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# Comparing green-house gas emissions of onshore and offshore log processing; Gisborne, New Zealand versus China

Peter Hall, written April 2020

# Report information sheet

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# Executive summary

The aim of this study was to quantify and describe the green-house gas emissions from energy use in six wood processing options (sawn lumber, LVL, plywood, particle board, OSB and MDF) with differing supply chains. The principle difference being that the New Zealand grown logs could be processed into products in New Zealand and the products shipped to China; or the logs could be exported to China and manufactured into finished products in China.

The functional unit was 1 cubic metre ($m^3$) of the products in a wholesale market in China. The GHG outputs were summarised as kg of $CO_2$-e per $m^3$ of product. The scope of the study was limited to emissions associated with energy used in log production, processing and transport of logs and products.

## Key results

For all the products, the energy related green-house gas (GHG) emissions associated with the log to finished wood product processing were substantially less with processing in New Zealand. The supply chain emissions for transport and processing energy for sawmilling in NZ and delivering the product to China were 38% of the emissions of delivering the logs to a sawmill in China and processing them there. For the LVL and plywood New Zealand based processing emissions were 40 to 49% of those from processing in China. For particle board products, the emissions of processing in New Zealand were 43 to 50% of those from processing in China. Even allowing for higher yields of products for sawn lumber and plywood in China due to differing processing practices, the difference between New Zealand and China emissions is substantial. In the worst case, New Zealand sawn lumber emissions are 44% of the emissions associated with making sawn lumber in China.

Energy related GHG emissions; kg of $CO_2$-e per $m^3$ of product delivered into a China market*

| **Wood prod**uct | **NZ based processing** *kg $CO_2$e per $m^3$* | **China based processing** *kg $CO_2$e per $m^3$* | **Difference** *kg $CO_2$e per $m^3$* | **Emissions; NZ processing as a % of China based processing** |
|---|---|---|---|---|
| **Sawn lumber China Low yield*** | 264.1 | 703.8 | 439.7 | 37.5% |
| **Sawn Lumber China High yield*** | 264.1 | 585.3 | 321.2 | 45.1% |
| **LVL** | 602.2 | 1,281.7 | 679.5 | 47.0% |
| **Plywood China High yield*** | 602.2 | 1,230.5 | 628.3 | 48.9% |
| **Plywood China Low yield*** | 602.2 | 1,488.8 | 886.6 | 40.4% |
| **Particle Board** | 378.9 | 755.8 | 376.9 | 50.1% |
| **OSB** | 346.8 | 717.8 | 371.0 | 48.3% |
| **MDF** | 438.2 | 1,015.2 | 577.0 | 43.2% |

*The yield of product per $m^3$ of log in China is typically higher than for New Zealand mills, but it also varies, hence a range of results is presented

The principal drivers of the differences in the GHG emissions were;

- The much lower GHG emissions from electricity generation in NZ compared to China (NZ at 0.0977 kg $CO_2$-e/kWh versus China at 0.825 kg $CO_2$-e/kWh respectively)
- The dry (12% moisture content) and processed nature of the products being shipped if processing occurs in New Zealand versus green whole logs at 58% moisture content. With processing in New Zealand, the tonnage being shipped is approximately 25% in the case of sawn lumber, LVL and plywood; and 41% in the case of particle board, MDF and OSB.

The drivers of the weight difference are the drying of the processed materials which removes approximately half the weight and the conversion factors for logs to products, which are quite low for sawn lumber (~57% in New Zealand and up to 75% in China), LVL and plywood (~55% in New Zealand, higher in China) with reconstituted board products higher at ~90% in both countries.

When the conversion factors and moisture content reduction are combined the shipped weight difference for the products versus logs are;

- NZ Sawn lumber; 0.255 of the original log weight
- China Sawn lumber low; 0.278 of the original log weight
- China sawn lumber high; 0.336 of the original log weight
- LVL; 0.259 of the original log weight
- NZ Plywood; 0.259 of the original log weight
- China plywood low; 0.202 of the original log weight
- China plywood high; 0.292 of the original log weight
- Particle board; 0.383 of the original log weight
- OSB; 0.383 of the original log weight
- MDF; 0.383 of the original log weight

A further benefit of processing logs in New Zealand is the reduced need for fumigation of export logs and associated ozone depleting emissions of methyl bromide.

## Further work

The analysis could be extended to cover a wider range of products including; remanufactured lumber (mouldings etc), wood pellets, Cross Laminated Timber, modified wood and a range of other wood products.

This analysis identified significant reductions in energy related GHG emissions from processing logs in New Zealand as opposed to in China. However, there are further issues that would be worth more detailed investigation to determine the wider magnitude of the opportunity;

- the full impact of harvested wood products, half-life and total carbon stored; and the impact to our National Greenhouse Gas Inventory reported emissions.

- a full LCA (Life Cycle Analysis) of the impact of wood processing in New Zealand versus China.

- a full analysis of the impact of employment and Gross Domestic Product of the expanded wood processing based on the potential wood available in New Zealand taking into account long run variations in wood supply by region.

- an assessment of the GHGs per job in wood processing versus other primary and manufacturing industries in New Zealand.

- a market assessment to determine the potential for large scale expansion of wood processing in New Zealand where the intention is selling the product into international markets.

# Comparing green-house gas emissions of onshore and offshore log processing; Gisborne, New Zealand versus China

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### *Glossary*

| | |
|---|---|
| c. f. | conversion factor ($m^3$ of product per $m^3$ of log) |
| CLT | cross laminated timber |
| $CO_2$-e | carbon dioxide equivalent |
| GHG | green-house gas |
| GJ | gigajoule |
| kWh | kilowatt hour |
| kg | kilogram |
| LVL | laminated veneer lumber |
| MDF | medium density fibreboard |
| $m^3$ | cubic metre |
| MCwb | moisture content wet basis |
| NG | natural gas |
| OSB | oriented strand board |
| odt | oven dry tonne |
| PB | particle board |
| t | tonne |
| t/km | tonne / kilometre |

# Introduction

The goal and scope of this work (Appendix A) is to quantify and describe the difference in energy related GHG emissions between processing New Zealand grown Pinus radiata logs into wood products in New Zealand (based in Gisborne) versus exporting the same logs and making them into the same wood products in China.

The end-point is 1 cubic metre of finished product in a wholesale market in China.

This analysis is not a full Life Cycle Analysis but focusses on two areas where there were identified major differences between countries (the emissions from electricity) and supply chains (the amount of material transported).

The wood products targeted specifically are kiln dried and dressed sawn lumber (from A grade logs), laminated veneer lumber (LVL) and plywood made from P and S grade logs and particle board, MDF and OSB made from chip / pulp grade logs.

The main areas of focus are the differences in energy emissions (particularly those from electricity generation, Appendix D) that will occur during processing in New Zealand or China and the effect of shipping logs versus finished products on transport emissions (Appendix C). When logs are processed into products there is a conversion loss (e.g. from logs to lumber) and moisture loss when the products are dried from around 58% moisture content wet basis (MCwb) to around 12% MCwb. These losses substantially reduce the weight of the wood in the products being transported. For example; 1 $m^3$ of green logs will weigh around 960kg and contain around 557 kg of water. This will convert into 0.55 $m^3$ of sawn dried lumber containing around 66 kg of water with a total weight of approximately 255kg. The implication is that by doing the sawmilling and drying in New Zealand, the tonnage to be shipped is reduced by approximately 73% if the goal is to deliver equivalent volumes of sawn lumber into a market in China.

Scion has data on fuel use during growing, harvesting and transport (to port or mill) of logs in New Zealand (Gifford et al 1998,) plus updates via Scion's Harvesting and Transport costing tool which was derived from Riddle, 1994. Informe Harvesting 2019 also provided data inputs to the fuel consumption analysis. The GHG emissions from this fuel use will be the same for either supply chain option as the logs are assumed to have the same inputs into their production whether they are supplied to either a processing site near Gisborne or to Eastland Port.

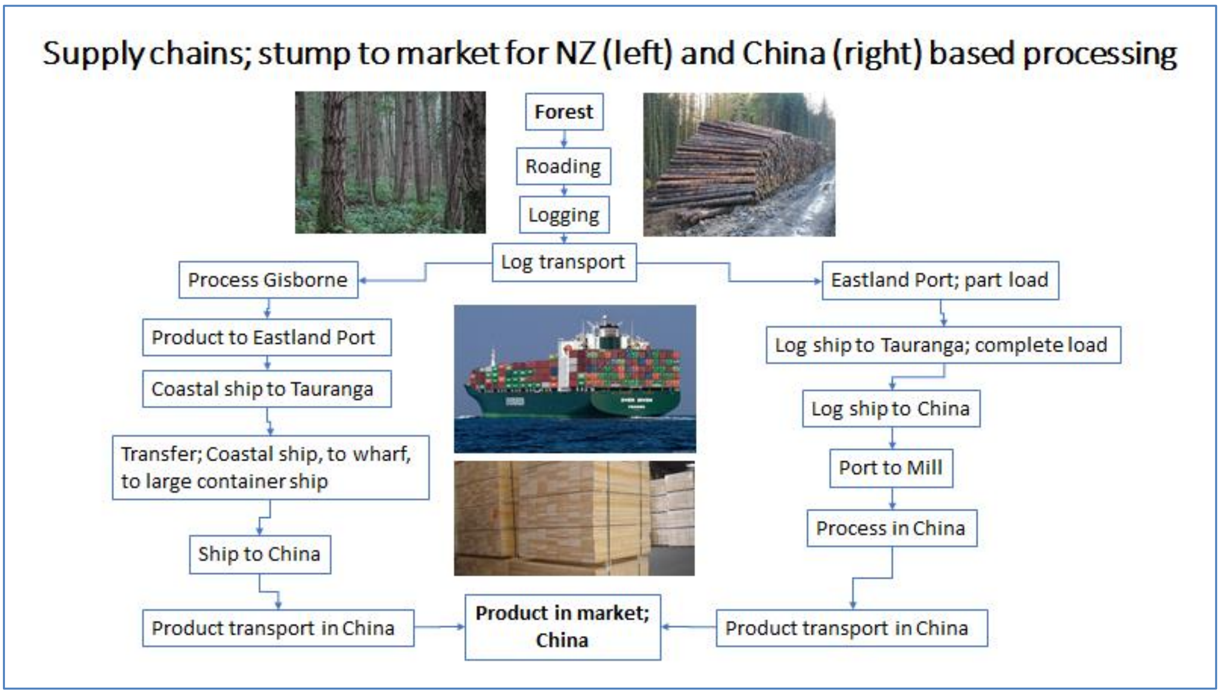
This study is not a full Life Cycle Analysis (LCA) of the process, as it does not cover the non-energy inputs and outputs (e.g. water / packaging / glues / chemicals). It is intended to identify the potentially large differences in energy derived GHG emission between the options of processing in New Zealand or in China based on two key assumptions;

- Electricity used in the processing in New Zealand will have much lower emissions associated with its generation than that used in China by a factor of over 8 - New Zealand at 0.0977 kg $CO_2$-e/kWh (MfE 2019) versus China at 0.825 kg $CO_2$-e/kWh (Li et al 2017).
- The shipping of processed product, which is dried (and has benefitted from the use of processing residuals as low carbon energy in its manufacture) will significantly reduce the number of tonnes being shipped from NZ to China, thus reducing the GHG emissions from this source.

The two supply chains being assessed are shown in Figure 1. The inputs to get the logs to port or mill in New Zealand are assumed to be the same. In both instances the cargo that is loaded in Gisborne also has to go through the Port of Tauranga before it goes to China. In the case of logs, the ships will typically fill the above deck cargo space in Tauranga due to limits on draft in Eastland Port and limits on fumigating logs[1]. For the processed products, the assumption is that the product is shipped in containers and these will be taken by coastal vessel from Gisborne to Tauranga before being transferred via the wharf at Tauranga to a larger vessel for shipping to China.

[1] Gisborne cannot do methyl bromide treatment of logs which go in the above deck space on log ships. Tauranga does have this capacity and so ships part loaded in Gisborne often then go to Tauranga to get a full load, including the above deck proportion.

Figure 1 – outline of supply chains with processing in NZ (left) versus processing in China (right)




**Note, in Figure 1 above;**

1. Process covers all processing options
2. An assumption is that product transport within China; mill to wholesale market or wharf to wholesale market is 50km.

For some products the conversion of logs to products is the same in China, as it is in New Zealand as the processes are typically large and automated (particle board, MDF, OSB) and the fibre yields are high, at around 90%.

For other products, such as sawn lumber and plywood, some mills in China use a lot more labour-intensive processes to increase the yields of product. This applies to sawmilling and plywood manufacture. China does not make much if any LVL from radiata pine logs from New Zealand.

The onshore wood processing opportunity presented by log exports nationally and in the Gisborne region, is significant. In 2019 New Zealand exported 21.7 million $m^3$ of logs (worth $3.450 billion), with 17.7 million $m^3$ of this (worth $2.759 billion) going to China (MPI website data, April 2020). The Gisborne region exported 2.98 million $m^3$ of logs worth an estimated $466 million.

# Methods

Fuel consumption for growing, logging and transporting of logs in New Zealand were derived from several sources (Gifford et al, 1998; Blackburne, 2009; Riddle, 2004; Scion unpublished data 2017 & 2018; NZFOA, 2007). This data was summarised into litres of diesel equivalent and the GHGs per $m^3$ of log were derived. The fuel consumption data for forest growing was derived from a full LCA study (Gifford et al, 1998) which included all the fuel used in establishing, tending and managing a forest; starting with energy use in a nursery providing seedlings, and then working through all the subsequent operations including land preparation (mechanical and chemical), planting, releasing, thinning, supervision etc.

A total figure for fuel consumption by fuel type (petrol, diesel and jet fuel) per hectare of forest was derived and converted into a per cubic metre consumption based on an estimated yield for forests grown in Gisborne (total recoverable volume 627 $m^3$ / ha) (MPI 2015 yield tables).

The fuel used in roading and landing construction were based on heavy machinery fuel use consumption figures (Informe, 2019) and earthmoving productivity figures obtained from publications (Robinson, 2011) and industry experts. Once the fuel used in the construction of a km of road and per landing were derived, these were converted to a per cubic metre basis using and an estimate of the kilometres of road and number of landings required to harvest the largely steep terrain that occurs in Gisborne. Yield of logs per ha is also used here.

A transport distance from forests to mill of 100km was assumed. The national average log transport was reported as 86km (NZFOA, 2007). However, we assumed that this would be slightly longer for East Coast forests (100km). An average haul distance of 100km implies a round trip distance of 200km (100km loaded and 100km unloaded) and a maximum log haul distance of round 150 to 160km. Fuel consumption figures for a log truck laden and unladen were used to estimate total fuel consumption.

Energy consumption and energy related GHG emissions from wood processing were derived from the WoodScape study (Jack et al, 2013) and the model which underpinned that analysis. These assumptions were supported by and adjusted based on data in other reports found in the literature and online (Jaques, 2004; Li et al, 2009; Wang et al, 2017 and Wilson, 2010).

The electricity emissions factor for New Zealand (0.0977 kg $CO_2$-e/kWh) was based on those reported in MBIE 2019a. The electricity emissions factor for China (0.825 kg $CO_2$-e/kWh) was derived from different studies (Li et al, 2009, Lixue et al 2013).

Shipping emissions factors were based on those reported in MBIE 2019b and from information supplied by local shipping industry (Tony Spelman, Pers. comm.) (Appendices B and C.)

The processing of logs to products, which affects the tonnages to be moved, were based on the following;

- 1$m^3$ of log weighs 960kg and has a moisture content wet basis (MCwb) of 58%, with the wood having a basic density of ~400 kg per $m^3$ (380 to 420 kg per $m^3$ depending on log grade)

- The conversion factor (c.f.) for logs to sawn lumber in a modern mill in New Zealand is 1:0.57 by volume and the kiln dried lumber as a MCwb 12%, giving a tonne per $m^3$ of lumber of 0.45 and 0.248 t of dried lumber per $m^3$ of log in. In China, the conversion of logs to lumber can have much higher ratios of lumber out (1:0.62 to 1:0.75) due to higher labour inputs and much greater re-sawing of small pieces of slabwood.

- Conversion of logs to LVL is approximately 1:0.55 by volume and the LVL has a MCwb of 12% giving a t/$m^3$ LVL of 0.45 and 0.259 of LVL per $m^3$ of log in. The conversion figures for LVL are the same for New Zealand and China – although China does not make much if any LVL from radiata pine (Manley and Evison, 2016).

- Conversion of logs to plywood in New Zealand is assumed to be 1:0.55. For China this is likely to vary, depending on the logs being used and the type of plywood being made. In some instances (larger diameter logs), the yield is expected to be higher (1:0.62) and lower in others (small diameter logs (1:0.45) (Arnold et al 2013). In the case of the larger logs going into plywood in China, the fish tails produced before a continuous peel is achieved are used as filler in an inside layer of the ply. New Zealand does not typically use small diameter logs for making plywood.

- Conversion of logs to reconstituted board products is assumed to be 90% by volume. The particle board has a MCwb of 12% giving tonnes of particle board per $m^3$ of log of 1 to 0.455.

## Other assumptions

Heat demand not able to be produced from wood processing residuals (sawdust, shavings etc.) was met from natural gas (NG). Some processes (plywood and LVL) have a high heat demand and a high level of processing residuals, whereas other processes (MDF, particle board) have a high heat demand and low percentage of residuals produced.

Sawmills typically have a slight excess of residuals versus heat demand, LVL, plywood and reconstituted boards generally have a heat deficit that must be met from another fuel source, here we assume that to be NG.

GHG emissions from NG combustion are the same for both NZ and China.

GHG emissions from Diesel combustion are the same for NZ and China.

Road transport emissions per tonne / km on truck are the same for NZ and China.

The amount of heat and electricity used per $m^3$ of product in the processing does not vary between countries, nor do the emissions from heat as the wood residues and natural gas emissions are assumed to be the same regardless of country.

# Results

The results of the analysis are shown in Tables 1 (sawn lumber), 2 (reconstituted panel products) and 3 (LVL and plywood). The inputs for forest growing, roading, log harvest and log transport are the same for processing in New Zealand or China as these do not vary per $m^3$ of log delivered to a wharf or mill. They do vary with the product being made due to the variation in log to product conversion factors between products.

The major differences in processing emissions comes from electricity used. Whilst the amounts used per cubic metre processed are assumed to be the same in both countries[2], allowing for variation by product; China has much higher emissions for its electricity as the majority of the electricity is generated from fossil-fired thermal plants (coal and gas) whereas New Zealand's electricity is largely from renewable sources (Appendix D).

The emissions associated with ship transport are substantially different for processing in New Zealand versus China. For example; in New Zealand 1 tonne of logs converts to approximately 0.255 tonne of sawn lumber, so processing in New Zealand reduces the tonnage to be shipped significantly.

Table 1 – Energy related GHG emissions (kg $CO_2$-e) per $m^3$ of processed wood product (sawn lumber) delivered to a wholesale market in China.

| **Country** | **NZ** | **China** | **China** | **China** |
|---|---|---|---|---|
| Product | Sawn Lumber | Sawn Lumber c.f. as per NZ | Sawn Lumber Low c.f. | Sawn Lumber High c.f. |
| Grow | 0.8 | 0.8 | 0.7 | 0.6 |
| Road | 13.2 | 13.2 | 12.1 | 10.0 |
| Log | 15.9 | 15.9 | 14.6 | 12.1 |
| Transport | 47.6 | 47.6 | 43.8 | 36.2 |
| **Delivered NZ mill** | **77.5** | | | |
| **Delivered NZ port** | | **77.5** | **71.2** | **58.9** |
| | | | | |
| Electricity | 2.1 | 17.3 | 17.3 | 17.3 |
| Heat | *0.0* | 0.0 | 0.0 | 0.0 |
| **Process energy** | **2.1** | **17.3** | **17.3** | **17.3** |
| | | | | |
| Transport to port | 1.8 | 0.0 | 0.0 | 0.0 |
| Load | 1.0 | 3.7 | 3.4 | 2.8 |
| Coastal ship | 13.5 | 7.0 | 6.5 | 5.4 |
| Unload | 1.0 | 3.7 | 3.4 | 2.8 |
| Load | 1.0 | 3.7 | 3.4 | 2.8 |
| Ship to China | 163.8 | 641.6 | 589.3 | 487.6 |
| Transport to market | 2.6 | 10.0 | 9.2 | 7.6 |
| **Product transport** | **184.6** | **669.8** | **615.3** | **509.1** |
| | | | | |
| **Total** | **264.1** | **764.6** | **703.8** | **585.3** |
| ***NZ emissions as a % of China*** | | ***34.5%*** | ***37.5%*** | ***45.1%*** |

[2] The electricity consumption in Chinese sawmills is not known, and as in New Zealand will vary from mill to mill. However, the process is fundamentally the same and the assumption is that a modern mill in either country will be very similar in its energy use for both electricity and heat, as these technologies are very mature.

Emissions from heat demand are the same for both countries as the assumption is that wood residues will be used as much as possible and when there are insufficient wood residues, natural gas will be used.

There is limited variation assumed for the conversion of log fibre to reconstituted panels between New Zealand and China (Table 2). These products have high conversion factors in both countries.

Table 2 – GHG emissions ($kgCO_{2}$-e) per $m^3$ of additional processed wood product (reconstituted panel products) delivered to a wholesale market in China.

| **Country** | **NZ** | **NZ** | **NZ** | **China** | **China** | **China** |
|---|---|---|---|---|---|---|
| Product | Particle board | OSB | MDF | Particle board | OSB | MDF |
| Grow | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Road | 8.8 | 8.8 | 8.8 | 8.8 | 8.8 | 8.8 |
| Log | 10.6 | 10.6 | 10.6 | 10.6 | 10.6 | 10.6 |
| Transport | 31.8 | 31.8 | 31.8 | 31.8 | 31.8 | 31.8 |
| **Delivered NZ mill** | **51.6** | **51.6** | **51.6** | | | |
| **Delivered NZ port** | | | | **51.6** | **51.6** | **51.6** |
| | | | | | | |
| Electricity | 15.4 | 14.7 | 42.3 | 130.4 | 123.8 | 357.2 |
| Heat | 127.3 | 95.9 | 159.7 | 127.3 | 95.9 | 159.7 |
| **Process energy** | **142.7** | **110.5** | **202.0** | **257.6** | **219.6** | **516.9** |
| | | | | | | |
| Transport to port | 1.8 | 1.8 | 1.8 | 0.0 | 0.0 | 0.0 |
| Load | 1.0 | 1.0 | 1.0 | 2.5 | 2.5 | 2.5 |
| Coastal ship | 13.5 | 13.5 | 13.5 | 4.7 | 4.7 | 4.7 |
| Unload | 1.0 | 1.0 | 1.0 | 2.5 | 2.5 | 2.5 |
| Load | 1.0 | 1.0 | 1.0 | 2.5 | 2.5 | 2.5 |
| Ship to China | 163.8 | 163.8 | 163.8 | 427.7 | 427.7 | 427.7 |
| Transport to market | 2.6 | 2.6 | 2.6 | 6.7 | 6.7 | 6.7 |
| **Product transport** | 184.6 | 184.6 | 184.6 | 446.6 | 446.6 | 446.6 |
| | | | | | | |
| **Total** | **378.9** | **346.8** | **438.2** | **755.8** | **717.8** | **1015.2** |
| ***NZ emissions as a % of China*** | | | | ***50.1%*** | ***48.3%*** | ***43.2%*** |

There are other non-energy emissions associated with processing the various products, such as glues and packaging. However, these are likely to be relatively small in comparison to the energy emissions.

Table 3 shows the comparison between New Zealand and China for LVL and plywood processing. LVL is assumed to have the same recovery in both countries. However, there is little manufacture of LVL from radiata pine in China.

For plywood, there are a range of yields possible;

- similar to NZ
- higher than NZ due to higher labour inputs and use of fishtails[3] in inner ply layers
- lower than NZ due to the use of small diameter low quality logs where the ratio of continuous peel to fish tails is lower.

[3] Fishtails are the uneven and incomplete pieces of veneer peeled off the outer part of the log before the lathe makes it round and is able to make a continuous veneer / peel. This material is sometimes called round-up

Table 3 – GHG emissions (kg$CO_2$-e) per $m^3$ of additional processed wood product (LVL and Plywood) delivered to a wholesale market in China.

| | NZ | China | NZ | China | China | China |
|---|---|---|---|---|---|---|
| | LVL | LVL | Plywood | Plywood c.f. as NZ | Plywood high c.f. | Plywood low c.f. |
| Grow | 0.8 | 0.8 | 0.8 | 0.8 | 0.7 | 1.0 |
| Road | 13.0 | 13.0 | 13.0 | 13.0 | 12.1 | 16.6 |
| Log | 15.7 | 15.7 | 15.7 | 15.7 | 14.6 | 20.1 |
| Transport | 47.0 | 47.0 | 47.0 | 47.0 | 43.8 | 60.2 |
| **Delivered NZ mill** | **76.5** | | **76.5** | | | |
| **Delivered NZ port** | | **76.5** | | **76.5** | **71.2** | **97.9** |
| | | | | | | |
| Electricity | 27.3 | 230.2 | 27.3 | 230.2 | 230.2 | 230.2 |
| Heat | 313.9 | 313.9 | 313.9 | 313.9 | 313.9 | 313.9 |
| **Process energy** | **341.2** | **544.1** | **341.2** | **544.1** | **544.1** | **544.1** |
| | | | | | | |
| Transport to port | 1.8 | 0.0 | 1.8 | 0.0 | 0.0 | 0.0 |
| Load | 1.0 | 3.7 | 1.0 | 3.7 | 3.4 | 4.7 |
| Coastal ship | 13.5 | 7.0 | 13.5 | 7.0 | 6.5 | 8.9 |
| Unload | 1.0 | 3.7 | 1.0 | 3.7 | 3.4 | 4.7 |
| Load | 1.0 | 3.7 | 1.0 | 3.7 | 3.4 | 4.7 |
| Ship to China | 163.8 | 633.2 | 163.8 | 633.2 | 589.3 | 811.0 |
| Transport to market | 2.6 | 9.9 | 2.6 | 9.9 | 9.2 | 12.7 |
| **Product transport** | **184.6** | **661.1** | **184.6** | **661.1** | **615.3** | **846.8** |
| | | | | | | |
| **Total** | **602.2** | **1281.7** | **602.2** | **1281.7** | **1230.5** | **1488.8** |
| ***NZ emissions as a % of China*** | | ***47.0%*** | | ***47.0%*** | ***48.9%*** | ***40.4%*** |

## *Other considerations*

One of the emissions avoided if logs are processed in New Zealand is that associated with the use of Methyl Bromide (MeBr). MeBr is used as a fumigant on logs which are being exported from New Zealand to kill insects and pathogens. This chemical is highly toxic and is only applied to the proportion of a log ship's cargo that is stored above the ships deck during transport. The proportion of the load that is stored in the ship holds are generally treated with phosphene during the ships travel from New Zealand to the export destination. Nationally, around 28% of export logs are treated with MeBr and 65% with phosphene. The balance is exported debarked (MPI, 2020).

MeBr is widely regarded as problematic as it needs to be carefully managed in order to avoid it causing health issues for those working on or near the fumigation site. It is also an ozone depleting substance and is included in the Ozone Layer Protection Act in 1996. The purpose of the Act is to phase out ozone-depleting substances, which includes CFCs and methyl bromide. MeBr has a Global Warming Potential (in a 100-year period) of 5 kg CO2-e (MfE 2019). The GHG emissions from this material are very low on a per cubic metre of log basis as only a very small amount of MeBr is consumed per $m^3$ of log exported (0.0135 kg per $m^3$ of log) meaning that the GHG emissions associated with the MeBr are estimated to be 0.0675 kg per $m^3$. This is a trivial amount in comparison to the emissions from energy used in delivering logs or wood products from NZ to China. However, the other issues (health and ozone depletion) are regarded as significant.

The use of MeBr as a fumigant is set to be banned from October 2020 unless the fumigation operations can recapture or destroy the MeBr; other chemicals may be used instead (MPI, 2020). Processing logs in New Zealand eliminates the need to use MeBr (or any other chemical) as a fumigant as well as the GHG emissions from MeBr and the other issues that this chemical pose.

# Discussion

The export of logs from New Zealand to China is substantial. In 2019 New Zealand exported 21.7 million $m^3$ of logs worth $3.451 billion. Of this volume 17.3 million $m^3$ (79%) went to China. The total log export volume from Gisborne was 2.98 million $m^3$, worth $466 million. If the national average ratio of total exports is assumed to go to China from Gisborne, then there would have been around 2.35 million $m^3$ of logs going from Gisborne to China. Whilst these volumes are expected to drop post 2035 as New Zealand's wood availability declines, the volumes of logs available in New Zealand are still expected to exceed processing capacity in most regions. In the case of Gisborne, the current log volume processed, whilst expanding, is still only around 5 to 10% of the total available harvest.

Beyond the reduction in energy related GHG emissions there are other potential benefits of processing logs in New Zealand. Increased onshore wood processing would lead to increases in employment and GDP. This was not addressed specifically in this analysis as employment and GDP figures are affected by the scale of the plants. However, a recent study conducted for the Forestry Ministerial Advisory Group (Hall, 2019) that looked at expanded wood processing in the Gisborne region gives some indication of the impact of this on employment and GDP; the clusters of processing included sawmilling, MDF, CLT remanufacturing and engineered wood products. For a cluster taking a total of 1.80M $m^3$ of logs of differing grades the direct employment was estimated at ~1,150 FTEs and GDP of ~$850 million per annum.

Wood processing, based on logs that would otherwise be exported, presents an opportunity for New Zealand to develop low carbon GDP and employment as the wood processing industry self-fuels from low carbon emission residues to a significant extent. This opportunity would seem to warrant more investigation.

If there was expansion of onshore wood processing in Gisborne, as outlined in the report to the FMAG, where 1.8 million cubic metres of logs was processed in New Zealand into a range of solid, engineered and reconstituted wood products, the reduction in GHG emissions would be in the order of 600,000 tonnes of $CO_2$-e per annum versus making the same logs into the same products in China.

If the same assumptions were applied to the current (2019) level of logs exports for the whole of New Zealand, then the reduction could be in the order of 6 million tonnes of $CO_2$-e. However, as New Zealand's wood supply varies over time, the current level of log exports is not viable in the long term. A more realistic long-term figure might be 10 million $m^3$ per annum of increased onshore processing, with an associated reduction in energy related emissions (in comparison to China) of 2.8 million tonnes of $CO_2$-e per annum.

There are several more considerations around the impact of wood processing in New Zealand or offshore on GHG emissions. In part this is down to the accounting procedures and a large number of assumptions around what products are made from the logs in China (Appendix E), and the half-lives of the various products (Appendix F). It was not the intention of this report to delve into these aspects, but the peer reviewer's comments have highlighted the need for more in-depth analysis that could be useful on a range of related topics.

# Conclusions

For all three products the GHG emissions associated with the log to finished wood product processing were substantially less in New Zealand. The supply chain emissions for sawmilling in NZ and delivering the product to China were approximately 38% to 45% of the emissions of delivering the logs to a sawmill in China and processing them there (Table 4). For LVL and plywood, New Zealand has 40 to 48% of the emissions of similar processing in China, except for small diameter logs. For reconstituted board products, the emissions of NZ based processing were 43 to 50% of those for processing in China.

Table 4 – GHG (kg $CO_{2}$-e per $m^3$ of process wood product) for New Zealand and China based processing of logs grown in New Zealand.

| **Wood prod**uct | **NZ based processing** *kg $CO_2$e per $m^3$* | **China based processing** *kg $CO_2$e per $m^3$* | **Difference** *kg $CO_2$e per $m^3$* | **Emissions from NZ processing as a % of China** |
|---|---|---|---|---|
| **Sawn lumber China Low yield*** | 264.1 | 703.8 | 439.7 | 37.5% |
| **Sawn Lumber China high yield*** | 264.1 | 585.3 | 321.2 | 45.1% |
| **LVL** | 602.2 | 1,281.7 | 679.5 | 47.0% |
| **Plywood China High yield*** | 602.2 | 1,230.5 | 628.3 | 48.9% |
| **Plywood China Low yield*** | 602.2 | 1,488.8 | 886.6 | 40.4% |
| **Particle Board** | 378.9 | 755.8 | 376.9 | 50.1% |
| **OSB** | 346.8 | 717.8 | 371.0 | 48.3% |
| **MDF** | 438.2 | 1,015.2 | 577.0 | 43.2% |

**The yield of product per $m^3$ of log in China is typically higher than for New Zealand mills, but it also varies, hence a range of results is presented.*

The principle drivers of the differences in the GHG emissions were;

- The much lower GHG emissions of electricity in NZ
- The dry and processed nature of the products being shipped if processing occurs in New Zealand; with the tonnage shipped being approximately 25% in the case of sawn lumber, ply and LVL and 41% in the case of particle board, MDF and OSB.

The drivers of the weight difference are the drying of the processed materials which removes approximately half the weight and the volumetric conversion factor of logs to products, which are for sawn lumber (57%), LVL and plywood (55%) and 90% for reconstituted board products (OSB, MDF and particle board).

Even allowing for higher yields of product per $m^3$ of log for mills in China than in New Zealand (as per Tables 1, 2 and 3) there is still a significantly lower amount of emissions from the energy inputs from processing in New Zealand.

The same methodology could be applied to other products being considered for manufacture in Gisborne, such as; wood pellets, CLT, remanufacture / mouldings and modified wood etc.

# Recommendations for further work

The analysis could be extended to cover a wider range of products including; remanufactured lumber, wood pellets, CLT, remanufactured / mouldings, modified wood and a range of other wood products.

This analysis identified significant reductions in energy related GHG emissions from processing logs in New Zealand as opposed to in China. However, there are further issues that would be worth more detailed investigation to determine the wider magnitude of the opportunity;

- the full impact of harvested wood products, half-life and total carbon stored; and the impact to our reported emissions in the National Greenhouse Gas Inventory,
- a full LCA of the impact of processing in New Zealand versus China,
- a full analysis of the impact of employment and Gross Domestic Product of the expanded wood processing based on the potential wood available in New Zealand,
- assessment of the GHGs per job in wood processing versus other primary and manufacturing industries in New Zealand,
- market assessment to determine the potential for large scale expansion of wood processing in New Zealand where the intention is selling the product into international markets.

# Acknowledgements

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# Appendix A – Scope of contract / analysis

| **Contract Details** | |
|---|---|
| Title | Wood Processing GHG analysis |
| Services | The goal of this work is to quantify and describe the difference in GHG emissions between processing NZ grown Pinus radiata logs into wood products in New Zealand (based in Gisborne) versus exporting the same logs and making them into the same wood products in China.<br>The end point is in-market in China.<br><br>Wood products targeted specifically would be sawn lumber (from A grade logs), LVL (from P and S grade logs) and particle board (from pulp logs).<br><br>Areas of focus will be on the energy emissions (particularly those from electricity) that will occur during processing and the effect of shipping logs versus finished products on transport emissions.<br><br>Scion has data on fuel use during growing, harvesting and transport (to port or mill) of logs in New Zealand. The fuel emissions from this fuel use will be the same for either supply chain option. |

# Appendix B – Shipping emissions factors by ship type and size

Source; https://www.mfe.govt.nz/sites/default/files/media/Climate%20Change/2019-detailed-guide.pdf

## 7.5. Coastal and international shipping freight

We calculated the domestic coastal shipping emission factor, table 51, based on the findings from the Samuelson paper.[45] We adopted the international shipping emission factors in table 52 from the *UK BEIS emission factors*.

**Table 51: Coastal shipping emission factors**

| Emission source | Unit | kg $CO_2$-e/unit | kg $CO_2$/unit | kg $CH_4$/unit | kg $N_2O$/unit |
|---|---|---|---|---|---|
| Container freight | tkm | 0.045 | 0.045 | 0.0001 | 0.0003 |
| Oil products | tkm | 0.016 | 0.016 | 0.00004 | 0.0001 |
| Other bulk coastal shipping | tkm | 0.030 | 0.030 | 0.0001 | 0.0002 |

Note: These numbers are rounded to three decimal places unless the number is significantly small. The kg $CH_4$ and kg $N_2O$ figures are expressed in kg $CO_2$-e.

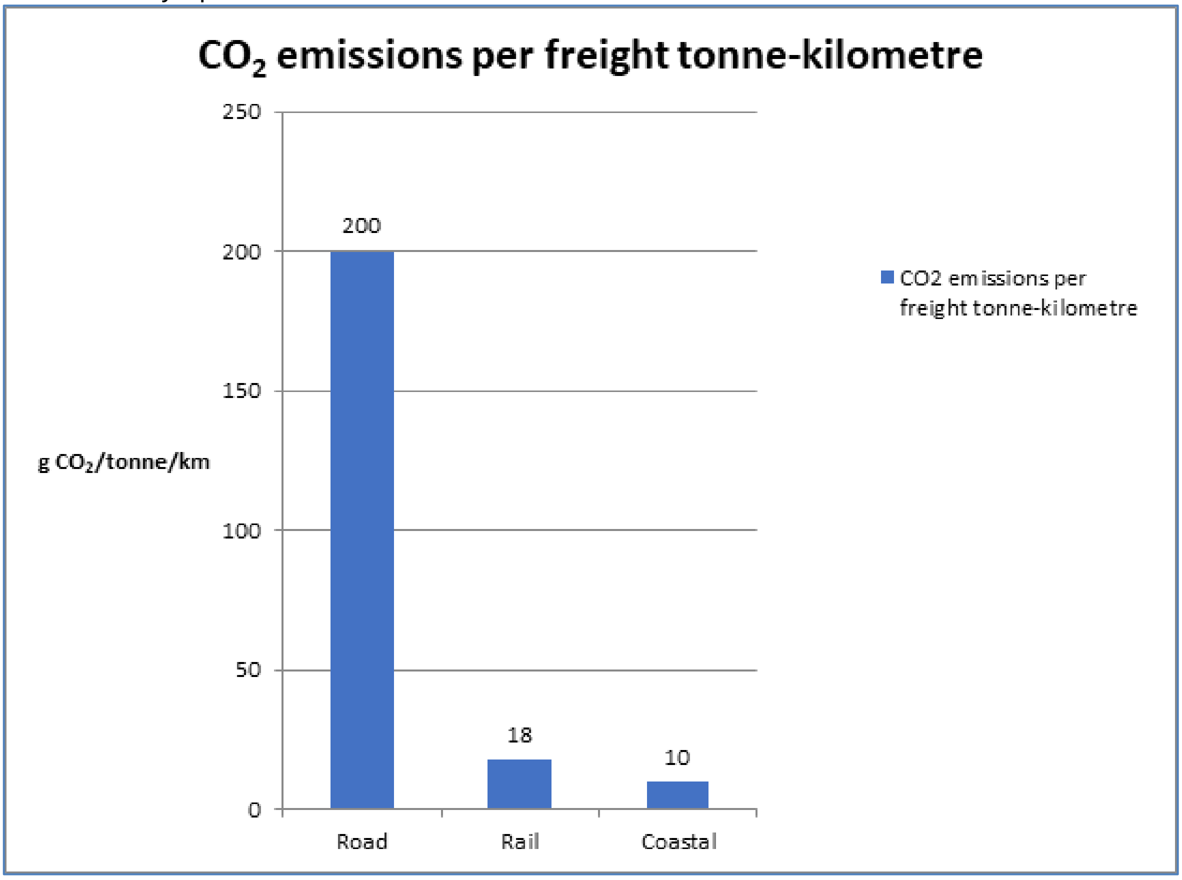
**Table 52: International shipping emission factors**

| Emission source | | Unit | kg $CO_2$-e/unit | kg $CO_2$/unit | kg $CH_4$/unit | kg $N_2O$/unit |
|---|---|---|---|---|---|---|
| Bulk carrier | 200,000+ dwt | tkm | 0.003 | 0.003 | 0.000001 | 0.00003 |
| | 100,000–199,999 dwt | tkm | 0.003 | 0.003 | 0.000001 | 0.00004 |
| | 60,000–99,999 dwt | tkm | 0.004 | 0.004 | 0.000001 | 0.0001 |
| | 35,000–59,999 dwt | tkm | 0.006 | 0.006 | 0.000002 | 0.0001 |
| | 10,000–34,999 dwt | tkm | 0.008 | 0.008 | 0.000003 | 0.0001 |
| | 0–9,999 dwt | tkm | 0.030 | 0.029 | 0.00001 | 0.0004 |
| | Average | tkm | 0.006 | 0.006 | 0.000002 | 0.0001 |
| General cargo | 10,000+ dwt | tkm | 0.012 | 0.012 | 0.000004 | 0.0002 |
| | 5,000–9,999 dwt | tkm | 0.016 | 0.016 | 0.00001 | 0.0002 |
| | 0–4,999 dwt | tkm | 0.014 | 0.014 | 0.00001 | 0.0002 |
| | 10,000+ dwt 100+ TEU | tkm | 0.011 | 0.011 | 0.000004 | 0.0002 |
| | 5,000–9,999 dwt 100+ TEU | tkm | 0.018 | 0.018 | 0.00001 | 0.0002 |
| | 0–4,999 dwt 100+ TEU | tkm | 0.020 | 0.020 | 0.00001 | 0.0003 |
| | Average | tkm | 0.012 | 0.012 | 0.000004 | 0.0002 |
| Container ship | 8,000+ TEU | tkm | 0.013 | 0.013 | 0.000004 | 0.0002 |
| | 5,000–7,999 TEU | tkm | 0.017 | 0.017 | 0.00001 | 0.0002 |
| | 3,000–4,999 TEU | tkm | 0.017 | 0.017 | 0.00001 | 0.0002 |
| | 2,000–2,999 TEU | tkm | 0.020 | 0.020 | 0.00001 | 0.0003 |
| | 1,000–1,999 TEU | tkm | 0.033 | 0.032 | 0.00001 | 0.0004 |
| | 0–999 TEU | tkm | 0.037 | 0.036 | 0.00001 | 0.0005 |
| | Average | tkm | 0.020 | 0.020 | 0.00001 | 0.0003 |
| | 4,000+ CEU | tkm | 0.032 | 0.032 | 0.00001 | 0.0004 |

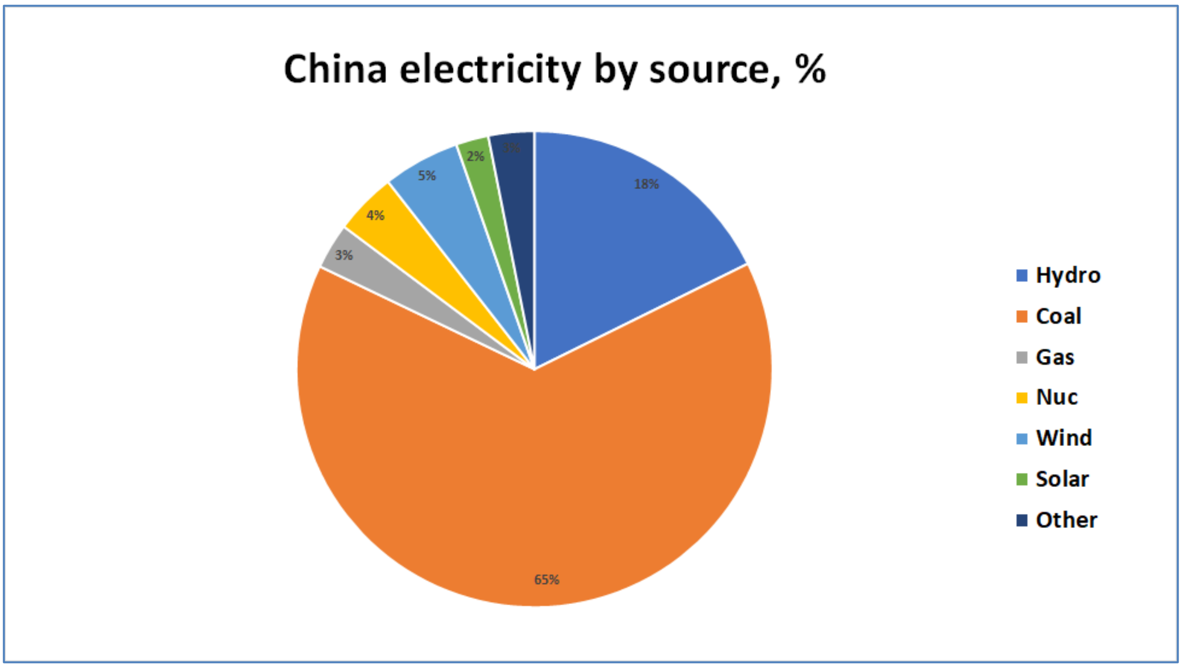
[45] What We Know and Don't Know About Freight Emissions by Mode, Ralph D Samuelson, 20 November 2018

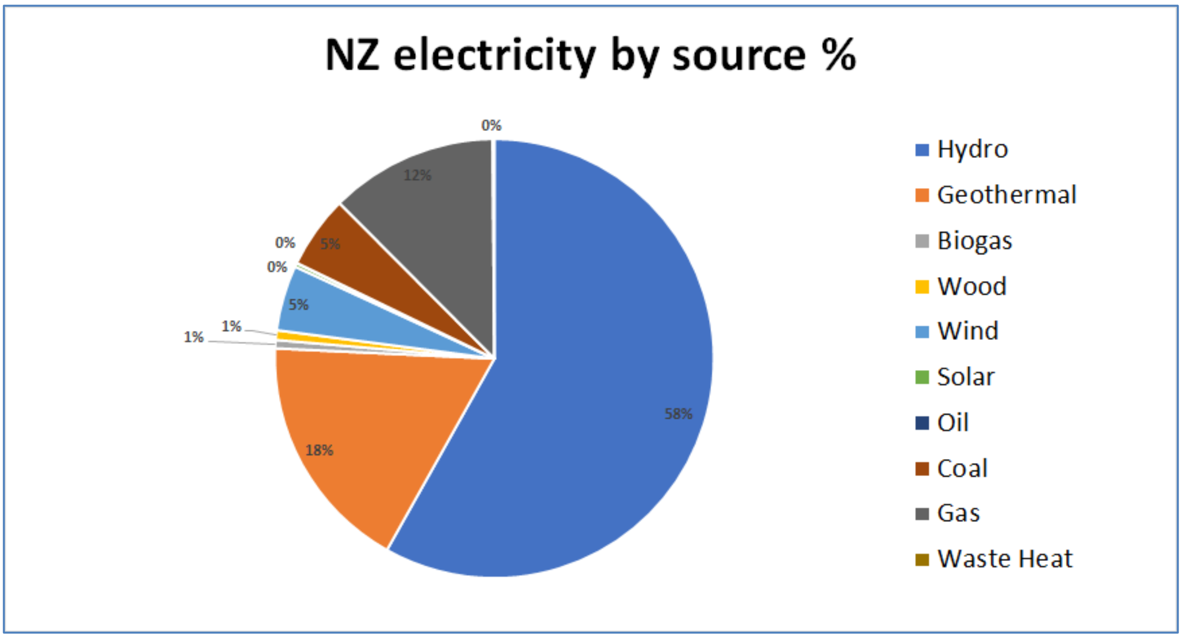
# Appendix C – Transport emissions for NZ

Source – Tony Spelman



# Appendix D - Electricity generation by type China and NZ



# Appendix E – Products made from Pinus radiata logs in China

(Source; Manley and Evison, 2016)

***China***

In 2015 China imported 10.5 million $m^3$ of logs from New Zealand including 9.9 million $m^3$ of radiata pine, 0.5 million $m^3$ of Douglas fir and 0.1 million $m^3$ of minor species. We estimate that 68% of the volume was sawn and 32% peeled to produce overall:

- 24% construction lumber
- 9% appearance lumber
- 11% packaging lumber
- 16% slabwood
- 8% sawdust
- 23% construction plywood
- 1% appearance plywood
- 3% packaging plywood
- 5% ply mill residues

# Appendix F - Half-lives of New Zealand wood products

(Source; Wakelin et al 2019).

| **Wood Product** | **Half Life, years** |
|---|---|
| Structural lumber | 35 |
| Appearance Lumber | 35 |
| Industrial Lumber | 3 |
| Plywood | 35 |
| LVL | 35 |
| CLT | 35 |
| MDF | 25 |
| Particle Board | 25 |
| Pulp | 1 |
| Paper | 0.5 |
| Posts and poles | 35 |