Publicly available

Bioeconomy Science Institute
Maiangi Taiao

# Efficient uses of biomass resources for bioenergy based on regional supply and demand in New Zealand

Peter Hall and Julio Botero

# Report information sheet

| | |
|---|---|
| **Report title** | Efficient uses of biomass resources for bioenergy based on regional supply and demand in New Zealand |
| **Authors** | Peter Hall and Julio Botero<br>Bioeconomy Science Institute Maingi Taiao |
| **Client** | MBIE |
| **MBIE contract number** | QT 79192 |
| **PAD output number** | 105380638 |
| **Signed off by** | Paul Bennett |
| **Date** | June 2026 |
| **Confidentiality requirement** | Publicly available |
| **Intellectual property** | © New Zealand Institute for Bioeconomy Science Limited, trading as Bioeconomy Science Institute. All rights reserved. Unless permitted by contract or law, no part of this work may be reproduced, stored or copied in any form or by any means without the express permission of New Zealand Institute for Bioeconomy Science Limited, (trading as Bioeconomy Science Institute). |
| **Disclaimer** | The information and opinions provided in the Report have been prepared for the Client and its specified purposes. Accordingly, any person other than the Client uses the information and opinions in this report entirely at its own risk. The Report has been provided in good faith and on the basis that reasonable endeavours have been made to be accurate and not misleading and to exercise reasonable care, skill and judgment in providing such information and opinions.<br><br>Neither Bioeconomy Science Institute, nor any of its employees, officers, contractors, agents or other persons acting on its behalf or under its control accepts any responsibility or liability in respect of any information or opinions provided in this Report. |

Published by: Bioeconomy Science Institute, Private Bag 3020, Rotorua 3046, New Zealand.
www.bioeconomyscience.co.nz

# Executive summary

New Zealand has a large supply of woody biomass in the form of in-forest post-harvest logging residues and low-grade logs that could be used for energy. The total energy supply from these resources at a national level could be as much as 60 PJ per annum for the next 30 years depending on the assumptions used.

Woody biomass is highly flexible as to its uses and can produce a variety of forms of consumer energy (heat, power, liquid fuels and gas). It has the potential to play a role in the energy constraints that are affecting New Zealand such as declining gas supply, electricity shortages and high liquid fuel prices due to international conflicts affecting supply.

This project aims to take a range of data; regional biomass resources, regional energy demands for various forms of energy, the conversion factors for wood to a range of consumer energies and determine priorities for the use of the bioenergy supplies available at a regional level based on the varying conversion efficiencies of different end-uses.

The demand for energy by type is changing as companies and individuals respond to price and regulation changes. Examples are the increase in EVs in the light vehicle fleet and the move by some dairy factories from coal and gas fired boilers to wood and electricity. At a regional level some of the changes (coal to electricity at dairy factories) mean material change to energy demand by fuel.

**Key results**

New Zealand possesses a substantial and nationally significant woody biomass resource derived from its 1.8 million hectares of plantation forests and the associated 30+ million cubic metres per annum of sustainable log harvest. This includes harvest residues, municipal wood waste, thinnings, shelterbelt and orchard turnover residues, and low-quality export logs. Even using conservative assumptions based on the forecast supply trough of 2036–2040, approximately 84 PJ per annum of woody biomass energy is available nationally, increasing to more than 120 PJ per annum in later decades if planting rates remain high.

The study highlights that woody biomass is unique among major energy sources in that it is renewable, dispatchable, storable, nationally distributed, and capable of supplying energy continuously rather than intermittently. Biomass can also act as a multi-vector energy resource, capable of producing heat, electricity, liquid fuels, and gaseous fuels such as synthetic natural gas (SNG).

The most efficient use of woody biomass is direct combustion for industrial and commercial heat production, achieving conversion efficiencies of approximately 82%. Combined heat and power (CHP) systems are the next most efficient pathway, with overall efficiencies of around 71% when heat is the priority product. By comparison, conversion of wood into liquid transport fuels is substantially less efficient, typically achieving only 48–50% conversion of the original biomass energy into liquid fuel due to the high oxygen content of wood. Wood to SNG to heat is estimated to be around 65% with further losses dependent on the use of the heat (CHP 56% or power only 40%).

Accordingly, the highest-value application of biomass in most regions is the displacement of coal used for space heating or industrial process heat. After coal displacement, the next preferred use is substitution for natural gas, either through direct conversion of industrial boilers to wood fuel systems or through production of synthetic natural gas that can utilise the existing North Island gas pipeline network. A caveat being that the SNG route is at a lower technology readiness (6) level than direct combustion of wood chip or pellets (9).

The study demonstrates strong regional differences in both biomass availability and energy demand:

- Bay of Plenty, Gisborne, Northland, Otago, and Hawke's Bay possess large biomass resources relative to their local energy demand.
- Canterbury has modest biomass availability but substantial coal demand.
- Auckland has by far the largest overall energy demand across all major fuel types and limited local biomass supply.
- Wairarapa possesses significant biomass resources but limited industrial energy demand.
- Southland's lignite demand is declining due to industrial electrification, particularly at Fonterra's Edendale site.

The analysis also identifies electricity transmission constraints as a major factor shaping the value of biomass energy projects. While New Zealand may appear adequately supplied with electricity nationally, regional constraints mean additional local generation can have disproportionately high value in some areas. The upper North Island, Northland, East Coast, and upper South Island are identified as regions where biomass-based generation could materially improve system resilience and reduce transmission constraints.

The HVDC Cook Strait electricity link is a particularly important constraint, limiting the ability to move additional South Island generation northwards. As a result, additional electricity generation in deep South Island regions often has lower marginal value than generation located near North Island demand centres.

Small to medium-scale biomass combined heat and power plants (5–50 MW) could provide meaningful benefits in constrained regions. In particular:

- Northland and the East Coast would benefit from improved local resilience and embedded generation.
- Nelson and Marlborough could support biomass CHP developments due to transmission constraints from the Waitaki hydro system.
- West Coast is structurally vulnerable to transmission interruptions and would benefit materially from local generation.
- The upper North Island has the highest need for large-scale biomass or biorefinery-integrated generation.

Raw wood residues have low volumetric energy density and are, compared to coal, expensive to move long distances in terms of dollars per giga Joule. In regions where biomass supply exceeds local heat demand, upgrading biomass into pellets, synthetic natural gas, or liquid fuels may provide a more economically efficient means of transporting energy to demand centres.

New Zealand has sufficient woody biomass resources to make a major contribution to industrial heat decarbonisation, regional energy resilience, and energy security. However, achieving maximum value from biomass will require regionally optimised priorities that account for:

- local fuel demand,
- conversion efficiency,
- transport economics,
- electricity transmission constraints,
- existing infrastructure,
- and future industrial fuel-switching decisions.

The prioritisation for biomass utilisation based on conversion efficiency, not cost and price, is therefore:

1. Direct combustion for industrial heat;
2. Combined heat and power where local electricity value exists;
3. Pellet production where long-distance transport is required to substitute for coal;
   4th =. Liquid biofuel production for hard-to-electrify sectors such as aviation and marine transport.
   4th =. Synthetic natural gas production where pipeline infrastructure provides an advantage (subject to further technology development);

To meet demands from industrial heat and combined heat and power would take around 60 to 70 PJ, depending on how much CHP develops, meaning there will be enough biomass leftover to initiate industries to convert wood to gas and liquid products. In this context it should also be noted that we can grow more wood as where and when we need it.

Overall, woody biomass represents one of New Zealand's most flexible and regionally important low carbon, renewable energy resources, capable of supporting industrial decarbonisation while improving resilience and reducing dependence on imported or declining fossil fuels.

The total GHG impact of greater use of woody biomass for bioenergy could be a reduction of up to 3.1 million tonnes of $CO_2$-e per annum.

**Further work**

Techno-economic analysis of; SNG production in New Zealand, white and black pellet production and small modular gasification systems including CHP. Detailed feasibility analysis of SNG in a New Zealand context to include, levelised cost of energy, capital intensity, carbon abatement costs, sensitivity to electricity and carbon prices.
Advanced biomass pretreatment research (feedstock engineering and de-mineralisation of wood and straw biomass).

Hub and cluster analysis of biomass agglomeration, upgrading and use.

Full modelling of the New Zealand energy system and its potential use of the available biomass resources, optimised at a regional level where full costs of different supply chains are included.

# Efficient use of biomass resources for bioenergy based on regional supply and demand in New Zealand

## Table of contents

# Introduction

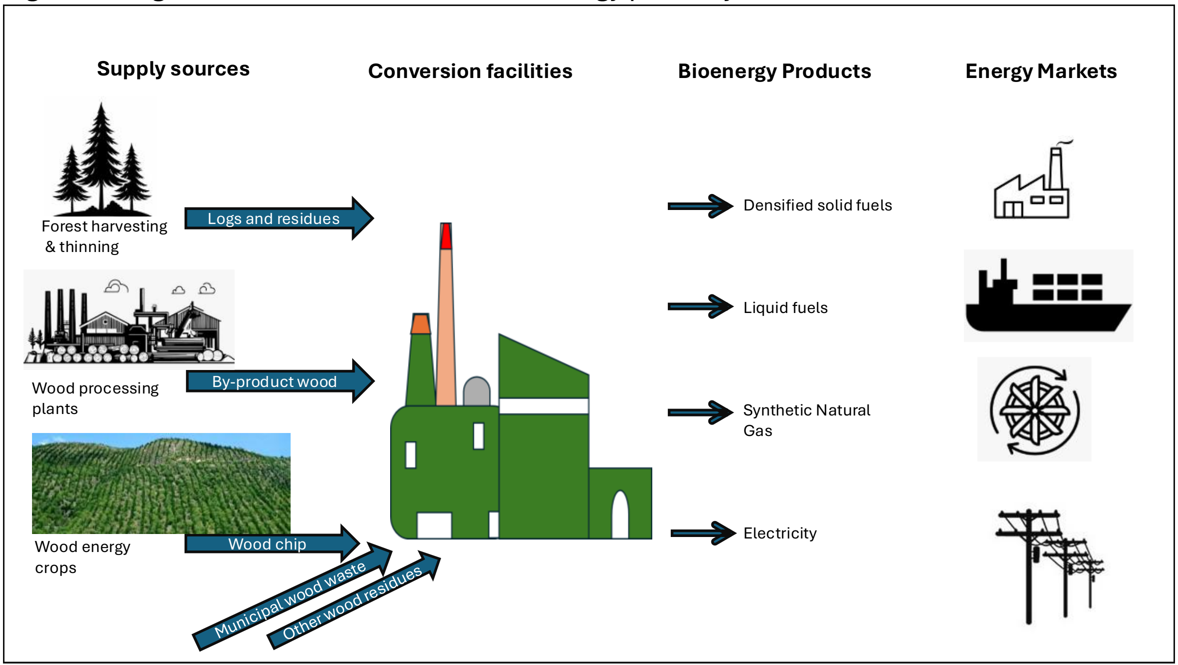
In previous work the Scion Group of the Bioeconomy Science Institute has assessed;

- Availability of a range of ligno-cellulosic resources at a regional level and over time out to 2060 (based on known forest resources and plantings by age class)
- The use of biomass to produce consumer energy such as heat, power and liquid fuels
- Regional energy demand for heat, electricity and liquid fuels

In this analysis we are using updated data on these three topics to determine the most efficient use of the biomass resources New Zealand has, to meet varying regional demands, shaped by logistical and infrastructure constraints. Given the large and all-pervasive demands for energy it is important to get the most out of the energy resources we have, by using them in ways that give the best efficiency of conversion from primary energy to consumer energy. As energy prices rise the efficiency of conversion becomes more important to minimising the impact of those increases on business income as well as national GDP.

Figure 1 shows a broad outline of the concept, the key point being that at regional levels the energy supply sources, including biomass, and energy markets might be very different with different routes from biomass to consumer energy being preferred in different districts.

Figure 1 – high-level biomass to consumer energy pathways.




Some examples of this would be;

- Gisborne region has a high volume of wood residues with limited demand for solid fuels such as coal or wood, but it does have a gas pipeline and some natural gas consumption.
- Canterbury has a modest wood resource but a very large demand for coal.
- The southern Wairarapa has a large wood resource, and no significant industrial demand for energy south of Masterton
- Producing significantly more electricity in the South Island is problematic without an upgrade to the HVDC (Cook Strait) transmission cables, with persistent inter-island price separation reflecting this constraint (Electricity Authority, n.d.).

The costs of transporting wood in its raw forms (logs, binwood, chips and other residues) are high in terms of $ per GJ due to the low volumetric energy density of the raw material in this form. To move it efficiently to a place where there is an energy demand may require changing its form, to a densified solid (wood pellet), a liquid (marine fuel) or a gas (synthesised methane).

Forest derived bioenergy stands out amongst energy sources. Compared to other energy options like hydro, wind, solar, coal or natural gas, bioenergy is the only one that meets the following performance criteria;

- Large-scale long-term supply
- Can regenerate
- Is a natural process
- Has low $CO_2$ emissions
- Fixes $CO_2$ and recycles $CO_2$ from the atmosphere
- Is nationally applicable
- It is not seasonal
- It is not cyclical, supply does not vary day to day
- It is storable as a forest (a forest is essentially a battery being charged), in a log yard, in a chip or in a pellet silo.

Woody biomass from New Zealand's roughly 1.8 million ha of plantation forests is our single largest biomass resource, and the one with the most potential to expand. Wood can be considered a multi-vector fuel as it can be used to make;

1. Heat
2. Electricity (preferably heat and electricity together)
3. Liquid fuels
4. Gaseous fuels

Wood can be made into a synthetic natural gas, which means it can be used as a pipeline quality natural gas substitute and be piped to users of natural gas to make heat or electricity, leveraging existing infrastructure with a low carbon substitute for what is in New Zealand, a resource with declining supply and rising prices. It can potentially move the energy in wood long distances to points of energy demand efficiently.

Future energy supply and demand is subject to change based on pricing, regulation and technology change. This analysis is based on what we know and is not attempting to predict changes to future energy demand.

# Literature Review

**Global context of bioenergy and the energy transition**
Bioenergy is increasingly recognised as a cornerstone of the global transition toward low-emission energy systems. According to the International Energy Agency (IEA, 2023), bioenergy currently contributes around 10% of global primary energy supply, making it the largest source of renewable energy worldwide. The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (2023) underscores bioenergy's dual role: as a direct substitute for fossil fuels and as a negative-emission option when coupled with carbon capture and storage (BECCS) (Chum et al., 2011).

Recent analyses emphasise the importance of aligning bioenergy deployment with regional biomass availability, land-use dynamics, and socio-environmental constraints (Sevigné-Itoiz et al., 2021; Creutzig et al., 2015). Early optimism around global biofuel expansion has been tempered by growing awareness of land-use change emissions and competition with food production (Searchinger et al., 2008; Searle & Malins, 2015; Tonini et al., 2012). Consequently, contemporary research stresses the need for regionally optimised bioenergy use that reflect local resource endowments and demand profiles.

The literature identifies two broad perspectives: (1) the resource potential approach, which estimates the physical availability of biomass feedstocks and their conversion efficiency into energy carriers (Batidzirai et al., 2019; Lamers et al., 2012); and (2) the systems optimisation approach, which models spatially explicit scenarios of biomass supply, logistics, and demand interactions (van der Hilst et al., 2012; Daioglou et al., 2019). Together, these frameworks guide policy and investment decisions across diverse national contexts.

In this context, forest-derived biomass has emerged as a particularly promising feedstock due to its scalability, carbon circularity, and established supply chains (Nepal et al., 2015; IEA Bioenergy, 2024). Internationally, the mobilisation of forestry residues and low-grade logs for bioenergy production is increasingly seen as a means to both mitigate waste and contribute to rural economic development (Naik et al., 2010; Batidzirai et al., 2019).

**The role of forestry biomass in sustainable energy systems**
Forestry-based biomass occupies a central role in global and regional bioenergy development due to its abundance, renewability, and compatibility with existing industrial processes. Globally, forestry residues, thinnings, and low-grade timber represent a vast, underutilised energy resource (Slade et al., 2014). Studies estimate that woody biomass could sustainably contribute between 10% and 20% of global energy demand by 2050 if mobilised under sustainable management regimes (Searle & Malins, 2015; IEA Bioenergy, 2024).

Forestry biomass is especially relevant for sectors that require dense, storable energy carriers. Technologies such as gasification, pyrolysis, and hydrothermal liquefaction enable the conversion of wood residues into synthetic gas, bio-oil, and advanced liquid biofuels suitable for marine and aviation use (Naik et al., 2010; Reid et al., 2020). In addition, combustion of forest residues can provide renewable process heat, a major area of fossil fuel use in many industrial economies (Sevigné-Itoiz et al., 2021).

However, forestry-based bioenergy systems are highly context-dependent. Their sustainability hinges on regional forest dynamics, transport infrastructure, and competing demands for wood products (Lamers et al., 2012). Spatially explicit analyses demonstrate that resource distribution, rather than simply total volume, often determines the technical and economic feasibility of bioenergy projects (van der Hilst et al., 2012; Daioglou et al., 2019). Consequently, regional-scale assessments have become an essential tool for bioenergy planning.

**Bioenergy transitions and policy in New Zealand**

New Zealand presents a distinctive case for bioenergy transition due to its geographical isolation, substantial forestry sector and its national commitment to decarbonisation. Forestry covers approximately 1.8 million hectares, representing the country's largest terrestrial carbon sink and primary source of biomass feedstock (Ministry for Primary Industries, 2020; Manley et al., 2020). The national cut from these forests is in the order of 32 million cubic metres per annum (MPI 2025), with uneven regional distribution. The Ministry of Business, Innovation and Employment (MBIE, 2024) reports that fossil fuels, particularly coal and natural gas, still provide over 60% of process heat used in industry, highlighting a significant decarbonisation opportunity.

Scion's bioenergy research programme has led efforts to quantify New Zealand's biomass resources and explore their potential for energy substitution (Hall & Gifford, 2022; Hall, Jack, & Barry, 2021; Hall & Jack, 2019). The wider wood processing sector, a key source of processing residues and an established platform for bioenergy integration, has been characterised in successive industry reviews and sustainability assessments (Andrew, Forgie & Lennox, 2008; Nielsen & Buckleigh, 2020). Estimates suggest that 4–5 million cubic metres of residual woody biomass are technically recoverable annually, complemented by 6–7 million cubic metres of low-grade export logs (Hall & Jack, 2017; IEA Bioenergy Task 43, 2023). These volumes represent a significant domestic energy potential that remains largely untapped.

Policy drivers, including the New Zealand Emissions Trading Scheme (ETS) and the government's Process Heat in Industry Decarbonisation Programme, have accelerated interest in biomass-based solutions (Ministry for the Environment (MfE), 2024; NZ Productivity Commission, 2018). At the same time, regional events such as the 2018 Tolaga Bay storm and Cyclone Gabrielle in 2023 have highlighted the environmental risks of unmanaged forestry residues, leading to changes in the National Environmental Standards for Plantation Forestry.

In regions like Gisborne and Northland, where forest residues have contributed to off-site damage during storm events, value-adding uses such as energy recovery could improve both economic and environmental outcomes. Such regional integration aligns with international best practice, which emphasises localised biomass utilisation to minimise transport emissions and maximise co-benefits (Sevigné-Itoiz et al., 2021; IEA Bioenergy, 2024).

**Regional biomass potential and energy substitution scenarios**

A growing body of New Zealand research employs spatially explicit modelling to match regional biomass supply with fossil fuel demand. In the last decade Scion's wood availability databases, NZ Bioenergy Systems Model (NZBSM) and the Bioenergy Supply Model (BSM) have been estimating how forestry residues, low-grade logs, and processing by-products could meet regional energy needs (Hall & Jack, 2017; Hall et al., 2025). These models integrate plantation forest area and age by district, projected harvest volumes by district, and transportation networks to forecast forest derived biomass availability over time and by distance from fuel users.

Regional energy demand patterns vary widely across New Zealand, reflecting industrial composition, population density, and resource endowment (EECA, 2025). The South Island's process heat sector is heavily reliant on coal, while the North Island depends more on natural gas (MBIE, 2024). Liquid fuel demand, meanwhile, is distributed across transport corridors and ports, with aviation and marine sectors contributing a large share of fossil-based emissions (Suckling et al., 2017).

Matching these demands with biomass availability requires not only technical conversion analysis but also geographic optimisation. Hall and Jack (2019) demonstrated that up to 30% of New Zealand's coal use could be substituted with local biomass, particularly in regions such as Bay of Plenty, Gisborne, and Southland, where forestry residues are abundant. Further research by Hall and Jack (2013) extended this analysis to liquid biofuels, showing that between 5 and 10% of national transport fuel demand could feasibly be met from domestic wood-based sources.

The literature consistently stresses that regional optimisation is the key to realistic substitution scenarios (BERL, 2023). Transport costs, feedstock seasonality, and competing uses for low-grade logs influence both the economics and the carbon balance of bioenergy systems (Lamers et al., 2012; Hall, 2018; Sevigné-Itoiz et al., 2021). Hence, a spatial approach, integrating regional demand profiles with local biomass supply, provides the appropriate analytical foundation.

**Drivers and barriers for bioenergy deployment**

Despite favourable conditions, large-scale deployment of bioenergy in New Zealand faces several structural barriers. These include limited infrastructure for biomass transport and processing, fragmented supply chains, and uncertainty in long-term policy and market signals (NZPC, 2018; Hall et al., 2021). The high cost of biofuel conversion technologies, coupled with competition from alternative decarbonisation pathways such as electrification and hydrogen, pose additional challenges (Solaymani & Botero, 2025).

Nonetheless, international experience suggests that well-designed policy frameworks can overcome these barriers. For instance, coordinated investment in feedstock aggregation, logistics hubs, and bio-refinery infrastructure has been shown to reduce costs and risks (Batidzirai et al., 2019; Sevigné-Itoiz et al., 2021). Similarly, stable carbon pricing mechanisms enhance investor confidence by improving the relative competitiveness of bioenergy (Scarlat et al., 2015; Nepal et al., 2015).

In New Zealand, strengthening institutional coordination between forestry, energy, and environmental agencies is a recurring recommendation. The Climate Change Commission (2023) and Scion (2024) both highlight the need for integrated governance frameworks that couple afforestation policy with industrial decarbonisation goals. Furthermore, the co-benefits of biomass utilisation, including waste reduction, slash / erosion control, and rural employment, can make bioenergy deployment politically and socially attractive at the regional level.

**Research gaps and emerging directions**

Despite considerable progress in quantifying biomass resources, several knowledge gaps remain. First, existing datasets often underestimate the temporal variability of residue production and overlook competing uses in the wood processing industry (Manley et al., 2020). Second, the alignment between regional biomass supply and specific fossil fuel demand profiles, especially for gas and jet fuel, remains underexplored in national policy documents. Third, while numerous techno-economic studies exist, fewer integrate sustainability, social licence, and circular economy considerations into bioenergy scenario modelling (Cherubini & Strømman, 2011; Börjesson & Tufvesson, 2011).

Globally, emerging work is moving toward dynamic modelling of biomass resource flows under changing land-use and policy scenarios (Duarah et al., 2022). New Zealand's bioenergy research could benefit from adopting similar approaches, integrating real-time forest inventory data, remote sensing, and lifecycle carbon modelling into predictive frameworks. Moreover, international studies highlight the importance of aligning bioenergy strategies with broader circular bioeconomy principles, ensuring that biomass use complements other ecosystem services (Sevigné-Itoiz et al., 2021; Scion, 2024).

In this context, the current study contributes to filling a key gap: assessing the demand for bioenergy based on regional fossil fuel consumption biomass availability and the most efficient options for its use. By quantifying the potential for biomass to replace coal, gas, and liquid fuels, and evaluating how regional resource endowments align with energy demand profiles, this research provides an integrated basis for national and regional bioenergy planning in New Zealand.

# Methods

**Biomass resources**
The biomass resources available at a regional level are taken from the Scion report: Residual biomass fuel projections for New Zealand; 2024 - Indicative availability by region and source (Hall, 2024). The full methodologies for the derivation of the resources are outlined in that report. The key underlying data is the National Exotic Forest Description (MPI, 2025), which has forest area and age data by Territorial Authority. The age data and associated yield tables allow prediction of wood supply out to 30 years from now, as it is based on the area planted, including stands that were only 1 year old in 2025.

The resource data presented here includes; post-harvest landing residues, post-harvest cutover residues, municipal wood waste, horticulture and viticulture turnover residues, shelter belt turnover, radiata pine production thinning residues and Douglas fir production thinnings. The categorisation of these residue streams follows earlier work characterising New Zealand wood processing residues for bioenergy (Nicholas et al., 2004). It also includes the gross supply of pulp logs, KIS, KI, KS and K grade logs. Chemically treated timber, which is unsuitable as a bioenergy feedstock without specialised emissions controls, is excluded from these volumes (New Zealand Timber Preservation Council, n.d.). The data is at a regional level.

**Regional energy demand**
Regional energy demand was derived from a range of sources. These include the Energy Efficiency and Conservation Authority Regional Energy Transition Accelerator studies, Ministry of Business, Innovation and Employment data (Energy in NZ 25), The energy end-use database, Scion's wood processing database (Hall, 2023), industry newsletters (Friday Offcuts; WoodWeek), and data contained in historic and current government data sets (EECA, 2014; EECA, 2025).

These data sets were compared and filtered to determine an estimate of regional energy use. There are differences between data sets and where discrepancies occurred, we used MBIE data as the best source of information. Some data (gas and electricity use) is more accurate than others as the use of these energy forms is metered. Other energy forms (coal, wood, geothermal) are estimates based on plant sizes and standard plant utilisation rates and conversion efficiencies. Further, some electricity generation and geothermal heat production and use is "behind the meter".

The figures on energy demand are not assumed to be precise but indicate the level of use for key energy types at a regional level and where there are peaks of demand for particular forms of energy and fuel. Some of these peaks are population driven (Auckland / petrol) and some are industry driven, e.g., coal and electricity in various regions based on large industrial users such as cement, steel and aluminium manufacture.

**Efficient use of biomass**
Information on the conversion efficiencies of various routes from wood to consumer energy was derived from a range of sources including the WoodScape study and model (Jack et al., 2013), New Zealand Biofuels Roadmap analysis and reports (Suckling et al., 2017), a major study by IEA Bioenergy (Hall & Jack, 2013), on-line sources and AI based data searching. The Bioenergy Options for New Zealand study was also used to source data on energy pathways (Hall & Jack, 2013; Gifford & Hall, 2014). These data were assembled and summarised.

The routes used include not just the primary conversion to a form of consumer energy (heat) but includes the possible conversion of that heat into another form of consumer energy such as electricity. There are many potential routes from woody biomass to liquid biofuels (Gasification and Fischer-Tropsch catalysis, fast pyrolysis, enzymatic hydrolysis etc). They all have a limitation on how much of the energy contained in the wood can be converted to energy in the liquid fuel of around 48 to 50%, driven by the oxygen (42 to 43%) and ash content (0.5 to 1.0%) of the wood as liquid fuels such as diesel and jet fuel have very low oxygen content and no ash content.

**Other constraints**
Artificial Intelligence (ChatGPT) was used to get an overview of regions of New Zealand with constraints on the electricity grid and where additional local generation would have value that does not appear in simple supply and demand analysis.

Major changes that have been announced by large energy users have been considered where relevant.

The technology readiness levels of the various processes were assessed and this needs to be considered as some uses are well proven and some are still at demonstration stage.

**Most efficient uses by region**
The biomass supply data, energy demand data and the best use rankings were then brought together to assess what the biomass available at a regional level would be best used for. The first priority use was to meet the coal demand; the second priority was to meet gas demand. If there is any biomass remaining after those demands are met, then they would be used for combined heat and power.

# Results and discussion

## Regional biomass resources

The volume of woody biomass available by region, over time is shown in Table 1 (Hall, 2024). There is a low point in supply around 2036 to 2040, based on historic planting rates affecting future supply volumes. This low point has been used as the maximum supply, to be conservative with estimates of what is possible.

The future supply after 2040 will be higher, but whether it will continue at the same levels as 2056 to 2060 will depend on planting rates over the next few years. If there is a drop off in planting, or deforestation (as in 2002 to 2007) then biomass availability may decline to the levels available in 2036 to 2040.

Table 1 – woody biomass supply, cubic metres of log equivalent per annum

| | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | 2051-2055 | 2056-2060 |
|---|---|---|---|---|---|---|---|
| **Northland** | 1,478,000 | 1,024,000 | 1,504,000 | 1,952,000 | 1,904,000 | 1,763,000 | 1,519,000 |
| **Auckland** | 617,000 | 408,000 | 282,000 | 244,000 | 370,000 | 617,000 | 727,000 |
| **Waikato** | 1,735,000 | 1,373,000 | 1,041,000 | 859,000 | 1,010,000 | 1,472,000 | 1,652,000 |
| **Bay of Plenty** | 3,304,000 | 3,051,000 | 3,383,000 | 3,642,000 | 3,398,000 | 3,314,000 | 3,218,000 |
| **Gisborne** | 1,949,000 | 1,184,000 | 927,000 | 1,079,000 | 1,276,000 | 1,523,000 | 1,610,000 |
| **Hawkes Bay** | 1,220,000 | 1,008,000 | 931,000 | 1,185,000 | 1,555,000 | 1,488,000 | 1,134,000 |
| **Taranaki** | 376,000 | 180,000 | 120,000 | 144,000 | 276,000 | 370,000 | 276,000 |
| **Manawatu-Wanganui** | 924,000 | 428,000 | 277,000 | 291,000 | 387,000 | 652,000 | 629,000 |
| **Wellington** | 368,000 | 216,000 | 111,000 | 96,000 | 176,000 | 268,000 | 182,000 |
| **Wairarapa** | 822,000 | 327,000 | 354,000 | 506,000 | 742,000 | 950,000 | 1,094,000 |
| **Tasman / Nelson** | 773,000 | 745,000 | 672,000 | 597,000 | 600,000 | 711,000 | 739,000 |
| **Marlborough** | 956,000 | 574,000 | 667,000 | 757,000 | 750,000 | 883,000 | 1,288,000 |
| **West Coast** | 140,000 | 127,000 | 127,000 | 118,000 | 117,000 | 114,000 | 711,000 |
| **Canterbury** | 1,217,000 | 724,000 | 403,000 | 431,000 | 507,000 | 801,000 | 944,000 |
| **Otago** | 1,589,000 | 1,133,000 | 971,000 | 1,182,000 | 1,354,000 | 1,503,000 | 1,210,000 |
| **Southland** | 910,000 | 608,000 | 412,000 | 446,000 | 541,000 | 734,000 | 742,000 |
| **Total** | **18,384,000** | **13,117,000** | **12,191,000** | **13,538,000** | **14,969,000** | **17,172,000** | **17,682,000** |

The supply volumes in Table 1 are converted to energy in Table 2. The assumption is that there is 6.9 GJ in each cubic metre of wood.

Table 2 – PJ per annum of energy from woody biomass

| | **2026-2030** | **2031-2035** | **2036-2040** | **2041-2045** | **2046-2050** | **2051-2055** | **2056-2060** |
|---|---|---|---|---|---|---|---|
| **Northland** | 10.20 | 7.07 | 10.38 | 13.47 | 13.14 | 12.17 | 10.48 |
| **Auckland** | 4.26 | 2.82 | 1.95 | 1.69 | 2.56 | 4.26 | 5.02 |
| **Waikato** | 11.97 | 9.48 | 7.19 | 5.93 | 6.97 | 10.16 | 11.40 |
| **Bay of Plenty** | 22.80 | 21.06 | 23.35 | 25.13 | 23.45 | 22.87 | 22.21 |
| **Gisborne** | 13.45 | 8.17 | 6.40 | 7.45 | 8.81 | 10.51 | 11.11 |
| **Hawkes Bay** | 8.42 | 6.96 | 6.43 | 8.18 | 10.73 | 10.27 | 7.83 |
| **Taranaki** | 2.60 | 1.24 | 0.83 | 1.00 | 1.91 | 2.56 | 1.91 |
| **Manawatu-Wanganui** | 6.38 | 2.96 | 1.92 | 2.01 | 2.67 | 4.50 | 4.34 |
| **Wellington** | 2.54 | 1.50 | 0.77 | 0.67 | 1.21 | 1.85 | 1.26 |
| **Wairarapa** | 5.68 | 2.26 | 2.45 | 3.50 | 5.12 | 6.56 | 7.55 |
| **Tasman / Nelson** | 5.34 | 5.14 | 4.64 | 4.12 | 4.14 | 4.91 | 5.10 |
| **Marlborough** | 6.60 | 3.97 | 4.61 | 5.23 | 5.18 | 6.10 | 8.89 |
| **West Coast** | 0.97 | 0.88 | 0.88 | 0.82 | 0.81 | 0.79 | 4.91 |
| **Canterbury** | 8.40 | 5.00 | 2.78 | 2.98 | 3.50 | 5.53 | 6.52 |
| **Otago** | 10.96 | 7.82 | 6.70 | 8.16 | 9.34 | 10.38 | 8.36 |
| **Southland** | 6.28 | 4.20 | 2.85 | 3.08 | 3.73 | 5.07 | 5.12 |
| **Total** | **126.85** | **90.51** | **84.12** | **93.42** | **103.29** | **118.49** | **122.01** |

## Regional energy demand

Regional energy demand by fuel type or energy carrier (electricity) is shown in Table 3. Table 3 excludes petrol, geothermal and solar energy as substitution for these fuels by woody biomass is either not required or not viable. A full table of all energy forms is shown in Appendix C.

Lignite and coal are reported separately. Use of lignite is restricted to Southland, where it has been extensively used in dairy and meat processing. Use of lignite has been in decline in recent years with the closure of a tannery, a meat works and one boiler (of 4) at Edendale dairy factory being electrified. This has reduced the annual demand for lignite by around 0.3 PJ from a peak of around 4.8 PJ in 2000.

Auckland has the largest energy demand by far, driven by its population. Auckland has the largest demands for almost all types of energy except geothermal and black liquor. These are niche fuels limited to regions that have geothermal resources and in the case of black liquor, Kraft pulp mills.

Table 3 – Regional energy demand by fuel type

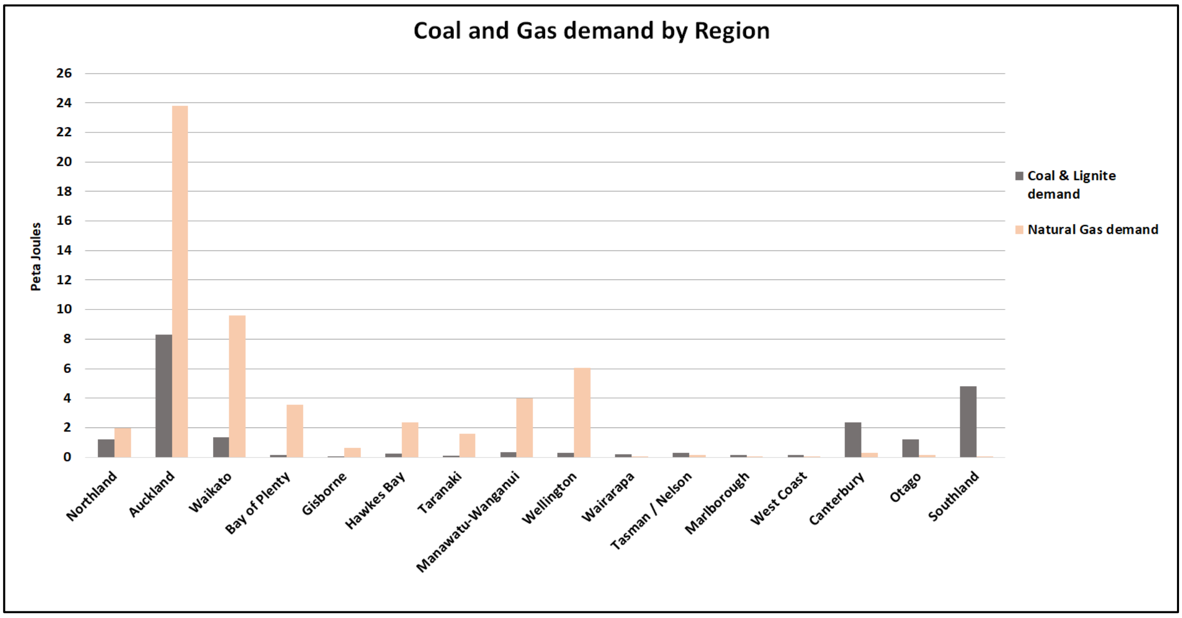
| Region | Wood | Black Liquor | Coal | Lignite | Natural Gas | LPG | Electricity | Aviation Fuel | Fuel Oil | Diesel | Total in PJ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Northland** | 1.02 | | 1.22 | | 1.97 | 0.30 | 4.07 | 0.12 | 0.07 | 5.77 | **14.53** |
| **Auckland** | 7.20 | | 8.33 | | 23.78 | 2.49 | 36.86 | 9.47 | 0.42 | 38.08 | **126.63** |
| **Waikato** | 2.77 | 5.90 | 1.32 | | 9.62 | 0.71 | 12.93 | 0.61 | 0.08 | 15.82 | **49.78** |
| **Bay of Plenty** | 2.27 | 5.20 | 0.15 | | 3.57 | 0.45 | 7.40 | 0.45 | 0.20 | 8.99 | **28.68** |
| **Gisborne** | 0.31 | | 0.05 | | 0.61 | 0.08 | 1.12 | 0.06 | 0.02 | 1.74 | **3.99** |
| **Hawke's Bay** | 0.80 | | 0.24 | | 2.37 | 0.29 | 3.96 | 0.20 | 0.09 | 5.48 | **13.42** |
| **Taranaki** | 0.56 | | 0.10 | | 1.57 | 0.21 | 3.54 | 0.20 | 0.14 | 4.86 | **11.17** |
| **Manawatu-Wanganui** | 1.13 | | 0.35 | | 4.00 | 0.38 | 7.21 | 0.57 | 0.01 | 8.03 | **21.68** |
| **Wellington** | 2.08 | | 0.31 | | 6.07 | 0.72 | 12.71 | 1.13 | 0.11 | 11.50 | **34.62** |
| **Nelson** | 0.37 | | 0.18 | | 0.02 | 0.14 | 2.62 | 0.85 | 0.16 | 2.56 | **6.90** |
| **Tasman** | 0.64 | | 0.30 | | 0.13 | 0.13 | 1.50 | 0.05 | 0.02 | 2.16 | **4.93** |
| **Marlborough** | 0.35 | | 0.13 | | 0.04 | 0.13 | 1.48 | 0.11 | 0.07 | 2.48 | **4.80** |
| **West Coast** | 0.26 | | 0.16 | | 0.02 | 0.09 | 1.33 | 0.19 | 0.02 | 1.91 | **3.98** |
| **Canterbury** | 4.06 | | 2.37 | | 0.29 | 1.66 | 18.47 | 2.14 | 0.28 | 20.68 | **49.94** |
| **Otago** | 1.37 | | 1.20 | | 0.12 | 0.54 | 6.81 | 0.53 | 0.12 | 7.52 | **18.22** |
| **Southland** | 0.71 | | 0.69 | 4.45 | 0.05 | 0.31 | 23.19 | 0.19 | 0.10 | 5.52 | **35.20** |
| **Total in PJ** | **25.90** | **11.10** | **17.10** | **4.45** | **54.21** | **8.63** | **145.19** | **16.86** | **1.91** | **143.12** | **428.47** |

*Excludes: Petrol, geothermal and solar, full table in Appendix C

Coal is largely used as heat fuel, and so is a target for substitution by wood in some form (chip, pellets, torrefied pellets etc). The demand for coal and gas by region are shown in Figure 2. In Figure 2 coal and lignite are combined. This only affects the data for Southland. There is very limited use of Natural Gas (NG) in the South Island as there is no NG pipeline. However, there is use of bottled NG with the largest use of NG in the South Island being in Canterbury, driven by the large population centre of Christchurch. Much of the electricity used comes from renewable sources (17 to 108 PJ), meaning that at a national level around 37 to 38 PJ is coming from non-renewable resources.

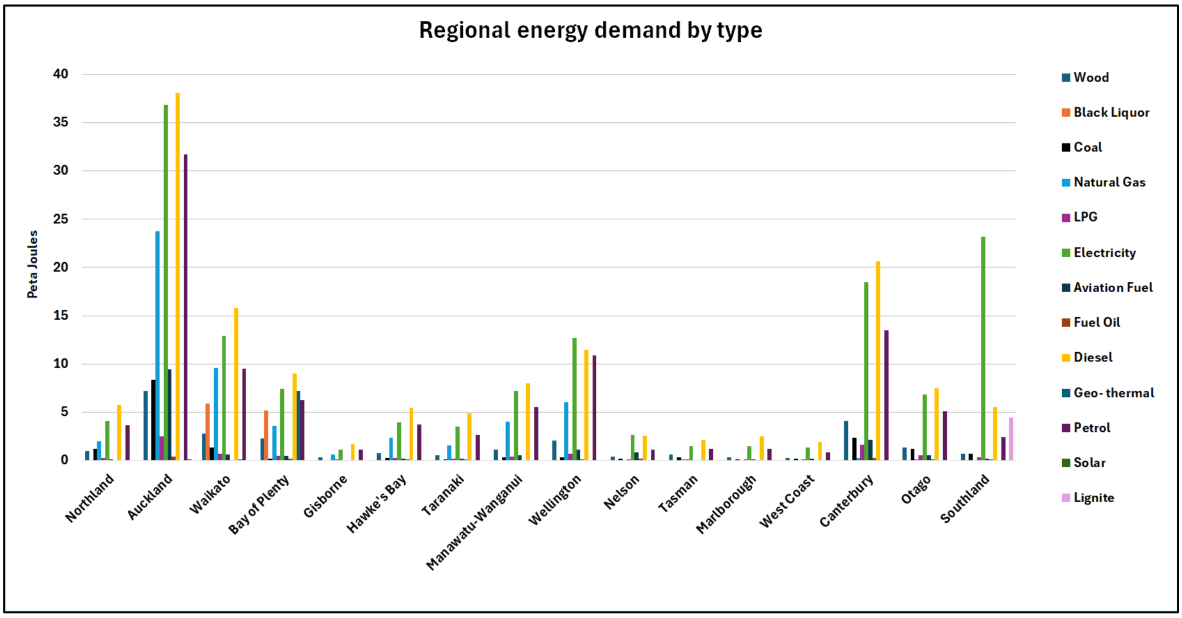
Figure 3 shows the regional demand for all the main forms of energy, including solar, geothermal and petrol. The peak in electricity demand in Southland, which has a low population compared to other regions with much lower electricity demand is the aluminium smelter at Tiwai Point. This single site takes around 12% of New Zealand’s electricity, largely from electricity generated in western Southland (Manapouri).

Figure 2 – coal and gas demand by region




Electricity and diesel are consistently the largest energy demands across most regions. Some fuels tend to have peaks driven by population, others by industry. Some by the presence of resources that other regions do not have (geothermal).

Figure 3 – All energy demand by region and energy type



## Best use of biomass - conversion efficiency

The results of the review of energy conversion efficiencies are shown in Table 4. The potential routes are ranked on their conversion from primary fuel to consumer energy, expressed as a percentage of the original energy in the primary fuel that becomes consumer energy. The lower the value the worse the result and the less preferred that route would be. Some fossil fuel routes are included for comparison (those rows are shaded).

The best use of wood fuels is for heat in the form of chip or hog. The second best is combined heat and power with heat as the priority product and electricity recovered using a back pressure turbine. The use of pellets for heat is less efficient than chip to heat due to the energy use and losses associated with manufacturing the pellets. These three routes all also have high TRLs. There may be good reason to consider white pellet-based routes if there is incumbent infrastructure to consider in the long run cost of the heat produced. The use of white and black pellets for a heat priority combined heat and power plant (CHP) rank third and fourth. CHPs fired with white and black pellets rank fifth and sixth respectively. The lower rankings of TRLs for the black pellet-based routes is due to the lower TRL of making the black pellets.

It is possible to make a synthetic natural gas (methane) from wood, and this can be used in existing natural gas (NG) fired boilers, this option ranked seventh of the wood-based options, it has a lower TRL than wood combustion due to the wood to SNG technology still being at demonstration stage. The use of chip in a CHP to make electricity and heat (with electricity as first priority and a condensing turbine) was eighth. Making electricity on its own from biomass has low conversion efficiency.

For details on what the TRL numbers mean see Appendix E. However, TRL 9 means fully commercialised and widely used and a 6 indicates that a technology has been demonstrated in a relevant environment but is yet to be commercialised.

Table 4 – primary energy of fuel to consumer energy conversions Technology Readiness Levels (TRL), (fossil fuel options are shaded and provided for context)

| | Primary fuel to consumer energy route | Energy conversion factor % | Technology Readiness Level |
|---|---|---|---|
| | Gas to heat | 92.5 | 9 |
| | Coal to heat | 85.0 | 9 |
| | Gas to CHP OC HTH | 84.0 | 9 |
| 1 | Wood to heat | 82.5 | 9 |
| 2 | White pellets to heat | 72.0 | 9 |
| 3 | Wood to CHP steam + BPT | 71.6 | 9 |
| 4 | Black pellets to heat | 68.0 | 7 |
| 5 | Wood to CLG gas to heat | 65.8 | 6 |
| | Gas to CHP CC LTH | 62.0 | 9 |
| 6 | White pellets to CHP BPT | 61.2 | 8 |
| | Gas to electricity CCT | 61.0 | 9 |
| 7 | Wood to gas to heat | 59.1 | 6 |
| 8 | White pellets to CHP CT | 57.6 | 8 |
| 9 | Wood to CLG gas to CHP LTH CT | 56.8 | 6 |
| 10 | Wood to CHP + CT | 56.5 | 9 |
| 11 | Wood to gas to CHP LTH CT | 51.8 | 6 |
| 12 | Wood to CLG gas to CHP HTH BPT | 49.8 | 6 |
| 13 | Wood to liquid fuel | 48.5 | 6 |
| 14 | Black pellets to CHP BPT | 47.6 | 7 |
| 15 | Wood to CLG gas to electricity CCT | 47.0 | 6 |
| 16 | Black pellets to CHP CT | 44.8 | 7 |
| 17 | Wood to gas to CHP HTH BPT | 44.8 | 6 |
| 18 | Wood to gas to electricity CCT | 40.9 | 6 |
| | Gas to electricity OCT | 34.0 | 9 |
| 19 | Wood to electricity RC | 32.5 | 8 |
| 20 | Black pellets to electricity OCT | 26.4 | 6 |
| 21 | Wood to CLG gas to electricity OCT | 26.2 | 6 |

| | | | |
|---|---|---|---|
| 22 | White pellets electricity OCT | 25.5 | 8 |
| 23 | Wood to gas to electricity OCT | 22.8 | 6 |

Notes for Table 4; *SNG synthetic natural gas, **OCT = open cycle turbine, ***CCT = combined cycle turbine, ****CHP = combined heat and power, *****HTH = high temperature heat, ******BPT = back pressure turbine, *******CT = condensing turbine, CLG = chemical looping gasification

In simple terms the best uses for wood are outlined in Table 5. Based on these figures the best use, where possible, is to use the wood for heat production via combustion. The option of making heat and power is also quite efficient.

Table 5 – most efficient uses of wood by conversion route

| **Product** | **Route** | **Conversion factor, %** |
|---|---|---|
| Heat | Combustion | 82 |
| Combined heat & power | Combustion + steam turbine | 71 |
| Heat | CL wood gasification + combust gas | 65 |
| Liquid fuel | Various routes similar (e.g., gasification + FT or Fast catalytic pyrolysis) | 48 to 50 |
| Electricity | CLG plus CCT | 47 |
| Electricity | Combustion + Rankine cycle steam turbine; no heat recovery | 32 |

*CL = chemical looping, CLG = chemical looping gasification

### *Sector substitution limits*

Feasible replacement of coal by biomass varies significantly by sector. For moderate-temperature processes such as meat, dairy, and other food processing, along with wool, timber, pulp, and paper production, biomass can fully replace coal, these applications primarily require steam generation and process heating below 200 °C, which biomass combustion readily delivers. For high-temperature processes used in cement, steel, and some chemical manufacturing, full substitution is not currently feasible; co-firing with coal at partial substitution rates is the established pathway.

Table 6 – Coal-to-biomass substitution potential for industrial process heat by sector

| Sector | Site types | Substitution (%) | Source |
|---|---|---|---|
| Commercial | Accommodation (hotels/motels), entertainment venues, and other commercial enterprises | 80–100% | Lenz, Szarka, Jordan & Thrän (2020) |
| Dairy product manufacturing | Dairy product manufacturing/processing sites | 100% | EECA (2025) |
| Education | Tertiary education (university/polytechnic), schools (primary and secondary) | 80–100% | Ciolkosz (2024) |
| Food and beverage manufacturing (excl. dairy, meat) | Food and beverage product manufacturing (excluding dairy and meat); fruit, vegetable | 80–100% | Lenz, Szarka, Jordan & Thrän (2020) |
| Government (central / local) | Council buildings, defence/military facilities, prisons | 80–100% | U.S. Department of Energy (2004) |
| Healthcare | Hospitals, aged care facilities | 80–100% | Triple Green Products (2025) |
| Indoor cropping | Glasshouses, indoor cropping buildings | 80–100% | Lenz, Szarka, Jordan & Thrän (2020) |
| Meat product manufacturing | Meat product manufacturing/processing sites | 100% | EECA (2025) |
| Metals | Steel, aluminium, and metal products | 10–30% | Lenz, Szarka, Jordan & Thrän (2020) |
| Mining | Mining, quarrying | 30% | Ciolkosz (2024) |
| Non-metallic minerals | Concrete, cement, limestone production | 20–30% | Mikulčić et al. (2019) |
| Oil & gas | Gas treatment, hydrocarbon production | 15–30% | U.S. Department of Energy (2004) |
| Other manufacturing | Mechanical products, building construction products | 50–80% | Lenz, Szarka, Jordan & Thrän (2020) |
| Petrochemicals, chemicals, polymers and rubber | Petrochemicals, chemicals, asphalt, bitumen, and rubber product manufacturing | 30–50% | Lenz, Szarka, Jordan & Thrän (2020) |
| Textiles | Textile and fabric manufacturing, associated products | 80–100% | Saidur et al. (2011) |
| Waste management | Waste treatment | 50–80% | U.S. Department of Energy (2004) |
| Wood product manufacturing | Wood products, sawmills | 100% | Holmberg & Gustavsson (2007) |

Table 6 summarises sectors and site types from the Regional Heat Demand Database (EECA, 2025). Considering each sector's heat requirements, we assessed the proportion of coal that can be feasibly replaced by biomass without affecting process performance. The percentage column indicates replacement potential, for example, dairy product manufacturing can be entirely substituted (100%), whereas non-metallic minerals (cement, lime) is limited to 20–30%.

In cement processing, research demonstrates that biomass co-firing with coal at 20% thermal substitution has been successfully implemented in industrial rotary kilns (Mikulčić et al., 2019). Comprehensive testing indicates that co-firing rates up to 30% can be achieved without significant operational problems, provided fuel-handling equipment is compatible with biomass characteristics.

Similarly, in steel production, biochar substitution ranges from 5% to a maximum of 50% are technically possible, though most applications operate at approximately 20–25% to avoid compromising process performance (Al Hosni et al., 2024). Woody biochars specifically have demonstrated potential to replace about 20% of coke in large blast furnaces without causing quality problems in the steel produced (Peters et al., 2024).

## Other constraints and drivers

In New Zealand the issue around electricity is not just total generation, but where the generation is relative to demand, transmission distances and transmission constraints. The result is that some regions, and the operation of the local grid, would benefit materially from additional local generation, even if the country as a whole appears adequately supplied most of the time.

In some instances, geography drives local issues, due to two key structural facts:

- Most hydro generation is in the South Island
- Most demand is in the North Island (especially upper North Island / Auckland)

Electricity flows north via the HVDC link (Cook Strait cables), which can become constrained. It has a maximum capacity (northbound) of 1200 MW, although operational limits are somewhat lower (700 MW to 1100 MW) depending on conditions. When the cable is a constraint on supply, prices spike in the North Island. Local generation in North Island regions then becomes very valuable. It also means additional generation in the South Island, especially the deep south has diminishing marginal value.

There are some regions with known or emerging supply constraints (Table 7). Most obvious and important is the upper North Island (Northland, Auckland and Waikato). This is the single most important constrained region;

- Largest and fastest-growing demand centre (population + industry + data centres)
- Electrification (EVs, process heat) increasing load rapidly
- Limited large-scale local generation relative to demand
- Transmission constraints into Auckland (historically and still relevant under peak conditions)

Indicators of the constraints are; high spot prices during peaks and reliance on Huntly Power Station (thermal backup) and gas peakers (declining gas availability is now a risk). What would help alleviate the constraints is firming generation near the load.

A typical useful scale to help the upper North Island supply would be;

- Distributed: 10–50 MW (industrial co-gen, biomass, geothermal satellite)
- Grid-scale: 100–300 MW (peakers, geothermal expansions)

The upper north Ilsand is the region where a biomass/biorefinery-integrated power plant has the highest system value.

Northland on its own has some separate issues;

- Radial grid (weak connection to the rest of NZ)
- Growing industrial load (e.g. port, potential hydrogen, liquid biofuel processing)
- Historically vulnerable to outages

In this situation local embedded generation is disproportionately valuable. Suitable scales would be 5–20 MW which could materially improve resilience or 50–100 MW which would be transformational locally

East Coast, North Island - Gisborne and Hawke's Bay.
These regions re weakly connected to main grid, have limited local generation and have long radial grids (transmission vulnerability). Local generation would improve both reliability and voltage stability. Suitable scales would be similar to the Northland situation.

The Central North Island (Bay of Plenty / Rotorua / Taupō or CNI) have significant geothermal generation already but also have large wood processing load, potential electrification of currently gas fuelled process heat and grid constraints between East Coast and main trunk network. Generation scale of 10–50 MW distributed is highly useful, larger (>100 MW) would be viable if tied to an industrial load (e.g. biorefinery) .

The upper South Island (Nelson / Marlborough) is not well supplied by major hydro schemes as there are transmission constraints from the Waitaki system. Small to medium sized (10 to 50 MW) local generation would help.

Table 7 – What scale of generation matters?

| Scale | System Impact | Where it matters |
|---|---|---|
| <5 MW | Mostly behind-the-meter | Local industry only |
| 5–20 MW | Improves local resilience | Weak grids (Northland, East Coast) |
| 20–50 MW | Meaningful regional impact | Most constrained grids |
| 50–150 MW | Grid-significant | Upper North Island especially |
| 150–300 MW | National relevance | Replaces thermal / defers transmission |

### *Other remote regions*

Wairarapa:

- No fundamental electricity shortage
- Main issue = fragile distribution network
- Small–medium embedded generation helps resilience

West Coast:

- Structurally vulnerable supply due to long distance transmission dependence
- One of the clearest regions in NZ where additional local generation materially improves security
- 20–100 MW scale generation is genuinely valuable

## Intentions of major energy users

An example of announced intended changes that have a material effect are those of Fonterra, specifically at their Edendale site. This is a large site which historically had four boilers of 32 to 38 MWth; all of these ran on lignite (as opposed to coal). One of these boilers has changed to electricity. The plan is to move two more boilers to electricity by 2028. This takes the demand for lignite (and therefore the potential demand for wood) in Southland down from its historical level of 4.8 PJ (Fonterra's share being around 3.1 PJ) to approximately 2.4 PJ with around 0.7 to 0.8 PJ of lignite demand remaining at Fonterra. It is difficult to be certain around the future electrification as these decisions can change based on electricity prices, which in turn can be influenced by such events as the Iran / USA war which may lead to higher energy prices and specifically higher natural gas prices, which is used in electricity generation in the North Island during periods of peak load. However, the Edendale site being in Southland is close to both hydro and wind generation sites. Another recent announcement is related to the Aluminium smelter in Southland, which is considering reponing its currently moth-balled 4$^{th}$ potline, increasing its demand by around 50 MWe. This development is linked to the Contact energy wind farm being developed near Slopedown Hill. A large data centre is also being mooted for Southland.

## Best uses by region

The "best" use of biomass for energy is defined here as the pathway that converts wood into consumer heat with the highest overall efficiency. In most regions of New Zealand, this means displacing coal for process and space heating first, and natural gas (piped or bottled) second, assuming the SNG route maintains its conversion efficiencies as it moves from demonstration to fully commercial operations.

Demands for coal and gas vary markedly between the two islands. The North Island has a reticulated natural gas pipeline network and uses a mix of coal and gas for industrial heat, with regional variation, for example, Gisborne is distant from the nearest coal mine but has pipeline gas access.

The South Island has no gas pipeline; much of its industrial heat demand is met by burning coal and lignite. Two-thirds of New Zealand's plantation forest resource is in the North Island, which coincidentally aligns with the higher energy demand and the presence of gas infrastructure. These two factors substantially shape the regional options for biomass use.

The volume of woody biomass (m$^3$ per annum) required to meet the various demands are shown in Table 8.

Table 8 – volume of woody biomass required to substitute for the various energy demands

| Region | Coal & Lignite | Natural Gas | LPG | Aviation Fuel | Fuel Oil | Diesel | Total in GT per annum | Exc. Diesel and LPG |
|---|---|---|---|---|---|---|---|---|
| **Northland** | 185,000 | 316,000 | 47,000 | 37,000 | 22,000 | 1,741,000 | 2,348,000 | 560,000 |
| **Auckland** | 1,270,000 | 3,828,000 | 401,000 | 2,860,000 | 124,000 | 11,497,000 | 19,980,000 | 8,082,000 |
| **Waikato** | 202,000 | 1,548,000 | 114,000 | 185,000 | 23,000 | 4,778,000 | 6,850,000 | 1,958,000 |
| **Bay of Plenty** | 23,000 | 574,000 | 72,000 | 135,000 | 58,000 | 2,715,000 | 3,577,000 | 790,000 |
| **Gisborne** | 7,000 | 97,000 | 13,000 | 16,000 | 6,000 | 525,000 | 664,000 | 126,000 |
| **Hawke's Bay** | 36,000 | 381,000 | 46,000 | 60,000 | 25,000 | 1,654,000 | 2,202,000 | 502,000 |
| **Taranaki** | 15,000 | 252,000 | 33,000 | 59,000 | 42,000 | 1,468,000 | 1,869,000 | 368,000 |
| **Manawatu-Wanganui** | 53,000 | 644,000 | 61,000 | 171,000 | 3,000 | 2,424,000 | 3,356,000 | 871,000 |
| **Wellington** | 46,000 | 977,000 | 115,000 | 341,000 | 33,000 | 3,472,000 | 4,984,000 | 1,397,000 |
| **Nelson** | 27,000 | 2,000 | 23,000 | 255,000 | 46,000 | 773,000 | 1,126,000 | 330,000 |
| **Tasman** | 45,000 | 20,000 | 20,000 | 16,000 | 6,000 | 650,000 | 757,000 | 87,000 |
| **Marlborough** | 20,000 | 6,000 | 21,000 | 33,000 | 20,000 | 749,000 | 849,000 | 79,000 |
| **West Coast** | 24,000 | 2,000 | 14,000 | 56,000 | 5,000 | 576,000 | 677,000 | 87,000 |
| **Canterbury** | 361,000 | 46,000 | 267,000 | 644,000 | 81,000 | 6,243,000 | 7,642,000 | 1,132,000 |
| **Otago** | 182,000 | 20,000 | 87,000 | 158,000 | 34,000 | 2,271,000 | 2,752,000 | 394,000 |
| **Southland** | 750,000 | 7,000 | 49,000 | 56,000 | 29,000 | 1,668,000 | 2,559,000 | 842,000 |
| **Total in PJ** | **2,609,000** | **8,729,000** | **1,389,000** | **5,090,000** | **564,000** | **43,212,000** | **61,593,000** | **16,992,000** |

Table 9 presents biomass supply alongside coal and gas demand at a regional level for the period 2036–2040, which represents the low point for biomass supply in the medium term. The biomass volumes include not only forestry residuals and wastes but also the large volumes of low-quality logs (K, KS, KIS, etc.) currently exported, on the assumption that this material could be redirected to domestic energy use if cost-beneficial.

Displacing coal: At a regional level, most regions have sufficient biomass to meet their coal and lignite demand for process heat and space heating. The exceptions are Auckland (where demand includes the Glenbrook steel mill) and Southland, both of which have a biomass deficit relative to coal demand. However, when biomass is allowed to move from physically adjacent regions with a surplus, all coal demand can be met nationally, with a substantial amount remaining for other energy uses.

Displacing gas: Natural gas demand varies significantly by delivery method. South Island gas demand is met from bottled gas, while much of the North Island demand is delivered via the pipeline network. This distinction is important because it determines the substitution approach available in each island.

Two approaches to substituting wood for natural gas are considered, each with distinct trade-offs:

- Indirect substitution (boiler replacement): Gas boilers are replaced with wood-fired boilers at individual sites. This has a high capital cost but achieves 85% conversion efficiency from wood to heat. Under this approach, most regions retain a biomass surplus after meeting both coal and gas demands. Allowing for inter-regional biomass transfers, the surplus is maintained nationally.
- Direct substitution (synthetic natural gas): Wood is converted to synthetic natural gas (SNG) at centralised facilities connected to the pipeline network, directly displacing fossil natural gas in existing heat plant. Conversion efficiency is lower (65%), but this approach avoids the capital expenditure of replacing individual boilers. In the North Island, the pipeline network enables SNG distribution across multiple regions, and the wood resource can meet all North Island gas demand except Auckland's, which is very large. The South Island has no pipeline network, limiting the SNG approach to localised clusters of gas users.

The wood demand associated with each substitution method is detailed in Table 9.

Table 9 – regional biomass supply versus coal and gas demand (gap in Table separates North and South Islands)

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Region | PJ p. a. of recoverable wood 2036-2040 | PJ p. a. of Coal and lignite demand | PJ p.a. of Wood left after coal demand met | Demand balanced across adjacent regions | PJ p.a. of Natural gas demand | Wood left after coal and gas demand; in-direct substitution (requires a gas to wood boiler conversion) | Balance across adjacent regions, in-direct substitution | PJ of wood left after coal and gas demand; indirect substitution using wood to SNG | Balance across regions; direct substitution | PJ of heat from indirect substitution via changing wood boilers for gas boilers | PJ of SNG from wood |
| Northland | **10.38** | 1.22 | 9.11 | 2.32 | 1.97 | 0.06 | 0 | -0.71 | 0 | 7.74 | 5.92 |
| Auckland | **1.95** | 8.33 | -6.79 | 0.00 | 23.78 | 0.00 | -13.52 | -36.58 | -33.60 | 0.00 | 0.00 |
| Waikato | **7.19** | 1.32 | 5.80 | 5.80 | 9.62 | 0.00 | 0 | -9.00 | 0 | 4.93 | 3.77 |
| Bay of Plenty | **23.35** | 0.15 | 23.19 | 23.19 | 3.57 | 19.09 | 0 | 17.70 | 0 | 19.71 | 15.07 |
| Gisborne | **6.40** | 0.05 | 6.35 | 6.35 | 0.61 | 5.65 | 5.65 | 5.41 | 0 | 5.40 | 4.13 |
| Hawkes Bay | **6.43** | 0.24 | 6.17 | 6.17 | 2.37 | 3.45 | 3.45 | 2.53 | 0 | 5.25 | 4.01 |
| Taranaki | **0.83** | 0.10 | 0.73 | 0.73 | 1.57 | 0.00 | 0 | -1.68 | 0 | 0.62 | 0.47 |
| Manawatu-Whanganui | **1.92** | 0.35 | 1.55 | 1.55 | 4.00 | 0.00 | 0 | -4.61 | 0 | 1.31 | 1.01 |
| Wellington | **0.77** | 0.31 | 0.45 | 0.45 | 6.07 | 0.00 | 0 | -8.89 | 0 | 0.38 | 0.29 |
| Wairarapa | **2.45** | 0.18 | 2.26 | 2.26 | 0.02 | 2.24 | 0 | 2.23 | 0 | 1.92 | 1.47 |
| | | | | | | | | | | | |
| Tasman / Nelson | **4.64** | 0.30 | 4.33 | 4.33 | 0.13 | 4.18 | 4.18 | 4.13 | 4.13 | 3.68 | 2.81 |
| Marlborough | **4.61** | 0.13 | 4.46 | 4.46 | 0.04 | 4.41 | 4.42 | 4.40 | 4.40 | 3.79 | 2.90 |
| West Coast | **0.88** | 0.16 | 0.71 | 0.71 | 0.02 | 0.69 | 0.65 | 0.68 | 0.68 | 0.60 | 0.46 |
| Canterbury | **2.78** | 2.37 | 0.29 | 0.29 | 0.29 | -0.04 | 0.00 | -0.15 | -0.15 | 0.25 | 0.19 |
| Otago | **6.70** | 1.20 | 5.44 | 3.24 | 0.12 | 3.10 | 3.04 | 3.05 | 3.05 | 4.62 | 3.54 |
| Southland | **2.85** | 4.81 | -2.20 | 0.00 | 0.05 | -0.06 | 0.00 | -0.07 | -0.07 | 0.00 | 0.00 |
| Total | **84.12** | **21.22** | **61.84** | **61.84** | **54.21** | **42.77** | **7.86** | **-21.56** | **-21.56** | **60.20** | **46.04** |

*See Appendix D for a larger font option

Combined heat and power opportunities

In some South Island regions, the biomass resource exceeds combined coal and gas demand, as gas demands are very small. In these cases, the next-best option based on conversion efficiency is combined heat and power (CHP), adding electricity generation at sites where coal has been displaced by wood. CHP would increase biomass demand by approximately 45%, assuming the same heat output, with electricity as a secondary product. However, the value of additional electricity generation is limited outside the West Coast and Nelson regions, as Southland, Otago, and Canterbury are on average net exporters of electricity and generation is sometimes constrained by the transmission network.

Regional CHP potential varies significantly:

- West Coast: The available wood resource could support a small heat-priority CHP plant of approximately 14 MW thermal and 3 MW electrical.
- Tasman/Nelson: The T/N biomass resource is much larger the West coasts, with the potential to fuel a single CHP of 36 MW thermal and 20 MW electrical (electricity-priority), or several smaller plants with the same combined capacity. A heat-priority configuration would allow a slightly larger plant due to higher overall conversion efficiency (82% versus 70% for electricity-priority).
- Marlborough: A biomass resource very similar to that in Tasman / Nelson exists, and the region's location within the grid may also favour CHP.
- Otago: Some spare biomass is available, but the value of CHP is limited by the presence of existing hydro generation. The more viable option may be manufacturing wood pellets for transport to Canterbury, where some wood pellet demand is currently met by imports from south-east Asia.

### *Greenhouse gas reduction potential*

Taking the potential to displace coal and gas directly, New Zealand's woody biomass resource could displace 2.2 million tonnes of GHG emissions from coal combustion and a further 1.1 million tonnes from natural gas combustion. After accounting for emissions from the wood consumed (0.165 Mt $CO_2$-e), the net potential reduction is in the order of 3.1 million tonnes of $CO_2$-e per annum.

### *Fuel costs*

This analysis is not about the cost of fuel and its impact on fuel choices. However, the cost of fuel is often a factor in decision making. In 2026 there are questions about both the cost and supply of some of our commonly used fossil fuels, coal and gas. Gas supply is dwindling and the price is rising. The solution to the supply issue is uncertain at the moment, as is the future price, but up to $40 per GJ for imported LNG has been suggested. The use of coal for low and medium temperature heat faces restrictions after 2037 based on legislation to reduce the use of coal and the price of coal is heavily affected by the cost of carbon, which has fluctuated a lot in the last few years ($45 to $88 per tonne of CO2-e). For every $10 per tonne of carbon, coal costs around $1 per GJ more. Some comparative costs of heat fuels are outlined in Table 10.

Table 10 – approximate costs of delivered heat fuels

| **Fuel type** | **Low** | **High** |
|---|---|---|
| Biomass chip | $12 per GJ | $20 per GJ |
| Coal | $10 per GJ | $15 per GJ |
| Gas | $15 per GJ | $40 per GJ |
| Electricity | $40 per GJ | $50 per GJ |

# Conclusions

New Zealand possesses a large and important woody biomass resource, primarily derived from its 1.8 million hectares of plantation forest. Even under conservative assumptions using the forecast supply trough of 2036–2040, approximately 84 PJ per annum of woody biomass energy is available nationally, with future supply likely to increase if planting rates are maintained. This figure includes most of the current export K, KS, KI and KIS export log volume.

Biomass resources and energy demands are highly variable by region. This means the optimal use of biomass differs significantly between regions. Regional infrastructure, existing fuel use, industrial demand, transmission constraints, and transport logistics strongly influence the preferred energy pathway.

The low energy density of raw woody biomass makes long-distance transport of logs, chips, and residues expensive on a $/GJ basis. In many cases, upgrading biomass into pellets, synthetic natural gas (SNG), or liquid fuels may be justified to economically move energy from surplus regions to deficit regions.

Forest-derived bioenergy is unique among major energy sources because it combines large-scale long-term availability, renewability, storability, low net $CO_2$ emissions, national applicability, and dispatchability. Unlike solar and wind, woody biomass is not intermittent or seasonal and can be stored at multiple stages of the supply chain.

The most energy-efficient use of woody biomass is direct combustion for process or space heat, with conversion efficiencies of approximately 82%. Combined heat and power (CHP) systems with heat as the primary product are the second most efficient pathway, achieving around 71% conversion efficiency.

Conversion of wood into liquid transport fuels is substantially less efficient than direct heat use, with practical conversion efficiencies limited to approximately 48–50% due to the high oxygen and ash content of wood relative to hydrocarbon fuels. Consequently, liquid fuel production should be prioritised only where other non-fossil alternatives are limited, such as aviation or marine fuels.

Biomass gasification to produce synthetic natural gas potentially offers a potentially important pathway for leveraging existing gas infrastructure, particularly in the North Island where the natural gas pipeline network already exists. Although this pathway is less efficient than direct combustion, it may avoid substantial capital expenditure associated with replacing industrial gas-fired boilers.

Coal displacement represents the highest-priority and highest-value use of biomass in most regions. Significant opportunities exist to replace coal used for industrial process heat, particularly in Canterbury, Waikato, Bay of Plenty, Otago, and Southland.

Even after meeting regional coal demand, substantial biomass resources remain available nationally for further energy applications, including natural gas substitution and selected CHP developments.

The North Island gas network creates opportunities to centralise biomass conversion to SNG and distribute renewable gaseous fuel efficiently across multiple regions. This provides an effective mechanism for transferring energy from wood-rich regions such as Gisborne and Bay of Plenty into major demand centres such as Waikato and Auckland.

Auckland remains the most challenging region to fully decarbonise using biomass alone due to its exceptionally large energy demand, including major industrial users such as the Glenbrook steel mill. Biomass from adjacent regions can partially offset demand, but Auckland will likely require a combination of electrification, biomass, gas substitution, and other low-carbon energy sources.

Several regions possess substantial biomass resources but relatively low local industrial energy demand, particularly Wairarapa, Gisborne, and parts of the South Island. These regions are well positioned to become exporters of upgraded bioenergy products such as pellets, SNG, or liquid biofuels.

Electricity system constraints are increasingly important in determining the value of biomass energy projects. Additional local generation in the Upper North Island, Northland, East Coast, and upper South Island would provide system resilience, reduce transmission constraints, and improve regional supply security.

Biomass-based CHP plants integrated with industrial heat loads may deliver disproportionately high value in constrained regions, especially where they can provide both firming electricity generation and process heat simultaneously.

Additional large-scale electricity generation in the deep South Island has diminishing marginal value because of HVDC transmission constraints between the South and North Islands. In these regions, biomass may be more effectively utilised for industrial heat, pellet production, or transportable fuels rather than electricity generation alone.

Small to medium-scale distributed biomass generation (5–50 MW) could materially improve electricity resilience in weak-grid regions such as Northland, Gisborne, Hawke's Bay, West Coast, and Nelson/Marlborough.

Announced industrial fuel-switching projects, such as Fonterra's electrification programme at Edendale, demonstrate that future biomass demand is sensitive to electricity prices, gas availability, and policy settings. Future energy system evolution remains uncertain and flexible planning approaches are required.

This analysis demonstrates that New Zealand has sufficient woody biomass resources to make a substantial contribution to industrial heat decarbonisation and regional energy resilience, particularly when biomass is allocated according to regional comparative advantage and conversion efficiency.

The total GHG impact could be a reduction of as much as 3.1 million tonnes of $CO_2$-e per annum.

If efficient use of the biomass resources we have is considered as a primary driver, a national approach to biomass utilisation could prioritise:

- Direct biomass combustion for industrial heat;
- CHP where regional electricity constraints justify generation;
- SNG production where gas infrastructure provides system advantages;
- Liquid biofuel production only for hard-to-electrify sectors;
- Regional optimisation of biomass flows and conversion pathways.

It should be noted that the costs of various fuels may affect fuel choice in the short to medium term. The availability of some of the current fuel options may be constrained after 2037 (coal) and in the next 5 years (natural gas).

The highest-value role for woody biomass in New Zealand's future energy system is not necessarily as a universal substitute for all fossil fuels, but as a flexible, dispatchable, regionally optimised energy resource capable of supporting industrial decarbonisation, grid resilience, and energy security simultaneously.

## Further work

Techno-economic analysis of SNG production in New Zealand;
- large, centralised units with distribution by existing gas grid,
- small modular gasification systems including CHP operating behind the meter.

SNG analysis to include, levelised cost of energy, capital intensity, carbon abatement costs, sensitivity to electricity and carbon prices.

Detailed SNG feasibility analysis in a New Zealand context.

Advanced biomass pretreatment research (feedstock engineering and de-mineralisation).

Hub and cluster analysis of biomass agglomeration, upgrading and use.

Full modelling of the New Zealand energy system and its potential use of the available biomass resources, optimised at a regional level where full costs of different supply chains are included.

# Acknowledgements

The authors wish to acknowledge the support of the Ministry of Business, Innovation and Employment for their support of this analysis through Strategic Science Initiative Funding. Data from the Ministry of Business, Innovation and Employment and the Energy Efficiency and Conservation Authority were used extensively in this analysis.

# References


Al Hosni, S., Domini, M., Vahidzadeh, R., & Bertanza, G.  (2024). Potential and environmental benefits of biochar utilization for coal/coke substitution in the steel industry. Energies, 17(11), 2759. https://doi.org/10.3390/en17112759

Andrew R., Forgie V. and Lennox J (2008) Sustainability Indicators of the Wood Processing Industry in New Zealand. Report under Objective 1 of the Ecological Footprint Plus Programme. New Zealand Centre for Ecological Economics (Massey University and Landcare Research). Palmerston North 4442.

Batidzirai, B., Schotman, G. S., van der Spek, M. W., Junginger, M., & Faaij, A. P. C. (2019). Techno-economic performance of sustainable international bio-SNG production and supply chains on short and longer term. Biofuels, Bioproducts and Biorefining, 13(2), 325–357. https://doi.org/10.1002/bbb.1911

BERL. (2023). Bioenergy Options for New Zealand: Economic and Regional Opportunities. Business and Economic Research Limited, Wellington.

Börjesson, P., & Tufvesson, L. M. (2011). Agricultural crop-based biofuels — resource efficiency and environmental performance including direct land use changes. Journal of Cleaner Production, 19(2–3), 108–120. https://doi.org/10.1016/j.jclepro.2010.01.001

Cherubini, F., & Strømman, A. H. (2011). Life cycle assessment of bioenergy systems: state of the art and future challenges. Bioresource Technology, 102(2), 437–451. https://doi.org/10.1016/j.biortech.2010.08.010

Chum, H., et al. (2011). Bioenergy. In IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation. Cambridge University Press.

Ciolkosz, D. (2024). Co-firing biomass with coal. Penn State University. https://extension.psu.edu/co-firing-biomass-with-coal

Creutzig, F., Ravindranath, N. H., Berndes, G., Bolwig, S., Bright, R., Cherubini, F., Chum, H., Corbera, E., Delucchi, M., Faaij, A., Fargione, J., Haberl, H., Heath, G., Lucon, O., Plevin, R., Popp, A., Robledo-Abad, C., Rose, S., Smith, P., Stromman, A., Suh, S., & Masera, O. (2015). Bioenergy and climate change mitigation: an assessment. GCB Bioenergy, 7(5), 916–944. https://doi.org/10.1111/gcbb.12205

Daioglou, V., Doelman, J. C., Wicke, B., Faaij, A., & van Vuuren, D. P. (2019). Integrated assessment of biomass supply and demand in climate change mitigation scenarios. Global Environmental Change, 54, 88–101. https://doi.org/10.1016/j.gloenvcha.2018.11.012

Duarah, P., Haldar, D., Patel, A. K., Dong, C.-D., Singhania, R. R., & Purkait, M. K. (2022). A review on global perspectives of sustainable development in bioenergy generation. Bioresource Technology, 348, 126791. https://doi.org/10.1016/j.biortech.2022.126791

EECA heat plant database - 2011. Compiled by CRL Energy Ltd, on behalf of the Energy Efficiency and Conservation Authority (EECA).

EECA Heat plant database – 2014. Updates provided by University of Waikato, GNS Science and Scion as part of the Wood energy Industrial Symbiosis project in 2018.

EECA. (2025). Biomass boilers for industrial process heat. Energy Efficiency and Conservation Authority, New Zealand. https://www.eeca.govt.nz/insights/eeca-insights/biomass-boilers-for-industrial-process-heat/

Electricity Authority. https://www.ea.govt.nz/news/eye-on-electricity/new-zealands-geography-and-price-separation/?utm_source=chatgpt.com

Friday Offcuts. http://www.fridayoffcuts.com/

Gifford J. and Hall P. 2014. Bark utilisation - Contract Report to Solid Wood Innovation.

Hall P. (2023) Wood energy use in wood processing; - notes to accompany wood processing database. Scion contract report for the Ministry of Business Innovation and Employment. Scion Sidney output No. 58549.

Hall, P. (2018). Opportunities for bioenergy use in New Zealand’s process heat sector. Scion Technical Report.

Hall, P. (2024). Residual biomass fuel projections for New Zealand; 2024 – Indicative availability by region and source. IEA Bioenergy Task 43, TR2024-03. https://task43.ieabioenergy.com/publications/residual-biomass-fuel-projections-for-new-zealand-2024-indicative-availability-by-region-and-source-tr2024-03/

Hall, P., & Gifford, J. (2022). Woody biomass supply and potential for bioenergy in New Zealand. Scion, Rotorua.

Hall, P., & Jack, M. (2013). Bioenergy options for New Zealand: key findings from five studies. Wiley Interdisciplinary Reviews: Energy and Environment, 2(6), 587–605. https://doi.org/10.1002/wene.60

Hall, P., & Jack, M. (2017). Regional bioenergy supply-demand balance in New Zealand. Scion Report, Rotorua.

Hall, P., & Jack, M. (2019). Wood availability and forest residue estimates for New Zealand. Scion, Rotorua.

Hall, P., Jack, M., & Barry, L. (2021). Bioenergy supply chain optimisation and regional modelling for New Zealand. Scion Report S0006.

Holmberg, J. M., & Gustavsson, L. (2007). Biomass use in chemical and mechanical pulping with biomass-based energy supply. Resources, Conservation and Recycling, 52(2), 331–350. https://doi.org/10.1016/j.resconrec.2007.06.001

https://www.eeca.govt.nz/co-funding-and-support/products/about-reta/

https://www.eeca.govt.nz/insights/data-tools/energy-end-use-database/

IEA Bioenergy Task 43. (2023). Mobilising sustainable biomass supply chains in New Zealand. Paris: IEA Bioenergy.

IEA Bioenergy. (2024). Sustainable Bioenergy Deployment Pathways. Paris: IEA.

IEA. (2023). Renewables 2023: Analysis and Forecast to 2028. International Energy Agency, Paris.

IPCC. (2023). AR6 Synthesis Report: Climate Change 2023. Geneva: Intergovernmental Panel on Climate Change.

Jack M., Hall P., Goodison A., and Barry L. (2013). WoodScape Study - Summary Report. Scion Contract report to the Wood Council of New Zealand. February 2013. http://www.woodco.org.nz/strategic-plans/woodscape

Lamers, P., Junginger, M., Hamelinck, C., & Faaij, A. (2012). Developments in international solid biofuel trade — an analysis of volumes, policies, and market factors. Renewable and Sustainable Energy Reviews, 16(5), 3176–3199. https://doi.org/10.1016/j.rser.2012.02.022

Lenz, V., Szarka, N., Jordan, M., & Thrän, D. (2020). Status and perspectives of biomass use for industrial process heat for industrialized countries. Chemical Engineering & Technology, 43(8), 1469–1484. https://doi.org/10.1002/ceat.202000077

Manley, B., Morgenroth, J., & Visser, R. (2020). Quantifying the small-scale owners' estate in Canterbury, Otago and Southland. New Zealand Journal of Forestry Science, 47, 19. https://doi.org/10.1186/s40490-017-0100-8

Mikulčić, H., Cerinski, D., Baleta, J., & Wang, X. (2019). Improving pulverized coal and biomass co-combustion in a cement rotary kiln by computational fluid dynamics. Chemical Engineering & Technology, 42(12), 2539–2545. https://doi.org/10.1002/ceat.201900086

Ministry for Primary Industries. Contract Report by Margules Groome. (2020). Wood availability Forecast – New Zealand 2021 to 2060. https://www.mpi.govt.nz/forestry/forest-industry-and-workforce/forestry-wood-processing-data/new-zealand-forest-data

Ministry of Business, Innovation and Employment (2024). Energy in New Zealand 2024. Wellington: MBIE.

Ministry of Primary Industries (2025). A national exotic forest description as at 1 April 2024. Wellington: MPI.

Ministry of Primary Industries (2025). A national exotic forest description 1 April 2025.

Ministry of the Environment. (2024). Measuring emissions: a guide for organisations. 2024 detailed guide. Wellington. Ministry for the Environment. Environment.govt.nz

Naik, S. N., et al. (2010). Production of first and second generation biofuels: a comprehensive review. Renewable and Sustainable Energy Reviews, 14(2), 578–597.

Nepal, P., Ince, P. J., Skog, K. E., & Chang, S. J. (2015). Net change in carbon emissions with increased wood energy use in the United States. GCB Bioenergy, 7(4), 820–835. https://doi.org/10.1111/gcbb.12193
New Zealand Climate Change Commission. (2023). 2023 Advice to Government: Delivering on the Emissions Reduction Plan. Wellington: CCC.
New Zealand Productivity Commission. (2018). Low-Emissions Economy: Final Report. Wellington: NZPC.
New Zealand Timber Preservation Council; https://www.nztpc.co.nz/woodmarkLicensees.php
Nicholas ID., Evanson T., Anderson C. J., Dare P., Hall P. and Gifford J. (2004). Wood processing residues for bioenergy. Paper to: NZIF 2004 Conference "Profitable Wood Processing", Gisborne, April 2004
Nielsen D and Buckleigh D (2020). The New Zealand Forest Products Industry Review. 2020. 12th edition. DANA Publishing 2020.
Peters, K. M., Hazlett, P. W., Morris, D. M., & Greene, D. F. (2024). Carbon footprint of biochar from forest harvest residues as a substitute for coal during steel production. ACS Sustainable Resource Management, 1(10), 2451–2464. https://doi.org/10.1021/acssusresmgt.4c00263
Reid, W. V., Ali, M. K., & Field, C. B. (2020). The future of bioenergy. Global Change Biology, 26(1), 274–286. https://doi.org/10.1111/gcb.14883
Saidur, R., Abdelaziz, E. A., Demirbas, A., Hossain, M. S., & Mekhilef, S. (2011). A review on biomass as a fuel for boilers. Renewable and Sustainable Energy Reviews, 15(5), 2262–2289. https://doi.org/10.1016/j.rser.2011.02.015
Scarlat, N., Dallemand, J. F., Monforti-Ferrario, F., & Nita, V. (2015). The role of biomass and bioenergy in a future bioeconomy: Policies and facts. Environmental Development, 15, 3–34. https://doi.org/10.1016/j.envdev.2015.03.006
Scion. (2024). Bioenergy and Bioproducts Research Portfolio 2024–2025. Rotorua: Scion.
Searchinger, T., et al. (2008). Use of U.S. croplands for biofuels increases greenhouse gases through emissions from land-use change. Science, 319(5867), 1238–1240.
Searle, S., & Malins, C. (2015). A reassessment of global bioenergy potential in 2050. GCB Bioenergy, 7(2), 328–336. https://doi.org/10.1111/gcbb.12141
Sevigné-Itoiz, E., Mwabonje, O., Panoutsou, C., & Woods, J. (2021). Life cycle assessment (LCA): informing the development of a sustainable circular bioeconomy? Philosophical Transactions of the Royal Society A, 379(2206), 20200352. https://doi.org/10.1098/rsta.2020.0352
Slade, R., Bauen, A., & Gross, R. (2014). Global bioenergy resources. Nature Climate Change, 4(2), 99–105.
Solaymani, S., & Botero, J. (2025). Reducing carbon emissions from the transport sector: experience and policy design considerations. Sustainability, 17(9), 3762. https://doi.org/10.3390/su17093762
Suckling, I. D., Jack, M. W., Lloyd, J. A., Murton, K. D., Newman, R. H., Stuthridge, T. R., Torr, K. M., & Vaidya, A. A. (2017). A mild thermomechanical process for the enzymatic conversion of radiata pine into fermentable sugars and lignin. Biotechnology for Biofuels, 10, 61. https://doi.org/10.1186/s13068-017-0744-x
Tonini, D., Hamelin, L., Wenzel, H., & Astrup, T. (2012). Bioenergy production from perennial energy crops: a consequential LCA of 12 bioenergy scenarios including land use changes. Environmental Science & Technology, 46(24), 13521–13530. https://doi.org/10.1021/es3024435
Triple Green Products. (2025). TGF biomass boilers & furnaces. https://triplegreenproducts.com/tgf-biomass-boilers-furnaces/
U.S. Department of Energy. (2004). Biomass cofiring in coal-fired boilers. National Renewable Energy Laboratory Report NREL/TP-510-33811. https://docs.nrel.gov/docs/fy04osti/33811.pdf
van der Hilst, F., Lesschen, J. P., van Dam, J. M. C., Riksen, M., Verweij, P. A., Sanders, J. P. M., & Faaij, A. P. C. (2012). Spatial variation of environmental impacts of regional biomass chains. Renewable and Sustainable Energy Reviews, 16(4), 2053–2069. https://doi.org/10.1016/j.rser.2012.01.027
Weekly online forestry and wood processing newsletter (Australasian focus)
Weekly online forestry and wood processing newsletter (Australasian focus)
WoodWeek. http://www.woodweek.com/ **Note;** in 2022 WoodWeek ceased being published and was replaced by a weekly newsletter with a different focus – that being innovation in the use of solid wood products.

# Appendix A – woody biomass volume by district; main forestry residues only.

Includes; landing and cutover residues, 50% of pulp logs, 80% of K grades, Douglas fir production thinnings and radiata production thinning residuals.

Excludes; municipal wood waste, wood processing mill residues, prunings, waste thinnings, stumps and scrub.

| Territorial Authority | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | 2051-2055 |
|---|---|---|---|---|---|---|
| Far North District | 597,652 | 474,894 | 418,073 | 536,410 | 768,485 | 675,554 |
| Whangarei District | 233,415 | 224,642 | 144,097 | 165,059 | 288,845 | 264,486 |
| Kaipara District | 279,040 | 272,089 | 144,638 | 157,220 | 347,379 | 540,130 |
| Auckland Council | 350,365 | 368,167 | 325,770 | 178,893 | 105,981 | 112,821 |
| Thames-Coromandel District | 124,383 | 119,898 | 163,719 | 180,564 | 147,047 | 92,918 |
| Hauraki District | 54,313 | 30,487 | 9,617 | 6,309 | 14,175 | 11,050 |
| Waikato District | 176,692 | 120,319 | 69,636 | 53,230 | 82,362 | 114,845 |
| Matamata-Piako District | 16,267 | 7,072 | 8,058 | 8,050 | 9,187 | 10,710 |
| Hamilton City | 270 | 1,771 | 635 | 336 | 192 | 40 |
| Tauranga District | 1,990 | 1,349 | 225 | 0 | 0 | 117 |
| Western Bay of Plenty District | 144,203 | 141,595 | 121,436 | 97,546 | 128,846 | 164,176 |
| Rotorua District | 195,063 | 298,226 | 399,308 | 296,883 | 279,099 | 291,728 |
| Kawerau District | 4,225 | 1,063 | 1,763 | 1,866 | 962 | 1,406 |
| Whakatane District | 334,687 | 614,669 | 641,838 | 689,362 | 773,475 | 681,040 |
| Opotiki District | 91,869 | 54,274 | 51,624 | 121,236 | 176,551 | 82,718 |
| Waipa District | 32,598 | 19,070 | 8,845 | 5,454 | 4,552 | 7,492 |
| Otorohonga District | 75,827 | 64,144 | 54,293 | 8,014 | 9,241 | 24,415 |
| Waitomo District | 268,828 | 249,636 | 177,562 | 109,553 | 51,881 | 53,784 |
| Ruapehu District | 399,240 | 412,112 | 134,633 | 169,534 | 291,236 | 346,368 |
| South Waikato District | 306,199 | 559,312 | 446,214 | 243,236 | 298,161 | 321,715 |
| Taupo District | 534,228 | 1,015,268 | 1,167,392 | 1,231,867 | 1,394,598 | 1,247,750 |
| Gisborne District | 1,128,507 | 1,041,147 | 594,003 | 524,587 | 727,469 | 707,077 |
| Wairoa District | 284,021 | 300,287 | 282,949 | 231,289 | 328,263 | 414,667 |
| Hastings District | 200,733 | 403,072 | 480,868 | 356,639 | 408,661 | 686,548 |
| Napier City | 49 | 34 | 0 | 0 | 408 | 835 |
| Central Hawkes Bay District | 41,151 | 141,675 | 76,877 | 59,876 | 47,818 | 89,391 |
| New Plymouth District | 55,499 | 30,912 | 20,507 | 7,582 | 4,472 | 3,010 |
| Stratford District | 92,721 | 39,088 | 17,047 | 14,780 | 12,582 | 34,056 |
| South Taranaki District | 153,146 | 58,446 | 24,251 | 8,250 | 15,178 | 45,800 |
| Wanganui District | 279,566 | 156,709 | 87,724 | 59,419 | 60,870 | 42,262 |
| Rangitikei District | 235,005 | 198,446 | 58,376 | 20,534 | 16,756 | 29,607 |
| Manawatu District | 103,122 | 35,936 | 18,608 | 8,382 | 8,211 | 17,068 |
| Kapiti Coast District | 45,707 | 17,637 | 12,328 | 2,546 | 2,646 | 3,711 |
| Upper Hutt City | 38,785 | 24,570 | 12,877 | 2,426 | 0 | 2,929 |
| Porirua City | 24,588 | 771 | 1,134 | 1,581 | 366 | 618 |
| Wellington City | 12,622 | 4,540 | 748 | 876 | 1,053 | 102 |
| Lower Hutt City | 6,643 | 1,286 | 13 | 0 | 0 | 0 |
| Palmerston North City | 28,462 | 5,132 | 3,067 | 4,286 | 7,790 | 25,210 |
| Tararua District | 227,465 | 139,271 | 48,902 | 51,750 | 100,458 | 143,765 |
| Masterton District | 402,448 | 254,281 | 144,795 | 94,695 | 149,562 | 243,790 |

| Territorial Authority | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | 2051-2055 |
|---|---|---|---|---|---|---|
| Horowhenua District | 99,812 | 29,425 | 34,018 | 35,978 | 31,351 | 22,389 |
| Carterton District | 107,353 | 99,756 | 36,116 | 36,541 | 64,075 | 33,868 |
| South Wairarapa District | 96,861 | 78,429 | 37,949 | 21,654 | 29,897 | 44,020 |
| Nelson City | 184,731 | 252,370 | 363,994 | 363,565 | 303,150 | 253,316 |
| Tasman District | 338,345 | 292,409 | 244,335 | 268,012 | 214,066 | 238,028 |
| Marlborough District | 817,317 | 447,145 | 324,067 | 360,722 | 498,372 | 427,453 |
| Kaikoura District | 17,761 | 11,269 | 2,807 | 2,078 | 3,084 | 17,733 |
| Buller District | 15,246 | 6,121 | 12,100 | 11,228 | 13,024 | 19,354 |
| Grey District | 28,076 | 20,092 | 27,280 | 29,608 | 34,220 | 28,173 |
| Westland District | 21,921 | 17,707 | 26,574 | 27,982 | 19,013 | 18,043 |
| Hurunui District | 217,912 | 189,422 | 167,091 | 109,412 | 102,397 | 86,237 |
| Waimakariri District | 106,079 | 45,189 | 32,559 | 18,913 | 13,788 | 14,399 |
| Selwyn District | 116,146 | 51,977 | 20,770 | 11,022 | 15,935 | 19,690 |
| Christchurch City | 87,730 | 54,906 | 22,937 | 16,809 | 32,796 | 41,167 |
| Ashburton District | 21,396 | 14,705 | 9,461 | 7,808 | 7,105 | 8,612 |
| Mackenzie District | 73,600 | 37,427 | 20,133 | 50,023 | 25,602 | 21,469 |
| Timaru District | 48,328 | 21,422 | 10,404 | 11,026 | 5,641 | 5,627 |
| Waimate District | 80,541 | 66,120 | 48,941 | 19,018 | 21,572 | 42,409 |
| Waitaki District | 150,476 | 164,847 | 150,075 | 44,890 | 110,334 | 174,691 |
| Queenstown-Lakes District | 130,993 | 45,827 | 37,957 | 79,276 | 147,487 | 110,703 |
| Central Otago District | 11,596 | 2,614 | 1,736 | 469 | 0 | 9 |
| Dunedin City | 54,542 | 22,795 | 23,939 | 19,028 | 6,187 | 6,228 |
| Clutha District | 557,042 | 481,735 | 482,547 | 327,787 | 271,182 | 393,616 |
| Gore District | 62,292 | 31,463 | 24,025 | 2,439 | 1,859 | 1,847 |
| Southland District | 467,815 | 398,462 | 498,067 | 301,286 | 255,959 | 316,622 |
| Invercargill City | 7,766 | 3,464 | 2,172 | 3,932 | 8,841 | 7,067 |
| **Total** | **11,503,275** | **10,790,392** | **9,036,502** | **7,890,628** | **9,301,757** | **9,888,481** |

# Appendix B: Woody biomass in energy equivalent; PJ per annum

Based on data in Appendix A

| Territorial Authority | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | 2051-2055 |
|---|---|---|---|---|---|---|
| Far North District | 4.44 | 3.78 | 3.19 | 3.77 | 5.37 | 4.85 |
| Whangarei District | 1.61 | 1.55 | 0.99 | 1.14 | 1.99 | 1.82 |
| Kaipara District | 1.93 | 1.88 | 1.00 | 1.08 | 2.45 | 3.75 |
| Auckland Council | 2.43 | 2.55 | 2.26 | 1.23 | 0.83 | 0.78 |
| Thames-Coromandel District | 0.89 | 0.84 | 1.14 | 1.25 | 1.04 | 0.68 |
| Hauraki District | 0.37 | 0.21 | 0.07 | 0.04 | 0.10 | 0.08 |
| Waikato District | 1.22 | 0.83 | 0.51 | 0.37 | 0.57 | 0.79 |
| Matamata-Piako District | 0.12 | 0.05 | 0.06 | 0.06 | 0.06 | 0.07 |
| Hamilton City | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| Tauranga District | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| Western Bay of Plenty District | 1.00 | 0.98 | 0.84 | 0.67 | 0.91 | 1.15 |
| Rotorua District | 1.63 | 2.32 | 3.15 | 2.42 | 1.95 | 2.03 |
| Kawerau District | 0.03 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Whakatane District | 2.44 | 5.61 | 5.81 | 6.28 | 5.36 | 4.75 |
| Opotiki District | 0.63 | 0.37 | 0.36 | 0.84 | 1.22 | 0.57 |
| Waipa District | 0.23 | 0.13 | 0.06 | 0.04 | 0.04 | 0.05 |
| Otorohonga District | 0.57 | 0.46 | 0.38 | 0.06 | 0.07 | 0.17 |
| Waitomo District | 1.94 | 1.87 | 1.26 | 0.76 | 0.46 | 0.39 |
| Ruapehu District | 2.92 | 2.95 | 0.97 | 1.17 | 2.11 | 2.44 |
| South Waikato District | 2.17 | 3.87 | 3.08 | 1.68 | 2.06 | 2.22 |
| Taupo District | 4.80 | 7.52 | 9.13 | 10.19 | 9.75 | 8.61 |
| Gisborne District | 8.17 | 7.49 | 4.13 | 3.62 | 5.11 | 4.92 |
| Wairoa District | 1.99 | 2.08 | 1.95 | 1.60 | 2.27 | 2.86 |
| Hastings District | 1.41 | 2.90 | 3.43 | 2.73 | 2.82 | 4.80 |
| Napier City | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| Central Hawkes Bay District | 0.29 | 0.98 | 0.55 | 0.49 | 0.33 | 0.62 |
| New Plymouth District | 0.38 | 0.21 | 0.14 | 0.05 | 0.04 | 0.02 |
| Stratford District | 0.64 | 0.27 | 0.12 | 0.10 | 0.09 | 0.23 |
| South Taranaki District | 1.06 | 0.40 | 0.17 | 0.06 | 0.11 | 0.32 |
| Wanganui District | 1.95 | 1.13 | 0.64 | 0.42 | 0.44 | 0.29 |
| Rangitikei District | 1.66 | 1.43 | 0.40 | 0.14 | 0.22 | 0.40 |
| Manawatu District | 0.72 | 0.25 | 0.13 | 0.06 | 0.06 | 0.12 |
| Kapiti Coast District | 0.32 | 0.12 | 0.09 | 0.02 | 0.02 | 0.03 |
| Upper Hutt City | 0.27 | 0.17 | 0.09 | 0.02 | 0.00 | 0.02 |
| Porirua City | 0.17 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 |
| Wellington City | 0.09 | 0.03 | 0.01 | 0.01 | 0.01 | 0.01 |
| Lower Hutt City | 0.05 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| Palmerston North City | 0.20 | 0.04 | 0.02 | 0.03 | 0.06 | 0.17 |
| Tararua District | 1.58 | 0.96 | 0.34 | 0.36 | 0.73 | 0.99 |
| Masterton District | 2.79 | 1.77 | 1.02 | 0.65 | 1.05 | 1.69 |
| Horowhenua District | 0.75 | 0.27 | 0.30 | 0.29 | 0.34 | 0.18 |
| Carterton District | 0.75 | 0.70 | 0.25 | 0.25 | 0.44 | 0.23 |
| South Wairarapa District | 0.67 | 0.54 | 0.26 | 0.15 | 0.23 | 0.34 |
| | | | | | | |

| **Territorial Authority** | **2026-2030** | **2031-2035** | **2036-2040** | **2041-2045** | **2046-2050** | **2051-2055** |
|---|---|---|---|---|---|---|
| Nelson City | 1.28 | 1.78 | 2.51 | 2.52 | 2.09 | 1.75 |
| Tasman District | 2.77 | 3.04 | 2.49 | 2.61 | 1.59 | 1.68 |
| Marlborough District | 5.66 | 3.43 | 2.27 | 2.68 | 3.56 | 2.96 |
| Kaikoura District | 0.12 | 0.09 | 0.02 | 0.01 | 0.02 | 0.12 |
| Buller District | 0.25 | 0.09 | 0.10 | 0.08 | 0.32 | 0.19 |
| Grey District | 0.35 | 0.15 | 0.19 | 0.20 | 0.24 | 0.19 |
| Westland District | 0.16 | 0.12 | 0.18 | 0.19 | 0.13 | 0.12 |
| Hurunui District | 2.10 | 2.23 | 1.27 | 1.00 | 0.71 | 0.60 |
| Waimakariri District | 0.75 | 0.34 | 0.24 | 0.14 | 0.10 | 0.10 |
| Selwyn District | 0.85 | 0.41 | 0.16 | 0.13 | 0.21 | 0.16 |
| Christchurch City | 0.75 | 0.54 | 0.44 | 0.29 | 0.26 | 0.29 |
| Ashburton District | 0.18 | 0.18 | 0.09 | 0.08 | 0.07 | 0.06 |
| Mackenzie District | 2.65 | 0.34 | 0.20 | 0.36 | 0.24 | 0.17 |
| Timaru District | 0.73 | 0.35 | 0.22 | 0.13 | 0.06 | 0.04 |
| Waimate District | 0.72 | 2.33 | 0.36 | 0.15 | 0.17 | 0.29 |
| Waitaki District | 1.23 | 3.50 | 1.07 | 0.35 | 0.78 | 1.21 |
| Queenstown-Lakes District | 1.01 | 0.44 | 0.33 | 0.66 | 1.03 | 0.76 |
| Central Otago District | 0.10 | 0.09 | 0.07 | 0.14 | 0.02 | 0.00 |
| Dunedin City | 1.97 | 0.27 | 0.19 | 0.20 | 0.05 | 0.04 |
| Clutha District | 7.68 | 7.56 | 3.97 | 3.26 | 1.87 | 2.72 |
| Gore District | 1.23 | 0.26 | 0.18 | 0.02 | 0.01 | 0.01 |
| Southland District | 9.11 | 9.07 | 3.60 | 2.29 | 1.79 | 2.22 |
| Invercargill City | 0.05 | 0.02 | 0.01 | 0.03 | 0.07 | 0.05 |
| **Total** | **99.01** | **96.22** | **68.47** | **61.64** | **66.10** | **69.24** |

# Appendix C – Total New Zealand domestic energy demand (PJ) by fuel type

| Region | Wood | Black Liquor | Coal | Natural Gas | LPG | Electricity | Aviation Fuel | Fuel Oil | Diesel | Geo-thermal | Petrol | Solar | Total in PJ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Northland** | 1.02 | 0.00 | 1.22 | 1.97 | 0.30 | 4.07 | 0.12 | 0.07 | 5.77 | 0.00 | 3.67 | 0.01 | **17.21** |
| **Auckland** | 7.20 | 0.00 | 8.33 | 23.78 | 2.49 | 36.86 | 9.47 | 0.42 | 38.08 | 0.02 | 31.71 | 0.11 | **159.48** |
| **Waikato** | 2.77 | 5.90 | 1.32 | 9.62 | 0.71 | 12.93 | 0.61 | 0.08 | 15.82 | 0.13 | 9.54 | 0.03 | **59.48** |
| **Bay of Plenty** | 2.27 | 5.20 | 0.15 | 3.57 | 0.45 | 7.40 | 0.45 | 0.20 | 8.99 | 7.21 | 6.28 | 0.02 | **42.18** |
| **Gisborne** | 0.31 | 0.00 | 0.05 | 0.61 | 0.08 | 1.12 | 0.06 | 0.02 | 1.74 | 0.00 | 1.13 | 0.00 | **5.12** |
| **Hawke's Bay** | 0.80 | 0.00 | 0.24 | 2.37 | 0.29 | 3.96 | 0.20 | 0.09 | 5.48 | 0.00 | 3.76 | 0.01 | **17.20** |
| **Taranaki** | 0.56 | 0.00 | 0.10 | 1.57 | 0.21 | 3.54 | 0.20 | 0.14 | 4.86 | 0.00 | 2.67 | 0.01 | **13.85** |
| **Manawatu-Wanganui** | 1.13 | 0.00 | 0.35 | 4.00 | 0.38 | 7.21 | 0.57 | 0.01 | 8.03 | 0.00 | 5.53 | 0.02 | **27.23** |
| **Wellington** | 2.08 | 0.00 | 0.31 | 6.07 | 0.72 | 12.71 | 1.13 | 0.11 | 11.50 | 0.00 | 10.87 | 0.04 | **45.53** |
| **Nelson** | 0.37 | 0.00 | 0.18 | 0.02 | 0.14 | 2.62 | 0.85 | 0.16 | 2.56 | 0.00 | 1.12 | 0.00 | **8.02** |
| **Tasman** | 0.64 | 0.00 | 0.30 | 0.13 | 0.13 | 1.50 | 0.05 | 0.02 | 2.16 | 0.00 | 1.17 | 0.00 | **6.11** |
| **Marlborough** | 0.35 | 0.00 | 0.13 | 0.04 | 0.13 | 1.48 | 0.11 | 0.07 | 2.48 | 0.00 | 1.17 | 0.00 | **5.98** |
| **West Coast** | 0.26 | 0.00 | 0.16 | 0.02 | 0.09 | 1.33 | 0.19 | 0.02 | 1.91 | 0.01 | 0.86 | 0.00 | **4.85** |
| **Canterbury** | 4.06 | 0.00 | 2.37 | 0.29 | 1.66 | 18.47 | 2.14 | 0.28 | 20.68 | 0.01 | 13.50 | 0.05 | **63.50** |
| **Otago** | 1.37 | 0.00 | 1.20 | 0.12 | 0.54 | 6.81 | 0.53 | 0.12 | 7.52 | 0.00 | 5.07 | 0.02 | **23.31** |
| **Southland** | 0.71 | 0.00 | 0.81 | 0.05 | 0.31 | 23.19 | 0.19 | 0.10 | 5.52 | 0.00 | 2.45 | 0.01 | **33.33** |
| **Total in PJ** | **25.90** | **11.10** | **17.22** | **54.21** | **8.63** | **145.19** | **16.86** | **1.91** | **143.12** | **7.38** | **100.49** | **0.36** | **532.37** |

# Appendix D – Regional biomass use based on supply, demand and "best use"

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Region | PJ p. a. of recoverable wood 2036-2040 | PJ p. a. of Coal and lignite demand | PJ p.a. of Wood left after coal demand met | Demand balanced across adjacent regions | PJ p.a. of Natural gas demand | Wood left after coal and gas demand; in-direct substitution (requires a gas to wood boiler conversion) | Balance across adjacent regions, in-direct substitution | PJ of wood left after coal and gas demand; indirect substitution using wood to SNG | Balance across regions; direct substitution | PJ of heat from indirect substitution via changing wood boilers for gas boilers | PJ of SNG from wood |
| Northland | **10.38** | 1.22 | 9.11 | 2.32 | 1.97 | 0.06 | 0 | -0.71 | 0 | 7.74 | 5.92 |
| Auckland | **1.95** | 8.33 | -6.79 | 0.00 | 23.78 | 0.00 | -13.52 | -36.58 | -33.60 | 0.00 | 0.00 |
| Waikato | **7.19** | 1.32 | 5.80 | 5.80 | 9.62 | 0.00 | 0 | -9.00 | 0 | 4.93 | 3.77 |
| Bay of Plenty | **23.35** | 0.15 | 23.19 | 23.19 | 3.57 | 19.09 | 0 | 17.70 | 0 | 19.71 | 15.07 |
| Gisborne | **6.40** | 0.05 | 6.35 | 6.35 | 0.61 | 5.65 | 5.65 | 5.41 | 0 | 5.40 | 4.13 |
| Hawkes Bay | **6.43** | 0.24 | 6.17 | 6.17 | 2.37 | 3.45 | 3.45 | 2.53 | 0 | 5.25 | 4.01 |
| Taranaki | **0.83** | 0.10 | 0.73 | 0.73 | 1.57 | 0.00 | 0 | -1.68 | 0 | 0.62 | 0.47 |
| Manawatu-Whanganui | **1.92** | 0.35 | 1.55 | 1.55 | 4.00 | 0.00 | 0 | -4.61 | 0 | 1.31 | 1.01 |
| Wellington | **0.77** | 0.31 | 0.45 | 0.45 | 6.07 | 0.00 | 0 | -8.89 | 0 | 0.38 | 0.29 |
| Wairarapa | **2.45** | 0.18 | 2.26 | 2.26 | 0.02 | 2.24 | 0 | 2.23 | 0 | 1.92 | 1.47 |
| | | | | | | | | | | | |
| Tasman / Nelson | **4.64** | 0.30 | 4.33 | 4.33 | 0.13 | 4.18 | 4.18 | 4.13 | 4.13 | 3.68 | 2.81 |
| Marlborough | **4.61** | 0.13 | 4.46 | 4.46 | 0.04 | 4.41 | 4.42 | 4.40 | 4.40 | 3.79 | 2.90 |
| West Coast | **0.88** | 0.16 | 0.71 | 0.71 | 0.02 | 0.69 | 0.65 | 0.68 | 0.68 | 0.60 | 0.46 |
| Canterbury | **2.78** | 2.37 | 0.29 | 0.29 | 0.29 | -0.04 | 0.00 | -0.15 | -0.15 | 0.25 | 0.19 |
| Otago | **6.70** | 1.20 | 5.44 | 3.24 | 0.12 | 3.10 | 3.04 | 3.05 | 3.05 | 4.62 | 3.54 |
| Southland | **2.85** | 4.81 | -2.20 | 0.00 | 0.05 | -0.06 | 0.00 | -0.07 | -0.07 | 0.00 | 0.00 |
| **Total** | **84.12** | **21.22** | **61.84** | **61.84** | **54.21** | **42.77** | **7.86** | **-21.56** | **-21.56** | **60.20** | **46.04** |

**Appendix D** (Table 8) outlines the supply of biomass and the demands for coal and gas at a regional level. In this table , **Column 1** indicates the region.

**Column 2** shows the annual PJ of recoverable biomass for the period 2036 to 2040, which is the low point for biomass supply in the medium term. The amounts of biomass deemed to be available are large as they include not only residuals and wastes but also the large volumes of low-quality logs (K, KS, KIS etc) that are exported. The assumption being that we could choose to use this material as a domestic energy source if we needed to and the cost benefits were positive.

**Column 3** shows the total demand for coal for process heat and space heating.

**Column 4** shows the amount of wood left at a regional level after the coal and lignite demands are met. Some regions have more demand for coal than they have wood supply (Auckland and Southland). The Auckland demand includes the Glenbrook steel mill.

**Column 5** allows for biomass to be moved from adjacent regions with excess biomass supply to regions with a deficit and shows the amount of biomass remaining in each after all the coal demands are met. Even after the coal demand is met, there is still a large amount of biomass left for other energy use at a regional and national level.

**Column 6** shows the demand for natural gas. It is important to note that the South Island gas demand is met from bottled gas and much of the North Island demand is met from gas delivered by the pipeline network.

There are two different ways of substituting wood for natural gas. The first (**Column 7**) assumes indirect substitution where the gas boilers are replaced with wood boilers. This is high capital cost at the user, but a higher conversion efficiency from wood to heat (85%). The other way of getting wood to gas users is by converting the wood to a synthetic natural gas (SNG) at a central site connected to the pipeline network and directly substituting the wood derived SNG into the existing natural gas (NG) fired plant. This has a lower conversion efficiency (65%) but would avoid a lot of capital expenditure on changing boilers. The demand for wood for meeting these demands are shown in **Columns 11 and 12.**

**Column 7** shows the amount of wood left after the coal and gas demands are met at a regional level, assuming an indirect substitution approach.

**Column 8** shows the amount of wood left after the regional demands are met, allowing for movement of wood across adjacent regions.

**Columns 9 and 10** show the impact on gas demand and remaining wood supply if a direct substitution of NG by SNG is used. The impact of assuming wood to SNG in the North and South Islands are different. In the North Island, the presence of the gas pipeline means that gas can be moved across multiple regions, not just physically adjacent ones. The wood resource can meet all the North Island gas demand, except that of Auckland, which has a very large gas demand. As the South Island has no pipeline network the applicability of the SNG approach is limited but may be applicable for a cluster of NG users.

# Appendix E – Descriptions of Technology Readiness Levels