Bioenergy Association of New Zealand

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# Bioenergy Opportunities for the Forestry and Wood Processing Sectors: Potential Value Propositions for Investment

Bioenergy Association of New Zealand

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## Contents



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## Approval for Publication

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|---|---|---|---|
| **Author** | **Name** | **Signature** | **Date** |
| | John Gifford | | 28/06/2013 |
| **BANZ Executive Officer** | **Name** | **Signature** | **Date** |
| | Brian Cox | | 29/7/13 |

## Abstract

This report has been prepared based on a range of published information and other sources. In some cases the information sources span the last 10 years so it is apparent that there is a requirement for updated information. It is anticipated that BANZ will update the value propositions presented here on an ongoing basis as engagement with the forestry sector continues.

Opportunities may exist for forest owners and wood processors to invest in forest residue collection, its conversion into wood fuels, optimization of biomass feedstocks, and for the production of wood pellets. Many of these opportunities are niche and will need to be developed on a case by case basis. Forest derived woody biomass can be collected and processed into wood fuel at a cost which is potentially competitive with coal (around $4 – 5 /GJ), through these costs do not necessarily allow for payment of the residues. If around $2-5/ green tonne is paid for forest residues this would only add about another $0.5 – 1 /GJ to the fuel cost. At these costs, wood fuel derived from forest residues is still going to be competitive with alternative fuels. Where a wood fuel supply business is established, then a range of other costs may need to be considered and this can increase the sale price closer to around $9-13/GJ.

Typically, there are three major types of market operating, niche situations where wood processing residues can be available for around $7/GJ, a market servicing smaller heat plants, though collectively may add up to around 15 MWt, here fuel will be available for around $11-$13 /GJ. Then there is larger scale contracts for the supply of large quantities of a specific type of fuel for the likes of meat, dairy or food processing sites, here fuel is typically available at $8 - $9/GJ. Fuel quality guidelines or standards and a fuel supplier accreditation scheme will assist to accelerate the introduction of a more robust wood fuels market.

Wood pellets can potentially be sold cost competitively into both the US (sale price around US$269 /tonne) and European markets (sale price around €180/tonne). Structural issues within the forestry industry and market competition in the energy sector, such as high log prices the current reduced cost of coal and lack of incentives or valuing environmental services, are currently constraining investment into bioenergy by these sectors.

# 1. Introduction

The Forest Industry in New Zealand owns and or manages over 1.7 million ha of plantation grown forests, predominantly radiata pine which is distributed widely throughout New Zealand. The total amount of forest residues that may exist at landings can vary between 4.5 -8% of the recoverable harvest. Significantly larger quantities of residues are left on the cut-over of a harvesting operation, 15 -21% of the total recoverable volume. Currently much of this material either goes to waste or contributes to other costs such as landing management or environmental mitigation costs (for example the removal of birds' nests on landing sites which can collapse downhill or into water ways, or debris collapse during rain events).

Similarly, wood processors can produce substantial quantities of residues – though in this case much of it is used on site for producing heat.

The occurrence of these residues, represent a potentially useful resource that can be used for wood fuels or feedstocks for other bio-processing.

This paper provides an overview of the potential value propositions for utilising these residue resources by forest owners and wood processors in the current market. This report is not an analysis of future markets or potential future markets in which a range of environmental service pricing regimes may exist. The existence of these value propositions assumes that there is a market for the materials available from forests.

# 2. Overview of the forestry and wood processing sectors

## Industry structure

Forest owners are a diverse group consisting of entities that own between around 200,000 ha of forest to a large number of owners with less than 1,000 ha. In the case of wood processors these can be companies processing over 1 million tonnes (or 1 million $m^3$) of logs a year to others processing less than 1,000 tonnes. Furthermore, they vary in complexity from fully integrated pulp and paper mills to small scale family businesses producing timber products for domestic and export markets such as furniture or joinery manufacture (Figure 1, Sector map). The nature of any bioenergy related value proposition to these entities will significantly vary depending on size, location, demand for fuel, fuel supply options, and adjacent infrastructure. Furthermore, the value propositions will also varying depending on the position of a company or player in the supply or value chain and the specific fibre supply dynamics that may exist in a region or area.

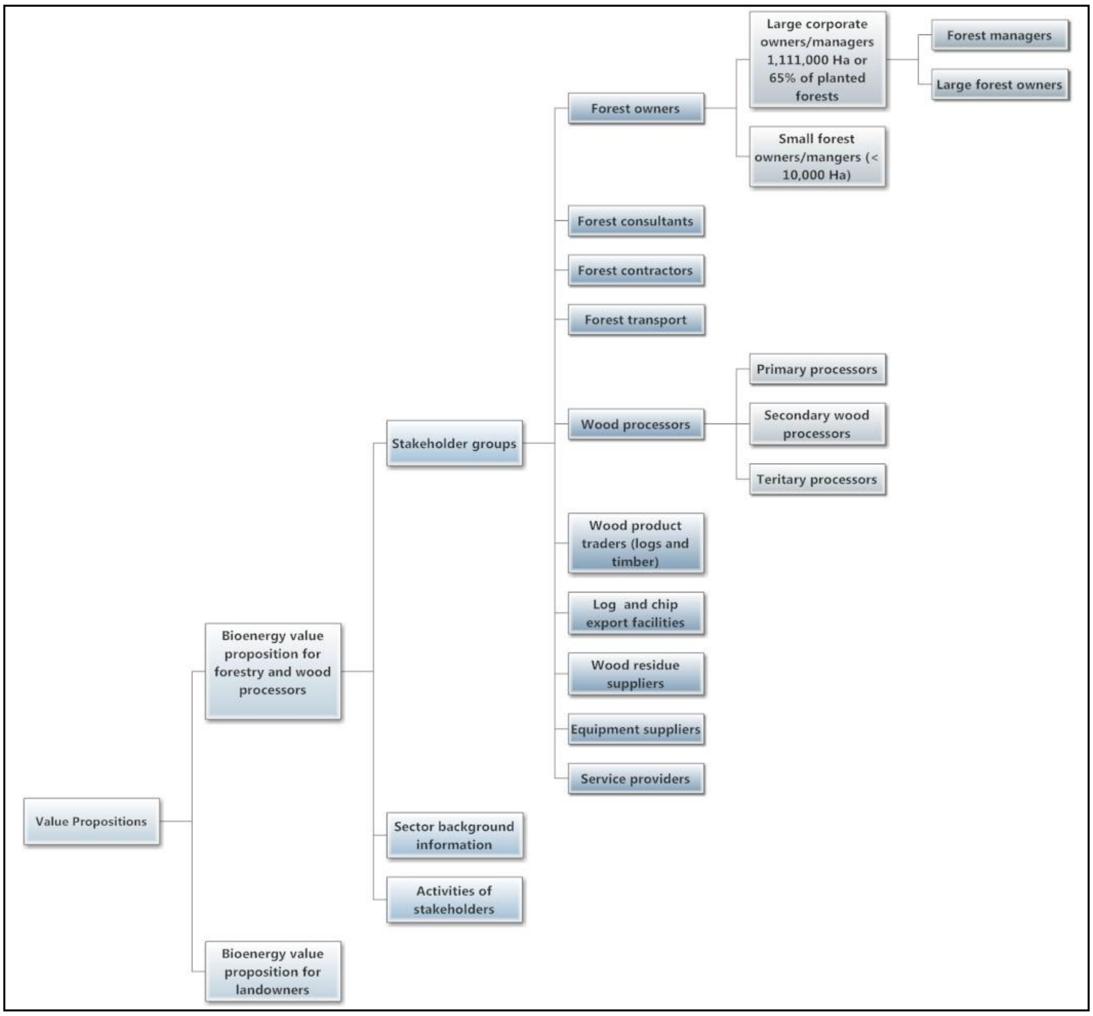


**Figure 1: Industry and sector map**

**Forest owners**

The forest owner category can be divided into three subsectors, forest managers (entities managing greater than 20,000 ha), large forest owners (entities that own and manage > 10,000 ha) and small forest owners (entities that own < 10,000 ha). This later group was further subdivided in 'tree farmers' (with > 1000 – 9,999 ha) and 'farm foresters' with <1,000 ha). The farm forester group is considered in a separate land owner paper.

**Wood processors**

Wood processors can be classified on the basis of products produced and production capacity. The three subsectors considered are primary, secondary and tertiary wood processors (Table 1).

For the purposes of this paper the main subsectors considered are forest managers, large forest owners, tree farmers, and primary and secondary wood processors. Other potential subsectors will be considered at a later date.

In the case of the forest owners, the various companies may also be landowners (for example Matariki has 56,000 ha freehold, 36,000 in Crown lease, 32,000 owned by Maori Incorporations and 6,000 in other lease hold situations where as Kaingaroa Timberlands has only 1,000 ha..

freehold, 4,000 ha crown lease and the balance of 177,000 ha is owned by a Maori Incorporation.

**Table 1: Wood processing subsectors**

| Subsector | Activities | Round wood/timber use (m3/an) | Energy demand and supply |
|---|---|---|---|
| Primary processors | Sawmilling, integrated sites, kiln drying and treating<br>Panel and engineered wood product producers (MDF, particle board, Triboard, plywood and LVL)<br>Pulp and paper producers | 40,000 -1,000,000<br>200,000 – 500,000<br>600,000 -1.5 million | Use of bark, sawdust, chip and off-cuts (hogged or un-hogged) for on-site energy use for process heat and product drying |
| Secondary processors | Sawn timber remanufactures (finger jointers, laminators, gauging and profiling, product finishing) | 1,000-200,000 | Dry sawdust, shavings, off-cuts – used for on-site heat for drying products |
| Tertiary processors | Furniture, joinery and packaging manufacturing | 100 -1,000 | Typically no onsite energy system. Wood waste disposed to landfill. |

Ownership of the land affects the long term management approach adopted for a forest and the values that both the landowner and forest owner may extract from the resource.

In this report the focus is on a companies' or peoples role as forest owners rather than a land owner. Furthermore, the forest owner is the primary decision maker regarding utilisation of the forest resource.

## Sector Description

The forest sector is a major contributor to the New Zealand economy and currently ranks third in terms of contribution to export earnings ($4.7 billion in 2011) with the export earnings increasing by over 21% between 2010 and 2011 (FOA2011/12). Forest owners have over 1.7 million ha of plantation forest or 6% of New Zealand's total land area. Each year around 44,000 ha of plantation forest are clear fell harvested yielding about 21 million $m^3$ of roundwood.

The dominant forest type is radiata with 1.5 million ha followed by Douglas fir (107,000 ha). The balance is made up of cypress, eucalypts, acacia and other softwoods and hardwoods.

The average age of the forest is about 16 years which reflects the level of planting over the last 20 years. During the mid 1990s, forest planting peaked at 92,800 ha in 1994 with relatively high levels of planting sustained through until 1997. As radiata is typically harvested at between 26 – 32 years old the current age structure means that after about

2025-2030 the overall standing volume of forest will start to decrease and the harvest will decline for around 10-15 years. This affect and the geographic distribution of the various age classes of trees will have an impact on the availability of forest residues for bioenergy and bio-processing.

The number of forest owners with small blocks (40 -99 ha) of forest is just under 1000 and those owning more than 10,000 ha is 17 owners or managers (Figure 3).

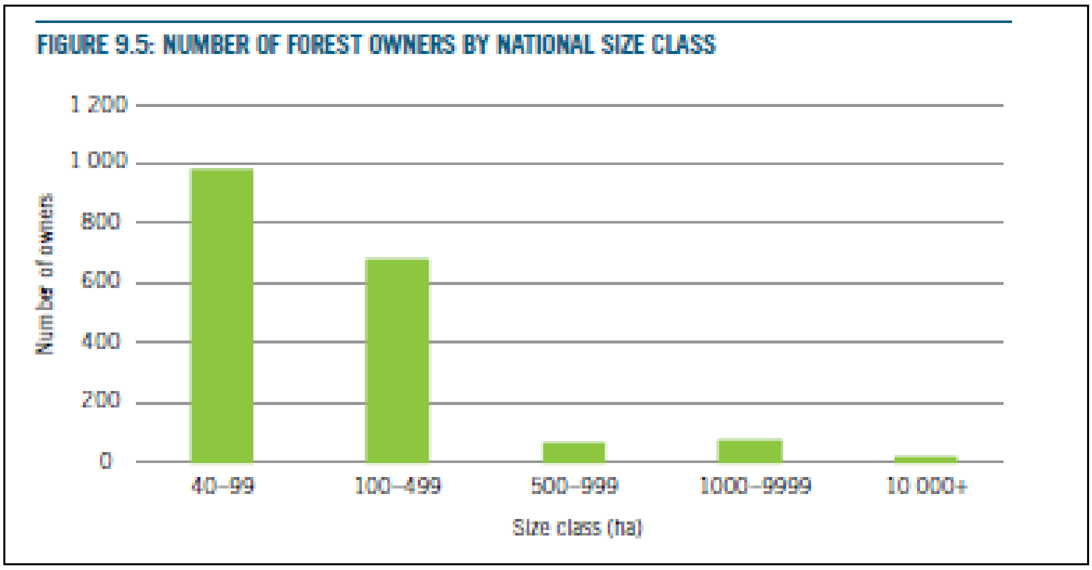


**Figure 3: Number of forest owners by national size class (taken from the NEFD, 2012**)

Note. The number of farm foresters may be greater than the level indicated above and in part due to the way the statistics are collated for the NEFD.

The predominant silvicultural regime is pruned without production thinning (692,000 ha) which is then followed by unpruned without production thinning (603,000 ha); pruned with production thinning (207,000 Ha) and unpruned with production thinning (41,000 ha). The tendering regime will have an impact on the quantity and nature of forest residues available for a specific forest or region.

To the end of December 2011, 26 million $m^3$ of round wood from plantation forests were harvested and about 14,000 $m^3$ from natural forest. Fifty percent of the total harvest is exported as logs and the remaining 50% is used domestically for wood processing with about 8 million $m^3$ used for saw logs, 3.7 million $m^3$ used for pulp and paper and 0.8 million $m^3$ used for panel products. The location of the main wood processing facilities by forest region is shown in Figure 2.

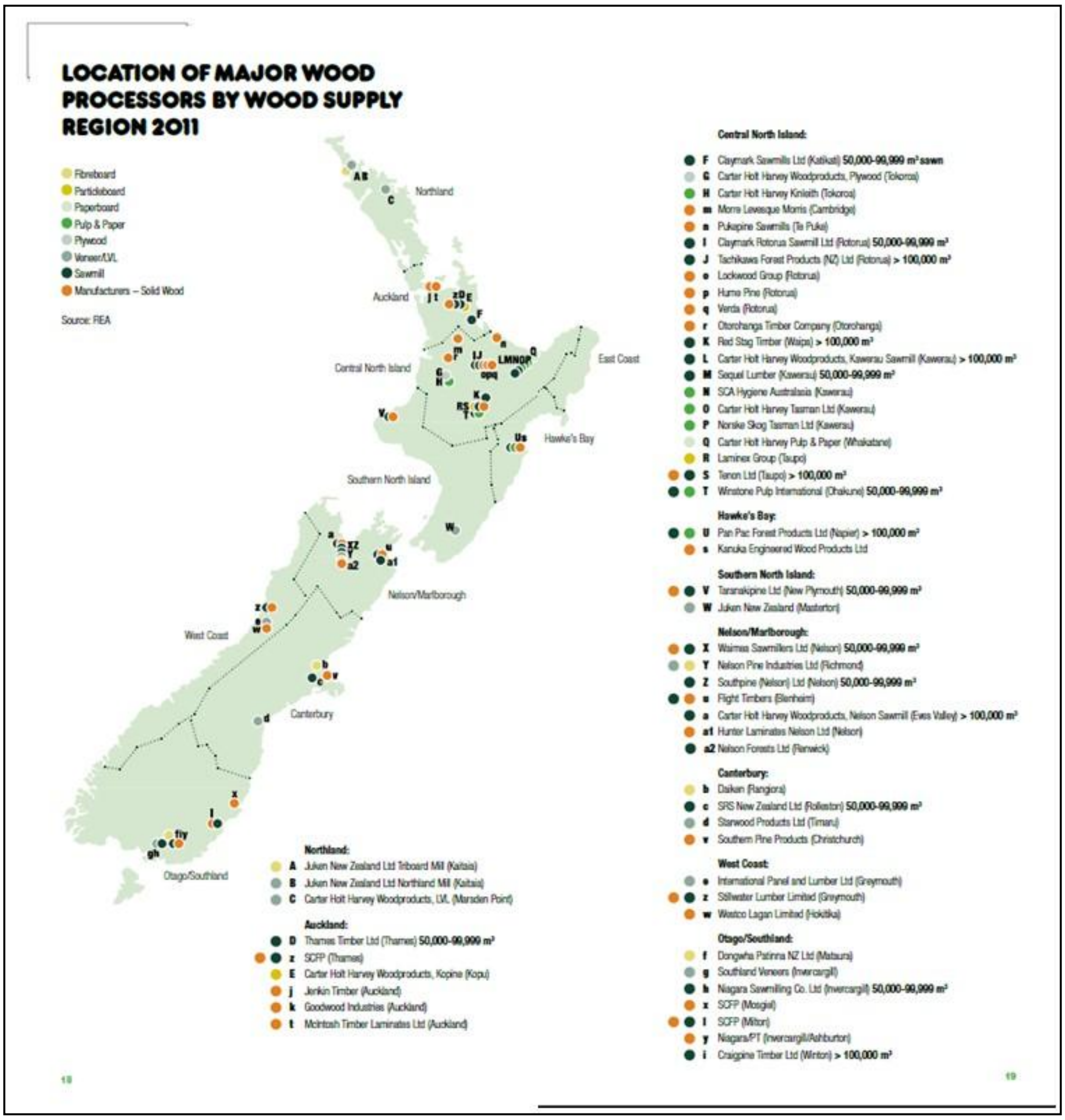


**Figure 2: Distribution of wood processing plants by forest region (from FOA, 2011/12)**

The typical outturn of logs, product and waste from the harvesting of radiata are shown in Figure 3. For a typical pruned tree around 8% of the volume ends up as harvest residues (waste) and this will increase to around 10-13% for an unpruned tree. The volume of products recovered from a tree depends on whether it is grown for appearance (pruned stem) or structural (typically un-pruned stems) products. Other grades of logs which are typically exported tend to be of lower quality and used for a wide range of uses in export markets.

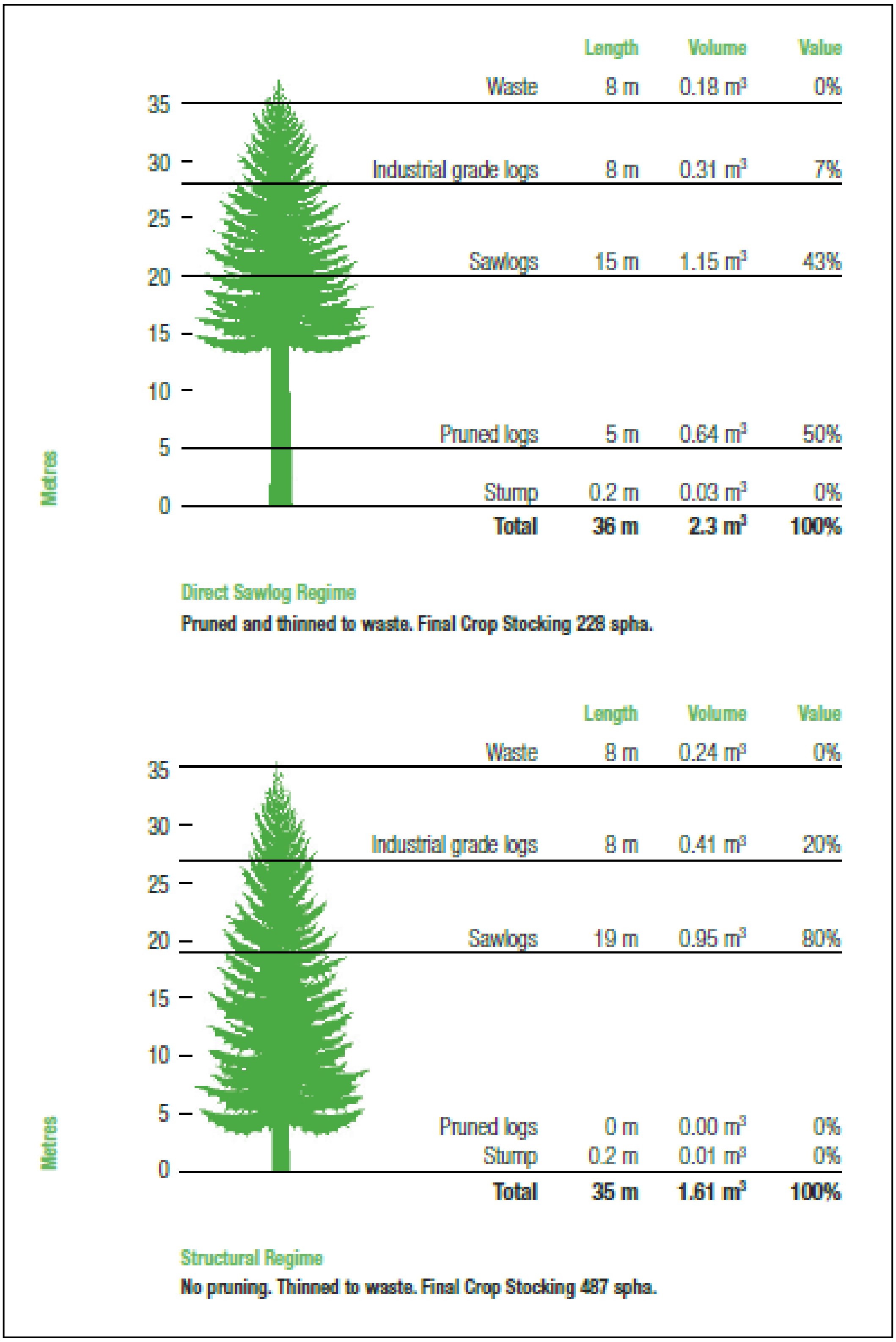


**Figure 3: Typical out-turns from the harvesting of a radiata stem for appearance (pruned stem) and structural (un-pruned stem) products (from FOA, 2011/12).**

The total export earnings from the sector are around NZ$4.7 billion, which is made up of $1.7 billion for logs and chips, $0.8 billion sawn timber, $0.6 billion wood pulp, $0.4 billion paper and paper board, $0.6 billion panel products and $0.4 billion for other products. For most product classes well over 50% of the production is exported.

## Energy use by the forestry sector

The total energy use of the forestry, logging, wood and pulp and paper industries is around 68.8PJ. This is made up of around 21 PJ coming from a range of energy sources (electricity, coal, and natural gas). The balance is from wood derived sources. The forest industry is one the larger energy users in the country and the largest user of wood fuels.

## Forestry sector and bioenergy

Woody biomass currently provides around 7.5% (61PJ) of New Zealand's primary energy supply or 56 PJ of consumer energy with wood processing residues and domestic firewood providing around half. The balance is derived from the burning of black liquor arising from the Kraft pulp and paper process. Almost all of this energy is derived from the burning of wood residues to provide heat, only a small proportion is used for electricity generation via combined heat and power and this is estimated to be around 2 PJs.

The potential of the forest and wood processing industries to produce either raw material for energy production or energy has been well described in the Bioenergy Options Study (2007). Predictions of the total logging residues that may be available, including both landing and cutover material (ground based terrain), are around 2.6 million tonnes for 2016 -2020 nationwide. This potentially will increase to over 5 million tonnes by 2030. Some of the forest residue material is being collected and used for onsite energy by large wood processors.

## Forestry and bioenergy supply, conversion and energy production routes

A diverse range of potential value streams exist for the forestry sector in terms of using the resource for bioenergy or other bio-based products. Forest derived residues (cutover residues or landing residues can be collected and sold as wood fuel or as feedstocks for other fuel processing, wood processing residues can be sold for wood fuel to heat users or upgraded into wood pellets which can then be exported or sold domestically). The range of fuel supplies, conversion routes and possible products are summarised below (Figure 4).

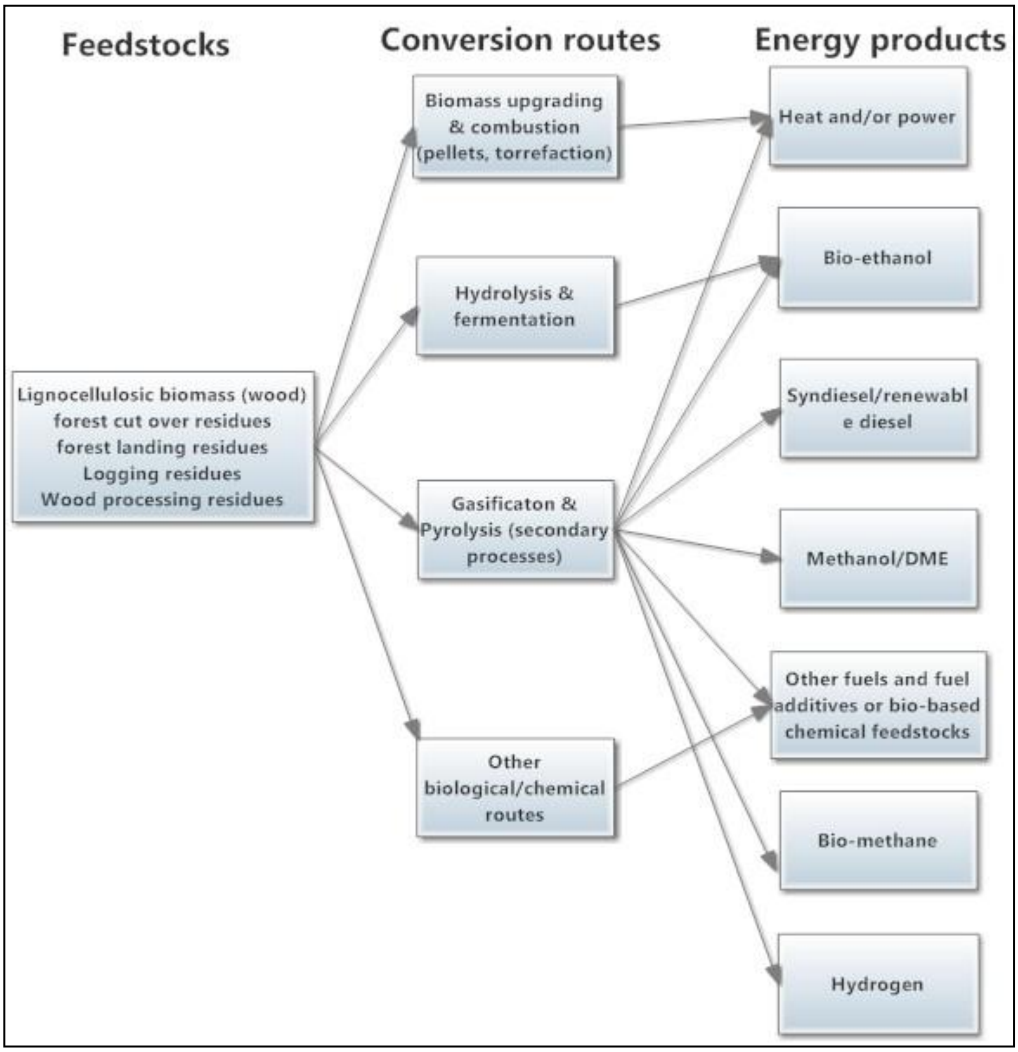


**Figure 4: Potential value generating pathways for producing bioenergy by the forestry and wood processing sectors**

## 3. Bioenergy value propositions

For each of the subsectors identified above there is a mix of potential bioenergy pathways which can yield value streams. Where possible this mix of opportunities will be identified, but the specifics of all value propositions are beyond the scope of this project at this time. This paper focuses on identifying the most significant value opportunities that currently may exist in selected niche markets or areas. It is anticipated that future papers will address opportunities not covered here.

### Supplying wood fuels

Although the forest products sector is a substantial user of woody derived fuels for heat and for some sites are using forest derived material, the supply of wood fuels to other sectors is currently relatively small. However, over the last 10 years (more so in the last 5-6 years) a number of commercial players have started either a new wood fuel supply business or activity as part of an existing business (for example Wood Energy New Zealand; Living

Energy, Spark Energy; Canterbury Wood Chip Supplies; and Azwood). Typically these businesses are operating within existing niches but there is still substantial opportunity to continue to grow these existing businesses and to develop new businesses as the growth in wood fuels continually expands.

The quantity of forest residues likely to be available for collection and processing is quite variable and will depend on terrain, and harvesting type, but indicative yields per hectare of total forest residue (including both landings and cutover are around 100-130m$^3$ per hectare for ground based logging, logging flat to rolling terrain. Whereas, for hauler logging on steep terrain the total may be 140 -160m$^3$ per hectare (Table 2).

**Table 2: Tonnes of residues per hectare available for conversion to wood fuel from a mix of pruned and unpruned regimes (from EECA 2007).**

| | **Ground-based logging flat to rolling terrain** | **Hauler logging steep terrain** |
|---|---|---|
| Total extracted stem volume | 500 to 700 m$^3$ per ha | 500 to 700 m$^3$ per ha |
| Stem waste at landing<br>- Manual log making<br>- Mechanised log making | <br>20 to 28m$^3$ per ha (4%)<br>30 to 42m$^3$ per ha (6%) | <br>25 to 35m$^3$ per ha (5%)<br>30 to 42m$^3$ per ha (6%) |
| Branch waste at landing | 2.5 to 3.5m$^3$ per ha (0.5%) | 15 to 21m$^3$ per ha (3%) |
| Total waste at landing | 22 to 32m$^3$ per ha (4.5%) | 40 to 56m$^3$ per ha (8%) |
| Stem waste on cut-over | 25m$^3$ per ha (5%) | 49m$^3$ per ha (10%) |
| Branch waste on cut-over | 52m$^3$ per ha (10%) | 58m$^3$ per ha (11%) |
| Total waste on cut-over | 77m$^3$ per ha (15%) | 107m$^3$ per ha (21%) |
| Total in forest waste | 100 to 130m$^3$ per ha (ca 20%) | 140 to 160m$^3$ per ha (ca 28%) |

Hauler based systems will typically have more material available at the landing due to the removal of intact trees up to the felling break-point and smaller broken pieces, both of which have most of the branches still attached. As a result the landing residues, for this situation, will consist of stem off-cuts, branches and small diameter top logs.

The economics of supplying wood fuels from the forestry sector is complex and is affected by a wide range of parameters which will vary from site to site. A number of studies have investigated the cost of supplying wood fuels (Hall, 2001; Robertson, 2006; Bioenergy Options Study 2007) so it is not necessary to go into the full details here. As an example of an indicative case study, Robertson (2006) undertook a detailed assessment of the cost of supplying forestry based wood fuels for the Canterbury region. In this study, the cost of supplying wood fuels was based on supplying a mix of forestry and wood processing residues to plants in the Canterbury area (i.e. to meet an identified demand). Key parameters considered in the study included the collection, chipping and screening of biomass material, transport costs based on location and haul distances to the point of use, location of biomass at wood processing plants and forest sites, yields of biomass at landing and cutovers and specific opportunity costs. The main assumptions or parameters considered in this analysis are summarised below (Table 3).

**Table 3: Assumptions/parameters used for Canterbury cost supply curves**

| **Assumption/parameter** | **Value/comment** |
| --- | --- |
| Residues at landing (hauler based recovery)<br>Residues at landing (Ground based recovery) | 9% total recoverable volume<br>5% of total recoverable volume |
| Collection/Chipping costs<br>- Chip logs<br>- Landing residues<br>- Cutover residues | $/odt<br>4.02<br>15.02<br>21.02 |
| Transport costs<br>- Chip logs<br>- Landing residues<br>- Cutover residues<br>- Sawdust, bark and chip | $/odt/km<br>0.31<br>0.36<br>0.36<br>0.26 |
| Cost of heat (combustion plant costs) for 20 MW plant | $0.01/kWh |

In this study the cheapest biomass (from wood processing sites) that could be delivered to energy plants had costs of $12/odt or $0.7/GJ.  Once this was used the next cheapest source of fuel was a close source of landing residues and the next cheapest was a close source of cutover residues at around $23/odt.  Chip logs have the highest delivered cost and chip could be supplied slightly cheaper than chip logs (Figure 5).

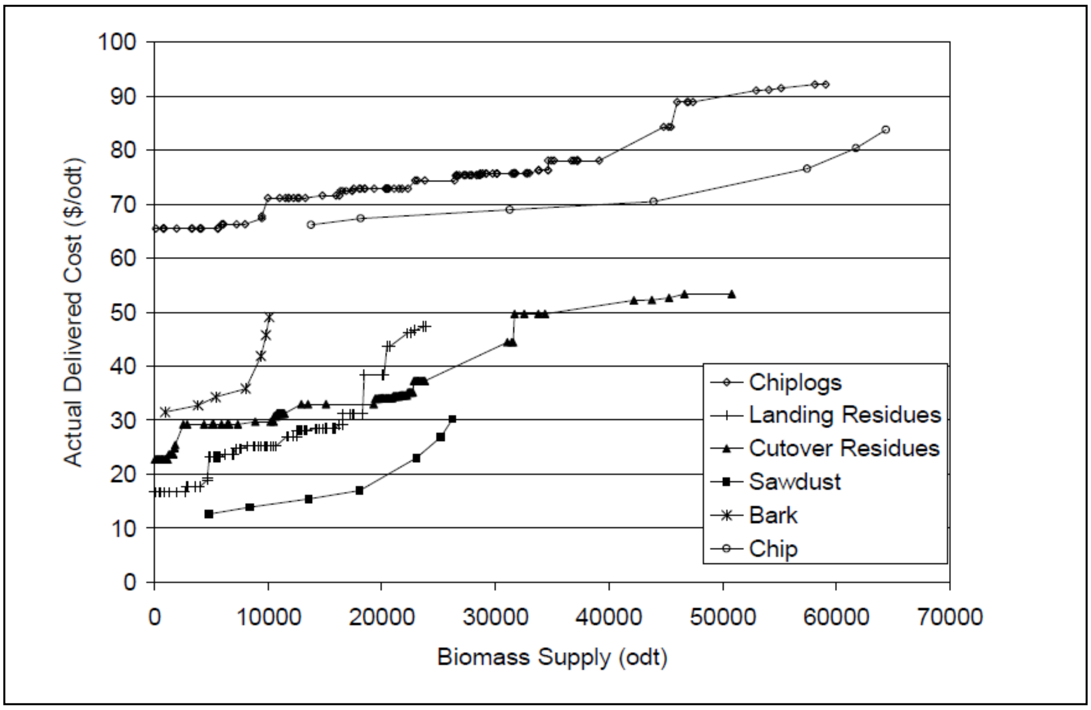


**Figure 5: Delivered cost of forest derived residues to a Canterbury site in 2007 ($/odt) (from Robertson, 2006).**

These costs do not take into account margins and other business related expenses – so in many cases the actual price that may be charged may be higher than the values indicated above. Other factors typically affecting the price of forest residues are transport distance and the quantity purchased.

In this case study the cheapest cost of biomass ranged between $12.58 -51.68/odt and $0.71 -2.99 /GJ. These costs would provide a potentially competitive fuel supply cost compared to other solid fuels (e.g. coal at around $4-6/GJ delivered), in particular if there is no cost for the recovered material and other benefits are also either costed or valued.

Although the cost of supplying wood fuels was demonstrated to be potentially economic for energy plants located in Canterbury and using Canterbury sourced forestry and wood processing residues – specific assessments would be required to validate if the same cost structure applies for other areas in New Zealand.

For this study no allowance was made for paying the forest owner for the residues or margins to the wood fuel supplier. For the forest owner to make money from the residues currently left in the forest, either cutover or landing residues then they would need to either sell the residues to a wood fuel supplier or develop their own wood fuel supply business and supply processed wood fuel direct to energy users. If the purchase price for residues from the forest were between $2-5 per green tonne, then this would add around another $4-10 per tonne on an odt basis to the costs indicated above. This would increase the cost of wood for the delivered wood fuels to around $16.58-$61.68 /odt ($0.90 – 3.6/GJ), which would still be competitive with coal. Higher payments can be paid to growers, but this in turn will mean that the delivered cost of energy would increase. Such increases may impact on market demand for the wood fuel.

The estimates of the costs to supply forest harvesting residues above are similar to those provided in other economic assessments (EECA, 2007). In this study estimates at the lower end of the cost range, were for residues to be delivered for $2.50-$3.00 /GJ, while at the higher end, costs are likely to be $6-$7/GJ, and the weighted average was $4-$5GJ.

Typically chipping costs are around $7-12/tonne for a chipper at a central site using a mobile plant or $3-9/tonne for a fixed plant. Transport costs for chipped material varied between $0.17-0.45/tonne/kilometre (EECA 2007).

As an example of the larger scale operation which was being used to supply wood fuel to a major wood processing operation, up to around 70,000 tonnes per year of hogged wood, then the following costs applied (EECA 2010):

- Overall cost of machines per hour: $710
- Production costs: $22-24 tonne
- Transport cost: $11/tonne
- Delivered cost of fuel: $33-35/tonne
- Average moisture content 57%
- Fuel cost $4.70/GJ

As another example of the cost to supply forest residues, EECA (2010) provide some further estimates for larger scale operations.

Assumptions:

- Interest rates 11%, Diesel $0.98 per litre, Wages $18.00 per hour
- Forest residues without drying = 6.5GJ per tonne, 6.2GJ per m3 of solid wood
- Distance to a central processing yard = 10 km, transport distance for product delivery = 70 km

1. **Set-out bins / truck to CPY / hog and screen / truck to user (costs in $/tonne):**
   Fill bins: $3.50
   Truck to central processing yard: $8.00
   Hog + screen $18.30 (hog to ground), ($14.65 no screening)
   Reload: $5.00
   Truck to user: $14.70
   Wood cost: $20.00
   **Total $69.50 per tonne**
   **$10.70 per GJ**

   If the material is hogged directly to truck the cost would reduce slightly to $64.5/ tonne $9.95/GJ.

2. **Set-out bins / truck to CPY / store and dry for four months / hog and screen /truck to user (costs in $/tonne):**
   Fill bins: $5.90
   Truck to CPY: $13.50
   Interest cost $0.50: (stored material)
   Hog + screen: $30.80 (hog to ground), $14.65 (no screening)
   Reload: $8.40
   Truck to user: $24.75
   Wood cost: $20.00
   **Total $103.85 per tonne**
   **$9.10 per GJ**

The difference between the above examples is that in the second case material was dried. The cost per tonne rises, but cost per GJ falls. The fuel is more likely to be marketable at the lower moisture content, as it will meet the needs of a wider range of users in particular smaller commercial operators.

For forest and wood processing residues to be of value to either the forest owner or wood processor, these fuels probably need to be competitive with alternative fuels for example coal or gas. Alternatively, there may be other factors that influence the economics of producing wood fuels from forest residues such as off-setting cost against waste management and landing site management costs (i.e. environmental, occupational safety and health, or operational efficiency issues). The impact of these other cost factors is highly site specific and there are a range of alternative approaches that can be taken to mitigate these alternative factors (for example, waste material can be burned on a landing site) so these addition values may not be applicable in all situations.

As a guideline to the relative cost competitiveness of wood fuels based on $/GJ and the corresponding cost of the wood fuel in $/tonne (for a given moisture content), it is useful to refer to Table 4. The costs in $/tonne of delivered fuel need to take into account all the costs incurred in securing, transporting, processing (including drying), and delivering the fuel to a user as well as other business related costs (overheads, financing costs, maintenance, down time, relocation and margins etc).

**Table 4: Value per tonne of wood fuel for varying energy values ($/GJ) and moisture content (%) (taken from EECA 2010).**

| | Energy Value ($/GJ) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Moisture Content (% w.b.) | $ 2.50 | $ 3.00 | $ 3.50 | $ 4.00 | $ 4.50 | $ 5.00 | $ 5.50 | $ 6.00 | $ 6.50 | $ 7.00 | $ 7.50 |
| 0 | 47.18 | 56.61 | 66.05 | 75.48 | 84.92 | 94.35 | 103.79 | 113.22 | 122.66 | 132.09 | 141.53 |
| 5 | 44.51 | 53.41 | 62.31 | 71.22 | 80.12 | 89.02 | 97.92 | 106.82 | 115.73 | 124.63 | 133.53 |
| 10 | 41.85 | 50.21 | 58.58 | 66.95 | 75.32 | 83.69 | 92.06 | 100.43 | 108.80 | 117.17 | 125.54 |
| 15 | 39.18 | 47.02 | 54.85 | 62.69 | 70.52 | 78.36 | 86.20 | 94.03 | 101.87 | 109.70 | 117.54 |
| 20 | 36.52 | 43.82 | 51.12 | 58.42 | 65.73 | 73.03 | 80.33 | 87.64 | 94.94 | 102.24 | 109.55 |
| 25 | 33.85 | 40.62 | 47.39 | 54.16 | 60.93 | 67.70 | 74.47 | 81.24 | 88.01 | 94.78 | 101.55 |
| 30 | 31.19 | 37.42 | 43.66 | 49.90 | 56.13 | 62.37 | 68.61 | 74.84 | 81.08 | 87.32 | 93.56 |
| 35 | 28.52 | 34.22 | 39.93 | 45.63 | 51.34 | 57.04 | 62.74 | 68.45 | 74.15 | 79.86 | 85.56 |
| 40 | 25.86 | 31.03 | 36.20 | 41.37 | 46.54 | 51.71 | 56.88 | 62.05 | 67.22 | 72.39 | 77.57 |
| 45 | 23.19 | 27.83 | 32.47 | 37.10 | 41.74 | 46.38 | 51.02 | 55.66 | 60.29 | 64.93 | 69.57 |
| 50 | 20.53 | 24.63 | 28.74 | 32.84 | 36.95 | 41.05 | 45.16 | 49.26 | 53.37 | 57.47 | 61.58 |
| 55 | 17.86 | 21.43 | 25.00 | 28.58 | 32.15 | 35.72 | 39.29 | 42.86 | 46.44 | 50.01 | 53.58 |
| 60 | 15.20 | 18.23 | 21.27 | 24.31 | 27.35 | 30.39 | 33.43 | 36.47 | 39.51 | 42.55 | 45.59 |
| 65 | 12.53 | 15.04 | 17.54 | 20.05 | 22.55 | 25.06 | 27.57 | 30.07 | 32.58 | 35.08 | 37.59 |
| 70 | 9.87 | 11.84 | 13.81 | 15.78 | 17.76 | 19.73 | 21.70 | 23.68 | 25.65 | 27.62 | 29.60 |
| 75 | 7.20 | 8.64 | 10.08 | 11.52 | 12.96 | 14.40 | 15.84 | 17.28 | 18.72 | 20.16 | 21.60 |

To decide if it is going to be economic to introduce wood fuels to a particular market, it will be important to consider what the competing fuel price is, what other economic trade-offs may exist and if it is feasible to offer fuel at an economically viable level to a user. Table 4 effectively sets the target costs/pricing on a $/tonne basis to offer fuel at a competitive rate. Where it is shown to be uneconomic, (i.e. the cost/price is greater than what the market will bear), then efficiencies in the fuel supply chain or alternative costing structures are needed to reduce costs on a $/tonne basis.

The other key thing to note from this table is the effect of moisture content and that the drier the wood fuel then the cost/price of the fuel $/tonne increases as more wood fuel needs to be handled and processed. If a user has the demand for a dry wood fuel, then the cost/price of the wood fuel will be higher compared to a user who can use fuel with higher moisture content.

The ability to supply wood fuels to the market is however, totally dependent on the market and its demand for wood fuels. Several other issues to keep in mind when considering the potential value of wood fuels are:

- Wood fuel suppliers can operate in a number of different ways and can establish their businesses using a range of business structures or delivery mechanisms and in some cases may focus on quite specific markets.
- Within the market there is an inherent trade off between capital cost for the heat plant and operating costs (i.e. there is a trade-off between the cost of fuels, its quality and the design of the boiler). Typically, a boiler that can use cheaper lower quality wood fuel will have higher capital cost due to more complex grate design, fuel in-feed systems and systems to control emissions. A boiler designed to use higher quality fuels can often be supplied at a reduced capital cost.
- Fuel quality can be highly variable and range in moisture content, ash content, particle size distribution, and chemical composition. Where wood fuels are to be traded in the market, it is advantageous to have a standard approach for describing the wood fuels and to quantify their specifications. It is important therefore that a set of either standards or guidelines exist at a national level that allow fuels to be defined in common and consistent terms and which facilitate trading. BANZ has developed the Wood Fuel Classification Guidelines.
- Guidelines and standards can be taken a step further and an accreditation scheme be introduced for wood fuel suppliers. Accredited fuel suppliers would be providing fuels consistent with the national standards and or guidelines and be recognised as an accredited supplier.

The existence of both national wood fuel characterisation guidelines and an accreditation scheme are seen as being important for developing a sustainable, long term viable wood fuels market and a number of wood fuel suppliers are pushing for the implementation of these schemes.

As indicated above, the price of wood fuels can be quite variable, depending on quality, scale of supply, transport distance, type of boiler, nature of the heat demand, and currently in New Zealand three broad wood fuel categories exist. These are:

- Niche regional markets where there are surplus wood processing residues. These can be supplied at $7/GJ or in some situations less for purpose built boilers with higher fuel tolerance (and low spec fuels). Value to resource supplier is generally an avoided waste disposal fee, or marginal value to take the problem away.
- In cities such as Christchurch and Dunedin where a medium scale wood fuels can be serviced by billet wood and other clean residues. This market may be up to15MWth of distributed smaller boilers and in this situation need to be of reasonable quality (M30 or better – as described in the BANZ Wood Fuel Classification Guidelines). In addition, these fuel supplies need to be secure and reliable and with proper

transport/supply systems for smaller loads and smaller storage areas - Prices to customers for this market may be $11 and $13/GJ for M30 standard seasoned or dry chip, loaded once or twice a week to storage. Alternative is wood pellets at >$13/GJ. Value to resource owners is matched to wood processing market so based on pulp and billet wood commodity prices ex forest or ex wharf.

- The third main type of market is a large scale supply for larger applications (>15MWth+) such as a dairy, meat, and food processing where supply contracts are larger and longer term. This would be a tailored specification and contract - so could range from $8-$9/GJ through to $10/GJ. Anything higher is probably uneconomic under most circumstances and anything lower is probably too risky for wood fuel suppliers. Price range is due to specification and the boiler selection as Industrial investors will make a cost trade-off between low specification fuels (high moisture content) fuels and capital costs of the long life boilers. The cost differences between the larger scale and city supplied fuel contracts is generally having lower transport and storage requirements for example. direct to or on the processors site, and economies of scale for handling. Value to resource owners for large scale supply is going to be either export pulp or billet wood markets with some economies of scale, value gains or an integrated harvest regime - given longer term contracting arrangements.

The markets identified above are indicative only and the combination of fuel supplier and fuel user will reach an agreed price. Such prices may well differ from those indicated above due to variable margins, differing business costs, structure of the supplier and overheads, and other issues.

So far in this report, the assumed coal price is around $ 4-5/GJ which reflects existing market rates. However, current predictions are for coal prices to continue to increase in real terms and out to 2015 the price for industrial coal supplies is likely to be around $4.06 – 6.66/GJ (Covec 2011). This increase in price is expected to occur due to higher costs of mining, the bringing in of more expensive mining operations and increasing demand for coal from off-shore customers. An increase in the price of coal both in real terms and potentially with a carbon charge would markedly favour the economics of using forest residues for energy. Such price increases will also allow greater flexibility for increasing the sale price of residues at the cut-over or landing.

Other opportunities for wood processors may arise from optimizing the use of on-site residues for revenue generation and evaluating the potential to use forest residues for wood fuels. For example, if a wood pellet manufacturer were to take dry shavings then it may be more cost effective for a wood processor to sell these and use other wood fuels for onsite heat production. Though such changes are often not easy as existing on-site equipment is only suitable for certain types of fuel and its installation pre-dates the opportunity to switch fuel. This would mean that capital investment would be required to change.

At the time of developing ether a green-fields wood processing site or upgrading an existing site, there is an opportunity to optimise capital expenditure on the type of boiler, the opportunity to sell residues and to use other lower cost fuels for heat production (for example invest in a higher specification heat plant that provides the opportunity to use a range of lower grade wood fuels and then sell higher quality materials to other users). The wood processor should regularly review their options to cost effectively utilise all of the fibre they purchase and include energy and other wood fibre uses in the mix (i.e. extend the range of fibre based products they deal in).

## Economics of pellet production

The economics of pellet manufacture have been investigated and reported by a number of authors Nelson et al, 2004; Estcourt 2009; and Horgan 2009. The analysis below is based on information presented by Horgan (2009).

Pellets are usually graded with the highest grade pellets generally being reserved for use in domestic burners which typically lack some of the sophisticated controls that larger industrial systems have. The costs of cleaning up post harvest residues and ensuring such material is free of bark, stones and dirt etc., material that will produce ash and clinker when burned, tend to preclude the use of forest harvest residue for high quality domestic pellet market. Though, this may be addressed by using more sophisticated fuel clean up processes or producing a lower quality pellet.

Pellet manufacturers prefer low cost or free dry sawdust or untreated residues from wood product manufacturing – planer shavings, dry sawmilling off-cuts etc., - as feedstock for processing, as this type of material minimises feedstock preparation costs. However, there are only relatively limited amounts of un-utilised material of this type available. An expanded pellet manufacturing industry therefore needs to be able to at least offer as much for feedstock as other wood fibre-using industries such as the pulp and paper and panels industries - if suppliers are to avoid an opportunity cost in supplying the pellet industry. Studies, both local and from overseas, indicate that the cost of pelletizing, i.e., the labour capital and consumables associated with preparing feed-stocks for pelletizing by grinding or communting it into to a suitable size range, putting this prepared material through a pellet machine and then cooling screening and storing the resulting product – will cost NZ$80 ~ $110 per tonne of product. This cost assumes a production scale of around 10,000 tonnes per year. To get the full cost of pelletizing then the costs of the feedstock and (any) drying also needs to be included.

The amount of feedstock required to manufacture a tonne of pellets (and the cost of getting this feedstock into a suitable moisture content range for pelletizing) depend on the target density for the pellet being manufactured, the basic density of the wood species being used and the moisture content of this feedstock. The total cost of producing pellets in New Zealand is typically around $200 -$240 per tonne - $11 to $14/GJ (Table 5).

**Table 5: Breakdown of pellet cost per tonne (from Horgan, 2009).**

| Item | Cost /tonne of Pellets |
|---|---|
| Wood raw material (fresh, delivered to processing plant@$47/tonne) | $94.00 |
| Drying of raw material (2.6~3.4GJ energy required) | $26.00 - $34.00 |
| Pelleting cost | $80.00 - $110.00 |
| PELLET PRODUCTION COST/Tonne | **$200.00 - $238.00** |

There is an expanding supply of material that is potentially suitable as feedstock for pellet manufacture. However, at an ex factory price of $11 to $14/GJ, the local market for energy from pellet fuel is currently limited and tends to be confined to the domestic residential sector. However, in some cases pellets may be used for commercial or industrial applications. Currently, other energy sources, such as coal, tend to be cheaper.

However, there appears to be potential for export. Internationally prices for energy are often higher than in New Zealand and pellets are already transported globally. Based on this, there is an opportunity for New Zealand to develop an international market for pellets.

Internationally prices for energy are typically higher than in New Zealand and likewise pellets are worth more than compared to domestic markets. In the United States quoted pellet prices of US$150 - $499/tonne– (see www.woodpelletprice.com) – are usual. The mid-point for this range is around US$260/tonne which in New Zealand dollar terms translates to (currently) NZ$325/tonne (at an exchange rate of NZ$1 = US$0.8). In terms of the inference drawn above over the price required for a fully viable NZ based pellet industry, provided pellets could be shipped from New Zealand to the US for less than NZ$80/tonne, then the export of pellets to the US appears to be viable.

In Europe pellet prices are even higher. In Germany loose deliveries of 5 tonnes of pellets to households within a 50km radius of a pellet plant are typically priced at around €227/tonne (around NZ$372/tonne - see www.pelletcentre.info/CMS/site.aspx?p=5351). However, to assume a New Zealand based industry could achieve that sort of price on a regular basis may be optimistic. The typical price at the ARA (Amsterdam-Rotterdam-Antwerp) port complex for delivery of a 40,000 tonne load of €180/tonne (NZ$295 @ NZ$1=€0.61 ). This would be a more realistic price on which to base any analysis of a significant NZ based pellet industry wanting to supply product to Europe over the long term.

The above analysis for wood pellets assumes a cost for the raw material for pellet manufacture as this is based on an opportunity cost for the fibre. However, this cost may be reduced were the feedstock material is treated as waste arising from the processing of solid timber. In this instance there would be a trade-off between disposal costs, using the material onsite for energy or off-setting the value of this material against other saleable solid wood products (i.e. processed boards).

Small pellet plants can be purchased for around NZ $30k but these plants can produce only around 800-1,000 kg per day or perhaps only 200 – 300 tonnes per year. Such production rates are small and it may not be cost effective to establish a distribution channel which would be competitive to other larger suppliers. This limitation could be addressed by several wood processors combining efforts to create cooperative arrangements with joint distribution and marketing of their pellets.

# 4. Current constraints affecting the uptake of bioenergy within the forestry sector

During December 2012 through to April 2013 discussions were held with a range of New Zealand forestry stakeholders to better understand issues affecting the uptake of bioenergy by the forestry sector. The main findings arising from these discussions are summarised below.

- Wood supply for small energy installations <2 MW is generally not regarded as an issue – as wood fuel can be sourced from a range of small wood fuel producers. (often small to medium sized wood processing facilities).
- Wood fuel supplies from forest residues is currently becoming less economic due to:
  - Decreasing cost of competing fuels (coal)
  - Increasing price for export logs which is encouraging the export of unprocessed logs and limiting the supply of chip and low grade logs
  - Chip users are increasingly competing for the quality end of forest residues, which in turn is forcing the wood fuel suppliers further afield and to use lower quality material
  - The benchmark price for wood fuel fibre is underpinned by the export price of logs or the current chip price
- Larger energy users are hesitant to commit to bioenergy based projects due to uncertainty regarding long term supply of substantial quantities of wood fuel and security around future costs and pricing.
- Bin and billet wood suppliers are currently seeing an improving market due to the chip users requiring a supply of fibre at as low a cost as possible – bin and billet wood is being collected to substitute for lower grade logs as these logs are being exported. These suppliers are developing new equipment (such as self tipping trucks) which will reduce the delivered cost of wood fuels.
- Although the export of chips is struggling and declining largely due to surpluses in export markets and a high exchange rate in NZ, chip suppliers are tending to reduce or close production rather than reduce the price and build market share in the wood fuels market.
- Growth in the wood pellet market has been slower than expected, so NZ is currently oversupplied with wood pellets and prices have been static or have reduced. There has been rationalisation of the production capacity of wood pellets in New Zealand over the last 12 months.

- The current price structure for the supply of wood fuels is linked to the price of wood fibre, costs of processing material (which is affected by scale), and transport.
- More efficient harvesting and the integration of forest residue collection with harvesting of merchantable logs would allow greater recovery of wood fibre from the forest which in turn can reduce the cost of wood fibre and lead to a reduction in the cost of wood fuel supplied from forest residues.
- The best new target areas for the emerging wood fuels market are in Northland, Wanganui – Manawatu areas. These areas have underutilised supplies of wood fuel and potentially untapped demand though in some of these cases cheaper alternative fuels exist.
- Smaller energy users tend to require a high quality feedstock due to the nature of their heat plant (high quality wood fuel tends to be more expensive to produce). Though for these installations the economics of using wood fuels can be competitive.

# 5. Conclusions

The forestry sector is a major activity in New Zealand with total exports being around NZ $4.7 billion a year. Plantation forests are around 1.7 million ha and the total harvest was 26 million $m^3$ to December 2011. Over the last 4 years the percentage increase in logs exported as a proportion of the total log harvest went from 34 to 47 percent or 6.6 million m3 to 12.8 million $m^3$. The forest estate has a current average age of just over 16 years which means that the forest harvest will potentially increase until around 2020-2025, but after this there will be a declining harvest rate. The availability of forest residues has the possibility of being constrained from around 2025-2030 and depending on how the residues are used.

The wood processing sector is already a major contributor to the bioenergy sector but this role has the potential to increase significantly through the use of significant wood residue streams being used for heat, biofuel production or other feedstocks for bio-based products. In addition, wood processors have an opportunity to use a range of different fuel types depending on the type of equipment on site. Wood processing residues need to seen as a valuable resource that can be managed in a range of ways to derive revenue and provide cost savings.

For the forest owner, the main value proposition is to be paid for residues left in the forest after clear fell harvesting, however this assumes that the wood fuel can be sold economically to an energy user for a competitive price. Indicative cost assessments for the combined supply of forest residues and wood processing residues to an energy plant in Canterbury indicate that wood fuel could be sold for around $12 – 15/odt and could go as high as $50/odt. These costs would be competitive with other solid fuel alternatives such as coal – however these costs do not take into account margins and other business related costs. For processing and utilizing forest residues in other situations the costs of wood fuel may go higher (up to $103.85/tonne).

Forest residues can be collected and processed into wood fuel at a cost which is potentially competitive with coal (around $4 – 5 /GJ), through these costs do not necessarily allow for payment of the residues.  If around $2-5 / green tonne is paid for forest residues this would only add about another $0.5 – 1 /GJ. At these costs, wood fuel derived from forest residues would potentially be competitive with coal. Where a wood fuel supply business is established, then a range of other costs may need to be considered and this can increase the sale price closer to $9-10/GJ.

Typically, there are three major types of market operating, niche situations where wood processing residues can be available for around $7/GJ, a market servicing smaller heat plants, though collectively may add up to around 15 MWt, here fuel will be available for around $11-$13 /GJ.  Then there is larger scale contracts for the supply of large quantities of a specific type of fuel for a meat, timber, dairy or food processing site, here fuel is typically available at $8 - $9/GJ.  Fuel quality guidelines or standards and a fuel accreditation scheme will assist to accelerate the introduction of a more robust wood fuels market.

At these costs the wood fuel is likely to be cost effective for smaller commercial heat producers where a higher quality of fuel is required and price sensitivity may not be so critical.

For the wood processor a range of options exist regarding value propositions for bioenergy, they may become wood fuel suppliers through the sale of wood processing residues or alternatively process their residue streams into value added products such as pellets.

Although a range of options exist for pellet manufacturing in terms of scale and operating structure, the wood processor is going to have to secure a sustainable market which is cost competitive to other larger suppliers to make pellet production economically viable.

At this time, the forestry and wood processing sectors are largely neutral regarding the economic opportunity for either becoming active or for investment into bioenergy projects and for becoming a player in the wood fuel supply chain – to a large extent this is currently due to high log prices being received by forest owners due to strong offshore demand, in particular from China.  In addition, the market for wood fuel is still seen as immature and limited.

The rising price of logs is having the following flow on effects:

- Forest owners are making good returns for their logs and harvesting rates are increasing to meet the rise in demand.  Forest owners and managers wish to maintain maximum harvesting rates and currently have no interest in introducing other cutover or landing processes or activities that may slow harvest production rates or add cost.  The cost of retaining forest residues on landing sites is not significantly large enough to become a driver for removing this material for environmental or safety reasons – though this could change other time.

- The high log prices are forcing the chip users (e.g. pulp mills) to look for alternative fibre sources which includes bin and billet wood at landing sites. This in turn is pushing wood fuel suppliers into more remote areas of forests for lower quality wood residues – which have higher transportation and processing costs. This is reducing the economic viability of harvesting derived residues in some areas.
- High log prices is increasing inputs costs to sawmills which currently have only limited ability to pass on such costs to wholesalers and or retailers of sawn products. This is reducing or limiting wood processing margins and this 'margin pinch' is reducing the appetite of wood processors for investment in new value added ventures. However, increasing waste disposal costs is forcing some processors to look for alternative solutions for wastes produced on-site.

Although this report considers conditions as they exist today the situation could change rapidly with changes in global financial structures, changing exchange rates, and demand for wood in the global market. These changes can influence both the supply of wood fuels and the demand side for energy as lower exchange rates may rapidly impact on the cost of imported fuels. Furthermore, competing fuel costs may rise, which would significantly improve the cost competitiveness of wood fuels.

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