meet security of supply regulations set by the Electricity Authority and financial regulatory constraints set by the Commerce Commission. This combination aims to optimise the reliability and cost of supply to all electrical consumers. This process is regulated and is intended to prevent the grid and network owners from taking financial advantage of their monopoly statuses.

The regulations cannot currently be bypassed and therefore the infrastructure is built to meet current peak consumer demands at minimal cost, while meeting the required service reliability expectations, with just enough spare capacity to meet known future demand. Due to the Commerce Commission's oversight, the capacity can only be built for committed demand and not predicted future demand. Requests from proposed new or upgraded generators to be able to distribute their energy, or demand from loads for increased energy, is what triggers upgrades i.e., **currently stakeholders must first signal a commitment for electrical capacity in order for it to be built.**

Would be parties seeking to decarbonise their respective industries are concerned about the uncertainty surrounding availability of electricity and the long lead times in infrastructure builds. Regulation settings need to be reviewed and modified to allow grid and EDB infrastructure investment to keep pace with decarbonisation targets.

### 2.3.1 Capacity within the Grid and Networks for new Generation or Loads

New generation will be a variety of types, constant and intermittent generators, and in multiple locations, with the decarbonisation loads also being in multiple locations. The existing underutilised capacity within the grid and networks can be seen in the 10-year Asset Management Plans. It should be noted peak infrastructure loading at each substation node is reported in the AMPs and greater capacity may be available at times, however coincident loading may also decrease the capacities reported.

**Unused spare distribution capacity within the existing networks can signal an opportunity for new or increased load** at that geographical location without the need for grid or network upgrades within Southland Murihiku. **Opportunities for generation developers can be seen via shortages in capacity**, particularly if there is a possible nearby grouping of new or increasing loads.

### 2.3.2 Need for and scale of upgrades.

The scale and pace of change required to enable a transition away from fossil fuels in order to meet net zero goals is unprecedented. Electricity will provide the lion's share of the clean energy required. The regional energy balance indicates the electricity demand could potentially increase from 2022 levels of 940MW[7] by 260MW in 2030, 550MW in 2035 and 604MW in 2050 (Scenario 3). The increases are significant when

[7] Includes NZAS load of approx. 580MW

considering the maximum coincident demand on the Southland Murihiku substations during 2021 was approximately 300MW[8].

The departure of NZAS and SGH not being constructed in Scenario 1 would not negate the need for electricity infrastructure upgrades. While there is surplus supply to meet the new decarbonisation loads, infrastructure upgrades will still be needed to re-distribute the supply to locations load. The current planned upgrades to substation capacity are not sufficient to supply the increased demand created by the decarbonisation of industry.

For this gap in electricity distribution to be resolved, commitment to electrification will be required from all stakeholders. This includes supply side stakeholders (transmission, distribution and generation) and demand supply (industry, businesses, consumer). Even so enabling transmission and distribution infrastructure to be built in a timely manner will be a challenge. Refer to section 5.4 for enabling options.

If this energy demand is to be met within the Southland Murihiku region this highlights the need for considerable additional generation, transmission, and distribution upgrades to enable decarbonisation and associated electricity demand. If the generation is an intermittent type, considerable storage will be required to firm the supply, to meet the demand.

If the generation increases are not within Southland Murihiku or are insufficient, the transmission and distribution may need more upgrades to deliver nationally generated electricity to the loads. While the current transmission infrastructure is fit for purpose, the planned network upgrades are not sufficient to deliver the capacity needed to supply industrial users with the required electricity for them to decarbonise. The increase in demand due to decarbonisation of current industry in Southland will likely be over 150MW, this does not include new industries such as SGH, and the distribution network as reported in the AMPs is not on track to be able to deliver this supply. It is important to note the investments that Transpower and the EDBs can make for future loads are constrained by current regulations, as discussed further in 5.4.9. With the forecast of new industries such as hydrogen facilities and data centres coming to Southland, the current electricity network is undersized for future demands. Large demands will need to explore the option of electrifying through direct connection to Transpower's transmission network, rather than to the local distribution network. Commitment will be required from users before the transmission and distribution infrastructure can be built.

Energy reliability is a regional issue due to the lack of firm capacity (N-1) to all locations. Most industrial users do not currently access an electricity supply which will remain available when any single item is unavailable or fails. Currently most zone substations and the connected networks do not feature full redundancy or alternative supply routes, and therefore are not able to deliver a secure supply of electricity to the end users. Equipment failure, damage or maintenance will cause a black-out or reduction in supply. This poses risk to industrial processes that require a constant supply and may be a barrier to decarbonisation, or the establishment of new industry in Southland Murihiku. It is possible for energy users to request a higher level of supply security and PowerNet will work with the customer to develop a solution.

### 2.3.3 Planned upgrades by Transpower

The total existing 2022 Southland Murihiku GXP transmission capacity is approximately 1170MW. As described in Transpower's 2022 Transmission Planning Report[9]. Transpower is currently upgrading Gore GXP replacing the two 60MVA 110/33kV transformers with 80MVA transformers increasing the total to 1200MW. Further upgrades throughout the network increases the 2035 capacity to 1260MW. As Transpower cannot commit to upgrades beyond 10 years, no increase is signalled from 2035 to 2050 at this time.

[8] This value is substation load and excludes NZAS

[9] https://www.transpower.co.nz/resources?keywords=transmission+planning+report

Prior to 2022 there was a constraint in the South Island transmission grid whereby it was not possible to send excess Southland Murihiku power north through the Clyde – Upper Waitaki area. During 2022 activity was undertaken by Transpower to increase the capacity through this area and hence reduce the risk to New Zealand of Manapouri's generation not being available as part of the whole generation pool should NZAS close.

#### 2.3.4 Planned Upgrades by EDBs

PowerNet develop 10-year Asset Management Plans which forecast demand and growth, including any demand known with certainty as well as some large customer loads that are likely to occur. Asset expenditure is then planned within the bounds of existing regulatory regimes to meet regulatory and contractual requirements, and to provide equitability to our customers.

The maximum coincident demand on the Southland Murihiku zone substations during 2021 was approximately 298MW. The maximum total demand, not coincident demand, is approximately 100MW higher. 2021 zone substation supply capacities totalled 594MW.

The PowerNet administered asset management plans[10] for Electricity Invercargill, OtagoNet and The Power Company Limited show numerous upgrades which will bring the 2030 substation total capacity to 614MW. No further upgrades are planned within their 10-year planning window. Minor degrades then occur causing the 2035 and 2050 totals each to reduce slightly to 611MW.

Note: While the above summated values indicate that time dependant available spare network capacity for supply or generation of 138 to 238MW in 2021 and 216 to 316MW in 2030 this conclusion cannot be made as spare capacity at some geographical locations may be near zero due to nearby connection constraints (voltage or overloads).

For further background on the electricity network, please see Appendix B.

## 2.4 Social Context

#### Requirements for community acceptance of renewable energy projects

It is evident that there will be a greater reliance on renewable energy moving forward and to create a balance, community acceptance of new generation investment such as hilltop wind, large scale solar and potentially offshore wind is critically important. The imbalance created by increasing demand and static level of generation will adversely affect price and affordability. This situation is also likely to be further exacerbated as the national generation moves to 100% renewables by 2030. Social license for these projects and the associated energy transition is vitally important to achieve successful implementation and deliver a secure and affordable energy future. To generate greater social license, an economic assessment of the impacts of changes to the energy sector and new investment is required.

Community acceptance is an essential element of a successful transition from carbon-based fuel and energy systems to renewable energy systems. Resistance to renewable energy transitions emerges in local communities who may object to specific projects even though there is widespread support for renewable energy in general. Resistance may be based on unfamiliarity with new technologies, nostalgic preferences for current technologies, aesthetic issues, cultural reasons, or the lack of adequate information. Local traditions and levels of trust in public entities have also been shown to influence acceptance of renewable energies and renewable energy investment.

[10] https://powernet.co.nz/disclosures/the-power-company/asset-management-plans/

https://powernet.co.nz/disclosures/electricity-invercargill-ltd/asset-management-plan/

https://powernet.co.nz/disclosures/otagonet/asset-management-plan/

To overcome or mitigate the potential for objections and local resistance, energy transitions, at a minimum, should afford ample opportunity for community engagement. For engagement to be meaningful and impactful it should occur early in the planning process. It should also be clear and consistent as to what level of involvement is appropriate and required at each step. The diagram in Figure 2-5 gives definitions of different levels of engagement. Mana whenua must be brought into the discussions as early as possible as their perspectives and insights are critical to the process. The earlier mana whenua are engaged, the greater the opportunity to get a project right and for it to be well supported. Any engagement, whether it be with mana whenua or other members of the community, should always present an honest position of the benefits and the burdens of energy transitions.

INCREASING IMPACT ON THE DECISION

| | INFORM | CONSULT | INVOLVE | COLLABORATE | EMPOWER |
|---|---|---|---|---|---|
| PUBLIC PARTICIPATION GOAL | To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions. | To obtain public feedback on analysis, alternatives and/or decisions. | To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered. | To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution. | To place final decision making in the hands of the public. |
| PROMISE TO THE PUBLIC | We will keep you informed. | We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how public input influenced the decision. | We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision. | We will look to you for advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible. | We will implement what you decide. |



**Figure 2-5 - Diagram showing levels of public engagement and their increasing impact on the decision (taken from IAP2 and Organizing (sic) Engagement.)**

# 3 Energy Balance

Section 3 details the purpose of developing an energy balance, the methodology and the scenarios that have been considered, along with the assumptions made for each scenario.

## 3.1 Purpose of Developing an Energy Balance

To meet Southland Murihiku's vision to be a thriving zero-emissions economy, a plan is needed to transition existing fossil fuel use to renewable forms of energy for each site. To develop this plan, the following needs to be understood:

- Who are the current users of fossil fuels in the region
- Where are they located
- What are the fossil fuels used for and what practical renewable alternatives exist
- When is it feasible for them to transition to a renewable form of energy

Through the work lead by Great South and EECA, there is a clear understanding of the fossil fuels used by the 187 consented commercial and industrial boilers within the region and the amount of renewable energy required to convert these to a renewable energy source.

By understanding the questions above for each major site in the region, insight can be gained about what infrastructure will be required to enable the transition to happen. It also highlights potential opportunities to approach these changes in a more co-ordinated way which will enable efficiencies to be realised both in terms of capital and minimising downtime. For example, one larger upgrade to a sub-station for several sites will be more cost effective than stepwise upgrades in short succession.

Additionally, by aggregating the data for all demands together into one dataset, predictions can be made about the potential quantum of energy required which allows the relevant organisations to plan and provision for the capital, resourcing and regulatory approvals required to deliver the infrastructure in the timeframe required. It should be noted that Great South have developed and maintained a database of fossil fuel heat demands in the region for many years hence there is a robust repository of historical data as a starting point for this work.

## 3.2 Methodology

The approach taken for the regional energy balance has been to split the total energy requirements into the following sectors:

- Industrial
- Commercial – includes large public facilities such as schools and hospitals
- Residential
- Transport[11]

The energy balance considers existing demands for all energy types and a view of potential demands for electricity, biomass, and hydrogen in 2030, 2035 and 2050. This is based on transition of existing fossil fuel demands to renewable energy sources and new industry in the pipeline. This data has then been displayed in a Geographic Information System (GIS) model, linked to a dashboard with summaries of the demand for different energy types over time. This allows the user to see where demand pinch points may be and the quantity of the potential demand (and therefore infrastructure shortfall). The benefit of displaying the information in this format is that it can be updated over time as information changes, keeping the view of regional energy demands live.

[11] This includes light and heavy road transport only. The energy requirements for coastal shipping, rail and aviation were out of scope for this strategy

Note, all demands have been converted to megawatts (MW) to show the relative difference in the proportions for different energy sources on one output. Assumptions have been made about daily use to convert from absolute energy values in joules (J) or megawatt hours (MWh). For further detail on the methodology used to develop the energy balance, please see Appendix A.

## 3.3 Assumptions

The energy balance has been built up from individual demands to create the overall picture. Given the breadth of the scope, the authors have had to make assumptions and estimates around the quantum and type of energy required and dates when the transitions will happen. The purpose of the energy balance is not to provide an exact inventory of energy use but rather an indication of where biggest challenges and opportunities lie. For detail on the assumptions used, please refer to Appendix A. It is important to understand that this strategy does not promote the principle of self-sufficiency in energy availability at a regional level as this has significant inherent risks associated with windless days, a lack of sunshine and underutilisation of generation assets. While the principle of utilising energy close to demand is the most efficient energy use it is recognised that energy needs can be addressed by generation from a range of diverse range of locations throughout the country. The options for new local generation shown in this report are simply assessed to illuminate possible future options. The wind modelling prepared by Great South for the Southland Murihiku Energy Strategy have been identified utilising a global wind modelling tools and Geographic Information Systems which indicate the locations where commercial wind speeds may be available and are possibly worthy of further detailed investigation. Identification of potential sites is the preliminary phase of the wind planning process and is by no means an indication that a project is culturally, environmentally, or commercially viable.

## 3.4 Scenarios and their Implications

There are four possible electricity need scenarios. Three scenarios have been chosen to illustrate the implications of major electrical loads on the energy transition pathways for Southland Murihiku. They have been deliberately selected to consider two extreme cases (low and high demand) and a middle case. It is important to note that these scenarios are not weighted in a manner that present a bias or give any indication of the likelihood of one of these scenarios playing out. These scenarios are summarised in Table 1. The key differences between the scenarios are as follows:

- If NZAS closes before another large electricity user is ready to take the load, there will be an oversupply of electricity in the region. This will result in more of industry likely switching to electricity rather than biomass for process heat.
- Significant investment will be required in transmission infrastructure in all scenarios, particularly the low and high demand scenarios.

At the time of writing, NZAS plans to close at the end of 2024 but are actively seeking a new electricity supply contract. Southern Green Hydrogen has selected Woodside Energy as their preferred partner to move the study into the development phase. Based on public statements It is likely that the NZAS's Tiwai smelter will remain operating beyond the stated closure date and therefore an additional scenario could be considered that contemplates that Tiwai remains operating and that the Southern Green Hydrogen (SGH) project doesn't proceed. This hasn't this stage been modelled, and it is recommended that the further modelling should occur when the position on the Smelter's future and SGL development is known.

Table 1 - Summary of scenarios and the assumptions and potential implications on energy demand

| Scenario | Generation & Transmission Implications | Demand Implications |
|---|---|---|
| *Scenario 1 – Baseline Scenario*<br>NZAS closes at the end of 2024 and Southern Green Hydrogen (SGH) does not proceed. | Less investment in additional renewable generation required to meet regional need.<br>Upgrades required to local Grid Exit Points (GXPs) for increased electrical load.<br>Electrical infrastructure will be lightly loaded and will become available for future loads in the region. | Surplus electrical load available for decarbonising industry, transport, domestic & commercial.<br>Lower reliance on biomass for fuel switching existing domestic, industrial & commercial loads |
| *Scenario 2 – Transition Scenario*<br>There is a managed transition of load between NZAS closing and commissioning of the Southern Green Hydrogen plant in 2030 (date chosen to align with short term roadmap). | Assuming SGH is positioned close to NZAS or transmission lines from Manapouri, most of the electrical infrastructure can be repurposed, however should assume a new GXP may be required (impacts time & cost).<br>Additional renewable generation and electrical transmission required for regional electrical fuel switching across domestic, industry, commercial & transport.<br>Potential opportunity to investigate dry year storage options utilising SGH once operational. | Transfer of electrical load from NZAS to SGH.<br>Heavier reliance on biomass for fuel switching existing domestic, industrial & commercial loads. |
| *Scenario 3 – Green Energy Growth Scenario*<br>NZAS remains open long term (until 2050), production of Southern Green Hydrogen commences in 2030. We have assumed the total load between the two plants is 850MW. | New generation and transmission required to supply 600MW to SGH plus additional electrical fuel switching domestic, industry, commercial, transport loads.<br>Noting there will be a need for new or upgraded transmission and distribution (like scenario 2) to cope with proposed regional generation, fuel switching and growth loads. | Heavier reliance on biomass for fuel switching existing domestic, industrial & commercial loads.<br>Additional electricity supply available by 2035 for decarbonising industry, transport, domestic & commercial however significant proportion of these loads may have already fuel switched to other renewable fuels. |

# 4 Energy Balance Insights

This section summarises insights that have been drawn from the energy balance and digital twin interface that have been developed for this strategy. One of the purposes of developing the digital twin (FACILITYtwin$^{TM}$) was to enable other stakeholders to review this same information and draw insights relevant to their own context and subject knowledge. For access to the FACILITYtwin platform for this strategy, please contact Great South.

## 4.1 Scenario Snapshots

The figures below are snip taken from the Power BI dashboard of the energy balance showing the energy profile evolution for each scenario.

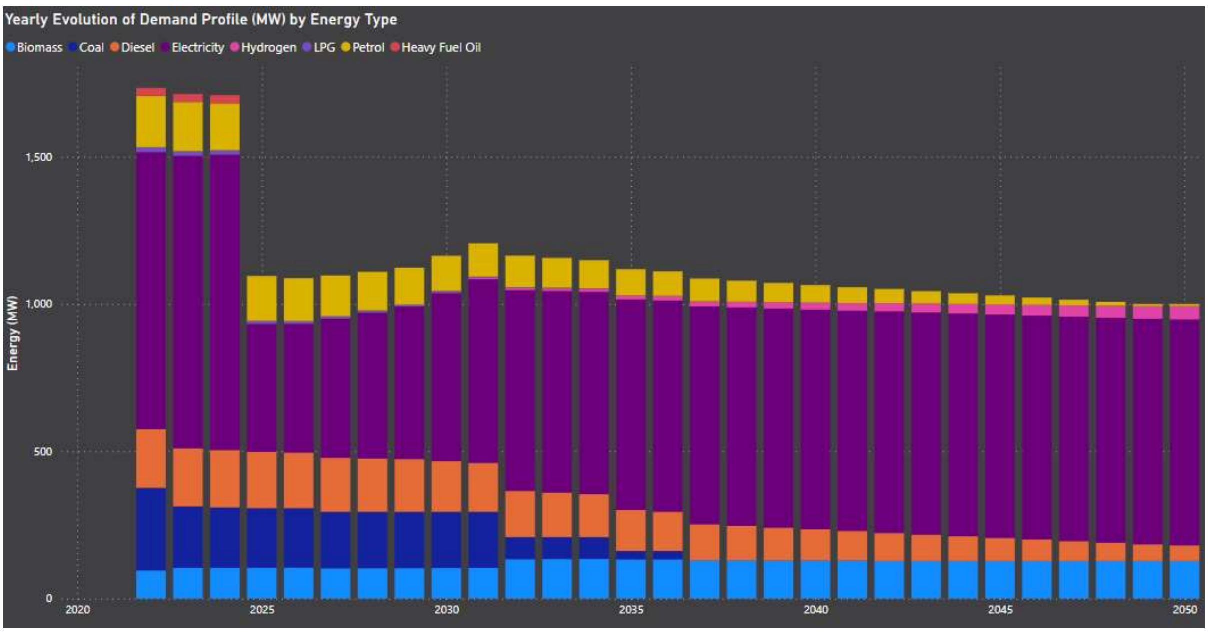



**Figure 4-1 - Snapshot of the forecast demand by energy type for Scenario 1 where NZAS closes and SGH does not go ahead (baseline scenario)**

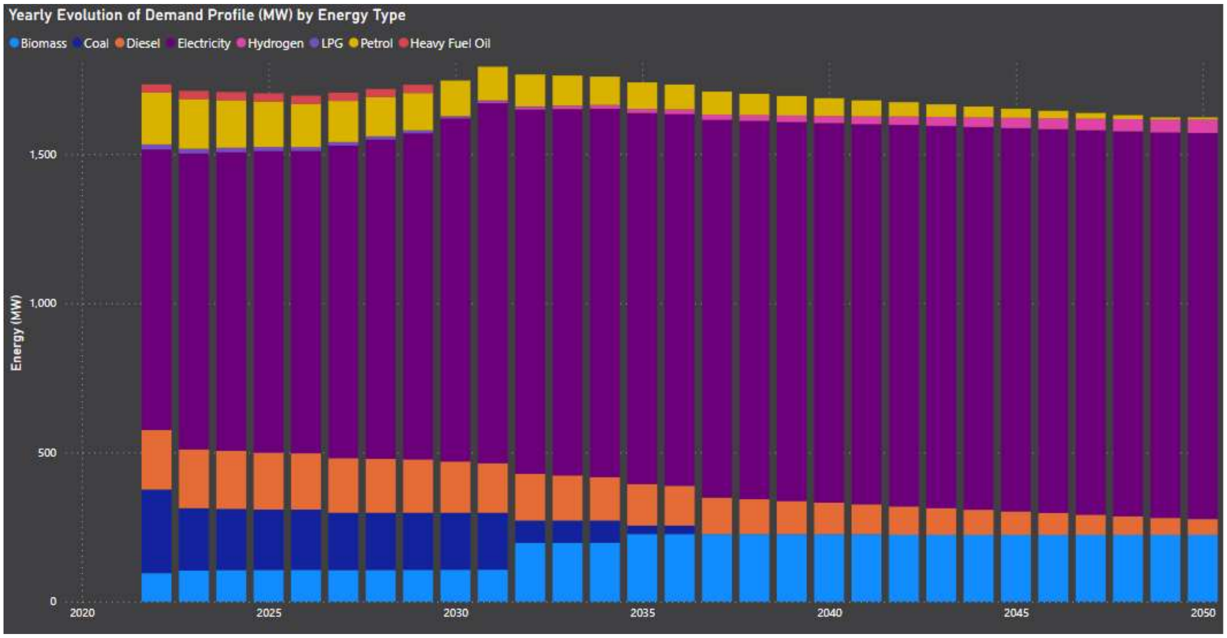



**Figure 4-2 - Snapshot of the forecast demand by energy type for Scenario 2 where there is a managed transition from NZAS and SGH (transition scenario)**

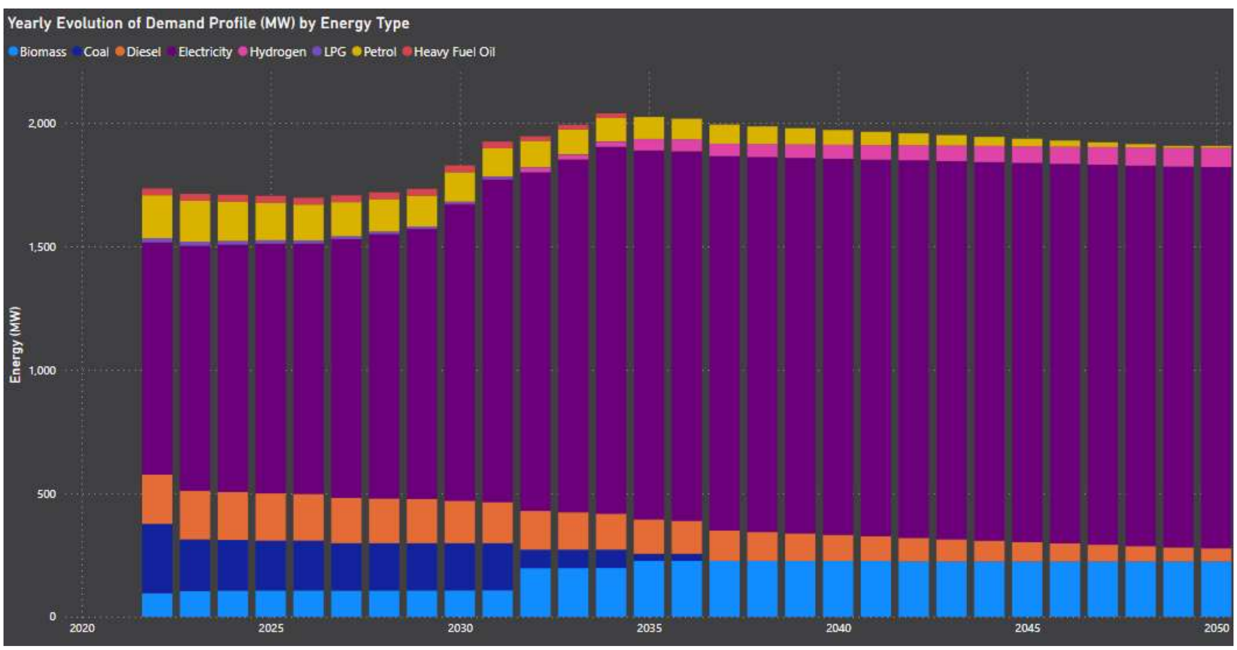



**Figure 4-3 - Snapshot of the forecast demand by energy type for Scenario 3 where NZAS continues to operate and SGH proceeds (green energy growth scenario)**

## 4.2 High Level Insights

The following high-level insights have been revealed by the energy balance outputs:

- For scenario 1 (baseline) the future demand in the region for electricity will not make up for the loss of NZAS, even if it assumed that the majority of the existing coal boilers are electrified (see Figure 4-1).

In this scenario investment will be required in the national grid to send this power out of the region (which is already underway).

- If new energy demands are excluded (i.e., new industry, population growth, etc.), the total energy demand for the region decreases over time due to energy efficiency improvements, new technology and the efficiency benefits of electrification.
- In scenarios 2 and 3, the demand for electricity in Southland Murihiku will increase which will **require investment in more electricity generation in the region** or for more to be imported from the national grid.
- The demand for biomass in Southland Murihiku could be almost four times greater by 2035. The ability to supply this volume is considered in Section 4.5.

## 4.3 Insights by Sector

### 4.3.1 Transportation

For the same distance travelled, the total demand for energy for transport reduces significantly over time. This is due to electric vehicles (EVs) and Fuel Cell Electric Vehicles (FCEVs) being more energy efficient than internal combustion engines. i.e., the total energy supplied to the region today in the form of petrol and diesel does not need to be replaced by an equivalent amount of electricity and hydrogen. This is illustrated below in Figure 4-5.

We assume that 80% of light electric vehicles (EVs) will be charged at home and 20% by public fast chargers. Figure 4-4 shows the current electric vehicle charging stations in Southland. The estimated average demand for each in 2050 is as follows:

- Home EV charging load = 46MW
- Public (fast) EV charging load = 19MW

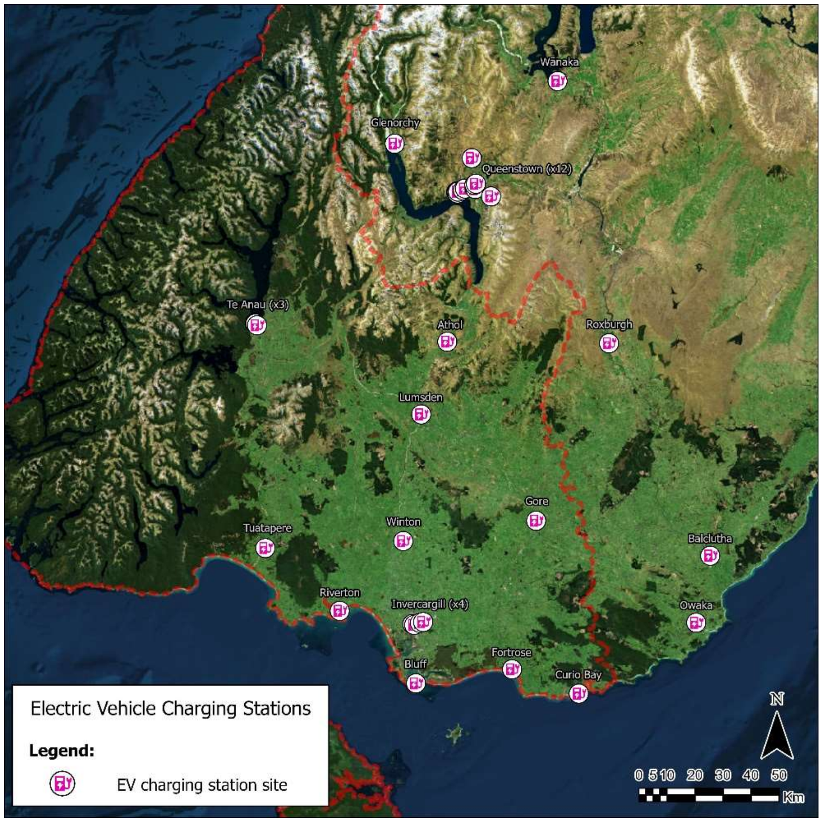



**Figure 4-4 Map of electric vehicle charging stations in Southland (Source: Great South)**

In the dashboard, these two figures are added together to show the total relative energy requirement. However, most home charging is expected to be done overnight and fast charging during the day so in reality these loads are likely to be out of phase with each other.

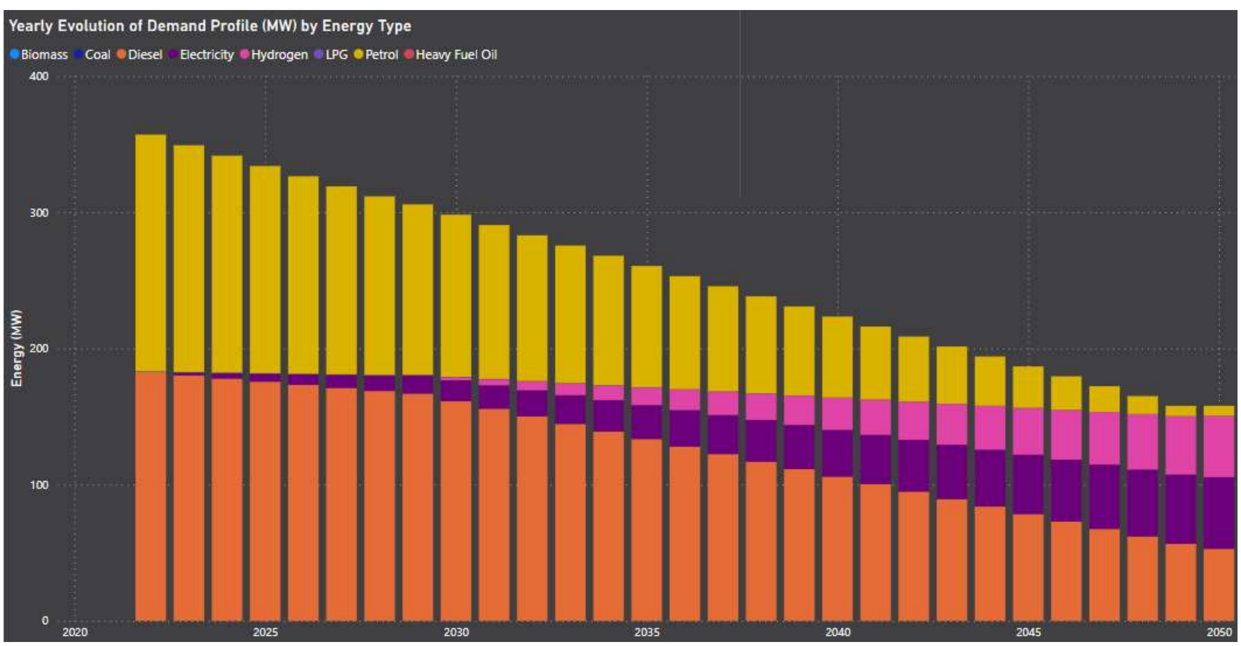



**Figure 4-5 - Graph showing the relative demand for different energy sources for the transport sector.**

For transport recommendations, see section 5.15.

### 4.3.2 Industry

The processing industry make up most of the coal demand in Southland Murihiku. Therefore, it is the proportion of these sites that transition to biomass which will determine the biomass demand and the supply chain that is required, Selection of energy format at Fonterra's Edendale site is a significant determining factor in that equation.

The price and the availability of different energy types will influence when industries switch their energy source and which energy source they will switch to. For example, in scenario 1 (low demand), it is possible that the levelised cost of heat[12] for an electrode boiler could be similar to that of a biomass boiler. The capital cost of the boiler systems however can be significantly different. Some existing boiler systems can be converted to biomass with minor modification to fuel feed systems and air management etc. However, the transmission infrastructure is not currently in place for many large industrial sites to be able to make the switch to electricity at present.

Energy efficiency improvements are realised by the following factors:

- Heat pumps can achieve efficiencies of greater than 300%, depending on the heat source. Therefore, the more heat demand that can be serviced by heat pumps, the lower the energy demand will be.
- Electrode boilers achieve efficiency of close to 100% compared to around 75% for fossil fuel boilers.
- New technologies and incentivisation of energy conservation will result in energy savings, reducing existing loads.

For recommendations for industry, see section 5.1.

### 4.3.3 Commercial Buildings and Public Facilities

Whilst the energy demand associated with these buildings is smaller when compared to transport and industry, the forecast additional electricity load is estimated at around 20MW across the region by 2037 as shown in Figure 4-6.

[12] The levelised cost of heat is a measure of the total cost of a unit of heat/energy taking into account the fuel, capital, operating and maintenance costs

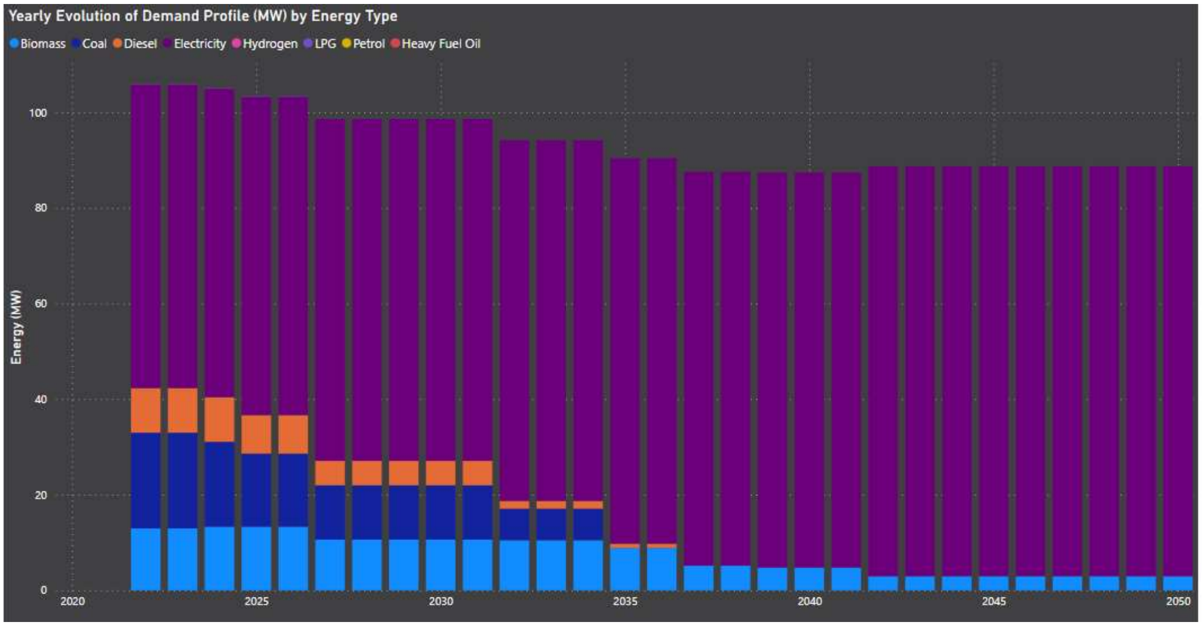



Figure 4-6 - Demand by energy type for commercial buildings and public facilities

### 4.3.4 Residential

Like the commercial buildings and public facilities, the increase in electricity demand from residential buildings is forecast at around 20MW by 2035 across the region (see Figure 4-7). Note, this does not include additional load from electric vehicles. This load is captured in the transportation figures.

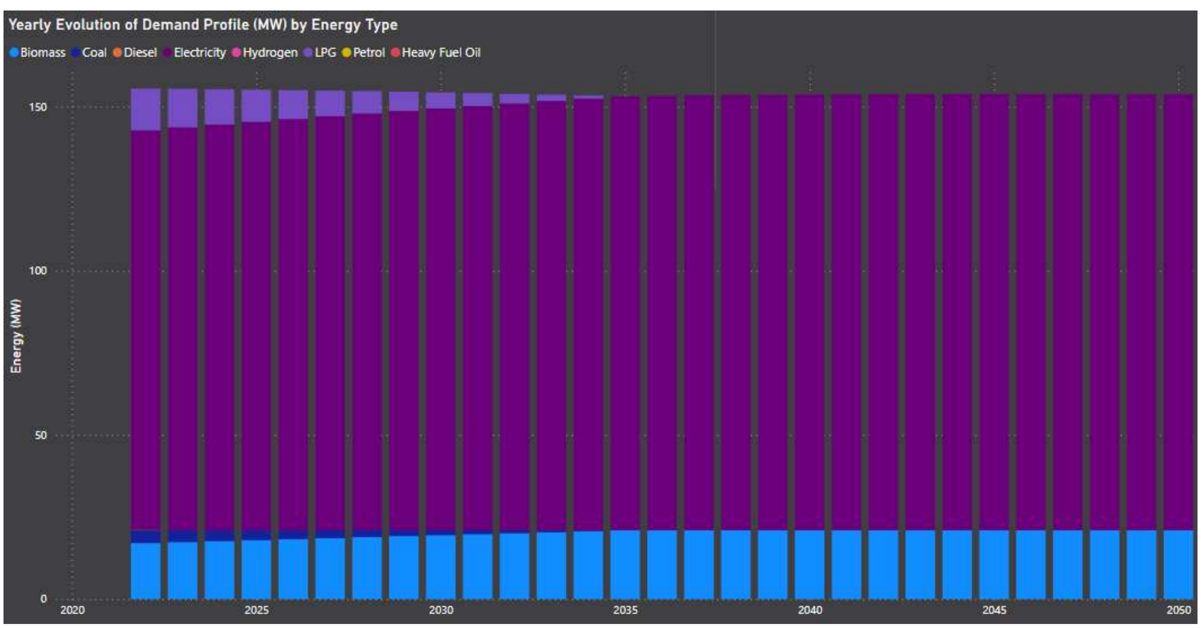



Figure 4-7 - Demand by energy type for residential buildings

## 4.4 Electricity

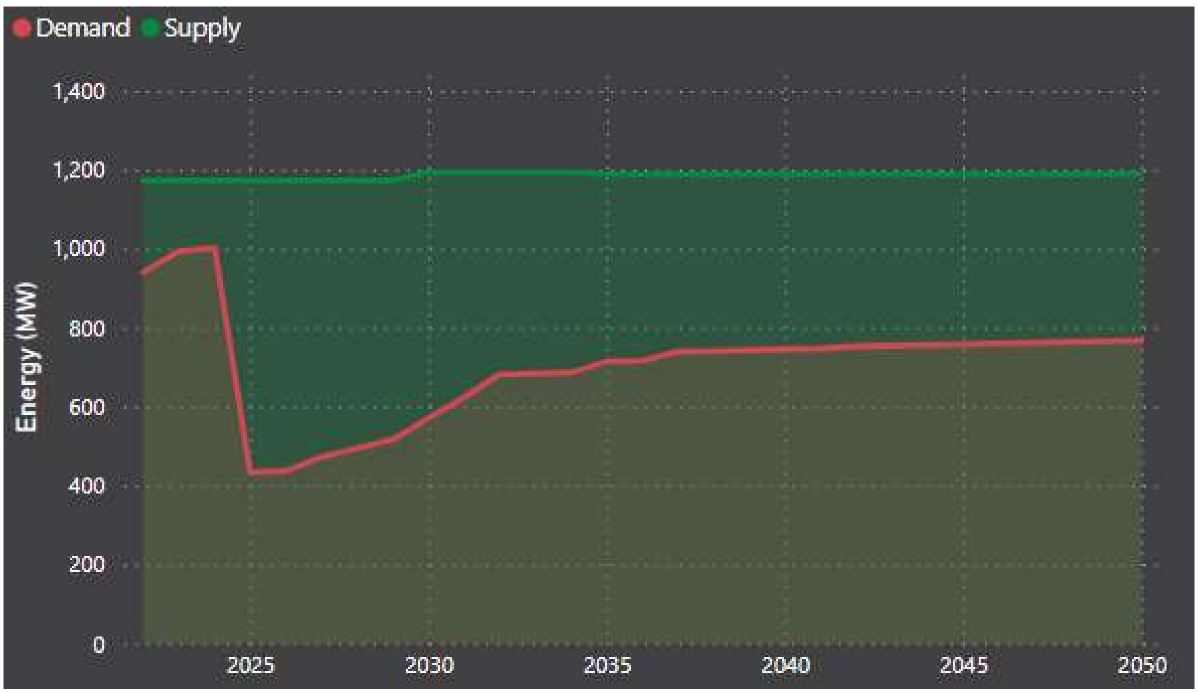
### 4.4.1 Southland Murihiku

The regional energy balance indicates that the electricity demand is set to increase disproportionally when compared to the supply in Scenario 2 or 3, highlighting that current planned upgrades will not be sufficient to support the decarbonisation of transport and industry. Below are three possible scenarios and the associated electricity energy balance from 2022 through to 2050.

Electricity Supply is estimated by summing all distribution zone substation capacities and adding Tiwai GXP, as this substation feeds NZAS directly from the transmission network. It is assumed that the constraint on supply is the capacity of substations, rather than the generation.

Electricity demand is estimated by collating the current peak demand seen at associated distribution zone substations and NZAS in 2022. Then any decarbonisation loads are added to this baseline amount through time, giving a trajectory from 2022 to 2050.

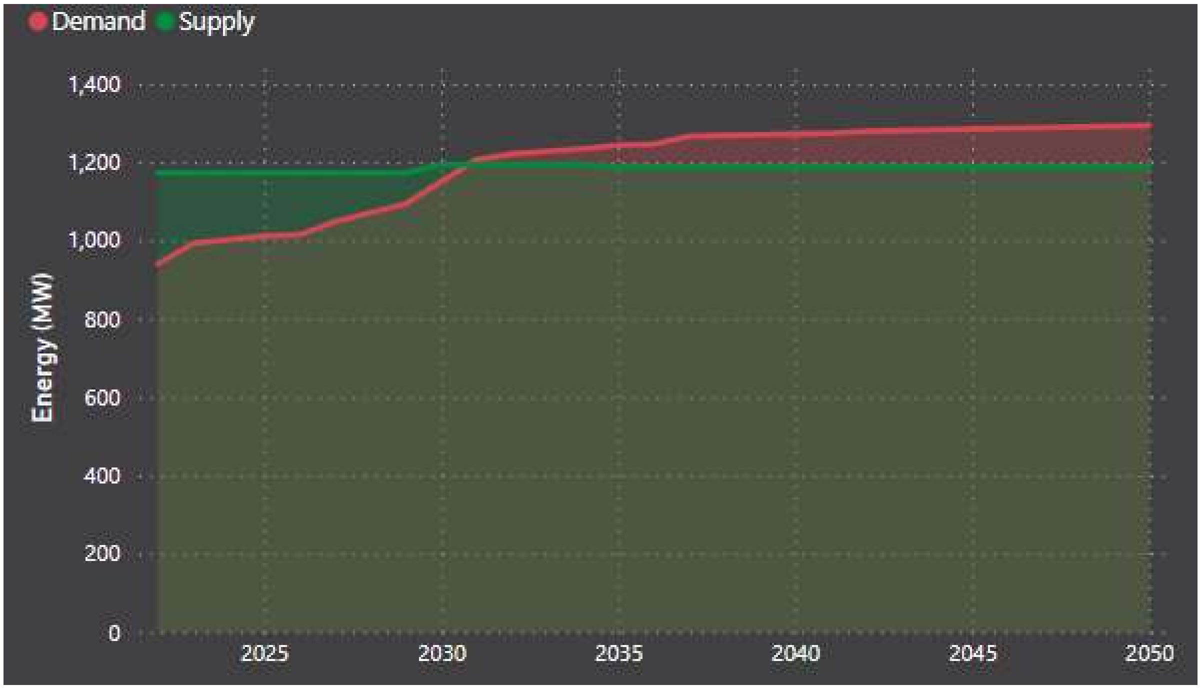
**Electricity Balance Scenario 1: Baseline**




| Year | Demand (MW) | Supply (MW) |
|---|---|---|
| 2022 | 940 | 1173 |
| 2030 | 570 | 1194 |
| 2035 | 715 | 1189 |
| 2050 | 767 | 1190 |

**Figure 4-8 Scenario 1 NZAS closes & SGH does not go ahead**

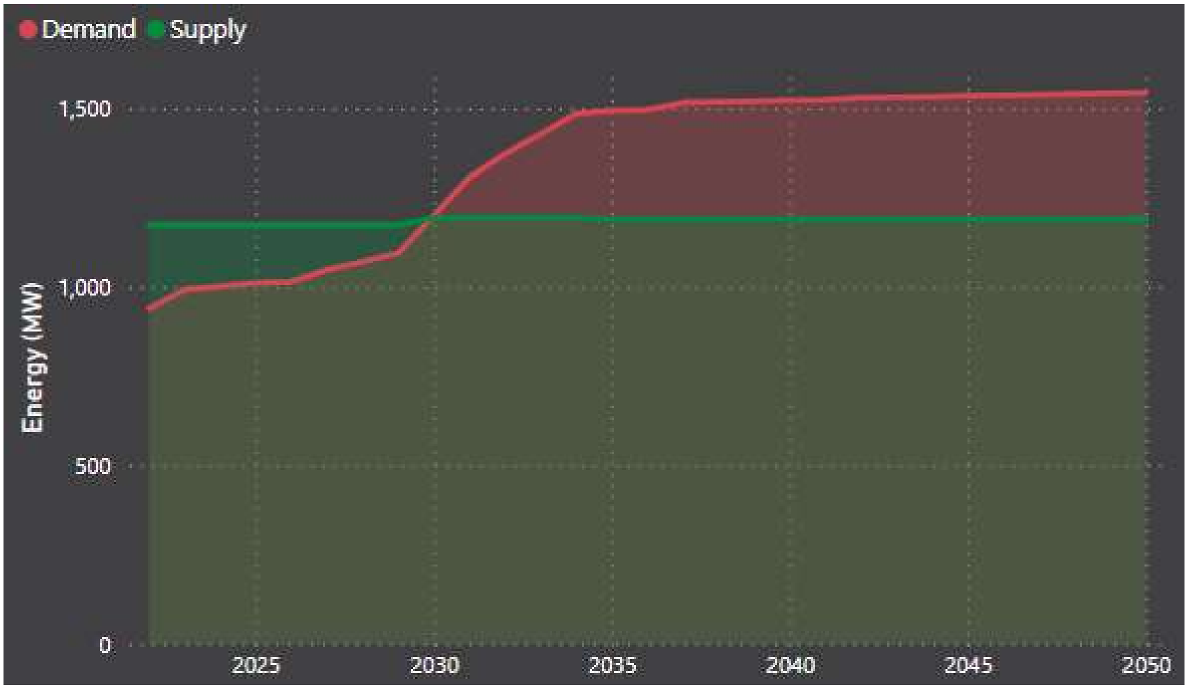
**Electricity Balance Scenario 2: Transition**




| Year | Demand (MW) | Supply (MW) |
|---|---|---|
| 2022 | 940 | 1173 |
| 2030 | 1150 | 1194 |
| 2035 | 1244 | 1189 |
| 2050 | 1294 | 1190 |

**Figure 4-9 - Scenario 2 Managed transition from NZAS closure and SGH commencement energy balance**

**Electricity Balance Scenario 3: Green Energy Growth**




| Year | Demand (MW) | Supply (MW) |
|---|---|---|
| 2022 | 940 | 1173 |
| 2030 | 1200 | 1194 |
| 2035 | 1494 | 1189 |
| 2050 | 1544 | 1190 |

**Figure 4-10 - Scenario 3 NZAS continues to operate and SGS commences electricity balance.**

The only scenario where the supply-side can meet the demand, is in Scenario 1. In this scenario, due to NZAS's closure and SGH not being constructed, there is surplus supply to meet the new decarbonisation loads. However, infrastructure upgrades will still be needed to re-distribute the supply to locations load across Southland Murihiku. For this to be resolved, within the current regulatory constraints, **commitment to electrification will be required from industry to enable transmission and distribution infrastructure to be built.**

Decarbonisation demand increase could be over 150MW. This highlights the need for considerable additional generation, transmission, and distribution upgrades to enable decarbonisation and associated electricity demand.

If a regional balance is the goal and the generation is an intermittent type, considerable storage will be required to firm the supply, balancing its output over time with the real time demand. Alternatively, greater levels of renewable generation could be considered at each location, known as overbuild, so that lulls in water, wind or sun have lesser impact on fluctuating or minimum output. When the energy source is high (wind, sun, water) the excess energy could be exported outside the region. Another possibility to reduce the volume of storage is if wind generation is built over a much wider geographic spread so that it experiences different weather patterns. Many locations still experience a daily wind cycle, and there can be entire region wide period of light wind and hence this is not a complete solution. Geographical diversity is useful for solar farms, mitigating some of the cloud triggered irradiation intermittency.

If the generation increases are not within Southland Murihiku or are insufficient, the transmission and distribution may need more upgrades to deliver nationally generated electricity to the loads. Large demands will need to explore the option of electrifying through direct connection to Transpower's transmission network, rather than to the local distribution network. Commitment will be required from users before the transmission and distribution infrastructure can be built.

To assess the specific locations that may be bottlenecks to electrification, loads were geographically mapped to their closest substation. When looking at the combination of new site developments and electrification of process heat, the following specific locations do not have sufficient capacity at the local substation to meet the forecast demand. Note, some industrial users will instead connect directly into the transmission network, if the demand is large enough.

**Table 2 – Key locations where infrastructure upgrades will be required**

| Location | Large Decarbonising Loads Nearby | % Overload (Demand/N) | Overload Timeframe |
|---|---|---|---|
| **Awarua Zone Substation** | Open Country Dairy*<br>South Pacific Meats | 450% | By 2030 |
| **Edendale Zone Substation** | Fonterra | 170% | 2030-2035 |
| **Makarewa Zone Substation** | Data Storage<br>NZFF food processing plant<br>Sandford Spat production facility<br>SDE Plastics recycling plant | 840% | By 2030 |
| **Mataura Zone Substation** | Alliance Group (Mataura) | 110% | By 2030 |
| **Underwood Zone Substation** | Alliance Group | 160% | By 2030 |

*Open Country Dairy is currently supplied directly from the distribution feeders

New potential industries situated at Green Hills and Ocean Beach are in the early stage of planning and if these proceed additional capacity will be required in or around the Awarua Zone Substation.

The table above highlights key locations that require significant action to enable local industry to decarbonise. It is understood that some industrial users above will not connect into their local zone substations, however this exercise highlights that a simple solution is not possible. Rather, a bespoke solution should be found for each area to enable all stakeholders to prosper and ensure all opportunities are taken. These opportunities could include executing a large infrastructure upgrade to enable other industries in the area to decarbonise too or enable new industry to move to Southland Murihiku. Extreme increases in demand, such as near Awarua and Makarewa, will require more than a zone substation upgrade and will require a transmission network upgrade. This could be as much as a new Grid Exit Point (GXP). The exact solution should be agreed between users, distribution companies and Transpower. It is therefore critical to involve all parties in discussions to ensure a suitable solution is identified for each area and that infrastructure investment aligns with customer demand.

For energy generation recommendations see section 5.2.

Note – Southern Green Hydrogen is not discussed here. Given the scale of this potential development, it is the subject of a major engineering study that will investigate the transmission requirements.

### 4.4.2 Rakiura Stewart Island

Stewart Island Electricity Supply Authority (SIESA) provides the generation and supply of electricity to consumers on Rakiura Stewart Island. There are around 450 permanent electricity connections connected to a distribution network powered by up to five diesel generators at a central power station. The generators consume approximately 440,000 litres of diesel annually, resulting in approximately 1,850 tonnes of carbon dioxide emissions. The generators are in a 4+1 configuration with full redundancy via one generator capable of supplying the entire island load when necessary. The price per kWh to consumers is currently approx. 2.5 times higher than mainland New Zealand and it is predicted it may rise by up to 50% due to increases in diesel costs. Electricity costs are a driver as to why the average Rakiura Stewart Island consumer's annual electricity consumption is around 3300 kWh in comparison to average South Island consumption of 9000 kWh.

For Rakiura Stewart Island recommendations see section 5.12.1.

### 4.4.3 Piopiotahi Milford Sound

Piopiotahi Milford Sound's electricity network is made up of a 3.3 kV backbone, with a sub-transmission at 415 V, powered by hydro and diesel generation. The network powers two main nodes, Milford village and Cleddau residential area. Milford's pricing structure is currently a base price of $0.25/kWh. There have been refurbishments and performance improvements of the hydrogeneration in recent years, however during periods of low flow the scheme is struggling to meet peak demands. The recent addition of a 480kW diesel generator will enable the network to handle periods of peak demand. Use of diesel will also push up the electricity price, particularly due to recent increases in diesel costs.

Piopiotahi Milford Sound is facing the challenge of increasing base and peak load, which is not easily resolved with a net-zero solution. It has specific challenges similar to Rakiura Stewart Island (environment, consenting and scale). The region has however taken great action implementing a load control system, allowing the hydro to reduce outages. Piopiotahi Milford Sound should continue to explore opportunities to introduce an alternative base supply to support the hydro and a peaking system to manage the 480kW peak load. Piopiotahi Milford Sound could also explore variable electricity prices to discourage peak loads.

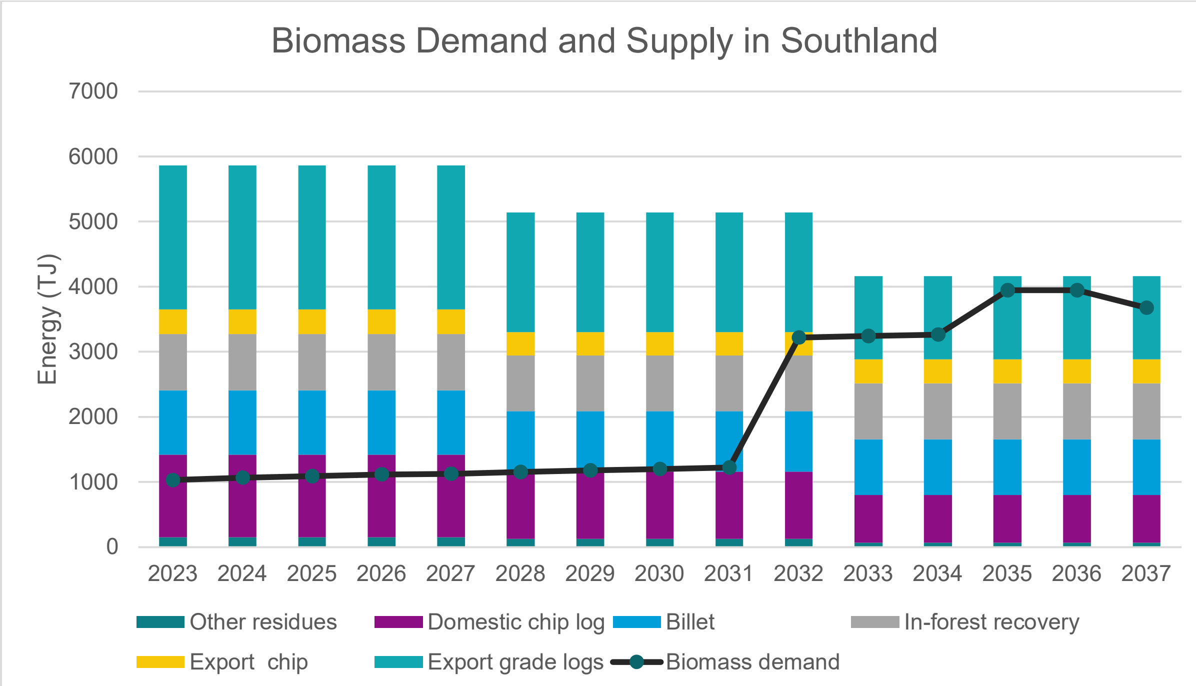
Recommendations for Piopiotahi Milford Sound are detailed in section 5.12.2.

## 4.5 Biomass

The Biomass Availability Assessment for the Southland Murihiku Region Report estimates that the total average biomass that could be diverted to bioenergy is 705,000 t/a[13], equivalent to >5000 TJs. The EECA Southland Murihiku Regional Energy Transition Accelerator (RETA) Report, identified that 380,000 t/a[14] of Southland woody biomass that could be recovered and/or diverted in near term to a bioenergy market. The RETA report considers only Southland Murihiku forests and does not include volumes of residues from the Niagara Sawmill whereas the Ahikā report, and earlier report undertaken by Venture Southland, includes adjacent Otago forests where the biomass flows into Southland Murihiku.

[13] Ahikā 2022, Southland Region Bioenergy Availability Assessment

[14] EECA 2022, Regional Energy Transition Accelerator (RETA) Southland - Phase One Report




| | Biomass ($/GJ) | | | | |
|---|---|---|---|---|---|
| | Residues | MDF + billet | In-forest | Export chip | Export grade logs |
| 2022 | 10.2 | 13.2 | 14.7 | 19.2 | 23.4 |
| 2050 | 17.8 | 23.0 | 25.6 | 33.4 | 40.7 |

**Figure 4-11. Biomass Supply and Demand in Southland Murihiku. Table data sourced from Ahikā, 2022**

**Figure 4-11** details the predicted biomass supply out to 2037 (Ahikā, 2022) and the potential biomass demand in scenarios 2 and 3 (scenario 1 not considered)[15]. The predicted supply uses data from the Biomass Availability Assessment for the Southland Murihiku Region Report[16]. Ahikā developed an age class profile for the remaining Radiata pine estate.

This profile shows that as the volume of biomass available in remaining forest estates reduces, the demand for biomass increases.

We estimate the future demand of biomass for bioenergy to be around 4000 TJs. This demand is just below the total available biomass in the region. As stated by Ahikā, in order to access the full potential volume of biomass the unit price of biomass becomes relatively high and may be a barrier for the full utilisation of this resource. The increase in biomass demand of this scale (4-fold increase) needs to be managed so that the supply chains, infrastructure and market can be co-ordinated and developed in a planned way to ensure security of supply and price certainty (and fairness) for all.

At this demand, export supply would be required at a delivered price of $23.4/GJ[17]. The rising carbon price does incentivise planting permanent forestry, however as the carbon price increases the price of fossil fuels,

[15] Note – for the purposes of region wide modelling, the changes in industrial demand are grouped in year brackets and the actual demand will be more gradual.

[16] Ahikā 2022, Southland Region Bioenergy Availability Assessment

[17] Southland Regional Development Agency, Southland's Power Demand Projections, 2022

it also increases the value of wood as a fossil fuel substitute. This increases the value of plantation forestry especially if forest residues are collected and sold as solid fuel. Maximising the collection and sale of forest residues as solid energy should help to maintain a sensible balance between permanent and plantation forestry.

Based on these volumes of supply and demand for the region, **it is likely that biomass (preferably in the form of wood pellets) will need to be imported from elsewhere in New Zealand** to meet the biomass demand in Southland Murihiku in scenarios 2 and 3.

For recommendations biomass recommendations, see section 5.7.

# 5 Options to Achieve Energy Transition Goals

## 5.1 Co-ordination of Industry

One of the challenges of the energy transition is that many organisations lack the scale and capital required to make the infrastructure upgrades and setup the supply chains required. Additionally, they often lack the internal resource required to plan and manage these projects in addition to their day-to-day business operations. However, by bringing organisations together and co-ordinating their energy transition efforts, there is an opportunity to bring about economies of scale (for example with shared utilities) and reduce rework which will result in better outcomes for all. Co-ordination of industry may also support sectors challenged by the seasonality of energy requirements. Consideration should also be given to opportunities to incorporate (or make provision for) hydrogen generation or other forms of energy storage at the same time.

**We recommend that a working group, comprising of the largest coal users and other relevant stakeholders including Transpower and PowerNet is formed.** This could build on the successful Wood Energy South and Carbon Neutral Advantage programmes which have been led and inspired by Great South. The purpose of this group would be:

- To provide regular updates on their respective business's energy transition plans
- Further investigate the potential fuel switching options and define the specific infrastructure and supply chains required in their respective locations
- Co-ordinate their energy transition related capital upgrades to realise mutual benefits
- Pool resources to avoid double-up between organisations

The energy transition of large industrial users such as Fonterra will have a large impact on the regional energy requirements. **Engagement with large industrial users, especially Fonterra, will be critical to planning the regional energy demand.**

Great South's involvement in the group could involve the following:

- Co-ordination and facilitation of the group
- Execution of further research, studies and trials required by the group
- Sourcing of funding from local and central government to support the work
- Communicating feedback from the groups to inform government policy and initiatives
- Bring in outside technical expertise to support the group on specialist knowledge areas (such as hydrogen or biogas)

A suggested structure for the working group is shown in Figure 5-1 with sub-groups for the specific locations where it is known that the existing electricity network and/or biomass supply infrastructure is inadequate to meet the future demands.

This approach may be a paradigm shift for some organisations. For this approach to be successful there are some challenges that may need to be overcome, such as:

- Managing confidentiality to give comfort for the organisations involved to enable sharing of the information required to support their collective efforts
- Freeing up sufficient time for each of the participants to make substantive progress. Commitment will be required from senior management in each organisation involved
- Recommendation – developing a group charter may be a good way of gaining buy-in from the participants.

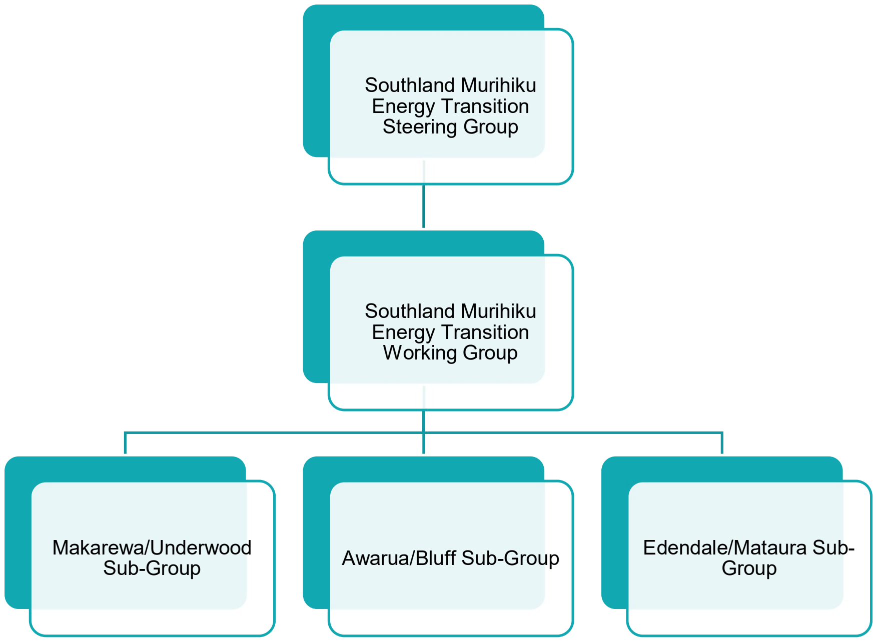



**Figure 5-1 - Indicative organisation structure for a Southland Murihiku energy transition working group**

## 5.2 Electricity Generation

The departure of NZAS with no significant replacement (scenario 1) causes excess generation within Southland Murihiku compared to electricity demand. This may impact on the probability of attracting new generation as the electricity market will react and the local nodal wholesale price will likely be lower than other nodes elsewhere in the grid. This disincentivises new generation within the Southland Murihiku region. On the other hand, it also creates a competitive and comparative advantage for the attraction of new industry, situated close to generation which also supports efficient use of tier 1 transmission infrastructure.

Scenario 2, where there is a transition from NZAS to SGH (or a similar large alternative load or loads), may still leave a gap for new generation to supply the decarbonisation loads.

Scenario 3, with both NZAS and SGH or alternative large new loads will be highly attractive to new generation, although the attractiveness may be somewhat dampened by the expectation of very large loads to receive electricity price contracts that are highly discounted and there will be caution over a future departure of NZAS leaving any recently established generation fighting with Manapouri for transmission capacity.

Fundamentally the scenarios concerning NZAS and SGH will have a large impact on the energy balance, electricity availability and the new renewable energy requirements in the region. Therefore, onshore wind will likely provide the most economical solution to filling the electricity generation gap within the region. If only one of NZAS and SGH are in operation, then new onshore wind and solar developments should be sufficient to provide the needed supply. However, **if both NZAS and SGH are operational there may be is a need for the offshore close to the coast, onshore wind and/or hydro resource to be considered to meet the large electricity demand.** Alternatively, electricity will need to be imported into the region from the national grid system. The electricity generators will always make commercial decisions that are in the best interests of the business. Energy can be generated nationally or locally optimising existing grid investment. This strategy supports the need to access generation at an affordable price no matter where it is generated.

The renewal of the Manapouri Hydro Electric Power station consent will occur in 2031 and there are certain risks associate with the reconsenting process that need to be factored into strategic planning processes.

### 5.2.1 Solar

Solar generation is a useful source of electricity to meet small demands or provide minor increases in generation but solar in Southland Murihiku is unlikely to be economic in most areas to warrant many large utility-scale developments. This is because the current $/kWh for most solar developments in New Zealand is greater than wind developments and the solar resource in Southland Murihiku (~1250 kWh/kWp) is lower than the New Zealand average.[18][19] Note the economics on Rakiura Stewart Island are very different and therefore considering both dispersed and network scale solar is warranted.

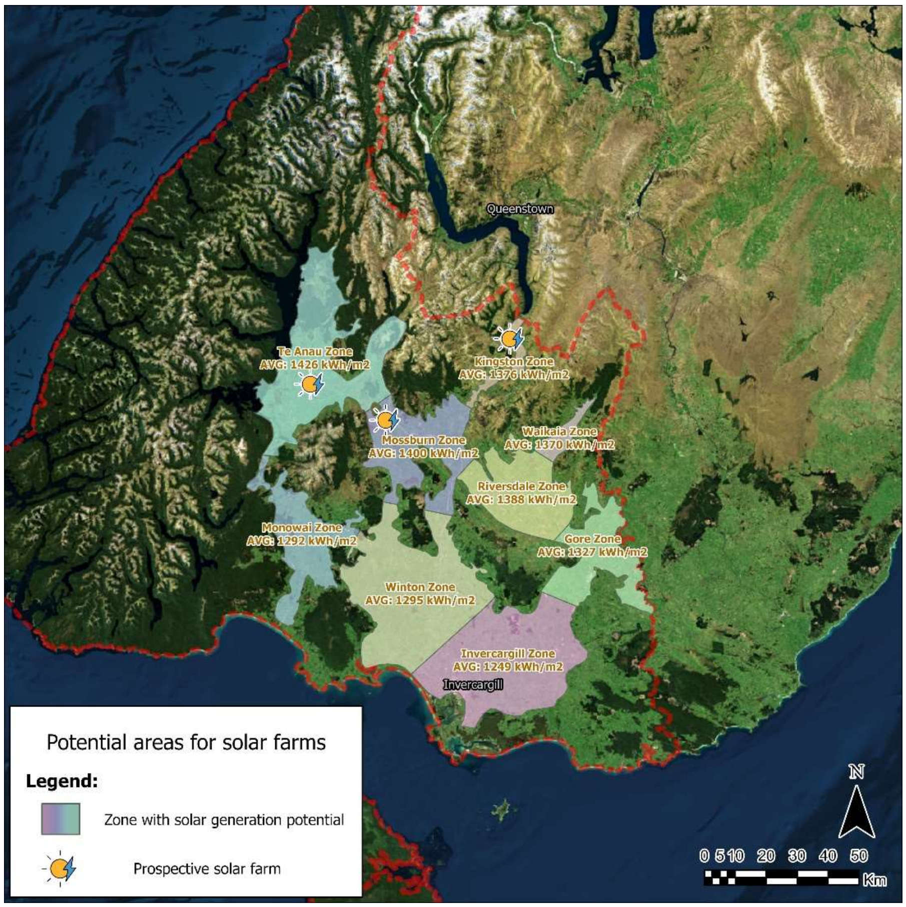



**Figure 5-2 Potential areas for solar farms (Source: Great South)**

**Recommendations:**

- **The best solar resource is available in Southland appears to be in Te Anau, Mossburn and Kingston areas** as shown in Figure 5-2. These locations present a starting point for utility-scale feasibility studies. Ultimately the commercial viability and factors such as the Avoided Cost of Transmission (ACOT) will determine whether these projects are developed.

[18] https://www.mbie.govt.nz/assets/Uploads/utility-scale-solar-forecast-in-aotearoa-new-zealand-v3.pdf

[19] https://globalsolaratlas.info/

- The best use of solar would be embedded solar generation, close to electricity loads, to offset the demand on the grid.
- **Solar should not be considered as the main source of generation to meet the energy balance gap.**

### 5.2.2 Wind

Prospecting a potential wind farm site is an iterative process, with increasing detail, considering three principal factors: technical requirements, environmental considerations, and financial viability. This report will discuss these factors at a high-level for offshore and flatland wind generation in Southland Murihiku. Figure 5-3 shows planned and potential windfarm sites that have been identified by Great South.

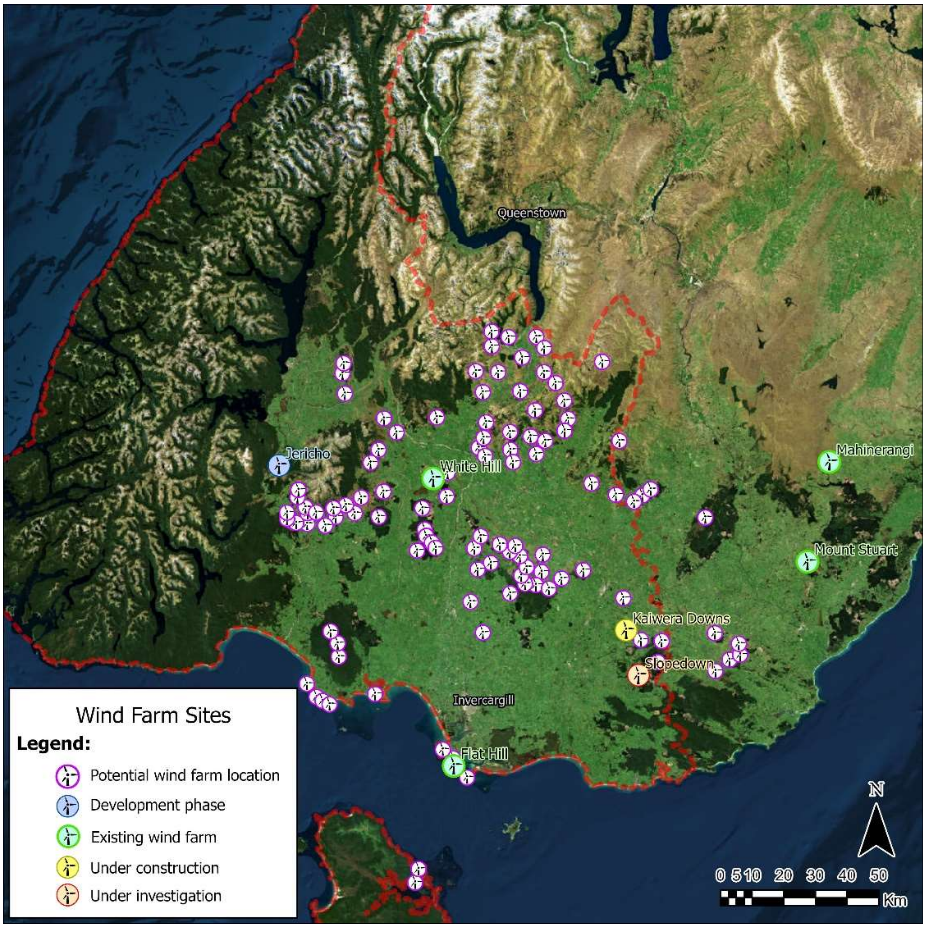



**Figure 5-3 Planned and potential wind farm sites in Southland Murihiku (Source: Great South)**

#### Onshore Wind

Technical Requirements

There are four main technical requirements to evaluate: wind resource, availability of suitable land, site access and grid infrastructure.

When considering flatland areas for development within Southland Murihiku, there are limited locations that can deliver over 800W/m2. The primary location to further investigate would be to the east of Invercargill, particularly west of Edendale, which presents a mean power density close to 900W/m2. Edendale has existing

110 kV infrastructure and would provide suitable site access. A detailed site assessment would be needed to understand land suitability and environmental impacts. Potential sites, moving from Edendale, would be to either the east or the south.

Wind currently under investigation or development includes Kaiwera Downs, Blackmount, Kuriwao Peak/Kaihiku Range and Venlaw Station.

Further wind farm information is available on the New Zealand Wind Energy Association website[20].

Environmental Considerations

Developers of onshore windfarms must seek to mitigate all environmental impacts to reduce the overall impact upon the public. This is often done by developing sites away from habitation to remove visual and noise impacts. There will remain the need to assess the environmental sensitivity of the area including the impact upon native and rare fauna and flora. Proximity to sites of environmental or cultural significance will be an important consideration and will need to include an assessment of environmental impacts and mitigation. 58% of Southland's total land area is managed as part of the New Zealand conservation estate, therefore consideration should be given to early engagement with iwi, councils, community and stakeholder entities such as the Department of Conservation to facilitate a smooth planning process.

A comprehensive record of publicly acknowledged sites of special cultural significance are contained within the iwi planning document, Te Tangi a Taura. This is a natural resource and environment iwi management plan that reflects the attitudes and values of the four Rūnanga, Hokonui Rūnanga, Te Rūnaka o Awarua, Oraka Aparima Rūnaka and Waihōpai Rūnaka. This resource is an excellent starting point for the planning process.

Financial Viability

Financially wind farms present one of the cheapest forms of new electricity generation, with windenergy.org.nz quoting a long run marginal cost (LRMC) of wind energy of $70 to $80/MWh[21]. Civil development costs are significant with wind farms, particularly on slopes, ridges and challenging terrain and this impacts the LRMC. It may be possible to develop large scale win on flat sites for $55 to $60/MWh.

It is preferable to explore potential onshore sites, preferably near loads, to meet electricity demand before exploring the need to go offshore. However, a detailed financial assessment would be needed to accurately determine a $/MWh value for proposed sites before initiating development.

### Offshore Wind

Technical Requirements

The offshore wind resource off the coast of Southland Murihiku is plentiful, ranging from 1100W/m$^2$ to 2200W/m$^2$ when assessing 20km from the land's edge[22]. The largest resource is available to the west and is at its lowest between Rakiura and the mainland. Both the east and west coasts pose difficulties due to access and the unavailability of an electricity grid on the closest land. These locations are not recommended. Therefore, the south coast, closest to existing HV electrical infrastructure would present the best area to further assess potential wind farm sites. At a high level, potential areas to investigate would firstly be west of Invercargill and then south-east of NZAS. The suitability of the seabed must be assessed when a site location is proposed.

[20] https://www.windenergy.org.nz/proposed-wind-farms https://www.windenergy.org.nz/consented-wind-farms https://www.windenergy.org.nz/operating-&-under-construction

[21] https://www.windenergy.org.nz/the-cost-of-wind-energy

[22] https://globalwindatlas.info/

Offshore hydrogen production from wind energy is currently being investigated in Northern Europe. If this technology advances in the future, it could be considered in Southland.

Environmental Considerations

Offshore wind presents many benefits when considering environmental considerations, such as noise, flicker, landscape impacts, land use and electromagnetic interference. An offshore wind farm presents minimal impact on the public and removes the above considerations. Key factors to consider when proposing an offshore wind farm include safety, environmentally sensitive areas and visual impacts. Constructing or servicing the farm will be much higher risk than onshore and the site must be assessed for impacts on natural habitats. Visual impacts are reduced when developing offshore, but complaints are possible if the farm is seen from the coastline or if a flight path passes over the site.

Financial Viability

Offshore wind farms remain significantly more expensive than onshore but are forecast to reduce by 30% by 2030.

**Recommendations:**

- Southland Murihiku should actively explore both onshore and offshore options.
- **Wind should be seen as a dominate source of energy to meet the energy gap presented by the energy balance.** Begin by optimising the available onshore resource, as this will provide lower cost energy and come online sooner.
- **Focus should begin with detailed feasibility studies for lowland wind sites between Invercargill and Edendale.**
- Potential offshore sites should be assessed whilst technology is still developing so that future generation can be forecast and developed in time to meet demand.
- **If NZAS and SGH are both online, then the need to develop offshore wind may become critical for Southland Murihiku.**
- New generation should be located close to new load and transmission infrastructure where possible.

### 5.2.3 Hydrogeneration

Southland Murihiku is fortunate to have potential hydropower sites at its disposal within the region and immediately to the north in Otago. Hydrogeneration is likely to be required to meet the energy gap if both NZAS and SGH are operational. The Otago region is used to provide the majority of New Zealand's current hydro generation. MBIE's 'Hydro generation stack update for large-scale plant' details a range of potential new large-scale hydro plants that should be investigated. Hydropower schemes need to be developed sensitively to avoid any detrimental environmental effects and as such resource management, fisheries, conservation, flood defence, navigation and recreation all need to be considered when prospecting a potential site.[23]

Focus should be on modified river systems such as the Clutha and possibly Waiau systems recognising the need to consider aspects such as cultural Mahinga kai sites, minimum flushing flows irrigation and public water schemes, etc. Providing transmission for new hydrogeneration will be a lesser challenge than the listed aspects.

MBIE stated in their report:

[23] https://www.mbie.govt.nz/assets/hydro-generation-stack-update-for-large-scale-plant.pdf

> "Whilst the area around Lake Roxburgh has received the most attention through various studies and reports, especially the Lake Onslow scheme and to a lesser extent the Lake Hawea scheme, there hasn't been a great deal of investigations into opportunities in other parts of New Zealand. The attention given to Lake Roxburgh is understandable as it provides a lower reservoir that receives a significant inflow fed by three of New Zealand's large lakes (Wakatipu, Wānaka and Hāwea). Additionally, and more importantly, it is surrounded by large areas of sparsely populated land at a significantly higher elevation. This presents opportunities for very large-scale Pumped Hydro Energy Storage (PHES) schemes – something that could address New Zealand's dry year risk."

MBIE's report should form the basis for future investigations into hydrogeneration within Southland Murihiku. The report ranks possible opportunities and as such, detailed feasibility studies should be undertaken for the highest-ranking schemes. This exercise can be completed whilst the Lake Onslow Scheme is further investigated and will enable development to take place sooner if required. Key potential sites for development can be seen below in Figure 5-4.

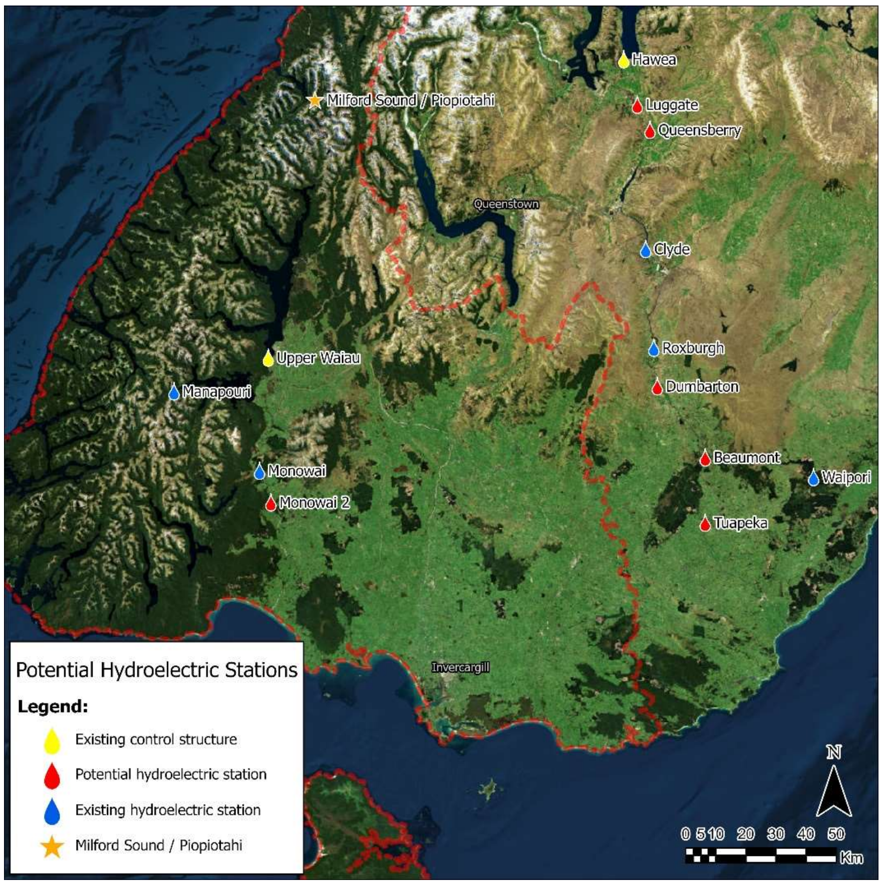



**Figure 5-4 Potential hydroelectric station sites (Source: Great South)**

**Recommendations:**

- MBIE's report should form the basis for future investigations into hydrogeneration within Southland Murihiku
- Detailed feasibility studies should be undertaken for the highest-ranking schemes
- If NZAS & SGH are both operational, hydrogeneration will likely be needed in conjunction with wind to generate the needed electrical supply

### 5.2.4 Ocean Power

Ocean power presents two key opportunities for energy: wave and tidal. With Southland Murihiku benefiting from a long coastline, both wave and tidal power could be harnessed if deemed cost effective. The wave power in New Zealand is strongest on the west & south-west coast and would suggest the Curio Bay area to be a potential site of investigation. Currently there are no commercial wave or tidal power schemes in New Zealand and as such the technology should be tested on site before committing any resource to a large development. It is therefore recommended that attention and effort should be focused on other technologies ahead of Ocean power.

## 5.3 Electricity Storage

The New Zealand grid will need firming capacity as it increases the amount of variable and intermittent energy sources. Off peak energy storage will be able to harness power during times of over-generation and redeliver it during times of under-generation. The durations of each period and the scale of the intermittent sources and loads will determine the required scale and ratings of the energy storage systems.

If NZAS is to close, it may trigger the closure of some thermal generation plants due to the reduction in baseload demand and this will increase the need for grid scale firming. There are three possible technology types that should be investigated to understand the opportunity and benefit to Southland Murihiku.

### 5.3.1 Battery Energy Storage

Cost is likely the most important and fundamental issue affecting the market penetration of Battery Energy Storage Systems (BESS). Where batteries are under consideration for grid-connected energy storage, the design trade-off relates directly to the cost and performance of the electrical energy storage itself. Until recently it has not been cost-effective to use batteries in grid-connected, tier 3 local network and individual domestic and business applications as capital installation costs could not be covered by the savings from not using alternative generation sources. However, with year-on-year reductions in the cost of battery cells, this balance is now changing, and grid scale and small-scale batteries are now closer to financial viability.

**Recommendations:**

- Grid scale BESS should be investigated to better understand the benefit to the network and users
- Potential developments with Southland Murihiku should be identified in anticipation of an upcoming inflection point where **BESS will become financially viable including potential use Remote Area Power Schemes (RAPS) on Rakiura Stewart Island, Piopiotahi Milford Sound, Kingston/Garston Area and remote areas such as Te Waewae Bay.**

### 5.3.2 Hydrogen

The application of green hydrogen as an energy storage medium is discussed in section 5.5.

### 5.3.3 Pumped Hydro Energy Scheme (PHES)

As discussed in the hydro generation stack update, there are many pumped hydro energy storage (PHES) opportunities including existing operational assets that could be used for PHES. The report describes that asset owners have from time to time looked at the opportunity of PHES and have determined that it is not economic and would have negative impacts on the operation of existing assets. As the need for off-peak energy storage increases, new or repurposed PHES developments should be continuously considered to assess the economic viability of providing firming or dry-year support.

Benefits of projects like the Lake Onslow Scheme are:

- More efficient operation of all South Island hydro power stations with less spill.

- 'Dry year' risk cover.
- Reduced need for sending power from the North to South Island during times of low South Island hydro inflows, reducing carbon dioxide emissions from North Island fossil fuel thermal stations.
- The new 1,300 MW capacity could be used for frequency keeping and buffer the short-time variability of wind power, enabling wind power expansion without risking grid instability. The additional installed capacity could also provide peaking capacity generally, including offsetting plant outages.
- There will be some degree of flood peak reduction in the lower Waitaki River, because of reduced spill magnitudes from Lakes Tekapo and Pukaki. At the same time, more stable lake levels should result in reduced lake shore erosion.
- The large increment of energy storage capacity may have the effect of stabilising electricity price fluctuations in the wholesale market, reducing the need to take out hedging contracts.

**Recommendations:**

- **The role of pumped hydro as a firming solution should be investigated alongside any hydrogeneration investigations.**

## 5.4 Electricity Transmission and Distribution

### 5.4.1 Use of existing capacity first

It is recognised there is existing spare capacity available from most distribution zone substations and from each grid exit point. The first mover (first developer) to commit to build of generation or load, may be able to take advantage of this and connect with minimal connection cost. This benefits the region as there are no upgrades required, least cost, least materials, least environmental change and fastest connection allowing the new generator to consumer and contribute to Southland Murihiku's economy. The existing networks are capable of supporting this regional ambition as the summated capacity of all zone substations is almost double the coincident peak demand on the substations, however the actual spare capacity of each substation varies and due to the need to be adaptable to emergency events: storms, equipment failure, unexpected coincident peaks, etc. The actual spare load capacity at each can be negligible in some locations and the Beca Digital Twin and AMPs should be referred to in first instances to see geographical specific values.

It should be noted that while often spare load capacity is also indicative of spare generation distribution capacity into the network or grid this is not always the case. In some situations, a lack of spare capacity can be a good indicator of the opportunity to inject generation into the location, decreasing the network load and creating spare capacity for through flow or new loads.

**Recommendations:**

- **Lead stakeholders and Consumer-owned electricity distribution businesses (EDBs) to encourage developments to be built in locations where there is existing spare capacity.** The Beca developed Digital Twin can be used to display the locations with known spare load capacity.
- EDBs to consider the value of commissioning a load flow study which would demonstrate the changes in network capacities for load and generation for the 3 major scenarios and for several of the predicted major decarbonisation conversions.

### 5.4.2 Early Communication

As detailed in section 2.3 the grid owner Transpower and the distribution network owners Electricity Invercargill (EIL), The Power Company (TPCL), OtagoNet (ONL), Stewart Island Electricity Supply Authority (SIESA) and Milford Sound Infrastructure Limited (MSI) build, maintain and reinforce their infrastructure to 10-year publicly disclosed Asset Management Plans which are developed to meet agreed service, safety, quality and profitability targets. Furthermore, the major customers are consulted about the service levels they prefer and the price they are willing to pay.

Due to these service and commercial drivers the existing infrastructure has adequate, however not excess capacity. This can be a constraint for connecting new generation or loads i.e., small or first new connections may be possible using existing spare capacity, however large or later connections may not be possible using the existing infrastructure.

When enabling many new, small connections, the EDBs capital spend for network infrastructure upgrades is low and can be recovered via monthly lines charges. However large new connections to the grid or network can require significant investment and this needs to be planned and justified to the Commerce Commission. Hence this process, design, consenting, procurement, and construction can cause delays of many months, or for some situations 3-5 years of delay before electricity supply can be provided. The earlier Transpower and the EDBs are made aware of the potential connections the shorter the delay. Working with the electricity provider early may allow identification of alternative supplies or co-ordination with the planning for other new supplies resulting in less cost to all.

**Recommendations:**

- Developer of new generation and/or loads, storage, etc to communicate with Transpower or the applicable EDBs as soon as practicable stating proposed location, demand and service levels.
- Developer to communicate with Great South as soon as practicable to begin possibility of co-ordination with other developers to share resources.
- Advocate for a review of the investment planning process for electricity transmission and distribution with the aim of reducing timelines for accommodating new large loads. This should be done in consultation with electricity generators, network operators and major users to get a full picture of the needs of industry and how risks can be managed to deliver new infrastructure in a timely, cost-effective and efficient manner.

### 5.4.3 Load Management & Capacity Sharing

Load management is critical for grid stability and electricity prices and should be installed for all large industrial users. Load management systems enable loads to instantaneously adjust their usage to meet changes in generation and supply. This enables increased grid stability and balancing, which is typically managed from the supply side only. Load management can also include reducing load for long periods of time, such as reducing production during times of low generation for weeks or months. **If implemented and managed effectively, load management will reduce the requirement for grid infrastructure upgrades to provide firm supplies to users.**

NZAS offers firming support through its load management system, which allows for an instantaneous reduction in load. In addition to instantaneous reductions at peak times, NZAS is also able to shut down reduction lines to reduce load for medium periods, weeks and months.

Capacity sharing should be considered within areas of high demand, such as industrial centres. Through co-ordination and shared goals, multiple users can use load management systems to enable each other to decarbonise without needing major upgrades. During times of low supply users that do not have critical energy requirements could reduce their load to enable others to operate. This would ultimately reduce the required upgrades This approach will require all stakeholders to agree on scenarios and methodology but should be investigated to reduce the cost of infrastructure upgrade.

**Recommendations:**

- Large industry users should implement load management systems to respond to the networks supply vs load and work with the EDBs to prevent extreme peaking of demand.
- Shift daily processes to times of low load, such as night-time, to reduce the variation in demand on the network during a 24-hour period.
- Shift annual processes to summer where demand is less, and electricity is cheaper.
    - Engage with the market to understand what financial mechanisms can be put in place to incentivise this.
    - Enable more effective electricity storage and managing of dry year risk
- Areas with multiple industrial users should explore the possibility of capacity sharing to reduce the cost of infrastructure upgrades.

### 5.4.4 Renewable Energy Zones & Energy Clusters

Renewable Energy Zones (REZ) are a way of connecting multiple new renewable electricity generation and major electricity users to the electricity network and can quickly increase renewable energy supply and its use. The REZ concept can be particularly useful to encourage development of new generation into regions where currently, high connection costs or the first mover disadvantage could inhibit investment. REZs could enable access to this generation as the costs of connection can shared. Great South, Transpower and the EDBs could work together to encourage the development of a REZ within the region.

Renewable Energy Industrial Clusters (REC) are where electricity users are co-located with renewable generators. This enables the electricity users to take advantage of lower cost electricity due to decreased transmission costs.

Both REZ and REC provide benefits to regional development and/or decarbonisation in conjunction with efficient network investment. This approach helps build the economic cases for zone or cluster development.

**Recommendations:**

**Stakeholders should familiarise with REZ and REC concepts and become a conduit for communication and promotion of a REZ and REC within Southland Murihiku.**

### 5.4.5 Focused network upgrades and improvements

All stakeholders should focus on electrical infrastructure which delivers to this strategy.

Power Factor if poorly managed leads to greater system losses and voltage drop issues which impact on the power quality to all consumers. Similarly, harmonics cause power quality issues leading to overheating and increased losses.

Traditionally, supply networks across New Zealand have satisfactory power factor and harmonics levels, however over time there has been an increased need for the EDBs to enforce compensation or correction by the customers. This has been due to increased numbers of electric motors and heat pumps, and an increase in harmonics from variables speed drives, electronics and in future battery chargers.

**Recommendations:**

- Where prudent Great South, PowerNet and other **stakeholders should promote investment in new distribution and transmission infrastructure to support the acceleration and deployment of new renewables at multiple scales across the network.** This should be selective promotion of locations following analysis of all factors so that the upgrades do not promote generation or loads to be established in suboptimal locations which can be better served with REZ/REC or alternatives.
- All new loads should have power factor of 0.95pf or better.

- Harmonic voltages and currents introduced into the Network by appliances in an installation shall not exceed the levels specified in NZECP36 and AS/NZS 61000, part 3 series.

### 5.4.6 Consenting and Easements

Electricity transmission and distribution is principally achieved in two different ways. Via high voltage overhead lines interconnecting grid exit point substations and network substations, and via mixed medium voltage and low voltage overhead lines and underground cables between the network substations and the customer loads. Both overhead line and cables require legal easements for their routes. Substations also require consents or designations that allow the development of the utility buildings. Generally, district plans allow such consents and easements to be established. However, this is not always the case, and the process often requires the consents to be publicly notified which can lead to considerable delays and the possibility of objections preventing the development occurring. While the views of all parties and aspects need to be considered in a balanced and fair way the process can cause considerable delays or block the developments. District Plans must consider the needs of all residents and businesses and a useful methodology to establish utility locations which have a right to build infrastructure for the conveyance of energy. This is anticipated within the District Planning and Spatial Plan designations.

**Recommendations:**

- **Great South to work with Southland District Council, Gore District Council and Invercargill City Council, Transpower and the EDBs to include locations for REZ/REC, substations, and core transmission and distribution routes within the district plans and new spatial plans.**
- Great South to work with Transpower and the EDBs while negotiating Designations for utility locations.
- Climate change including sea level rise, flooding, earthquake, tsunami, and liquefaction impacts need to be carefully considered to ensure that infrastructure is located clear of all designated risk areas.

### 5.4.7 Behind the meter solutions

Behind the meter solutions present the opportunity for industrial users to become self-sufficient with their energy requirements by managing generation and usage, on-site without the need for enhanced grid support. A behind the meter solution is a generation or storage system, or both, to enable a load to continue operating without the grid, or during times of grid unavailability. Large industrial energy users should investigate their ability to generate and store energy on-site. This type of system for example, could be a solar or wind installation and battery or hydrogen storage system. Behind the meter solutions reduce the need for transmission and distribution upgrades, whilst creating firm supplies of electricity on site and could ultimately reduce overall cost of capital and avoid price uncertainty.

In addition, these systems could be installed at large or remote loads to supplement the existing weak supplies into the area. This can be cost effective and reduce the cost of capital investment compared to strengthening the existing distribution systems to handle increased load. An example is the Kingston/Garston area where the network is weak and would benefit from local generation and/or storage.

**Recommendations:**

- **Large, remote industrial energy users should investigate their ability to generate and store energy on-site.**

### 5.4.8 Transmission Pricing Methodologies (TPM)

The Transmission Pricing Methodology Review summarised that:

- Changes to the TPM are long overdue and should be implemented without delay.

- The Residual Charge masks the true cost of transmission and should be reduced to reflect the areas of benefit.
- The Price Cap should be removed as its existence means that consumers continue to pay for transmission assets that they do not receive any benefit from. [24]

The TPM reform was passed in 2022 and announced that "The Authority believes households and businesses should pay for the service they receive according to how much they are expected to benefit from it, so the new TPM is centred around a benefit-based charge." [25]

Particularly of benefit to industry in Southland Murihiku, EA said "Another key change in the new TPM is to address the current 'first mover disadvantage'. Under the new TPM, the transmission customer who first funds the capital cost of a connection asset (the first mover) only pays for what they need – not any extra capacity that Transpower decides to build – and so is on a level playing field with any second mover who connects later."

It was further added in EA's media release:

"The old approach was not fit for purpose, smearing transmission costs across the country and encouraging industrial consumers and regional distributors to invest in their own batteries or generation (including diesel generation) simply to avoid paying transmission charges. This meant other New Zealanders had to pay more."

This change in policy and action following Great South's letter should enable new generation to be built in Southland Murihiku and accelerate the electrification of industry. The reform is of great benefit to the Southland Murihiku region as it aims to resolve the long ongoing issue of Southland Murihiku overpaying for transmission assets built in the North Island. The new TPM aims to fairly charge users for what they use, rather than even distribution of transmission costs across the country regardless of actual benefit to the connected consumer or region.

In Great South's letter to Electricity Authority Submissions, it was stated:

'6. The financial effect of this investment, however, has added $220m to Transpower's revenue expectations, yet only 39% of this cost is paid by the upper North Island consumers, leaving the lower North Island and South Island consumers paying 61% for the grid investment in the Auckland area. The effect of this approach is that grid investment cost is socialised across consumers that do not receive any benefit from the investment.'[26]

In the context of TPM the advantages and disadvantages of having off-grid dedicated industry specific electricity generation are mentioned below.

<u>Advantages</u>

- The off-grid user pays the real cost of their energy system, rather than an estimated value calculated by the TPM.
- The off-grid user is isolated from market volatility and enables more accurate financial forecasting
- An off-grid system often involves a larger CAPEX investment and lower OPEX, which lowers future energy price risks to the user.

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[24] https://www.ea.govt.nz/development/work-programme/pricing-cost-allocation/transmission-pricing-review/

[25] https://www.ea.govt.nz/development/work-programme/pricing-cost-allocation/transmission-pricing-review/news/media-release-better-transmission-pricing-supports-our-low-emissions-future/

[26] Great South, Letter to Electricity Authority Submission. 30 Sept. 2019. Transmission Pricing Methodology Review: 2019 Issues Paper

Disadvantages

- Those remaining on the grid have less diversification which could see an increase in volatility, comparing base load to peak load, and potentially increasing electricity prices.
- The off-grid user often experiences decreased reliability and is unsupported if their system fails.
- Off-grid systems can be adversely impacted by local weather events.
- Off-grid systems generally do not have the surge and peak capacity that is available from grid supplies. These limitations can prevent industry from operating during abnormal events.
- If the off-grid user wishes to operate during periods of low generation, it needs to be able to provide its own alternative supply and this could incur an enormous cost to install a large battery or additional generation (overbuild).
- While an off-grid system may have lower OPEX there will be future periods where significant maintenance or age-based replacements and upgrades are required. This may require significant CAPEX within those years, particularly if load demand or technology has changed since the off-grid system was first installed.

### 5.4.9 Grid & Network Upgrade Regulations

The current security of supply regulations set by the Electricity Authority and financial regulatory constraints set by the Commerce Commission seek to optimise the reliability and cost of supply to all electrical consumers. While the regulatory combination in principle is good in that it looks at all options and prevents grid or network owners from taking financial advantage of their monopoly statuses, it can hamper new generation or demand investment as it causes uncertainly if capacity will be available and causes delays in providing the increased capacity. Costs to connect to network and/or costs to upgrades parts of network can take a long time to obtain.

Uncertainly and delays can disincentivise the choice of decarbonisation through electricity, and may lead to continued use of fossil fuels, or less than optimal temporary solutions while waiting on certainty of electricity supply capacity and cost. These issues are not resolved until the new connecting generation or demand make a commitment to pay a portion of any required grid or network upgrades, and then it takes months to years for the capacity to be designed, consented and built.

**Recommendations:**

- This is not only a Southland Murihiku issue and therefore changes to regulations nationally should be considered to allow **fast tracking of electricity grid and network upgrades** where they will enable decarbonisation to occur. This change will allow the ‘service provider’ to be the leader and take some of the risk rather than the ‘user’ being the upgrade initiator and taking all the risk. **Some degree of ‘build it and they will come’ should support more rapid decarbonisation.**
- Consideration should be given nationally by the Commerce Commission, Electricity Authority, Ministry of Business, Innovation and Employment and the collective Electricity Networks Association as to how to modify the regulated processes to enable potential major decarbonisation electricity users (converting from fossil fuels) and enablers (renewables generators) to have greater visibility and certainty to the availability and the price of energy. This will assist industry to make decisions on true merit and less hindered by delays such as obtaining electricity capacity.

## 5.5 Green Hydrogen

One of the strengths of green hydrogen as a future energy source is its versatility. The potential for green hydrogen to replace fossil fuels in several applications is being developed at pace on a global scale and the development of a global green hydrogen economy has significant potential for New Zealand and the Southern region. New Zealand’s most significant green hydrogen project, Southern Green Hydrogen (SGH), if it proceeds to construction, will be situated in the Southern region, and represents a very significant investment.

This investment is in not just the hydrogen manufacturing facility but also in a potential large scale green ammonia plant, HV power infrastructure, water treatment facility and port infrastructure. Even though the primary output being green ammonia will be destined for export, there is also potential for some of the green hydrogen produced by SGH to be utilised in a domestic setting such as for local Fuel Cell Electric Vehicles (FCEV's) or as a boiler fuel at industrial sites and the green ammonia could be used as a shipping fuel, or as an input to the manufacture of urea for the fertiliser industry.

### 5.5.1 Fuel Cell Electric Vehicles

The use of green hydrogen in fuel cells which in turn generate electricity is one the most promising applications of green hydrogen in New Zealand with FCEV's a potential alternative to Battery Electric Vehicles (BEV's), particularly in high utilisation application with a requirement for short recharge/refuelling time and where heavy payloads need to be transported. The heavy transport industry is actively implementing FCEV solutions with companies such as Hiringa Energy based in Taranaki rolling out several hydrogen refuelling stations over the next five years, with Invercargill, Queenstown and Dunedin part of this roll-out plan.

Other companies in the heavy transport industry including Invercargill-based HW Richardson Group are actively investing in hydrogen and have recently announced the rollout of dual fuel trucks as a precursor to FCEV technology. A network of hydrogen refuelling stations form part of their hydrogen strategy with the first scheduled to open in May 2023.

There are currently two types of FCEV domestic vehicles in New Zealand, the Toyota Mirai and the Hyundai Nexo, however the rapidly expanding BEV charging network and rapidly increasing selection of cost competitive BEVs in New Zealand suggest that FCEVs in domestic passenger applications will struggle to compete with BEV in the short term.

If we assume that 60% of heavy vehicles in Southland Murihiku switch to FCEVs, around 25 tonnes of hydrogen fuel per day will be required in 2050. If NZAS were to remain open, there may be an additional demand for hydrogen.

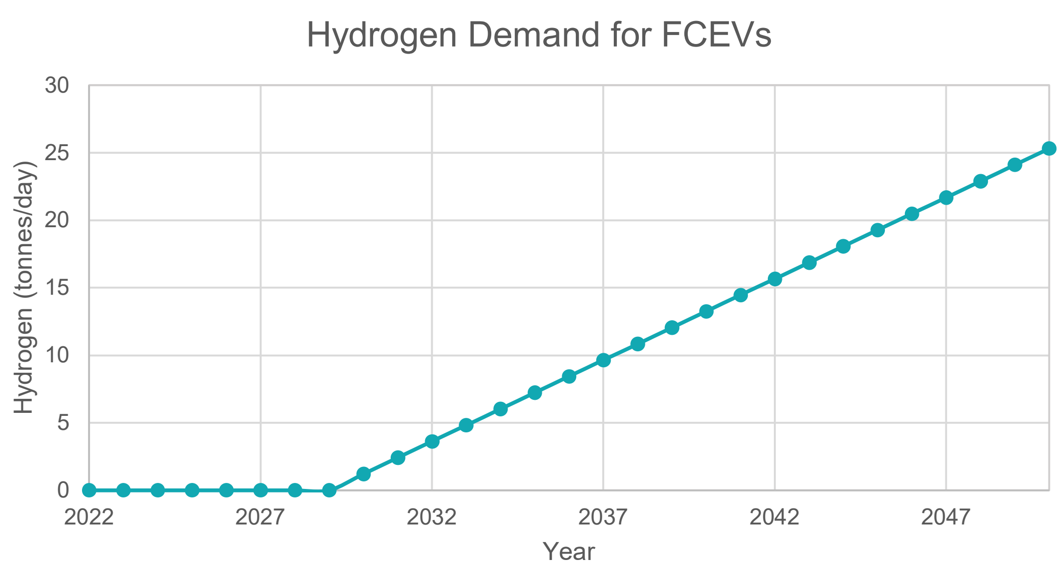


**Figure 5-5 Hydrogen demand for FCEVs**

**Recommendations:**

To help support the uptake of FCEVs in Southland Murihiku, we recommend the following:

- Advocate for incorporating hydrogen in national energy strategy
- Facilitate collaboration between the companies who are establishing hydrogen refuelling infrastructure and major heavy vehicle fleet owners.
- The climate commission should re-evaluate the role of hydrogen in decarbonising New Zealand given recent developments in the establishment of a global hydrogen industry.
- The New Zealand government should be urged to develop at pace an integrated green hydrogen strategic plan supported by robust standards and regulating framework.
- Adopt existing and tested international standards for the production, distribution, storage, and dispersing of hydrogen including for the use of fuel in the transport sector.
- Develop a green hydrogen certification standard or guarantee of origin.
- Hydrogen fuel cell battery systems should be considered as an option for load management and resilience.
- Consider the establishment of a national policy statement to streamline and standardise the consenting of hydrogen infrastructure.
- Encourage or incentivise transport related decarbonisation by supporting the roll-out of hydrogen fuelled heavy transport, rail, marine and aviation rail transport and light vehicles.
- Consider the allocation of a proportion of the government's Government Investment in Decarbonising Industry fund (GIDI) to assist with the hydrogen fuel transition.
- These initiatives should involve parties such as the New Zealand Hydrogen Council, MBIE, transport sector agencies, hydrogen producers, Standards NZ and EECA.

### 5.5.2 Industrial Applications

Industrial plants create process heat through the combustion of predominantly fossil fuels. To reduce the reliance on carbon emitting fuel, there is a move towards the use of biomass, electricity, and potentially green hydrogen. For industrial applications which require low to medium temperature heating, electric boilers/heat-pumps can be utilised but when higher grade heat is required, then an alternate to natural gas or coal is required. The replacement of coal fired boilers with biomass is underway exemplified by Fonterra who have already converted two of their sites in other regions to burn either wood chip/pellets or co-fire on wood biomass. An example of a potential application of hydrogen is that it could be blended with or ultimately replace the use of LPG which is a more viable solution for the North Island given its reticulated natural gas supply.

### 5.5.3 Grid Energy Storage Applications

If produced without emitting carbon, green hydrogen offers a much more energy-dense (kWh/kg) way of storing electricity compared to batteries or capacitors but has a very low volumetric density (kWh/L). This creates both benefit and difficulty when comparing hydrogen to other storage types. Storing a large quantity of hydrogen for use as a medium or long-term electricity source is challenging. If stored as a gas, it needs to be pressurised which in any significant quantity would mean very large pressure vessels. To store it in liquid form is expensive and technically challenging due to its very low liquification temperature (-253°C). Storing hydrogen in depleted gas fields or in salt caverns is also being investigated but requires the correct geological formation. If hydrogen could be stored in any significant quantity it could then be converted into electricity using a gas turbine however in the Southland Murihiku context, the use of a hydrogen derivative such as green ammonia as an energy source may be more applicable. [27]

Hydrogen storage is an emerging energy solution however there are still several boundaries to overcome before it can be seen as a commercially viable primary energy solution, particularly long-term storage of hydrogen or its derivates. However, if a hydrogen economy is to develop in New Zealand, then all opportunities to utilise hydrogen as a fuel source to provide dry-year and firming solutions should be considered as the technology matures.

**Recommendation:**

- Monitor the development of hydrogen storage technologies and in particular the use of its derivatives such as green ammonia and in the event of a potentially viable solution becoming available, investigate it as an option for the Southland Murihiku context.

## 5.6 Biogas

A high-level review of the existing biogas production in Southland Murihiku reveals 300 TJ/year being available. This is outlined in Table 3 below.

| Site | Type of Production | Current Use of Biogas | Annual Production |
|---|---|---|---|
| **Clifton WWTP** | Municipal WWTP | Onsite heat | 20 TJ/year |
| **Blue Sky Meats** | Meat works onsite WWTP | Flared | 10 TJ/year |
| **Alliance Lorneville** | Meat works onsite WWTP | Not captured or utilised | 200 TJ/year |
| **South Pacific Meats** | Meat works onsite WWTP | Onsite heat | 80 TJ/year |

**Table 3 Existing biogas production in Southland Murihiku**

Southland Murihiku has many opportunities to expand biogas production. A new municipal food water digestion plant has the potential to generate up to 60 TJs per year. Around 100 TJs of landfill gas may be able to be recovered from AB Lime landfill (gas is currently flared, with a portion used in a nearby lime kiln).

If onsite energy use is not feasible and reticulation is not viable, biogas/biomethane can be used to generate electricity and exported or upgraded to renewable liquified natural gas (LNG) for transport fuel e.g., at a landfill, fuelling rubbish trucks. This would have to be considered against other potential future transport fuels e.g., hydrogen and electricity.

From 2027, biogas to rLPG (renewable LPG) processing may prove commercially viable and present a low-capital cost option for current LPG users. The current LPG demand in Southland Murihiku is 310 TJs, of which 100 TJs is demand from NZAS. Therefore, based on these estimates, the current production could therefore replace almost all of Southland Murihiku's LPG usage. If NZAS closes, there will be additional available biogas which could be supplied to other users. It is also worth noting that LPG represents only a relatively small portion of the total fossil fuel used for process heat at NZAS. When considering what role rLPG could play in helping decarbonise these processes, the highest temperature applications should get the first priority as they are the hardest to abate.

[27] Mohammad Alhuyi Nazari, Morteza Fahim Alavi, Mohamed Salem, Mamdouh El Haj Assad, Utilization of hydrogen in gas turbines: a comprehensive review, International Journal of Low-Carbon Technologies, Volume 17, 2022, Pages 513–519, https://doi.org/10.1093/ijlct/ctac025

Centralised biogas upgrading plant versus containerised upgrading plants on each site would depend on the economic analysis and consideration of gas users in the Southland Murihiku region. Creating a small, reticulated network with some users connected to this could be feasible based on location, otherwise virtual pipelines (i.e., LNG production and transportation) should be considered. Incentives may be required to encourage biogas producers to provide gas into a network rather than for onsite use or flaring. Onsite biogas consumption (i.e., for heating) should also be considered. For meat works, onsite biogas can help offset approximately half of the site's energy demand. For WWTPs, this can be much higher.

Methane recovery on dairy farms in Southland Murihiku should be considered. Regulatory change may support multiple farms collaborating to install in-pond anaerobic bio digestion systems incorporating spark ignition generators and heat recovery systems. Consideration should also be given towards installing primary solids collection and anaerobic digestion plants on metropolitan waste ponds in areas such as Te Anau as Gore.

**Recommendations:**

To understand the full potential for biogenic methane in Southland Murihiku, the following is recommended:

- A more detailed review to quantify possible sources and users of biogas/renewable natural gas
- Identify best use cases/hard to abate applications - onsite heat generation, upgrading to drop-in fuel for residential/commercial markets, transport fuel, a replacement for LPG as a cooking fuel, electricity generation and export.

## 5.7 Biomass

Biomass has a transitional role to play in energy transition by allowing existing coal-fired boilers to be switched to wood-fired. In the long-term, once all the combustion-based assets have reached end of life, many of these boilers may be replaced by electrode boilers if the cost of electricity is sufficiently low, or high temperature heat pumps may have improved so much that these are able to be used to heat at temperatures above 100$^{o}$C. This would reduce the demand of biomass. However, it is likely that there will always be a mixture of biomass, electrode and high temperature heat pumps and the split will be driven by market forces. Government investment in forest floor recovery and favourable Government policies are required to increase wood processing and biomass fuel use within New Zealand. Based on declared demand it appears that the demand for woody biomass fuels will increase from 196,000mt 2023 to 500,000mt by 2030.

One of the issues with security of supply, is that forest harvests vary greatly from year to year due to the age structure of the forests and the prevailing market conditions when trees are mature. Some years may have large surpluses of forest and sawmill residues and other years availability may be very low. Any surplus residues left in the forest in good years will decompose over a period of years. To smooth out the annual supply of residues, surplus biomass energy from good years would need to be stored in a way to prevent decomposing, degrading and/or spontaneously combusting. The most practical storage solution is to make steam exploded black pellets or torrefied wood pellets as these can be stored outside and do not decompose, degrade or spontaneously combust. Alternatively, biomass could be stored in very low oxygen environments, e.g., large vats under vacuum or purged with nitrogen, although this may not be practical nor economical. This 'biomass battery' can provide a buffer between years of good and bad harvests and should reduce the risk of making long term supply agreements with the prospective forest owner / aggregator.

Best value from the whole tree (from plantation forestry) can be extracted by increasing sawmilling capacity in New Zealand. The sawn lumber (and any other post-processing product such as cross-laminated timber or glue laminated timber) is utilised in buildings (sequestering carbon for a long period). Residues generated from the sawmill (e.g., sawdust and shavings etc.) can be used to make wood pellets. The sawmill process also produces wood chips which can be used in the pulping process or can be used for energy. Government is working with industry and regulatory authorities to update building standards to allow and promote greater use of mass timber. This will lead to the opportunity to develop more sawmilling capacity in New Zealand. Increased wood processing in Southland Murihiku would enable more residues to be available for biomass or the production of biomass.

Biomass supply in Southland Murihiku could be increased by short rotation forestry, however the viability of this is unknown at this stage. We recommend that the local industry work closely with the forest owners, Southern Wood Council and with government research organisations such as Scion to understand the viability of this in the Southland Murihiku context. Even if this option was to be progressed, the turnaround time on these plantations could be in the order of 7-10 years so this resource would not be ready in time to meet the forecast biomass demand by 2030.

### 5.7.1 Wood Pellets

Producing wood pellets (white wood pellets, steam exploded black pellets, or torrefied wood pellets) using wood residues not only enables storage of surplus biomass energy, but it is also one of the best ways to increase energy density of biofuel feedstocks. White wood pellet production is very common all over the world, whereas steam exploded black pellet and torrefied pellet technologies (commercial scale) are progressing towards commercialisation. Wood feedstocks can also be used to produce biocrude using pyrolysis / hydrothermal liquefaction, but there are currently no commercially successful operations. Steam exploded (SE) black wood pellets solve many of the problems of white pellets. Most notably, they can be stored uncovered which reduces the cost and complexity of supply chains as well as on-site storage, handling and use. They also have similar heating value and grindability as sub-bituminous coal which makes them a much more suitable drop-in replacement for existing coal-fired boilers.

There may be an opportunity to grow wood pellet production in Southland Murihiku close to forests and wood processors, particularly given the forecast demand in the region. It is expected white wood pellet manufacture would be the most viable option for Southland Murihiku. Since one of the key benefits of SE black pellets is eliminating the need for covered storage, their most beneficial use case is geared more towards biomass export. Therefore, given that Southland Murihiku is predicted to be a net importer of biomass by the 2030's, consideration should be given to the potential cost benefits of importing SE black pellets versus other forms of biomass.

### 5.7.2 Should industry own its own biomass supply?

Industrial users owning and managing their own biomass energy supply may only work for large energy users because of the costs involved in the ownership and management of production and supply chain. This concept will ensure security of supply of biomass energy provided it works financially. The advantages of forest owners, processors and possibly users uniting to create a single market platform for the production, processing, and distribution of standard quality biomass are security of supply, possibility of long-term supply contracts which will create sustainable employment opportunities. It will also encourage more investment over a longer period. This concept could also result in changes to harvesting methods, skid site locations and residues recovery to meet the needs of the users of biomass. Government support will be required to initially create a single market platform on a trial basis.

#### Recommendations:

To prepare for the potential large increase in demand by 2032 (or earlier), we recommend the following actions:

- Advocate for favourable Government policies to increase wood processing within New Zealand. Changes in building standards to promote the use of mass timber in multi-storied (medium) structures will also encourage increased wood processing in New Zealand and help with the reduction in logs being exported. Government policy support is also required to improve forest residue recovery. Refer to the Forestry and Wood Processing Industry Transformation Plan[28].

- Recommend establishing the Wood Energy South Advisory Group to plan and drive wood biomass development and a stable, reliable supply chain for biomass in Southern New Zealand.
- Consideration should be given to the collection and utilisation of construction and demolition waste/resource (dry timber) within Southland. A study should be conducted to determine the feasibility of large process heat users using construction and demolition waste/resource as a biofuel to reduce demand on clean wood and allow clean wood resources to be available for higher value products.
- Investigate what kinds of market structures could incentivise the production and storage of biomass energy when there is surplus supply.
- A feasibility study should be undertaken for more domestic wood processing (sawmills) in Southland to produce wood residues that would otherwise be exported.
- Incentivise investment in increased forest floor recovery is important and will reduce costs for potential users of biomass. The wood / biomass recovery from the forest floor can be done most effectively at the time of forest harvesting when the equipment is already there. More work (and potentially pilots) should be done to understand the opportunity for forest floor recovery.
- Steam exploded black pellets could be an option to reduce capital cost of conversions once supply becomes established. Great South should keep abreast of any developments in New Zealand and consider the potential differences this would make in terms of infrastructure investment in the biomass supply chain.
- Investigate a formal collaboration with a government research organisation such as Scion to investigate the opportunities for short rotation forestry.
- Develop a plan for improving the efficiency of transporting bulk biomass including the relative costs and benefits of coastal shipping, rail and road transport. Government policy support will enable increased availability in Southland.
- Investigate the establishment of a wood energy market that provides users with a reliable quality supply of biomass and long-term price certainty.
- Investigate effective bulk biomass handling rail side to enable traditional fossil fuel supply nodes to be transitioned to biomass processing supply points. An example could be the establishment of new biomass processing and loading facilities in the Ohai area which could be implemented as coal mining is phased out. Likewise, specialist rail offloading infrastructure could be built at Edendale or other strategic locations to support the efficient use of biomass to assist in the decarbonisation of hard to abate, large-scale sites such as the Fonterra site at Edendale. Such an approach would reduce roading impacts, improve safety and drive rail efficiency.
- Investigate the feasibility of several smaller white wood pellet plants throughout Southland Murihiku close to wood processing facilities.
- The entire biomass value chain needs to be optimised. Work with industry to understand what opportunities and risks exist. This should cover infrastructure, transport, recovery of residues and workforce development.

## 5.8 Waste to Energy

Waste to Energy is normally used as a term to describe the thermal combustion of waste materials to generate heat and/ or power. The fuels used can vary from waste timber from construction and demolition through to

[28] https://www.mpi.govt.nz/forestry/forest-industry-and-workforce/forestry-and-wood-processing-industry-transformation-plan/

municipal solid waste (residual waste collected from households). Neither of these technologies are likely to be useful in the context of the Southland Murihiku Regional Energy Strategy as explained below.

### 5.8.1 Waste Timber

Waste timber is a low carbon fuel as it is considered carbon neutral by virtue of the carbon it absorbed as the timber grew. However due to the chemical treatments applied to preserve timber for construction use its combustion must be carefully controlled and have appropriate flue gas emissions control built into the technology. This increases the capital cost of the combustion equipment and there is unlikely to be sufficient waste timber within the Southland region to invest in a plant of this nature.

### 5.8.2 Municipal Waste to Energy

Municipal waste to energy is a common technology deployed overseas as the availability of land for landfills decreases and drivers to divert waste from landfill through landfill taxes or legislation are adopted. It is seen as partly renewable as the organic content (from food waste and paper/card etc) in a standard household waste stream in a developed nation is approximately 60-70%. This is generally higher than the renewable level of most nations' electricity grid and is therefore seen as better than new fossil fuel generation.

In a New Zealand context, the electricity grid is already more renewable than the above biogenic content. Currently, a proposal to require dedicated collection of organics from households and businesses is included as part of the new Aotearoa Waste Strategy[29] (draft) and Transforming Recycling[30] consultation. This would further reduce the biogenic content of this stream decreasing the attractiveness of this option with respect to a net zero future even further.

## 5.9 Heat Pumps and Thermal Storage

### 5.9.1 Industrial Applications

Use of high temperature (90-95°C hot water) heat pumps will likely play a major role in displacing fossil fuel burn. Combined with sufficient heat storage capacity, this technology will very likely be a mainstay of near-term energy efficiency projects. Longer term the use of ultra-high temperature heat pumps (greater than 100°C) may be able to replace the use of some low-pressure steam or pressurised hot water systems currently using fossil fuel. This includes both chemical absorption and thermo-mechanical heat pumps.

The opportunity to utilise heat pumps on an individual site will be determined by the quantity and quality (temperature) of waste heat that can be harvested. Sites that have both heating and cooling loads (i.e., boilers and refrigeration plants) have the greatest opportunity to utilise heat pumps. Another consideration is the relative timing of these loads. If the requirement for heat does not align with when waste heat is available, thermal storage is required to capture that heat for use later. This is particularly a challenge for smaller sites who run batch processes. On these sites, the capital investment required to install the required thermal storage may not have sufficient payback to justify the investment. This is where government financial support could help to increase the uptake of these technologies which will reduce carbon emissions and the overall load on the grid longer term.

When looking at locations for new sites, consideration should be given to co-locating industries which have waste heat and a need for heat. For example, taking waste heat from a datacentre and using it to pre-heat boiler feedwater in a food and beverage production facility.

[29] https://environment.govt.nz/what-government-is-doing/areas-of-work/waste/waste-legislation-review/

[30] https://environment.govt.nz/what-government-is-doing/areas-of-work/waste/transforming-recycling/

**Recommendations:**

- Support businesses in connecting to central government agencies and supplier who can support with developing the information required to apply for funding for energy efficiency projects.
- Ensure businesses are aware of the best technical practice in the application of heat pumps to ensure successful project outcomes with respect to efficiency and cost-effectiveness. The Australian Meat Processors Corporation (AMPC) Refrigeration Energy Efficiency Opportunities New Technology Guide is a good resource[31].

### 5.9.2 Building Applications

Heat pumps are increasingly viable in cold climates but are currently limited by the quality of heat produced. This precludes them from being used in many building retrofits (unless the entire heating system is being replaced). Technology is advancing (and is seeing a significant shift in the EU) which will likely deliver simpler centralised heat pump options for heating hot water and domestic hot water in existing buildings (for domestic dwellings in particular).

An enabler of heat pump technology on existing buildings is better management of building energy demands. Building performance reporting, analytics, AI controls and smart building technologies are becoming much more accessible and can significantly improve building peak demands (including heating) and overall energy consumption. For example, Beca's B-Tune service typically achieves commercial building energy reduction in the order of 20% through changes to building operational controls, without any capital works upgrade. However, low capital, high payback investments are often not pursued - reporting that creates a behavioural change could be supported through a digital platform.

The use of thermal storage (which holds a buffer of heating energy) could also significantly reduce peak loads and enable conversion to heat pumps (or other low carbon technologies) as well as reducing grid peak energy demands.

There are also emerging technologies such as sand battery[32] heat storage which can be used to absorb excess renewable electricity generation and later release the energy into heat processes or buildings.

For residential buildings, improving airtightness, increasing insulation levels, retrofitting double glazing and providing mechanical heat recovery ventilation can significantly reduce energy consumption and enable low carbon technologies such as heat pump heating. Designing for passive heating from the sun can also reduce (or eliminate) the need for heating in buildings. This passive approach to building design can introduce significant costs (especially in NZ where the market and supply chain are not well established).

Onsite renewables are becoming the cheapest form of energy unless significant battery storage requirements are needed to match building loads. Electric vehicle "Vehicle to Grid" V2G technology is becoming more common and will enable the grid to leverage battery storage within vehicles if they are connected.

**Recommendations:**

- Provide a platform for sharing building performance information that can act as a league table and give Southland businesses a forum for showing their commitments to reducing carbon.
- Support/enable thermal storage or district heating schemes which can accelerate the decarbonisation of buildings that require higher heating hot water temperatures.

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[31] https://www.ampc.com.au/getmedia/355b92a9-eaba-4c1b-ba5c-ea27704e68/HANDBOOK_New_Technology.pdf?ext=.pdf

[32] https://polarnightenergy.fi/sand-battery

- Provide advice and support for residential buildings wishing to design/upgrade building envelopes and pursue greater passive design performance.
- Unlock solar potential with co-funding, simplified consenting, and incentivise the provision of V2G connection (when/if available).

## 5.10 Building Standards

The Government's "Building for Climate Change " (BfCC) programme is tasked with setting new NZ Building Code (NZBC) requirements that align with NZ's decarbonisation commitments in the Paris Agreement. BfCC's "Transforming Operational Efficiency" framework sets out a pathway to building operational carbon reduction with an initial cap of 180kWh/m² reducing to 45kWh/m² by 2035 (75% reduction). This will also include a ban on fossil fuel use in buildings from 2035. This applies to all building typologies but will only be applied to new construction. Most operational emissions in Southland Murihiku will come from existing buildings and the BfCC programme is looking to introduce retrofitting requirements for existing buildings but have not proposed any mechanisms to date.

As part of New Zealand's Emissions Reduction Plan (ERP), Government is proposing to introduce mandatory reporting or building energy performance. As seen in other jurisdictions (e.g. NSW), the introduction of mandatory reporting for commercial buildings (NABERS) has resulted in an average energy saving of 42% over the past 14 years. This is purely market driven and we would anticipate similar levels of performance across building typologies if the right incentives/reporting mandates were introduced. Whilst housing related transactions are less likely to consider energy efficiency, EECA's "Warmer Kiwi Homes" grant programme is to be expanded under the ERP and minimum performance requirements for tenanted properties will improve energy efficiency and building performance expectations.

Changes to Building Code, and creating mechanisms to capture existing buildings, will take time. In the interim, the Government's "Carbon Neutral Government Programme" requires Government Agencies to lead the change by reducing carbon emissions across their operations (including building efficiency). Local Government are recommended to align but not required under the Act.

Market-driven sustainability frameworks for building design such as GreenStar and Homestar also drive operational carbon reductions. Green Star rated buildings typically achieve a 50% improvement over building code (pre 2022 updates to NZBC) and this framework has been mandated by NZ Government Procurement for all new non-residential buildings developed/owned by agencies.

The Southland Warm Homes Trust in partnership with EECA and local, Southland Electric Power Supply Trust, local councils and funding organisations is a leading example of an effective energy efficiency organisation which has to date insulated and/or upgraded 10,000 homes in Southland. For further information on the trust, see Appendix B.

**Recommendations:**

To further encourage sustainable buildings, the following actions are recommended:

- Incentivise / mandate energy efficiency performance disclosure for non-residential buildings.
- Align publicly funded buildings with proposals within the BfCC programme to help establish competency and supply chain experience in the region.
- Align Southland Local Government Assets with the Carbon Neutral Government Programme to advance energy efficiency within both existing and new buildings.
- Introduce development incentives for buildings that are rated Homestar, GreenStar or other equivalent rating frameworks.

- Continue support for the Southland Warm Homes Trust to upgrade the energy efficiency of homes in Southland.
- Encourage the requirement of an energy plan to accompany building consents in specific parts of the market.

## 5.11 Planning and Consenting

The Government is currently progressing work to repeal and replace the Resource Management Act (RMA) with three new pieces of legislation. The Natural and Built Environment Bill and the Spatial Planning Bill were introduced on 15 November 2022 and the Climate Change Adaptation Act will follow in 2023. The new legislative framework requires the preparation of a Natural and Built Environment Plan (NBE) and a Regional Spatial Strategy (RSS) for the region. The national planning framework is expected to provide direction for renewable electricity generation including incorporating and strengthening existing national policy for renewable electricity generation. The anticipated future framework is set out in Figure 5-6 below.

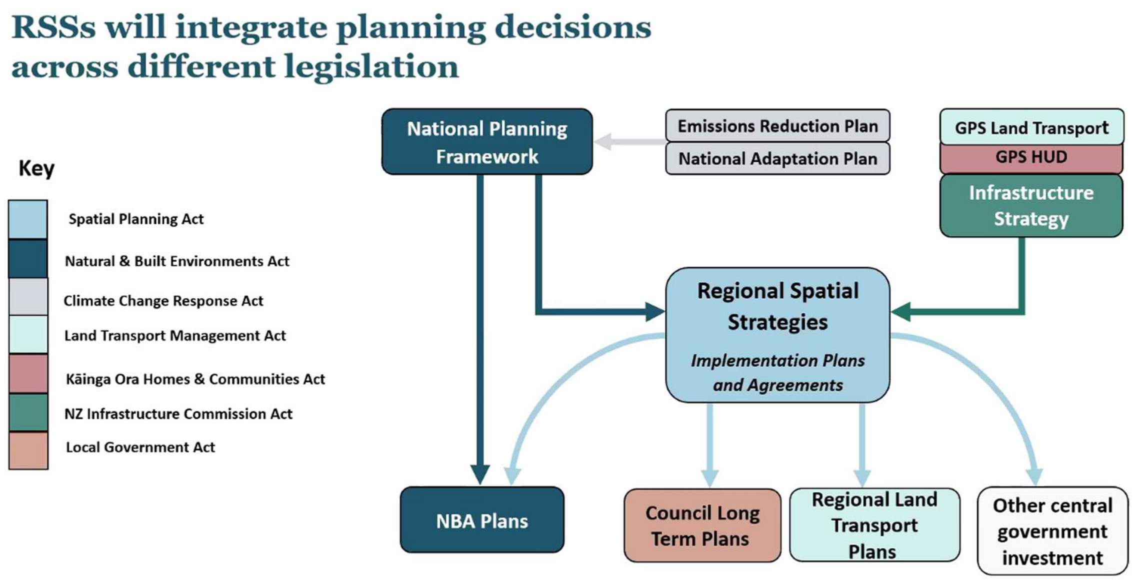


Figure 5-6 - Anticipated future planning framework that will replace the RMA

The NBA and RSS plans will respond to local considerations including managing pressure on resources and enabling positive outcomes for the region. The mapping of opportunities and constraints can assist with the development of the plans. The regional planning committee will be responsible for the development of these documents.

The Government has set five objectives for the new resource management system. One of these objectives is to better prepare for adapting to climate change and risks from natural hazards and better mitigate the emissions. It is therefore expected that a much greater emphasis will be placed on considering climate change risks to new infrastructure investment. Regardless of the planning framework in place, recent flooding events in the North Island demonstrate the importance of carefully considering climate change risks in the planning of energy infrastructure and systems.

It will be several years before the new plans are in place and the existing planning regime will apply in the interim. The existing regime provides pathways for consenting, providing different levels of involvement by the councils, iwi and the community.

Understanding upcoming projects and where and when these will occur will enable the councils to plan for their approvals process, communicate with communities and inform the development of planning documents that manage outcomes for the region.

In Southland Murihiku, Te Ao Mārama Inc. represents the interests of iwi in RMA consenting matters and offers a cultural perspective, liaises with iwi and comprises representatives of local rūnaka in the context of the consent processes.

**Recommendations:**

- Establish a consenting taskforce that will provide consenting expertise to regional leadership entity. The taskforce should include representation from Murihiku four Papatipu Rūnaka. The taskforce should investigate opportunities for streamlining regulatory processes through:
  - staff capacity building and capability
  - coordinated pre-application discussions with developers.
  - joint district and regional consenting for projects
  - exploring consenting pathways with developers (e.g., fast-track, direct referral)
  - review existing district and regional plans to strengthen alignment with National Policy Statement for Renewable Electricity Generation and support the implementation of the clean energy vision.
- Identify a streamline processing team with relevant expertise that can be called on for complex applications. This team could be bolstered with consultants as workload increases.
- Track the development of legislation to understand impact for the region and provide feedback on consultation drafts and bills when available. For example, the NBA Bill is currently open for comment.
- Regular engagement with industry to understand the pipeline of projects and potential approval barriers. Investigate options for formalising this engagement.
- More detailed mapping of energy areas/projects that can feed into the Regional Spatial Strategy.
- Plan for transition to Natural and Build Environment Plan and Regional Spatial Strategy.
- Consider climate adaptation risks in planning decisions to ensure resilience of future infrastructure.

## 5.12 Rakiura Stewart Island and Piopiotahi Milford Sound

### 5.12.1 Rakiura Stewart Island

**The current situation on Raikura Stewart Island is not sustainable economically or environmentally.** Additionally, it will not be meeting the expectations of tourism visitors who are increasingly aware of the impacts they and the services they expect have on the environment.

There have been reports conducted looking at Rakiura Stewart Island's energy challenge which have explored an undersea cable, on-shore wind, off-shore wind, utility solar, hydro and storage solutions. Such reports have indicated environmental consenting challenges and found that a single energy source does not provide an adequate solution, and that unifying Rakiura Stewart Island's network with the mainland would offer a real, albeit expensive solution. Past attempts to advance proposals and consent renewable energy sources on Rakiura Stewart Island have failed, generally due to environmental concerns as the current consenting process is not sensitive to the unique aspects of the island. It is stifling the environmental improvement of the electricity supplies.

Rakiura Stewart Island has specific challenges due to the environment, the size of the network and limited number of users. This reduces the diversity of supply and demand and increases the volatility within the network. Current price to consumers is approximately 2.5 times that on mainland NZ and is expected to rise further due to diesel prices. Completely decarbonising Rakiura Stewart Island is therefore expensive and difficult to achieve, and as such the first stage should be to build one, or ideally several renewable energy sources that are supported with back-up diesel generators.

Since the Stewart Island Future Power Supply Report of 2016, the cost of solar has fallen significantly and presents the opportunity for behind the meter generation to offset the demand on the electricity grid. In recent years this approach has become cost effective on the mainland, and with electricity prices being around three times more expensive on Rakiura Stewart Island, this option could be financially viable despite lower irradiance levels and lower solar output.

Rakiura Stewart Island should first explore the opportunities to reduce their overall diesel demand, reduce carbon emissions and reliance on global commodity prices. **Distributed solar should be explored to offset demand.** If approximately half the customers were to install 21m$^2$ of rooftop PV, then savings in excess of 33,000L of diesel per year could be made. **An actionable solution that would heavily reduce the reliance on diesel would be to install a mixed renewable energy supply with an interim level of storage, whilst keeping the diesel generators as backup to supply energy during long periods of low generation.**

Sea transport, like land transport is predicting a change from fossil fuels to electricity and hydrogen. For Rakiura Stewart Island this means the renewables should be sized so that excess energy not used on the island can be used to charge boats or produce hydrogen.

**Recommendations:**

- Explore opportunities to reduce and eventually eliminate diesel use on the island. This will reduce carbon emissions and lessen the effect of global supply chain and commodity price fluctuations on the island's energy requirements.
- Install distributed solar to off-set demand.
- Ease the consenting challenges as the current process, while addressing environmental concerns, is stifling environmental improvement.
- Install a mixed renewable energy supply, wind and solar, with a level of storage (battery or hydrogen), whilst initially keeping the diesel generators as back up, to supply energy during long periods of low generation.
- The co-fuelling of the existing generators with hydrogen should also be investigated.
- SIESA to consider facilitation of bulk solar installations on buildings and residences so that efficiencies in equipment transport and installation can be achieved.

### 5.12.2 Piopiotahi Milford Sound

The increase in demand for decarbonisation of transport and electricity generation as well as visitor expectations, would suggest that **significant effort should be made to plan a robust pathway for renewable energy generation to meet existing and future demands at Piopiotahi Milford Sound.** Sea level impacts will influence the location of infrastructure in this area.

This report doesn't investigate specific options as this work needs to be a collaborative exercise with the current infrastructure operators, local stakeholders and should be considered as part of the Government funded Milford Opportunities program which is charged with investigating the future planning and investment pathway for Piopiotahi Milford Sound. However, it is noted that batteries and hydrogen production and storage are being considered as part of creating a resilience and peak load management system. Hydrogen fueled buses to and from Piopiotahi Milford Sound are also being considered.

**Recommendations:**

- Continue to explore opportunities to introduce an alternative base supply to support the hydro and a peaking system to manage the 480kW peak load.
- Explore variable electricity pricing strategies to discourage peak loading.

## 5.13 New Zealand Aluminium Smelter at Tiwai Point (NZAS) and Southern Green Hydrogen (SGH)

### 5.13.1 Continuation of NZAS

Should NZAS continue to operate, then there will likely be a need to:

- Negotiate a long-term power supply contract (negotiations are ongoing).
- Consider flexible demand with corresponding price flexibility.
- Have a commitment to reducing emissions from the site. It is worth noting that Rio Tinto, in partnership with Alcoa, are developing a carbon anode free smelting technology called Elysis[33]. If this technology is successfully commercialised, the NZAS site could potentially be redeveloped to utilise this technology. Given the 100% renewable electricity source the site benefits from, this (along with eliminating fossil fuel use) would present an opportunity for the site to achieve net zero emissions.
- Have a commitment to environmental clean-up on the site. NZAS have reached agreement with Murihiku Rūnaka and Te Rūnanga o Ngāi Tahu to work together to monitor and remediate the site, regardless of the future of NZAS beyond 2024.[34]
- Based on public statements It is likely that the NZAS's Tiwai smelter will remain operating beyond the stated closure date and therefore an additional energy modelling scenario could be considered that contemplates that Tiwai remains operating and that the Southern Green Hydrogen (SGH) project does not proceed. This has not been modelled, and it is recommended that the further modelling should occur when the position on the Smelter's future and SGL development is known.
- There is an expectation that if the smelter continues to on its excellent record of reducing its process and electricity related emissions and be a positive contributor to the Net Zero Southland emissions reduction targets.

### 5.13.2 Closure of NZAS

Tiwai is a significant load on the regional electricity supply system, however the presence of the load also creates some advantages. The generation supplying Tiwai i.e., predominantly Manapouri, supplies the load while also providing voltage control and inertia to be able to handle slow and rapid system changes and/or disturbances e.g., daily load cycles, lightning strikes, system faults, etc.

Transpower's planning report addresses the closure of the smelter and concludes an excess of renewable generation will be seen in the lower South Island. [35] The report predicts this excess generation will be used for future development such as:

- Datagrid & Meridian's hyperscale data centre in Invercargill
- Meridian's potential green hydrogen facility

However, this will not be entirely sufficient, and any remaining surplus renewable generation will need to be transmitted to other regions of New Zealand. It is therefore likely an upgrade is needed for the HVDC link, and the North Island grid to further enable the flow of this renewable energy to the load.

NZAS's closure may result in light load challenges, which Transpower have investigated and determined a likely optimum solution being a combination of circuit switching, grid investment and reactive power support from generation.

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33 https://www.elysis.com/en

34 https://www.nzas.co.nz/files/3885_2023020874746-1675795666.pdf

35 https://www.transpower.co.nz/resources?keywords=transmission+planning+report

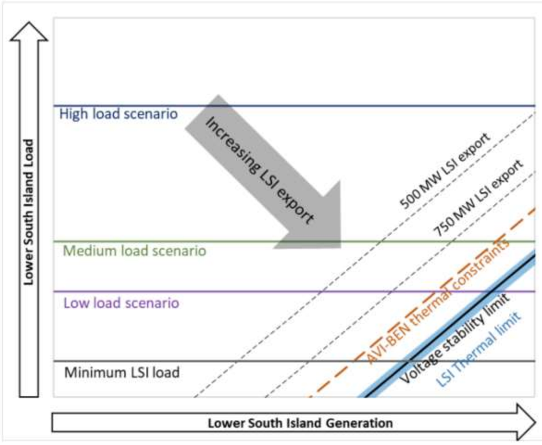


Figure 5-7 Graph showing load scenarios and associated limits

High voltages will also occur overnight in the Lower South Island if NZAS closes and is not replaced by a similar industrial load. Transpower have conducted studies and concluded that switching out lightly loaded transmission circuits (while maintaining N-1 security to load and generation) and installation of a new 50 Mvar reactor in the Lower South Island area will assist in managing the issue. There are ongoing studies investigating potential transient stability issues associated with high export from the Lower South Island region following the possible closure of NZAS.

Less generation will be required to remain online overnight to supply load if NZAS were to close. This particularly affects the Lower South Island, and some generators will need to be on-line to assist with holding down the voltage.

**Recommendation:**

- Complete studies investigating potential transient stability issues associated with high export from the Lower South Island region following the possible closure of NZAS.

### 5.13.3 Possible transition to Southern Green Hydrogen (SGH)

The phasing of transition between NZAS closing and SGH opening is an important time for all stakeholders. Either end of the possible options are two difficult scenarios of both facilities either being online or offline. In either case the network must handle an energy imbalance of over-load or over-generation. The most ideal outcome would be a smooth transition between SGH starting up and NZAS closing, which would not cause a large change in demand on the network. This is unlikely to be an entirely smooth transition and instead should be a series of steps. With each step having some aspect of SGH starting up and some aspect of NZAS closing. This plan should be agreed with Transpower, PowerNet and publicised to network users to ensure all stakeholders are informed and prepared for each stage.

As much existing infrastructure from NZAS should be used for SGH's connection to avoid wasting assets and to reduce the overall cost of SGH. This is mutually beneficial for all parties involved to avoid commissioning or de-commissioning expenses.

**Recommendations:**

- If NZAS is to close, Southland Murihiku should work to facilitate a smooth, stepped transition between NZAS closing and Southern Green Hydrogen coming online.
- If NZAS stays, Southland Murihiku should work to ensure that new generation is developed in the region to ensure that the network is not constraint by the increased demand

- Either Scenario should be agreed with Transpower, PowerNet and publicised to network users to ensure all stakeholders are informed and prepared for each stage.
- As much existing infrastructure from NZAS should be used for SGH's connection to avoid wasting assets and to reduce the overall cost of SGH.

## 5.14 Public Engagement

A community-wide education program can help facilitate meaningful community engagement. Education programs serve multiple functions, first to help counteract negative impressions and preconceptions of renewable energies, second to empower local communities and third to foster engagement. Having this program led by knowledgeable individuals from within the community can help mitigate against defensive localism and widespread resistance from local communities, as research shows local leadership is a key factor in transitioning economies. Collectively, the public, or communities are comprised of local actors creating a shared narrative. To guide transitions, this narrative should include case studies of successful implementations of energy transitions. **Successful transitions can influence views and should be included as an education tool** as the public can be easily side-tracked by perceived inadequacies in renewable energy systems. It is critical for the public to understand the effects of energy scarcity, whether that is machinery not working, the lights going out, or when disruptions to current energy supplies upset the balance of supply and demand leading to spikes in energy prices.

This is where an education program led by trusted locals can help change attitudes and guide members of the community from a position of uncertainty to one of advocacy for the acceptance of renewables. Engagement and education can further shift the narrative from one of "these fancy new technologies will not work for me" to one of "these new technologies open up new possibilities as the old technologies cease availability." A critical aspect of gaining public and community acceptance is to illustrate how business as usual will be unable to operate at some point in the future. Fuel supplies and fossil fuels for value-added exports will increasingly face market competition and consumer demand for change. People will be influenced by economic incentives, so it is recommended that an economic assessment of the energy sector changes, and new investment (including new generation) is required to support public engagement.

Presenting the transition to renewable energy as an opportunity, rather than a challenge to be overcome, can also guide and inform community acceptance. People and their communities are going to need electricity as it represents an essential service. Power must be reliable, it must available and affordable. With community engagement and education programs in place, community acceptance of renewable energy systems can be achieved.

**Recommendation:**

- Develop a community engagement and education programme to support energy transition acceptance and adoption.
- Conduct an economic assessment of the energy sector changes and new investment.

## 5.15 Transport

### 5.15.1 Active

A goal has been set to increase the proportion of trips taken via active transport modes. Encouraging greater uptake of active modes of transport, such as walking, cycling, or using public transport, can have numerous benefits for individuals, communities, and the environment. To encourage more people to choose active modes of transport, there are several strategies that can be employed. Firstly, governments and local authorities can invest in infrastructure and end of trip facilities that make it safer and more convenient to walk or cycle. Additionally, education campaigns can be launched to promote the benefits of active transport and to encourage its uptake. Employers can also play a role by providing incentives for employees who choose to cycle or walk to work, such as access to showers or bike storage facilities.

**Recommendations:**

- Active transport should be considered in urban planning decisions.
- Encourage businesses to incorporate goals around the greater uptake of active transport in their net zero plans.

### 5.15.2 EV Charging Infrastructure

It is important that an active plan is developed to ensure that investment in new charging infrastructure keeps step with growing demand, specific locations such as Invercargill Airport, Bluff, the Bluff Ferry terminal, hospitals, public buildings and accommodation facilities are the type of candidate sites that should be encouraged. Given the pace at which this sector is developing, it is important that Southland Murihiku keep abreast of developments and trends in the industry that will impact the infrastructure required such as:

- Increased take-up of EV sharing schemes[36] such as Zilch in New Zealand and Volvo's Sunfleet service (which is planned for international roll-out)[37].
- Battery swapping and battery as a service (BaaS) scheme[38].
- Smart charging and vehicle to grid (V2G) technologies.

[36] https://genless.govt.nz/stories/zero-carbon-cars-for-rent/

[37] https://www.slashgear.com/volvo-is-taking-its-sunfleet-car-sharing-service-global-14471975

[38] https://www.forbes.com/sites/neilwinton/2022/09/12/battery-swapping-revival-could-threaten-electric-car-charging-networks/?sh=664c3a341b1b

# 6 Summary of Recommendations

The table below gives a summary of the key recommendations for the strategy and implications of the different scenarios on these recommended actions.

| **Recommendation** | **Page** Ref | **Scenario Dependence** |
|---|---|---|
| **Co-ordination of Industry**<br>• Form a working group comprising of the largest coal users and other relevant stakeholders in Southland Murihiku. The purpose of the group would be:<br>o To provide regular updates on their respective business's energy transition plans<br>o Further investigate the potential fuel switching options and define the specific infrastructure and supply chains required in their respective locations<br>o Co-ordinate their energy transition related capital upgrades to realise mutual benefits<br>o Pool resources to avoid double-up between organisations | 31 | These recommendations apply equally in all scenarios |
| **Solar Generation**<br>• Feasibility studies should be executed in areas north of Te Anau and Mossburn<br>• The best use of solar would be embedded solar generation, close to electricity loads, to offset the demand on the grid<br>• Solar should not be considered as the main source of generation to meet the energy balance gap. | 33 | These recommendations apply equally in all scenarios |
| **On-shore Wind Generation**<br>• Potential generators should actively explore onshore wind sites, beginning west of Edendale.<br>• Wind should be seen as a dominate source of energy to meet the energy gap presented by the energy balance.<br>• Begin by optimising the available onshore resource, as this will provide lower cost energy and come online sooner.<br>• Focus should begin with detailed feasibility studies of sites between Invercargill and Edendale.<br>• New generation should be located close to new load and transmission infrastructure. | 34 | These recommendations apply in Scenarios 2 & 3 |
| **Off-shore Wind Generation**<br>• Potential offshore wind sites should be explored, beginning south of Invercargill.<br>• Potential offshore sites should be assessed whilst technology is still developing so that future generation can be forecast and developed in time to meet demand.<br>• If NZAS and SGH are both online, then the need to develop offshore wind becomes more important if Southland Murihiku's ambition to be an energy exporting region is to be fulfilled | 34 | These recommendations apply in Scenarios 3 |

| **Recommendation** | **Page** Ref | **Scenario Dependence** |
|---|---|---|
| **Hydrogeneration**<br>• The reports by MBIE and Great South should form the basis for future investigations into hydrogeneration within Southland Murihiku<br>• Detailed feasibility studies should be undertaken for the highest-ranking schemes<br><br>• If NZAS & SGH are both operational, hydrogeneration will likely be needed in conjunction with wind to generate the needed electrical supply | 36 | These recommendations apply equally in all scenarios<br><br>This recommendation applies in Scenario 3 |
| **Grid-Scale Battery Storage**<br>• Grid scale battery storage should be investigated to better understand the benefit to the network and users<br>• Potential developments should be identified in anticipation of an upcoming inflection point where battery storage will become financially viable | 38 | These recommendations apply equally in all scenarios |
| **Hydrogen Storage**<br>• Hydrogen production, storage and use for generation within Southland Murihiku should be investigated regardless of SGH's development, as smaller installations could provide firming solutions alongside battery or pumped hydro if deemed economically viable<br>• Monitor the development of hydrogen storage technologies and in particular the use of its derivatives such as green ammonia and in the event of a potentially viable solution becoming available, investigate it as an option for the Southland Murihiku context. | 38 | These recommendations apply equally in all scenarios |
| **Pumped Hydro Storage**<br>• The progress and impact of Lake Onslow should be monitored as it will have a significant influence on the financial viability of new generation within Southland Murihiku.<br>• Any hydrogeneration investigations should also consider if they have potential in a pumped hydro firming role | 37 | These recommendations apply equally in all scenarios |
| **Use of existing capacity first**<br>• EDBs and stakeholders to co-operate to encourage developments to be built in locations where there is existing spare capacity. The Beca developed Digital Twin can be used to display the locations with known spare load capacity.<br>• EDBs to consider the value of commissioning a load flow study which would demonstrate the changes in network capacities for load and generation for the 3 major scenarios, and if included, for several of the predicted major decarbonisation conversions | 39 | These recommendations apply equally in all scenarios |

| Recommendation | Page Ref | Scenario Dependence |
|---|---|---|
| **Early Communication**<br>• Developers of new generation and/or loads, storage, etc to communicate with Transpower of the applicable EDBs as soon as practicable stating proposed location, demand and service levels<br>• Developers should communicate with Great South as soon as practicable to begin stakeholder communications and possible coordination of resources<br>• Advocate for changes to electricity network providers are regulated nationally, to allow fast tracking of electricity grid and network upgrades where they will enable decarbonisation to occur. This change will allow the electricity network providers to lead the way and upgrade ahead of demand, rather than demand being the trigger for upgrades. This will effectively allow the network service providers to 'build it and they will come', which should support more rapid decarbonisation. | 39 | These recommendations apply equally in all scenarios |
| **Load Management**<br>• Large industry users should implement load management systems to respond to the networks supply versus load and work with the EDBs to prevent extreme peaking of demand.<br>• Shift daily processes to times of low load, such as night-time, to reduce the variation in demand on the network during a 24-hour period<br>• Shift annual processes which are not seasonal market or annual growth cycle driven to the summer period where electrical demand is less, and electricity cost is lower<br>• Engage with the market to understand what financial mechanisms can be put in place to incentivise load management or capacity sharing<br>• Enables more effective electricity storage and managing of dry year risk<br>• Areas with multiple industrial users should explore the possibility of capacity sharing to reduce the cost of infrastructure upgrades | 40 | These recommendations apply equally in all scenarios |
| **Renewable Energy Zones & Energy Clusters**<br>• Stakeholders should familiarise with REZ and REC concepts and become a conduit for communication and promotion of a REZ and REC within Southland Murihiku | 41 | This recommendation applies to Scenarios 2 & 3 |
| **Focused Network Upgrades**<br>• Where prudent Great South should promote investment in new distribution and transmission infrastructure to support the acceleration and deployment of new renewables at multiple scale across the network. This should be selective promotion of locations following analysis of all factors so that the upgrades do not promote generation or loads to be established in suboptimal locations which can be better served with REZ or alternatives.<br>• All new loads should have power factor of 0.95pf or better.<br>• Harmonic voltages and currents introduced into the Network by appliances in an installation shall not exceed the levels specified in NZECP36 and AS/NZS 61000, part 3 series | 41 | These recommendations apply equally in all scenarios |
| **Transmission & Distribution Consenting and Easement**<br>• Great South to work with iwi, Southland District Council, Invercargill City Council, Gore District Council, Environment Southland, Transpower and the | 42 | These recommendations apply equally in all scenarios |

<table>
<tr><th>Recommendation</th><th>Page Ref</th><th>Scenario Dependence</th></tr>
<tr><td>EDBs to include within the district plans' locations for REZ, substations, and core transmission and distribution routes.<ul><li>Great South to work with Transpower and the EDBs while negotiating designations for utility locations.</li><li>Climate change impacts need to be carefully considered to ensure that infrastructure is located clear of all designated risk areas</li></ul></td><td></td><td></td></tr>
<tr><td>Remote Area Power Systems<ul><li>Large, remote industrial energy users should investigate their ability to generate and store energy on-site</li></ul></td><td>42</td><td>This recommendation applies equally in all scenarios</td></tr>
<tr><td>Grid & Network Upgrade Regulations<ul><li>This is not only a Southland Murihiku issue and therefore changes to regulations nationally should be considered to allow fast tracking of electricity grid and network upgrades where they will enable decarbonisation to occur. This change will allow the 'service provider' to be the leader and take some of the risk rather than the 'user' being the upgrade initiator and taking all the risk. Some degree of 'build it and they will come' should support more rapid decarbonisation.</li><li>Consideration should be given nationally by the Commerce Commission, Electricity Authority, Ministry of Business, Innovation and Employment and the collective Electricity Networks Association as to how to modify the regulated processes to enable potential major decarbonisation electricity users (converting from fossil fuels) and enablers (renewables generators) to have greater visibility and certainty to the availability of and the price of energy. This will assist industry to make decisions on true merit and less hindered by delays such as obtaining electricity capacity</li></ul></td><td>44</td><td>These recommendations apply equally in all scenarios</td></tr>
<tr><td>Green Hydrogen<ul><li>Advocate for incorporating hydrogen in national energy strategy</li><li>Facilitate collaboration between the companies who are establishing hydrogen refuelling infrastructure and major heavy vehicle fleet owners</li><li>The climate commission should re-evaluate the role of hydrogen in decarbonising New Zealand given recent developments in the establishment of a global hydrogen industry.</li><li>The New Zealand government should be urged to develop at pace an integrated green hydrogen strategic plan supported by robust standards and regulating framework.</li><li>Adopt existing and tested international standards for the production, distribution, storage, and dispersing of hydrogen including for the use of fuel in the transport sector.</li><li>Develop a green hydrogen certification standard or guarantee of origin.</li><li>Consider the establishment of a national policy statement to streamline and standardise the consenting of hydrogen infrastructure.</li><li>Encourage or incentivise transport related decarbonisation by supporting the roll-out of hydrogen fuelled heavy transport, rail, marine and air vehicles.</li></ul></td><td>44</td><td>These recommendations apply equally in all scenarios</td></tr>
</table>

<table>
<tr><th>Recommendation</th><th>Page Ref</th><th>Scenario Dependence</th></tr>
<tr><td><ul><li>Consider the allocation of a proportion of the government's Government Investment in Decarbonising Industry fund (GIDI) to assist with the hydrogen fuel transition.</li><li>These initiatives should involve parties such as the New Zealand Hydrogen Council, MBIE, transport sector agencies, hydrogen producers, Standards NZ and EECA.</li></ul></td><td></td><td></td></tr>
<tr><td>Biogas<br>Biogas recovery could play an important role in decarbonising hard to abate industry and therefore warrants further investigation.<ul><li>A more detailed review to quantify possible sources and users of biogas/renewable natural gas</li><li>Identify best use cases/hard to abate applications - onsite heat generation, upgrading to drop-in fuel for residential/commercial markets, transport fuel, electricity generation and export</li></ul></td><td>47</td><td>These recommendations are independent of these scenarios.</td></tr>
<tr><td>Biomass<ul><li>Advocate for favourable Government policies to increase wood processing within New Zealand. Changes in building standards to promote the use of mass timber in multi-storied (medium) structures will also encourage increased wood processing in New Zealand and help with the reduction in logs being exported.</li><li>Investigate what kinds of market structures could incentivise the production and storage of biomass energy when there is surplus supply.</li><li>Government investment in forest floor recovery is important. The wood / biomass recovery from the forest floor can be done most effectively at the time of forest harvesting, when the equipment is already there. More work (and potentially trials) should be done to understand the opportunity for forest floor recovery.</li><li>Steam exploded black pellets could be an option to reduce capital cost of conversions once supply become established. Great South should keep abreast of any developments in New Zealand and consider the potential differences this would make in terms of infrastructure investment in the biomass supply chain.</li><li>Instigate a formal collaboration with a government research organisation such as Scion to investigate the opportunities for short rotation forestry.</li><li>Develop a plan for importation of biomass including the relative costs and benefits of coastal shipping, rail and road transport.</li><li>Investigate the establishment of a wood energy market that provides users with a reliable quality supply of biomass and long-term price certainty.</li><li>Investigate effective bulk biomass handling rail side to enable traditional fossil fuel supply nodes to be transitioned to biomass processing supply points.</li><li>Investigate the feasibility of a number of smaller white wood pellet plants throughout Southland Murihiku close to wood processing facilities.</li></ul>The entire biomass value chain needs to be optimised. Work with industry to understand what opportunities and risks exist. This should cover infrastructure, transport, recovery of residues and workforce development.</td><td>48</td><td>The recommendations regarding biomass are independent of scenario unless otherwise indicated.<br><br>Lower priority for scenario 1.</td></tr>
</table>

| Recommendation | Page Ref | Scenario Dependence |
|---|---|---|
| **Buildings**<br>• Support businesses in connecting to central government agencies and supplier who can support with developing the information required to apply for funding for energy efficiency projects.<br>• Ensure businesses are aware of the best technical practice in the application of heat pumps to ensure successful project outcomes with respect to efficiency and cost-effectiveness. The Australian Meat Processors Corporation (AMPC) Refrigeration Energy Efficiency Opportunities New Technology Guide is a good resource.<br>• Provide a platform for sharing building performance information that can act as a league table and give Southland Murihiku businesses a forum for showing their commitments to reducing carbon.<br>• Support/enable thermal storage or district heating schemes which can accelerate the decarbonisation of buildings that require higher heating hot water temperatures.<br>• Provide advice and support for residential buildings wishing to design/upgrade building envelope and pursue greater passive design performance.<br>• Unlock solar potential with co-funding, simplified consenting, and incentivise the provision of V2G connection (when/if available).<br>• Incentivise / mandate energy efficiency performance disclosure for non-residential buildings<br>• Align publicly funded buildings with the proposals within the BfCC programme to help establish competency and supply chain experience in the region.<br>• Align Southland Murihiku Local Government Assets with the Carbon Neutral Government Programme to advance energy efficiency within both existing and new buildings.<br>• Introduce development incentives for buildings that are rated Homestar, GreenStar or other equivalent rating frameworks.<br>• Continue support for the Southland Warm Homes Trust to upgrade the efficiency of homes in Southland.<br>• Encourage the requirement of an energy plan to accompany all building consents | 52 | These recommendations are independent of these scenarios. |

<table>
<tr><th>Recommendation</th><th>Page Ref</th><th>Scenario Dependence</th></tr>
<tr><td>Consenting<ul><li>Establish a consenting taskforce that will provide consenting expertise to regional leadership entity. The taskforce should include representation from Murihiku four Papatipu Rūnaka. Task force should investigate opportunities for streamlining regulatory processes through:<ul><li>staff capacity building</li><li>coordinated pre-application discussions with developers</li><li>joint district and regional consenting for projects</li><li>exploring consenting pathways with developers (e.g., fast-track, direct referral)</li><li>review existing district and regional plans to strengthen alignment with National Policy Statement for Renewable Electricity Generation and support the implementation of the clean energy vision.</li></ul></li><li>Identify a streamline processing team with relevant expertise that can be called on for complex applications. This team could be bolstered with consultants as workload increases.</li><li>Track the development of legislation to understand impact for region and provide feedback on consultation drafts and bills when available. For example, the NBA Bill is currently open for comment.</li><li>Regular engagement with industry to understand the pipeline of projects and potential approval barriers. Investigate options for formalising this engagement.</li><li>More detailed mapping of energy areas/projects that can feed into the Regional Spatial Strategy.</li><li>Plan for transition to Natural and Build Environment Plan and Regional Spatial Strategy.</li><li>Consider climate adaptation risks in planning decisions.</li></ul></td><td>54</td><td>These recommendations are independent of these scenarios.</td></tr>
<tr><td>Transport<ul><li>The technology to decarbonise the transportation sector is evolving rapidly. Great South should keep abreast of developments in other countries further ahead on this journey and consider the implications for Southland Murihiku. They should also follow the developments in aviation and coastal shipping and factor the potential requirements into updates to the energy strategy once the likely paths forward become clearer.</li><li>Conduct more detailed study looking into a region wide fast charger network and the infrastructure bottlenecks</li><li>Active transport should be considered in urban planning decisions</li><li>Encourage businesses to incorporate goals around the greater uptake of active transport in their net zero plans.</li></ul></td><td>59</td><td>These recommendations are independent of these scenarios.</td></tr>
<tr><td>Rakiura Stewart Island and Piopiotahi Milford Sound<ul><li>Consider behind the meter solar to supplement diesel generation.</li><li>SIESA to consider facilitation of bulk solar installations on buildings and residences so that efficiencies in bulk purchasing transport and installation can be achieved.</li></ul></td><td>55</td><td>These recommendations are independent of these scenarios.</td></tr>
</table>

| **Recommendation** | **Page** Ref | **Scenario Dependence** |
|---|---|---|
| • Ease the consenting challenges as the current process, while addressing environmental concerns is stifling environmental improvement.<br>• Continue to explore opportunities to introduce an alternative base supply to support the hydro and a peaking system to manage the 480kW peak load.<br>• Explore variable electricity pricing strategies to discourage peak loading.<br>• Combination with wind and battery storage may make sense longer term to give diversity and achieve net zero.<br>• The co-fuelling of the existing generators with hydrogen should also be investigated | | |
| **NZAS and SGH**<br>• Complete studies investigating potential transient stability issues associated with high export from the Lower South Island region following the possible closure of NZAS<br>• If NZAS is to close, Southland Murihiku should work to facilitate a smooth, stepped transition between NZAS closing and Southern Green Hydrogen coming online.<br>• If NZAS stays, Southland Murihiku should work to ensure that new generation is developed in the region to ensure that the network is not constraint by the increased demand.<br>• Either Scenario should be agreed with Transpower, PowerNet and publicised to network users to ensure all stakeholders are informed and prepared for each stage.<br>• As much existing infrastructure from NZAS should be used for SGH's connection to avoid wasting assets and to reduce the overall cost of SGH | 57 | These recommendations are dependent on whether NZAS closes and SGH proceeds, indicated in each recommendation. |
| **Public Engagement**<br>• Develop a community engagement and education programme to support energy transition acceptance and adoption<br>• Conduct an economic assessment of the energy sector changes and new investment. | 59 | The recommendation is independent of these scenarios. |

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# A

## Appendix A – Energy Balance Methodology and Assumptions

## Industrial and Commercial

Great South provided the energy usage (GJ) of each industrial and commercial user in Southland Murihiku in the *Murihiku Energy Balance (2022)*. This energy was converted to MW assuming hours of annual operation for each sector.

| | Hours per day | Days per year | Annual hours |
|---|---|---|---|
| *Lime works* | 8 | 250 | 2,000h |
| *Accommodation* | 10 | 180 | 1,800h |
| *Dairy Processing* | 20 | 320 | 6,400h |
| *Education* | 8 | 180 | 1,440h |
| *Hospitals* | 20 | 300 | 6,000h |
| *Industrial* | 20 | 300 | 6,000h |
| *Laundry & Drycleaning* | 10 | 320 | 3,200h |
| *Local Government* | 10 | 180 | 1,800h |
| *Meat/ Skins / Food Processing* | 20 | 250 | 5,000h |
| *Prisons* | 12 | 200 | 2,400h |
| *Rest home / Care Provider* | 12 | 200 | 2,400h |
| *Timber Processing* | 12 | 300 | 3,600h |
| *Office/Retail/Restaurant/Other* | 12 | 350 | 4,200h |
| *Construction / Mining* | 20 | 300 | 6,000h |

The following assumptions taken from the *Murihiku Energy Balance* (2022) assumptions.

- a biomass boiler has the same efficiency as a coal boiler (75%)
- an electrode boiler is 100% efficient

### Industrial

The following assumptions have been made for all industrial users:

- For boilers under 500kW:
  - 95% of the load is convert to heat pumps in conjunction with energy efficiency upgrades (5%).
- For boilers over 500kW:
  - 5% demand reduction due to energy efficiency upgrades
  - 15% of the existing boiler load is switched to heat pumps. Note that 15% heat recovery is a conservative measure. It is likely many industrial users could replace more that 15% of their load with heat pumps. The exact proportion of load that can be switched will depend on the quantity of rejected heat not currently utilised. A coefficient of performance (COP) of 3 was assumed for heat pumps in industrial applications. *Daiken is an exception to this, as the site will not be using heat pumps.*
  - the remaining load (80%) is fuel switched. The boilers were switched either to electricity or biomass (accounts for biomass/pellets). The fuel switch of each industrial user was looked at

separately and assumptions were based on industry type and GIDI funding/publicly available data.

- New coal boilers less than 10 years old will reduce their coal input by 40% by blending in biomass for 15 years (to be used as a transition fuel), then will fuel switch to either electricity or biomass.
- The date of fuel switch has been prioritized based on age of the current boiler & switched in increments between now and 2037 to align with current legislative dates. If there was no information on the boiler age/intended date, then a switch in 2037 was assumed.

| *Age of boiler* | Year of switch |
|---|---|
| *< 1985* | 2027 |
| *1985 - 2000* | 2032 |
| *2000 - 2010* | 2035 |
| *> 2010* | 2037 |

These assumptions were also used for the Alsco commercial boilers.

Below states the fuel switch for each fossil fuelled industrial boiler:

| *Industrial user* | Current fuel | Transition fuel |
|---|---|---|
| *AB Lime* | Coal | Biomass |
| *Alliance Group - Lorneville* | Coal | Electrode boiler |
| *Alliance Group - Mataura* | Coal | Electrode boiler |
| *Blue Sky Meats* | Coal | Biomass |
| *Blue Sky Meats* | Coal | Electrode boiler |
| *Blue Sky Meats (Ex Clover Export)* | Diesel | Electrode boiler |
| *Bluff Proteins Ltd* | Diesel | Electrode boiler |
| *CRT Farmlands* | Diesel | Electrode boiler |
| *Daiken (Ex Dongwha Pattina)* | Coal | Biomass |
| *Downer EDI Works Ltd* | Diesel | Electrode boiler |
| *Downers Roading* | Diesel | Biomass |
| *DT King Ltd* | Coal | Biomass |
| *Fonterra - Edendale* | Coal | Biomass 70%, electrode boiler 30% |
| *Fulton Hogan Southland Ltd* | Diesel | Electrode boiler |
| *Great Southern Timber* | Diesel | Electrode boiler |
| *Lindsay Dixon Sawmill* | Coal | Biomass |
| *Mataura Valley Milk* | Coal | Electrode boiler |
| *New Zealand Growing Media Ltd* | Coal | Biomass |
| *Ngahere Sawmill* | Coal | Biomass |
| *Open Country Dairy* | Coal | Electrode boiler |
| *Prime Range Meats* | Coal | Electrode boiler |
| *Prime Range Meats* | Diesel | Heat pump |
| *Ravensdown* | Coal | Biomass |
| *Resolution Developments Limited* | Coal | Biomass |
| *Silver Fern Farms - Waitane* | Coal | Biomass |
| *Slinkskins* | Diesel | Heat pump |

| | | |
|---|---|---|
| *Southland Crematorium / Invercargill City Council* | LPG | Heat pump |
| *South Pacific Meats* | Coal | Electrode boiler |
| *Southtile* | Coal | Heat pump |
| **Wool industry* | Diesel | Heat pump |

These assumptions varied for each scenario:

For Scenario 1:

there was no change to boilers that switched prior to 2025

80% of boilers switching to biomass will instead switch to electricity except for those in the forestry industry or close to a biomass source

timing for fuel switching of boilers remained the same as this is based on the age of asset & investment

For Scenario 2:

there were no changes to base case energy balance

For Scenario 3:

there was no change to fuel boilers switch (i.e., split between biomass and electricity)

timing for fuel switching of boilers remained the same as this is based on the age of asset & investment

### Commercial

The following assumptions were made for commercial boilers:

New boilers less than 10 years old will switch to biomass for 15 years (transition fuel), then will switch to electricity. All commercial boilers will eventually switch to electricity.

- For heat pumps, a COP of 1.36 was assumed. This is a relatively conservative COP to account for the low temperatures experienced in Southland Murihiku.
- SIT, Invercargill Prison and Southland Hospital boilers are being considered under the Government's decarbonisation program. The two former projects will be decarbonized by mid-2024 and Southland Hospital will be decarbonized by 2025.
- The energy transition for Southland Hospital will be staged with decentralized electric sterilization.
- The date of fuel switch has been prioritized based on age of the current boiler & switched in increments between now and 2037 to align with current legislative dates. These increments are the same as those stated in the industrial assumptions. If there was no information on the boiler age/intended date, then a switch in 2037 was assumed.

- These assumptions did not vary with each scenario as all buildings eventually switch to electricity and the timing for fuel switching of boilers is based on age of asset & investment.

## Residential

The Murihiku Energy Balance provided the current energy usage (GJ) for the residential sector in Southland Murihiku as well as the future domestic demand for new homes. Energy was converted to MW assuming this energy was used over 12 hours a day.

The following assumptions were made to determine future residential demand:

- All new homes are powered by electricity

- All LPG and diesel boilers will gradually switch to heat pumps by 2035 assuming it is economical to do so with current funding grants available (Warmer Kiwi Homes Programme). A conservative COP of 1.36 for heat pumps has been assumed
- All coal boilers (small quantity) will gradually switch to biomass by 2035
- Linear rate of fuel switching out to 2035

- These assumptions did not vary with each scenario as drivers for switching are based on economics/available funding and policy and legislation.

## Transport

The Murihiku Energy Balance provided the current energy usage (GJ) for the transport sector in Southland Murihiku as well as the annual milage and number of cars in Southland Murihiku. Using this information, the average milage per day of a light vehicle in Southland Murihiku (assuming the vehicle runs for 365 days per year) was calculated as 38 km/day.

Assuming a mixed use of slow chargers and fast chargers, the time required for a car to charge by slow charger and fast charger was calculated. It was assumed that 80% of light vehicles were charged by slow charger (at home) and the remaining 20% were charged by fast chargers.

| | Charge Capability | Charging Rate | Time for car to charge for 1 day (38 km) | Portion of cars charged |
|---|---|---|---|---|
| Slow Charger | 7 kW | 40 km/h | 0.95 h/car | 80% |
| Fast Charger | 43 kW | 80 km/h | 0.24 h/car | 20% |

Charging rates were based off NZTA website: https://www.nzta.govt.nz/planning-and-investment/planning/transport-planning/planning-for-electric-vehicles/national-guidance-for-public-electric-vehicle-charging-infrastructure/using-public-charging-infrastructure/charging-an-electric-vehicle/

From this information, the total number of cars charged by slow and fast charger was calculated. Assuming a fast charger was utilised for 12 hours/day and a car required 0.25 h of charging time each day, the total number of fast chargers and power usage of a fast charger was calculated.

To determine the power usage of slow chargers, it was assumed cars were charged overnight (12 hours) and that the demand was managed through a smart charging mechanism that charged the car gradually over a 12-hour period. This gives an average power draw per car of 0.58kW. Combining the power demand of slow chargers (46.3MW) and fast chargers (18.7MW), gave a total power demand of 60.6 MW.

Allowing for an 85.7% charging efficiency (as assumed in Murihiku Energy Balance), this results in 65 MW of power being required from the grid if 92% of light vehicles transitioned to EVs.

It is important to note that most charging by fast chargers will be done during the day and home charging done at night, therefore the peak demands from slow and fast chargers will not coincide.

The following assumptions were taken from the Murihiku Energy Balance:

- Gradual conversion of light vehicles to 92% EV’s by 2050.
- Gradual conversion of heavy vehicles to 60% FCEVs by 2050.

To show the relative proportions of energy use from different transport fuels, versus electricity, the following efficiency factors were used.

- efficiency of LPG vehicles: 15%
- efficiency of petrol vehicles: 25%
- efficiency of diesel vehicles: 35%

The power demand of heavy vehicles was determined based on the light vehicle calculation and number of heavy vehicles in Southland Murihiku. A hydrogen fuel cell efficiency of 60% was assumed (https://www.energy.gov/sites/prod/files/2015/11/f27/fcto_fuel_cells_fact_sheet.pdf) calculate the relative proportion of hydrogen required.

### Mode shift

In Invercargill, 7% of current transport is active (walking and cycling) with the remaining 92.5% of transport by private vehicle and 0.5% by public transport. Queenstown's transport is currently 17% active. Queenstown have a goal of 40% active transport by 2048. If we apply the same expansion factor to Invercargill, we can assume 14% active transport by 2028 and 21% by 2048. These assumptions have been used in the energy balance.

Note that the Net Zero Southland report estimated the proportion of commuters that lived less than 5km from work and still commute by car and assumed 30% of commuters living less than 5km from work would shift their mode of transport from car to cycling, walking, public transport or shared transport.

- These calculations and assumptions did not vary with each scenario as the drivers for switching are based on economics, convenience, supporting infrastructure development, policy & legislation & technology advancement.
- No aviation, rail or shipping demands have been accounted for in this energy balance.

# B

## Appendix B – Further Discussion

## Current electrical demand

The baseline Murihiku Energy Balance did not detail electrical demands for most sites. The difference between the total electricity demands in the energy balance and peak observed network demands was split between sectors based on a ratio of electricity usage from the Murihiku Energy Balance and known residential demand. The proportion of electricity usage for each sector is as follows:

- Industrial 37%
- Commercial 30%
- Residential 33%

The 2022 electrical demand values were taken from the latest Asset Management Plans reported by Transpower and the associated local Energy Distribution Businesses (EDB). We have used the peak load values reported, which overestimates the realistic total demand as not all substations will experience their peak load coincidentally. However, this approach allows areas of concern to be identified and further investigated to understand the true demand and constraint on the network at that node.

## Current electrical supply

The electrical supply values were taken from the latest Asset Management Plans reported by Transpower and the associated local Energy Distribution Businesses (EDB). These reports detail 2022 capacity (N) and firm capacity (N-1) values and upgrades planned in the next 10 years (up to 2032). Any upgrades that are scheduled to be deployed before 2030 been included in in the 2030 supply value. Any additional upgrades that are scheduled for 2030-2032 been included in in the 2035 supply values. When estimating the total regional supply, we have summed the capacity (N) values for zone substations within the distribution network and added NZAS GXP. This summation delivers the closest estimate for accessible supply, as the transmission network capacity is predominately used to supply the distribution network. There are currently no confirmed transmission or distribution upgrades published for 2033-2050 and as such the regional supply will be the same in 2035 and 2050.

It is assumed there will be no reductions in GXP or zone substation capacities i.e., the supply nodes and all grid and network at minimum will be maintained to current 2022 capacity.

## Substation percentage overload

The Substation percentage overload calculation was completed by tagging demands to their nearest zone substation. Some demands will not be connected to their closest substation and instead a more suitable electricity supply. The demand on the substation was then estimated by adding the additional decarbonisation demand to the 2022 base peak load. It is understood that some industrial users above will not connect into their local zone substations, however this exercise highlights where ‘business as usual’ cannot take place.

## Transmission & Distribution Real Time Balancing and Strength

### Background

The existing electrical supply infrastructure’s purpose is to connect the national and regional generation to the demand of the regional loads. Unlike most other energy systems where there is considerable fuel/energy storage and time flexibility the electrical system must be in constant equilibrium, with the balancing time frame constant and in seconds, not hours, days, weeks, or months. If not constantly balanced it can lead to a cascading supply brownout, then blackout within seconds.

The figure below depicts how the electricity infrastructure operates like a balance beam with the generation on one side and the loads on the other. The geographical position of the existing generation and loads influence the required strength of the grid and network. Generally, if the generation is nearby the load the network infrastructure and transmission losses can be minimised however if geographically distant the connection needs to be much stronger. Therefore, the position of new generation or loads will influence if existing 'strength' in the grid or network can be utilised, or if upgrades are required. Note electrical storage i.e., batteries, can act as both generation and load and therefore depending on point in time can be on either side of the fulcrum.

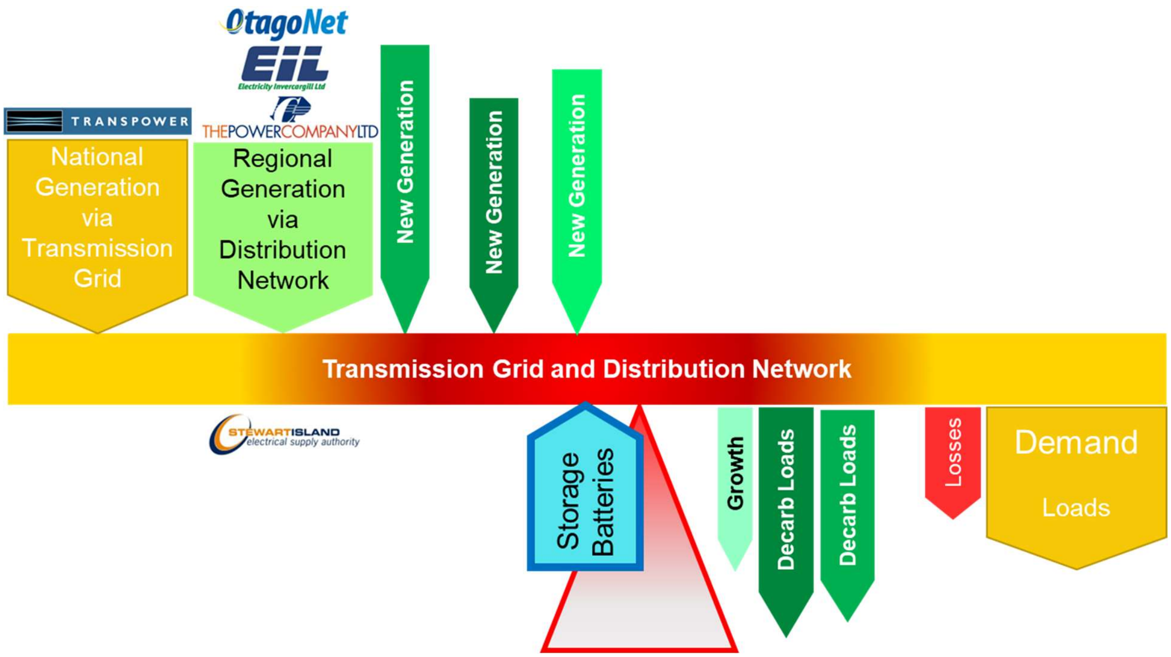


Figure B1-1 - Electrical generation and load balance

Energy is transported via the national transmission grid and the regional distribution networks. Transpower enables the national generation to reach the region and selected major users within the region. Electricity Invercargill, OtagoNet and The Power Company manages networks to distribute generation and electricity flow within the region. Similarly, Stewart Island Electrical Supply Authority provides and manages Stewart Island Rakiura network and Milford Sound Infrastructure Limited provides the Piopiotahi Milford Sound generation and network.

The transmission grid and distribution network are built to meet security of supply regulations set by the Electricity Authority and financial regulatory constraints set by the Commerce Commission. This combination of Electricity Authority and Commerce Commission aims to optimise the reliability and cost of supply to all electrical consumers. The net effect is the grid and networks are built to meet current peak consumer demands, with just enough spare capacity to meet known future demand. Due to the Commerce Commission oversight the capacity can only be built for known and not predicted future demand. Demand from the generator to be able to distribute their energy or demand from loads for energy is what triggers upgrades i.e., stakeholders must first signal a commitment for electrical capacity for it to be built.

### Ability to upgrade Grid and Network Capability for new Generation or Loads

The reality is the new generation will be a variety of types, constant and intermittent generators, and in multiple locations, with the decarbonisation loads also being in multiple locations. It is highly unlikely a strategy will direct the development of renewable generation as they are solely triggered by demand stakeholders signaling a need for electrical energy. A strategy however can signal to generation developers the possibility of opportunity occurring in certain geographical areas within Southland Murihiku.

Generators are commercial enterprises and select locations for analysis and then progress to design and construction due to needs expressed by demand. The generation developers will seek financial return on investment. The return will be impacted on by the cost of grid or network capacity upgrades that may be necessary which can be directly attributable to their new generation. Load nearby will decrease the scale of the upgrade and hence the cost that be apportioned to the generator.

The placement and the size of each generation and supply point interact thereby influencing the required strength of the grid and distribution network infrastructure. If the new generation is nearby new load and it generates electricity at the same time as the new load demands it the likelihood of upgrades is decreased, hence why co-ordination of new generation and new load stakeholders is preferred.

The grid owner Transpower and the distribution network owners Electricity Invercargill (EIL), The Power Company (TPCL), OtagoNet (ONL), Stewart Island Electricity Supply Authority (SIESA) and Milford Sound Infrastructure Limited (MSI) build, maintain and reinforce their infrastructure to a 10 year publicly disclosed Asset Management Plan (AMP) Report[39] while meeting agreed service, safety, quality and profitability targets. Their major customers are consulted about the service levels they prefer and the price they are willing to pay. This is known as the price/quality trade off or the cost of power supply versus number of power cuts. Customers' views about service levels are combined with internal and the Government's required service levels to form the foundation of the 10-year AMPs. Transpower and the EDBs must find the right balance between cost to the customer, safety, environmental requirements, service levels and network investment.

The existing under-utilised capacity within the grid and network can be seen in the AMPs. Note the asset planning is based on committed loads and 10-year projections. Increases of Grid Exit Point (GXP) and Network Substation capacities are generally customer-driven investments, and capacities will not change unless the customer makes a commitment to invest.

These plans show the capability of the infrastructure to supply the existing and committed loads during the next 10 years. They also show the spend and build plans during the next 10 years. The plans allow for growth in population, changes in loads due to efficiency, changes in technology etc., during the 10-year period however due to Commerce Commission constraints they cannot account for new non committed loads as they unable to spend to build for them.

## Electricity Security, Reliability & Affordability

Reported in the 'World Energy Trilemma Index', the World Energy Council rates New Zealand 9th (AAA) in the world in respect to the Energy Trilemma, a rating formed from; Energy Security (A), Energy Equity (A) & Environmental Sustainability (A). The report narrates that New Zealand is unlikely to experience large change in electricity prices or energy security as the country is self-sufficient and does not rely heavily on the import of fossil fuel to meet energy demand[40].

[39] https://www.transpower.co.nz/resources?keywords=transmission+planning+report

https://powernet.co.nz/disclosures/the-power-company/asset-management-plans/

https://powernet.co.nz/disclosures/electricity-invercargill-ltd/asset-management-plan/

https://powernet.co.nz/disclosures/otagonet/asset-management-plan/

[40] https://www.marshmclennan.com/content/dam/mmc-web/insights/publications/2022/december/World_Energy_Trilemma_Index_2022.pdf

MBIE's energy outlook aims to forecast the future electricity price and predicts a wholesale price of 11.5 c/kWh for 2040, a 2.5c rise from roughly 9 c/kWh today[41]. Although generation may become cheaper due to renewables, an increase in electricity price will be seen due to the required network upgrades and firming infrastructure needed to deliver the supply from sources such as solar and wind. The intermittency of these new renewables will increase price volatility; however, a competitive generation market will assist to keep prices low. Generators which aim to use existing spare transmission or distribution capacity or are developed near loads are typically developed first and able to operate at least cost. Finally, if NZAS closes then electricity prices will fall due to the lower baseload demand and increased available supply.

Energy reliability is a regional issue due to the lack of firm capacity (N-1) for industrial users. Most zone substations are not able to deliver a secure supply of electricity to the end user, meaning that maintenance will cause a black-out or reduction in supply. This proposes risk to industrial processes that require a constant supply and may prevent decarbonisation, or new industry in Southland Murihiku.

Considering the above, it can be taken with confidence that energy availability and affordability is not a major concern to the New Zealand and Southland Murihiku market. Generation needs can be met if renewable developments can be built, with wind likely providing the dominate supply within the region. If SGH and NZAS are both to be operational, there is an urgent need for new generation. However, there is an urgent need to improve energy reliability in the region if new industry is to move to Southland Murihiku with confidence.

## Southland Electric Power Supply Consumer Trust

In January 1998 the Government returned the ownership of the local electricity network to the people of Southland by establishing the Southland Electric Power Supply Consumer Trust.

The Trust holds all the shares in The Power Company Limited on behalf of consumers connected to the company's network and distributes the benefits to these consumers.

The Trustees' prime responsibility is to hold the shares in the Company on behalf of consumers connected to the network. The Trust's investment comprises 68,165,402 shares in the Company issued equally to each of the five elected trustees. The Trustees' objective is to ensure the secure delivery of electricity through its network, reasonable line charges for consumers and that the network is maintained in a resilient manner and is fit for delivering electricity to facilitate a decarbonised future.

While the Trustees do not have any direct involvement with the operation of The Power Company or PowerNet, they are responsible for appointing the Directors of The Power Company Limited, negotiating strategic direction and performance objectives with the Directors on behalf of consumers, this is reported annually. Consumers receive an annual discount that reflects the benefits of operational efficiencies and local ownership.

## PowerNet's Role

PowerNet was established in 1994 to extract operational efficiencies from the merger of field work management, asset management and office-based functions performed by The Power Company Limited (TPCL) and Electricity Invercargill Limited (EIL).

Since PowerNet was established, EIL and TPCL have together fully acquired another adjoining Electricity Distribution Business (EDB), being OtagoNet, and have developed another network in the Queenstown Lakes and Central Otago region, being Lakeland Network Limited.

Having one network management company managing multiple EDBs for the two shareholders, EIL and TPCL, have created significant synergies, including improved capacity and capability to manage the significant asset base. This ongoing drive for efficiency by merging operations and achieving scale was recently acknowledged

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[41] https://www.mbie.govt.nz/assets/1597b02644/nz-energy-outlook-electricity-insight.pdf

by the recent Government Pricing Review, and the terms of reference required investigation into the "PowerNet Model" as the review looked at how other EDBs could potentially do the same."

## Southland Warm Homes Trust

Southland Warm Homes Trust Operating since 2008, the Southland Warms Home Trust is very proud to have achieved a great milestone of installing insulation in over 8400 Southland homes.

The Southland Warm Homes Trust (SWHT) was established in June 2008 by Electricity Invercargill Limited (EIL) and the Southland Electric Power Supply Consumer Trust (SEPSCT) to provide an umbrella to facilitate the establishment of dryer, warmer homes throughout the region.

The Energy Efficiency and Conservation Authority (EECA) had been encouraging a Southland wide initiative for some time and have been very supportive of this project.

The Vision of the trust is to ensure Southlanders have a more energy-efficient home, an improved living environment, improved well-being, better health, and greater energy efficiency awareness

In association with the Energy Efficiency and Conservation Authority (EECA), the Southland Power Trust, Electricity Invercargill Limited, Invercargill City Council, Gore and Southland District Councils, Environment Southland, Invercargill Licensing Trust, ILT Foundation, Community Trust of Southland, Southland Primary Health Organisations, Te Ara a Kewa Health Trust, The Southern Trust, have also contributed to the project over the years providing valuable funding to allow support for warmer, healthier homes by providing insulation and heating assessments and retrofits for Southland homes. This work is ongoing and is also evolving to include clean energy heating.

# C

## Appendix C – Advisory Group Members

| Name | Organisation |
| --- | --- |
| Jason Domigan | Gore District Council |
| Lucy Hicks | Environment Southland |
| Andrew Cameron | Invercargill City Council |
| Matt Russell / Cameron McIntosh | Southland District Council |
| Mervyn English | Murihiku Regeneration |
| Terry Nicholas | Hokonui Rūnanga |
| Eric Roy | Murihiku Regeneration |
| Hamish Fitzgerald | Rayonier |
| Kavi Singh | PowerNet |
| Nicolas Vessiot | Transpower |
| Carl Findlater | Southland Electric Power Supply Trust |
| Wade Devine | Southland Electric Power Supply Trust |
| Rewi Davis | Ōraka Aparima Rūnaka |
| Megan Reid | Te Rūnaka o Awarua |
| Evelyn Cook | Waihōpai Rūnaka |
| Dion Williams | NZAS |
| Chris Blenkiron | NZAS |
| Dale Cocker | HW Richardson |
| Kanchana Marasinghe | EECA |
| James Flannery | Contact Energy |
| Dr Linda Wright | NZ Hydrogen |
| Guy Waipara | Meridian |
| David Dodunski | Fortuna Group |
| Richard Gray | Fonterra |
| Lloyd McGinty | Ahikā |
| Ian Collier | Great South |
| Steve Canny | Great South |