**Confidential**

# Potential for the use of wood-based energy in expanded and integrated primary processing in the Gisborne region

- Report for the Forestry Ministerial Advisory Group

Peter Hall, September 2019

# Report information sheet

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| **Report title** | ***POTENTIAL FOR THE USE OF WOOD-BASED ENERGY IN EXPANDED AND INTEGRATED PRIMARY PROCESSING IN THE GISBORNE REGION*** |
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| **Client** | Forestry Ministerial Advisory Group / Te Uru Rakau |
| **Client contract number** | 19840 |
| **PAD output number** | 171795538 |
| **Signed off by** | Paul Bennett |
| **Date** | September 2019 |
| **Confidentiality requirement** | Confidential (for client use only) |
| **Intellectual property** |  |



Published by: Scion, 49 Sala Street, Private Bag 3020, Rotorua 3046, New Zealand. www.scionresearch.com

# Executive summary

The objective of this study was to identify the potential for expanded wood processing based on current wood supply, whilst taking into consideration the potential for expansion of other primary processing, such as wood, meat, fruit etc, with the symbiotic development of heat and power generation across these industries.

The Gisborne Region and Wairoa District plantation forest resources were considered together as the forests in Northern Wairoa are closer to Gisborne than Napier.

The Gisborne / Wairoa area has long term wood availability of approximately 3.1 M $m^3$ per annum.

| Grade | **2018 - 2022** | **2023 - 2027** | **2028 - 2032** | **2033 - 2037** | **2038 - 2042** | **2043 - 2047** |
|---|---|---|---|---|---|---|
| **Pruned** | 769,000 | 1,111,000 | 1,030,000 | 730,000 | 496,000 | 643,000 |
| **S** | 1,235,000 | 1,282,000 | 1,435,000 | 1,639,000 | 1,001,000 | 905,000 |
| **A** | 889,000 | 1,128,000 | 1,154,000 | 1,153,000 | 680,000 | 675,000 |
| **K** | 588,000 | 715,000 | 756,000 | 792,000 | 474,000 | 454,000 |
| **Pulp** | 725,000 | 677, 00 | 873,000 | 1,208,000 | 675,000 | 491,000 |
| **Total** | **4,208,000** | **4,915,000** | **5,251,000** | **5,524,000** | **3,328,000** | **3,170,000** |

There is variation in volume available over time and current volumes available are higher than the long run supply. This supply is made up of a wide range of log grades. Only a small proportion of the Gisborne / Wairoa wood supply is processed locally.

There is a significant opportunity for expanded wood processing to be developed and the impacts of this on GDP and employment are substantial.

However, there are limits on the power and natural gas supply into Gisborne City due to infrastructure constraints which could limit the potential expansion in wood processing.

Wood processing can be substantially self-fuelled with the use of wood processing residues such as bark, sawdust etc as an energy source. The production of electricity via combined heat and power plants is also possible. Depending on the type of wood processing, energy demands per cubic metre of product can be high. The ability to self-fuel varies widely across processes, with sawmills and secondary processing having spare residues and reconstituted panel products requiring imports of fuel to meet their heat demand

Five scenarios for expanded wood processing were considered;

1. WSI. A large cluster with near the maximum volume possible based on the long-term wood supply; 2.1 to 2.3M $m^3$; a mix of engineered products (LVL), sawmilling and reprocessed lumber (CLT etc). Near the limit of the maximum wood supply.

2. Industry Example. 1.19M $m^3$ per annum. Smaller volume than WSI with high energy demand low residue producing processes (OSB and MDF) prominent as well as sawmilling.

3. WSII. A smaller cluster with a significant amount of secondary wood processing (CLT and Remanufacture), similar to the large cluster, but without the large LVL plant, includes a large MDF plant.

4. WS III. A smaller cluster with a significant amount of secondary wood processing (CLT and Remanufacture), similar to the large cluster, but without the large LVL plant, includes a medium sized OSB plant.

5. Smaller / staged development. Starting with three OEL™ modules followed by a large sawmill aligned with secondary processing. The third stage (MDF) would depend on the ability / viability of exporting sawmill chip via road, rail or barge to other regions or to the port at Napier.

| Cluster | Total log volume in; $m^3$ p.a. | Total Capital; $M | Capital weighted RA ROCE | Total direct jobs | Total employment including indirect and induced | GDP $M p.a. |
|---|---|---|---|---|---|---|
| WSI | 2,250,000 | $949 | 25% | 1,427 | 3,540 | $1,441 |
| Industry | 1,190,000 | $478 | 17% | 671 | 1,797 | $592 |
| WSII | 1,850,000 | $829 | 26% | 1,183 | 2,886 | $1,224 |
| WSIII | 1,800,000 | $702 | 23% | 1,258 | 3,087 | $855 |
| Small / staged* | 1,450,000 | $655 | 27% | 1,085 | 2,771 | $1,120 |

In terms of the RA ROCE the smaller cluster (WSII) with an MDF mill was the best performer.

The MDF option also has the advantage of taking all the sawmill chip. OSB cannot take this material and therefore another market for the chip would need to be found.

There is potential to take a range of local organic waste streams (waste fruit and vegetables, meat works effluent, municipal bio-solids) and feed them into an anaerobic digestion system with the biogas going to a heat and power unit (ICE genset). This waste stream could make around 2MWe and 2MWth which could be used either in the meat works or the wood processing cluster.

The inclusion of secondary processors is important to the overall energy supply and demand. These operations have low energy inputs and comparatively high proportions of residuals, which mean they make a positive contribution to the energy supply / demand of the cluster.

A large-scale cluster of wood processing technologies with high energy demands per cubic metre of product is problematic as their demand for energy exceeds their supply of residues and if too many operating plants are put in one location this can also exceed the supply of locally available wood residues. This is in part why the Industry example cluster does not look as attractive as the other clusters based on our analysis.

A cluster of mills as described in the report as WSII had an attractive set of metrics. The scale of the operations, capital investment, return on investment, employment and GDP are outlined below. This cluster has the best RA ROCE and the best fit with the energy available from residues and the grid. This cluster of operations has a high demand for total labour in comparison to the local population.

| Mill Type | Log volume in ($m^3$ per annum) | Capital cost ($M) | ROCE %*** | Capital weighted ROCE % | Total Employment | GDP $M p.a. |
|---|---|---|---|---|---|---|
| Large S & A sawmill | 750,000 | 85 | 8 to 12 | - | 522 | $129 |
| Industrial sawmill | 400,000 | 54 | 16 | - | 41 | $59 |
| OEL™ (3 modules) | 300,000 | 78 | 27 | - | 216 | $127 |
| MDF | 400,000* | 220 | 32 | - | 292 | $482 |
| CLT (2 modules) | 140,000** | 162 | 31 | - | 295 | $254 |
| Remanufactured (2 modules) | 132,000** | 110 | 29 | - | 1446 | $128 |
| Glulam | 18,200** | 20 | 22 | - | 74 | $45 |
| **Total log intake** | **1,850,000** | **729** | | **27.0** | **3,540** | **1,441** |

*MDF mill also takes 340,000 $m^3$ per annum of sawmill chip
** Lumber not logs
***Current and long run log prices

Supply and demand for energy for WoodScape cluster II are outlined here. This demand can be met using the spare residues from the cluster, in-forest residues and around 6MWe from the grid.

| Mill type | Heat demand; GJ p.a. | Power demand; kWh p.a. | Residues; odt p.a. | Residues; GJ p.a. | Heat fuel deficit / surplus; GJ p.a. |
|---|---|---|---|---|---|
| Large S & A sawmill | 892,500 | 10,625,000 | 57,000 | 1,037,400 | 144,900 |
| Industrial sawmill | 441,000 | 5,250,000 | 30,400 | 553,280 | 112,280 |
| OEL™ (multiple modules) | 530,100 | 16,758,000 | 55,200 | 1,004,640 | 474,540 |
| MDF | 875,000 | 108,250,000 | 20,800 | 378,560 | -496,440 |
| CLT | 64,260 | 2,261,000 | 8,400 | 152,880 | 88,620 |
| Remanufactured | 53,460 | 4,059,000 | 13,200 | 240,240 | 186,780 |
| Glulam | 9,720 | 342,000 | 1,893 | 34,449 | 24,729 |
| **Total** | **2,866,000** | **147,545,000*** | **186,893** | **3,401,449,** | **535,409** |

* equivalent to a power plant of 17MWe

## Further work

Investigation of sawmill slabwood as an OSB feedstock would be useful as if this is possible it allows an option other than MDF to be considered at large-scale for the Gisborne region.

Investigation of the option of barging freight (containers and wood chip) from Gisborne to Napier.

There are many potential combinations of wood processing, wood residues to energy, waste to energy that could be deployed. Some of them are dependent on more information (transport options) and value of the waste to energy plant in the long term. A study that considers these in more detail may have value.

Previous work by Scion for the FMAG (Hall and Palmer, 2019) focussed on the extraction and use in-forest residues in the Gisborne Region to reduce post-harvest issues with residues being mobilised in flood events.

One option has always been to extract the broken tops that occur during tree felling to logging landings in greater volumes. This has traditionally had a cost attached to it that is a barrier.

A developing option that addresses this is may be the use of fixed head feller bunchers as opposed to dangle heads. The fixed heads can give much greater control of the stem during felling and this can lead to reduced breakage. There was a short article in the August 2019 edition of NZ logger (page 18) that quoted a presentation from a logging operator (HarvestTech 2019 conference) on the substantially increased extraction of longer unbroken stems from a fixed head machine versus a dangle head machine. The focus of the article was on the value of the greater volume of wood extracted that could be sold as posts.

However, this development would be worth a more detailed examination to determine the impact on the volume of residues left on the cutover.

# Potential for the use of wood-based energy in expanded and integrated primary processing in the Gisborne region

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# Glossary

| | |
|---|---|
| AD | Anaerobic digestion (used to extract energy from wet organic wastes) |
| CHP | Combined heat and power plant – can produce heat and electricity simultaneously |
| CLT | Cross laminated timber |
| Chip | Wood chips, can be derived from pulp logs or from the slabwood (outer wood) on a sawlog produced during primary breakdown of the log |
| Glulam | Glue laminated timber – often large dimension structural elements; beams and joists |
| GDP | Gross domestic product |
| GIS | Geographic information system |
| GJ | gigajoule (unit of energy – for context 1 green tonne of wood at 58% moisture content = ~6.9GJ) |
| FMAG | Forestry Ministerial Advisory Group |
| Fish-tails | uneven shaped pieces of veneer produced from the outer part of a log when it is rotary peeled |
| LVL | Laminated veneer lumber |
| kWh | kilowatt hour |
| M | Million |
| MC | Moisture content (the % of the weight of wood that is water, calculated on the wet weight of the wood |
| MDF | Medium density fibre board |
| MPI | Ministry of Primary Industries |
| MWW | Municipal wood waste |
| MSW | Municipal solid waste |
| MW | Mega Watt |
| MWe | Mega Watt electrical energy |
| MWth | Mega Watt thermal energy |
| NEFD | National exotic Forest Description (annual publication from MPI) |
| odt | oven dry tonne |
| OEL™ | Optimised Engineered Lumber (sawn and laminated structural wood product) |
| OSB | Oriented strand board (a panel product made form large flakes of wood) |
| p. a. | per annum |
| ICE | Internal combustion engine |
| $m^3$ | Cubic metre |
| IRR | Internal rate of return |
| ROCE | Return on capital invested (a measure of profitability) |
| RA ROCE | Risk adjusted return on capital invested (accounts for variability over time in factors such as product price, feedstock costs etc.). |
| Round-up | See fish-tails, both terms are used within the wood processing industry |
| Reman. | Remanufactured lumber (sawn lumber, kiln dried and then processed into a range of finger jointed and moulded wood products. |
| WAF | Wood Availability Forecast (published by MPI, approx. 5 to 6 years apart). |

Log grades (outline only)

| | |
|---|---|
| Pruned | large diameter logs with clear wood from pruning; p1, P2 and export P |
| S | Medium to large diameter logs with small knots (S1, 2 and 3) |
| A | Medium to large diameter log with medium sized knots |
| K | Small to medium diameter logs with large knots (K, Ki, KS and KIS) |
| Pulp | Small to large diameter logs, with large knots, and other defects (kink, wobble etc). |

# Introduction

Scion has been contracted by Te Uru Rakau on behalf of the Forestry Ministerial Advisory Group (FMAG) to analyse the potential for the use of wood-based bioenergy in expanded and integrated primary processing in the Gisborne region. Due to the nature of the territorial authorities' boundaries in relationship to the logical wood supply catchment for Gisborne, the Wairoa district will be included in the analysis (Figure 1). If a 140 km road transport distance limit is applied (approximately a 100 km straight-line) virtually all the Gisborne Region and Wairoa District fall within a viable transport distance (Appendix A).

Figure 1a – Map of Gisborne region and Wairoa district forests (red dot indicates Matawhero location)

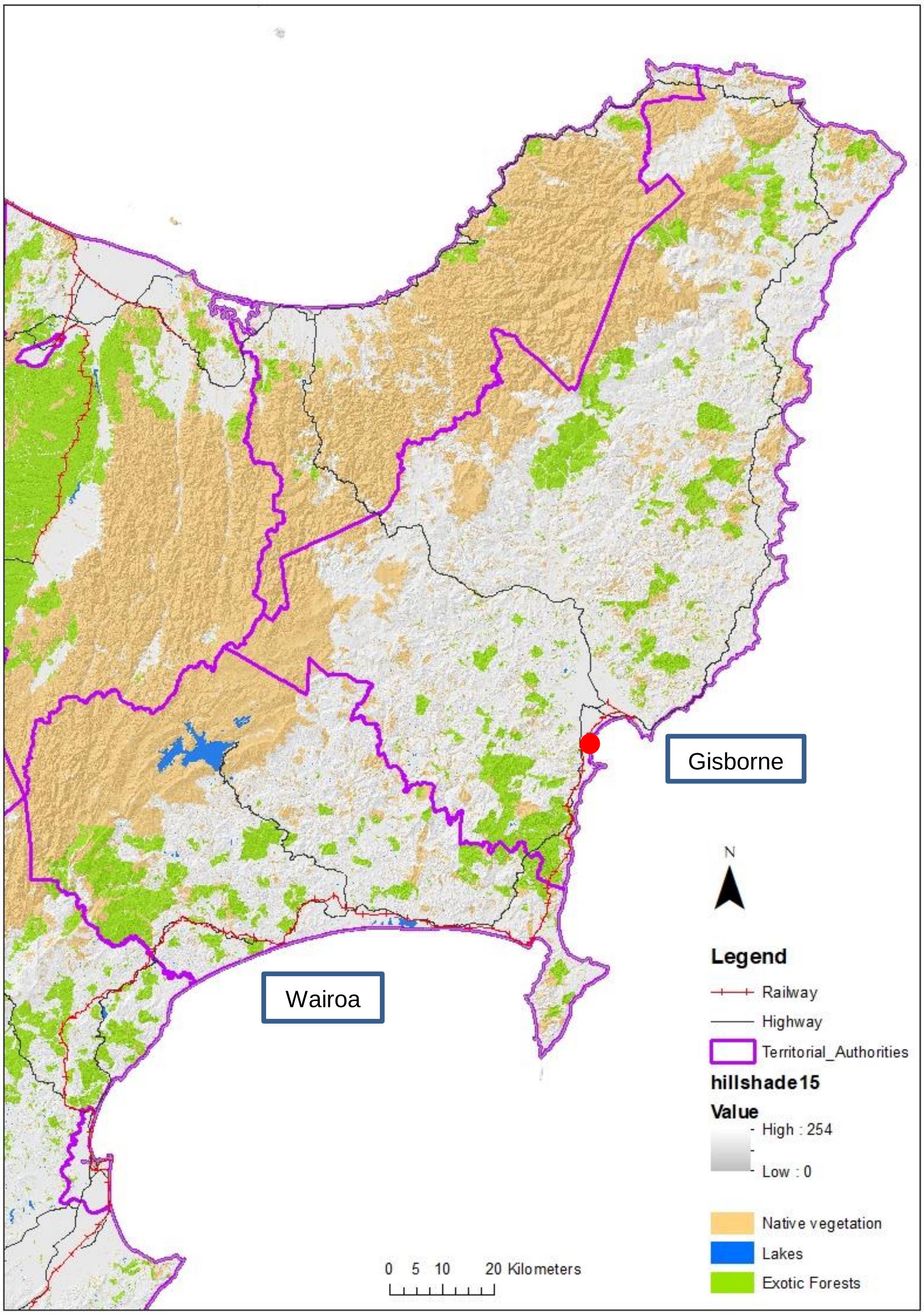


Figure 1b – current location of log yard, sawmill and meat works on industrial zoned land near Matawhero south of Gisborne city, suggested site for wood processing expansion.


This study is a follow-on to the previous Scion study for the FMAG earlier in 2019 (Hall et al) looking at processing options to increase the use of post-harvest in-forest residues on the East Coast. It is also aligned with work on use of in-forest residues for heat and power on the Gisborne Region for Eastland Community Trust (Hall and Palmer, 2019) and with the Gisborne Regional study completed for the Wood Energy Industrial Symbiosis study (Alcaraz and Hall 2018, Hall et al, 2016).

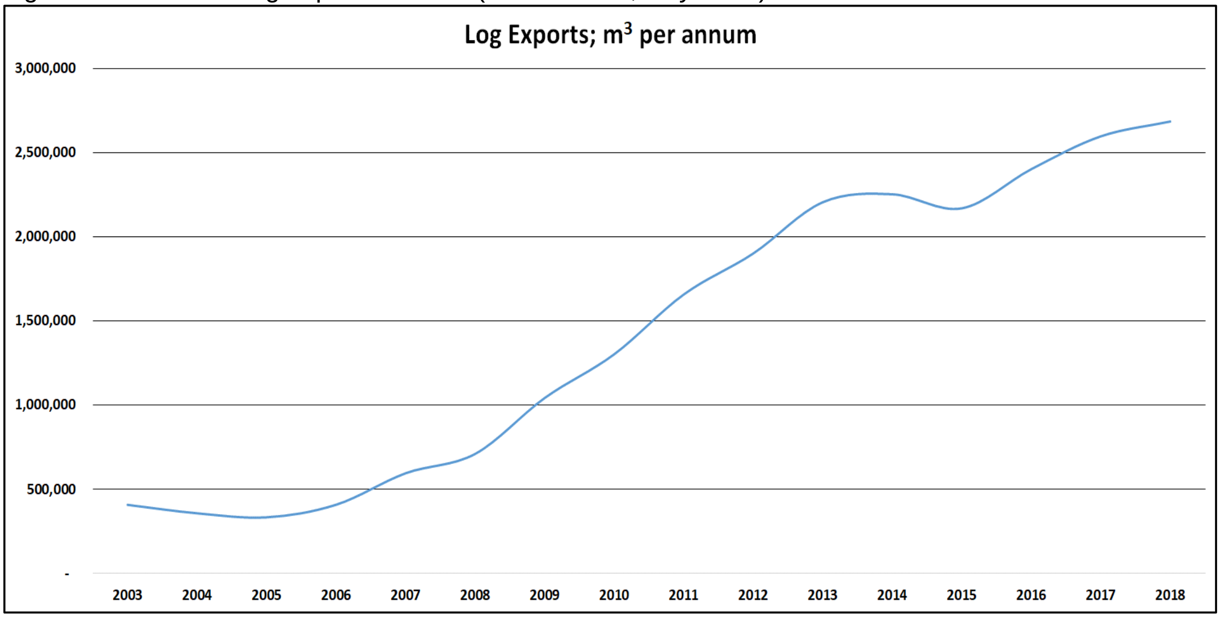
The processing location being considered is at Matawhero, a few kilometres South-west of Gisborne City where there is a developing wood processing cluster; sawmill, OEL™ plant and a central processing log yard, along with another wood processing site (Juken NZ; LVL and saw mill) four kilometres away and a meat works around 800 metres away from the sawmill noted in Figure 1b. Other primary processors and expansion of the existing sites are both possible.

Plantation forest area in the Gisborne region is 156,500 ha and the Wairoa district has a further 55,000 ha. Of this area, 97% is in Radiata pine and this report focuses on that species. Together these areas are 12% of New Zealand's total plantation estate.

The Gisborne region and Wairoa District together have a significant quantity of logs potentially available for on-shore processing as the current and long-term wood availability is substantially more than current processing demand of around 225,000 $m^3$ per annum of a mix of log grades (Appendix B).

The historic and current log export volumes from the port at Gisborne are shown in Figure 2. Current exports are ~ 2.6M $m^3$ per annum.

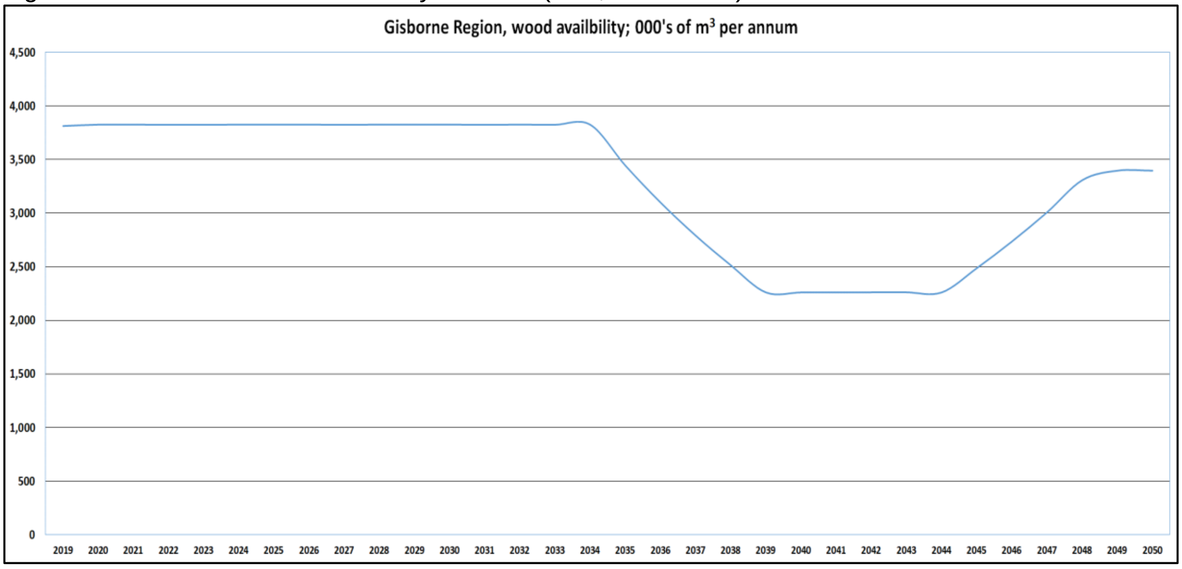
Figure 2 – Gisborne log export volumes (MPI website; July 2019)




The log exports at 2.6 M $m^3$ per annum represent a large part of the estimated Gisborne / Wairoa wood availability (Figure 3).

Wood availability varies over time and the long run availability of wood (Figure 3) dictates the scale and type of wood processing that can be developed.

Figure 3 - Gisborne wood availability forecast (MPI, scenario 3)

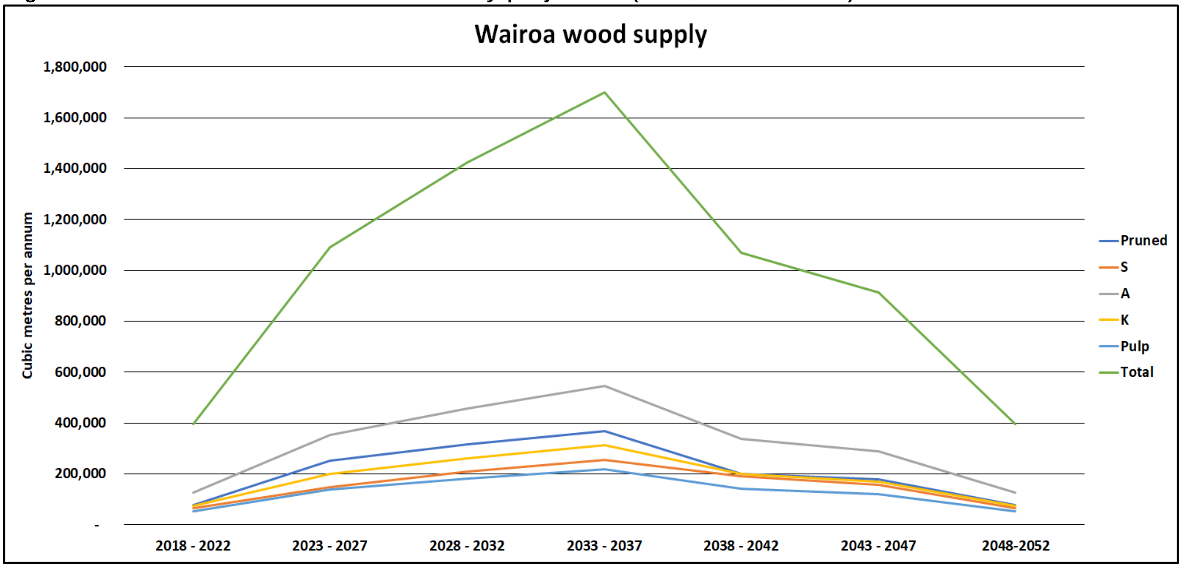



The wood supply currently going out as export logs represents a wood processing opportunity of over 2.0 million cubic metres per annum when long run wood supply is considered.

Some of the Wairoa District plantation forest resource is very close to the Gisborne region boundary and is closer to Matawhero than the next major wood processing centre at Whirinaki (just north of Napier). It is also closer to the port at Gisborne than the port at Napier (Appendix A).

The estimated wood supply from the Wairoa region is shown in Figure 4. The Wairoa wood availability is highly variable over time.

Figure 4 – Wairoa district wood availability projection (MPI, NEFD, 2018)




Log prices have a significant impact on the profitability of wood processing and in the month that this study commenced there was a significant drop in log prices (Appendix C). The duration and depth of the log price drop cannot be predicted, but the downwards movement in the price of saw logs (June / July 2019) was approximately NZ$30 per tonne delivered to wharf or mill. In many cases this is a drop of around 25%. It is worth noting that whilst the export log prices dropped noticeably in June, domestic log prices have not followed this movement, and have remained steady for now. These drops in price do not greatly affect the financial analysis results as the log prices used are long run averages.

Long run average export log prices (for the last 7.5 years) are 11% lower than they have been for the last 12 months.

This study will also take into consideration limits on energy (coal, gas and electricity) supply into the Gisborne region as well as government targets and aspirations (MBIE, 2019);

- transitioning to a low emissions economy by
    - improving energy efficiency
    - moving away from fossil fuels (particularly in process heat)
- regional growth

A critical issue when trying to align expanded primary processing and low emissions is to make sure that where possible new processing plant use low emissions fuels such as wood processing residues or post-harvest in-forest residues. Wood has the lowest GHG emissions of any other heat fuel on a unit of energy basis (Appendix D).

# Methods

## Regional wood supply

Regional wood supply (including in-forest residues) was summarised based on;
- data from the Ministry of Primary Industries wood availability forecasts (MPI, 2014),
- the 2017 National Exotic Forest Description (NEFD, MPI, 2018),
- log grades produced by regime (PradCalc_V4.0 Pro) and age and age class data by regime from the 2018 NEFD
- Scions recent report on wood energy industrial symbiosis opportunities in the Gisborne region (Hall et al 2018),
- and work conducted for the Ministry of Primary Industries on means to deal with the wood residue issues on the East Coast (Hall et al, 2019).

These data are presented to give context to the scale of the opportunity and underpins the biomass supply modelling.

## Wood processing demand

Wood processing demand was summarised from Scion’s wood processing database. This dataset was compiled for the WoodScape study (Jack et al, 2013) and has been maintained (updated and expanded) since then. It contains information (size, type and location etc.) on 228 wood processing sites across New Zealand. It is not considered to be 100% complete when considering smaller wood processors such as joinery factories and post yards etc. However, it does contain data on all the larger operations and many of the small ones.

## Log exports

Log export data was derived from the data provided on the Ministry of Primary Industries website (MPI, 2019) on quarterly forest products trade, which includes data on log exports by port.

## Biomass supply modelling - Wood supply to Matawhero

The supply of logs to the Matawhero site was estimated using the biomass supply model as outlined above and cross-checked against the regional wood supply data from MPI.

## In-forest residues supply to Matawhero

The supply volume and costs of post-harvest in-forest residues was derived from the biomass supply model data using up-to-date transport and handling costs.

## New wood processing opportunities

The WoodScape model was used to determine potentially profitable wood processing opportunities for mills based at Matawhero, operating on the scale and type of log supply identified as being available in the Gisborne region and Wairoa district.

The WoodScape model (Figure 5) was developed as part of the WoodScape study conducted by Scion for Woodco (Jack et al, 2013). The model is a tool for comparing the potential financial performance of wood processing options off a common basis. It currently includes 146 wood processing options (68 different technologies, some with scale variations of the same base technology). It covers a wide range of wood processing, from pulp mills (Kraft and thermo-mechanical) to sawmills (with a wide range of types and sizes), secondary solid wood processing (CLT and remanufacturing) engineered wood products (Plywood, LVL, OEL™ etc.) reconstituted panel products (MDF, particle board, OSB etc.) and a number of bioenergy products including, wood pellets, bark briquettes, combined heat and power plants and liquid fuels from woody biomass.

The model compares the different processes where all the key inputs (labour rates, interest rates, exchange rates, labour costs, energy prices etc.) are the same across all processing options. There are several financial metrics calculated, including; return on capital employed (ROCE), risk adjusted ROCE (RA ROCE), and internal rate of return (IRR). The initial comparison is with RA ROCE, expressed as a percentage, which is a measure of profitability. For context, the higher the RA ROCE number the better – for a new plant a RA ROCE of 10% for an established technology and 20% for a new technology would attract investor interest.

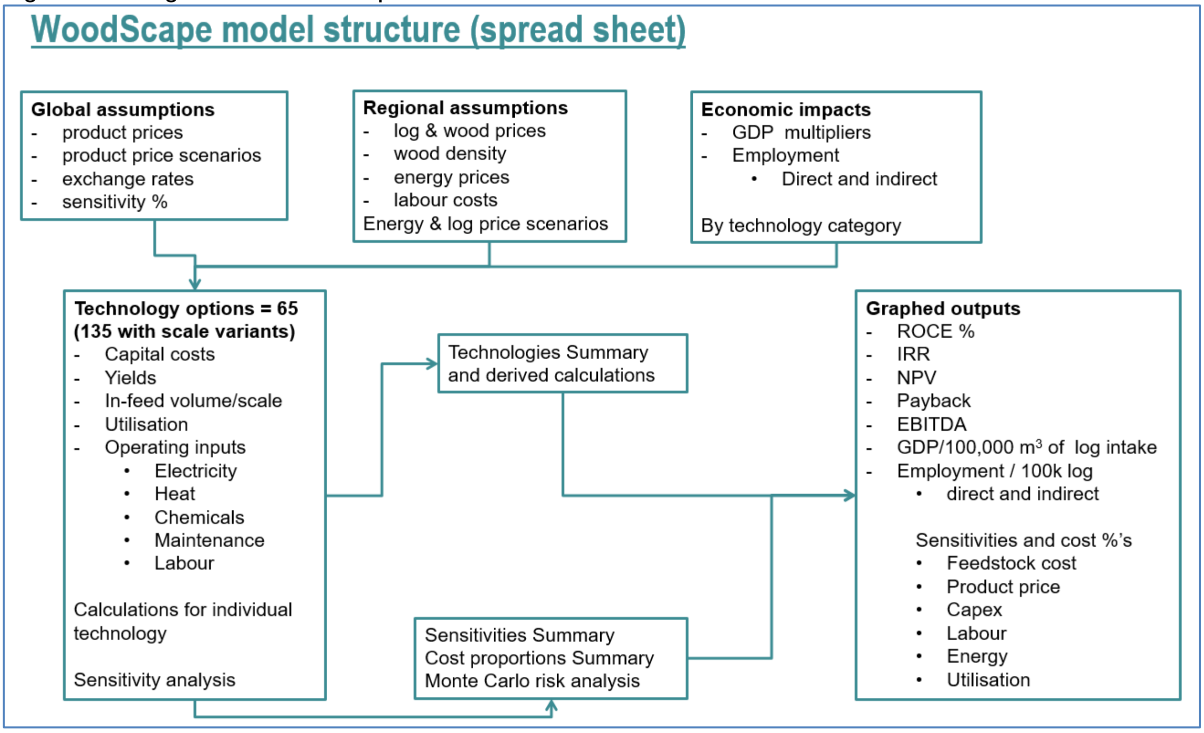
Key drivers of the financial returns of wood processing plants are feedstock cost and yield of product along with capital cost and the product sale price, which can be affected by exchange rate as export markets are assumed for many of the wood products (but not for heat and power).

The RA ROCE values are not the last point in the financial analysis, but the first. ROCE is a means of identifying opportunities that are worth more detailed analysis. The sensitivity of the ROCE of the different processing options to variations in feedstock and product prices are calculated.

The model does not optimise or deal with wood resource calculations and requires that the user filter out inappropriate options, based on their knowledge of the type and scale of wood resource available. Market knowledge (size, location, product type and price) is also important.

Key financial parameters in the model;
Discount rate; 8%
Plant life; 20 years
Forex rate; NZ$1 = US$0.69
Interest rate; 11%
Log prices = 7-year averages + sensitivity based on 2019 log prices

Figure 5 – diagram of WoodScape model structure



## Mill energy demand

The energy demands (heat and power) of mills of various types and scales were estimated based on industry data used in the WoodScape model which contains data on the consumption of heat and electricity for a wide range of wood processing operations (Appendix E). The figures for consumption of heat are for the fuel consumption, not the boiler output.

## New non-wood primary processing (meat, fruit etc) and its energy demand.

Scion was advised that there was potential for expansion or development of other primary processing (non-wood) at Matawhero. Consultation with Eastland Group, Gisborne District Council and others was conducted to determine the scale of these operations, their heat and power demands and their ability to align with the wood processing expansion.

## Power and gas supply

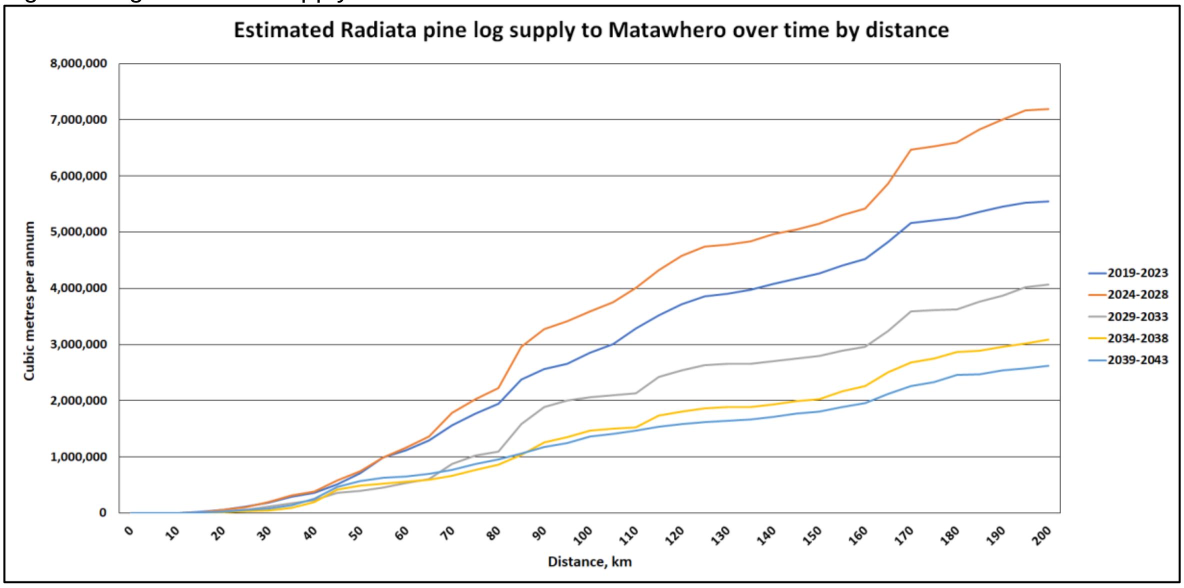
Eastland Group and the gas distribution company were consulted regarding the ability of expanding the lines and pipeline infrastructure to meet the expanded demand for heat and power at Matawhero.

# Results

## Wood supply

The gross supply of Radiata pine to Matawhero Is shown in Figure 6. This data has had no smoothing applied to it so the variation over time (the different lines on the graph) is substantial

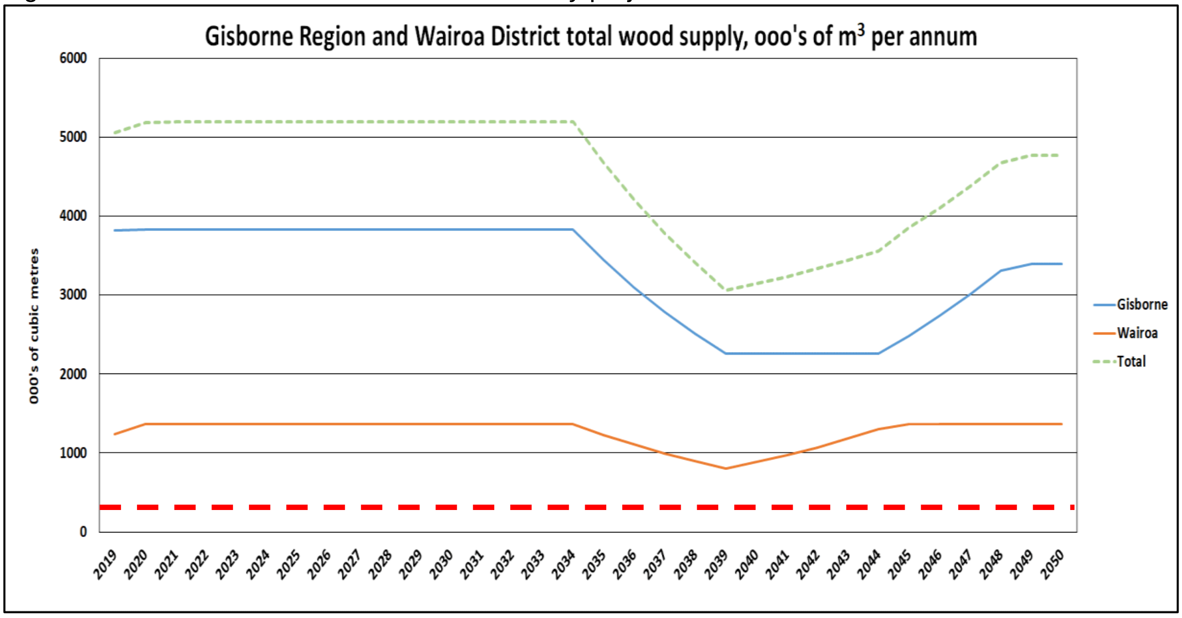
Figure 6 – gross wood supply to Matawhero from Gisborne and Wairoa districts.




The combined wood supply from the Gisborne region and Wairoa district, projected forward to 2050 is shown in Figure 7. This data has had the smoothing of supply (MPI wood availability forecast scenario 3).

Initially, the wood available in Gisborne / Wairoa is around 5.0M m³ per annum. However, this drops to around 3.3 M m³ per annum between 2035 to 2040, after which it increases again. The data in Figure 7 is a combination of MPI wood availability forecast for Gisborne and NEFD 2018 for Wairoa, with averaging across 3 lustrums of the NEFD data for Gisborne. The data in Table 4 gives slightly different total volumes, as the data is all derived from the 2018 NEFD and the same simple averaging to get some smoothing. The NEFD data had to be used in Table 5 to derive sawlog grade splits.

Figure 7 – Gisborne and Wairoa wood availability projection




*dotted red line represents 2019 wood processing demand in Gisborne and Wairoa (225,000 m³ per annum)

## Wood processing demand

Clearly there is a significant wood processing opportunity as there is only a small amount of the total wood available in the Gisborne / Wairoa area that gets processed there (Table 1, Appendix B). There are only around 40,000 m³ per annum of saw logs processed in the Wairoa region. The Wairoa district produces in the order of 900,000 m³ per annum in the long term, of which over 700,000 is sawlogs and the rest pulp grade.

In the Gisborne region there is in the order of 1.8M m³ per annum of sawlogs over the existing demand in the long term, including allowing for the dip in supply from 2033 to 2047. The excess wood supply is higher than this now, but when considering wood processing expansion, the wood supply over 20 to 30 years needs to be considered.

Table 1 – log volume by grade (approximate) processed in the Gisborne region.

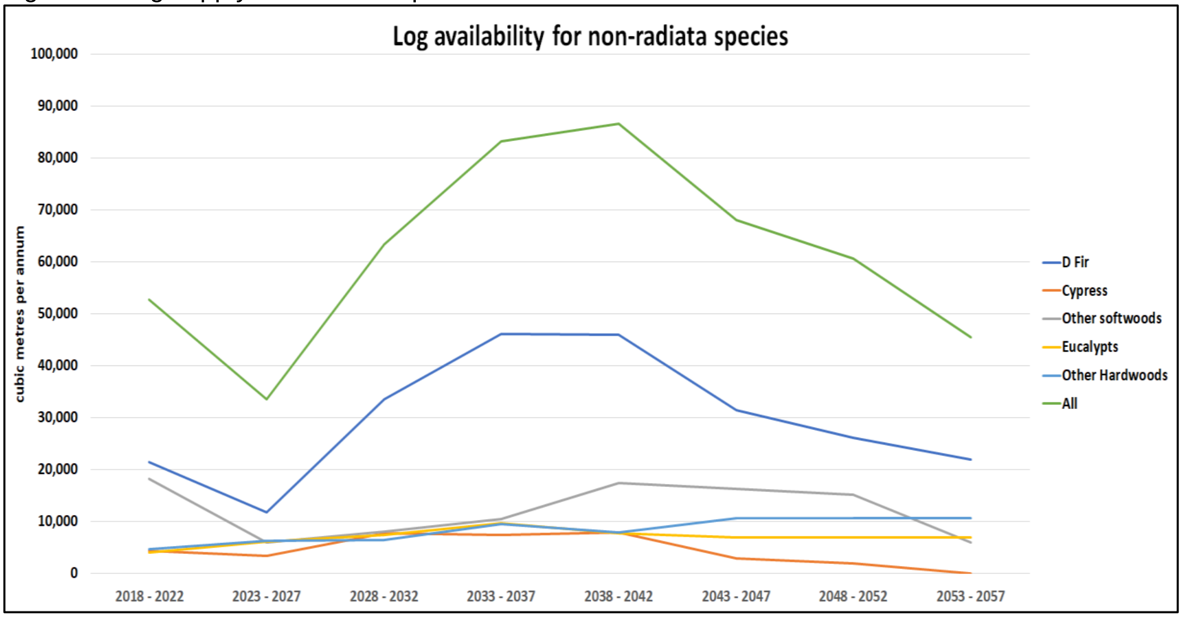
| **Log Grade** | **m³ per annum** |
|---|---|
| Pruned | 65,000 |
| S | 95,000 |
| A | 35,000 |
| K | 25,000 |
| Posts etc | 5,000 |
| Pulp | - |
| **Total** | **225,000** |

## Other species

Whilst this report focusses on processing of the *Pinus radiata* resource it should be acknowledged that there is a small volume of non-radiata species available (Figure 8). However, this resource is variable over time and the mix of species changes. This material is best suited to a small sawmill with secondary processing into higher value products.

These species include Douglas-fir, Cypresses, Eucalypts and other hardwood and softwood species. The log supply volumes were estimated from the MPI national exotic forest description (2018) which provides area and age class for plantings of these species. If it was determined that these species could be used profitably in wood processing, then further plantings would help with stabilising the wood supply. The total long run supply of non-radiata species is in the order of 40,000 $m^3$ per annum. This volume could potentially be processed by a sawmill that is also taking radiata. It seems unlikely that these species will be a major part of the wood processing sector in Gisborne over the next 30 years.

Figure 8 – log supply non-radiata species in Gisborne and Wairoa




However, other studies have not shown Douglas-fir, Cypress or other hardwoods to be either suitable for growing in the Gisborne region, or particularly profitable for anything other than very small-scale processing. Some Eucalypt species have potential but require slow and careful drying to avoid degrade of the sawn lumber.

## Afforestation to support long term wood processing

Without stable long-term wood supply, investment in primary solid wood processing (PSWP) and associated downstream (secondary) processing will be less likely to occur. Given the reduction in supply in Gisborne (around 2035), the ability to have a greater amount of wood processing established in Gisborne is in part limited by the long run maximum supply.

When looking at options as to what forest growing regime to use to fill in the gap in wood supply, one of the important drivers is when the wood is required to make up for the decline in supply from existing plantings. At a national level this is around 2035 (17 years from now). Traditionally a radiata sawlog regime is around 28 years, this would not see expanded wood supply available until 2046, around 10 to 12 years too late to smooth out wood supply and support new processing. However, there are plenty of examples of harvests of radiata pine at much earlier ages, with export log markets having taken logs from stems as young as 20 to 22 years.

A regime that provides wood in 16 to 17 years, would be considered non-traditional, but has been described by West (2018a and 2018b). This would give expanded supply in the period where there is a drop off in supply. Potentially, this regime (Ultra) can supply a range of log grades, including S grade, with the bulk of the harvest being sawlog grades with ,10% pulp (assuming the KIS grade market is present). This regime would also be flexible. It has a low initial stocking (500 stems per ha) and this means it could be grown on to a much older harvest age (25) without significant risks and issues.
The yields of logs by grade for the Ultra regime are shown in Table 2. Note – there are no pruned logs in this regime – the rotation age is too short to consider pruning.

Table 2 – Log grades and volumes produced by Ultra regime.

| **Region** | **Total merchantable volume $m^3$ per ha** | **S grade volume $m^3$ per ha** | **A grade volume $m^3$ per ha** | **K grade volume $m^3$ per ha** | **Chip grade volume $m^3$ per ha** |
|---|---|---|---|---|---|
| East Coast | 688 | 436 | 62 | 149 | 41 |
| Wairoa | 502 | 324 | 10 | 136 | 32 |

The area of planting required (and when it is required) to stabilise the Gisborne region wood supply at 3.5M $m^3$ per annum is shown in Table 3. Table 4 shows the planting required to stabilise the Radiata pine wood supply in the Wairoa district at around 1.0M $m^3$ per annum.

Table 3 – area of planting required to stabilise Radiata pine log supply in Gisborne

| **Year** | **Area, ha** |
|---|---|
| 2019 | 1,033 |
| 2020 | 1,438 |
| 2021 | 1,805 |
| 2022 | 1,805 |
| 2023 | 1,805 |
| 2024 | 1,804 |
| 2025 | 1,804 |
| 2026 | 1,805 |
| 2027 | 1,475 |
| 2028 | 1,113 |
| 2029 | 717 |
| 2030 | 281 |
| 2031 | 151 |
| **Total** | **17,306** |

Table 4 – planting required to stabilise Wairoa district wood supply

| **Year** | **Area, ha** |
|---|---|
| 2020 | 770 |
| 2021 | 770 |
| 2022 | 770 |
| 2023 | 770 |
| 2024 | 770 |
| **Total** | **3,850** |

This potential for expansion in wood supply is not considered in the wood processing analysis as the resource does not exist.

In both Gisborne and Wairoa, the planting schedule could be front loaded to give more flexibility in harvesting age.

## Other species

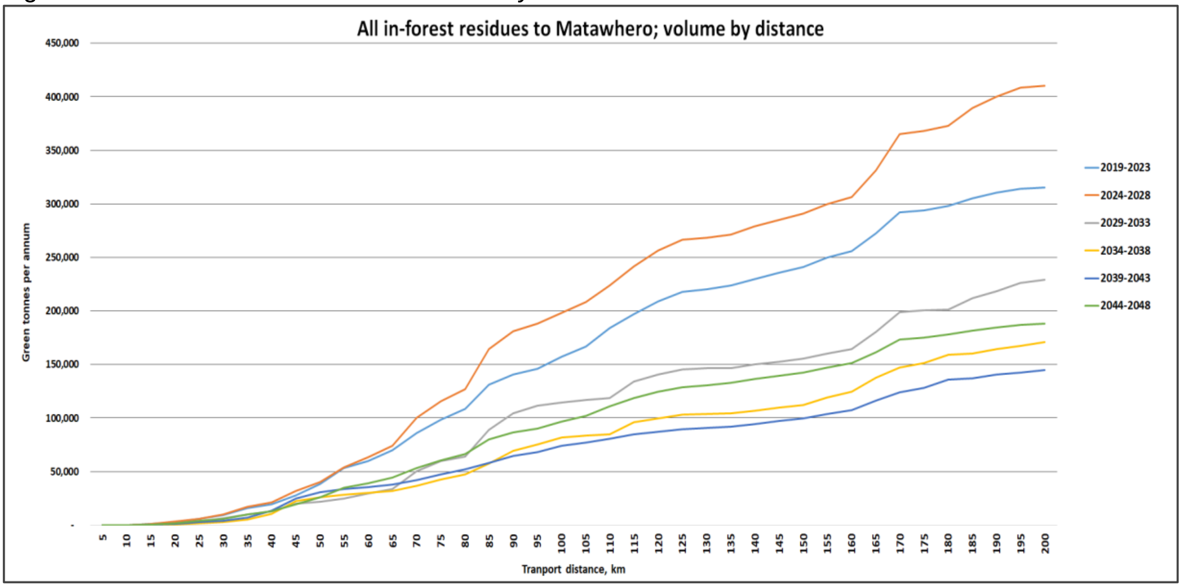
To alleviate variation in the supply of other (non-radiata) species there would need to be plantings of around 100 ha per annum, for 25 years.

## Wood residue supply

**Note** – for all the costs in this section it should be noted that the costs are estimates based of productivity in published studies and New Zealand based costing of machines and systems. There are few of these systems operating in New Zealand and benchmark prices are hard to obtain. There may be a difference between the cost of a system and the price that a contractor wishes to be paid. Actual costs of delivered fuel may vary by +/-10 to 15% with more upside risk.

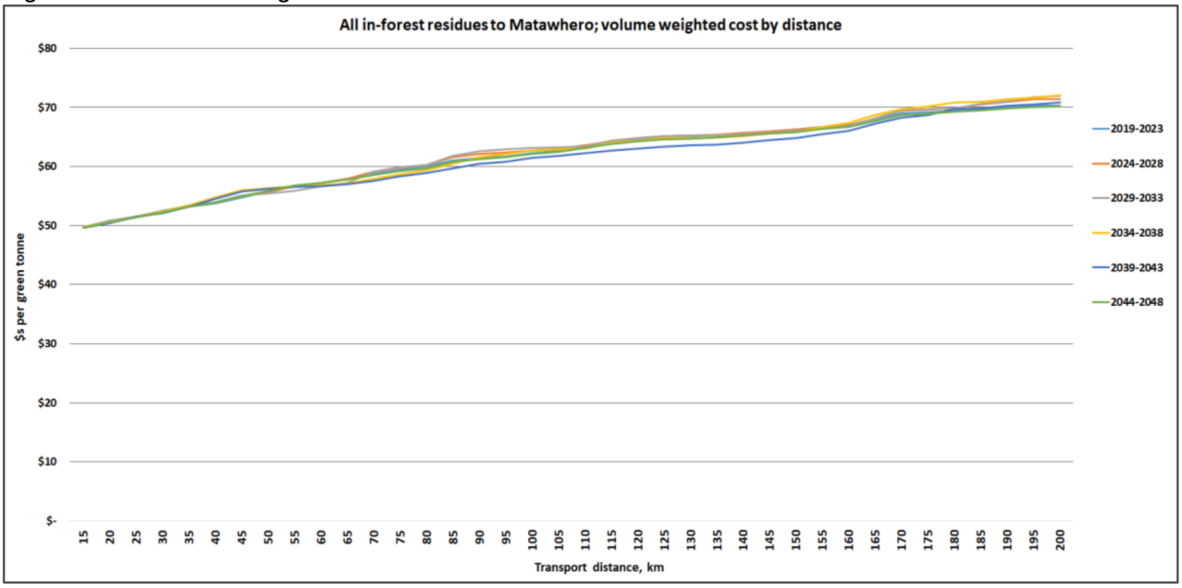
Volumes of post-harvest residues by distance from Matawhero are shown in Figure 9. At a transport distance of 85 km, there is consistently around 50,000 to 100,000 green tonnes per annum likely to be available.

Figure 9 – Volume of all in-forest residues by distance to Matawhero




For these residues the cost by transport distance is shown in Figure 10. For a transport distance of 85 km, the delivered cost is around $60 per tonne. As the size of the demand rises, the average delivered cost rises.

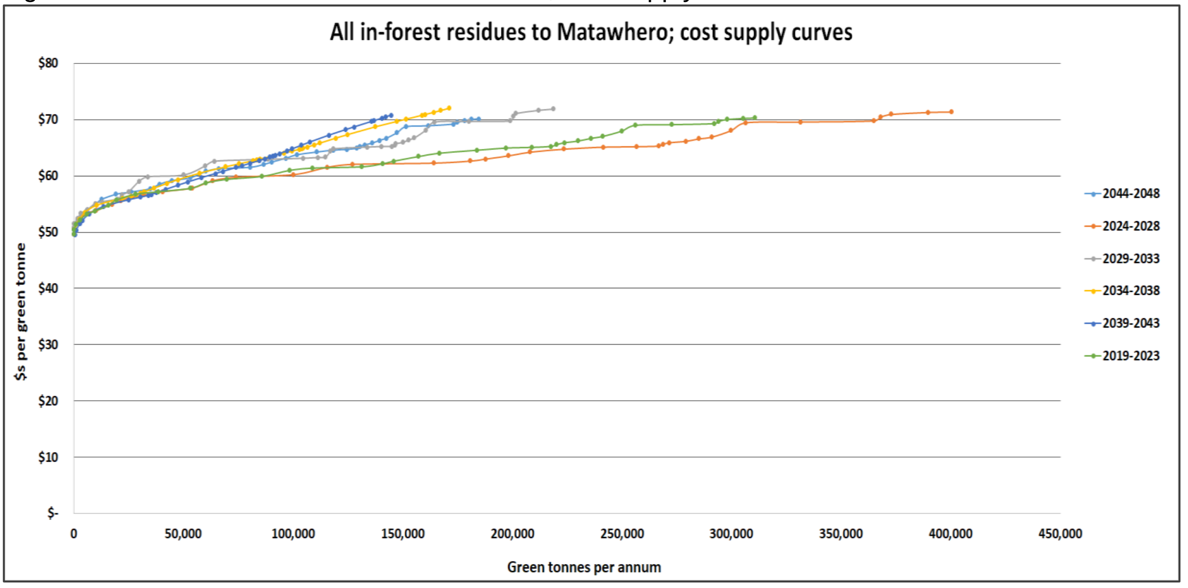
Figure 10 – volume weighted cost of residues delivered to Matawhero



The data on volume and costs by distance can be combined to develop cost supply curves for each of the time periods assessed. The costs supply curves for in-forest residues delivered to Matawhero are shown in Figure 11.

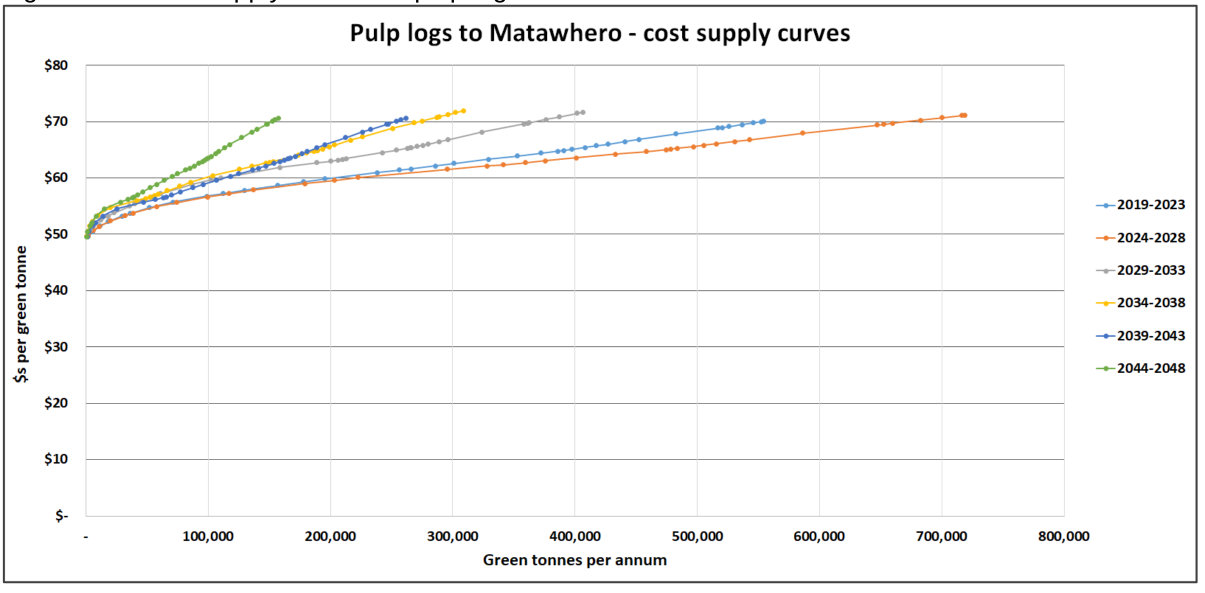
The data in Figure 11 shows that for a demand of 50,000 green tonnes per annum the delivered cost will vary over time between $58 and $60 per green tonne. For a larger demand, say 100,000 green tonnes per annum, the costs rise and the variation over time is greater; between $62 and $70 per green tonne with the highest cost around 2034 to 2038. The higher cost for a set volume in certain time periods is due to changes in total forest harvest available in that period. This is due to the age class distribution of the forests, which means that to meet a specific demand the working circle and transport distance must increase or decrease. Generally, the age class distribution is uneven, with a peak in supply around 2024 to 2028.

Figure 11 - All in-forest residues to Matawhero; cost supply curves




For pulp logs the cost supply curve for material delivered to Matawhero is presented in Figure 12. This data suggests that a volume of 100,000 tonnes could be available for a cost of $58 to $62 per green tonne.

Figure 12 – Cost supply curves for pulp logs delivered to Matawhero




The principal barriers to use of in-forest harvest residues are the delivered cost of the material and concern from potential users over its consistent availability.

## WoodScape analysis of wood processing options

### *Log supply by grade*

For the WoodScape modelling to make practical sense the long run available wood supply by log grade needs to be considered and is summarised in Table 5. The long run total log availability is ~3.0 M $m^3$ and current processing demand is 0.225M $m^3$ p. a, mostly pruned S grade and A grade. Of the existing processing, 40,000 $m^3$ (pruned and S grade) is in Wairoa, which is in the Hawkes Bay region / MPI Wood supply region. Therefore, the maximum primary solid wood processing opportunity is 2.775 M $m^3$ per annum.

Table 5 – long run supply of logs in Gisborne and Wairoa by grade

| Grade | **2018 - 2022** | **2023 - 2027** | **2028 - 2032** | **2033 - 2037** | **2038 - 2042** | **2043 - 2047** |
|---|---|---|---|---|---|---|
| **Pruned** | 769,000 | 1,111,000 | 1,030,000 | 730,000 | 496,000 | 643,000 |
| **S** | 1,235,000 | 1,282,000 | 1,435,000 | 1,639,000 | 1,001,000 | 905,000 |
| **A** | 889,000 | 1,128,000 | 1,154,000 | 1,153,000 | 680,000 | 675,000 |
| **K** | 588,000 | 715,000 | 756,000 | 792,000 | 474,000 | 454,000 |
| **Pulp** | 725,000 | 677, 00 | 873,000 | 1,208,000 | 675,000 | 491,000 |
| **Total** | **4,208,000** | **4,915,000** | **5,251,000** | **5,524,000** | **3,328,000** | **3,170,000** |

*derived from 2018 NEFD data and PradCalc4.0

When the current demands by grade (Appendix C) are accounted for the volume of logs by grade available in the long run can be estimated. There are significant processing opportunities in all log grades.  Increased capacity to process the following grades would be viable in the region:

Pruned; 350,000 $m^3$ p.a.
S; 750,000 $m^3$ p.a.
A; 600,000 $m^3$ p.a.
K; 400,000 $m^3$ p.a.
Pulp; 450,000 $m^3$ p.a.
Bark; 75,000 green tonnes p.a.
In-forest residues; 100,000 $m^3$ p.a. (~$66 per green tonne)

**Note** – *these volumes are the gross supply and are indicative of the supply. There will be competition for these logs from exporters and processors in adjacent regions. Not all of it will necessarily be available to local processors.*

Residues (wood processing and post-harvest in-forest) need to be considered both as a fuel and as a potential feedstock.

There has been a change in the ownership structure of the log harvest in the Gisborne region in the last 5 years (Appendix G; MPI 2015) with more of the cut coming from small owners. The cut from large owners is estimated to remain relatively consistent at just below 2.0M $m^3$ per annum out to 2050. The cut from small owners was predicted to rise markedly in the last 5 years and was estimated stay at around 1.8M m3 out to around 2035, at which point the supply from small owners is expected to decline.

It is assumed that the large primary mills have long term wood supply agreements in place with major forest growers. Without these finance for the mill development would be difficult to obtain.

## *Wood processing opportunities*

### WoodScape

The WoodScape analysis, when Monte-Carlo risk adjustment was used, identified 22 wood processing options that had a risk adjusted return on capital employed (RA ROCE) over 10% (Figure 13). For a new plant to be an attractive investment the RA ROCE would preferably be over 20%. There are 14 options that fall into this category. In both groupings there are a mix of primary (sawmill, MDF mill) and secondary (CLT, remanufacturing) processors

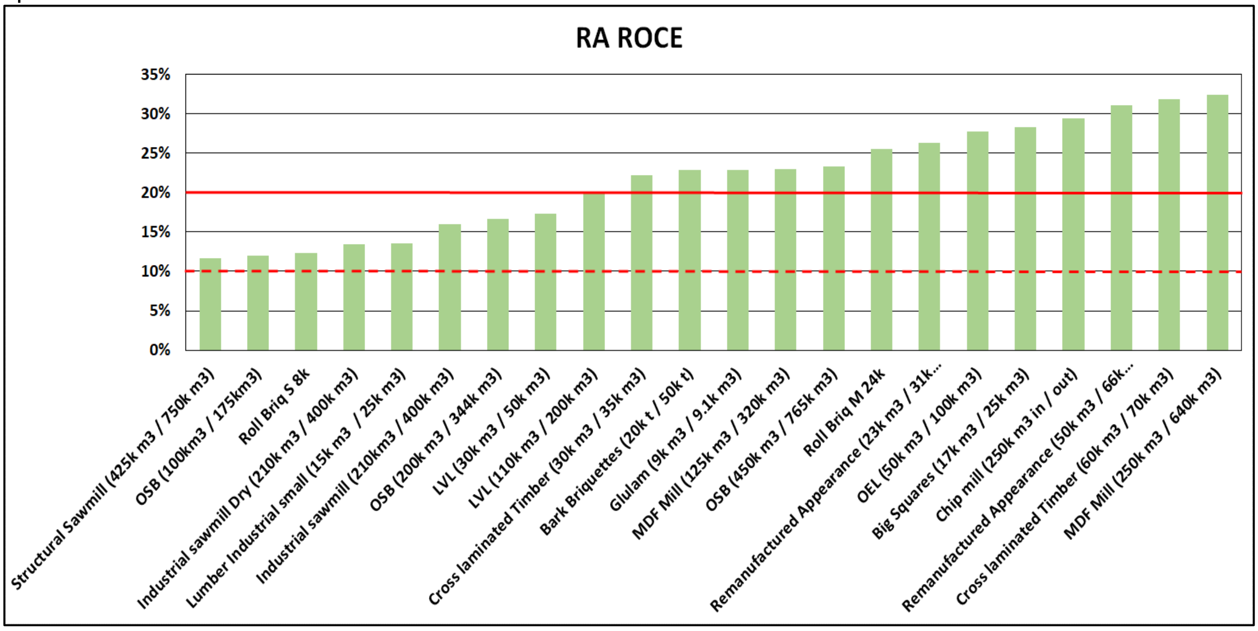
There is also a need to consider the interactions between mills. For a sawmill to be viable it needs an outlet for its chip. The slab wood chip can be 25 to 30% of its output by volume and without a market for this material the mill will not be financially viable.

Further, plants such as MDF mills, particle board plants and pulp mills are typically more viable at larger sizes and they can take sawmill chip as well as logs. Therefore, where possible co-locating a chip user with a sawmill will enhance both operations.

The pulp log supply on the East Coast is insufficient to support a pulp mill of economically viable size and MDF has an attractive ROCE at a size where it can be viable using the pulp logs and the chip residues from large scale sawmilling. This balancing of what mills are viable and what is required to make a viable cluster is assessed external to the model.

For the value add operations such as CLT and remanufacturing to possible there needs to be a sawmill to create the lumber that is their feedstock. They are also low in energy demand and comparatively high in production of residues such as shavings. There needs to be an outlet for these to avoid dumping costs, and comparatively high energy input mills such as LVL, MDF and particle board need and can take these materials as heat fuels. In the case of particle board, some of it could be feedstock as well as fuel.

Figure 13 – Risk adjusted return on capital employed (RA ROCE) for selected wood processing operations[1]




[1] The risk adjusted ROCEs presented in this analysis are intended to be used as a comparison across a range of wood processing opportunities within the study. They are not intended to be used for making investment decisions. The future earnings of the processing options identified will be affected by variation in key inputs such as log price and product price. Earnings over the lifetime of the plant will vary and the data here is indicative, not absolute. For investments, further more detailed analysis of some the options identified will be required.

Based on the wood resources available and the RA ROCE's in Figure 13 potentially profitable wood processing options were identified (Tables 6 and 7). Table 6 covers primary solid wood processing. Table 7 covers secondary wood processing where material e.g. (lumber) from the primary processors such as sawmills are further processed into higher value products (e.g. CLT).

The RA ROCE considers the variation in log prices, exchange rate (and therefore product prices). The assumption is that all the product made will be exported.

Table 6 – financial metrics for the selected primary processing options

| **Mill Type** | **In-feed** | **Scale; log in $m^3$ per annum** | **Scale; product out $m^3$ per annum** | **RA ROCE % Long run**** | **RA ROCE % 2019 ***** | **IRR %** | **Area, Ha** |
|---|---|---|---|---|---|---|---|
| LVL | Pruned logs | 400,000 | 220,000 | 20 | 19 | 11.1 | 12 |
| Large Structural & Appearance sawmill | S grade logs | 750,000 | 425,000 | 12 | 8 | 5.3 | 22 |
| Industrial sawmill | A grade logs | 400,000 | 210,000 | 16 | 13 | 6.7 | 8 |
| OEL™ (multiple modules) | K grade logs | 300,000 | 171,000 | 27 | 25 | 15.3 | 8 |
| MDF | Pulp logs and saw mill chip | 400,000* | 250,000 | 32 | 31 | 17.6 | 26 |
| **Total** | | **2,250,000** | **1,276,000** | | | | **76** |

*this mill also takes 340,000 $m^3$ of log equivalent in the form of sawmill chip
** 7-year average log prices
*** 2019 log prices

Table 7 - financial metrics for the selected secondary processing options

| **Mill Type** | **In-feed** | **Scale; log in $m^3$ per annum** | **Scale; product out $m^3$ per annum** | **RA ROCE %** | **IRR %** | **Area, ha** |
|---|---|---|---|---|---|---|
| CLT | Lumber | 140,000 | 119,000 | 31 | 17.3 | 4 |
| Remanufactured | Lumber | 132,000 | 99,000 | 29 | 17.0 | 4 |
| Glulam | Lumber | 18,200 | 18,000 | 22 | 12.7 | 1 |
| **Total** | | **290,200** | **236,000** | | | **9** |

Given the resources available in the various log grades there is an opportunity to have a cluster of wood processing operations. The various operations have different heat and electrical energy demands (some have excess residues, and some do not) and some (sawmilling) enable secondary processing (CLT etc.). Based on the RA ROCEs several possible cluster scenarios were developed.

Five scenarios for expanded wood processing were considered;

1. WSI. A large cluster with near the maximum volume possible based on the long-term wood supply; 2.1 to 2.3M $m^3$; a mix of engineered products (LVL), sawmilling and reprocessed lumber (CLT etc). Near the limit of the maximum wood supply (Table 8).

2. Industry Example. 1.19M $m^3$ per annum. Smaller volume than WSI with high energy demand low residue producing processes (OSB and MDF) prominent as well as sawmilling.

These first two clusters proved to problematic based on size (WSI) and energy intensity (Industry) so the following two clusters were developed and assessed.

3. WSII. A smaller cluster with a significant amount of secondary wood processing (CLT and Remanufacture), like the large cluster, but without the large LVL plant, includes a large MDF plant.

4. WS III. A smaller cluster with a significant amount of secondary wood processing (CLT and Remanufacture), like the large cluster, but without the large LVL plant, includes a medium sized OSB plant.

5. Smaller / staged development. Starting with three OEL™ modules followed by a large sawmill aligned with secondary processing. The third stage (MDF) would depend on the ability / viability of exporting sawmill chip via road, rail or barge to other regions or to the port at Napier.

Table 8 – capital weighted RA ROCE of the WSI cluster

| Mill | Log in; $m^3$ per annum | Capex; $M | RA ROCE % Long run log price | RA ROCE current log price |
|---|---|---|---|---|
| LVL Large | 400,000 | 120 | 20 | 19 |
| Large structural and Appearance sawmill | 750,000 | 85 | 12 | 8 |
| Industrial sawmill | 400,000 | 54 | 16 | 13 |
| OEL™ (multiple modules) | 300,000 | 78 | 27 | 25 |
| MDF | 400,000* | 220 | 32 | 31 |
| CLT | 140,000** | 162 | 31 | 31 |
| Remanufactured | 132,000** | 110 | 29 | 29 |
| Glulam | 18,200** | 20 | 22 | 22 |
| ***Capital weighted RA ROCE*** | | | ***25*** | ***23*** |

*does not include 340,000 $m^3$ of log equivalent as sawmill chip
**as lumber

There is potential for further expansion of secondary processing such as CLT and Remanufacturing based on the volume produced by the sawmills, but we did not wish to be excessively optimistic given;

- that CLT is still an emerging product

- the secondary processes are labour intensive, and the number of new employees required would already be substantial (Table 9). The direct employment of skilled labour is estimated to be 1427 people. The flow on effect into indirect and induced employment suggests a further 2240 jobs and a total impact on employment of 3540. Given that the total population of the Gisborne region is 43,656 (StatsNZ) and Gisborne city is estimated at 37,800 in 2018

Expansion of the secondary processing would improve the capital weighted RA ROCE. It would also generate more residues to feed back into the energy system for the whole cluster.

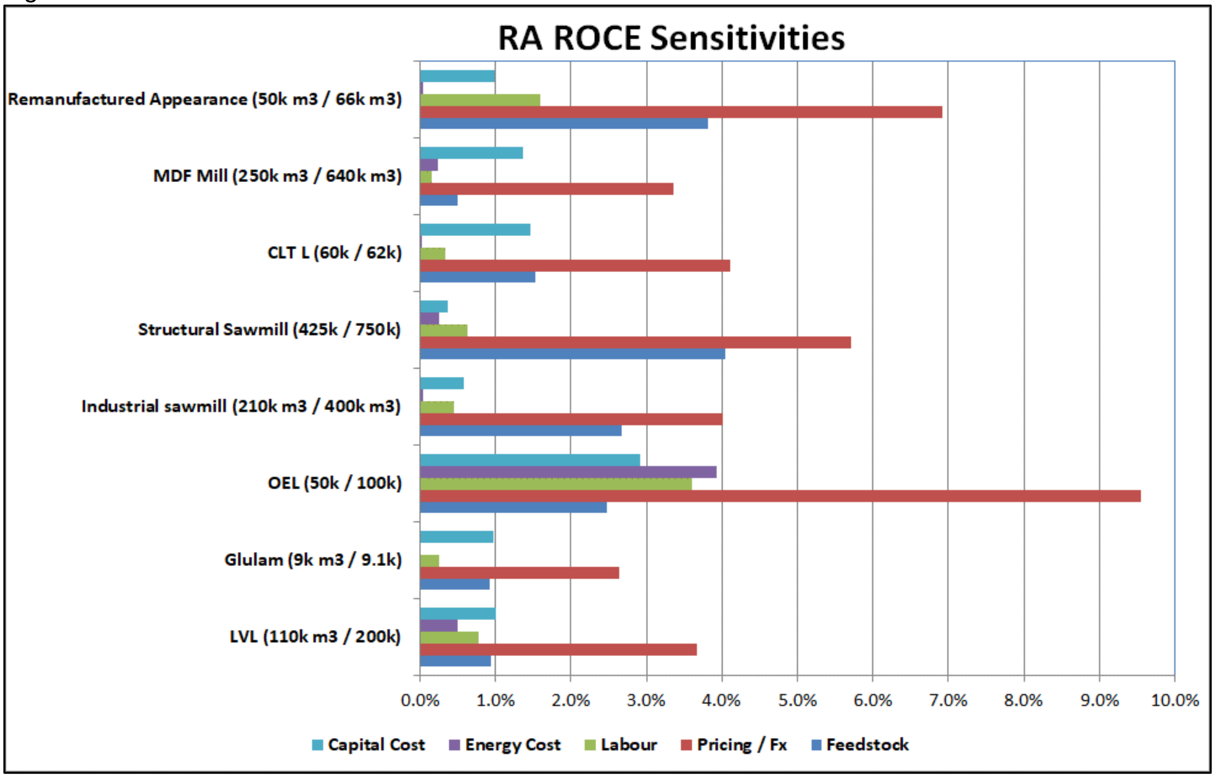
Table 9 – GDP and employment of the WoodScape derived cluster

| Mill | Direct employment | Indirect & Induced employment | Total Employment | GDP $M per annum |
|---|---|---|---|---|
| LVL Large | 244 | 410 | 654 | $217 |
| Large structural & Appearance sawmill | 195 | 327 | 522 | $129 |
| Industrial sawmill | 70 | 98 | 168 | $59 |
| OEL™ (multiple modules) | 81 | 135 | 216 | $127 |
| MDF | 109 | 183 | 292 | $482 |
| CLT | 160 | 135 | 295 | $254 |
| Remanufactured | 540 | 906 | 1446 | $128 |
| Glulam | 28 | 46 | 74 | $45 |
| ***Total*** | ***1427*** | ***2240*** | ***3540*** | ***1441*** |

The sensitivities of the RA ROCEs of the various processing operations to a 5% change in a range of cost factors are shown in Figure 14. These factors are; capital costs, energy costs, labour costs product price and feedstock cost. Product pricing is a major consideration for all mills and feedstock cost is has the second greatest impact for many; Reman., CLT, structural and industrial sawmill).

The movement in ROCE is an actual change in the ROCE, not a percentage of the percentage. That is if a technology has a ROCE of 20% and sensitivity of 7% to a change of 5% to an input the expected range would be 13 to 27%.

Figure 14 – ROCE sensitivities




There is also enough potential log supply for a plywood mill (industrial grade) taking 400,000 $m^3$ per annum of logs. However, this pushes the total log demand very close to the upper limit of the log supply. Plywood is also a high energy intensity processing option. It has a similar ROCE and IRR to the LVL mill (22% and 12% respectively). It would add to employment (300) and GDP $200M). It would have a net deficit of wood residues even for heat production and would require a power plant of around 7MWe. This option was not included further because if a plywood mill this large was added to the list of plants in Table 5, collectively it would be a very large cluster and it would add to the issues around energy supply as it is not self-sufficient in heat fuel.

Current log prices are around 10% higher than the long run average. This means that the ROCEs would drop by between 1 and 4% depending on the processing option (Table 8 and figure 14) if current lo0g prices were used instead of the long run average. This highlights the need for the sensitivity analysis and some assessment of the volatility in returns that can be expected in the long and short term.

## Industry Example cluster

As a comparison to the WoodScape clusters we made an example proposed development which is planned to be constructed in stages rather than all at once and looked at the expected financial returns of the individual plants and the cluster overall.

The outline of possible processing operations includes;

- LVL mill, 240,000 m$^3$ per annum log in
- OSB mill is added; 350,000 m$^3$ per annum of log in
- Sawmill is added; 600,000 m$^3$ per annum in
- MDF mill aligned with the sawmill to take its chip residues

We have specified an LVL mill as the returns appear to be slightly better than a plywood mill. The RA ROCEs of the Industry example cluster wood processing cluster is shown in Table 10.

Table 10 - financial metrics for the Industry example processing options

| **Mill Type** | **In-feed** | **Scale; log in m$^3$ per annum** | **Scale; product out m$^3$ per annum** | **RA ROCE %** | **IRR %** |
|---|---|---|---|---|---|
| LVL | Pruned | 240,000 | 125,000 | 20 | 11 |
| Sawmill | S & A | 600,000 | 342,000 | 12 | 5.3 |
| OSB | Pulp | 350,000 | 203,000 | 20 | 9.0 |
| MDF | Saw mill Chip | 180,000 | 69,000 | 15 | 7.8 |
| **Total** | | **1,190,000** | **670,000** | | |

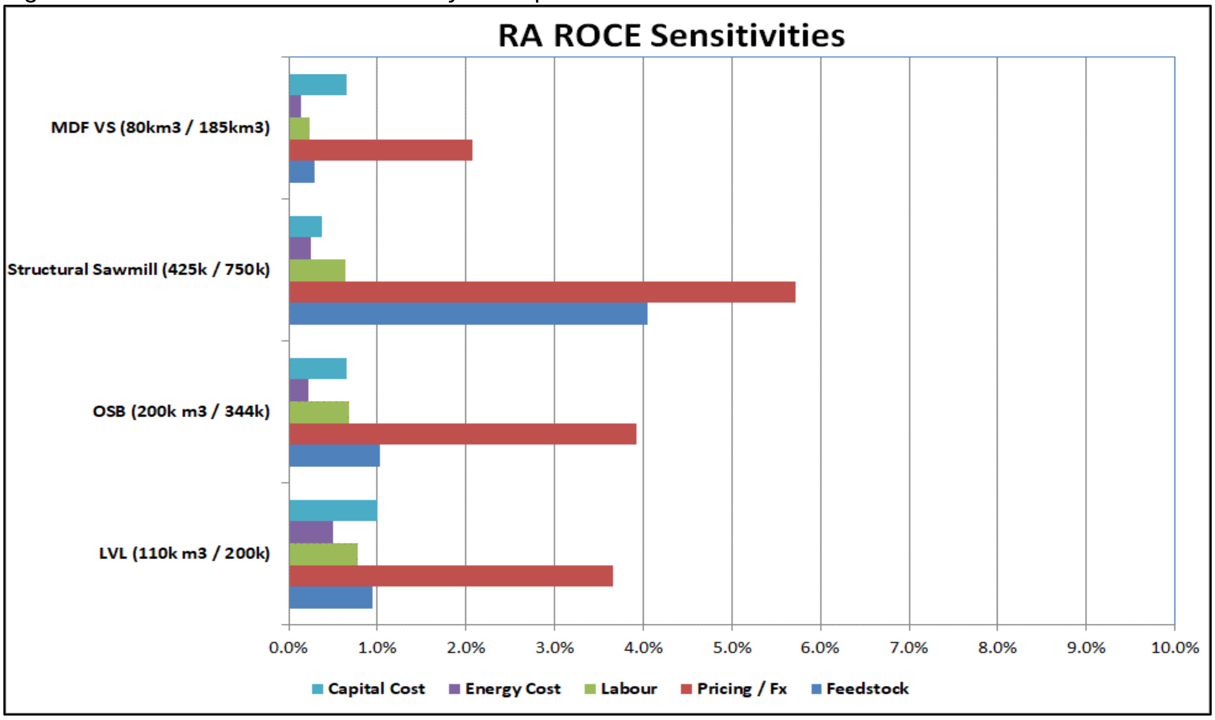
The Industry example cluster is shown in Table 11. It is lower than that derived for the larger cluster described previously (25%). That cluster includes value added processing (CLT and Remanufacture) of sawn lumber (Table 9).

Table 11 - capital weighted RA ROCE of the total Industry example cluster

| **Mill** | **Capex; $M** | **RA ROCE % Log run log prices** | **RA ROCE % Current log prices** |
|---|---|---|---|
| LVL | 120 | 20 | 19 |
| Sawmill | 105 | 12 | 8 |
| OSB | 93 | 23 | 22 |
| MDF | 160 | 15 | 14 |
| **Total capex** | **478** | | |
| **Capital weighted RA ROCE** | | **17** | **15** |

Figure 15 shows the RA ROCE sensitivities for the Industry example cluster. Product pricing is again the most significant driver of change in the RA ROCE.

Figure 15 - ROCE sensitivities Industry example cluster




The GDP and employment impact of the Industry example cluster are shown in Table 12.

Table 12 - GDP and employment of the Industry example cluster

| Mill | Direct employment | Indirect employment | Total Employment | GDP $M per annum |
|---|---|---|---|---|
| LVL | 244 | 410 | 654 | $217 |
| Sawmill | 156 | 261 | 417 | $104 |
| OSB | 184 | 309 | 493 | $115 |
| MDF | 87 | 146 | 233 | $156 |
| **Total** | **671** | **1126** | **1797** | **$592** |

The critical differences between the Industry example cluster and the WoodScape derived one is that the Industry cluster has only one sawmill and no secondary processing of the sawn lumber. This limits the generation of spare residues and means it is more reliant on external sources of fuel. The ROCE's of the secondary processors are higher than those of the sawmills, and the inclusion of these value adding options therefore has two major benefits; increased ROCE and greater volumes of residues available to fuel the energy intensive board manufactures.

## Gas and Power demand and supply capacity in Gisborne

The gas pipeline into Gisborne has spare capacity given current demands. This is in the order of 6MWth. The gas company supplying the Gisborne region has also indicated that the pipeline could be upgraded, and after that the spare capacity could increase by up to 20MWth.

Electricity demand in Gisborne has seen little increase in the last few years. The closure of the Juken New Zealand Ltd plywood mill would have reduced electricity demand by around 3 to 4 MWe.

Electricity demand in the Gisborne Region in 2016 was 55 - 56MWe. Maximum growth is expected to be to 75MWe in 2026 (2.5% growth per annum).

The lines leading into Gisborne have capacity to deliver a further 10 to 12MWe. Demand beyond that would require lines being upgrading. One option would be to conduct a line tightening exercise that would increase capacity by a further 10MWe, but only with expenditure in the order of $2M to $3M.

The Juken New Zealand Ltd plywood mill closure implies a lines capacity into Gisborne of ~15MWe which with the 10MWe from the lines tightening means spare capacity sufficient to deliver a further 25MWe without major new capacity being constructed.

## Energy demand from expanded primary processing

### Wood processing

An outline of potential material flows between different processing plants is shown in Appendix H. Some of the processing (CLT etc.) is secondary and relies on a sawmill to provide it with raw material. Different processes have different residual streams and these materials may include a mix of; bark, sawdust, shavings, off-cuts, edge trim, breakage, sander dust and fishtails from log peeling. All these residuals can be used as fuel to meet the heat and or power demand of the processing operations. Sawmill slab chip is not considered to be a residual; it is a secondary product and its sale is critical to the financial viability of the mill.

### WoodScape cluster I (WSI)

The heat and electricity demand of the first WoodScape derived cluster (WSI, described in Tables 6 & 7) is shown in Table 13. This shows a deficit in heat fuel from wood processing residues of around 267,000 GJ per annum. The 100,000 green tonnes per annum of in-forest residues would more than meet this demand, as it would provide around 690,000 GJ.

The power demand is the equivalent of 24 MWe. In the first instance the use of wood residues would be for meeting heat demand. However, consideration also needs to be given to use of combined heat and power (CHP) units to provide a mix of heat and electricity.

The inclusion of secondary wood processing (CLT, Remanufacture and Glulam) helps with residue supply / fuel demand balance as they have low heat demand and comparatively high residue production.

Different wood processing plants have varying levels of residuals produced within the process and different heat demands, the surplus numbers deficit indicate the position of each mill, and in total for the cluster. A deficit in total means a cluster would have to import fuel from outside sources, such as in-forest residues.

Table 13 – supply and demand for heat fuel by mill

| **Mill type** | **Heat demand; GJ p.a. (peak MW)** | **Power demand; kWh p.a. (peak demand, MW)** | **Residues; odt p.a.** | **Residues; GJ p.a.** | **Heat fuel deficit / surplus; GJ p.a.** |
|---|---|---|---|---|---|
| LVL | 2,200,000 (73MW) | 61,380,000 (7.3) | 76,800 | 1,382,400 | -802,240 |
| Large S & A sawmill | 892,500 (50) | 10,625,000 (2.1) | 57,000 | 1,026,000 | 144,900 |
| Industrial sawmill | 441,000 (27) | 5,250,000 (1.1) | 30,400 | 547,200 | 112,280 |
| OEL™ (3 modules) | 530,100 (32) | 16,758,000 (3.6) | 55,200 | 993,600 | 474,540 |
| MDF | 875,000 (29) | 108,250,000 (12.9) | 20,800 | 374,400 | -496,440 |
| CLT (2 modules) | 64,260 (7) | 2,261,000 (1.0) | 8,400 | 151,200 | 88,620 |
| Remanufactured (2 modules) | 53,460 (6) | 4,059,000 (1.7) | 13,200 | 237,600 | 186,780 |
| Glulam | 9,720 (1) | 342,000 (0.2) | 1,893 | 34,070 | 24,729 |
| **Total** | **5,066,040 (225)** | **208,925,000* (29.9)** | **263,393** | **4,746,000** | **-266,831** |

*equivalent to a power plant of around 24MWe

## Industry example cluster

The Industry proposed wood processing cluster (Table 14) although smaller than WSI one above has a larger heat fuel deficit as it has a mix of operations that generally have high heat inputs (LVL) and lower residue production (OSB, MDF).

The Industry example cluster has a heat fuel deficit that is over 1.4M GJ; equivalent to 210,000 green tonnes of wood. This is challenging given the in-forest residue availability of 100,000 green tonnes.

Table 14 - supply and demand for heat fuel by mill for Industry example cluster

| **Mill type** | **Heat demand; GJ p.a. (Peak demand)** | **Power demand; kWh p.a. (Peak demand)** | **Residues; odt p.a.** | **Residues; GJ p.a.** | **Heat fuel deficit / surplus; GJ p.a.** |
|---|---|---|---|---|---|
| LVL | 1,250,000 (41) | 34,875,000 (4.2) | 46,080 | 829,440 | -420,560 |
| Sawmill | 718,200 (43) | 8,550,000 (1.9) | 43,200 | 777,600 | 59,400 |
| OSB | 1,339,800 (44) | 30,450,000 (3.6) | 18,200 | 327,600 | -1,012,200 |
| MDF | 241,500 (8) | 29,877,000 (12.4) | 9,360 | 168,480 | -73,020 |
| Total | 3,549,500 (137) | 103,752,000* (22) | 116,840 | 2,103,120 | -1,446,380 |

*equivalent to a power plant of ~19MWe

For these first two clusters (especially the Industry one) getting sufficient supply of energy, particularly heat, is challenging and would require investment outside of the wood processing.

Two slightly smaller clusters, WoodScape clusters II and III, which were less energy intensive were examined to address the energy challenges observed in the WSI and Industry scenarios.

## WoodScape cluster II (WSII)

WSII is a smaller cluster, with an overall lower energy demand. This is essentially the same cluster as WSI without the LVL mill. LVL is energy intensive with high heat demand per $m^3$ of product and moderate to high electricity demand (Appendix E).

The financial, employment and GDP metrics for the WSII cluster are shown in Table 15.

Table 15 – financial metrics for WoodScape cluster II

| Mill Type | Log volume in ($m^3$ per annum) | Capital cost ($M) | ROCE % Long run log price and (2019) | Capital weighted ROCE % | Total Employment | GDP $M p.a. |
|---|---|---|---|---|---|---|
| Large S & A sawmill | 750,000 | 85 | 12 (8) | - | 522 | $129 |
| Industrial sawmill | 400,000 | 54 | 16 (13) | - | 41 | $59 |
| OEL™ (3 modules) | 300,000 | 78 | 27 (25) | - | 216 | $127 |
| MDF | 400,000* | 220 | 32 (31) | - | 292 | $482 |
| CLT (2 modules) | 140,000** | 162 | 31 | - | 295 | $254 |
| Remanufactured (2 modules) | 132,000** | 110 | 29 | - | 1446 | $128 |
| Glulam | 18,200** | 20 | 22 | - | 74 | $45 |
| **Total log intake** | **1,850,000** | **729** | | **27.0 (25.8)** | **3,540** | **1,441** |

*MDF mill also takes 340,000 $m^3$ per annum of sawmill chip; ** Lumber not logs

The energy demands of the WSII cluster are shown in Table 16. This option has spare wood residues remaining (535,400 GJ p.a.) after its heat demand is met. These residues, if used in a CHP could create 8.5 MWe and 13 MWth. The cluster needs around 17MWe and this could be met with the wood fuelled CHP and from the existing lines infrastructure. It would have spare heat to provide to other users.

Table 16 – supply and demand for energy for WoodScape cluster II

| Mill type | Heat demand; GJ p.a. (Peak demand) | Power demand; kWh p.a. (Peak demand) | Residues; odt p.a. | Residues; GJ p.a. | Heat fuel deficit / surplus; GJ p.a. |
|---|---|---|---|---|---|
| Large S & A sawmill | 892,500 (50) | 10,625,000 (2.1) | 57,000 | 1,037,400 | 144,900 |
| Industrial sawmill | 441,000 (27) | 5,250,000 (1.1) | 30,400 | 553,280 | 112,280 |
| OEL™ (3 modules) | 530,100 (32) | 16,758,000 (3.6) | 55,200 | 1,004,640 | 474,540 |
| MDF | 875,000 (29) | 108,250,000 (12.9) | 20,800 | 378,560 | -496,440 |
| CLT | 64,260 (7) | 2,261,000 (0.9) | 8,400 | 152,880 | 88,620 |
| Remanufactured | 53,460 (6) | 4,059,000 (1.7) | 13,200 | 240,240 | 186,780 |
| Glulam | 9,720 (1) | 342,000 (0.2) | 1,893 | 34,449 | 24,729 |
| **Total** | **2,866,000 (152)** | **147,545,000* (22.5)** | **186,893** | **3,401,449,** | **535,409** |

* equivalent to a power plant of 17MWe

## WoodScape cluster III (WSIII)

WSIII also has no LVL plant and has a medium sized OSB mill instead of instead of a large MDF mill.

OSB uses more heat but less electricity than MDF and overall more energy (Appendix E). MDF mills have high electricity demand in comparison to other reconstituted board products, and lower heat demand. This is because some heat energy is recovered from the mechanical refiners (which are driven by electricity) and used in the MDF process.

The down side of this option is that there is no local outlet for sawmill chip as OSB requires logs as a feedstock not chip. The use of sawmill slab wood is theoretically possible, but not confirmed as a commercially viable operation. Slabwood from the two sawmills would be around 280,000 $m^3$ per annum, increasing the possible size of the OSB plant to 625,000 $m^3$ per annum. There is no substantial difference between the RA ROCEs of the OSB plants of these sizes. However, it would have a higher capital cost and a higher total energy demand. A particle board plant could take sawmill chip but, in our analysis, it had a ROCE of only 9.2% for a plant that had a scale that fits with the resource.

The financial, employment and GDP metrics for the WSIII cluster are shown in Table 17.

Table 17 - financial metrics for WoodScape cluster III

| **Mill Type** | **Log volume in ($m^3$ per annum)** | **Capital cost ($M)** | **ROCE % long run and (2019) log prices** | **Capital weighted ROCE %** | **Total Employment** | **GDP $M p.a.** |
|---|---|---|---|---|---|---|
| Large S & A sawmill | 750,000 | 85 | 12 (8) | - | 522 | $129 |
| Industrial sawmill | 400,000 | 54 | 16 (15) | - | 41 | $59 |
| OEL™ (3 modules) | 300,000 | 78 | 27 (25) | - | 216 | $127 |
| OSB | 344,000 | 93 | 23 (22) | - | 493 | 113 |
| CLT (2 modules) | 140,000** | 162 | 31 | - | 295 | $254 |
| Remanufactured (2 modules) | 132,000** | 110 | 29 | - | 1446 | $128 |
| Glulam | 18,200** | 20 | 22 | - | 74 | $45 |
| **Total** | **1,800,000** | **602** | | **24.5 (23.9)** | **3,087** | **855** |

The energy demands of the WSIII cluster are shown in Table 18. This option has low amounts of spare residuals other than the sawmill chip. This would be a slightly more expensive fuel option than the forest residues. Sawmill chip is estimated to have a value of $75 per green tonne ex-mill. Forest residues are estimated at $66 to $68 per green tonne delivered to the sawmill.

Table 18 - supply and demand for energy for WoodScape cluster III

| Mill type | Heat demand; GJ p.a. (peak demand) | Power demand; kWh p.a. (peak demand) | Residues; odt p.a. | Residues; GJ p.a. | Heat fuel deficit / surplus; GJ p.a. |
|---|---|---|---|---|---|
| Large S & A sawmill | 892,500 (50) | 10,625,000 (2.1) | 57,000 | 1,037,400 | 144,900 |
| Industrial sawmill | 441,000 (27) | 5,250,000 (1.1) | 30,400 | 553,280 | 112,280 |
| OEL™ (3 modules) | 530,100 (32) | 16,758,000 (3.6) | 55,200 | 1,004,640 | 474,540 |
| OSB | 1,320,000 (44) | 30,000,000 (3.6) | 20,800 | 3785,60 | -941,440 |
| CLT (2 modules) | 64,260 (7) | 2,261,000 (0.9) | 8,400 | 152,880 | 88,620 |
| Remanufactured (2 modules) | 53,460 (6) | 4,059,000 (1.7) | 13,200 | 240,240 | 186,780 |
| Glulam | 9,720 (1) | 342,000 (0.1) | 1,893 | 34,449 | 24,729 |
| **Total** | **3,300,040 (167)** | **69,295,000* (13.1)** | **186,893** | **3,022,889** | **90,409** |

*equivalent to a power plant of ~8MWe

Both the WSII and WSII clusters have capital weighted ROCEs that are higher than the Industry example one when assessed on a common basis. Of the 3 WS based clusters, WSII had the best result in terms of RA ROCE, although given margins of error it is not a lot different to WSI. However, WSI is a very large cluster and would be pushing the limits of wood supply and energy supply.

## Smaller cluster

Most of the previous clusters described (except for the Industry example) are large (1.8 to 2.25M m$^3$ per annum) of log in and the different plants are assumed to be coming on line at around the same time. This would be a significant development and would likely have to be undertaken by a single entity / owner.

A different option would be to go to a smaller cluster, possible staged. It is worth bearing in mind that some of the plants require each other due to interdependencies, the relatively small size of the existing processing industry and the relative isolation of the Gisborne region which makes moving material in and out of region challenging. It is worth noting that barging of freight from Port of Gisborne to the Port at Napier has been considered, but the results of this study are not available. However, consideration of this option is important as it would allow the movement of containers of processed product to the container terminal at Napier, along with bulk product such as chip.

Given the ROCEs of the various wood processing options, the start point for expanded wood processing would logically be the development of the OEL™ processing to include three 100,000 m$^3$ per annum modules. OEL™ mills can operate independently of other wood processors and can use their residues for making the process heat they need. Their electricity demand can be met from the spare capacity in the grid. They are likely to have some residues spare after meeting their own heat demand, so a CHP would be possible.

The next stage based off the ROCEs would be an MDF mill. However, there is insufficient pulp log supply to make an MDF mill of a size that is financially attractive. To get a larger scale MDF mill a large sawmill, with its production of chip, which is suitable for MDF feedstock is required. A sawmill on its own does not have a highly attractive ROCE, but when paired with CLT and Remanufacture the combination is attractive (as per WSI, WSII and WSII). A suggested second stage would therefore be a large sawmill aligned with a substantial CLT and remanufacturing operation.

The sawmill needs an outlet for its chip and the best option identified was an MDF mill. Other options would include exporting the chip via road to the CNI, by rail to OJI Fibre Solutions at Whirinaki or Barging it to Napier for export. There is insufficient data available to be able to say which option is preferable.

If the sawmill chip could be viably exported from the Gisborne region then a large sawmill with CLT and Remanufacture could be established without the need for the MDF mill to take the chip. This cluster of aligned primary and secondary processing would also be able to meet its own heat demands and have residues available to run a CHP plant.

If the MDF plant was established, it would mean that there was a supply of residues sufficient to meet all the heat demand of the cluster with enough residue left over to generate around 6MWe. The whole cluster would demand around 21 to 22MWe. The spare capacity in the grid along the 6MWe CHP and the heat and power from the organic waste to energy potential identified in Table 21 would be sufficient meet the cluster demand. The smaller cluster is described in Tables 19 and 20.

Table 19 – scale, RA ROCE employment, GDP and capital weighted ROCE of the smaller cluster.

| **Stage** | **Mill type** | **Log in; $m^3$ per annum** | **Product out; $m^3$ per annum** | **RA ROCE; %** | **Capex; $M** | **Capital weighted RA ROCE %** | **Employ ment; Direct jobs** | **GDP; $M p.a.** |
|---|---|---|---|---|---|---|---|---|
| **1** | OEL™ | 300,000 | 171,000 | 27 (25) | 78 | 27 | 81 | $127 |
| **2** | Sawmill | 750,000 | 425,000 | 12 (8) | 85 | | 195 | $129 |
| | CLT | | 119,000 | 31 | 162 | | 160 | $254 |
| | Reman. | | 99,000 | 29 | 110 | 26* | 540 | $128 |
| **3** | MDF | 400,000 | 210,000 | 32 | 220 | 32 | 109 | $482 |
| **Total** | | **1,450,000** | | | **655** | **28 (27)**** | **1,085** | **$1,120** |

*capital weighted RA ROCE for the sawmill and the secondary processors combined, as the secondary processors are not possible without the sawmill; ** capital weighted ROCE based on 2019 log prices

Table 20 – supply and demand for energy of the smaller cluster.

| **Mill** | **Heat demand; GJ p.a. (Peak demand, MW)** | **Electricity demand; kWh p.a. (Peak demand, MW)** | **Residues; GJ p. a.** | **Surplus / deficit of residues after heat demand is met** |
|---|---|---|---|---|
| **OEL™** | 530,100 (32) | 16,758,000 (3.6) | 1,004,640 | + 474,900 |
| **Sawmill Large S & A** | 892,500 (50) | 10,625,000 (2.1) | 1,035,400 | + 144,900 |
| **CLT** | 64,260 (7) | 2,261,000 (0.9) | 152,800 | + 88,620 |
| **Reman.** | 53,460 (6) | 4,059,000 (1.7) | 240,240 | + 186,780 |
| **MDF** | 875,000 (29) | 108,250,000 (12.9) | 378,560 | -496,440 |
| **Total** | **2,415,320 (114)** | **141,953,000 (21.2)** | **2,811,640** | **+ 398,760** |

## Adjacent heat demand – Meat works

The nearest adjacent heat demand which could be linked to the wood processing cluster energy demand is the Ovation Meats plant, approximately 800 m East of the Matawhero sawmill site. It has two boilers running on gas. They are 0.4 and 0.5 MWth and have a fuel demand estimated at 20,000 GJ per annum (1 MWth) (or equivalent to 2,900 green tonnes of wood fuel). However, as these boilers are gas fuelled converting them to run on wood is not easy. On the other hand, it is entirely possible to pipe hot water a distance of 800m.

## Heat and electricity demand from expanded non-wood primary processing

There are no known major expansion plans in meat, fruit, vegetable or other primary processing that would have a significant effect on demand for electricity or heat fuel from these industries adjacent to Matawhero.

## Integrated wood and other primary processing heat and electricity supply and demand

There are several primary processing industries that produce wet or high moisture content waste streams that are unsuitable for combustion that can be converted into biogas and then into heat and power via anaerobic digestion (AD) system coupled to an ICE genset. These waste streams and their energy value are outlined in Table 21. Some of these streams are seasonal and the system would run on a varied mixture of feedstocks. However, having a variety of feedstocks going into a digestor is generally regarded as a good thing as it improves the stability of the fermentation in the AD.

Table 21 – energy potential from anaerobic digestion of organic municipal and industrial waste streams

| **Feedstock** | **Gross GJ / yr.** | **kWh** | **MWh** | **MWe** | **MWth** | **MW Loss*** |
|---|---|---|---|---|---|---|
| Meat process waste | 9,168 | 2,546,669 | 2,547 | 0.16 | 0.20 | 0.05 |
| MWW | 9,286 | 2,579,447 | 2,579 | 0.16 | 0.20 | 0.05 |
| MSW | 28,819 | 8,005,284 | 8,005 | 0.50 | 0.63 | 0.15 |
| Fruit & Vegetable waste | 80,135 | 22,260,000 | 22,260 | 1.39 | 1.74 | 0.41 |
| **Total** | **127,408** | **35,391,399** | **35,391** | **2.21** | **2.76** | |

*Conversion loss from gross energy in the biomass to user energy

An anaerobic digestor and associated biogas fuelled CHP genset, set up at the meat works or nearer to the wood processing cluster taking all the waste streams in Table 14 would provide enough heat and power to supply the meat works with all its needs and could export both electricity (~2MWe) and heat (1.7MWth). The main issue with this setup is that the financial returns on this plant would be unattractive (ROCE of -1.1%) if the feedstock is assumed to be available at zero cost (as a waste disposal option). If a gate fee of $40 per tonne was charged, then the AD plant could have a ROCE of around 12%.

## Other wood resources available near Matawhero

There are small quantities of wood residues from other sources that could be used as boiler fuel at Matawhero;

- Municipal wood waste; 100 green tonnes per annum
- Orchard residues; 2,000 green tonnes per annum, removal of over-mature trees
- Shelter belt replacement; 1,100 green tonnes per annum, removal of over-mature trees

Together this material is around 22,000 GJ of wood fuel.

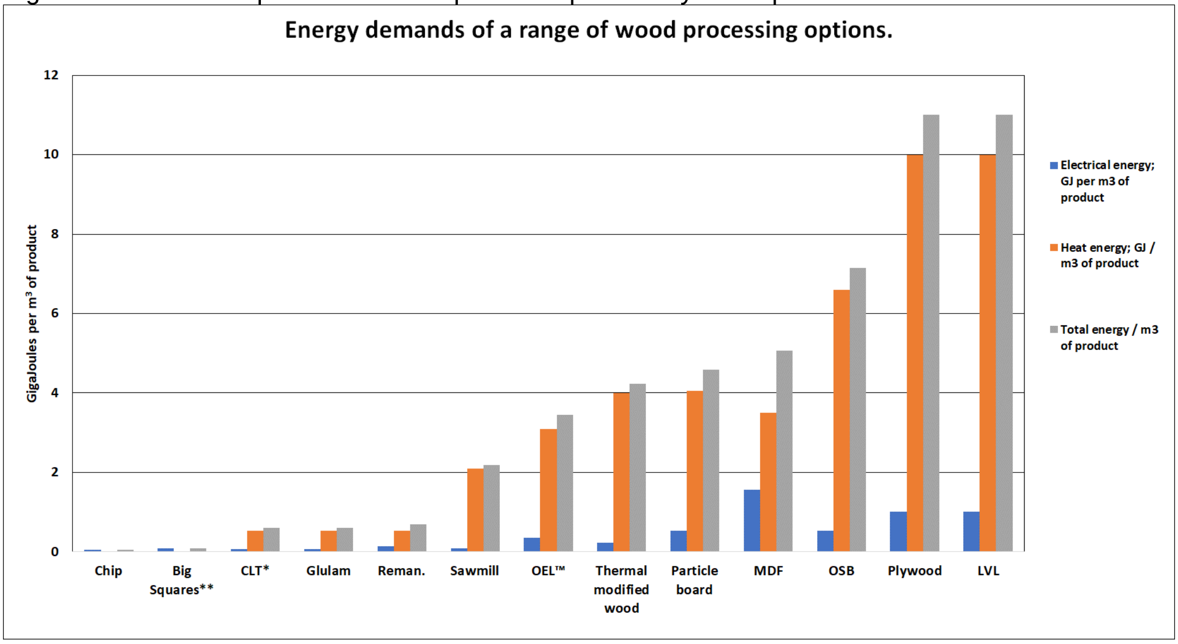
Bark from the port is another possible resource. Currently this resource is in the order of 46,000 tonnes per annum, but that is with high log harvests and low volumes being processed locally. As the log harvest declines in the future, and the log volume being processed goes up the total volume of exports will decline and some of the bark will be captured at mills. An estimate of future bark volumes at the port where an expanded wood processing industry has reduced log exports by over half would be 15,000 to 20,000 green tonnes per annum (100,000 to 135,000 GJ per annum). The level of debarking in the future is uncertain but could include all export logs being debarked in New Zealand.

Total locally derived woody residues (outside of forestry and wood processing) were estimated to be in the order of 18,000 green tonnes per annum or 124,000 GJ p.a. in the long run, accounting for a reduction in bark from the port due to increased local processing. Bark on logs processed locally is assumed to be available at the mills in the clusters described in this analysis.

## Demand of heat from different process types and supply from internal residues

Different wood process can have very different energy demands (Figure 16).

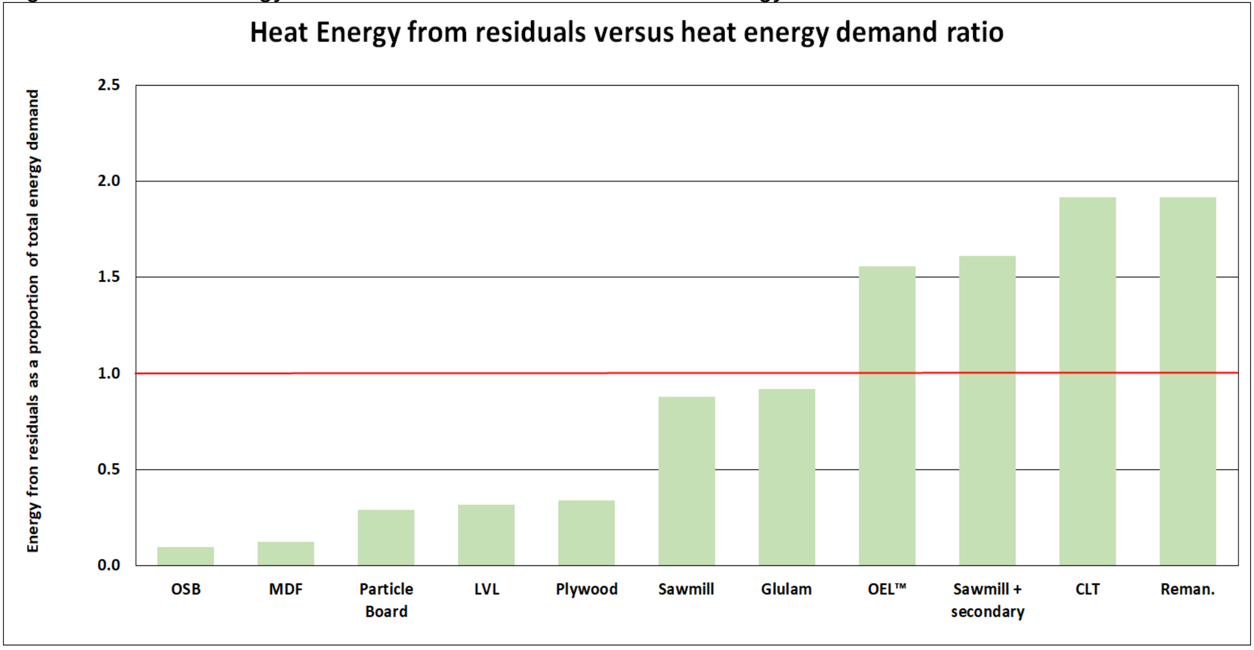
Figure 16 – heat and power demands per m$^3$ of product by wood product




These different wood processes also have different levels of residue production. These two things together make a significant difference to how much of its own heat demand a mill might create (Figure 17).

For example, an OSB plant has a high demand for heat and a low amount of residues produced per m$^3$ of product. A sawmill with some secondary processing (e.g. remanufacturing) attached has a moderate heat demand and a high level of residue production per m$^3$ of product. When considering what the various parts of a wood processing cluster should be, especially where the grid supply of gas and electricity is constrained, consideration of these factors becomes important.

Figure 17 – heat energy from internal residues as a ratio of energy demand




## Overall energy supply and demand

### *WoodScape cluster (WSI)*

In summary, the first WoodScape derived cluster has a deficit of heat of 266,800 GJ or 13.2 MWth. It also has a deficit of ~24MWe as it does no electricity generation as all the residues produced with the cluster are required for heat.

There is potential to add an AD plant located at or near the meat works to take its own and other locally produced wastes and generate enough heat and power to run the meat works at its current size and export 2MWe and 2.7MWth to the wood processing cluster.

The local supply of wood residues is insufficient to meet the heat and power demand of this cluster on its own. There would need to be electricity supply from the grid and the AD plant of 22 MWe. The grid is believed to have 10 to 15MWe of extra capacity as it stands, with another 10 MWe available if a line tightening exercise was conducted on the transmission lines supplying the Gisborne region.

Therefore, after taking the possible 22MWe outlined above off the wood processing cluster electricity demand of 24MWe there is a need for an extra 2MWe of electricity generation capacity. Likewise, we can derive a heat demand that needs to be met from external sources of 13 to 14 MWth with 2.7 MWth possibly from the AD plant mooted to run off local wet organic waste streams (located at the meat works or another site nearby).

A CHP system running on wood that could meet the 2MWe electrical demand would have a thermal output of around 15MWth. This is slightly more than 13 to 14 MWth demand of the cluster.

A CHP of this size, running on imported hog fuel would have a RA ROCE of around 2% and an IRR of -2.9%, depending on the assumptions about the value of the heat and power to the cluster. The assumptions used were; heat has a delivered value of $12/GJ and electricity has a value of $0.14 per kWh. This CHP would not be attractive as a stand-alone operation and heat and electricity prices would have to increase substantially for it to have a ROCE approaching 20%.

However, the CHP unit does enable the cluster to have adequate heat and power supply, which is otherwise unable to be delivered by the existing infrastructure. When this plant is added to the calculation of the capital weighted ROCE of the WoodScape based cluster the result is a capital weighted RA ROCE of 23%, as opposed to 25% without a CHP (Table 7).

The low ROCES of the CHPs based on wood or AD would indicate that the first supply of electricity sued would be from the grid, with the CHPs added as demand requires it.

### *Industry example cluster*

The Industry example cluster (which had the lowest RA ROCE) would have energy deficits of 1.45M GJ (48MWth) equivalent to 210,000 green tonnes of wood and 19MWe. There are insufficient wood residue resources within the cluster or from in-forest post-harvest residues to meet this heat demand. Even if all the available residues and the spare capacity in the gas pipeline was used there would be insufficient heat fuels available. In terms of the electricity there is spare lines capacity available of around 12MWe and assuming the AD plant for the organic wastes was built (2MWe and 2.7MWth) there would still be a deficit of around 5MWe. To meet this demand a line tightening exercise would be required, whilst this could add another 10MWe of capacity it would also have a capital cost for others to pay for.

Overall this cluster would be right on the limit of the heat and electricity capacity that exists, or which could be developed based on existing biomass resources.

Given its modest RA ROCE it seems like a problematic option.

It reinforces the point that for wood processing to be either self-sufficient in energy or able to export to others there needs to be careful consideration of the energy intensity of the processing options.

### *WoodScape II cluster*

The WSII cluster has a heat fuel surplus of 535,400 GJ per annum (16 to 17 MWth) it also requires around 17MWe of power generation to meet its demand.

It would be possible to put all the processing residues into a CHP plant as fuel. This would allow a plant of 91MWth (meeting all the heat demand) and around 8MWe which would generate around 8 MWe.

Therefore, this cluster with a CHP using the al of its residues could meet all the heat demand and a significant part of its own electricity demand with the rest (~9MWe) coming from the grid.

The financials of the CHP as a stand-alone are not particularly attractive with a ROCE of 0% to -1.8% depending on the assumptions around heat sales, with a capital cost of $52 million. This plant, if viewed as an essential enabler of the wood processing expansion would give the whole cluster a capital weighted RA ROCE to 24%. However, this is still attractive and would enable the cluster to develop without placing large demands on the existing grid supply.

Future use of the heat could develop as it would be attractive to new processors. However, if it is viewed as an essential part of the wood processing expansion it is still viable where as it is not as a stand-alone investment.

### *WoodScape III cluster*

The WSIII cluster (OSB instead of MDF) has a heat fuel surplus of 90,400 GJ per annum (~3MWth) and requires a power plant of around 8MWe.

This level of power could be drawn from the grids capacity or supplied from a CHP fuelled in part from the on-site residues and in part from other local residues and in-forest post-harvest residues.

A CHP of 8MWe would need around 73,000 green tonnes of wood fuel. Of this, 13,000 tonnes would come from the on-site processing residues and then from local supplies (orchards, MWW, port bark etc) estimated at around 18,000 tonnes and with the rest (42,000 tonnes) coming from in-forest post-harvest residues.

The caveats around the financial returns for the CHP as outlined above also apply here. It would reduce the overall RA ROCE of the cluster to 21.4%.

A further issue with this cluster is the lack of an outlet for the sawmill chip which could be a significant barrier unless the chip could be exported to other regions or internationally.

The MDF mill in WSII also has a higher RA ROCE so is a more logical choice.

### *Smaller staged cluster*

The first stage of this development would be 3 modules of the OEL™ technology. These would be self-sufficient in heat fuel and the electricity demand is well within the capacity of the grid. They have some residues spare after meeting their own heat demand, so a small CHP would be possible but not necessarily financially desirable.

The second stage of the development would be the sawmill / CLT / Remanufacturing cluster. The sawmill on its own does not necessarily have a sufficiently attractive ROCE, but when joined with the secondary processors (which need the sawmill) these combined operation are potentially attractive. The sawmill / CLT / Reman. plants collectively have a surplus of residues after meeting their own heat demands. The total electricity demand of this additional processing capacity could still be met from the grid. The collective spare residues would be in the order of 895,000 GJ p.a. This is enough to fuel a CHP of 30MWth and 5MWe. If a CHP was built to do all the heat and power require from the OEL™ mills, sawmill, CLT and reman. the cluster would have almost enough fuel to supply itself, with around 40,000 green tonnes of forest residues required to be imported to meet the rest of the demand.

The complication with this option is the timing of the building and commissioning of the various plants.

The addition of an MDF mill increases demand for electricity substantially. Once this is in place the cluster would have sufficient residues to meet all its heat demand. How the electricity demand is best met will depend on several factors, including the level of interest in an anaerobic digestion plant aimed at dealing with waste streams whilst generating heat and power.

# Discussion

During the review process two points were raised.

The first was whether log prices in Gisborne differed greatly from the national average log prices used. The AGRIHQ data used in the analysis has some regional pricing by log grade and the Gisborne / Napier prices were compared to the price (national average) used in the economic analysis. There were some log grades that differed in price to some extent and some are consistent with national average prices. This also changes over time (Table 22). Some of the differences were greater in 2019 than they were in 2018 (e.g. P2s). P1s are close to national prices. Export P log prices are consistent with national prices. S grade logs in Gisborne are around are around 6 to 7% cheaper in Gisborne than nationally. A and K grades (with the exception of KIS) are consistent with national prices. Posts and poles are cheaper in Gisborne ad pulp logs are a little more expensive.

Most of these changes are quite small when expressed as a percentage and fit within the sensitivity analysis shown in Figures 14 and 15. In the sensitivity analysis we calculated the impact of 5% change in various key inputs (including log prices) on the RA ROCE. The change in the pulp log price is a 4% increase, which would reduce the RA ROCE of the MDF mill by 1.5% (moving the ROCE of the large MDF mill from 32% to ~30%). The smaller MDF mill used in the Industry cluster would be unaffected as its intake is sawmill chip not pulp logs. The OSB plant in the Industry cluster would have its RA ROCE reduced by 1% (from 20 to 19%). The Gisborne A and K grade logs (except KIS) are all similar in price to national averages and would not be expected to have any impact on the RA ROCEs of the mills taking them.

The data appears to show that S grade logs is Gisborne are cheaper than nationally, which would increase the profitability of the mills that take those logs (LVL, Structural sawmill). Overall the price differences found were not large and would not affect most of the operations substantially in terms of their profitability.

Table 22 – log price differences by grade between Gisborne / Napier average prices and national averages; negative values indicates Gisborne log prices are lower.

| | **2018** | **2019** | **2-year average** |
|---|---|---|---|
| **P1 Peeler** | 1 | 4 | 2 |
| **P2** | -3 | 17 | 6 |
| **Export P** | 1 | 1 | 1 |
| **S1** | -8 | -8 | -8 |
| **S2** | -7 | -8 | -8 |
| **S3** | -7 | -7 | -7 |
| **Industrial Dom or Ex.** | 0 | 0 | 0 |
| **L 350** | -12 | -16 | -14 |
| **A** | 2 | 1 | 1 |
| **K** | 0 | 1 | 1 |
| **KS** | -1 | 1 | 0 |
| **KI** | 3 | 1 | 2 |
| **KIS** | | -10 | -10 |
| **Posts & Poles** | -15 | -15 | -15 |
| **Pulp logs** | 3 | 1 | 2 |

The second point raised was that focussing on log prices only was not helpful and that other measures can be used to compare options and to monitor an operations progress. One of the measures suggested was lumber price to log price ratio (LPLPR), where a higher number indicates better potential returns.

LPLPR = lumber price / log price. For example; \$450m$^3$ (lumber sold) / \$125 m$^3$ (logs purchased) = an LPLPR of 3.6. Operationally LPLRs of 2.2 to 4.0 are normal depending on market conditions.

The WoodScape model has a similar calculation which we refer to as the value add ratio (VAR).

VAR = m$^3$ of product per m$^3$ of log x product price / log price (\$/m$^3$). For a sawmill the product calculation includes the chip volume and chip price.

VAR = (0.57*\$450m$^3$) + (0.30*\$65) / \$125/m$^3$ = 2.21

The VARS and the LPLRs of the operations assessed in the various clusters are shown in Table 23. These values do not vary with the size of the operation and do not reflect differences or variations in operating costs. They simply indicate the difference in cost / price between the feedstock going in and the products coming out, and therefore the potential for profit. The higher the number in the ratio, the more potential it is likely to have, although this heavily dependent on the costs of the operation.

Table 23 – VAR and LPLPRs for a range of wood processing options

| | **VAR** | **LPLPR** |
|---|---|---|
| MDF | 6.87 | - |
| OEL™ | 3.06 | - |
| OSB | 4.51 | - |
| LVL | 4.67 | - |
| Structural sawmill | 2.12 | 3.35 |
| Industrial sawmill | 2.11 | 3.77 |
| Glulam. | 2.32 | - |
| Reman. | 2.11 | - |
| CLT | 2.77 | - |

The reconstituted products such as MDF, OSB and LVL have high VARs in comparison to the sawmills but they are also much more capital and energy intensive. The VAR and LPLPR are not necessarily a useful tool for comparing across different types of processes but are useful in terms of seeing where in the cycle of feedstock and product prices a mill might be.

# Conclusions

The Gisborne / Wairoa area has long term wood availability of approximately 3.1M $m^3$ per annum. There is variation in volume available over time and current volumes available are higher than the long run supply. This supply is made up of a wide range of log grades. Only a small proportion of the Gisborne / Wairoa wood supply is processed locally.

There is a significant opportunity for expanded wood processing to be developed and the impacts of this on GDP and employment are substantial. However, there are limits on the power and natural gas supply into Gisborne City due to infrastructure constraints in comparison to the size of increase in energy demand from the potential expansion in wood processing.

Wood processing can be substantially self-fuelled in terms of heat due to the use of wood processing residues such as bark, sawdust etc. The production of electricity via combined heat and power is also possible, but depending on the type of wood processing, energy demands per cubic metre of product can be high. The ability to self-fuel varies widely across processes, with sawmills and secondary processing having spare residues and reconstituted panel products requiring imports of fuel to meet their heat demand.

Five scenarios for expanded wood processing were considered (Table 24);

1. WSI. A large cluster with near the maximum volume possible based on the long-term wood supply; 2.1 to 2.3M $m^3$; a mix of engineered products (LVL), sawmilling and reprocessed lumber (CLT etc). Near the limit of the maximum wood supply.

2. Industry example. 1.19M $m^3$ per annum. Smaller volume than WSI with high energy demand low residue producing processes (OSB and MDF) prominent as well as sawmilling.

3. WSII. A smaller cluster with a significant amount of secondary wood processing (CLT and Remanufacture), like the large cluster, but without the large LVL plant, includes a large MDF plant.

4. WS III. A smaller cluster with a significant amount of secondary wood processing (CLT and Remanufacture), like the large cluster, but without the large LVL plant, includes a medium sized OSB plant.

5. Smaller / staged development. Starting with three OEL™ modules followed by a large sawmill aligned with secondary processing. The third stage (MDF) would depend on the ability / viability of exporting sawmill chip via road, rail or barge to other regions or to the port at Napier.

Table 24 – descriptions of clusters

| Cluster | Total log volume in; $m^3$ p.a. | Total Capital; $M | Capital weighted RA ROCE | Total direct jobs | Total employment including indirect and induced | GDP $M p.a. |
|---|---|---|---|---|---|---|
| WSI | 2,250,000 | $949 | 25% | 1,427 | 3,540 | $1,441 |
| Industry | 1,190,000 | $478 | 17% | 671 | 1,797 | $592 |
| WSII | 1,850,000 | $729 | 26% | 1,183 | 2,886 | $1,224 |
| WSIII | 1,800,000 | $602 | 26% | 1,258 | 3,087 | $855 |
| Small / staged* | 1,450,000 | $655 | 27% | 1,085 | 2,771 | $1,120 |

*total cluster figures – figures for separate stages are identified in Table 15

In terms of the RA ROCE the smaller cluster with an MDF mill was the best performer. The OEL / Sawmill / CLT / Reman. cluster was very close with an estimated RA ROCE of 26%. This option would have a log intake of just over 1.0M $m^3$ per annum, a capital cost of $435M, employment of 2,479 and GDP of $638M p.a. These results are dependent on the sawmill being able to sell its chip outside the region.

The MDF option also has the advantage of taking all the sawmill chip. OSB cannot take this material and therefore another market for the chip would need to be found.

There is potential to take a range of local organic waste streams (waste fruit and vegetables, meat works effluent, municipal bio-solids and organic wastes) and feed them into an anaerobic digestion system with the biogas going to a heat and power unit (ICE genset). This waste stream could make around 2MWe and 2MWth which could be used either in the meat works or the wood processing cluster.

It is critical to consider the energy balance of individual processors and their interactions with other symbiotic processors. Inclusion in the cluster of high residue producing and low energy demanding processes is important if the ROCEs are sufficiently high. Some mills have very low residue production (OSB, MDF) and high energy inputs. These can be problematic where electricity supply is constrained, and minimal residues are produced within the cluster.

The inclusion of secondary processors (e.g. Remanufacturing and CLT) is important to the overall energy supply and demand. These operations have low energy inputs and comparatively high proportions of residuals per $m^3$ of product, which means they make a positive contribution to the energy supply / demand of the cluster.

A large-scale cluster of wood processing technologies with high energy demands per cubic metre of product is problematic as their demand for energy exceeds their supply of residues and if to many are put in one location they can also exceed the supply of locally available wood residues.

The Industry cluster does not look as attractive as the other clusters attractive based on our analysis.

A cluster of mills as described in the report as WSII had an attractive set of metrics. The scale of the operations, capital investment, return on investment, employment and GDP are outlined below (Table 25).

Table 25 – description of processing cluster WSII

| **Mill Type** | **Log volume in ($m^3$ per annum)** | **Capital cost ($M)** | **ROCE %** | **Capital weighted ROCE %** | **Total Employment** | **GDP $M p.a.** |
|---|---|---|---|---|---|---|
| Large S & A sawmill | 750,000 | 85 | 12 (8)*** | - | 522 | $129 |
| Industrial sawmill | 400,000 | 54 | 16 (13) | - | 41 | $59 |
| OEL™ (3 modules) | 300,000 | 78 | 27 (25) | - | 216 | $127 |
| MDF | 400,000* | 220 | 32 (31) | - | 292 | $482 |
| CLT (2 modules) | 140,000** | 162 | 31 | - | 295 | $254 |
| Remanufactured (2 modules) | 132,000** | 110 | 29 | - | 1446 | $128 |
| Glulam | 18,200** | 20 | 22 | - | 74 | $45 |
| **Total log intake** | **1,850,000** | **729** | | **26.9** | **3,540** | **1,441** |

*MDF mill also takes 340,000 $m^3$ per annum of sawmill chip
** Lumber not logs
***ROCE values were calculated on 7-year average log prices, ROCE values in brackets indicate 2019 log prices

Supply and demand for energy for WoodScape cluster II are outlined in Table 26. This demand can be met using the spare residues from the cluster, in-forest residues and around 6MWe from the grid.

Table 26 – energy supply and demand for wood processing cluster WSII

| **Mill type** | **Heat demand; GJ p.a.** | **Power demand; kWh p.a.** | **Residues; odt p.a.** | **Residues; GJ p.a.** | **Heat fuel deficit / surplus; GJ p.a.** |
|---|---|---|---|---|---|
| Large S & A sawmill | 892,500 | 10,625,000 | 57,000 | 1,037,400 | 144,900 |
| Industrial sawmill | 441,000 | 5,250,000 | 30,400 | 553,280 | 112,280 |
| OEL™ (multiple modules) | 530,100 | 16,758,000 | 55,200 | 1,004,640 | 474,540 |
| MDF | 875,000 | 108,250,000 | 20,800 | 378,560 | -496,440 |
| CLT | 64,260 | 2,261,000 | 8,400 | 152,880 | 88,620 |
| Remanufactured | 53,460 | 4,059,000 | 13,200 | 240,240 | 186,780 |
| Glulam | 9,720 | 342,000 | 1,893 | 34,449 | 24,729 |
| **Total** | **2,866,000** | **147,545,000*** | **186,893** | **3,401,449,** | **535,409** |

* equivalent to a power plant of 17MWe

There are some potential obstacles to wood processing expansion at this scale. These are; adequate labour supply developing over time as the industry expands, adequate power supply, lack of export container facility at Gisborne port, lack of a rail connection to Napier (where there is a container terminal). However, none of these potential barriers are insurmountable.

# Further work

Investigation of sawmill slabwood as an OSB feedstock would be useful as if this is possible it allows an option other than MDF to be considered at large-scale for the Gisborne region.

Investigation of the option of barging freight (containers and wood chip) from Gisborne to Napier.

There are many potential combinations of wood processing, wood residues to energy, waste to energy that could be deployed. Some of them are dependent on more information (transport options) and value of the waste to energy plant in the long term. A study that considers these in more detail may have value.

Previous work by Scion for the FMAG (Hall and Palmer, 2019) focussed on the extraction and use in-forest residues in the Gisborne Region to reduce post-harvest issues with residues being mobilised in flood events.

One option has always been to extract the broken tops that occur during tree felling to logging landings in greater volumes. This has traditionally had a cost attached to it that is a barrier.

A developing option that addresses this is may be the use of fixed head feller bunchers as opposed to dangle heads. The fixed heads can give much greater control of the stem during felling and this can lead to reduced breakage. There was a short article in the August 2019 edition of NZ logger (page 18) that quoted a presentation from a logging operator (HarvestTech 2019 conference) on the substantially increased extraction of longer unbroken stems from a fixed head machine versus a dangle head machine. The focus of the article was on the value of the greater volume of wood extracted that could be sold as posts.

However, this development would be worth a more detailed examination to determine the impact on the volume of residues left on the cutover.

# Acknowledgements

The author wishes to acknowledge the assistance of David Palmer and Andrew Dunningham (Scion) with GIS data and mapping.

Input from Alice Pettigrew, Eastland Group Business development manager is also appreciated.

Comments from reviewers have also contributed to the final version of the report.

The support of the Forestry Ministerial Advisory Group and the Ministry of Primary Industries which enabled this study is also acknowledged.

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# Appendix A – GIS biomass supply model methodology

The Biomass Supply Model (BSM) is a GIS based tool developed by Scion and used for estimating the volume of wood that can be supplied to a specific location both now and into the future. Inputs include the MPI National Exotic Forest Description (NEFD) area and age class tables, yield tables, Land Cover Database (LCDB) layers, a road network raster, forest source locations, and a destination location (port/s, mill/s, processing plant/s). For the Eastland project the BSM was executed at a 30-m cell-size resolution to optimise accuracy.

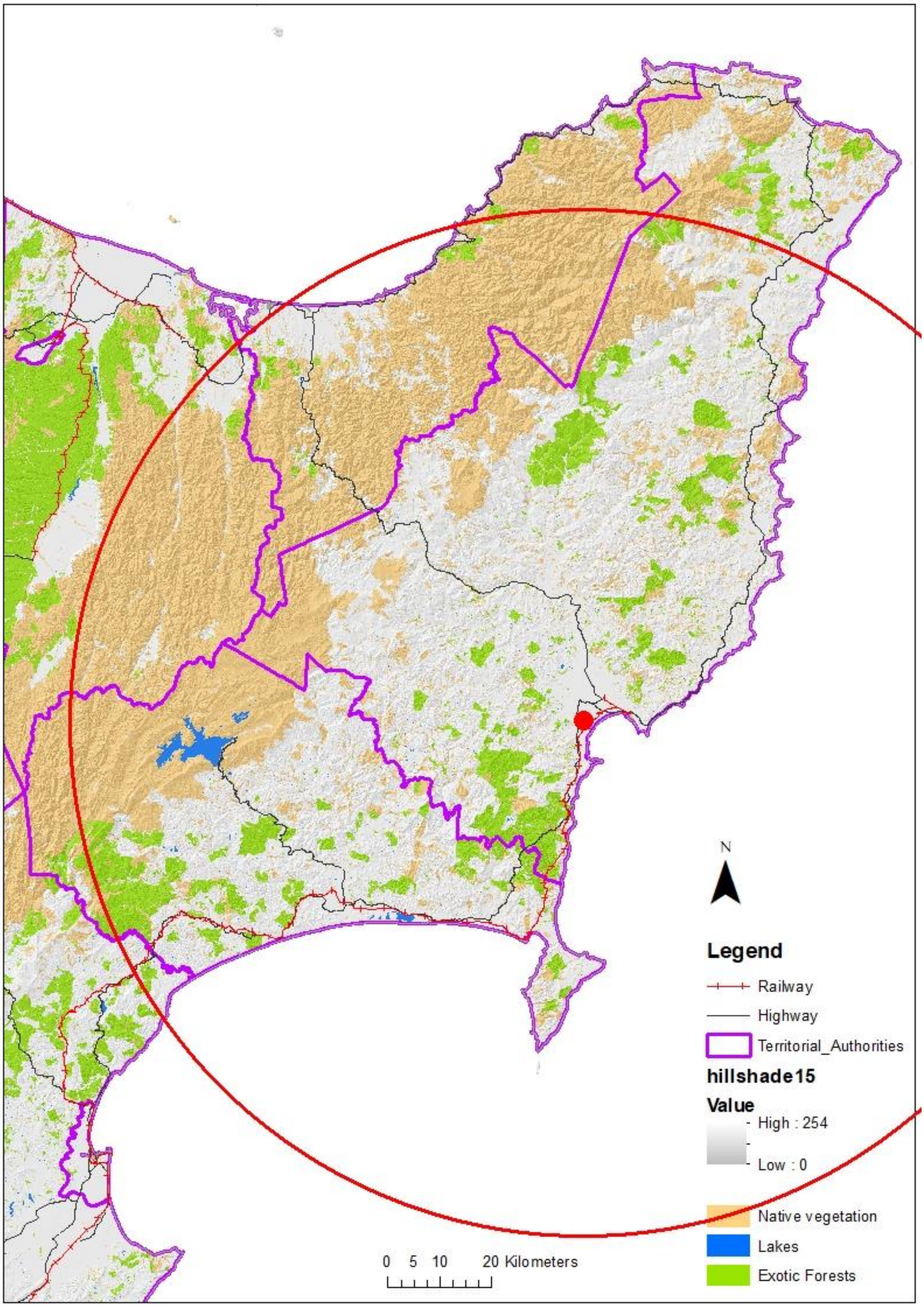
The Biomass Supply Model (BSM) as described in Hock et al. (2012) was used to calculate standing volume by distance from the Matawhero destination site. Biomass was estimated across the Opotiki and Wairoa districts as well as the Gisborne region by using information from the National Exotic Forest Description (NEFD: MAF 2018) and Land Cover Database version 4.2 (Thompson et al. 2003). The NEFD tables are updated annually and provide net stocked area in 5-year age classes for the 72 territorial authorities (Districts) across New Zealand. Because the project covers most of the north eastern regions of New Zealand's North Island, we selected both the Wairoa and Gisborne territorial authorities' districts to represent biomass supply. New Zealand's predominant plantation species is *Pinus radiata* covering approximately 90% of the plantation estate nationally. In the Gisborne region *P. radiata* is 97% of the planted area (MPI 2018) so for the biomass supply modelling we assumed all plantation area was *P. radiata*. The NEFD tables provide us with harvestable yield and area on a district basis, for (1) radiata pine pruned with production thinning, (2) radiata pine pruned without production thinning, (3) radiata pine unpruned with production thinning, and (4) radiata pine unpruned without production thinning regimes across five-year age classes. This allows us to estimate the supply of standing volume from the time of plantation establishment into the future. The BSM takes each 5-year age class and proportions the standing volume across each year into the future.

Because the NEFD tables are estimates across each district, the BSM uses the plantation forest land cover (LCDB version 4.2) to provide spatially explicit estimates of where biomass is supplied from across each of the NEFD age classes. LCDB identifies plantation forests using a series of satellite images captured in the summers of 1996/97, 2001/02, 2008/09, and 2012/13. The assumption is that if a tree can be identified it is more than 2 years old, and by identifying the same location in each satellite capture we can estimate age class through presence/absence of plantations. Because the plantation area per NEFD district (total) and the sum of area from LCDB age classes are not identical, the BSM allocates the NEFD area randomly to the LCDB plantation locations. This method allows the BSM modelling to be spatially explicit (provide sub-district detail), whereas the NEFD tables are at the territorial authority level. The purpose of this approach is to allocate distance from the biomass supply to its destination with greater precision.

The ground-based versus hauler-based recoverability is also calculated. To achieve this the modelling area is divided by slopes above (hauler logging) and below (ground-based logging) 16 degrees. A secondary calculation is undertaken using the premise that a skidder, wire rope and winch can extract logs from steeper areas (> 19°) from a ground-based location. To calculate this potential log extraction a 50-m thickness from a cell centroid from a contiguous area was identified (identified using zonal geometry library zonal thickness). Further, a 5ha minimum plantation forest size was set to remove small uneconomic plantation areas. These spatial operations were validated using aerial photography of harvested areas and comparing to the modelled recoverability areas. All modelling was undertaken at a 30-m cell size resolution.

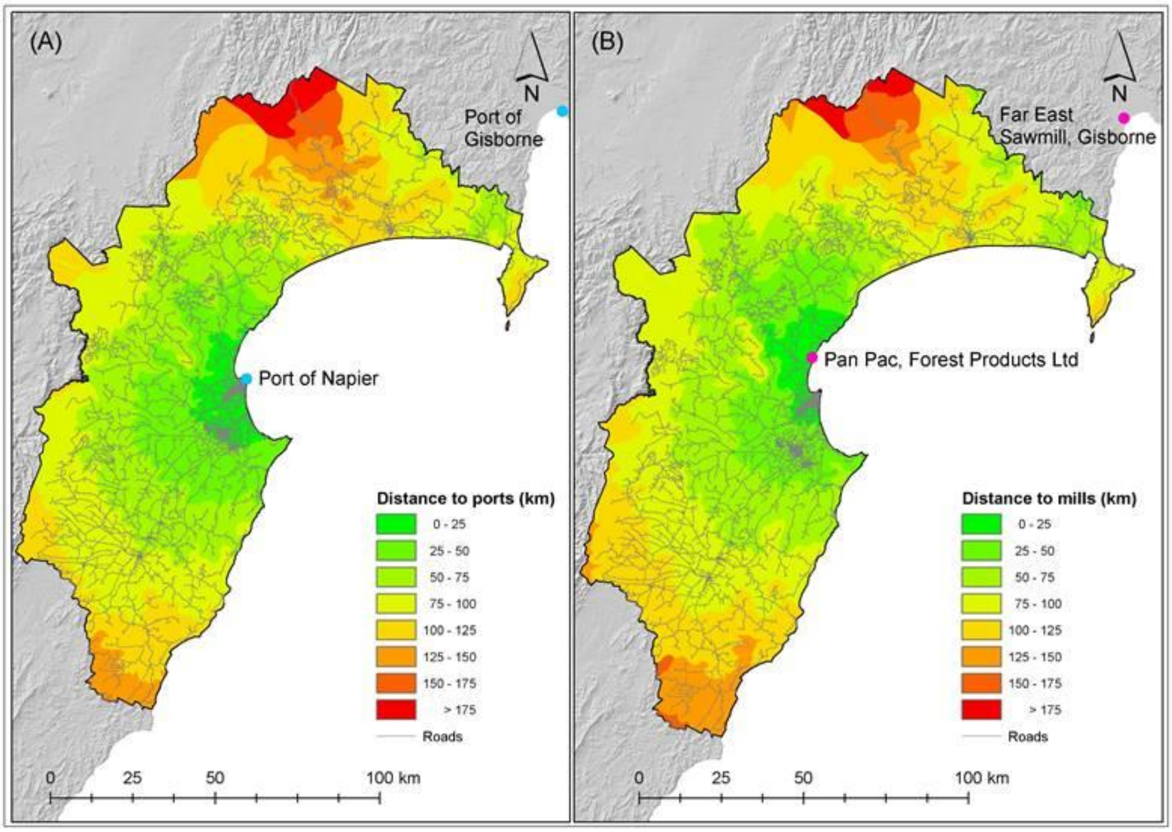
Once the BSM has estimated age class distribution, and calculated standing volume, it calculates the distance from its preselected destination (port, mill, or processing plant) resulting in a total standing volume of biomass by distance table. This data is exported to a spreadsheet where cumulative volumes by distance and cost calculations are added. Cost supply curves are derived from volume by distance weighted calculations.

# Appendix B – 140 km transport working circle for Matawhero



**Appendix B - continued**

**Log Transport distances to nearest port for Hawkes Bay; logs from Mahia and near the Northern Boundary of Wairoa district are closer to Matawhero and Port of Gisborne.**

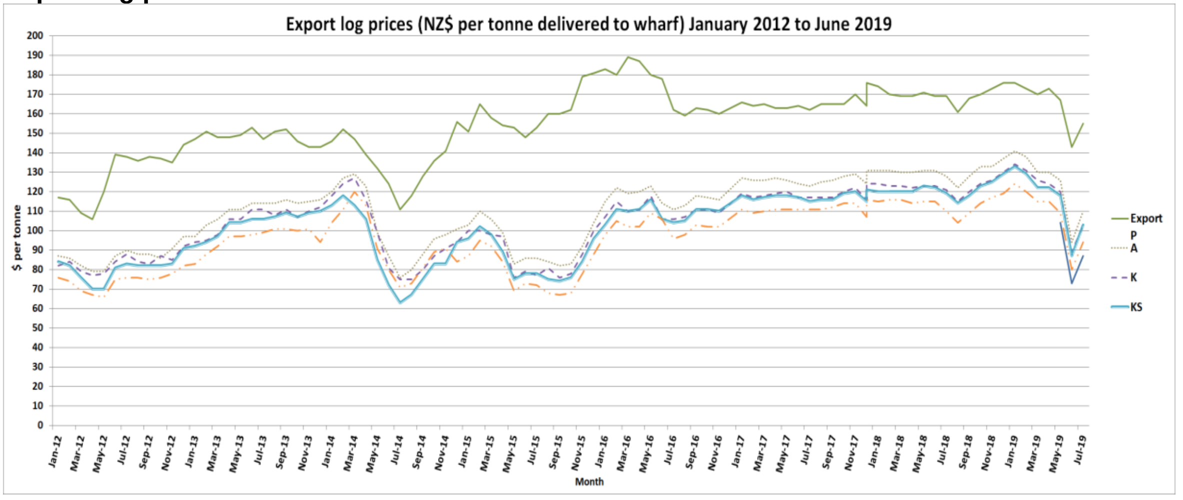


# Appendix C - Gisborne and Wairoa wood processors

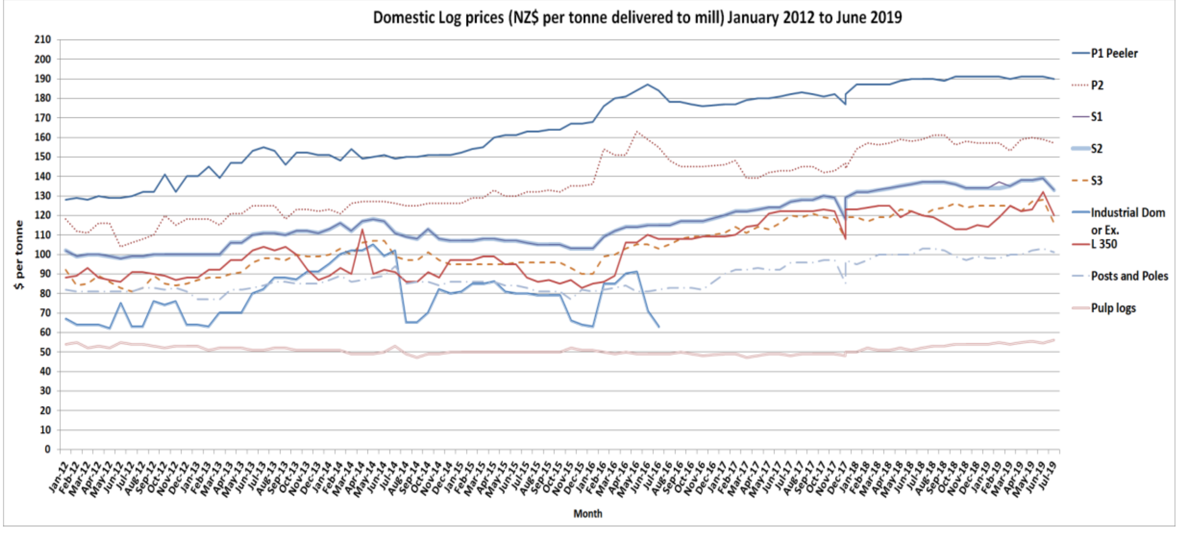
| Region | Location | Owner | Log vol. in; m3 per annum | Product | Type | Other | Chip Factor | By-product chip | Product out | kWh per unit of product | Annual power demand; GWh | Heat Plant Yes or No | Heat plant size, MW | Fuel type | Heat plant, Loading | Heat output, Gwh | Fuel demand, GJ p.a. | Wood Fuel demand, green tonnes p.a. | Log grade in | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gisborne | Ruatoria | Ron Hedley Ltd | 9,000 | Sawn Lumber | Structural | Treated wood | 0.28 | 2,520 | 5,000 | 21 | 0.105 | N | - | | | | | - | S and A | Small sawmill |
| Gisborne | Matawhero | Juken NZ Limited | 65,000 | LVL | Structural | | | | 55,000 | 279 | 15.345 | Y | 5 | Gas | 0.8 | 28.03 | 118,724 | - | Pruned and S1 | Integrated site shares boiler with saw mill |
| Gisborne | Matawhero | Juken NZ Limited | 50,000 | Sawn Lumber | Appearance | | 0.22 | 11,000 | 28,000 | 21 | 0.588 | N | - | Wood residuals | 0.75 | | | - | Pruned and A | 100% pruned, export |
| Gisborne | Makaraka | Larsen Sawmilling Ltd | 5,000 | Treated products | Posts, poles | Sawn lumber | 0.15 | 1,500 | 3,000 | 21 | 0.063 | N | - | | | | | - | Post and poles | Mostly treated poducts |
| Gisborne | Matawhero | Far East sawmills | 30,000 | Sawn Lumber | Appearance | | 0.25 | 7,500 | 16,000 | 21 | 0.336 | Y | 4 | Wood residuals | 0.55 | 15.42 | 65,298 | 9,463 | S and A | Redevelopment of mill closed in 2009 |
| Gisborne | Matawhero | WET Ltd | 25,000 | OEL™ | Structural | | 0.2 | 5,000 | 13,000 | 98 | 1.274 | N | - | | | | | - | A and K | Commercial demo plant |
| Wairoa | Wairoa North | East Coast Lumber | 30,000 | Sawn lumber | Appearance | | 0.24 | 7,200 | 16,000 | 21 | 0.336 | Y | 3 | Wood residuals | 0.65 | 13.67 | 57,878 | 8,388 | Pruned and S1 | 90% pruned |
| Wairoa | Wairoa North | Wairoa Timber processors | 10,000 | Sawn lumber | Structural | | 0.22 | 2,200 | 5,500 | 21 | 0.1155 | Y | 4 | Wood residuals | 0.35 | 9.81 | 41,553 | 6,022 | S and A | Aligned with East Coast Lumber |

# Appendix D – Log prices

## Export log prices




## Domestic log prices



**Appendix D - continued**

**Long run (7.5 year) average log prices NZ$/tonne delivered to wharf or mill**

| Log Grade | $/m³ | $/odt |
|---|---|---|
| P1 Peeler | $ 164 | $ 411 |
| P2 | $ 136 | $ 339 |
| Export P | $ 155 | $ 388 |
| | | |
| S1 | $ 115 | $ 289 |
| S2 | $ 115 | $ 289 |
| S3 | $ 104 | $ 259 |
| | | |
| Industrial Dom or Ex. | $ 78 | $ 196 |
| | | |
| L 350 | $ 102 | $ 256 |
| A | $ 111 | $ 277 |
| K | $ 105 | $ 263 |
| KS | $ 102 | $ 256 |
| KI | $ 97 | $ 242 |
| Posts and Poles | $ 88 | $ 220 |
| Pulp logs | $ 51 | $ 127 |

# Appendix E - GHG emissions by energy unit for different fuels (kg $CO_2e$ per GJ)

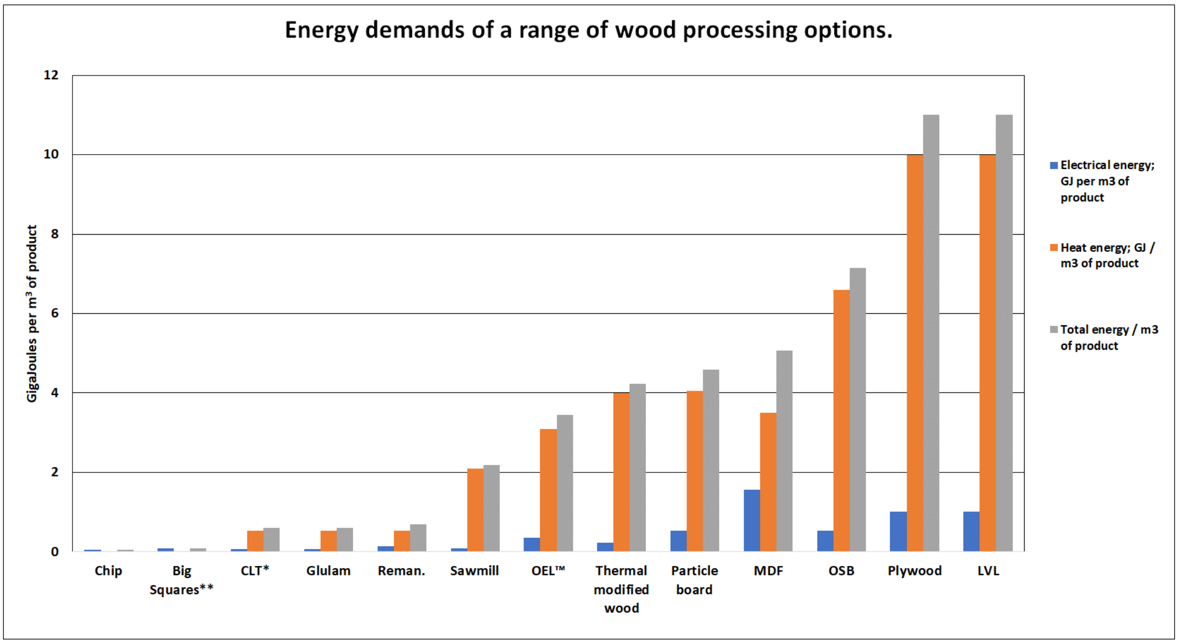
| Fuel | kg CO2e per GJ |
|---|---|
| Wood | 2.17 |
| Electricity* | 27.1 |
| Natural gas | 54.1 |
| LPG | 65.2 |
| Coal** | 100.5 |

*can vary with mix of electricity generation source
**assumes sub-bituminous coal at 20GJ per tonne

# Appendix F – Heat and electricity demand for different wood processing options

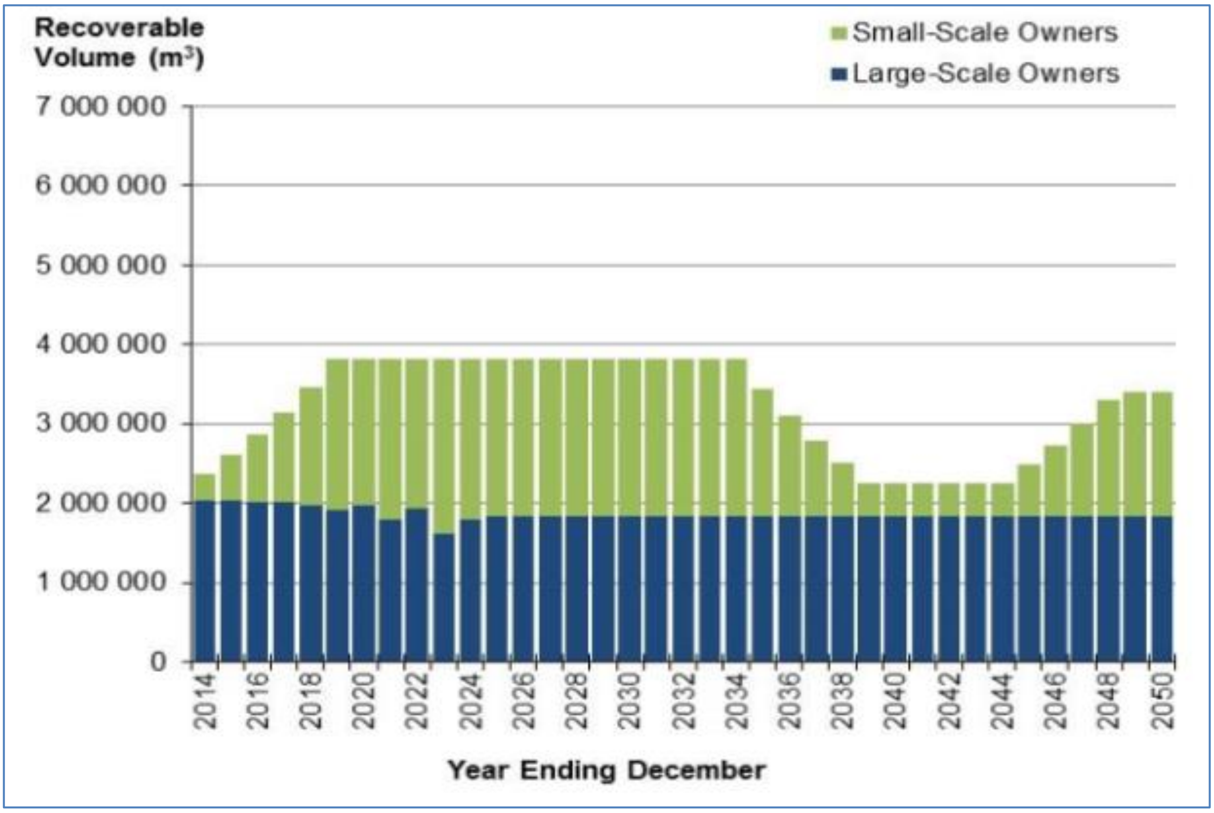
| Process | Heat energy demand; GJ / m³ of product | Electrical energy demand; kWh / m³ of product |
|---|---|---|
| Sawmill | 2.10 | 25 |
| OEL™ | 3.10 | 98 |
| Reman. | 0.54 | 41 |
| Thermal modified wood | 4.00 | 65 |
| CLT* | 0.54 | 19 |
| Particle board | 4.05 | 150 |
| MDF | 3.50 | 433 |
| Plywood | 10.00 | 279 |
| LVL | 10.00 | 279 |
| OSB | 6.60 | 150 |
| Glulam | 0.54 | 19 |
| Big Squares** | 0 | 25 |
| Wood pellets | 1.8 (odt) | 160 (odt) |
| Briquettes (extrude) | 3.2 | 400 |
| Briquettes (roll) | 2.1 | 160 |
| Chip | - | 15 |

***assumes its buying in kiln dried lumber from a sawmill**
****no forced drying – sold green with a anti sap-stain treatment applied**



# Appendix G - projected forest harvest by small and large owners

**Source – Ministry of Primary Industries; Wood Availability Forecasts East Coast (2014)**



# Appendix H – potential material flows between processing types