Prepared for

Energy Efficiency and Conservation Authority

East Harbour

Assessment of Possible Renewable Energy Targets

– Direct Use: Woody Biomass

By

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and

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Next generation biomaterials

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Executive Summary

Purpose

This report was commissioned by the Energy Efficiency and Conservation Authority with a view to possible formulation of targets for direct use of energy from woody biomass under the National Energy Efficiency and Conservation Strategy (NEECS).

Woody biomass is potentially a major source of renewable energy for New Zealand.

Methodology

The approach used in this report was to determine present biomass usage for direct use of energy based on a number of sources including the Energy Efficiency and Conservation Authority (EECA) heat plant database and project this into the future based on: an economic comparison of biomass with alternative fuels, using Ministry of Economic Development (MED) scenario modelling of future fuel prices; the National Exotic Forest Description (NEFD) harvest predictions; and other identified drivers.

The NEFD predictions were used for two purposes: to determine scenarios for volumes of wood processed domestically; and to calculate recovery costs of forest residue based on location and volumes.

All numerical figures and relationships between the various industries given here, although based on present trends and best available models and data, are based on informed assumptions.

Woody biomass usage

Analysis shows that the use of woody biomass as a source of energy will principally be driven by the wood processing industry. In addition, there will be increased use of woody biomass in the residential commercial and industrial sectors in the form of high-quality biomass fuels, such as wood pellets and high-quality chip, as a replacement for coal and gas.

Present and projected consumption of wood-processing residue

The wood processing industry is, and will continue to be, the major user of woody biomass for heat in New Zealand. We estimate, that presently, 94% of South Island sawmills and 74% of North Island sawmills use some biomass as fuel (evaluated by installed heat production capacity), resulting in 9.5 PJ/year of primary energy use. In addition biomass makes up 82% of the fuel mix in the wood panel manufacturing industry resulting in another 9.5 PJ/year of primary energy and the pulp and paper industry 25.6 PJ/year, mainly in the form of black liquor. The total use in 2005 was 44.6 PJ/year. One of the main drivers for this uptake in bioenergy is the cost of otherwise disposing of processing residue as a waste product.

National exotic forest description (NEFD) predictions show a large increase in harvesting over the next 10 years, the effect of this on bioenergy utilization depends on what proportion of this harvest is exported in log form, as the amount of logs processed is linked to the amount of residue available on-site for fuel use. Assuming sawmills follow the present fuel mix trends, a scenario of increased processing only up to current installed capacity results in 49.5 PJ/year (up 4.9 PJ/year from 2005) by 2020 and 47.7 PJ/year (up 3.1 PJ/year from 2005) by 2030, and an alternative scenario of processing following harvesting with current log export trend of 33%, results in 58.6 PJ/year (up 14.0 PJ/year from 2005) by 2020 and 57.9 PJ/year (up 13.3 PJ/year from 2005) by 2030. The drop in biomass utilization in 2030 is due to reduced planting rates. As the main driver for process residue utilization in the wood-processing industry is cost of disposal a carbon charge (or equivalent priced-based measure of CO_2 mitigation) is expected to have a minimal impact.

Present and projected consumption of forest residue

In addition to processing residue, there is also a large biomass resource at forest landing sites. Presently 100,000 tonnes of forest residue (almost exclusively from farm conversions) is being harvested for fuel at the Kinleith and Kawerau pulp and paper mills. Assuming a carbon charge of $15/t CO_2 (or equivalent priced-based measure of CO_2 mitigation) above MED base case fuel projections, we estimate that in 2020 it will be economically competitive with coal to harvest 7.2 PJ/year of residues from forests in the North Island to be used in industrial heat and in 2030, 6.6 PJ/year. The reduction in 2030 being due to reduced planting rates. This does not include residues from farm conversions which we assume are a short term phenomena. Without the charge, forest residue will not be economically competitive with coal and quantities could be expected to remain insignificant. The significantly lower cost of coal in the South Island means that with this level of carbon charge, forest residue is still uncompetitive. In the high oil price MED scenario the volume of residue extracted will drop back to 3.4 PJ/year in 2020 and 2.3 PJ/year in 2030, largely because the delivered price of biomass is more sensitive to transportation costs than coal because of its lower energy content per unit volume.

Present and projected consumption of wood pellets

It is estimated that in 2005 the residential sector used 8.2 PJ of primary energy in the form of fire wood, representing 38% of total space heating energy use in this sector. Following international trends, wood pellets are likely to have a significant impact on the fuel mix for heat in the residential, commercial and institutional sectors and is likely to be a replacement for gas. Currently 30,000 tonnes of wood pellets or 0.6 PJ of wood pellets are sold each year. We estimate this annual quantity is likely to increase to 2.5 PJ by 2020 and 4.0 PJ by 2030 in the absence of a carbon charge. The increase in utilization of wood pellets is likely to be driven by the increasing cost of other fuels and air emission restrictions on conventional wood.

As the production of wood pellets requires high grade residue the upward trend in the utilization of wood pellets is likely to create an additional demand for quality wood processing residues above current levels. Currently sawmills could be approximately self-sufficient in heat if they utilized all processing residues so any increased economic demand for these residues will reduce the waste disposal pressure on the wood processing industry and mean that mills are likely to sell some of their higher quality residues for wood pellet manufacture if a cheaper substitute fuel is available. This substitute fuel could be forest residues or coal depending on the economics (or in some cases geothermal energy depending on location). Therefore, the growth of the wood pellet (or liquid biofuels) industry could, perversely, result in mills switching to coal due to the chain of linkages of the residues. As a consequence of this it is possible that unless forest residues become economic to harvest in 2020 and 2030 the biomass usage in the sawmill industry will drop by 2-4 PJ/year from the above predictions as quality process residue is diverted to production of wood pellets.

Impact of CO_2 pricing measures on projected usage

The following table summarizes the impact of a simple CO_2 pricing measure on the amount of woody biomass consumed in (PJ/year) above the 52.8 PJ consumed in the 2005 year. In Table ES1, 2020 and 2030 increases from 2005 figures are shown together separated by a slash.

These results are derived from a consideration of the interdependence of the individual sectors which cannot be considered in isolation. Details of this analysis are given in Section 9. These results should be treated as an indication of what may result given the possibilities investigated. As such they demonstrate more about the way the New Zealand bioenergy system responds to outside economic factors (given our analysis) than as accurate figures in their own right.

Table ES 1 Increase in woody biomass consumed for direct energy use with CO_2 pricing

	2020/2030 (PJ/year)	2020/2030 high oil (PJ/year)
MED base case	0.0/0.0	-
No increase in domestic log processing	3.9/2.6	-
No increase in domestic log processing + carbon charge	11.4/9.2	7.8/5.1
Increase in domestic log processing	13.1/12.9	-
Increase in domestic log processing + carbon charge	20.4/19.5	16.8/15.5

Proposed targets and suggested measures of increasing usage

The draft New Zealand Energy Strategy (NZES)[1] emphasised the joint themes of energy security and greenhouse gas emission reductions and these have therefore been used to guide the determination of targets in this report. In 2001 the government set the target of 30 Petajoules (PJ) of new renewable energy by 2012, and it was generally expected that bioenergy would provide half of this. The expectation was that this report would suggest new targets in Peta Joules (PJ) of woody biomass consumed in 2020 and 2030, such as those presented in the above table. However the analysis leading to the above projections strongly suggests that a blanket PJ target over-simplifies the New Zealand bioenergy system and will at best, have little effect on achieving the aims of the NZES and, at worst, reverse some of the gains made so far. The three most important arguments against setting an overarching PJ target are: 1) the analysis shows that the amount of PJ consumed is determined in large by the proportion of wood processing carried out domestically rendering the achievement of the target at the whim of international markets, and 2) the interconnections between different sectors, such as wood-pellet manufacturing and wood processing, makes the results of trying to achieve the blanket target via specific actions on individual sectors uncertain and 3) the unreliability of data on wood processors energy consumption for heat production.

Instead, analysis shows that the areas represented by the following proposed targets are likely to be the best method of both maintaining gains made so far and increasing the replacement of fossil fuel with biomass and therefore reducing greenhouse gas emissions.

1. *The proportion of wood processors using biomass for heat production (by installed capacity) or (other renewable heat sources) is 90 % by 2020 and 95% by 2030*

As the amount of biomass consumed in the wood processing industry depends on the amount of processing carried out in NZ, numerical targets in amounts of primary energy are not useful in this case and we suggest that a target focusing on proportion of heat plants fuelled by biomass is more appropriate. It is also suggested that this target is measured using the EECA heat plant database (the alternative, of measuring consumed process residue is extremely unreliable due to the lack of either measurement or recording of process residues used as fuel on processing sites). To increase the accuracy of this monitoring it is suggested that the Heat Plant Database should be kept up to date and made more comprehensive so as to include average run capacity and annual run times, to give better estimates of fuel usage. Note that in the case of co-firing, the precise fuel mix would need to be established. At present the high cost of residue disposal is a positive driver for this target, and suggests that the waste management strategy could be a vehicle for achieving this target. However, with the growth of the wood pellet market and other industry demands for high-quality process residue this will not be sufficient to grow biomass use in the wood processing

[1] Draft New Zealand Energy Strategy released by Ministry of Economic Development, December 2006

industry. Analysis of the present situation shows that in the South Island the sawmill fuel mix is 90% biomass, so the above target is achievable reasonably easily and acts more to preserve current gains than to stimulate new growth. However, by setting a target beyond the current uptake (of 85% biomass) exerts a positive pressure to reach the target.

2. *The increase in the quantity of forest residues extracted nationally be 7 PJ by 2020 and 9 PJ by 2030*

It is suggested that this is measured by requiring residue harvesting operations to report volumes recovered. (Note that while analysis has been undertaken on the basis of pellet market applications, an alternative market for chip is also recognised. Care will need to be taken in measuring chip residue which could be used directly in heat plant or exported to ensure that these outputs are separately identified). The analysis of this report suggests that the achievement of this target is conditional on the introduction of price-based measures to integrate the costs of CO_2 emissions (e.g. a carbon charge) into the price of fossil fuels and in particular coal. Analysis shows that this will need to be greater than \$15/t CO_2 for this target to be reached. The utilization of this resource is likely to be in the forest industry but could also be in other industrial sites with a large heat demand. Note that due to reduced planting rates recovering residue may increase in cost between 2020 and 2030, suggesting that sustaining these targets to 2030 and beyond requires reversing current deforestation trends. Analysis shows that with a \$15/t CO_2 charge, it is economically viable to extract at least 7 PJ in 2020, but only 6.6 PJ in 2030. However, in order to send a clear signal to industry that the government is committed to the growth of renewable energy from forest residues a higher target of 9 PJ by 2030 has been suggested. Clearly to achieve the 2030 target of 9 PJ more incentives would be required.

3. *The proportion of biomass co-generation plants in the wood-processing industry (by installed heat capacity) be increased 10% by 2020 and 20% by 2030*

Presently, 22% (by installed thermal capacity) of the heat plants in the wood processing sector provide for biomass cogeneration, mainly in the pulp and paper industry. Increasing the amount of cogeneration will result in an increase in the amount of mitigated CO_2 as the electricity generated will replace that from the national grid. This target can again be measured using the heat plant database. Cogeneration requires a greater amount of fuel, and in the case of sawmills is only likely if a sawmill has sufficient quantities of on-site process residues. Therefore, increasing the efficiency of on-site heat production and the efficient utilization of biomass is necessary for the achievement of this target. This target is also relevant for energy security as distributed generation has been shown to make the electricity supply system more resilient to outages.

4. *An increase in the utilization of high-quality biomass fuels, such as, wood pellets and high-quality chip, of 2.0 PJ by 2020 and 3.6 PJ by 2030*

High quality biomass fuels are likely to be increasingly important and because of their ease of use have the potential to replace fossil fuels in sectors without experience in using woody residue fuels, such as, the residential, commercial and institutional sectors. Examples of high quality fuels are wood pellets and high-quality chip. This target is easily measured by having fuel manufacturers or suppliers record volumes of sales to the public and heat plant owners. This target is based on estimates of the uptake of the wood pellets (presently the most expensive of these fuels) given a \$15/t CO_2 charge or equivalent price based measure. However, targets should not reflect a particular technology choice and therefore reference to wood pellets has been removed. This target should be used in conjunction with target 1 and 2 above as used on its own this target could lead to the perverse situation where biomass utilization by wood processors is reduced so that residues can be are made available to wood pellet manufacturers. Analysis suggests that in combination with the first two targets above, it will be possible to avoid such effects and allow for the growth in the high-quality biomass supply industry, while preserving the gains made in the wood-processing industry.

A key aspect affecting the achievement of all of the above targets is a shift in perception from regarding woody-biomass as a waste product to regarding it as a valuable fuel. To this end it is suggested that efforts are made to improve technologies and develop skills in processing and handling biomass fuels. In particular, development of a set of quality standards, including considerations of moisture content and contamination, is likely to assist with the mainstreaming of woody biomass as a quality fuel. In addition, since processing residues play an important role in the bioenergy system it is necessary to have much more detailed information of flows of processing residue.

As a final note, to achieve the goals of the NZES without compromising economic well-being it is necessary to decouple economic gains from fossil fuel consumption. If heat for domestic log processing of value-added timber exports is derived from biomass then domestic wood processing is a clear example of an industry that results in a decoupling of export earnings from fossil fuel consumption. An analysis in this study shows that the largest magnitude gains in bioenergy utilization would occur if the proportion of logs processed domestically continued at or above the present amount of 70%. Achieving this would require more political intervention than the above targets (the nature of which is beyond the scope of this report), but serious consideration should be given to this type of intervention as the analysis in this report shows that the potential return could be large.

Taking the achievements of the targets outlined above, along with government policy initiatives such as the introduction of a carbon charge, and encouraged domestic wood processing, it is assessed that an increase above 2005 levels of between 16-21PJ of energy for direct use is achievable by 2020.

1 Introduction

The Energy Efficiency and Conservation Authority (EECA) sought assistance in furthering its understanding of possible renewable energy targets for direct use of energy in particular for the bioenergy sector. This is part of the process of informing the final National Energy Efficiency and Conservation Strategy in order to state targets to achieve policies and objectives that are measurable, reasonable, practical and appropriate.

This report has been jointly prepared by East Harbour Management Services (East Harbour) and Scion.

The purpose of this report is to provide up-to-date data, information and analysis towards the formulation (together with strategic context) of a 2020 and a 2030 target for biomass energy used to provide on site heat at residential, commercial, agricultural and industrial premises.

2 Woody Biomass Resource Assessment

The biomass resources available within New Zealand for heating purposes include: forest residues, wood processing residues, fire wood and, in the future, dedicated energy crops. Although a recent study has estimated household firewood consumption[2] there is a lack of detailed knowledge of the actual standing fire wood resource.

2.1 Forest Residues (2020/2030)

The National Exotic Forest Description (NEFD) provides a detailed regional description of New Zealand's planted forest. Based on this information it is possible to predict future harvest volumes, (the latest national study of this type was carried out in 2000[3]). The results are shown in Figure 2.1 compared against the actual harvested volumes to date[4]. From this information it is then possible to predict the residues left in the forest after harvesting, and forms the basis for our assessment of these resources.

The 2000 NEFD predictions of harvesting yield are regarded by some as an overestimate of harvesting volumes, however in the absence of published updates these are the most reliable source of information available. In fact, the existence of reasonably reliable harvesting predictions out to 2030 is a unique resource for determining projections of woody biomass consumption. The authors know of no other sector of the economy that has long-term predictions that rival the NEFD for reliability. In this report these predictions are use in two ways: 1) to develop scenarios on the volume of wood-processing taking place in New Zealand and from this projections on the consumption of biomass in the industry (see Section 2.2 for more details); 2) the volume and location of wood-processing residues which leads to a estimate of recovery cost which can be compared with alternative fuels.

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[2] BRANZ Household Energy End-use Project
[3] National Exotic Forest Description National and Regional Wood Supply Forecasts
[4] http://www.maf.govt.nz/statistics/primaryindustries/forestry/forestry-production-and-exports/index.htm

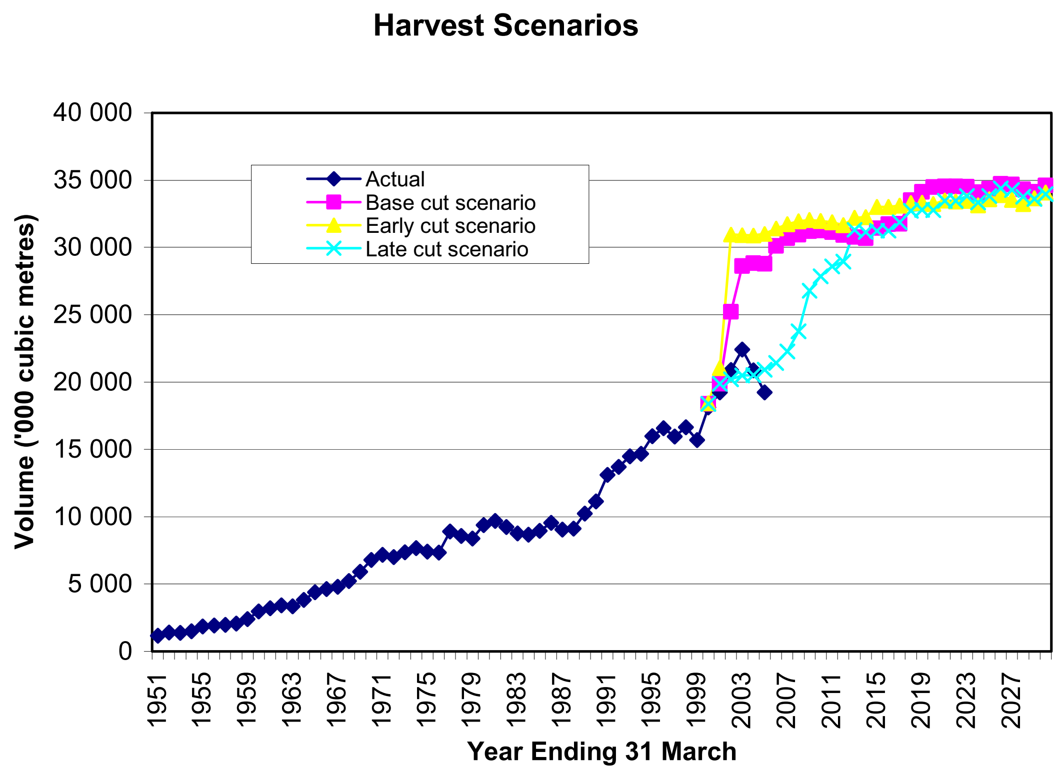

Figure 2.1 Forest harvesting scenarios

The forest residues considered in this study are those left on landing sites after harvesting, as these are the most cost effective to extract from the forest. The material produced at logging landings is a mixture of stem wood, bark, branches and needles. Depending on the tree crop, harvesting system and log-making method the composition and piece size of the residues varies[5]. However, in all cases the bulk of the volume is stem wood. The stem wood component is highly variable in the volumes and shapes of its individual pieces. This makes it difficult to handle with conventional logging equipment and requires loaders with special attachments for truck loading. The production of residues varies with a number of factors including the quality of the tree crop. A range of studies has found that, on average, ground based harvesting systems (used on flat to rolling terrain) produce around 4% of the extracted volume as residue. Hauler or cable logging systems used on steep terrain produce around 6% of the extracted volume as residue[6].

Due to the nature of the raw material, some which is quite large individual pieces, the machinery required to process the material from harvest residue to chip is medium to large sized (300 to 600kW), and have a throughput of 25 to 30 tonnes per hour. To some extent this dictates how the systems will be designed and operated. However, there are variations on how the systems are operated and the costs vary with processing capacity, utilisation and transport logistics and haul distance.

The nature of the raw material also dictates that processing occur as close to the source as is practicable. The transport of unprocessed residues is generally limited to short haul off-highway

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[5] Hall P. 1999. Effect of log making on production of stem wood residue at landings. LIRO Report Volume 24 No. 4 1999

[6] Hall P. 1994. Waste wood at logging landings. LIRO Report Volume 19 No. 15 1994; Hall P. 1998. Logging residue at landings. N. Z. Forestry May 1998

operations as it is difficult to get maximum payloads with current truck design and vehicle dimension regulations. Load compaction technology and purpose built trucks would be required to alter this.

At present, approximately 100,000 tonnes of forest residue is being harvested and converted into chip in the Central North Island and Nelson for fuel, however, a significant proportion of this is farm conversions.

Note that residues harvested from the forest are often contaminated with soil and of a quite high moisture content and, therefore, should be regarded as a low quality fuel. Upgrading is possible depending on system configuration and operation logistics.

2.1.1 Cost of supply

The cost of delivered supply of residue chip for use as an energy feedstock has been calculated for each region in New Zealand. The cost includes all components of processing from collection, processing and delivery to the site for use. Figure 2.2 shows an example cost curve for Rotorua. The calculation is based on a GIS model which uses forest cover by area, slope, road networks, age class distribution of forest within a territorial authority, yield tables, residue production factors by slope along with a cost regression equation to calculate delivered cost of fuel. The cost regression equations were developed using 2007 costs for machinery, fuel, and labour. Costings were done in the spreadsheet developed and available in the LIRO Business Management for Logging Handbook 1994. Diesel prices for transport are taken from MED's Energy Outlook's base case and from their high oil scenario.

Eleven wood processing centres in the North Island and four in the South have been chosen for the analysis of cost of supply. The names of the cities are shown in Table 2.1. These centres are chosen as the most likely places where forest residues will be taken up as a feedstock for fuel.

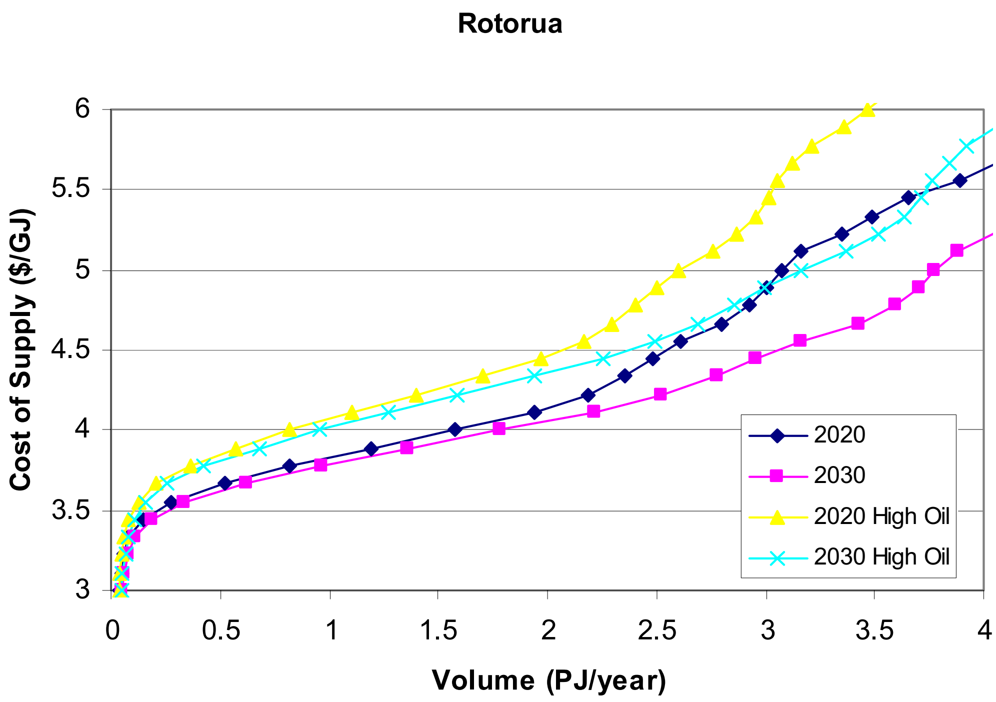


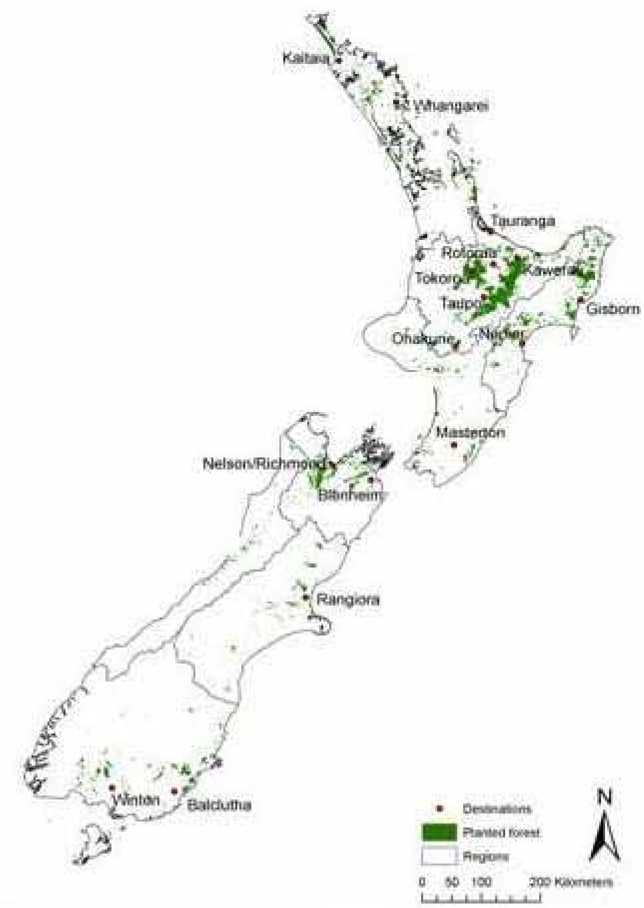
Figure 2.2 Supply costs of forest residues

Table 2.1 shows some of the results of the analysis of the cost of supply for each of these centres out to 2020 and 2030. The supply cost in $/GJ is for supply of 0.5 PJ per site. The volume 0.5 PJ is the minimum volume for a viable harvesting operation based on a hogger / residue processing machine needing around 50,000 tonnes per year for it to be a well utilised, economically viable operation. The difference in costs between the two years in each region is directly related to volume and distribution of available resource which is in turn related to planting schemes.

Detailed figures from each of the regions are shown in Appendix 3 and will be discussed in more detail in Section 9.2.

Table 2.1 Supply costs of forest residue

	$/GJ (0.5 PJ pa operation)	
	2020	**2030**
Northland		
Kaitaia	4.7	4.9
Whangarei	4.3	4.6
CNI		
Rotorua	3.6	3.6
Taupo	3.7	3.4
Tokoroa	3.3	3.2
Kawerau	3.4	3.4
Tauranga	3.9	3.9
Ohakune	4.0	4.3
Hawkes Bay/ East Coast		
Gisborne	3.6	3.9
Napier	3.9	3.7
Southern North Island		
Masterton	3.9	4.3
Nelson/Malborough		
Nelson	3.7	4.2
Canterbury		
Rangiora	6.0	6.2
Otago and Southland		
Balclutha	4.2	4.7
Winton	4.9	5.3



2.2 Wood Processing Residues (2020/2030)

There is a substantial biomass residue stream from wood processing activities, especially at the sawmill stage involving primary log breakdown. A 1997 study estimated that 23% of log round wood volume extracted from forests ends up as residue. For example, of the incoming volume at sawmills 29% ends up as slabs and chip, 13% as sawdust, 5.6% as bark, 7% as shavings and 6% as trim or sander dust[7]. Much of this processing residue is not available for energy production. For example, nearly all slab wood and chips arising from sawmilling is sold to pulp mills. Unfortunately, there does not exist accurate information on the flows of these residues in the wood processing industry. Table 2.2 shows some estimates of destination, but these should be treated as indicative only as they were based on a limited sample of mills.

[7] Wood Processing Residues for Bioenergy, I. D. Nicholas et. al. (2006)

Table 2.2 Estimated use of wood processing residues

	Landscape, Animal bed, Mulch	Landfill	Fuel	Firewood	Chip	Panel Manufacturing
Sawdust	20%	18%	59%	-	-	3%
Bark	54%	15%	31%	-	-	-
Shavings	4%	5%	5%	-	-	5%
Trim and Sander dust	-	2%	43%	37%	-	-
Slabs or Chip	-	1%	1%	1%	97%	-

As will be discussed later in this document an understanding of these residue flows is critical for understanding the total bioenergy "system" in New Zealand. However the high amount of residue going to landfill is clearly an area to be targeted.

Residues from the wood processing industry are presently the largest source of biomass for direct heat. Even now a major driver for the utilization of these residues for on-site heat production is the cost of disposal if not utilised on-site. The availability of the residues is directly coupled to the volume of wood undergoing processing in NZ. Note that the scenarios in Figure 2.1 indicate that across most regions in New Zealand there will be a 50% increase in harvesting over the next 5-10 years. The impact of this on bioenergy uptake depends critically on how much of these harvested logs are further processed in New Zealand as opposed to being exported in log form. Figure 2.3 shows the historical destination of the harvest. The percentage of logs exported in log form has historically ranged from 5-35%, with an average of 18%.

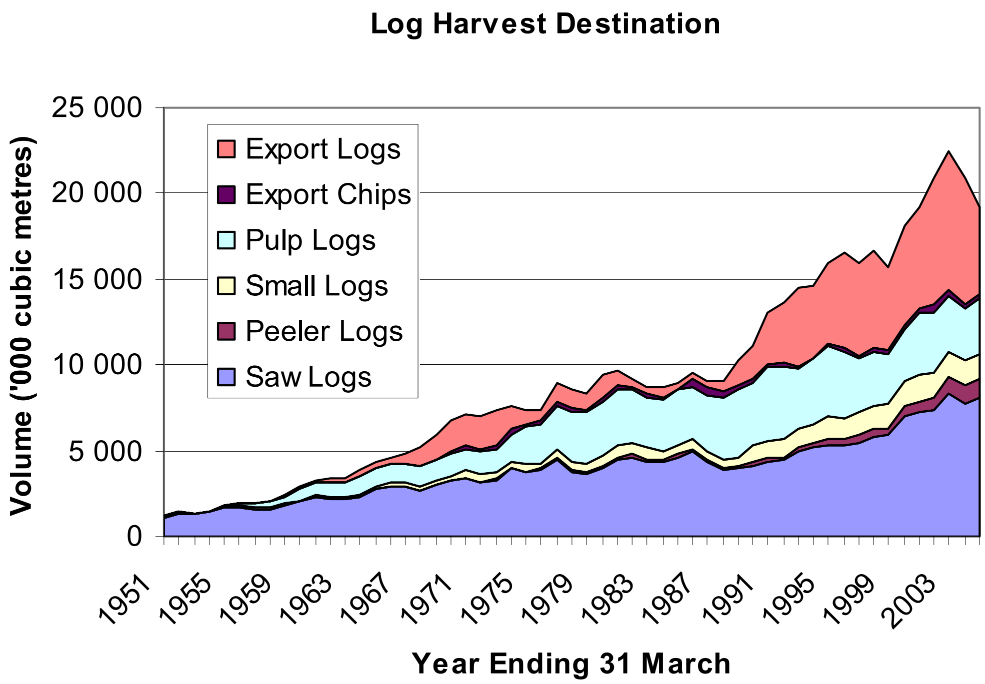


Figure 2.3 Log harvest destination

Two possible scenarios regarding future processing are shown in Figure 2.4. In scenario 1 there is 10% increase in processing over the next 5 years until current processing plants reach capacity and then a levelling off as investment in new processing halts. In scenario 2 the current trend of 35% of the harvest exported as logs continues, such that, domestic processing increases with the increasing harvest.

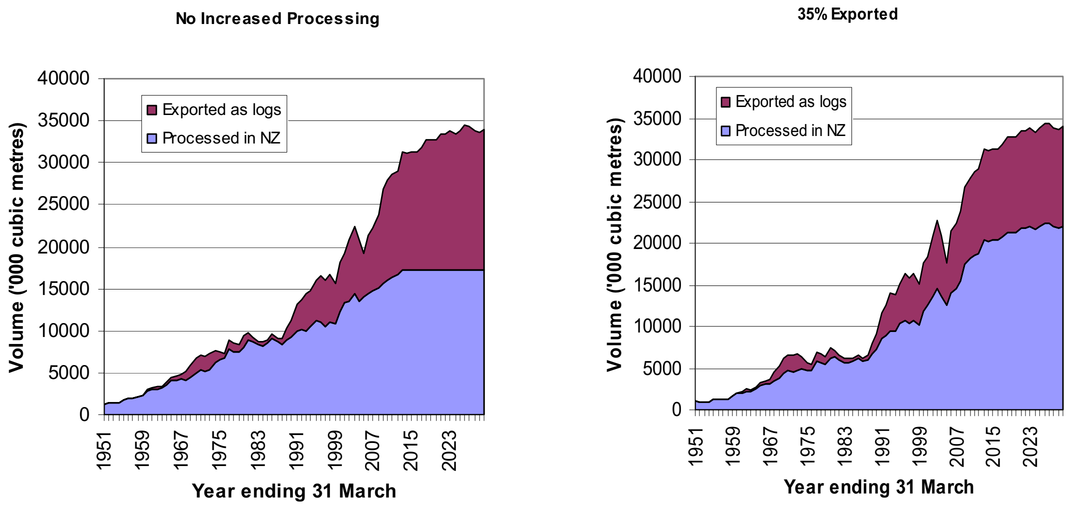


Figure 2.4 Wood processing scenarios 1 and 2

2.3 Dedicated Energy Crops

There is a growing interest in dedicated energy crops for bioenergy in New Zealand. A number of hardwood species are under consideration for this purpose due to their fast initial growth rate, and in their higher wood density than Radiata pine. These factors contribute to hardwoods having the ability to produce more biomass at an early age than most conifers. These attributes are advantageous in a land treatment system, where fast early growth usually indicates more water use and higher nutrient uptake in foliage; higher wood density is also important in fuelwood crops. Hardwoods are also characterised by a shorter fibre length than pine, useful in fine paper manufacture.

Activities involving Short Rotation Crops (SRC) with hardwoods in New Zealand currently involve three potential land use options:

- Hardwood plantations for pulp production
- Nutrient stripping from waste water
- Willow crops for ethanol and by-products

At present none of these crops are purpose grown for direct heat use and it is quite unlikely that growing dedicated energy crops for heat or cogeneration will be economic in the future. It is more likely that they are grown for other purposes such as ethanol production.

3 Technologies for Biomass Use

3.1 Conversion Technologies

3.1.1 Combustion and co-firing

Wood heating system technology has advanced significantly in the past decade. Modern wood-fuel boilers are clean, dust free, operate at over 90% efficiency, and provide consistent high-temperature heat (±1ºC). With fully automated ignition and controls, advanced automatic fuel feed and ash removal systems, the operating convenience of modern wood-fuel systems is similar to that of an oil or gas boiler.[8] Size of boilers can run from around 1MW - 35MW with the majority in the 5 - 20MW range.

In New Zealand, there are now also a variety of imported wood pellet boilers available. Pellet burners can range in size from 25 to 300 kW and are suitable for light commercial or industrial use[9]. There are also a range of locally manufactured wood burners which are compatible with wood chip or pellets.

Co-firing refers to simultaneous use of biomass and typically some other fuel such as coal or gas. Co-firing of biomass with coal has gained significantly over the last 5 years due to the introduction of regulations to encourage the reduction in greenhouse gas emissions and greater uptake of renewable energy. Substitution of coal (or natural gas) with biomass can occur at small and large scale, though many of the applications internationally have occurred at large-scale, power generation facilities which is not a possibility in New Zealand. However there would be opportunities in New Zealand in the mid range sized coal boilers such is at dairy processing plant. Co-firing systems have the advantage of reducing CO_2 levels while obtaining the calorific value of coal or gas.

Conversion of many coal boilers would be constrained by the form the wood residue is supplied in. Supply as shavings, sawdust and chip may not be acceptable at many sites because it can blow around the site. Supply however as wood pellets is the equivalent of supplying white coal as the wood pellets have all the handling characteristics of coal, but with a different calorific value.

A significant risk with biomass-fired heat plant is the often lack of security of biomass supply and in a form suitable for combustion. Coal and gas can be used as a security of supply backup to cover shortfalls in biomass supply.

3.1.2 Cogeneration

Cogeneration is the joint production of electricity and heat. Cogeneration is considered to be an example of direct use of heat as cogeneration plants are typically located at sites with significant process heat requirements[10]. On these sites fuel is burnt primarily to produce heat energy. The excess heat is used to produce electricity. In other words electricity is a by-product. Because of this dual utilisation of heat energy, cogeneration is an extremely efficient method of using fuel resources and internationally is considered “best practice” energy management. This is also the approach taken by the Ministry of Economic Development, particularly as reflected in their *Energy Outlook* publication. In that report, cogeneration, particularly in the forestry sector is treated as a direct use application.

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[8] http://www.sustainabledevelopments.ie/content/section/2/magazine?id_content=386&WOOD+FUELLED+HEATING+SYSTEMS&id_parent=384

[9] -http://www.naturesflame.co.nz/

[10] It should be noted that there are electricity power stations that can be referred to as cogeneration in that they supply excess heat after electricity production to heat users. Such plant are classified however as power stations as that is primarily why they were built

The advantage of cogeneration for industrial users is that there is a more economic use of energy with the possibility of some additional potential benefit of increased security of supply where the impact of incidents on the power system is lessened by local generation.

Biomass fuelled cogeneration plants are well suited to utilise local renewable energy resources, and can provide benefits in diverting wood waste from landfill.

The fragmentation of the energy market makes it very difficult for wood processors to implement initiatives that will reduce costs of energy. However areas where wood processors can reduce costs are in the reduction of peak electricity demand where network connection costs can be reduced, and from on-site heat and electricity production. Cogeneration is currently not economic in most situations, but as the cost of waste disposal increases and gas and electricity prices increase, on-site generation will become more financially attractive just to meet onsite energy needs. An extension is where heat or electricity can be exported from the site to neighbouring energy users. Such clusters of energy users can achieve a balancing of peak loads, economies of scale for fuel management, and make cogeneration economic.

Reduced electricity network costs can be achieved if the electricity supply from the site can be embedded into the producers local distribution system. This also limits the involvement of third parties. The network connection costs for embedded generation usually reflect the cost of network connection with a credit for the benefits embedding can provide the network for voltage support and supply security. The costs are based on peak capacity.

Barriers to cogeneration plants are the low relative cost of alternative energy sources and the general lack of industry/community investment in energy management initiatives. This includes the issue that, while it may be economically advantageous to generate electricity to supply the site requirements, it is less economic to sell any “exported” energy because of buy/sell price differentials. One solution to this may be to form “energy cooperatives”, where a number of industries, or a community connected to the same network operate on a collective basis minimising the purchase of electricity generated by other electricity providers.

3.1.3 Organic Rankine Cycle[11],[12]

Commonly, cogeneration plants in a biomass context will use conventional steam turbines to generate electricity. An alternative is to use Organic Rankine Cycle (ORC) systems, which are similar to conventional steam-cycle systems for generating electricity. However, they use an organic working fluid instead of water as the heat transfer medium. Such systems operate at lower temperatures and pressure. As such they can use lower grade heat sources, possibly including boiler exhaust. These systems typically have relatively high capital costs but are modular, save on maintenance, operator costs, and have greater flexibility to operate at variable loads between 30 and 100%.

3.1.4 Gasification

Gasification technologies have reached the commercial evaluation phase with several plants overseas undergoing detailed evaluation and monitoring. Gasification, as a technology has been proven for coal applications (though is still not widespread) and is currently being adapted for biomass. Several biomass integrated gasification combined cycle (BIGCC) plant could have high replication opportunities. The gas produced (“syngas”) is a mixture of carbon monoxide and hydrogen, with a low to medium heating value. Gas cleaning issues (particularly related to silica content) are now being addressed in MW-scale demonstration plant. The technology is progressing rapidly to full large-scale commercial uptake. The gas has potential as a heat source, as a fuel for electricity generation, or as a feedstock for other applications.

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[11] -http://www.orc-process.com/index2.htm?doc/gmk/
[12] -http://www.turboden.it/orc.asp

3.2 Technologies for Upgrading Fuels

3.2.1 Wood pellets

Wood pellets are a densified wood fuel typically made of shavings and/or sawdust. If the sawdust or shavings are wet they will have to go through a drying process to achieve a final moisture content of 10% after processing. The sawdust or shavings are processed through an extruder to develop a uniform 1 cm long pellet with diameter of 6 mm. The pellets are bagged for residential use or trucked bulk for larger scale consumers.

The wood pellet market in New Zealand is still new but has been taken up by many consumers. The manufacturing capacity is above 100,000 tonnes per year on 4 wood pellet plants, increasing in the next few months to 150,000 tonnes with the opening of a new plant in Rotorua. The present consumption of pellets is significantly lower – about 20,000 tonnes in 2006. The wood pellets are predominantly used for residential heating, although there are a few heating systems in institutions and the industry on wood pellets. Notably, four schools have converted from coal to wood pellets.

Wood pellets are seen as the principal means for institutions and the residential and commercial sectors to use biomass for heat. They are offered as a standardised, easily handled fuel through supply chains. The alternative of utilizing hog fuel or chip directly by these users is not expected, mainly due to the inconvenience of these systems compared to wood pellets.

3.2.2 Gasification

A wide range of biomass feedstocks can be used to produce synthetic fuels, including dimethyl ether (DME), methanol, Fischer-Tropsch (F-T) diesel and F-T kerosene. In particular, the conversion of lignocellulosic biomass appears very attractive as a medium- to long-term prospect for producing large quantities of biofuels. Although this option is not commercially proven, there is significant ongoing R&D effort, particularly in Europe. Lignocellulosic biomass can be converted into biofuels based on gasification technologies using a range of processes (Figure 3.1).

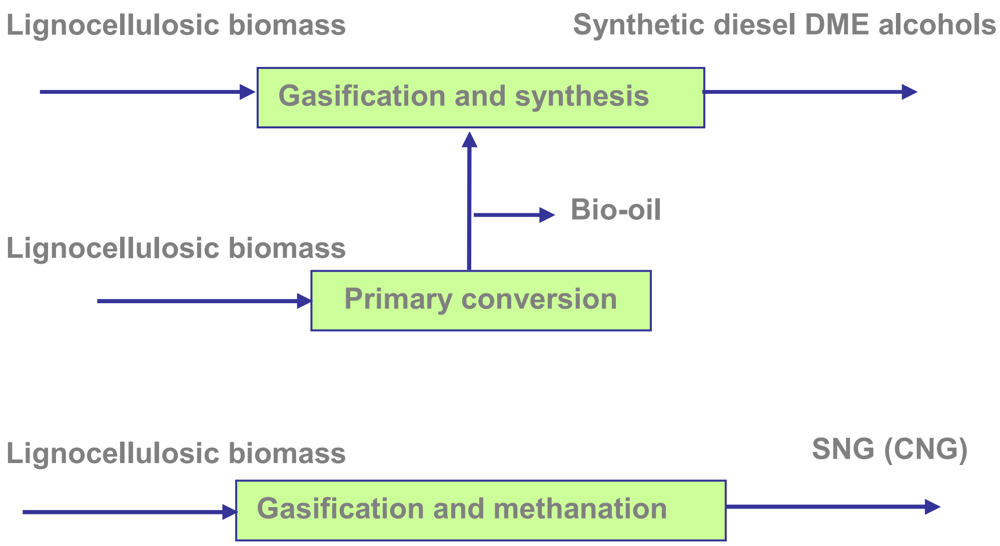

Figure 3.1 Gasification for second-generation liquid biofuels

New Zealand has access to a methanol plant so there is an opportunity to link the supply of forest material to the production of biofuels using these facilities[13], although this would need to be developed in collaboration with other partners.

3.2.3 Biorefineries

The expected growth of biofuel production and the ongoing development of new biotechnology-based transformations opens up the possible introduction of biorefineries which would have the capacity to convert biomass into a broader range of value-added product streams (biofuels, high-value chemicals, and fibre feedstocks) (Figure 3.2).

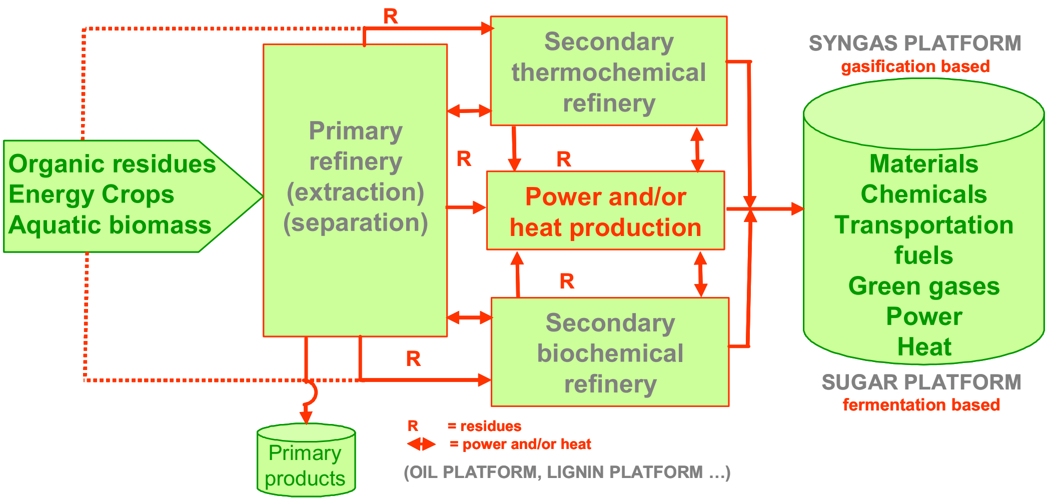

Figure 3.2 Biorefineries

Relatively simple biorefineries already exist today (e.g., sugar/ethanol plants; oil seeds crushing/trans-esterification plants; pulp and paper mill; biodiesel units). The co-production of fuels and co-products, i.e., basic chemicals for synthesis purposes or high-value components all contribute to meeting future challenges of more efficient production, improving financial returns from the use of resources, and for improving sustainability.

3.2.4 Pyrolysis

Fast pyrolysis is a process which converts organic materials to organic vapours, and charcoal. The vapours are condensed to a bio-oil. Typically, 70-75 weight % of the feedstock is converted into oil. The liquid produced in fast pyrolysis is of a more consistent quality compared to the solid biomass and allows for ease of handling and transport. Since the 1990s several fast pyrolysis technologies have reached commercial status.

Short-term applications of the bio-oil from fast pyrolysis are boilers and furnaces (including power stations), whereas turbines and diesel engines may become available on the somewhat longer term. Upgrading of the bio-oil to a transportation fuel is technically feasible, but needs further development. Transportation fuels such as methanol and Fischer-Tropsch fuels can be derived from the bio-oil through synthesis gas processes. Furthermore, there is a wide range of valuable chemicals that can be extracted or derived from the bio-oil.

While this is clearly a developing fuel upgrade option the focus of this report remains on the prospects more immediately presented by pelletising.

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[13] www.vtt.fi/uutiskirje/042006.jsp
www.biomatnet.org/publications/1919rep.pdf

4 Practical Restrictions on Uptake of Biomass for Direct Heat Use

4.1 Competing Uses for Biomass Resource

There is already a significant competition for biomass as a feedstock for processing such as MDF[14], for processing into wood pellets, or as a combustion fuel.

The value of a tonne of pulp turned into its final product, paper is much higher than the final price of wood pellets. The price of wood pellets at the residential market is $300/tonne, around $1,500/tonne for MDF boards and around $2,000 /tonne of plain white paper, depending on quality. To some extent, potential rewards will help to prioritise the use of the resource.

With a developing market for pellets, downstream processors may start to vie with alternative users for a reliable long term source of raw material of sufficient quality. Ultimately the best source of quality material may be from the main wood processors themselves, in which case, current bioenergy requirements of the wood processors may have to be satisfied from another source.

There is also a target for the use of liquid biofuels in New Zealand of at least 2 Petajoules a year by 2012 (about 65 million litres of biodiesel or bioethanol). In addition, the “Biofuels sales obligation” would require oil companies to sell a minimum percentage of biofuels in transport fuels, beginning with 0.25% of sales in 2008, and rising to 2.25% by 2012. To meet this target there may be a demand for woody biomass as a feed stock for a wood to ethanol conversion process, though this could be sourced from overseas.

There are other non-fuel competing uses for biomass including landscaping materials (mulches and bark), and animal bedding. It is already a feedstock for paper and MDF but could equally form a chemical feedstock for a range of other processes.

New Zealand’s developed land resources are limited, so there can also be competing land uses that may lead to a depletion of woody biomass stock. Recently a number of relatively young plantations have been removed and land has been converted for dairy farming in particular.

4.2 Boiler Replacement Rate

EECA has sponsored the development of a heat plant database that is currently administered by the Bioenergy Association of New Zealand (BANZ). This database covers a wide range of uses and is regularly updated.

Analysis of the age of boilers and those that have been replaced indicate that this occurs in 80% of the cases at around 35 years (Figure 4.1). This replacement age varies among the sectors. For the wood processing industry and education the age is around 25 years (though this partially represents relatively recent developments) and for the meat industry it is around 45 years, but 35 years is typical.

In practice, boilers are high capital cost equipment, normally representing a significant portion of the effective delivered energy cost at the consumer’s premises. Replacement would not normally be considered until fuel costs alone outweighed the combined fuel plus capital costs of alternatives, or may simply not be considered until the boiler requires replacement, especially if site space is limited and interruptions are unacceptable.

[14] Medium density fibreboard

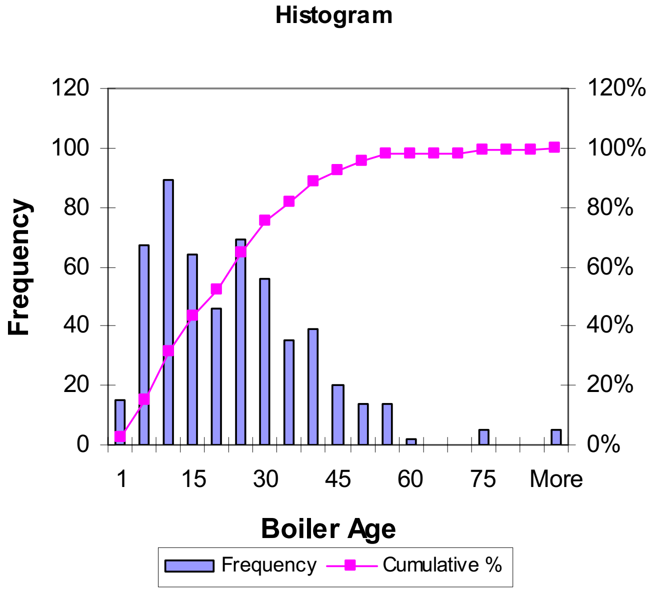

Figure 4.1 Histogram of boiler age for all sectors

4.3 Air Quality

The use of solid wood or coal fireplaces and burners has an adverse impact on community air quality during winter periods. Such impacts relate to the inefficient burning of home-heating fuels and the release of particulates and other smog-causing components. There is increasing positive action by councils, such as those covering Rotorua or Christchurch to phase out problem-causing fuel sources. In turn this is being driven by the introduction of the National Environmental Standards (NES) for Air Quality in September 2005. Under the NES, regional councils must achieve demonstrable consistent improvements in air quality between 2005 and 2013. If standards are not met, councils may be unable to issue new resource consents for new discharges of particulates, even for highly-efficient modern industrial burners that have negligible emissions in comparison to household burners. This could have a severe impact on regional and national economies[15].

While this is detrimental to the coal and solid wood industry, it is beneficial for the wood pellet suppliers, and companies supplying or modifying existing burners. Wood-pellet burners are highly efficient due to their design and the consistent quality of fuel supplied.

Overall, air quality is expected to be a driver towards biomass, rather than away from it, especially say in domestic markets in the South Island where the principal alternatives may have to be electric if coal burners are phased out.

4.4 Price of Competing Fossil Fuels

East Harbour has reviewed the cost of a range of technologies for delivering heat to industry, focussed on the provision of a steam supply. A fuller discussion of the implications of the heat supply curves is found in Appendix 2. Figure 4.2 shows a comparison between fuels.

Note that some heating options are geographically restricted. The indicated geothermal options are restricted to parts of the Central North Island and an area near Kaikohe in Northland. Gas is a North Island fuel (with the exception of bottled gas). There are lower coal prices in the South Island than in the North Island.

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[15] Solid Energy Annual Report 2006

Based on these curves, biomass process residues are competitive with almost every fuel type in the North Island (with some limited geothermal exceptions). Process residues would struggle to compete with South Island coal without, say incentives created by a carbon charge. Note that these prices do not include process residue disposal costs.

On the face of things, landing sourced forest residue material would initially fail to compete. However, this report sees a prospect for use of landing material where it enables displacement of process residues, as the process residues are generally a higher quality fuel more suitable for pelletising. This can happen if the cost of collection of landing material can be passed through to the pellet supplier. Opportunities are stronger in the North Island, particularly if some form of carbon charge were introduced.

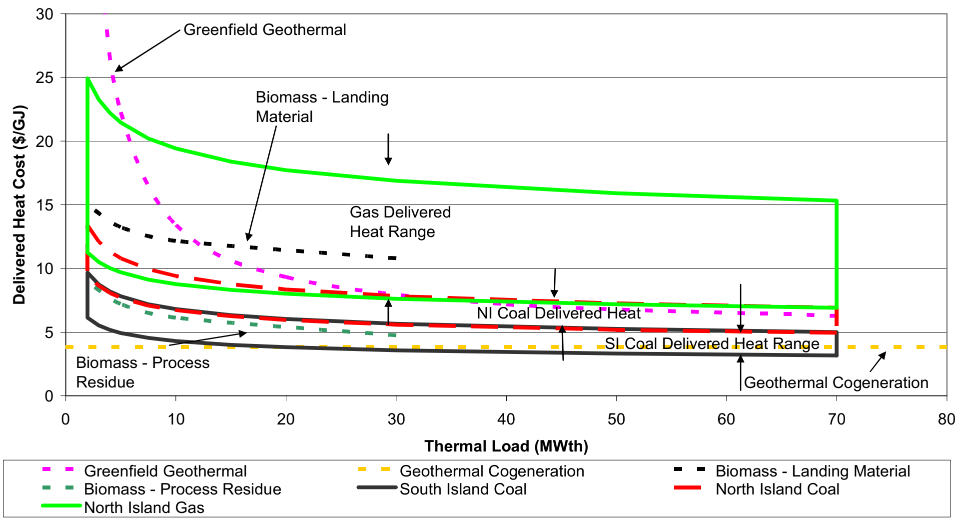

Figure 4.2 Sample output of heat cost modelling – 2005 heating costs with no carbon charge (10% IRR)

The opportunities for landing material is brought out in more detail in Appendix 3. This shows that currently almost no landing material can compete with coal (a fuel available in both islands). However, a carbon charge on fossil fuels can make increasingly useful quantities of landing material available and price-competitive (after considering the cost of heat plant). An example of the modelling work done on fuel supply costs and quantities is shown in Figure 4.3.

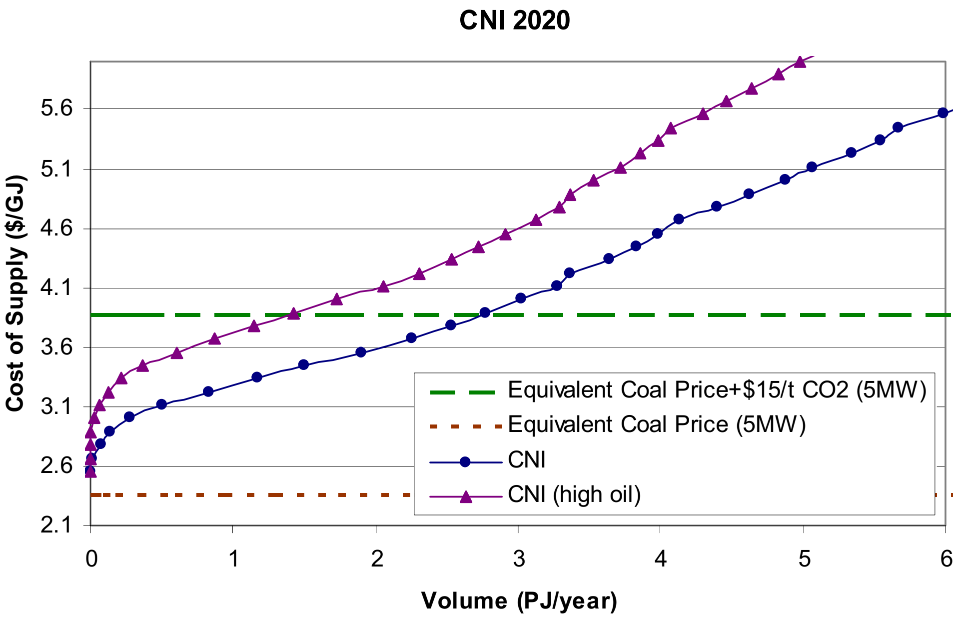

Figure 4.3 Sample supply curve indicating the type of scenario modelling undertaken and the increasing quantity of landing material that is expected to be economic as effective coal price increases

Note that Figure 4.3 shows reduced quantities of landing material being competitive in a high oil price scenario. This reflects the lower energy content in wood than coal on a volume basis, and hence the relatively high transportation costs for biomass. Transport fuel price increases can therefore negatively impact on uptake of biomass.

Also note that this analysis has been undertaken on the basis that coal is the competing fuel.

5 Potential Users

5.1 Current and Potential Direct Users

There are a number of opportunities for bioenergy facilities throughout New Zealand. Current economics for bioenergy plants are such that heat production from on-site processing residues is economic but sites are often constrained by limited residue quantities. While cogeneration is a possibility for some sites, in most situations it is unlikely to be economic.

5.1.1 Industrial and commercial

At the industrial and commercial levels of activity, energy from biomass is best developed where fuel source and heat demand opportunities can be optimised to provide good economic outcomes for biomass heat plant as either stand-alone plant or part of a co-generation facility.

The wood processing industry, including pulp and paper manufacturing and LVL[16] plants are the most likely candidate for suitable sites. These have the fuel resource, usually a waste or low value by-product of their processes, and usually have heat energy requirements associated with those processes or a related activity on an adjacent site may have heat energy requirements.

Existing sites hosting biomass energy plants are located throughout New Zealand. These sites range from the large pulp and paper processing plants[17] at places like Kawerau, Kinleith and Whirinaki, to specialist plants like the LVL plant at Marsden Point and the MDF plant at Rangiora, to a much larger number of smaller timber processing and sawmilling sites where the use of direct heat is usually associated with kiln drying of timber.

The direct combustion of wood processing residues in 2 - 20 MW_{th} [18] boilers or furnace systems is a common form of conversion in the forest processing industry throughout New Zealand producing steam, hot water, hot gases or hot air. A typical large sawmill could have a 10-20MW_{th} heat plant producing heat for timber kiln drying. Where the heat demand is less than the heat plant (boiler or hot water) can produce with the available fuel supply, electricity production (co-generation) is a possibility, as is increasing the kiln capacity. Electricity production from such a facility could have an electricity generation capability of around 1.5-2.5MW_e. A smaller sawmill site is likely to have a 4 - 6MW_{th} heat plant only for kiln drying.

The most strategic and financially attractive energy supply options for wood processors to manage increased energy costs relate to use of biomass residue streams. The fuel is within a wood processor's control and will invariably cost them money to dispose of otherwise. Contingency backup sources of supply can be arranged and the supply can be developed as demand increases.

Other initiatives such as cogeneration will most appropriately be installed when plant upgrade investments occur. Other local embedded generation opportunities may take years of investigation and the securing of land or resources, and then be held until appropriate for investment.

5.1.2 Horticultural

Greenhouses present another prospect for use of biomass. In New Zealand they are becoming an increasingly common means of intensive horticulture. They are usually single-skinned (either glass or plastic). Heating requirements are low grade and could be satisfied by a range of means, but energy use can be of the order of 2.7 GJ/m^2, though is assessed as normally being closer to 1.6

[16] Laminated veneer lumber
[17] Black liquor, a by-product of chemical pulping, is a significant biomass fuel even with a high water content
[18] MW_{th} = MWthermal

GJ/m^2. Frequently heated greenhouses rely on fossil fuels: especially coal[19], but also gas and waste oil[20]. These perform the dual functions of heating and providing a source of carbon dioxide for growth. These are especially focussed around Auckland, but include lesser concentrations in Northland, the Waikato and parts of Canterbury.

5.1.3 Commercial and residential

The replacement of open fires and the conversion of existing coal fuelled boilers for schools etc with high efficiency wood burners can be one of the most effective investments homeowners/energy users can make. In a home, if the wood burner is connected with a wet-back to the hot water storage cylinder, electricity costs for heating water could nearly be eliminated during winter. One biomass fuel source is wood pellets.

The use of wood-pellets for residential and commercial applications is relatively new to New Zealand. The New Zealand market was initially developed with wood pellets being supplied from a manufacturing facility in Christchurch. More recently a larger wood-pellet plant has been established in Rotorua because of the availability of feedstocks from the domestic wood-processing industry and the proximity to a number of major North Island markets.

The main target markets for the wood pellets are:

- Residential heating
- Community buildings (schools, hospitals, district council facilities)
- Motels and hotels
- Greenhouses

The heavy concentration of forests and processing plant in the vicinity of Rotorua, Christchurch and to a lesser extent Dunedin and Invercargill will make these areas preferential uptake sites.

5.2 Encouraging New Demand

The benefits of renewable energy cover both substitution of fossil fuels and increased energy consumption (associated with health or economic growth). In the present context this is quite relevant as much of the increase in bioenergy use will occur as a result of increased domestic processing, with wood process utilizing their on site waste as fuel.

There are sectors of the existing heat market that have not used biomass commercially in the recent past, examples include the meat and dairy industries. As boiler plants approach replacement, biomass energy options should clearly be in front of decision makers. Hence some key requirements for future uptake will be knowledge dissemination, case studies, and ideally access to vanguard installations.

Organisations such as Scion have been actively researching aspects of bioenergy for many years and making this growing pool of knowledge available.

The New Zealand Clean Energy Centre is an example of a new type of organisation developing around energy issues. The NZCEC specifically aims to encourage the development of geothermal and biomass energy forms, initially through direct facilitation. Ultimately NZCEC want to establish business clusters that can work more effectively on the development of projects and businesses in support of geothermal and biomass (direct use) development.

[19] Barber A (2003) *Greenhouse Energy Use & Carbon Dioxide Emissions.* MAF Technical paper No 2003/03
[20] Geothermal energy is also used but does not provide CO_2 currently

A number of organisations have developed competencies around biomass and so will continue to implement projects using this fuel where appropriate. One example is Energy for Industry (EFI). This is a Meridian subsidiary based on an energy service company (ESCO) model. It invests primarily in heat projects for large commercial and industrial operations around the country on a build own operate transfer (BOOT) basis. EFI has invested in a range of heat plants (including coal and biomass). In February 2007 it became a major sponsor of the NZCEC with focus on a specific project (though this initial project will be geothermal rather than biomass).

6 Qualitative Review of Key Drivers

6.1 User's Perspective

The bioenergy market is focused on heat, as electricity production from bioenergy is not currently economic, and is even only occasionally economic in a cogeneration situation. While the economics for cogeneration of electricity will become more financially attractive as electricity prices increase, it is unlikely that production of electricity alone from biomass will be economic for some years.

50% of the capital cost of bioenergy heat plant is in the boiler with the remainder in fuel storage and handling. There is little need for improvement in boiler plants as this is well proven and is adequately available. Substantial experience and development is needed in fuel handling and storage to improve performance and to reduce costs. This is an area where the transfer of overseas experience and knowledge would be of value.

The suppliers of bioenergy heat plant equipment are the principal providers of information to potential investors. Generally there is a high quality of advice given but investors are dependent on choosing the right suppliers from the start.

Except in the few large companies where specialist staff are available few wood processing companies have the resources to undertake significant investigation and development of bioenergy options.

The knowledge of the cost drivers throughout the bioenergy value chain is poorly researched and generally rarely publicly available. Making more information available on an open basis to industry participants will improve decision-making and allow better management of business risk.

The economics of bioenergy are currently driven by the need for heat and the avoided cost of woody biomass process waste. Currently bioenergy is attractive against gas and coal for heat production only with inclusion of the avoided cost of waste disposal. Bioenergy is only marginally more attractive against gas and coal if there is no avoided waste cost. The relative costs will change significantly in favour of bioenergy as gas prices increase over the next few years in response to the decline of Maui gas, and if a carbon charge is introduced.

Left to business-as-usual the bioenergy market will continue to grow but at only just above its current rate. To be fully effective as a hedge against increased energy prices the rate of uptake needs to be increased by effective collective action. Particular support is required for the large number of small/medium sized industry participants who will not have the resources to take individual action.

Forest residue as a fuel for energy production has the potential to meet all the wood processing industry's energy needs for heat and electricity. Currently the cost of residue as a fuel source is too expensive but because of its significant potential this is an area where more reliable information is required.

The economies of scale for heat plant indicate that there will be significant commercial advantages for clustering activities around common heat plant. This also provides a good fuel supply risk management mechanism as individual company fluctuations in waste wood supply can often complement each other. Energy demand peaks can also often be staggered to best advantage of all parties.

While clusters of energy activities are commercially attractive it can be very difficult in practice as the commercial and operational objectives of the various players may not align.

The internal drivers (opportunities and threats) for development of direct use applications from a user's perspective are seen as follows:

6.1.1 General concern over rising fuel prices

The public is generally aware that fuel and electricity prices are rising. This is forcing reconsideration of energy options for all user types. Biomass energy may be seen as a means of partially isolating the user from future imported fuel price movement.

Equally, if the public perception is that energy price is unstable then this may have the effect of delaying a decision on a new heat plant until trends have settled.

6.1.2 New developments or plant replacement

Whenever a new development is being considered, appropriate energy options will be reviewed by all user types. This will also apply to replacement of aging heat plant. The high capital investment required at these times gives users the opportunity to make a decision based on lifecycle costs, without having to face aversion to writing off existing capital intensive heat plant that may still have significant useful life remaining.

EECA has sponsored the development of a heat plant database, managed and available from the Bioenergy Association of New Zealand. This database can provide an indication of when existing boilers will face replacement.

6.1.3 A requirement for a quality fuel supply

In most cases, heating is a means to an end. It is a necessary service within a business or home established with an entirely different focus, other than heat itself. Thus heating options should ideally be trouble-free and reliable, and should rarely be a cause for concern after installation.

In the past, fuel wood has not met this quality requirement. Even in the case of large industrial applications such as the cogeneration facility at Kinleith, workers are known to have a preference for firing with gas rather than biomass because of fuel handling difficulties.

Modern pellet burner applications can offer fully engineered solutions with automatic control of different sectors within a property. This type of quality product can operate quietly in the background.

6.1.4 A requirement for a reliable fuel supply

A major blockage to large scale uptake of biomass fuels has been the absence of suitable contracts for supply of the fuel. The wood pellet industry is still in its infancy, and commercial parties faced with high capital cost investment must be sure of suitable quality and quantity of fuel at acceptable prices for long periods of time. This can only be reasonably achieved through suitable long term contracts.

Confidence in the supply chain should increase as the industry matures.

6.1.5 Proximity of resource and user

The high transport costs in terms of energy per unit volume compared with coal mean that resource and user must be within reasonable proximity for supply costs to remain competitive.

6.1.6 Concern over CO_2 and other air emissions

There is growing concern over the impacts of ongoing CO_2 emissions, particularly with respect to possible impacts on climate change. At one level this is a concern of heat consumers and may encourage the selection of renewable energy options over fossil fuel options for direct heat use applications.

When the concern is stemming from government, there can be a range of measures to encourage a shift from fossil fuel to renewables.

In a number of locations there is growing concern over particulate emissions from fossil fuel sources. A National Emissions Standard for Air Quality was introduced in September 2005 forcing regional councils towards improved air quality standards between 2005 and 2013. Regional and local councils are imposing restrictions on heating options in places like Rotorua and Christchurch. These restrictions can be accompanied by programmes to replace smoky fires, whether they are wood- or coal-fired, with some form of low emission technology. In both of the cases cited there could be wood pellet solutions. These considerations have impacted on the view of uptake in these respective areas.

6.1.7 Reduction of choice

Solid Energy has announced an intention to completely withdraw from the home heating coal market by the end of 2012, and has already stopped Canterbury home heating supplies with the exception of Timaru. While there may be competitors still in this coal market in some areas, withdrawal of a major supplier will send strong signals through the market that alternatives need to be identified. For South Island consumers, electricity (including heat pump options) and biomass will be the main options.

6.1.8 Concern over current levels of domestic heating

It is now recognised that many New Zealand homes are too cold, and that this is impacting health and possibly income. Consequently, users may choose to raise home temperatures, either by increasing a building's insulation levels, or simply by increasing heating requirements. Increased heating requirements may alter the optimal solution from one type of fuel to another, especially favouring more capital intensive low fuel cost solutions.

6.1.9 Home ambience

Many decisions at a domestic level are not based on economics, but on less economically rational factors. For many, the idea of a glowing fire is attractive for home ambience. Gas equipment suppliers have developed pseudo log burners because of demand. A pellet burner provides the real thing, either as a stand alone unit or one inset into a wall, while still offering near the same convenience of gas.

6.1.10 Aversion to high capital expenditure on heating

People are still averse to high capital expenditure on heating options. In the New Zealand domestic market, homes are kept for around 7 years before owners sell and move to another property leaving many consumers concerned that they will not recover their investment over that period. Depending on how the proposed Home Energy Rating Schemes (HERS) currently being set up by EECA are set up, this situation may change, with homeowners being able to point to benefits that can lead to long term cost reductions for the potential buyer.

Note that in Europe, where homes may be kept for generations, owners are less averse to long term investment in property improvements.

6.1.11 Current knowledge of biomass resources and equipment suitable for direct use

In reviewing drivers for investment in biomass direct heat, it seems that ignorance of the opportunity has been a factor behind the lack of forward momentum. The dominance of electricity as though it were the only energy source has constrained thinking about energy in general.

Technology for exploiting biomass energy has not changed much in recent years. However, some technologies such as pellet burners are new to New Zealand, and people's awareness of the option is just increasing.

There are four areas where further research effort should be focused:

Fuel Quality

- Improving the homogenous characteristics of fuel
  - Pelletising
  - Reducing boiler design costs
  - Reduced O & M costs
- Improving equipment for processing wastes
  - Improving ability to take all waste
- Improving forest residue collecting and handling practices
- Improving fuel storage
  - Reducing storage costs
  - Automating fuel handling

Fuel Supply

- Improving long term supply
  - Trade in surplus waste
  - Backup sources of biomass
  - Co-firing with coal and gas
- Forest residue as a contingency supply

- Improving delivered biofuel cost
  - Developed supply infrastructure
  - Economies of scale
  - Sourcing, processing and delivery technologies

Knowledge

- Preparation of:
  - Case studies
  - Handbooks
  - Good practice guides
- Research into economic drivers and risk management strategies
- Dissemination of international advances in technologies and equipment
- Dissemination of international conference papers
- Accreditation of pellet fire installers
- Training of heating trades

Experience

- Reference projects
- Case studies

6.2 Resource Owner's Perspective

6.2.1 Major national biomass developers[21]

The last three to four years have been difficult for the New Zealand forest-growing sector. A high exchange rate, increasing costs, particularly shipping costs, along with competitive and changing international markets have adversely affected forest growing profitability in New Zealand. The immediate future is still difficult, especially in the export market, as despite some price rises the

[21] http://www.climatechange.govt.nz/resources/reports/projected-balance-emissions-jun06/html/page12.html

exchange rate remains high and shipping costs are expected to reach record highs in the next 12 to 18 months.

There has been the largest volume of forest sales since state forest privatisation in the late 1980s. New Zealand's two largest corporate forestry companies (Fletcher Challenge and Carter Holt Harvey) have both sold forests. In the case of Fletcher Challenge all forests were sold. The pattern of forest ownership is changing. With Weyerhaeuser announcing the sale of its Joint Venture Nelson forests and the recent sale of Carter Holt Harvey to the Rank Group, and subsequently to Hancock Natural Resource Group, further changes are anticipated. Superannuation funds and timber investment management organisations (TIMOs) have purchased large areas of plantation forests in New Zealand. TIMOs now own around 20 percent of the total planted forest area in New Zealand. The nature of forest ownership and management has changed from largely owner managers to some more complex arrangements in some areas with land owners / tree owners / forest management by contract.

There is now greater separation between forest ownership and land ownership than has been the case historically. Land owners are looking to realise some of the increased land value through forest land sales. In some locations pastoral farmers are currently willing to pay higher prices for land than commercial forest owners.

The net result of all of these changes along with an uncertain future has led to:

- A major decline in the rate of afforestation. Afforestation has fallen from a 30-year annual average (1974 to 2004) of 43,000 ha to just 6,000 ha in the year to December 2005.

- The new phenomenon of deforestation where plantation forest land is converted to alternative land uses, particularly pastoral grazing. In the year ended March 2005, an estimated 7,000 hectares of deforestation occurred. This was predominantly in the Central North Island and Canterbury regions. Historically, little plantation deforestation has occurred.

On the policy side there has been strong opposition from the forest industry towards Government's climate change and forest policies. This is likely to have had both real and perceived impacts on forest growing investment decisions.

6.2.2 Fuel prices

Record fuel prices for diesel have had an impact on current harvesting decisions and future forest establishment. Areas which are marginally economic have had their harvesting deferred until the economic environment, (including fuel prices) improve. This deferment means this area is not available for replanting, or if it were harvested, may not be re-established in forest as it is seen as marginal. Reduction in re-establishment on marginal areas reduces long term availability of forest harvest.

6.2.3 Integration of forest ownership and processing

Recent sales of large areas of forest have seen a significant drop in the area of forest that is owned by companies also involved in wood processing. This disconnection means that it is likely to be more difficult for forest owners and processors to utilise forest residues as they are working as customer and provider as opposed to working in the interest of a single entity.

6.2.4 Guaranteed markets required

For forest-derived fuel to develop there needs to be a large stable market so that suppliers, usually contractors, can have adequate security of work to attract the necessary investment.

6.2.5 Fuel supply security

Levels of forest harvest are not static, and whilst a realistic minimum may be estimated, this may be well below the actual harvest in any year. However to base predicted supply on what potentially could be harvested is risky, as the harvest levels fluctuate from year to year and over a period of several years as forest growers increase and reduce harvest levels based on the log price at the time. Higher prices lead to higher levels of harvest (sometimes unsustainably high) and low prices lead to deferred harvest.

6.2.6 Environmental drivers and FSC

Many forest companies in New Zealand have got or are seeking Forest Stewardship Council Certification (FSC) for their forests and products so that they can continue to sell into overseas markets. To attain FSC forests must be managed in a sustainable way. Sustainability covers the impacts on the off-site environment as well as the forested area. In order to be sustainable, impacts on water and air (which can move off-site) must be minimised. This means that operations that adversely affect air and water quality must be avoided where possible. This reduces the attractiveness of burning as a forest management tool and any increase in volume recovery that also reduces the potential for slips on steep slopes is a benefit. These items make the use of forest residues environmentally if not economically attractive.

6.2.7 Transport and infrastructure

Transport and truck loading are an increasingly expensive part of getting any forest product to market. It is capital intensive and fuel price is a significant component of delivered cost. A key to getting a forest derived fuel system to work is having the fuel close to the user. Many of the areas of forest harvest expansion (the wall of wood) are in areas such as the East Coast, Northland, Nelson/Marlborough and Otago / Southland. These areas were established in forest because the land was cheap or for soil conservation reasons, not because it was close to population centres, ports or industry or even economic to harvest. Hence transport costs are high and are likely to contribute significantly to barriers to implementation of forestry biomass fuels. The roading networks in these areas are often underdeveloped and need upgrading and higher maintenance to cope with the increased traffic due to logging. The costs of these are often a source of contention between local authorities and forest companies.

6.2.8 Skills and workforce

The forest industry has had issues around workforce recruitment and retention for the last 20 years. This is particularly so in the silviculture workforce but still relevant to harvesting and transport sectors. Expertise in operating specialist equipment such as hoggers is also limited. There is a need to develop the knowledge and expertise at all levels in the forest industry around fuel quality and how to maximise it, fuel supply logistics and fuel production systems.

6.2.9 Forest resource

New Zealand has a proven ability to grow softwoods (Pinus Radiata) rapidly and on a large scale. This has lead us to being an exporter of logs and wood products. The resource is capable of harvest levels several times in excess of domestic demand. This resource is maturing and the long predicted wall of wood is becoming available now and increasingly over the next 5 to 10 years. Harvest levels could increase from current (approx 20 million tonnes per annum) to over 30 million tonnes by 2010. The trend beyond 2025 will depend on forest establishment levels and the extent of the current move towards deforestation and conversion of plantation forest to farming. Even with the short term deforestation trend, harvest levels are unlikely to drop below 30 million tonnes until after 2030.

The impact of the suggested compulsory retirement of some steep grazing lands into forestry by the Government at the end of 2006 (up to 1,170,000 ha) is yet to be determined, but could be significant depending on the species established and the management and harvesting regime applied.

6.2.10 World demand for wood products

The demand for logs and wood products on a world scale is expected to be strong. China's demand is substantial and the log supply it has been getting from Russia is likely to have substantially increased costs due to tariffs that are to be imposed over the next few years. India's demand is strong and growing, despite infrastructure issues that impede material flows. Competing log supply out of South-East Asia will continue but will be under increasing pressure as forests dwindle and environmental pressure to be sustainable increases. Traditional markets such as Australia are likely to decline as their own plantation forests mature.

6.2.11 Carbon credits

Currently there is considerable debate about the Governments plans around the allocation of carbon credits from forests. The announced intentions are having a negative impact on new forest plantations and on the replanting of harvested cutover. A further uncertainty is around what the level of possible carbon emission charges will be.

6.3 Solid Energy and Nature's Flame

As part of a diversification policy, and recognising tightening air quality standards, Solid Energy (previously Coal Corporation) reviewed energy trends, and identified key risks and opportunities for business over the last six years. From their 2006 Annual Report, they concluded that their base competencies as a coal miner applied readily to developing and marketing other sources of locally-produced energy, including biomass, "similar in virtually every business respect to coal and coal-related areas such as coal seam gas and hydrogen produced from coal". Consequently they acquired Nature's Flame in 2003.

Further in their marketing, Solid Energy makes the following observation:

> "Solid Energy's acquisition of the Nature's Flame business underlines it's recognition that burning solid fuels – wood and coal – on domestic open fires is unacceptable in New Zealand cities that suffer from poor air quality and moves to increase the use of renewable fuels.
>
> It is our intention to grow the wood pellet market for home heating and industrial energy and to further develop innovative biomass energy solutions."

This market, though still relatively small is accelerating quickly. Sales growth on burners for their 2006 financial year were up 31%.

Nature's Flame supplies wood pellets and associated systems including the burners and controls. In their marketing of Nature's Flame they note the following benefits which reflect drivers for potential uptake by users:

- Cost savings (cheaper than bottled gas or electricity)
- Attractive natural fire ambience
- High heat output (up to 11kW) able to heat large spaces
- Controllable clean heat even on low (2kW)
- Environmentally friendly (low emissions)
- Guaranteed supply of sustainable, natural fuel
- No dust, no smell, no smoke and no more chopping and carrying firewood
- Low maintenance with less than 1% ash
- Cosy, instant heat that can come at the flick of a switch

- Hot water booster (1.3kW)
- Safety features

Solid Energy is taking a number of proactive steps to encourage the market. These steps include:

- Establishing major pellet manufacturing plants
- Offering fully engineered pellet solutions to home, office and industry to enable replacement or conversion of existing plant. This has included a model conversion of a high school from coal to pellet firing
- Offering integrated solar and pellet central heating conversions as a renewable solution for homes and business
- Securing resource consents in batches for potential users of the pellets and burners (405 consents were obtained from Environment Canterbury to enable new installations or retrofit installations where there had not been a solid burner before)

7 Quantitative Review of Key Drivers

7.1 User's Perspective

An analysis of the current heating cost of alternative fuels compared to that of bioenergy for a new plant with no allowance for avoided waste disposal costs, is shown in Figure 7.1. Regional differences in the delivered price of coal and gas give rise to the range of prices.

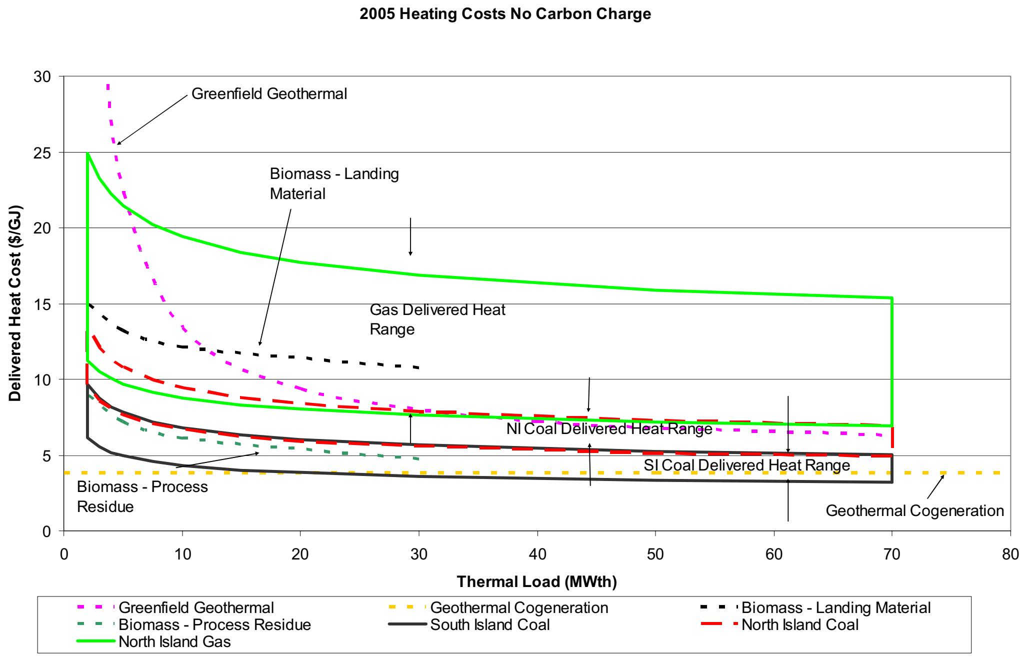

Figure 7.1 Heat Plant Delivered Energy Costs (includes capital, O & M and fuel costs at 10% WACC and 20 year life)

Figure 7.1 shows that bioenergy is currently competitive with coal for process heat. In a number of locations coal or gas would be the fuel of choice, while in other locations bioenergy will be more attractive. The choice will come down to risk management considerations and the future value that will be placed on carbon emissions to the atmosphere.

Bioenergy is currently marginally economic for heat production, but as the cost of gas and coal increases, wood processors will be more attracted to bioenergy for heat production. This will increase the industry experience with modern heat plant and, along with the future climate change policy implementation, will be the most significant driver for a greater use of bioenergy. On the other hand the cost of biomass for fuel will increase as it becomes recognised as a valuable feedstock for processing such as MDF.

High costs of disposal of waste to landfills are a principal driver of the economics for new bioenergy plant within the current economic context. As disposal costs increase the value of the waste as a fuel source will increase.

With increased gas and coal prices forest residue will be getting closer to being economic.

Table 7.1 Additional Heating Costs due to Gas Price Increases and a Carbon Charge

	Additional Heating Costs \$/GJ [22]			
Individual Cost Increases	**South Island Coal**	**North Island Coal**	**North Island Gas**	**Geotherm al**
Increased gas and coal cost only	1.3	1.9	2.7	0.0
\$25/t CO_2 charge only	2.6	2.7	1.8	0.4
\$10/t CO_2 charge only	1.1	1.1	0.7	0.2
Combined Increased costs \$/GJ				
Gas \$2/GJ plus \$25/t CO_2	3.9	4.6	4.5	0.4
Gas \$2/GJ plus \$10/t CO_2	2.3	3.0	3.4	0.2

In practice, these price increases are relatively minor when compared with the distributed (rather than wholesale) cost of energy. Appendix 4 shows delivered gas price, depending on consumer size and location in the range \$12-80/GJ, while delivered coal price will be in the range \$4-15/GJ (clearly more sensitive).

The bioenergy cost (\$/GJ of useful energy output) is particularly sensitive to:

- Fuel feedstock production costs
- Fuel collection and harvesting costs
- Transport/delivery costs
- Competition for biomass for processing and fuel
- Future climate change policy imposts
- Moisture content
- Fuel quality (including contamination issues)
- Transport distance
- Capital cost of equipment (especially fuel handling equipment)
- Labour requirements
- Conversion efficiencies
- Load characteristics

7.1.1 Capital costs

Analysis of typical heat plant indicates that approximately 50% of the capital cost is associated with the boiler cost, and 50% with the fuel storage and handling. If electricity generation is required this can double the capital cost because of the higher pressure of the boiler, costs of a turbine, generator and sometimes a cooling tower.

[22] Conversion factor: 1 \$/GJ =0.36 c/kWh

Approximate Split of Capital Costs

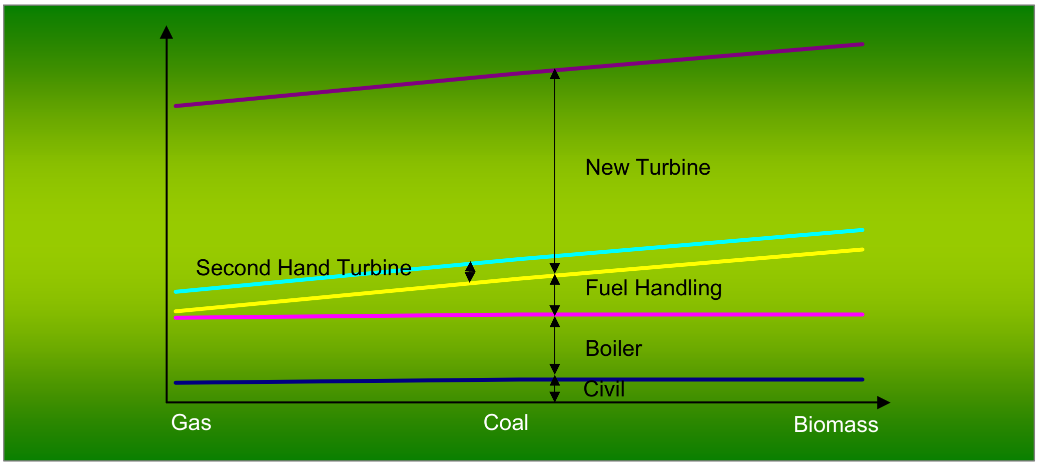

Figure 7.2

A bioenergy facility has a higher capital cost than a gas or coal facility but as can be seen from Figure 7.3 the fuel for the gas and coal facility can be substantially more. This applies to both heat and electricity generation plant.

Many coal facilities have been installed even when there are adequate quantities of biofuel available because second hand coal boilers are available at a fraction of the cost of new bioenergy plant.

Relationship Between Costs and Fuel Type

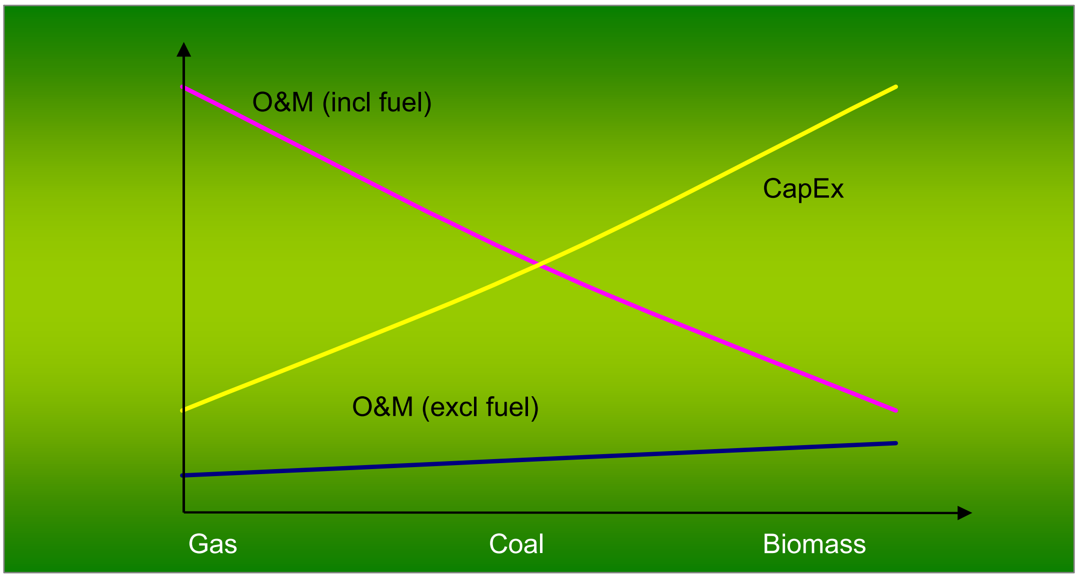

Figure 7.3

The cost of capital is a significant issue for all wood processors. Wood processors typically seek to recover their capital in 12 –36 months. This can mean that it may be a financially sound decision to keep current inefficient or fossil fuelled heat plant in use, as it is an operating expense, rather than incur capital expenditure.

Disposal of wood waste to a landfill also is an operating expense that may be preferable than committing capital funds that can be profitably used in investment in processing plant.

Gas and coal plant can be a serious competitor to bioenergy as the plant usually has a lower capital cost, again allowing capital to be used for other purposes.

7.1.2 End uses

	State of development	**Retrofitting of existing boilers and back up**	**What information do we need to advance implementation**	**Barriers for expansion of wood pellet applications**
Coal boilers	Combustion technology mature Gasification technology immature	Minor modification required In case more boilers are available on site a fossil fuel based boiler should be used to cover peak load; otherwise a suitable fossil fuel based system should be used for peak load	Number and size of coal boilers in New Zealand Options for retrofitting or co-firing Reasons for implementing new coal boilers Cost competitiveness of wood pellets as fuel	Security of supply of fuel pellets Cost of fuel pellets Information Lack of skilled personal to undertake conversion
Oil boilers	Technology mature	Modification required In case more boilers are available on site a fossil fuel based boiler should be used to cover peak load; otherwise a suitable fossil fuel based system should be used for peak load	Number and size of oil boilers in New Zealand Options for retrofitting or co-firing Reasons for implementing new oil boilers Cost competitiveness of wood pellets as fuel	Cost of modification Security of supply of fuel pellets Cost of fuel pellets Information Lack of skilled personal to undertake conversion
Natural gas boilers	Technology mature	Major modifications required and may not be possible In case more boilers are available on site a fossil fuel based boiler should be used to cover peak load; otherwise a suitable fossil fuel based system should be used for peak load	Number and size of natural gas boilers in New Zealand Options for retrofitting or co-firing Reasons for implementing new natural gas boilers Cost competitiveness of wood pellets as fuel	Cost of modification or investment cost in new technologies Security of supply of fuel pellets Cost of fuel pellets Information Lack of skilled personal to undertake conversion
Wood pellets boilers	Combustion technology mature Gasification technology not mature	A fossil fuel based boiler may be required for peak load	Competitiveness of wood pellet technologies with regard to costs, convenience and environmental advantages Cost competitiveness of wood pellets as fuel	Security of supply of fuel pellets Cost fuel pellets Information Lack of technical applications in NZ in this area
Furnaces/ heaters (residential applications)	Technology mature	A fossil fuel based boiler or electricity may be required for peak load	Competitiveness of wood pellet technologies with regard to costs, convenience and environmental advantages Cost competitiveness of wood pellets as fuel	Security of supply of fuel pellets Cost fuel pellets Information

7.2 Resource Owner's Perspective

Forests produce a range of products, not all of them wood based. Many forests have recreation activities which attract a small fee to cover the administrative costs. Any form of extra revenue that the forest owner can extract from the forest is attractive, as they are often not high return investments. The ability to extract a greater volume of wood (residues currently discarded) from the forest and charge for it is an attractive one. However, the price charged must cover the costs. On top of this, and perhaps more significant, are the avoided costs and non-dollar values that the removal of the residues creates.

7.2.1 Value to owner

The residues created during harvesting and log making have a potential value to the forest owner. These residues typically make up 4% to 6% of the total extracted volume. However, they will inevitably be very low value and charges of $1 to $2 per tonne are currently the norm where there is a charge. In many cases there is no charge for removal of the residues, although this may change over time if demand increases.

At charges of $2 per tonne on 5% of the volume, this material represents (approximately) a 0.1 to 0.2 % increase in revenue. The only way to increase this would be to increase the charge or improve the percentage of residues recovered. Greater residue recovery could be done, but may have a harvesting cost, so is unlikely to be significant as harvesting costs are in the order of $15 to $30 per tonne. If the charge for the residues was increased to the same level as that charged for pulp logs (approx $20 per tonne) then the revenues would be increased by 1% to 2%. If residue users were charged for the material, particularly at the higher rates, they would expect the material to be presented in a way that allowed easy access for loading and transport.

7.2.2 Avoided costs and non-dollar values

On some sites the residues created at logging cannot simply be abandoned and left to rot. They need to be treated, moved or managed in some way to reduce the risk they impose on off-site values. This is often the case in steep terrain with up-hill hauling of stems to processing landings (a common practice). As the waste is produced at the processing landing it builds up into a pile that impinges on the logging activity. At this point it must be removed, in many cases it is simply pushed over the side of the hill at almost no cost. However, this is not always possible and the material is sometimes trucked away to a less sensitive area and dumped, at a cost of several dollars a tonne incurred in the loading and transport.

In other instances the material that has been pushed over the side of the hill needs subsequent treatment to ensure that it does not cause or contribute to slips and damage streams and water quality. These treatments can vary, burning, benching or re-piling of the material back on the landing are some of the approaches used, all have a cost and some have risks (burning) that are hard to measure.

In the case of super-skid operations where the plan is for hundreds of tonnes per day to be processed over a period of months then the costs of dealing with the residues can be substantial as the rapid build-up needs managing.

The extent of these costs varies substantially from site to site and forest to forest, in some cases the costs are very low or nil as there are few risks, other forests are under constant pressure to manage the residues on steep sites to avoid the risk of environmental damage. Where there is need to manage the residues left at landings the costs are likely to be:

- Costs of burning are likely to be in the order of $800 to $1000 per landing, assuming there are no problems with the burn. This means a cost of $3 to $4 per tonne of landing residue.

- Costs of retrieving the material back onto the landing surface with an excavator are likely to be in the order of $2 to $4 per tonne of residue, with not all the residue retrievable.

- Other options are benching a flat area under the landing edge with an earthmoving machine, these costs are likely to be of a similar magnitude to those above (approximately $4 per tonne), varying with the nature of the terrain and soil type.

If the residues are removed as they are created during harvesting then these forest management costs are avoided.

Residue removal or treatment also have non-dollar values, that is there are benefits that occur from removing them, that are not easily quantifiable in dollar terms. This is mostly in the area of avoided risk. Landings with piles of residue perched at the top of a steep slope present a risk. The treatment of the residues is an exercise in risk management, the treatment has a cost but the value of the avoided risk is hard to ascertain. However, where there have been catastrophic failures with off-site impacts the negative publicity and reaction from local authorities has been substantial.

The second non-dollar value is in the area of forest certification. In some instances the granting of a sustainability certificate will require that certain management practices take place, or the certificate will not be granted. The value of having the certificate is hard to define. However, in order to gain it the residues may have to be treated or utilised. Having the residues removed in these situations has a non-dollar value.

8 A Baseline for Direct Heat Use – Historical and Current Use

In New Zealand use of biomass for heat is predominantly in the wood processing sector, in particular, at pulp mills, panel mills and sawmills, utilising the mill's own waste biomass materials. The pulp mills use the black liquor produced in the pulping process to generate heat and power. Over the last couple of years, extraction of forest residues for use as fuel has begun to take place, with 100,000 tonnes extracted in 2006 and utilised at two pulp and paper sites. Other than the wood processing industry, the other major user of biomass is the residential sectors use of fire wood for heat.

8.1 Wood Processing

The wood processing industry is the major user of biomass for heat. The following is a review of the current biomass uptake for heat in this industry.

8.1.1 Sawmilling

Sawmills use the residues of timber manufacturing to generate heat for timber drying. The present sawn timber production in NZ is shown in Figure 8.1.

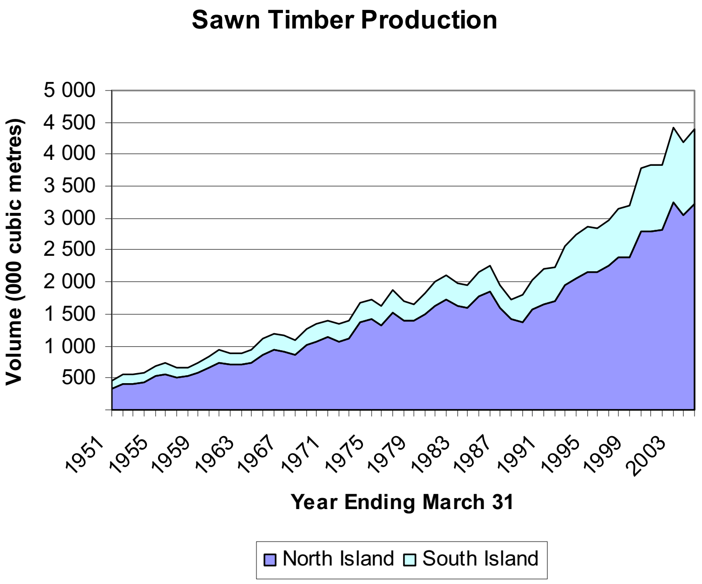

Figure 8.1 Sawmill production

The current installed processing capacity is 5,328,000 m^3.

Using the current EECA heat plant database cross referenced with unpublished survey results produces the results in Figure 8.2 for the distribution of fuel used in sawmill heat plants[23]. Co-firing is assumed here to be 90% coal, 10% biomass.

[23] Note that the database for sawmills is far from complete and may result in biased results, a more comprehensive survey of sawmill heat plants will increase the accuracy of this approach.

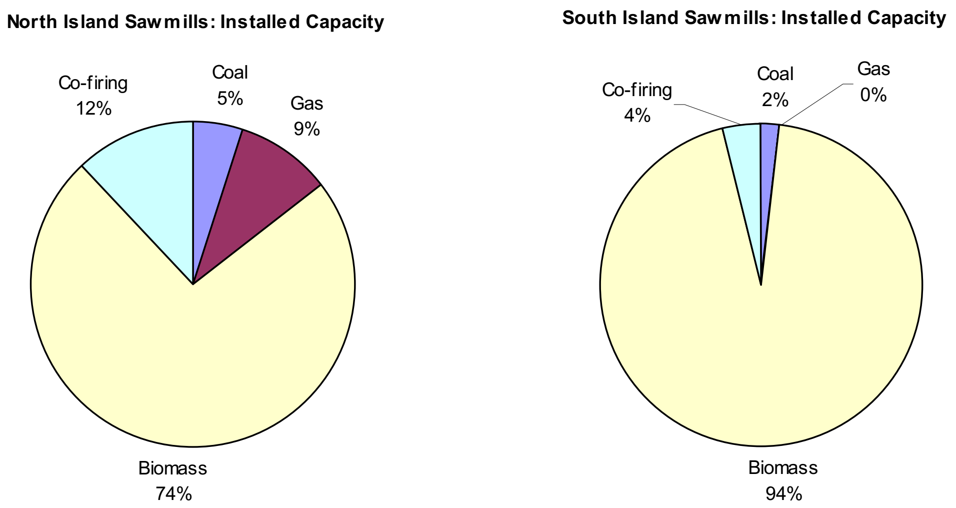

Figure 8.2 Fuel distribution for North and South Island sawmills

Current survey results show that 66% of sawn timber production is dried timber. Assuming an average energy intensity of 2.9 GJ/m^3 for drying[24], a 70% boiler efficiency, and the above distribution of fuels in the two islands we get the estimate of biomass utilization in the sawmill industry shown in Table 8.1.

Table 8.1 Biomass utilization in sawmills

Region	**Production (000 m3/year)**	**Heat demand (PJ/year)**	**Biomass use (PJ/year)**
Northland	279	0.53	0.57
Auckland	352	0.67	0.71
Central North Island	1 943	3.72	3.93
East Coast/Hawkes Bay	385	0.74	0.78
Southern North Island	269	0.52	0.54
Nelson/Marlborough	422	0.81	1.09
Canterbury	230	0.44	0.59
West Coast	88	0.17	0.23
Otago Southland	425	0.81	1.09
Total	4 394	8.41	**9.53**

A rough estimate shows that a sawmill drying 80% of their timber can be self-sufficient in heat by utilizing its residue as fuel. Assuming 50% of the incoming log is sold as sawn timber, 30% as chip, then the energy content of the remaining bark, wet sawdust and offcuts and shavings should be able to supply about 2.9 GJ per cubic metre of dry timber. On the other hand if a sawmill converted to a cogeneration plant and the residue were from dry shavings the residue would be able to supply only 2.7 GJ of heat per cubic meter of dried timber and would need an additional fuel source. Increasing on-site energy efficiency may alter this in the future.

[24] Energy use in the wood processing industry, C. Hodgson et al,(2002)

8.1.2 Panel manufacturing

There are 5 main categories of panel products produced in New Zealand: veneer, plywood, fibreboard (including hardboard, softboard and MDF), particle board (including strandboard and triboard), and laminated veneer lumber. The panel industry has historically experienced rapid growth as shown in Figure 8.3.

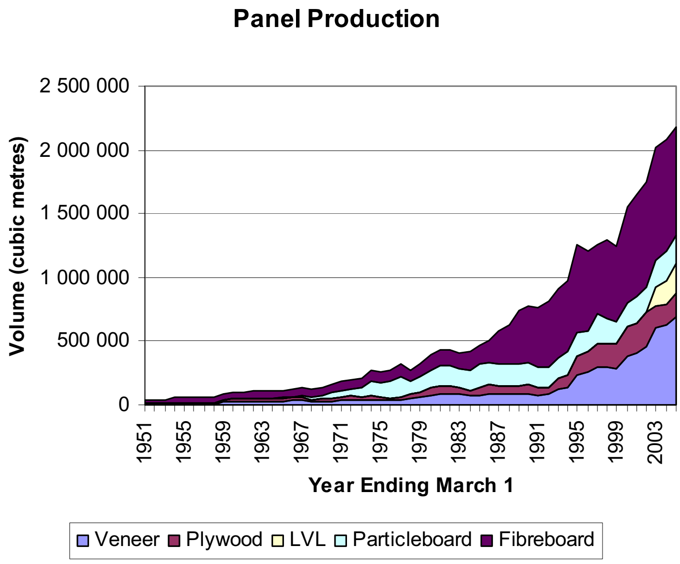

Figure 8.3 Panel production

The heat demand in the panel industry has been estimated from the installed heat plant capacity in the industry (see Table A1 in Appendix 1). The resulting total of 8.0 PJ is not consistent with the 9.4 PJ value found in 2002[25]. The discrepancy may arise from the incompleteness of the heat plant database, under estimating the operating capacity and not accounting for the heat from the pulp and paper plant at Tokoroa. This value gives a heat intensity of the industry as a whole of 3.7 GJ/m^3. The fuel distribution is shown graphically in Figure 8.4. Using this fuel distribution and assuming the boilers are 80% efficient we estimate that the Panel industry used 9.5 PJ of biomass as primary energy in 2005.

[25] Energy Use in Wood Processing Industry, C. J. Anderson et. al., 2002

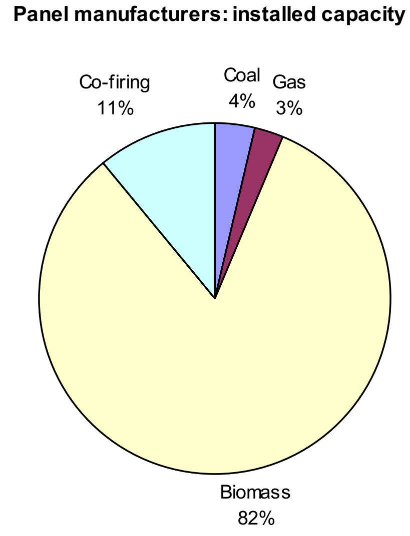

Figure 8.4 Fuel distribution by installed capacity

8.1.3 Pulp and paper manufacturing

8.1.3.1 International context

The New Zealand pulp and paper industry is a major user of logs and sawmill residues largely focussed on producing commodity products for export and sale on international markets.

It is difficult to predict the long-term future of the industry in New Zealand, as the continued viability of the P&P industry in NZ will depend on the continued need for the products they produce and the mills remaining internationally competitive. The P&P industry is a mature industry selling into an international market, favouring the low-cost producers with access to low-cost wood, energy, labour and modern efficient plants. This is why much of the new capacity has gone into South America and there has been closure of plants in North America.

The largest use of bioenergy within the industry is associated with pulp production. It is useful to consider the two types of pulps separately:

- Mechanical mills (especially Norske Skog Tasman, PanPac, Winstone Pulp International)

  These mills use electrical energy to refine wood to produce pulps in high yield (typically >95%) for use in products such as newsprint or packaging.

  The main source of bioenergy in these plants is from the combustion of bark (and at WPI effluent treatment solids) for heat recovery and waste reduction. The amount of bark burnt on-site will depend not only on the production but also on the extent to which they produce their own chips vs. purchase them in.

  The two biggest mills are focussed on production of newsprint or pulp for use in newsprint. This market is expected to decline in the long-term, so the continued viability of these mills will require the development of new markets for their products. The mills are major users of electrical energy in New Zealand, so their profitability is highly sensitive to the cost of electricity.

- Kraft mills (CHH Pulp and Paper sites at Kawerau and Kinleith)

  These mills use chemical pulping processes to produce pulps in a yield of ~40-60%. The remainder of the wood mass is solubilised in the pulping liquor. This liquor is concentrated and burnt to recover both process energy and the process chemicals.

These mills also burn bark and other residues (e.g. pin chips, tall oil). Both mills use a mix of purchased chip and on-site chipping, so the issues around bark are the same as for the mechanical mills.

It is unlikely that we will see any new greenfield kraft mills in NZ in the foreseeable future, as the economic size of plants is so large that there is nowhere in NZ with enough unallocated forest to support a plant. Incremental capacity additions are possible, but would require major capital investment and a continued profitability. Kraft mills are highly integrated, meaning that incremental reductions in capacity (e.g. shutting of one fibreline) are less feasible than in the case of mechanical mills.

8.1.3.2 Heat demand

We estimate the present heat demand in the pulp and paper industry to be 26.8 PJ per annum from the installed heat plant capacity (see Table A2 in Appendix 1). At the Kawerau site one paper machine was shut down since the data in Table A2 was taken, reducing production from 365,000 Adt to 315,000 Adt. Assuming a proportional drop in energy we estimate that there will be a drop in biomass use from 8.86 PJ to 7.64 PJ. From this we determine that 25.6 PJ of biomass is used for direct heat annually in the pulp and paper industry. Another paper machine is expected to close in the next few years reducing production to 157,000 Adt. This will further reduce the biomass utilization onsite to 3.81 and the total to 21.8 PJ. Note that this biomass volume includes that used to generate electricity via cogeneration.

8.2 Residential Sector

34% of energy use in the residential sector is for space heating according to the BRANZ Household Energy End-use Project (HEEP). HEEP has identified solid fuel (56% - about 38% use wood) and electricity (24%) as the main space heating fuels, and result in the estimate of 13.7 GJ/household/year of fuel used in households[26]. This leads to an assessed 8.15PJ/year of biomass energy being used for home heating.

The New Zealand Energy Data File shows 65PJ/year of energy being consumed by the residential sector. BRANZ is just completing its Household Energy End-use Project effectively surveying the details of energy use in 400 homes around the country. The end result will be the ability to effectively model household energy use and assess the benefits of various energy proposals.

Based on the houses surveyed, there appear to be only two heating zones in New Zealand when taking into account the combined heat requirements of space heating and water heating[27]: a cold south including Southland and Otago (and possibly the West Coast, though no houses were surveyed there), and the rest of New Zealand. The heating load (excluding other energy use for lighting, appliances, etc) is about 60% greater in the south than elsewhere. This suggests that any heating solutions will have far greater applicability in Otago or Southland than the Waikato or Auckland.

In the case of pellet and wood burners, their principal duty is space heating, and in that case there is a clear gradation in heating requirements across the whole country (with some cold and warm clusters) increasing going further south.

Unit costs have been assessed for small and large consumers at 5% and 10% internal rate of return. Pellet and wood burners become marginal for large consumers at the 5% IRR. Ultimately, uptake at domestic level will not be determined by pure economics, but by aesthetic aspects (the ambience of a warm fire). An advantage with this aesthetic choice is that ongoing energy costs will be less than some alternatives.

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[26] Report No. SR 141 (2005), MED Energy Data File (2006)
[27] Further zonation is evident when considering space heating only

Assuming an eventual uptake of pellet burners of 200,000 on a business-as-usual basis by 2030, the expected energy use for pellet burners is 1.44 PJ in 2020 and 2.88 PJ in 2030. If a $15/t carbon dioxide charge is introduced the corresponding energy uses are 1.55 PJ and 3.10 PJ. An allowance has been made for possible further uptake of modern wood burners, say for rural areas with access to free firewood, but uptake has been assumed to be a fraction of the pellet uptake. In fact pellet fires are likely to replace some existing wood burners. Energy associated with new wood burners is assessed to be 0.43 PJ in 2020 and 0.77 PJ in 2030 (with carbon charge 0.47 PJ in 2020 and 0.83 PJ in 2030).

8.3 Accommodation

Heat duration curves allow accurate assessments of the annual heating duty on heat supply plant. Scion has been involved with detailed energy studies on a range of accommodation properties in Rotorua. Figure 8.5 shows the heat duration curve for a hotel in Rotorua which is assumed to be typical of hotels throughout New Zealand. It indicates favourable conditions for high capital cost/low operating cost heat plant because typical load is relatively high at around 60% of peak.

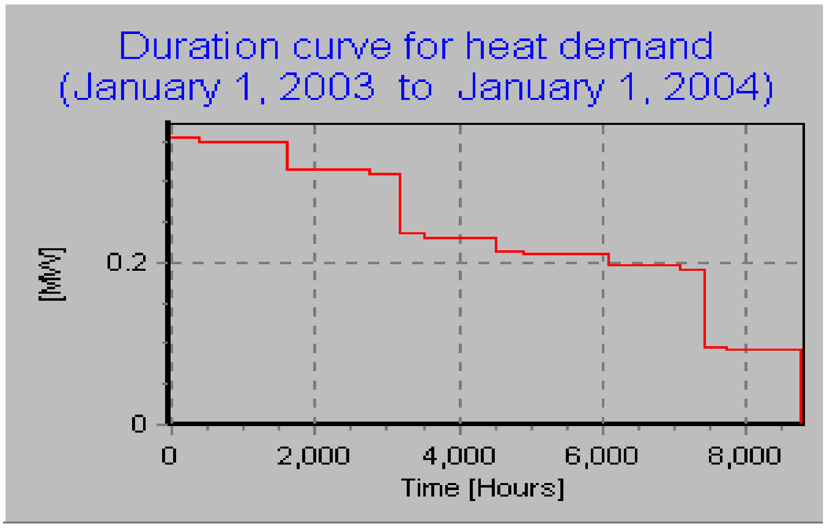

Figure 8.5 Heat duration curve from a hotel, with annual demand including space heating, hot water and washing

EECA has previously studied energy demand in a range of sectors[28]. For the hotel sector, average consumption was about 75GJ/year per bedroom of which about 19% was for water heating and 25% for space heating, so combined heating load was about 33GJ/year per bedroom (0.009GWh/year). Data is unavailable on hotel rooms by region.

The average hotel had 30 bedrooms. From the heat duration curve, the typical peak load for the average hotel will be 55kW with a 1.0TJ/year (0.28GWh/year) load.

The estimated variable cost of electricity, based on Energy Outlook, is 13.1 c/kWh and the estimated cost of heat from a pellet burner (at 10% WACC) is 9.2 c/kWh. Assuming that 6% of the accommodation sector (consisting of hotels, motels and backpackers) install pellet burners the expected energy use in 2020 is 0.17 PJ and 0.18 PJ in 2030. If a $15/t carbon dioxide charge is introduced the corresponding energy uses are 0.19PJ and 0.20 PJ

[28] EECA (2000) *The Dynamics of Energy Efficiency Trends in New Zealand – A compendium of energy end-use analysis and statistics*

8.4 Schools

The heat duration curve for a school is less attractive than for a hotel, in that demand is at a high level for a relatively short period then boilers are idle. More use is made of boilers where there is a swimming pool, or after-hours learning, or where the school is a boarding school. A heat duration curve from Scion research follows. Although the load factor will be much less than for a hotel, the higher demand means some economies of scale can be achieved in terms of the cost of any heat plant. This type of curve would probably favour a low capital/high fuel cost heat option, unless the school could be linked through to other users in a community heating scheme.

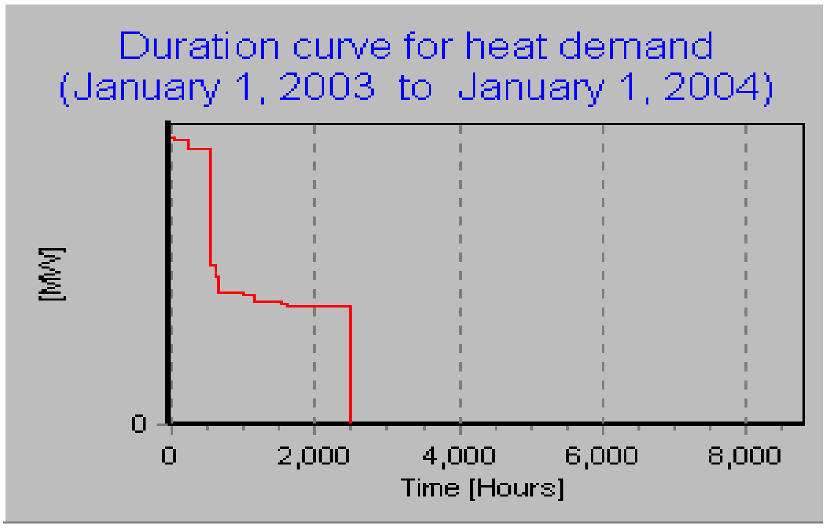

Figure 8.6 Heat duration curve for a primary school with heat covering space heating and a heated swimming pool

A review of the EECA Heat Plant database confirms that large New Zealand schools do have heat plant capable of MW duty, while demand in universities is an order of magnitude greater again. The curve above suggests a 1MW heat source could supply about 1.4GWh/year of heat.

Other data on school energy use suggests that the total annual heating requirement could be of the order of 750kWh/person, though is highly variable.

Based on Energy Outlook the estimated variable cost of electricity is 13.1 c/kWh, and the estimated cost of heat from a pellet burner (at 5% WACC) is 7.9 c/kWh. Assuming that 6% of the schools install pellet burners the expected energy use in 2020 is 0.11 PJ and 0.12 PJ in 2030. If a $15/t carbon dioxide charge is introduced the corresponding energy uses are both 0.12 PJ.

8.5 Local and Central Government

Under the draft New Zealand Energy Efficiency and Conservation Strategy, government is expected to lead the way in terms of energy efficiency and renewables maximisation. Government offices will essentially be a subset of the commercial sector in terms of energy use. The EECA survey referred to earlier shows that energy use per person in the commercial sector is about 55GJ/person/year of which 13% is for water heating and 39% is for space conditioning. Hence total annual heating requirement is about 7,900kWh/person. In 2001 there were approximately 32,000 state employees suggesting a total annual heating energy consumption of 0.9PJ/year. Building load factors are unknown. In practice, most state sector buildings are leased, and landlords will be little motivated to make a high capital investment for energy plant to save their tenants on operating costs. Few government buildings would have a boiler which could utilise pellets.

The estimated variable cost of electricity, based on Energy Outlook, is 13.1 c/kWh and the estimated cost of heat from a pellet burner (at 10% WACC) is 9.2 c/kWh. Assuming that 6% of the local and central government buildings install pellet burners the expected energy use in 2020 and 2030 is 0.02 PJ. If a $15/t carbon dioxide charge is introduced the corresponding energy uses change only marginally.

8.6 Greenhouses

Greenhouses are becoming an increasingly common means of intensive horticulture. In New Zealand these are usually single-skinned (either glass or plastic). Many of these are not heated, but those focussed on tomatoes, capsicum and cucumber generally are (MAF 2003). Heating requirements are low grade and could be satisfied by a range of means, but energy use can be of the order of 2.7GJ/m^2 [29], though is assessed at being closer to 1.6GJ/m^2 (MAF 2003).

Pellet burners can be installed for heating the greenhouse, they have the advantage of producing carbon dioxide for plant growth. The estimated variable cost of electricity, based on Energy Outlook, is 13.1 c/kWh and the estimated cost of heat from a pellet burner (at 10% WACC) is 9.2 c/kWh. Assuming that 4% of the heated greenhouses install pellet burners the expected energy use in 2020 is 0.14 PJ and 0.15 PJ in 2030. If a $15/t carbon dioxide charge is introduced the corresponding energy uses are 0.15PJ and 0.16 PJ.

[29] Based on discussion in White, B (2006) *An Assessment of Geothermal Direct Heat Use in New Zealand*

9 A View of Potential Uptake of Direct Heat Use – Four Scenarios

9.1 Ministry of Economic Development Baseline Projection

The Ministry of Economic Development (MED) has produced a report New Zealand Energy Outlook which evaluates a number of energy demand and supply scenarios for New Zealand until 2030. The report's Base Case is intended to represent a business as usual case, essentially a middle path between optimistic and pessimistic view points. As such it can be used to gauge the impacts possible policy actions may have on the bioenergy uptake in the future.

The base case scenario was derived from a report entitled Heavy Industry Energy Demand prepared by Covec in June 2006. In preparing this report, a number of issues arose surrounding the assumptions in the Covec report, which are outlined and discussed below.

Firstly, the report used timber availability data (see Figure 33 of the Covec report) which does not align with the NEFD predictions discussed in this report and does not refer to the NEFD predictions. In particular, the Covec data did not display the sustained growth in harvest volume that is predicted in the NEFD. This resulted in assessments of production of sawn timber that, although following harvesting trends, fluctuated over the 2005-2030 time period about the current average. In fact, the Covec report assumed that across the whole wood processing sector there will be a few years of increased production until the present capacity is reached and thereafter no further increase in production. This is similar to the "no increased production" scenario discussed in this report and means that the data presented by the Covec report represents a "conservative" estimate of the future development of the wood processing industry. In this report we also consider the alternative scenario that domestic processing increases with increased harvesting, which reflects historical and present trends.

In addition, the Covec report presents a table of heat plants in the pulp and paper industry which is inconsistent with the published EECA heat plant database. Furthermore the proportion of electricity and heat generation assumed in the Covec report for cogeneration is highly unlikely.

9.2 Four Scenarios

The analysis carried out in this report, indicates that the future bioenergy uptake, in particular the availability of biomass resources, is dependent on the future development of the wood processing industry. It has lead to the necessity to split the bioenergy scenario analysis in two. A scenario which is based on "no increase in processing" and another scenario referred to "increase in processing" for the wood processing industry. What happens in the wood processing industry has a direct impact on the production of wood processing residues and indirectly has an impact on the potential uptake of forest residues. We consider each of these scenarios with and without a carbon charge of $15/t CO_2, as this has an impact on the economic viability of extracting forest residues. In addition, we also consider a high oil price variation of the MED base case, which also has an effect on uptake of forest residues due to higher transport costs.

The analysis considers each woody biomass utilisation sector alone and then a combined integration of each of the sectors as the interface between each may affect the cumulative assessment.

9.2.1 Wood processing industry

For the analysis in this report we consider the bioenergy uptake in the wood processing industry for the two scenarios:

1. No increase in processing - domestic processing increases only to present installed capacity
2. Increase in processing - domestic processing follows current trends such that 35% of harvest is exported as logs

For both scenarios it is assumed that wood processors increase their use of biomass for heat in the future, the driver for this being waste disposal costs. All new mills/plants are likely to therefore install biomass fired heat plants and possibly involve co-firing with coal. It is also assumed that the majority of older heat plants will be replaced by biomass plants as they reach the end of their life. A simple approach is used to model these changes by assuming that in the North Island the percentage of sawmills using biomass increases by 1% every year until it reaches 85%. The same assumption holds for panel mills. Following present trends, it is also assumed that the percentage of dried timber increases by 1% per annum until it reaches 80%. To take into account energy efficiency improvements a 0.5% decrease in energy intensity is assumed each year.

Additional to these base assumptions which apply to each scenario there are specific different assumptions for each scenario as follows.

9.2.1.1 Sawmilling

Results for Scenario 1

In this scenario production of logs increases at 2.5% per annum in each region until the present sawmilling capacity is reached. In this case the regional changes in bioenergy utilization for heat are shown in Figure 9.1. The total expected bioenergy uptake is up 4.8 PJ per year in 2020 compared with 2005 and up 4.2 PJ per year in 2030 compared to 2005. It is important to note that the biomass uptake falls by 0.6 PJ from 2020 to 2030 due to increased energy efficiency. The values at 2020 and 2030 are shown in Table 9.1.

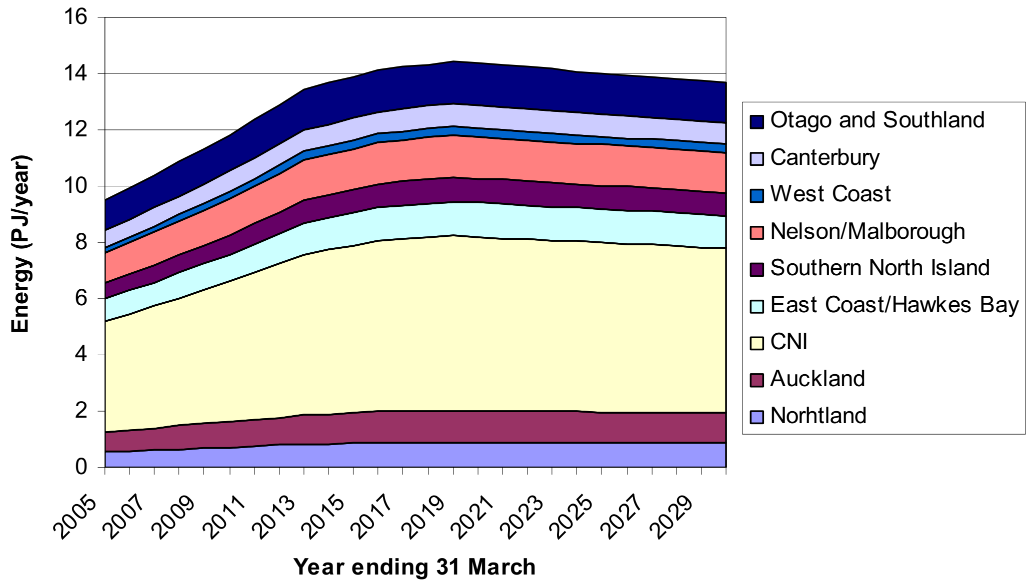

Figure 9.1 Scenario 1 annual regional biomass changes in sawmilling (PJ/year)

Table 9.1 Sawmilling – Scenario 1 annual regional biomass changes in sawmilling (PJ/year)

Region	2005 (PJ/year)	2020 (PJ/year)	2030 (PJ/year)
Northland	0.56	0.89	0.84
Auckland	0.71	1.12	1.07
Central North Island	3.93	6.19	5.88
East Coast/Hawkes Bay	0.78	1.23	1.17
Southern North Island	0.54	0.86	0.81
Nelson/Marlborough	1.08	1.49	1.41
Canterbury	0.59	0.81	0.77
West Coast	0.23	0.31	0.29
Otago Southland	1.09	1.50	1.42
Total	**9.53**	**14.38**	**13.68**

As the processing is not following harvesting there is much forest residue going unexploited in many regions where forests are reaching maturity due to insufficient domestic processing capacity.

Results for Scenario 2

In this scenario domestic processing follows present trends in log exports. More specifically we assume that in each region the ratio between sawn timber and harvested logs in the 2005 year is preserved through out the time period to 2030. The production volumes under this scenario are shown in Figure 9.2 and the corresponding biomass utilization trends are shown in Figure 9.3. The biomass utilization for heat production for the years 2020 and 2030 is shown in Table 9.2.

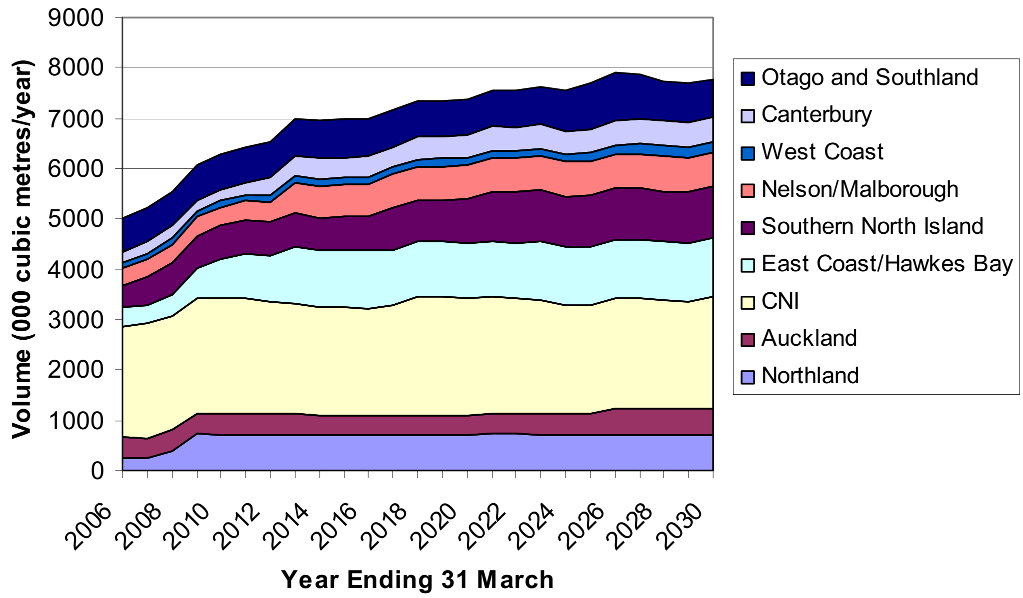

Figure 9.2 Regional annual sawmill production under scenario 2 (PJ/year)

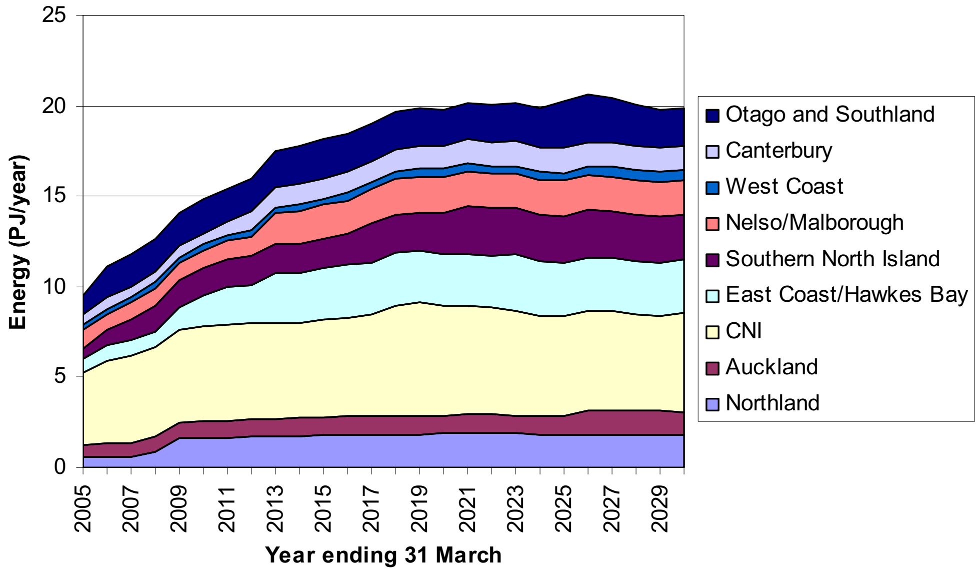

Figure 9.3 Annual biomass utilization trends under scenario 2 (PJ/year)

Table 9.2 Sawmilling – Annual biomass utilization trends under scenario 2 (PJ/year)

Region	**2005 (PJ/year)**	**2020 (PJ/year)**	**2030 (PJ/year)**
Northland	0.56	1.86	1.78
Auckland	0.71	1.04	1.30
Central North Island	3.93	6.06	5.51
East Coast/Hawkes Bay	0.78	2.86	2.89
Southern North Island	0.54	2.29	2.53
Nelson/Marlborough	1.08	1.96	1.88
Canterbury	0.59	1.26	1.32
West Coast	0.23	0.43	0.56
Otago Southland	1.09	2.02	2.09
Total	**9.53**	**19.78**	**19.86**

9.2.1.2 Panel Industry

Results for Scenario 1.

In this scenario the mills increase production by 5% each year until they reach the current capacity after which production is maintained at constant level. Figure 9.4 shows the production volumes and the biomass utilization for this scenario.

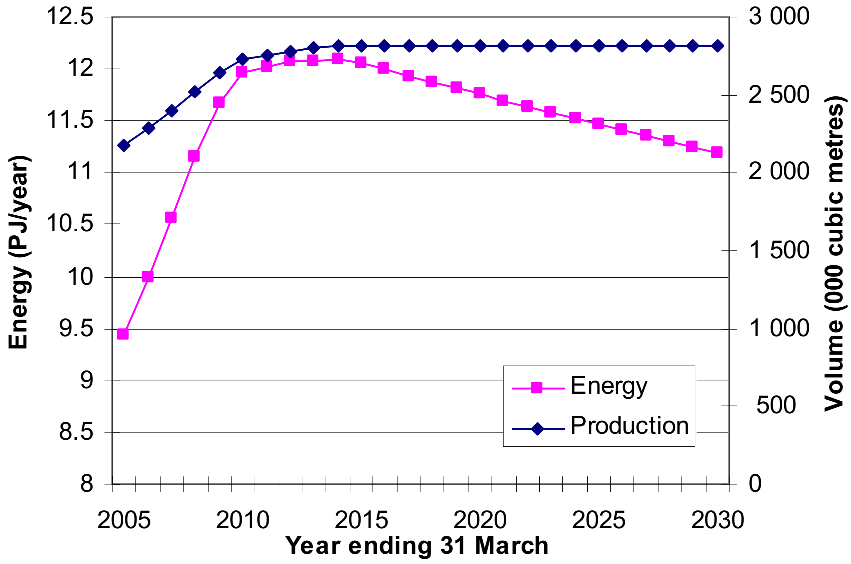

Figure 9.4 Annual biomass utilization for heat in the panel industry for scenario 1 (PJ/year)

An accurate regional breakdown of this prediction requires knowledge of future plant sites. In absence of this we assume that the present distribution of production across the regions will remain the same.

Table 9.3 Annual biomass utilisation in the panel manufacturing – Scenario 1

Region	2005 (PJ/year)	2020 (PJ/year)	2030 (PJ/year)
Northland	2.51	3.10	2.95
Auckland	0.10	0.12	0.12
Central North Island	0.71	0.88	0.83
East Coast/Hawkes Bay	0.93	1.15	1.09
Southern North Island	0.76	0.94	0.90
Nelson/Marlborough	2.59	3.21	3.05
Canterbury	0.63	0.78	0.74
West Coast	-	-	-
Otago Southland	1.28	1.59	1.51
Total	**9.50**	**11.76**	**11.18**

Results of Scenario 2

In this scenario processing follows present trends in log exports, similar to scenario 2 for the sawmill case. The production volumes and biomass utilization under scenario 2 for the panel industry are shown in Figure 9.5. The regional breakdown is carried out in the same way as for the previous scenario.

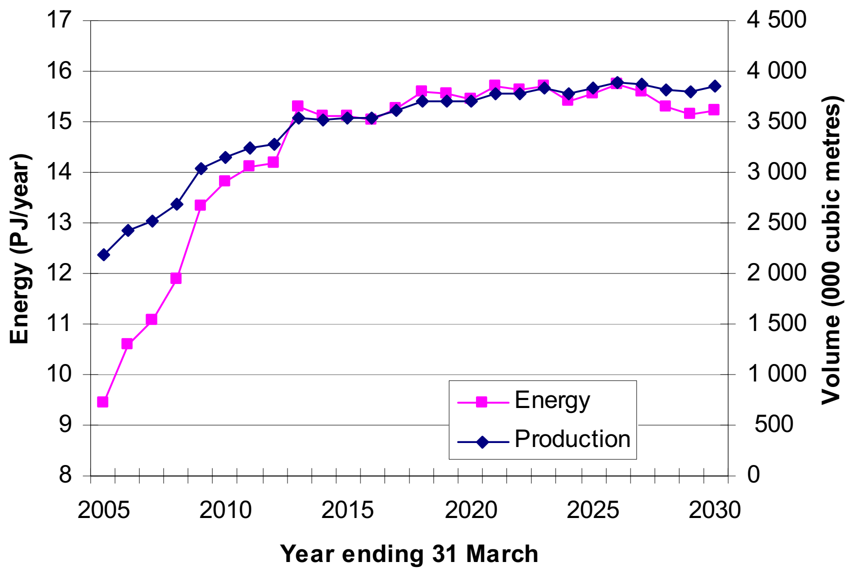

Figure 9.5 Annual biomass utilization in the panel industry for scenario 2 (PJ/year)

Table 9.4 Annual biomass utilisation in the panel manufacturing – Scenario 2

Region	2005 (PJ/year)	2020 (PJ/year)	2030 (PJ/year)
Northland	2.51	4.08	4.02
Auckland	0.10	0.16	0.16
Central North Island	0.71	1.15	1.13
East Coast/Hawkes Bay	0.93	1.51	1.49
Southern North Island	0.76	1.24	1.22
Nelson/Marlborough	2.59	4.21	4.15
Canterbury	0.63	1.02	1.01
West Coast	-	-	-
Otago Southland	1.28	2.08	2.06
Total	**9.50**	**15.46**	**15.24**

9.2.1.3 Pulp and paper industry

As discussed above, a further closure of a paper line at Kawerau is expected to occur in the next few years. Due to international competition in the industry it is not likely that there will be much further investment in pulp and paper industry in New Zealand. The analysis therefore only considers one scenario for this industry, which is a continuation of present production, however including the above closure. This means that the pulp and paper numbers are relevant for both scenario 1 and 2 discussed above. It is also assumed that the gas boilers at Kinleith which were installed before 1990 are replaced by biomass boilers in 2016. Figure 9.6 shows the biomass utilization for heat assuming a 0.25% per annum energy efficiency improvement and a closure of a paper machine in 2010. The regional breakdown is shown in Table 9.5.

Table 9.5 Pulp and paper industry annual biomass use

Region	2005 (PJ/year)	2020 (PJ/year)	2030 (PJ/year)
Hawkes Bay	1.45	1.40	1.36
CNI	25.38	21.96	21.47
Total	**26.83**	**23.41**	**22.83**

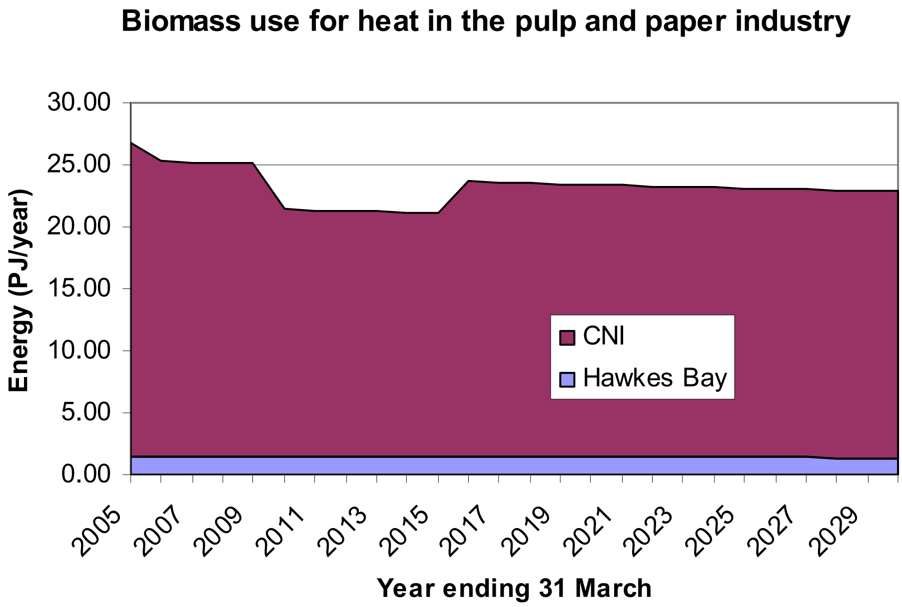

Figure 9.6 Annual biomass utilization in the pulp and paper industry (PJ/year)

9.2.1.4 Summary of biomass uptake in wood processing industry

In Table 9.6 the results are summarised for scenario 1 where a levelling out of wood processing volume is assumed. In this case the use of biomass in the wood processing industry will increase from 45.9 PJ per year in 2005 to 49.5 PJ/year in 2020, but fall again to 47.7 PJ/year in 2030. The use of biomass will fall mainly due to increased energy efficiency in the industry. In Table 9.7 the results are summarised for scenario 2 where an increase in the wood processing volume is expected. In this case the use of biomass is expected to go from 45.9 PJ per year in 2005 to 58.6 PJ per year in 2020. It is expected that the use of biomass will diminish from 2020 to 2030 following a reduction in forest harvesting. Note that these results assume all other influences on the wood processing industry are the same as present, we will argue in Section 9.2.3 that this is not very likely and that the growing wood pellet industry is likely to have a large influence on bioenergy usage in the sawmilling industry due to their demand for residues.

Table 9.6 Annual biomass utilisation in the wood processing –Scenario 1 (PJ/year)

Region	2005 (PJ/year)	2020 (PJ/year)	2030 (PJ/year)
Northland	3.07	3.99	3.79
Auckland	0.81	1.24	1.19
Central North Island	30.02	29.03	28.18
East Coast/Hawkes Bay	3.16	3.78	3.62
Southern North Island	1.3	1.8	1.71
Nelson/Marlborough	3.67	4.7	4.46
Canterbury	1.22	1.59	1.51
West Coast	0.23	0.31	0.29
Otago Southland	2.37	3.09	2.93
Total	**45.85**	**49.53**	**47.68**

Table 9.7 Annual biomass utilisation in the wood processing – Scenario 2 (PJ/year)

Region	2005 (PJ/year)	2020 (PJ/year)	2030 (PJ/year)
Northland	3.07	5.94	5.8
Auckland	0.81	1.2	1.46
Central North Island	30.02	29.17	28.11
East Coast/Hawkes Bay	3.16	5.77	5.74
Southern North Island	1.3	3.53	3.75
Nelson/Marlborough	3.67	6.17	6.03
Canterbury	1.22	2.28	2.33
West Coast	0.23	0.43	0.56
Otago and Southland	2.37	4.1	4.15
Total	**45.85**	**58.59**	**57.93**

9.2.2 Forest residues

In this section we will consider the economic viability of utilizing forest residues for heat given various scenarios based on the MED Energy Outlook fuel price assumptions, including the possibility of high oil prices and a carbon charge. We assume that for many large industrial users choice of fuel will be largely based on economic considerations, although there will still be a number of other factors that will determine their fuel choice such as convenience and air emissions. An economic comparison between coal and forest residue for heat production, taking into account the capital cost of the heat plants as well as fuel costs, (see figures in Appendix 3 and 4) shows that without a carbon charge, coal is the cheaper of the two. On the other hand, with a \$15/tonne CO_2 carbon charge, forest residues become competitive with coal in the North Island. Note that the costs of supply of forest residue in this analysis does not include a direct economic return to the forest owner but indirect benefits of reduced residue for disposal.

Due to the increasing cost of supplying forest residues with increasing volume, the price of coal represents an upper limit cutoff to the amount of residue that will be economically viable to harvest. This is shown for the Central North Island (CNI) in Figure 9.7. From this figure it is assessed that in 2020 it is economic to extract 2.8 PJ of residues in the CNI, and in the high oil price case half that at 1.4 PJ. The results for regions that are economically feasible (assuming a $15/tonne carbon charge) are shown in Table 9.8.

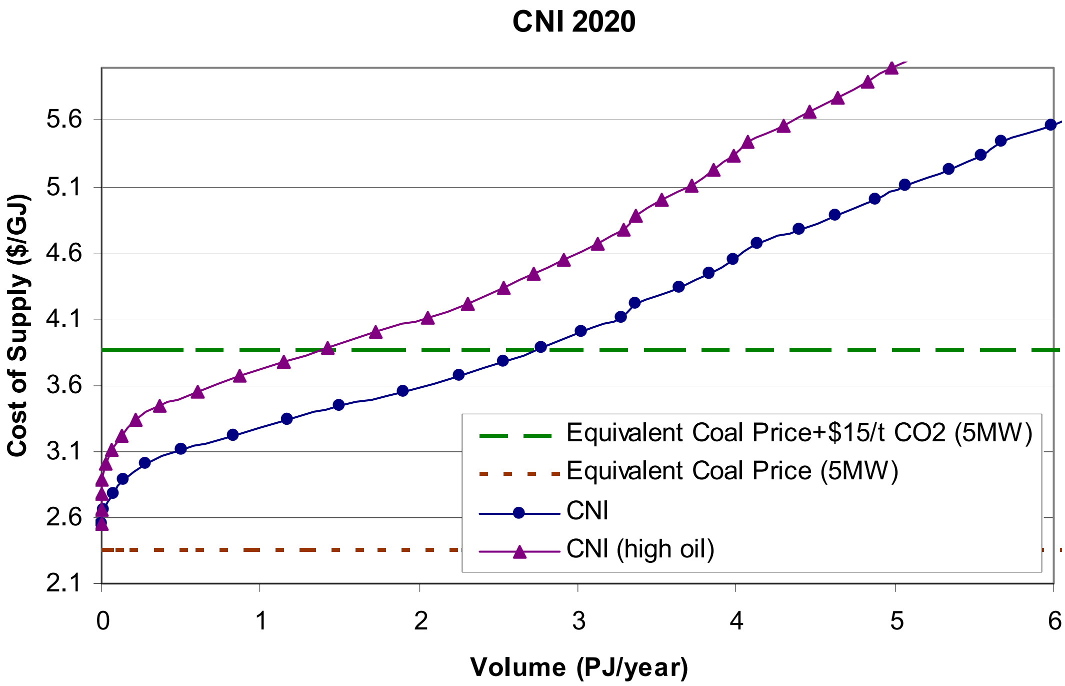

Figure 9.7 Central North Island delivered cost of forest residue in 2020

Table 9.8 Volume of forest residues (PJ/per annum) that are economically feasible to extract (assuming a $15/t carbon charge)

Region	2020 (PJ/year)	2020 High Oil (PJ/year)	2030 (PJ/year)	2030 High Oil (PJ/year)
Northland	0.5	0.1	0.4	0.1
Central North Island	2.8	1.4	2.8	1.0
East Coast/Hawkes Bay	3.0	1.3	1.9	0.8
Southern North Island	1.0	0.6	0.5	0.4
Total	**7.2**	**3.4**	**6.6**	**2.3**

Note that there is an implicit assumption in this analysis that the technologies for utilizing these residues already exist and uptake is simply a matter of changing economics. There is also an assumption that the time scale of 13 years is sufficient for this to occur.

9.2.3 Wood chips

While wood pellets are a premium quality fuel there is a growing recognition that high quality wood chips (A or B grade) can be utilised in a number of applications similar to that of wood pellets. The advantage of wood chips is that they are simpler and cheaper to make than wood pellets. The value of wood chips as a tradable fuel is increasingly being recognised as heat plant owners consider the importance of the quality of their fuel in ensuring smooth running plant and reduced operating costs. Wood chip is a well-proven and potentially more cost-effective fuel than wood pellets, though with a higher moisture content than pellets.

As well as sawmill chip, high quality, homogenous wood chip can be (and is) manufactured from forest residues. (Hog fuel, as used by the pulp mills, is a lower quality fuel that is typically not cleaned prior to comminution, and is of a more random size. This is acceptable for their grates, hence they tolerate it as it is lowest cost. Wood chip is in a different class to hog fuel).

There is expected to be some industrial applications where wood chip will be able to penetrate the coal market where more expensive wood pellets will not. A wood chip burner represents a very credible alternative for some applications where its quality can be guaranteed similar to coal or wood

In reality the ongoing cost of carbon abatement by converting small coal boilers to wood pellets is likely to be upwards of $65/tonne of CO_2 (assuming wood pellets are $15/GJ and coal is $9/GJ). Whereas installing a wood chip burner (which can be from 60kW upwards to 8MW) will mean that the cost of abatement (compared to coal at $9/GJ) will be negative $18/tonne of CO_2 (as wood chip will be cheaper than coal). This assumes that wood chip costs $70/tonne (which is at the high end).

Wood pellets can provide a credible security of supply of fuel as there is often a good range of sources of supply and quality chip it is easily obtainable. This is not necessarily the case with wood pellets where there may continue to remain a limited number of manufacturers of the pellets, and limited distribution points. There are around 3.5 million tonnes of chip that is currently produced at saw mills. In addition, a large amount is also produced by specialist wood chipping operations and there are over a thousand mobile tree-chippers in NZ, whose product is often acceptable for wood chip boilers.

After harvesting there is plenty of abandoned fibre available in our forests, as well as abandoned pulp logs in certain areas. Short logs/off-cuts as small as 1m can be, and are, converted to high-quality A grade chip. This, as well the plethora of potential wood chip suppliers, will ensure that prices of wood chip remain relatively stable.

Chip is a promising bulk fuel when compared to pellets for a number of applications – not requiring the elaborate transformation while being consistent in quality and with considerable volumes available if exports are displaced. The issues are however:

- Price – $9.00/GJ at least for a fuel that is low quality (i.e. high in moisture content), and
- Price uncertainty – with export/world prices rising significantly and likely to continue.
- As a fuel this will not compete with coal (or even gas) at closer to $4.5/GJ for a much higher quality fuel (and a flatter future price path) without significant incentives – a carbon charge at $15/tonne is unlikely to bridge this gap.

Chip has been discussed here, recognising that it could compete with wood pellets in a number of specialist situations. The focus of discussion and analysis in this report has been on wood pellets. In practice, chip could (and is likely to) gain some of the market share ascribed to pellets in this report, though not significantly changing the analysis or assessments.

9.2.4 Wood pellets

The use of wood pellets has increased dramatically in a number of countries around the world, especially Europe and Northern America. Wood pellets are regarded as a convenient and clean burning fuel, which is easy to handle by residential consumers generating heat efficiently. For this reason, wood pellets are likely to replace firewood and coal to a certain extent. They are, however, less able to compete with natural gas and electricity in convenience of handling and use.

In New Zealand wood pellets are likely to replace many log burners in the future due to increasing air emission standards, although a place is still seen for log burners in preference to open fires for those consumers with access to wood, especially rural consumers. Log burners exist which can fulfil modern air quality standards, however, their cost approaches that of the wood pellet heaters. Log burners are a good way of utilising biomass, which may not otherwise be used for energy. It is however, important to understand that a log burner which complies with new air emission standards does not provide the same service as the older log burners, by not being able to maintain heat output through the night. Therefore, it is expected that there will be natural decline in use of log burners and many homes will replace log burners with more convenient technologies. For bioenergy to maintain the current residential market-share it is important that this replacement of log burners occur with wood pellet heaters.

Outside the domestic market, the competition between wood pellets and electricity/natural gas is not in convenience but in price. Currently energy from wood pellets is not cost effective compared to coal. In some non-domestic applications wood pellets are able to compete with gas in fuel price, although the cost of a wood pellet heater is typically more expensive than a gas or electric heater (heat pumps) which in terms of total cost results in energy from wood pellets being less economic than for gas. So currently wood pellets are only able to compete with coal, electricity and gas fuels if the customer considers the long term benefits of installing and using wood pellets.

In the case of domestic consumers, the effective unit cost implies that pellet burners may only be price-justified for the largest installations. Pellet burners will be installed primarily because of home ambience, with a reward being that ongoing fuel costs are less than alternatives.

We estimate that in 2006 there were 20,000 pellet fires in New Zealand and 30,000 tonnes or 0.6 PJ of wood pellets consumed annually, mainly in the residential market.

The following table summarises the expected increase in uptake above the 2006 levels in various market segments based on the current market price of $21/GJ for wood pellets.

Table 9.9 Expected increase above 2006 levels in energy use by various heat market segments under differing scenarios (PJ/year)

	Segment	MED Base Case		MED Carbon Charge Case		MED Carbon Charge Case (High Oil)	
		2020	2030	2020	2030	2020	2030
Pellet Burner	Accommodation	0.2	0.2	0.2	0.2	0.4	0.2
	Schools	0.1	0.1	0.1	0.1	0.2	0.2
	Public Servants	0.02	0.02	0.02	0.02	0.04	0.03
	Greenhouses	0.1	0.2	0.2	0.2	0.3	0.2
	Residential	1.4	2.9	1.6	3.1	3.0	3.9
	Total	**1.9**	**3.4**	**2.0**	**3.6**	**3.9**	**4.5**
Wood Burner	Residential	0.4	0.8	0.5	0.8	0.7	1.0
	Overall Total	**2.3**	**4.1**	**2.5**	**4.4**	**4.6**	**5.5**

The considerations discussed in this section and the current trends in sales of wood pellets have been taken into account in determining the technology uptake S-curve for pellets shown in Figure 9.8.

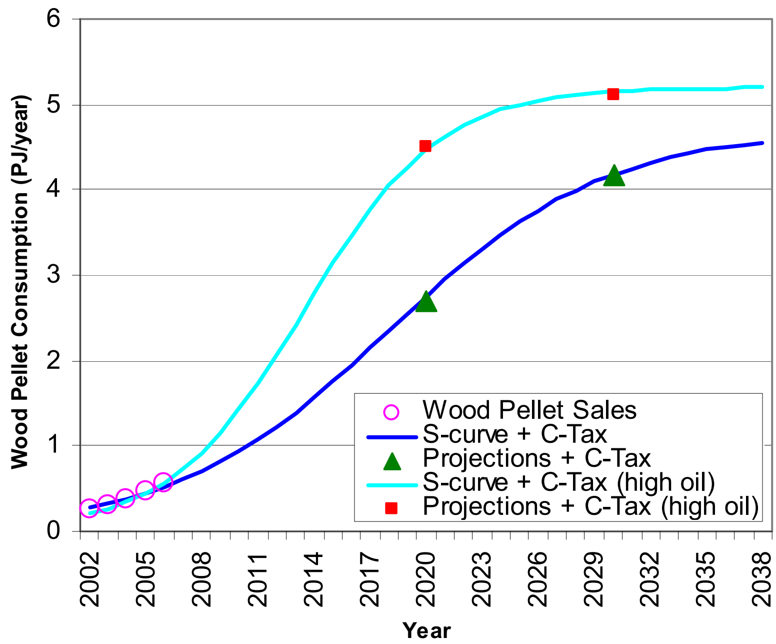

Figure 9.8 Projected uptake of wood pellets in New Zealand

The maximum uptake has been determined by a consideration of the lower price pellets for delivered heat than gas or heat pumps, given that most New Zealand households prefer greater than 10kW of heat output, and that this is expected to continue in future. The uptake is expected to be heavily influenced by domestic demand, with an additional increase to around 0.6 PJ/year expected to be taken up in hotels, institutional (such as schools, hospitals) and commercial buildings.

9.2.4.1 Consequences for the wood processing industry

If wood pellet production is to increase as in the previous section there will need to be a supply of raw material for wood pellet production. Due to the processing requirements for wood pellets the raw material used must be high quality wood processing residue such as sawdust and shavings from a sawmill. Forestry residue is often contaminated with bark and soil and is not a feasible alternative. On the other hand, a sawmill with a biomass boiler is likely to have just enough wood waste to be self-sufficient in heat production. As the main driver for sawmills to use their on-site residues for fuel was waste-disposal costs, this may cause sawmills to use other fuels for heat production so they can sell their process residues to the wood pellet manufacturers. The feasibility of this scenario can be tested by determining the price for wood pellet production given that the raw material will cost at least as much as a replacement fuel. Figure 9.9 shows the production costs as a function of replacement fuel costs.

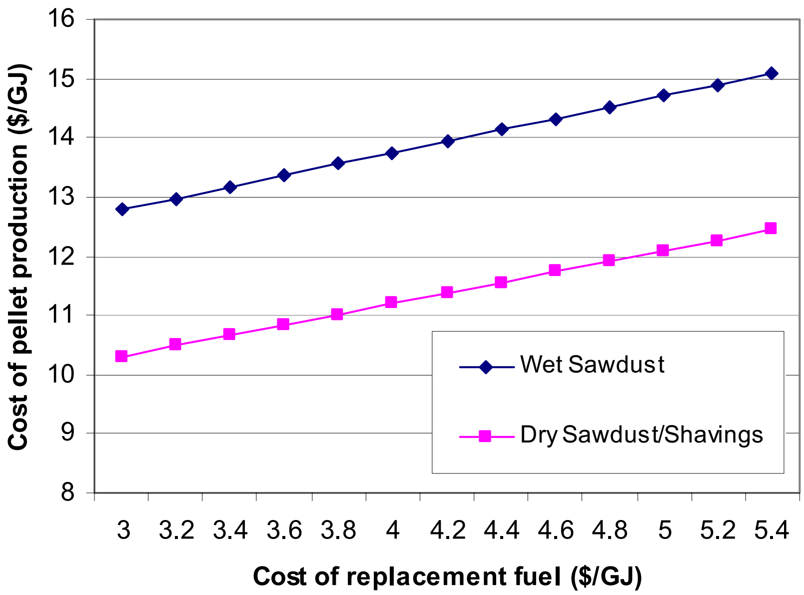

Figure 9.9 Wood pellet production costs for different replacement fuel costs

These costs are based on a simple economic model of a wood pellet plant (including capital, labour and raw material costs) assuming low quality residues are used for drying wet sawdust, a medium sized (32 tonne/day) pellet plant making a 10% after tax profit. We also assume an extra $10/tonne for high quality sawdust or dry shavings transport and handling costs.

In comparison, wood pellets are currently retailing for $21/GJ[30]. Using the same economic model but assuming dry shavings are free of charge, we estimate that currently wood pellets can be manufactured at $7.6/GJ.

Note that this scenario shows that a carbon charge will also lead to an increase in the production cost of wood pellets. This is because sawmills will choose the cheapest fuel to replace their sawdust. If there is no carbon charge this fuel will be coal but with a carbon charge they will have to pay more for their replacement fuel, which could now be forest residues or coal.

Assuming that wood pellet manufacturers are willing to pay this price, and from the current cost of wood pellets it seems that this is viable, the above type of increase in wood pellet use will have quite a dramatic impact on the wood processing industry. For example, the amount of sawdust required to produce the amount of pellets represented by Table 9.9 ranges from 18% to 26% of the sawdust produced at the sawmills in New Zealand, depending which of the wood processing scenarios discussed previously occurs. This may have unforeseen consequences on the fuel mix in the wood processing industry.

The increase represented in Table 9.9, means that a large number of sawmills will have to source their fuels for heat production either from forest residues or from other fuels like coal. The choice will depend on the economics of the various fuel choices. In the previous subsection we have considered the economics of coal vs. forest residues and shown that a carbon charge is necessary to make forest residues a viable option.

Assuming a no carbon charge scenario, and that sawmills begin to convert to coal as the demand for processing residues increases with increased wood pellet manufacturing (as in Table 9.9), the impact on bioenergy utilization in the sawmilling sector is shown in Tables 9.10 and 9.11, for the no increased wood processing and increased wood processing scenarios, respectively. These

[30] March 2007

numbers should be compared with Tables 9.6 and 9.7 which implicitly assumed biomass was used for fuel and reach a maximum of 88% of the installed capacity at sawmills using biomass.

Table 9.10 Scenario 1 (no increased wood processing) with coal substituting for sawdust

	Current	2020	2030
Percentage using biomass	81%	75%	66%
Bioenergy use (PJ/year)	9.5	12.3	10.2

Table 9.11 Scenario 2 (increased wood processing) with coal substituting for sawdust

	Current	2020	2030
Percentage using biomass	81%	79%	73%
Bioenergy use (PJ/year)	9.5	15.3	16.4

9.3 Summary

Table 9.12 presents a summary of the total bioenergy increase in 2020 and 2030 (note that this table shows both 2020 and 2030 separated by a slash) from 2005 for two wood processing scenarios with and without carbon charge. The second column shows the reduction in bioenergy uptake due to the negative impact of high oil prices (as determined by MED's high oil scenario) on the economic viability of harvesting forest residues, assuming that the high oil prices do not flow on to higher coal prices. The uptake of forest residues assumes a carbon charge of $15 per tonne of CO_2. Without a carbon charge, no uptake of forest residues is expected based on an economic comparison with coal. Of the economically viable volume of forest residues, the majority are assumed to be used in the wood processing and wood pellet manufacturing industries and the reminder in other industries. The increase in the uptake of wood pellets is potentially 3.4 PJ by 2030 (see Table 9.9). In the absence of a carbon charge, the economics suggest that the increase in wood pellet use will be offset by a decrease in bioenergy use in the wood processing industry as sawmills sell their residues to wood pellet manufacturers and convert to coal. Figure 9.10 to 9.13 illustrate the biomass flows between industries for scenario 1 and 2, with and without carbon charge. Note that with the charge, sawmills replace the processing residues they sell to the wood pellet manufacturers with forest residues, while without the charge they replace the processing residues with coal.

Table 9.12 Summary of biomass increases (PJ/year) above 2005 levels

	2020/2030	2020/2030 (high oil)
MED base case	0.0/0.0	-
Scenario 1	3.9/2.6	-
Scenario 1 + carbon charge	11.4/9.2	7.8/5.1
Scenario 2	13.1/12.9	-
Scenario 2 + carbon charge	20.4/19.5	16.8/15.5

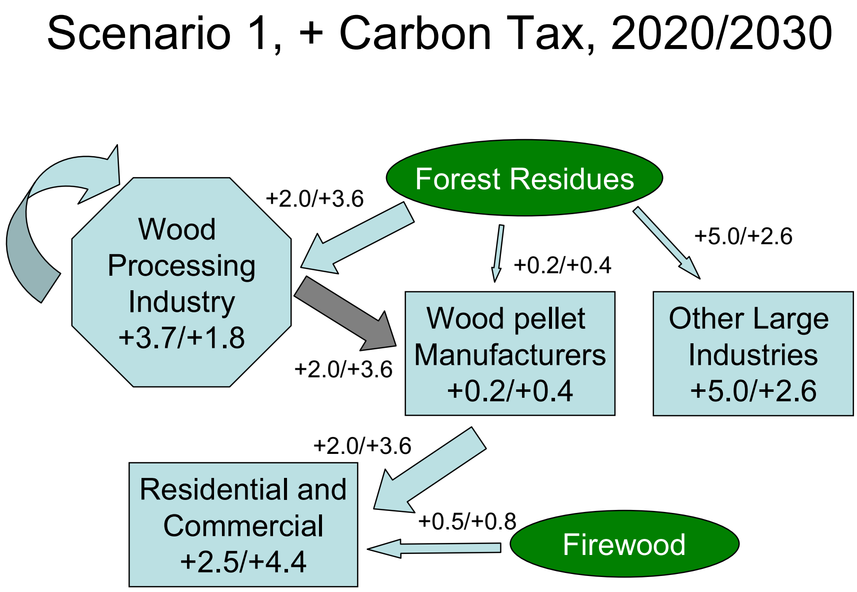

Figure 9.10 Biomass flows for scenario 1 (no increase in domestic processing) including carbon charge of $15/t CO_2

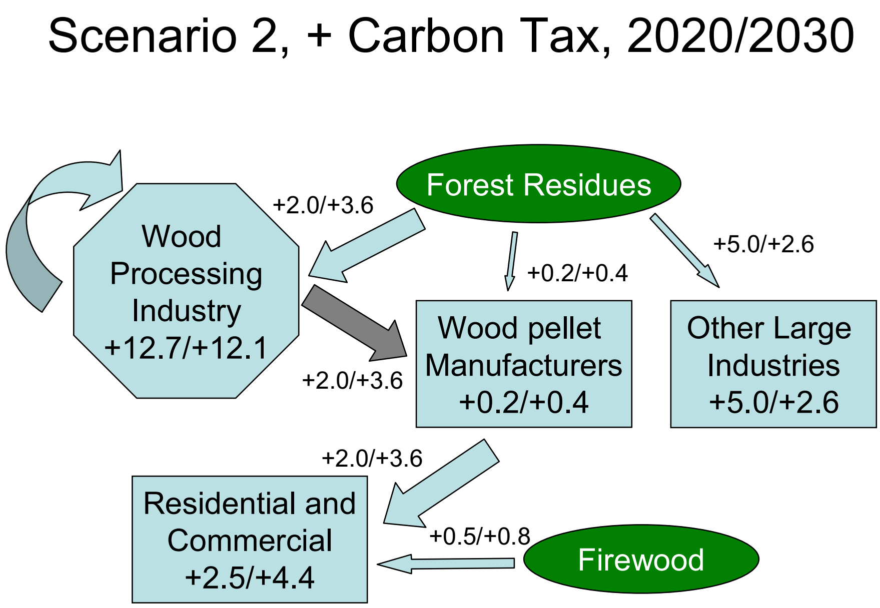

Figure 9.11 Biomass flows for scenario 2 (increased domestic processing) including carbon charge of $15/t CO_2

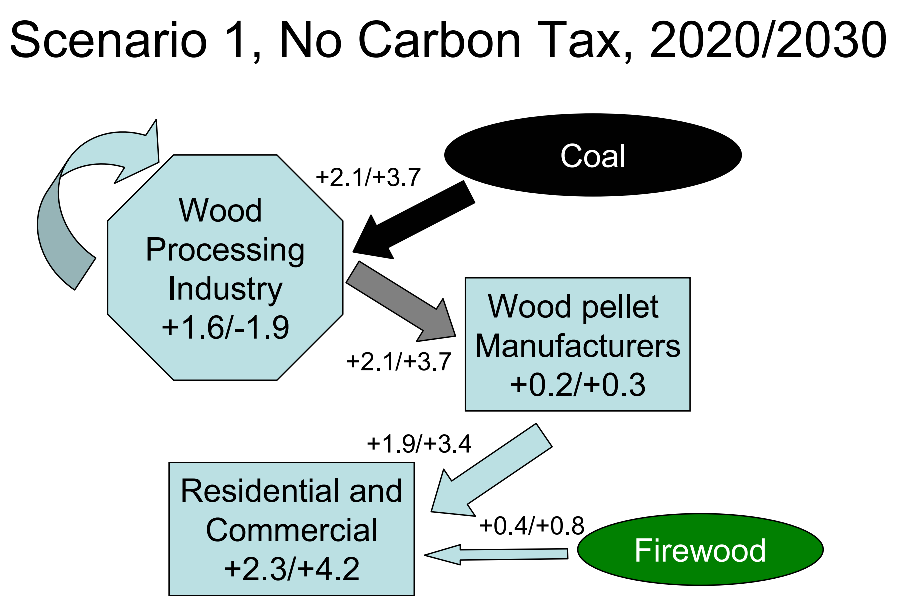

Figure 9.12 Biomass flows for scenario 1 (no increase in domestic processing) without a carbon charge

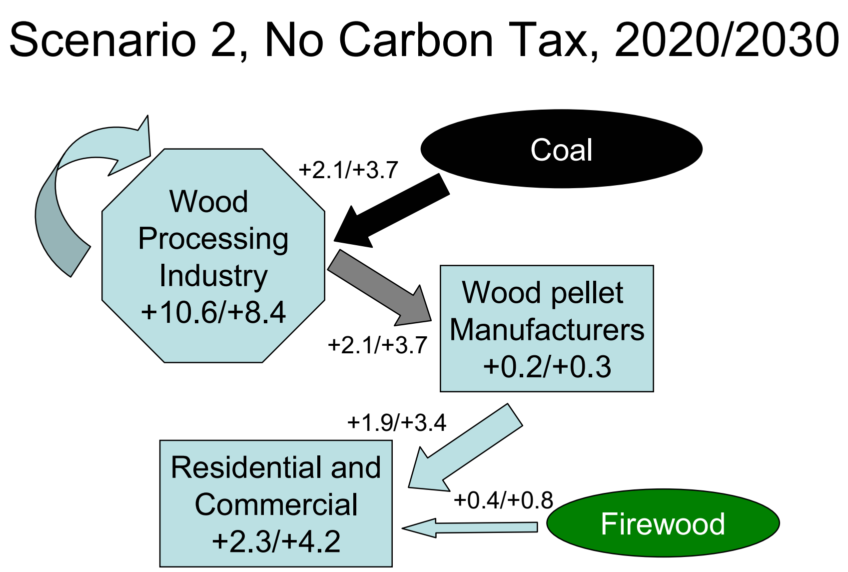

Figure 9.13 Biomass flows for scenario 2 (increased domestic processing) without a carbon charge

9.4 Targets

The results in the previous section should be treated as an indication of what may result given the possibilities investigated. As such they demonstrate more about the way the New Zealand bioenergy system responds to outside economic factors (given our analysis) than as accurate figures in their own right. In this section the consequences of the above analysis for determining specific targets are discussed.

The draft New Zealand Energy Strategy (NZES) which set the objectives for the NEECS emphasised the joint themes of energy security and greenhouse gas emission reductions and these themes have therefore been used to guide the determination of targets in this report. The expectation was that this report would suggest new targets in Peta-Joules (PJ) of woody biomass consumed in 2020 and 2030, such as those presented in the above table. However the analysis leading to the above projections strongly suggests that this approach over-simplifies the New Zealand bioenergy system and will at best, have little effect on achieving the aims of the NZES and, at worst, reverse some of the gains made so far. The three most important arguments against setting overarching PJ targets are: 1) the analysis shows that the amount of PJ consumed is determined in large by the proportion of wood processing carried out domestically rendering the achievement of the targets at the whim of international markets, and 2) the interconnections between different sectors, such as wood-pellet manufacturing and wood processing, makes the results of trying to achieve the targets via specific actions on individual sectors uncertain and 3) the unreliability of data on wood processors energy consumption for heat production.

Instead, based on the analysis carried out for this report, the areas represented by the following proposed targets are likely to be the best method of both maintaining gains made so far and increasing the replacement of fossil fuel with biomass and therefore reducing greenhouse gas emissions.

1. The proportion of wood processors using biomass for heat production (by installed capacity) or (other renewable heat sources) is 90 % by 2020 and 95% by 2030

As the amount of biomass consumed in the wood processing industry depends on the amount of processing carried out in NZ, numerical targets in amounts of primary energy are not useful in this case and we suggest that a target focusing on proportion of heat plants fuelled by biomass is more appropriate. It is also suggested that this target is measured using the EECA heat plant database (the alternative, of measuring consumed process residue is made extremely unreliable due to the lack of either measurement or recording of process residues used as fuel on processing sites). To increase the accuracy of this monitoring it is suggested that this database should be kept up to date and made more comprehensive so as to include average run capacity and annual run times, to give better estimates of fuel usage. At present the high cost of residue disposal is a positive driver for this target, and suggests that the waste management strategy is a vehicle for achieving this target. However, with the growth of the wood pellet market and other industry demands for high-quality process residue this will not be sufficient to preserve biomass use in the wood processing industry. Our analysis of the present situation shows that in the South Island the sawmill fuel mix is 90% biomass, so the above target is achievable reasonably easily and acts more to preserve current gains than to stimulate new growth. However, setting a target beyond the current uptake (of 85% biomass) exerts a positive pressure to reach the target.

2. The increase in the quantity of forest residues extracted nationally be 7 PJ by 2020 and 9 PJ by 2030

It is suggested that this is measured by requiring residue harvesting operations to report volumes recovered. The analysis of this report suggests that the achievement of this target is conditional on the introduction of price-based measures to integrate the costs of CO_2 emissions (e.g. a carbon charge) into the price of fossil fuels and in particular coal. Analysis shows that this will need to be greater than \$15/t CO_2 for this target to be reached. The utilization of this resource is likely to be in the forest industry but could also be in other industrial sites with a large heat demand. Note that due to reduced planting rates recovering residue increased in cost between 2020 and 2030, suggesting that sustaining these targets to 2030 and beyond requires reversing current deforestation trends. Our analysis shows that with a \$15/t CO_2 charge, it is economically viable to extract at least 7 PJ in 2020, but only 6.6 PJ in 2030. However, in order to send a clear signal to industry that the government is committed to the growth of renewable energy from forest residues a higher target of 9 PJ by 2030 has been suggested. Clearly to achieve the 2030 target of 9 PJ more incentives would be required.

3. The proportion of biomass co-generation plants in the wood-processing industry (by installed heat capacity) be increased 10% by 2020 and 20% by 2030

Presently, 22% (by installed thermal capacity) of the heat plants in the wood processing sector are biomass cogeneration, mainly in the pulp and paper industry. Increasing the amount of cogeneration will result in an increase in the amount of mitigated CO_2 as the electricity generated will replace that from the national grid. This target can again be measured using the heat plant database. Cogeneration requires a greater amount of fuel, and in the case of sawmills is only likely if a sawmill has sufficient quantities on-site process residues. Therefore, increasing the efficiency of on-site heat process and the efficient utilization of biomass is necessary for the achievement of this target. This target is also relevant for energy security as distributed generation has been shown to make the electricity supply system more resilient to outages.

4. An increase in the utilization of high-quality biomass fuels, such as wood-pellets and high-quality chip, of 2.0 PJ by 2020 and 3.6 PJ by 2030

High quality biomass fuels are likely to be increasingly important and because of their ease of use have the potential to replace fossil fuels in sectors without experience in using woody residue fuels, such as, the residential, commercial and institutional sectors. Examples of high quality fuels are wood pellets and high-quality chip. This target is easily measured by having fuel manufacturers or suppliers record volumes of sales to the public and heat plant owners. This target is based on estimates of the uptake of the wood pellets (presently the most expensive of these fuels) given a \$15/t CO_2 charge or equivalent price based measure. However, targets should not reflect a particular technology choice and therefore reference to wood pellets has been removed. This target should be used in conjunction with target 1 and 2 above as used on its own this target could lead to the perverse situation where biomass utilization by wood processors is reduced so that residues can be are made available to wood pellet manufacturers. Analysis suggests that in combination with the first two targets above, it will be possible to avoid such effects and allow for the growth in the high quality biomass supply industry, while preserving the gains made in the wood-processing industry.

A key aspect affecting the achievement of all of the above targets is a shift in perception from regarding woody-biomass as a waste product to regarding it as a valuable fuel. To this end it is suggested that efforts are made to improve technologies and develop skills in processing and handling biomass fuels. In particular, development of a set of quality standards, including considerations of moisture content and contamination, is likely to assist with the mainstreaming of woody biomass as a quality fuel. In addition, since processing residues play an important role in the bioenergy system it is necessary to have much more detailed information of flows of processing residue.

As a final note, to achieve the goals of the NZES without compromising economic well-being it is necessary to decouple economic gains from fossil fuel consumption. If heat for domestic log processing of value-added timber exports is derived from biomass then domestic wood processing is a clear example of an industry that results in a decoupling of export earnings from fossil fuel consumption. This analysis showed that the largest magnitude gains in bioenergy utilization would occur if the proportion of logs processed domestically continued at or above the present amount of 70%. Achieving this would require more political intervention than the above targets (the nature of which is beyond the scope of this report), but serious consideration should be given to this type of intervention as the analysis in this report shows that the potential return could be large.

Taking the achievements of the targets outlined above, along with government policy initiatives such as the introduction of a carbon charge, and encouraged domestic wood processing, it is assessed that an increase above 2005 levels of between 16-21PJ of energy for direct use is achievable by 2020.

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Appendix 1. Wood Processing Heat Plants

Table A1 shows the installed heat plant capacity in the panel industry. In this table the heat demand has been estimated by assuming that the listed boilers on average run for 8000 hours a year at about 80% capacity.

Table A1.1 Heat plants in the panel industry

	Company Name	Processing Plant Type	Annual Demand (PJ)	Installed Capacity (MW)	Fuel
Northland					
Kaitaia	Junken NZ Ltd	Fibreboard	0.88	38	Biomass/Coal
	Junken NZ Ltd	Veneer	0.83	36	Biomass
Whangarei	Carter Holt Harvey	Veneer	0.41	18	Biomass
Auckland					
Auckland	Laminex Group[31]	Particleboard	?	?	
Thames	Carter Holt Harvey	Particleboard	0.08	3.6	Biomass
Central North Island					
Taupo	Laminex Group[32]		3.92	17	Biomass
Tokoroa	Carter Holt Harvey[33]	Plywood	0.06	2.8	Gas
Tauranga	Carter Holt Harvey	Plywood	0.14	6	Gas
East Coast					
Gisborne	Junken NZ Ltd	Veneer	0.78	34	Biomass
Hawkes Bay					
Southern North Island					
Masterton	Juken NZ Ltd	Veneer	0.65	28	Biomass
Nelson/ Marlborough					
Nelson	Nelson Pine	Fibreboard			
	Nelson Pine	Veneer	2.19	95	Biomass
Canterbury					
Christchurch	Carter Holt Harvey	Fibreboard	0.41	18	Biomass
	Gunn's New Zealand Pty Ltd	Veneer	0.12	5	Biomass
West Coast					
Otago Southland					
	Southland Veneers	Veneer	0.30	13	Coal
	Dongwa Patinna NZ Ltd	Fibreboard	0.78	34	Biomass
Total			**8.03**		

The heat plant database yields the capacity of the heat plants at the pulp and paper sites throughout NZ. Assuming the boilers are utilized at 80% and run 8000 hours a year we have estimated the

[31] Relatively small plant likely to have small contribution to total
[32] Recent fire has closed plant, not likely to be rebuilt
[33] Likely also to receive heat from neighbouring pulp and paper plant

heat output from the thermal capacity. From this the biomass utilization can be determined from the fuel mix and boiler efficiencies. We have assumed 65% efficiency for cogen plants, 70% for wood waste boilers and 70% for recovery boilers. The results are summarized in Table A2.

Table A1.2 Heat plants in the pulp and paper industry

	Capacity (MW_{th})	**Heat Demand (PJ)**	**Biomass (PJ)**	**Geothermal (PJ)**
Kinleith (CNI)				
Cogen	160	3.69	2.72	
Gas boilers	95	2.19		
Boilers	284	6.54	9.35	
Total	539	12.42	12.07	
Kawerau (CNI)				
Cogen	240	5.53	4.25	
Recovery Boiler	140	3.23	4.61	
Geothermal	170	3.92		6.03
Total	550	12.67	8.86	6.03
Whakatane (CNI)				
Boilers	120	2.76	2.96	
Winstone Pulp (CNI)				
Cogen	42	0.97	1.49	
PanPac (Hawkes Bay)				
Cogen	42	0.97	1.45	
Total	**1293**	**29.79**	**26.83**	**6.03**

Appendix 2. Heat Supply Curves

An intention of this report is to enable an assessment of potential uptake of renewable energy options under a range of scenarios.

Given that costs are an essential driver of industry, supply curves have been derived for a range of energy conversion technologies. The supply curves show total cost to industry of a particular heat supply option, including fuel cost, capital cost and operating costs. All analysis has assumed a 10% internal rate of return. Plant life is 30 years. Fuel cost inputs have been taken from MED's "New Zealand's Energy Outlook to 2030" using the Base Case and Carbon Charge sensitivity case.

The results of modelling are shown in Figures A2.1 – A2.6 based on present costs and costs in 2020 and 2030.

While there are differences between the curves, the implications for biomass energy are consistent throughout.

Under recent and future gas price movements, the overall cost of a gas heat development has lifted to the point where it is difficult to justify in terms of new development. This situation will be reinforced as gas prices continue to rise. While gas will continue as a valuable fuel for electricity generation, price signals for direct users of gas are discouraging. There may be other drivers, such as it's handling convenience that continue to see some marginal uptake. However, heat plant owners will be considering their options as their existing heat plant comes up for replacement. On price alone, they will be driven to consider coal or renewables where these are available.

The price of coal heat plants, when coal is supplied from local mines continues to be competitive with gas, with or without carbon charge. In the South Island, coal has few competitors with neither gas nor conventional geothermal energy being available, but biomass process residue-based heat plant supplying strong competition especially in 10 to 15 years time or immediately if a carbon charge is applied to heat plant. For the most part, South Island coal supplies will be unchallenged.

Based on the various cost assumptions feeding in to these figures, biomass landing material will not provide competition for South Island coal on price or convenience under any scenario. It may be able to compete with North Island coal on price in high coal-priced areas by 2020 and especially for thermal loads less than 20 or 30MWth.

Biomass process residue-based heat plant is already strongly competitive with all fuels in the North Island, and with higher priced South Island coals. A carbon charge applied now to heat plant, or general expected moves in coal price by 2020 will leave this heating option unchallenged at most locations.

Stand-alone geothermal heat supplies based on conventional high temperature resources require a certain size before they become commercial. Currently, based on the assumptions of field conditions present in the model, it is difficult for a greenfield development to compete with coal for developments below a threshold 30MWth or so. A carbon charge (of $15/t CO_2) would see this threshold reduce to around 15MWth, while expected price movement for coal could see this reduced to 10MWth. While exact thresholds for competitiveness will be site-specific, these calculations indicate the requirement for a significant load for a development to be commercial.

A geothermal "cogeneration" price is also shown, this being the price that a generator must secure to remain revenue-neutral if it diverts its steam to another party on site. This price is lower than all other North Island fuel options, but requires a heat user to be on-site to take advantage of it.

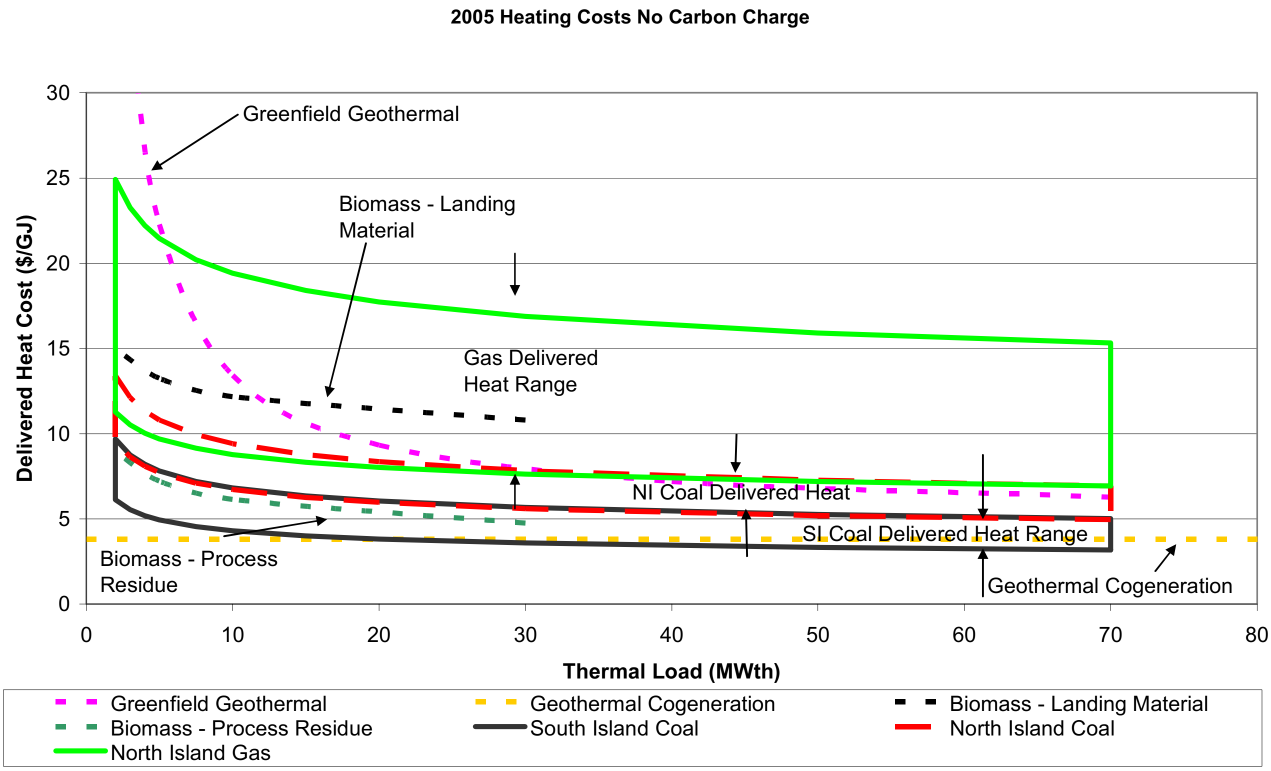

Figure A2.1 2005 heating costs no carbon charge

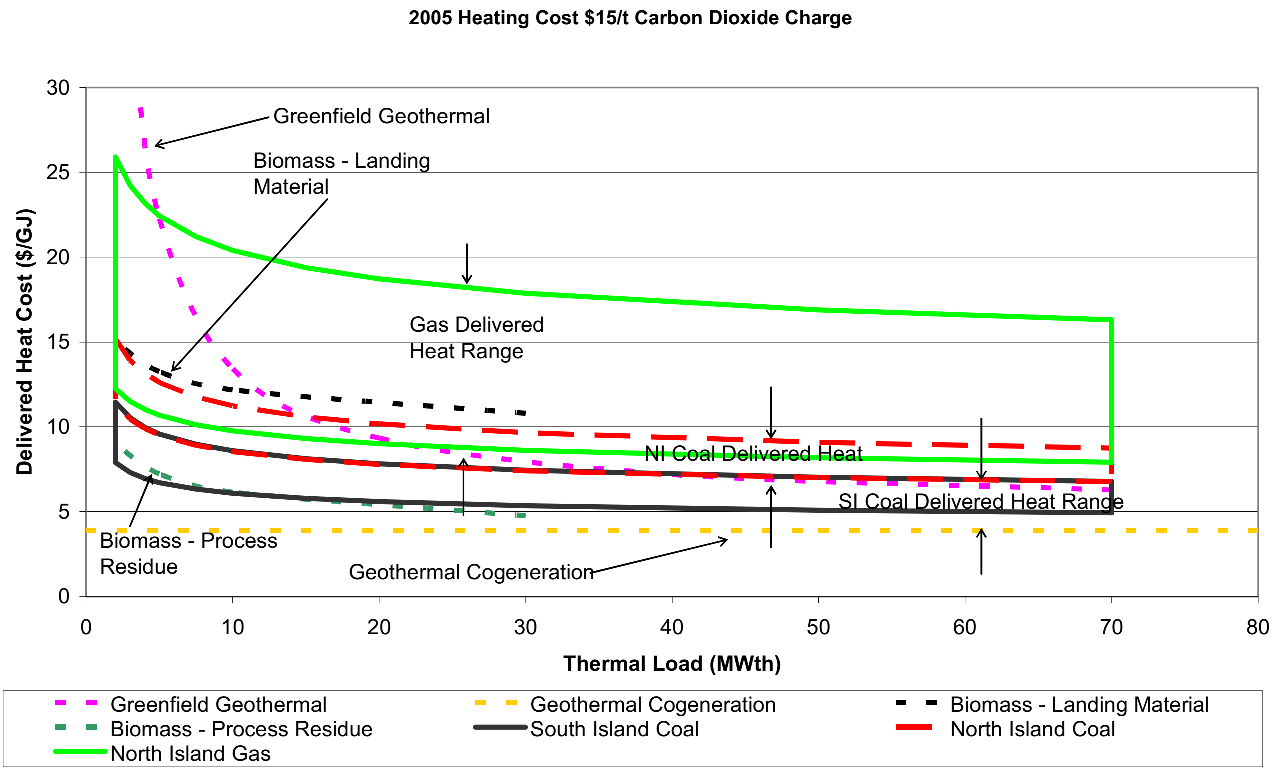

Figure A2.2 2005 heating costs with $15/t carbon dioxide charge included

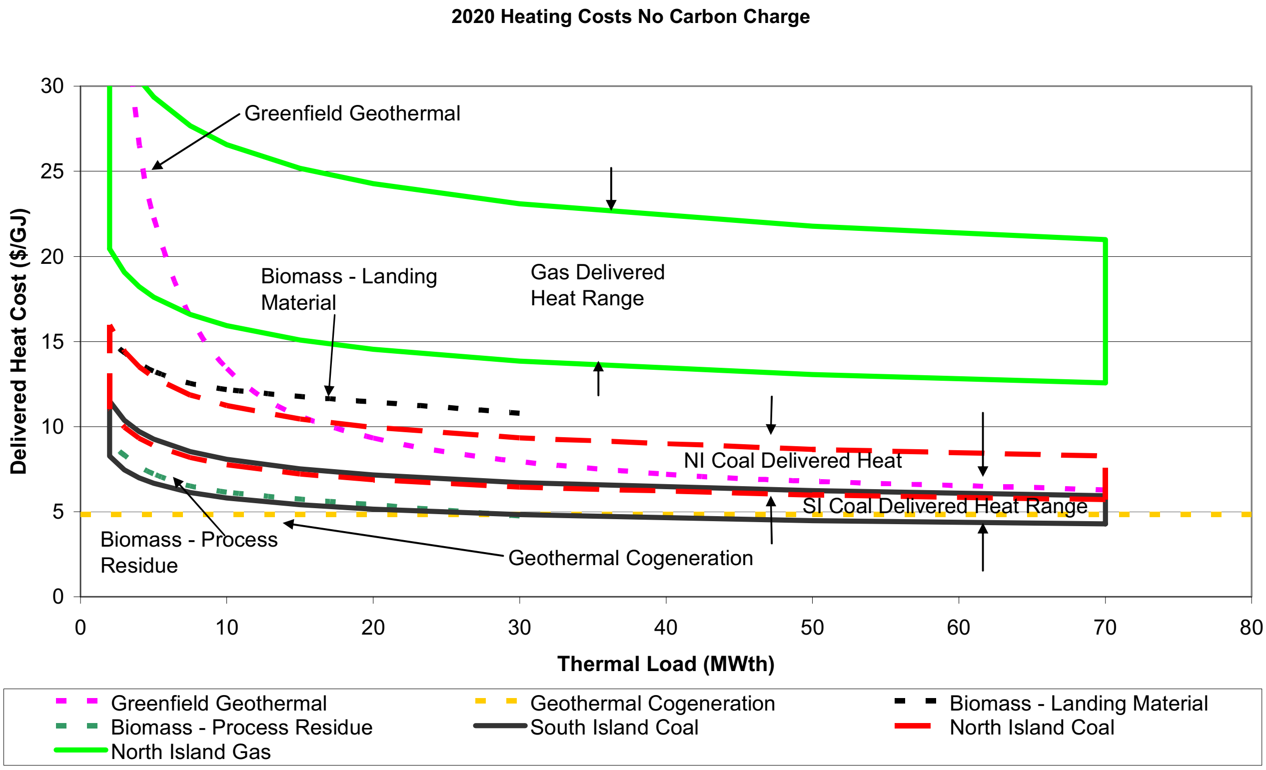

Figure A2.3 2020 heating costs no carbon charge

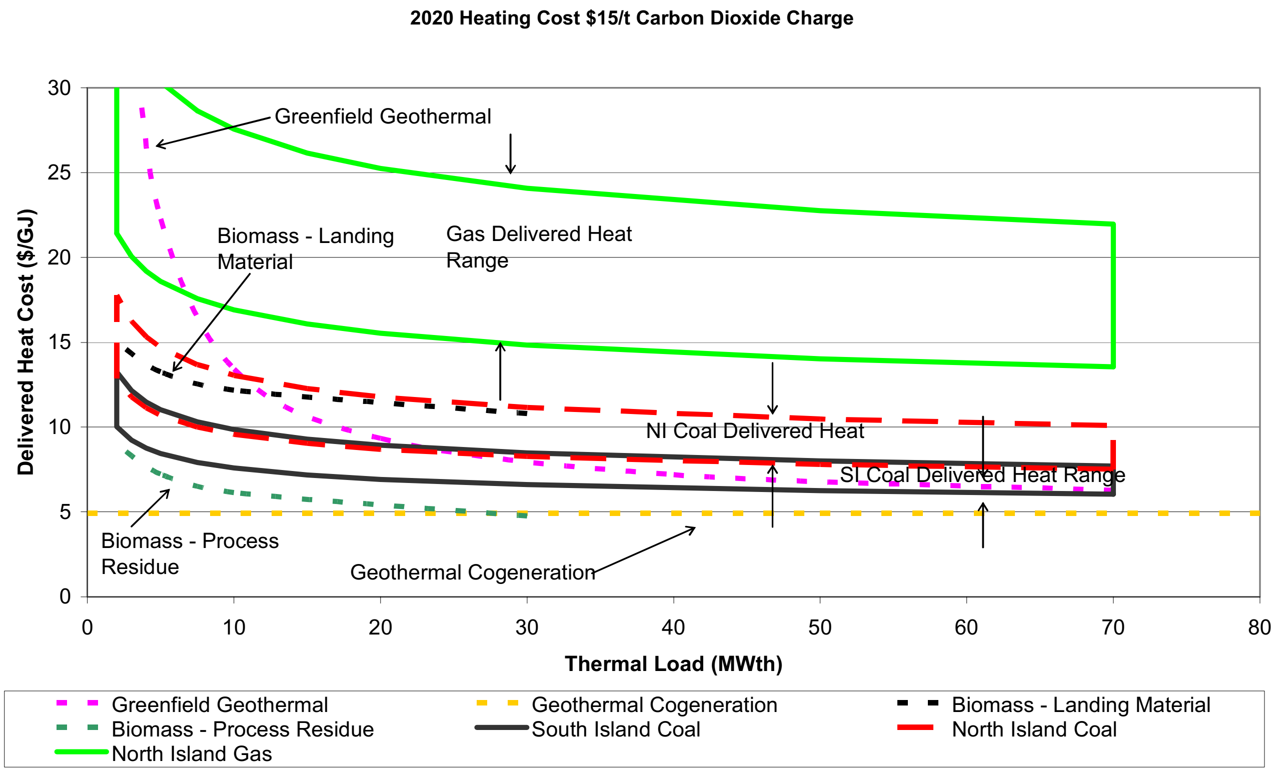

Figure A2.4 2020 heating costs with $15/t carbon dioxide charge included

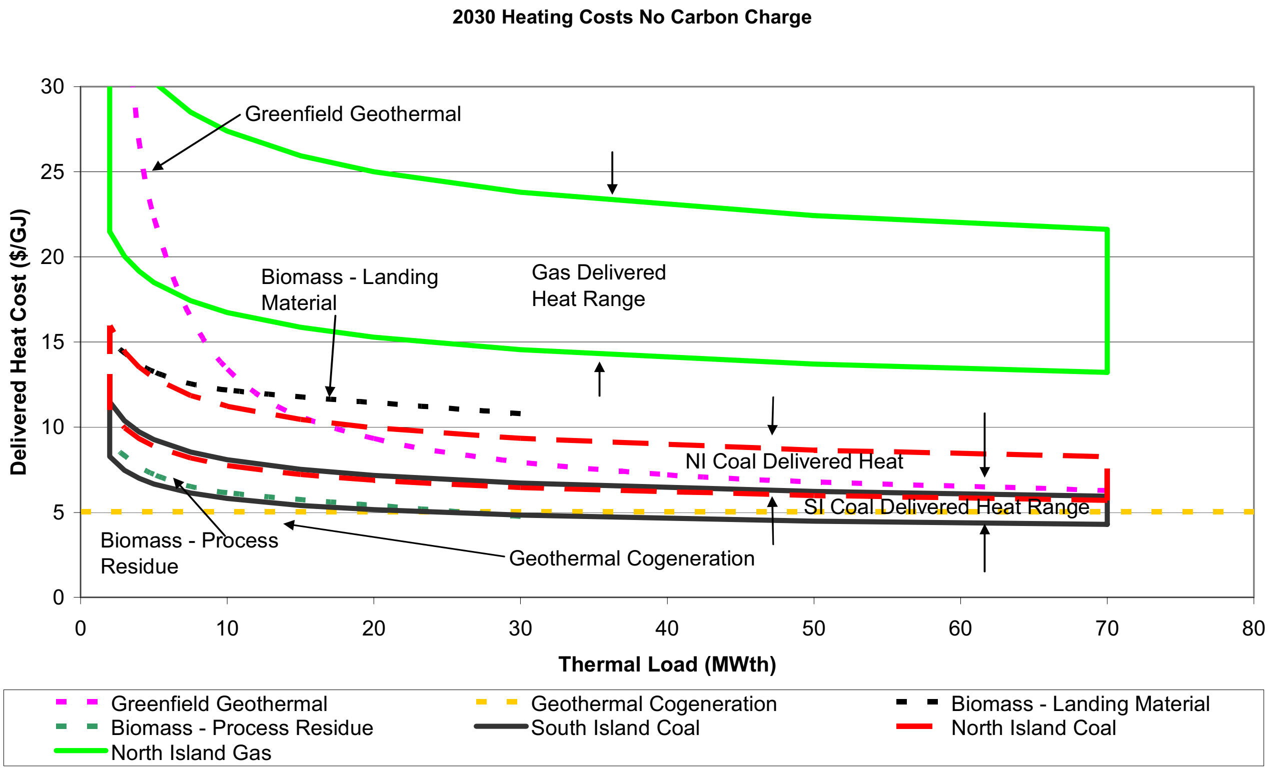

Figure A2.5 2030 heating costs no carbon charge

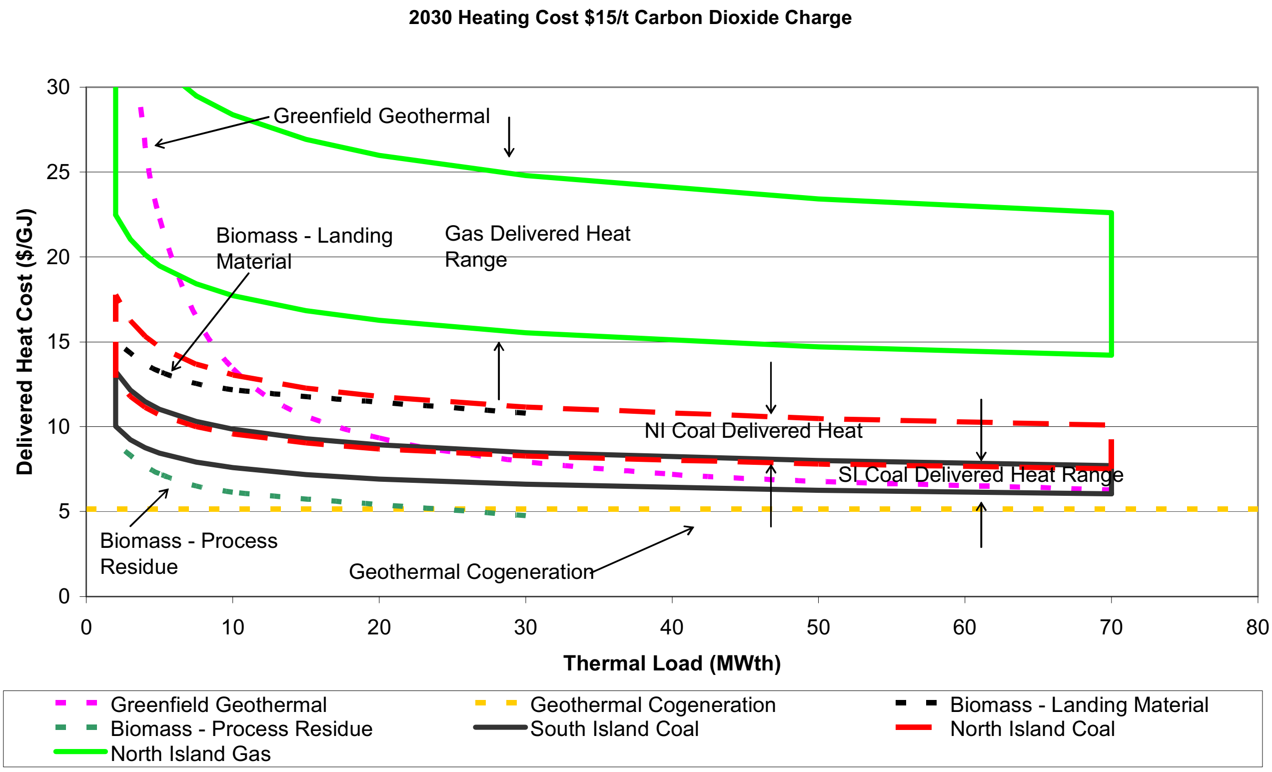

Figure A2.6 2030 heating costs with $15/t carbon dioxide charge included

Appendix 3. Regional Cost of Forest Residues vs. Coal

Figures A3.1-A3.7 show graphs for various regions comparing prices for coal and forest residues for 2020.
These curves were developed by determining the cost of supply to each of the selected wood-processing centres (as listed in Table 2.1) in the region. These costs are determined by landing site processing costs and transportation costs. The curves corresponding to high oil use the oil prices in the MED high oil price scenario of the Energy Outlook.

The "equivalent coal price" referred to in the graph in the figures is the price of coal adjusted to take into account differences in capital and operating costs of a 5MW coal plant and is based on the same model that generated the heat supply curves in Appendix 2. These curves obey a simple scaling rule such that

$$y = y0 + (x - x0)/C$$

where y is the new price of delivered heat from residue, y0 is the old price of delivered heat from residue, C = 0.7 is the biomass boiler efficiency (i.e. 70%), x is the new price for residue and x0 is the old price for residue. We can rearrange this equation to give

$$x = x0 + C*(y - y0)$$

Then, if we take y as the cost of delivered heat of coal we can determine the "equivalent coal price", i.e. the cost of forest residue which would lead to the same cost of delivered heat as coal.

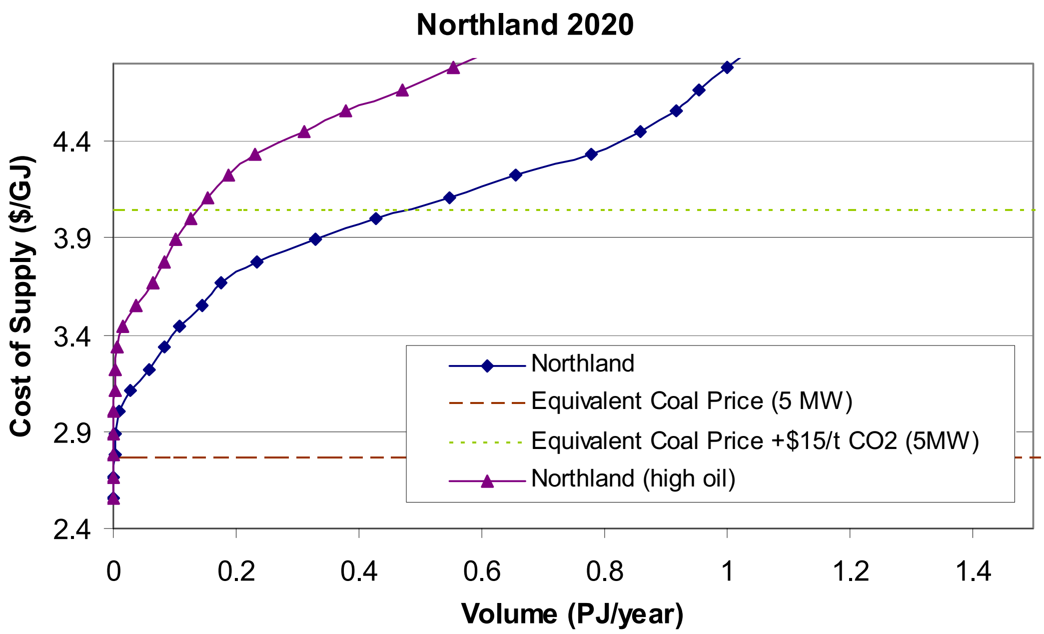

Figure A3.1 Comparative energy costs in the Northland region 2020

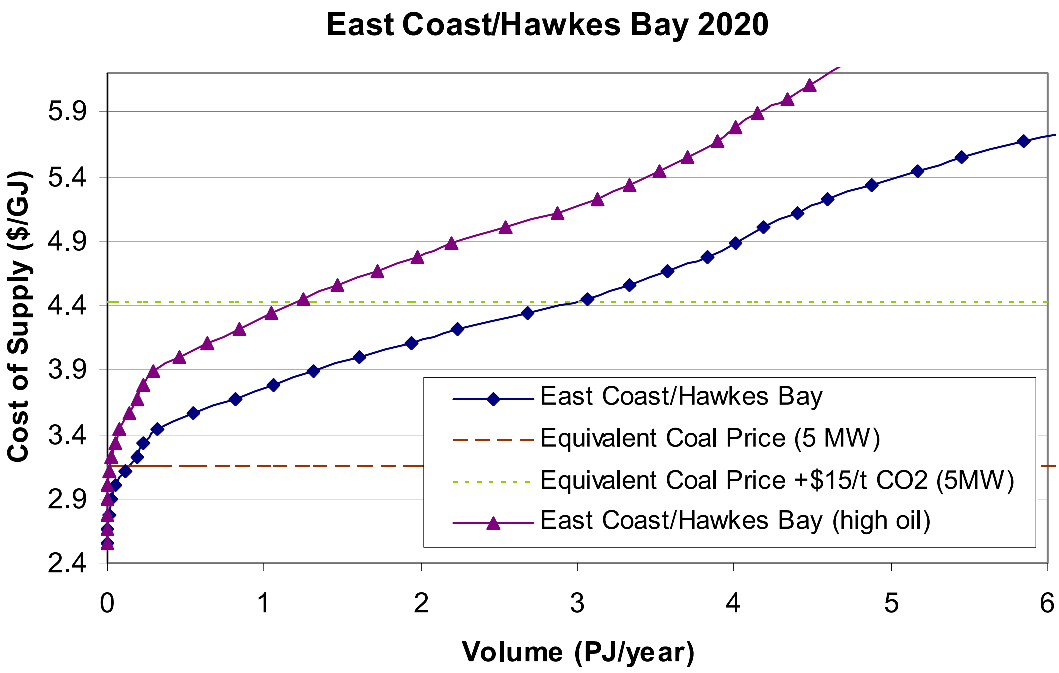

Figure A3.2 Comparative energy costs in the East Coast/Hawkes Bay region 2020

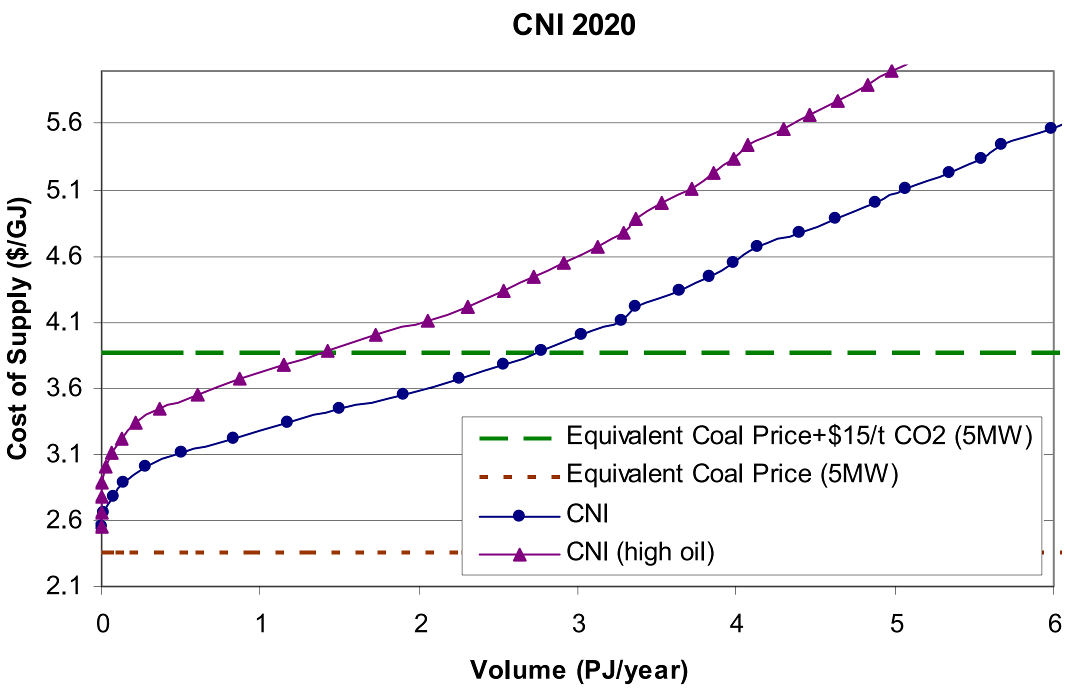

Figure A3.3 Comparative energy costs in the Central North Island region 2020

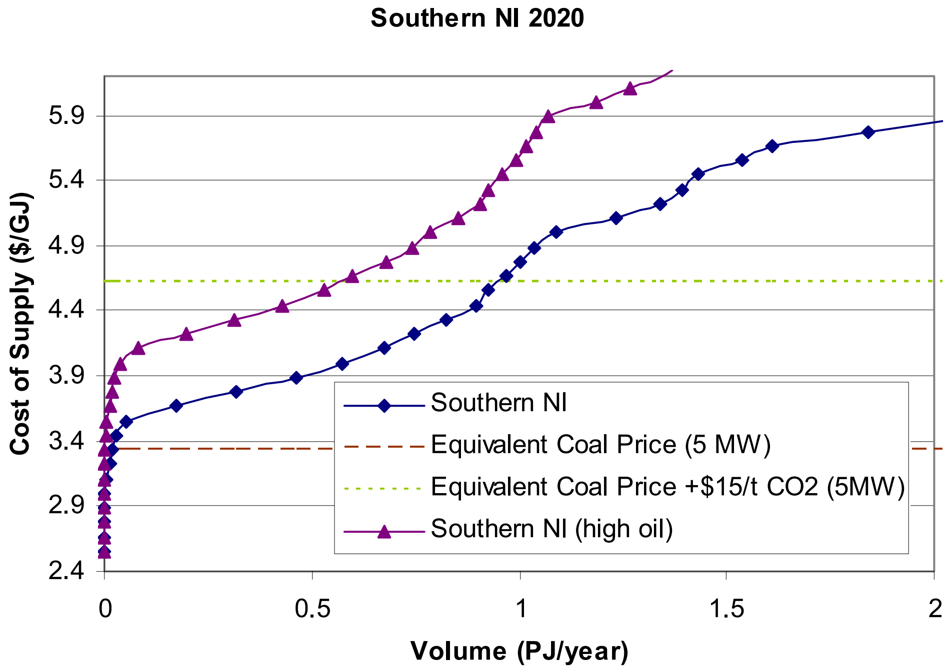

Figure A3.4 Comparative energy costs in the Southern North Island region 2020

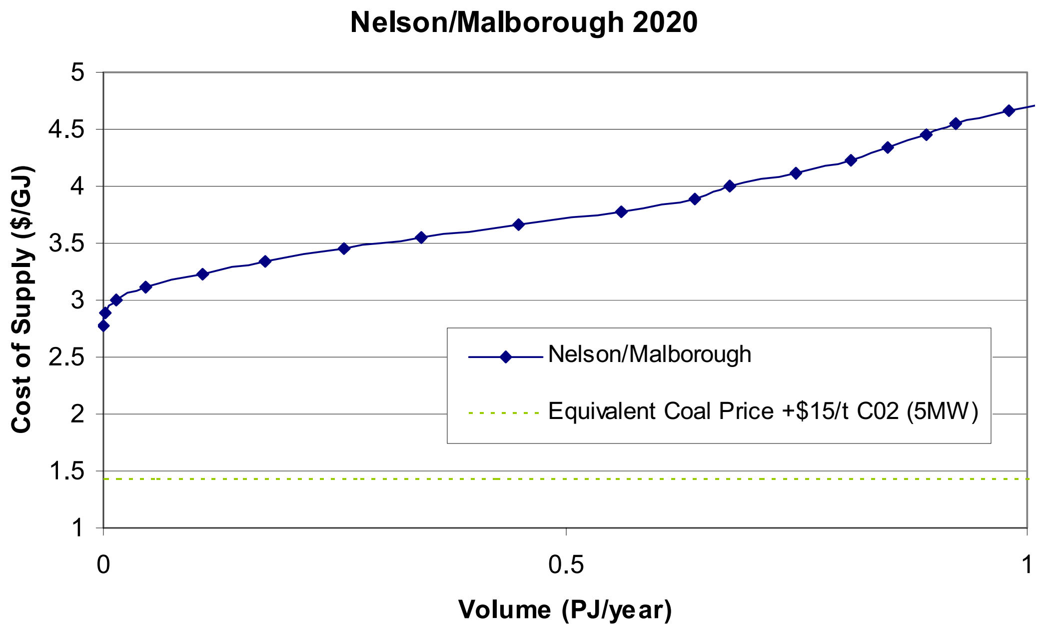

Figure A3.5 Comparative energy costs in the Nelson/Malborough region 2020

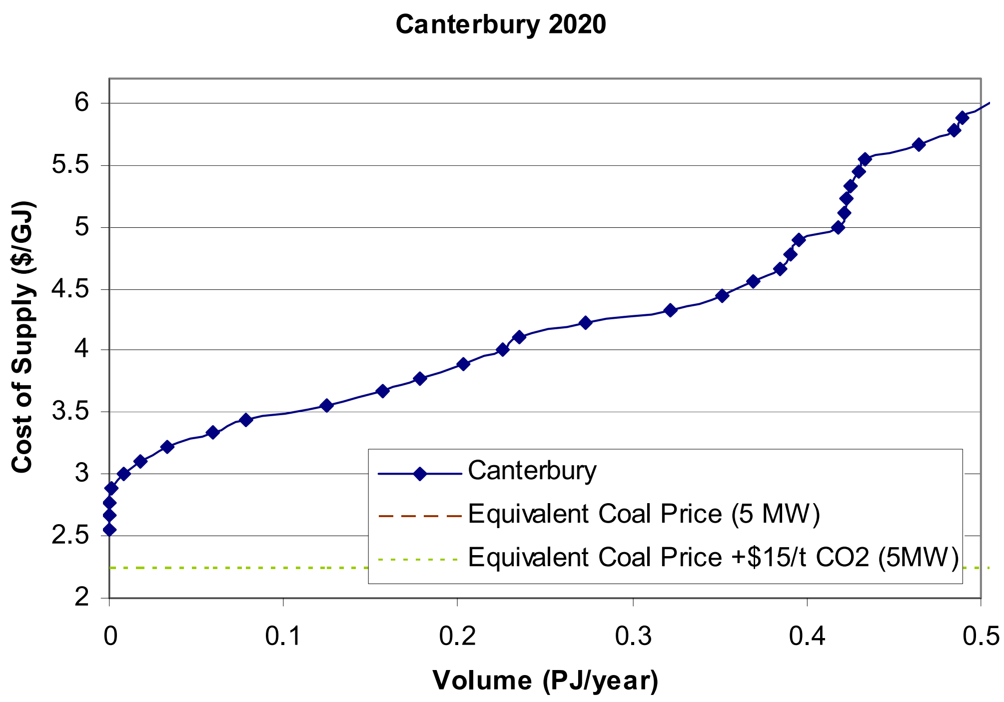

Figure A3.6 Comparative energy costs in the Canterbury region 2020

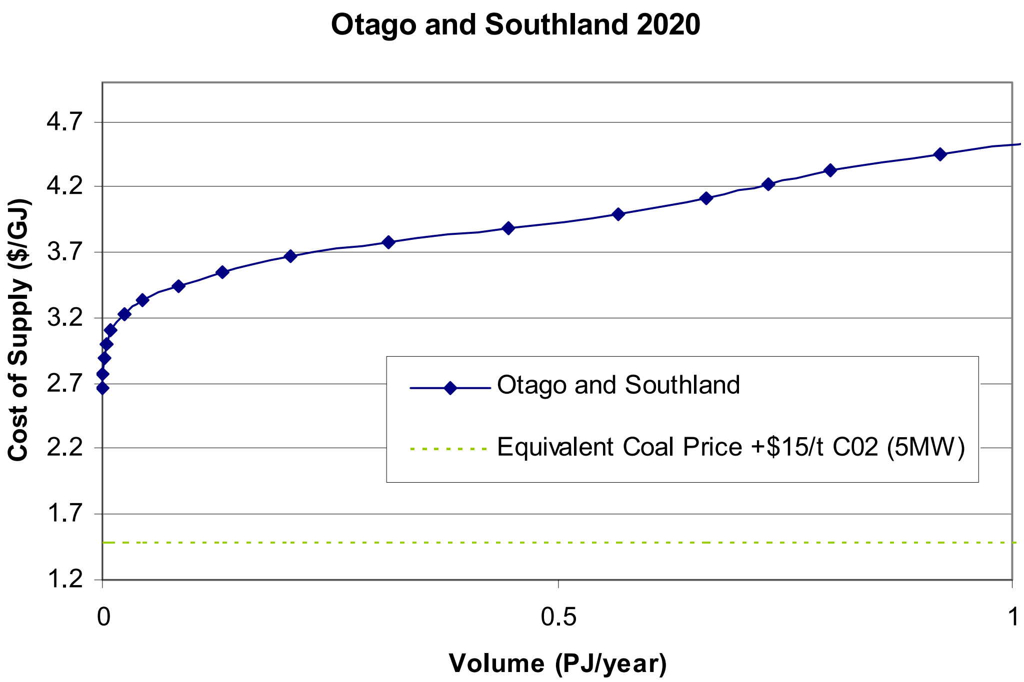

Figure A3.7 Comparative energy costs in the Otago/Southland region 2020

Appendix 4. Fuel Price Scenarios

The analysis for this study was based on the fuel prices assumed in the various scenarios set out in the ministry of Economic Development Energy Outlook to 2030.

Table A4.1 Consumer Prices By Energy Type ($/GJ): Energy Outlook Base Case

	2005	2010	2015	2020	2025	2030
Electricity (Residential)	45.9	46.7	49.6	54.0	55.3	55.3
Electricity (Wholesale)	20.6	20.6	22.8	26.2	27.3	27.3
Gas (Wholesale)	5.4	6.7	7.7	9.8	10.3	10.3
Coal (Wholesale)	3.5	3.5	4.0	4.0	4.0	4.0
Diesel (Wholesale)	20.8	26.6	26.6	26.6	26.6	26.6
With $15/t CO_2 charge						
Electricity (Residential)	47.9	48.7	51.6	56.0	57.3	57.3
Electricity (Wholesale)	22.2	22.2	24.3	27.8	28.9	28.9
Gas (Wholesale)	6.2	7.5	8.5	10.5	11.1	11.1
Coal (Wholesale)	4.9	4.9	5.4	5.4	5.4	5.4
Diesel (Wholesale)	21.8	27.7	27.7	27.7	27.7	27.7

Table A4.2 Consumer Prices By Energy Type ($/GJ): Energy Outlook High Oil

		2010	2015	2020	2025	2030
Electricity (Residential)		46.9	51.0	52.1	53.3	53.3
Electricity (Wholesale)		20.8	23.8	24.7	25.7	25.7
Gas (Wholesale)		6.7	8.3	11.2	12.7	12.7
Coal (Wholesale)		3.5	4.0	4.0	4.0	4.0
Diesel (Wholesale)		55.5	55.5	40.0	40.0	40.0
With $15/t CO_2 charge						
Electricity (Residential)		48.9	53.0	54.1	55.3	55.3
Electricity (Wholesale)		22.4	25.4	26.3	27.2	27.2
Gas (Wholesale)		7.5	9.1	12.0	13.5	13.5
Coal (Wholesale)		4.9	5.4	5.4	5.4	5.4
Diesel (Wholesale)		56.5	56.5	41.0	41.0	41.0

Table A4.3 Regional Delivered Coal Prices 2020[34]

	No Carbon Charge			+$15/t Carbon Charge		
	Industrial	**Commercial**	**Domestic**	**Industrial**	**Commercial**	**Domestic**
Whangarei	6.8	10.1	14.4	8.1	11.5	15.8
Auckland	6.0	9.4	13.6	7.3	10.7	15.0
Huntly	5.3	8.7	12.9	6.6	10.0	14.3
Hamilton	5.6	9.0	13.2	6.9	10.3	14.6
Tauranga	6.2	9.6	13.8	7.6	11.0	15.2
Gisborne	7.4	10.8	15.0	8.7	12.1	16.4
Rotorua	6.2	9.6	13.8	7.6	11.0	15.2
Taupo	6.4	9.8	14.0	7.8	11.2	15.4
Napier	7.0	10.4	14.6	8.4	11.8	16.0
New Plymouth	6.9	10.3	14.5	8.3	11.6	15.9
Wanganui	7.1	10.5	14.8	8.5	11.9	16.1
Palmerston North	7.4	10.8	15.0	8.8	12.2	16.4
Wellington	7.6	11.0	15.1	9.0	12.3	16.5
Blenheim	4.6	6.9	9.7	6.0	8.2	11.0
Nelson	4.5	6.7	9.5	5.8	8.1	10.9
Christchurch	5.5	7.8	10.7	6.9	9.2	12.1
West Coast (local)	3.8	6.1	8.9	5.2	7.4	10.3
Oamaru	5.4	7.7	10.7	6.8	9.1	12.0
Timaru	5.5	7.8	10.7	6.8	9.2	12.1
Dunedin	5.2	7.6	10.6	6.6	9.0	12.0
Southland (local)	3.9	6.3	9.2	5.3	7.7	10.6
Invercargill	4.7	7.3	10.5	6.1	8.7	11.9

Table A4.4 Regional Delivered Gas Prices 2020

	No Carbon Charge			+$15/t Carbon Charge		
	Industrial	**Commercial**	**Domestic**	**Industrial**	**Commercial**	**Domestic**
Whangarei	19.9	25.7	78.5	20.7	26.5	79.3
Auckland	12.4	16.0	48.9	13.2	16.8	49.7
Huntly	12.4	16.0	48.8	13.2	16.7	49.6
Hamilton	11.7	15.0	45.9	12.5	15.8	46.7
Tauranga	19.5	25.1	76.7	20.3	25.9	77.5
Gisborne	19.9	25.7	78.5	20.7	26.5	79.3
Rotorua	16.8	21.6	66.0	17.6	22.4	66.8
Taupo	19.4	25.0	76.5	20.2	25.8	77.3
Napier	19.9	25.7	78.5	20.7	26.5	79.3
New Plymouth	12.0	15.4	47.0	12.7	16.2	47.8
Wanganui	13.0	16.7	51.2	13.8	17.5	52.0
Palmerston North	14.4	18.6	56.8	15.2	19.4	57.6
Wellington	16.5	21.2	64.7	17.2	22.0	65.5

[34] Note: Carbon charge for transport is not included

Table A4.5 Regional Delivered Coal Prices 2030

	No Carbon Charge			+$15/t Carbon Charge		
Region	**Industrial**	**Commercial**	**Domestic**	**Industrial**	**Commercial**	**Domestic**
Whangarei	6.8	10.1	14.4	8.1	11.5	15.8
Auckland	6.0	9.4	13.6	7.3	10.7	15.0
Huntly	5.3	8.7	12.9	6.6	10.0	14.3
Hamilton	5.6	9.0	13.2	6.9	10.3	14.6
Tauranga	6.2	9.6	13.8	7.6	11.0	15.2
Gisborne	7.4	10.8	15.0	8.7	12.1	16.4
Rotorua	6.2	9.6	13.8	7.6	11.0	15.2
Taupo	6.4	9.8	14.0	7.8	11.2	15.4
Napier	7.0	10.4	14.6	8.4	11.8	16.0
New Plymouth	6.9	10.3	14.5	8.3	11.6	15.9
Wanganui	7.1	10.5	14.8	8.5	11.9	16.1
Palmerston North	7.4	10.8	15.0	8.8	12.2	16.4
Wellington	7.6	11.0	15.1	9.0	12.3	16.5
Blenheim	4.6	6.9	9.7	6.0	8.2	11.0
Nelson	4.5	6.7	9.5	5.8	8.1	10.9
Christchurch	5.5	7.8	10.7	6.9	9.2	12.1
West Coast (local)	3.8	6.1	8.9	5.2	7.4	10.3
Oamaru	5.4	7.7	10.7	6.8	9.1	12.0
Timaru	5.5	7.8	10.7	6.8	9.2	12.1
Dunedin	5.2	7.6	10.6	6.6	9.0	12.0
Southland (local)	3.9	6.3	9.2	5.3	7.7	10.6
Invercargill	4.7	7.3	10.5	6.1	8.7	11.9

Table A4.6: Regional Delivered Gas Prices 2030

	No Carbon Charge			+$15/t Carbon Charge		
	Industrial	**Commercial**	**Domestic**	**Industrial**	**Commercial**	**Domestic**
Whangarei	20.6	26.5	80.9	21.3	27.2	81.7
Auckland	13.0	16.8	51.3	13.8	17.6	52.1
Huntly	13.0	16.7	51.2	13.8	17.5	52.0
Hamilton	12.3	15.8	48.3	13.1	16.6	49.1
Tauranga	20.1	25.9	79.1	20.9	26.7	79.9
Gisborne	20.6	26.5	80.9	21.3	27.2	81.7
Rotorua	17.4	22.4	68.4	18.2	23.2	69.2
Taupo	20.1	25.8	78.9	20.8	26.6	79.7
Napier	20.6	26.5	80.9	21.3	27.2	81.7
New Plymouth	12.6	16.2	49.4	13.4	17.0	50.2
Wanganui	13.6	17.5	53.6	14.4	18.3	54.4
Palmerston North	15.1	19.4	59.2	15.8	20.2	60.0
Wellington	17.1	22.0	67.1	17.8	22.7	67.9