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Conceptual Lifecycle Greenhouse Gas Emissions for Wood Pellets Produced in New Zealand and Exported to Japan

July 2025

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AT A GLANCE

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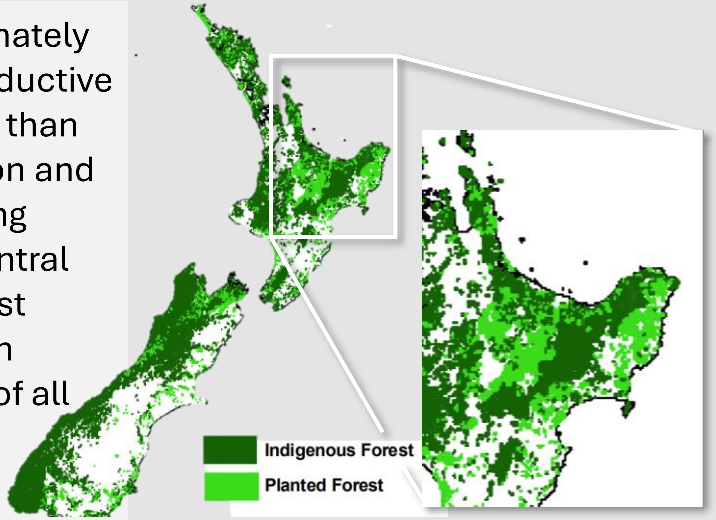
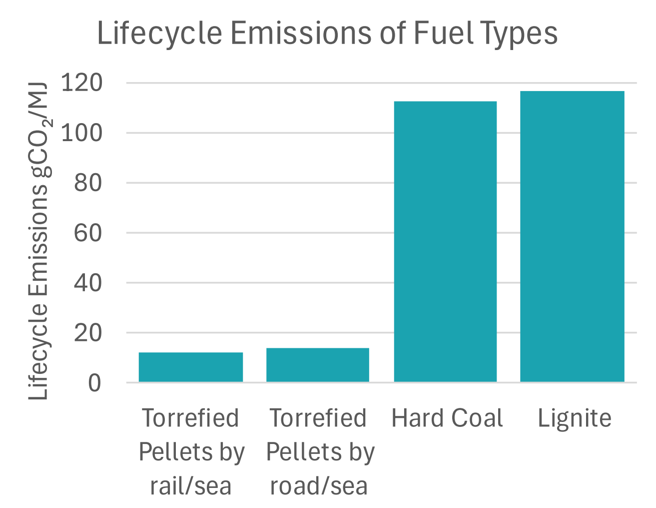
AT A GLANCE

New Zealand has approximately 1.7 million hectares of productive plantation area, with more than half having FSC certification and approximately a third having PEFC certification. The Central North Island has the highest concentration of plantation forests, containing a third of all plantation forests in the country.[1,2]



NZ-made wood pellets/briquettes exported to Japan (either white or torrefied), can achieve 88-90% lower greenhouse gas emissions than coal, based on lifecycle emissions data from the EU's Renewable Energy Directive (RED II).[3]

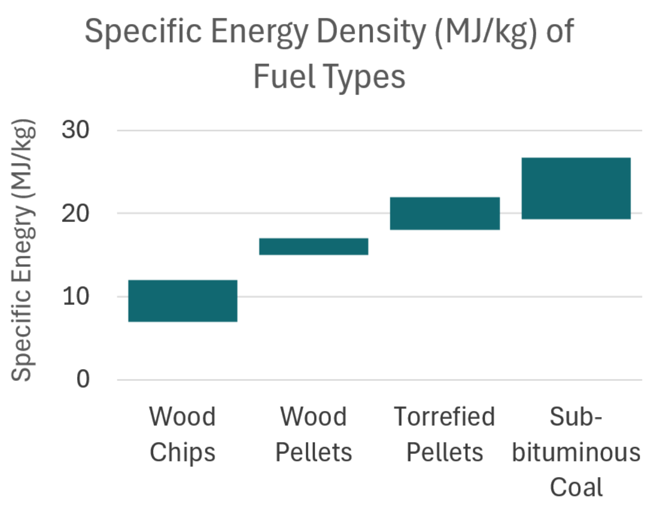


White (regular) wood pellets and briquettes (bottom left and right) are widely used forms of biomass fuel. Torrefied wood pellets and briquettes (top left and right), produced by heating wood in a low-oxygen environment, offer enhanced properties making them ideal for long-distance transport.




Torrefaction of wood significantly increases the energy density of the product.

The specific energy of torrefied wood is similar to that of sub-bituminous coal.[4]



1 - https://ir.canterbury.ac.nz/server/api/core/bitstreams/be233b83-6e26-48e1-9409-5b87c0fd36a5/content
2 - https://www.mpi.govt.nz/forestry/new-zealand-forests-forest-industry/about-new-zealands-forests/
3 – https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R1185
4 - https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/1225238/Factsheet-PELLETS-Accessible.pdf

2 OBJECTIVES & SCOPE

OBJECTIVES

Wood Beca Limited (Wood Beca) was commissioned by Invest New Zealand to undertake a conceptual life-cycle greenhouse gas (GHG) assessment of wood pellets and briquettes produced in NZ for export to Japan.

The goals of this study were to:

- Compare lifecycle GHG emissions between torrefied and white wood pellets
- Compare lifecycle GHG emissions between briquettes and pellets
- Understand differences in GHG emissions between road and rail transportation

The 60,000 tonne-per-year torrefaction reactor at Joensuu Biocoal in Finland. Image courtesy of Carbona.

SCOPE

This study modelled the lifecycle greenhouse gas (GHG) emissions of wood pellets and briquettes using our experience in this area as well as design information provided by Carbona, drawing on their experience with the 60,000 tonne-per-year Joensuu Biocoal torrefied briquette plant in Finland.

Key elements of the study include:

- **Feedstock Source**: Plantation forest pulplogs from the Central North Island, New Zealand.
- **Transport**: Pulplogs transported by road to a processing facility in the Central North Island. Product transported by road or rail to the Port of Tauranga, then by ship to Kobe, Japan.
- **Processing**: Feedstock converted into product using a portion of the feedstock for process heat.
- **Lifecycle Boundary**: Emissions (and removals) are assessed from cradle to grave—including growth, harvesting, processing, transport, and combustion.
- **Standards Alignment**: While the study cannot formally comply with ISO 14067:2018 — as it is not based on an operating plant in NZ — it aligns with the methodology as closely as possible.

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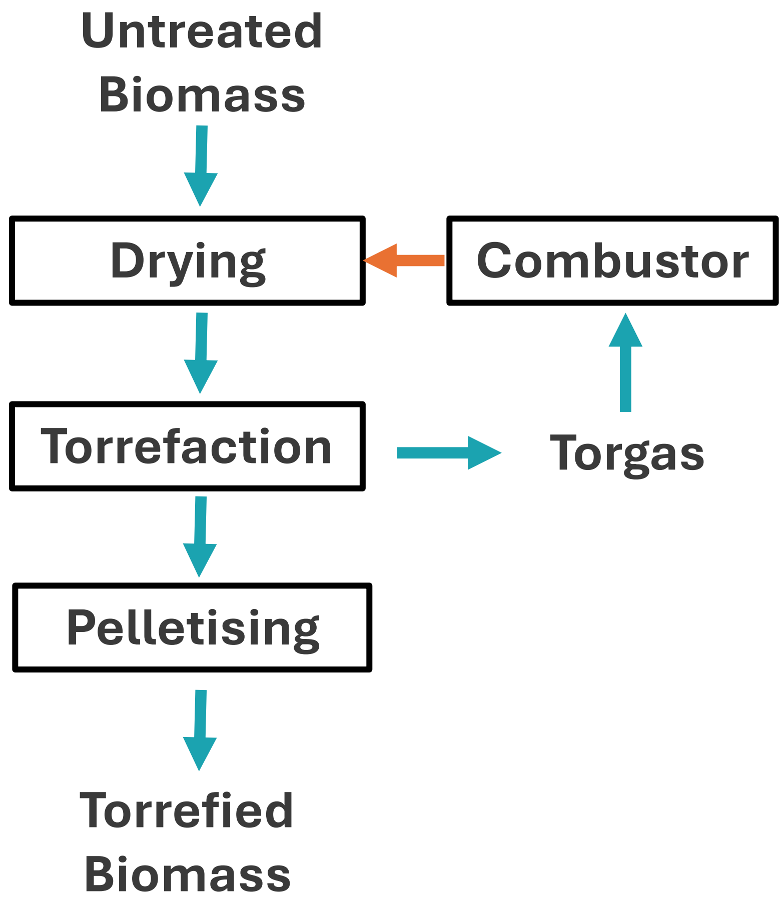
TORREFACTION

TORREFACTION



Torrefaction is a thermal treatment process which transforms biomass, in this case wood, into a coal-like material by heating it without oxygen at temperatures generally ranging from 200–300°C.

Volatile gases released from the wood during torrefaction are combusted to provide the heat required for the torrefaction reaction, as well as some surplus heat to the biomass dryer.

This process improves the fuel characteristics of biomass, resulting in a product that is more energy dense and water resistant (hydrophobic) — ideal for long-distance transport.

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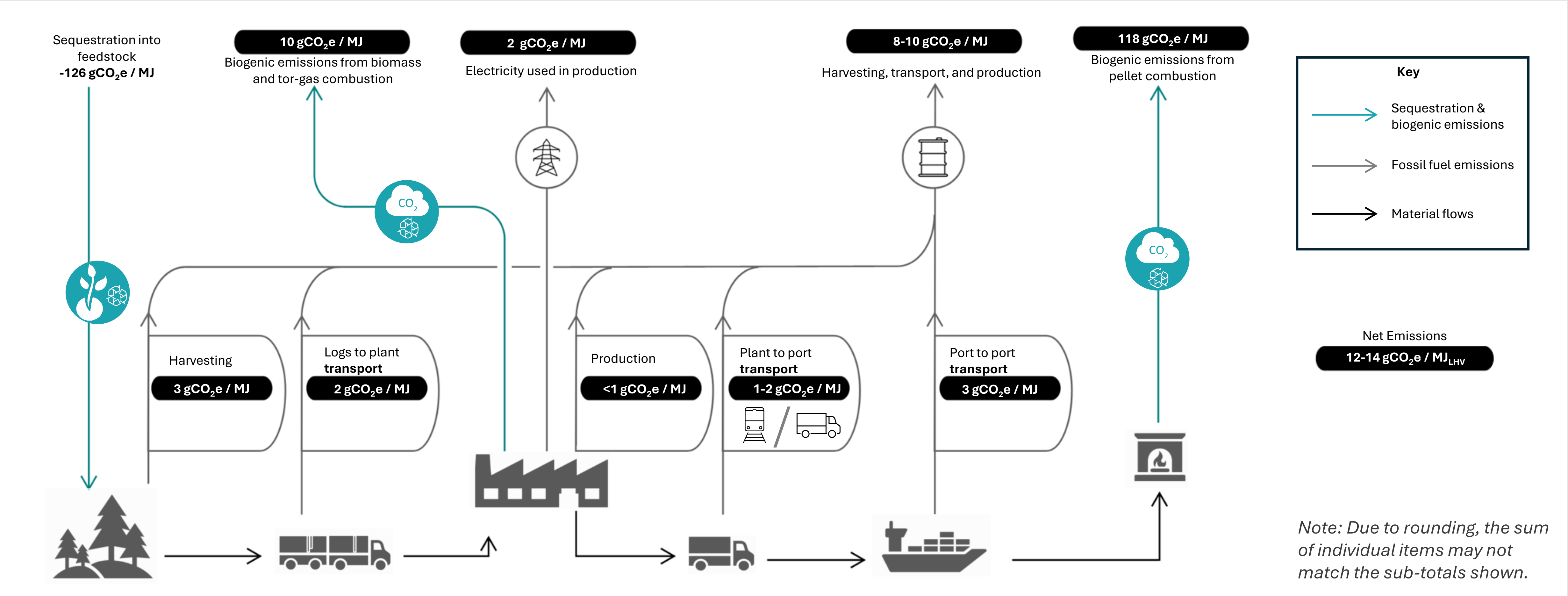
GHG LIFECYCLE OF TORREFIED WOOD PELLETS

THE LIFECYCLE

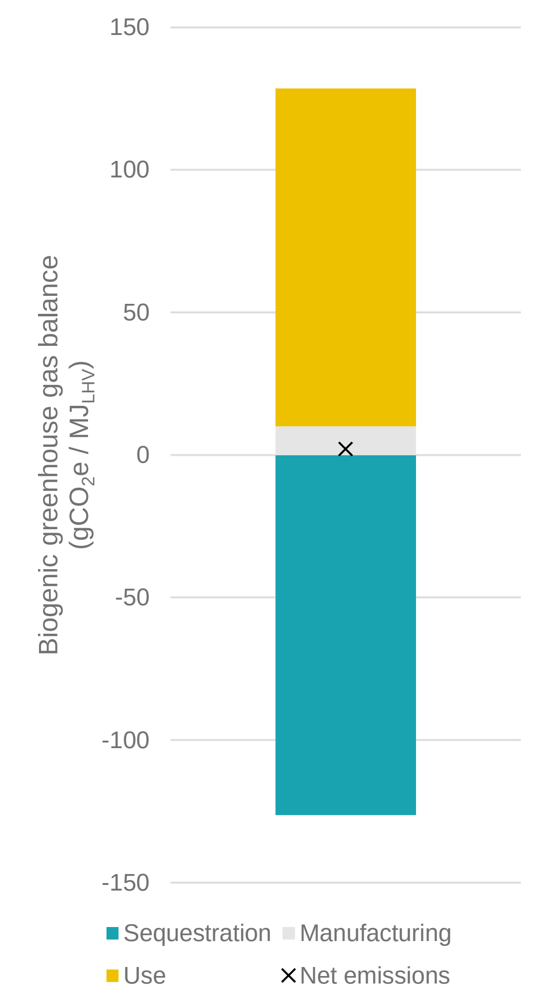
To illustrate the lifecycle GHG emissions, we have used **torrefied wood pellets** here as a representative example. All four products—torrefied and white pellets and briquettes—have very similar emissions profiles, so this example effectively reflects the overall process.
In New Zealand, forests are managed in blocks of different ages, ensuring that mature trees are always being harvested while younger ones continue to grow. This approach enables continuous carbon dioxide removal from the atmosphere at the plantation forest level.



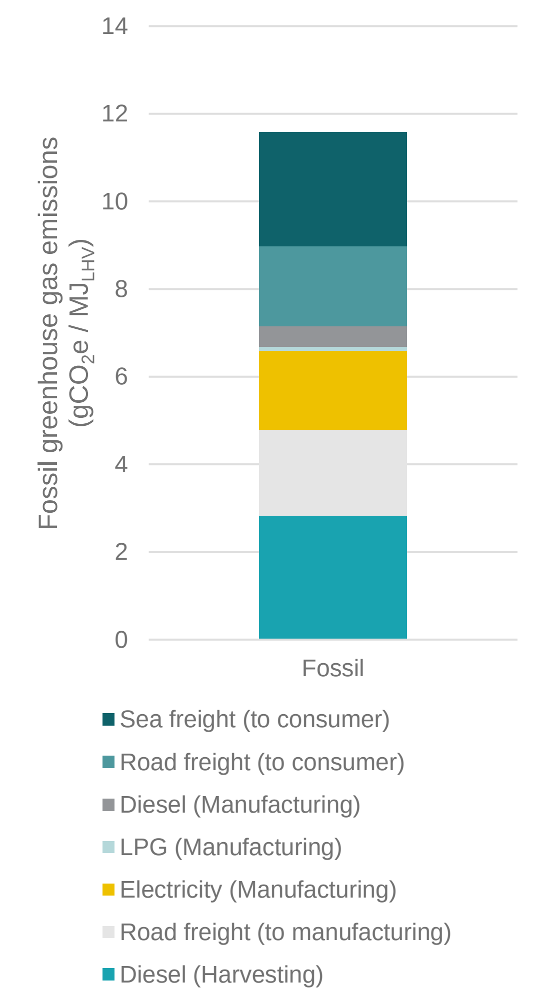
Note: Due to rounding, the sum of individual items may not match the sub-totals shown.

BIOGENIC AND FOSSIL EMISSIONS

Biogenic Balance



Fossil Emissions



The charts to the left show the breakdown of biogenic emissions and removals, as well as fossil emissions, using **torrefied wood pellets** as a representative example.

Biogenic carbon refers to carbon originating from biological sources—in this study, specifically from woody biomass. This includes carbon sequestered in trees prior to harvesting, which is tracked through the product's lifecycle until it is ultimately released through combustion or natural degradation.

While the biogenic GHG balance is considered carbon neutral, it is not entirely climate neutral. Minor emissions of methane from incomplete combustion and nitrous oxide from air oxidation contribute approximately 2.1 gCO_2e/MJ_{LHV}.

Fossil emissions total 11.6 gCO_2e/MJ_{LHV}, with almost 60% of that arising from harvesting and road freight. These sources present significant opportunities for reduction through the adoption of low-carbon transport technologies.

Approximately 20% of fossil emissions are attributed to sea freight, which remains challenging to decarbonise. However, progress is being made, with alternative fuels such as biomethanol currently undergoing trials.

5 LIFECYCLE GHG COMPARISON

PRODUCTS COMPARED

The study included a comparison of similar products (shown below), while keeping the system boundaries, functional unit, and methodology consistent across all scenarios. This allowed for a fair assessment of the lifecycle greenhouse gas emissions associated with each fuel type—torrefied wood pellets, torrefied wood briquettes, white wood pellets, and white wood briquettes—under both road and rail transport conditions.

Torrefied Wood Pellets
Torrefied pellets are small, dense pieces of biomass that have been heated in a low-oxygen environment to remove moisture and increase their energy density. They're dark in colour, water-resistant, and burn more efficiently than regular wood pellets. They are ideal for industrial use because they're easy to transport and store.

Torrefied Wood Briquettes
Similar to torrefied pellets, torrefied briquettes are made from biomass that's been heat-treated to improve energy content. However, they're larger and chunkier in shape, which makes them better suited for applications where bulk handling is preferred. They also resist moisture and offer high combustion efficiency.

White Wood Pellets
White wood pellets are made from untreated, dried wood and are commonly used for heating in homes and small-scale energy systems. They're lighter in colour, less energy dense than torrefied pellets, and can absorb moisture easily, so they need to be stored carefully.

White Wood Briquettes
White wood briquettes are larger blocks made from dried, untreated biomass. Like white wood pellets, they're used for heating but are more suitable for situations where larger fuel pieces are needed. They're less energy dense than torrefied briquettes, and they require dry storage conditions.

LIFECYLE GHG COMPARISON

The lifecycle emissions of white wood pellets and torrefied wood pellets are very similar —the difference is less than 1 gCO_2e/MJ_{LHV}.

The torrefaction process results in some energy loss between the feedstock and the final product, but the greater transportation efficiency for torrefied material offsets that loss.

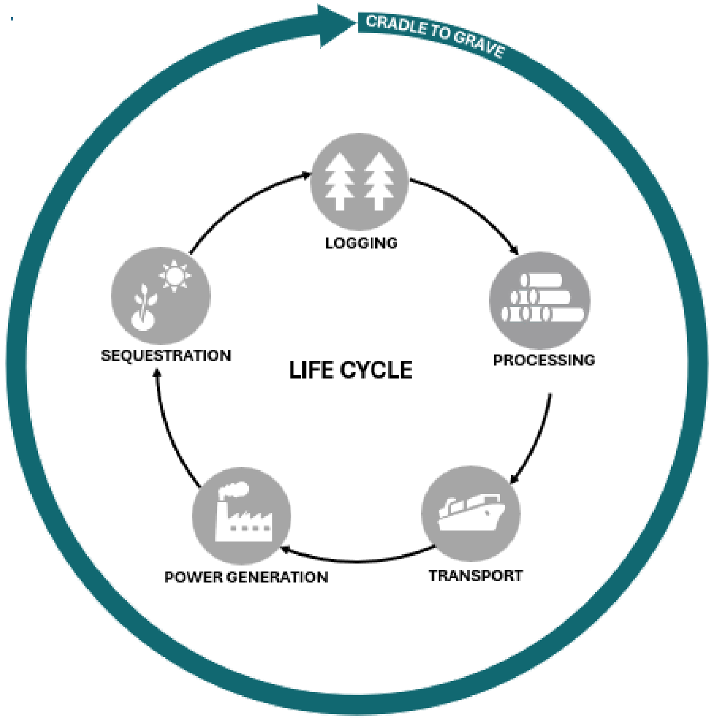
Note that rail transportation reduces the lifecycle GHG emissions for all products.

Briquettes provide a minor benefit to the overall emissions over pellets due to a reduction in electricity requirements during processing. However, due to the low GHG intensity of NZ's electricity grid, this benefit is hardly noticeable.

Regardless of product type (torrefied/white) or product format (pellets/briquettes), the lifecycle emissions are virtually indistinguishable.

Lifecycle GHG emissions for road transport scenario (gCO_2e/MJ_{LHV})
[Rail scenario results shown in square brackets]

	Product Format	
Product type	**Pellets**	**Briquettes**
Torrefied	14 [12]	13 [12]
White	14 [13]	13 [12]



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BIOMASS CERTIFICATION

NEW ZEALAND'S SUSTAINABLE FORESTS

New Zealand has over 10 million hectares of forests with approximately 1.7 million hectares of plantation forest.

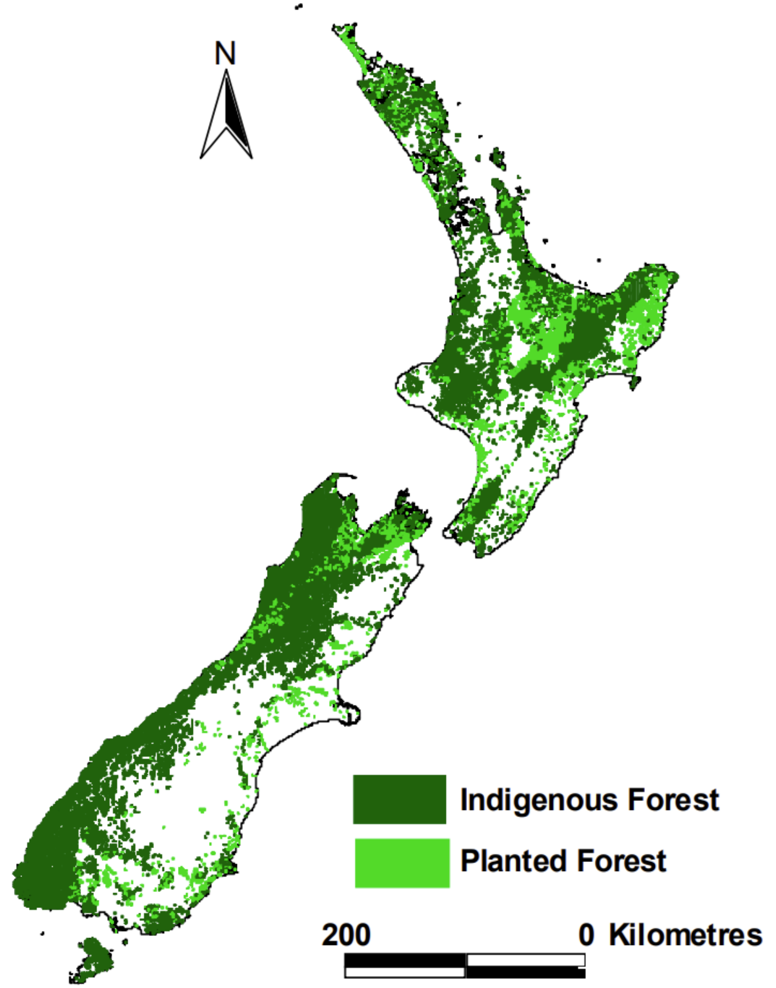
A large portion of these forests are certified as sustainable forests through FSC (Forest Stewardship Council) or the PEFC (Programme for the Endorsement of Forest Certification). The PEFC certification is achieved through NZFCA (New Zealand Forest Certification Association). It is possible for forests to be certified by both schemes concurrently.

72% of the total productive plantation forest area, consisting of a total of roughly 1.22 million hectares, is FSC compliant.[1]

There are more than 600,000 hectares of PEFC-certified forest area in the country.[2]

FSC

PEFC



1 - https://open.fsc.org/server/api/core/bitstreams/2143a3ed-64ea-491a-b8c5-107353a64aa9/content
2 - https://pefc.org/news/public-consultation-forest-certification-system-for-australia-and-new-zealand
3 – Image: https://ir.canterbury.ac.nz/server/api/core/bitstreams/be233b83-6e26-48e1-9409-5b87c0fd36a5/content

FIT AND FIP SCHEME IN JAPAN

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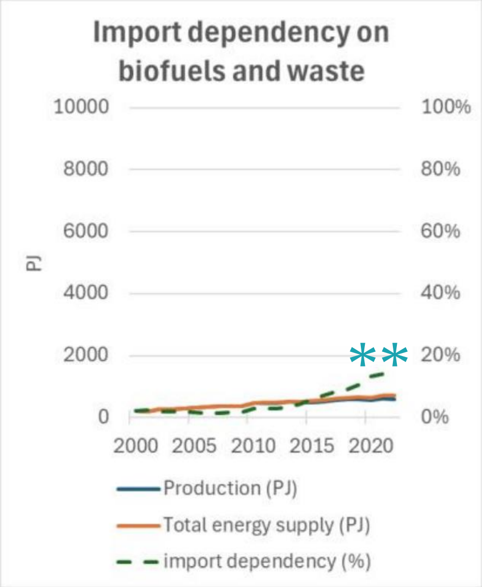
The emissions calculations in this study assume that the fuel is exported to Japan.

Japan has a Feed-In Tariff (FIT) (gradually being phased out for major users) and a Feed-In Premium (FIP) scheme to incentivise sustainable and low-emission energy sources. Since these programmes were introduced in 2012, there has been a significant increase in biofuel use in power generation and heating*, with an increasing proportion of this fuel being imported**.

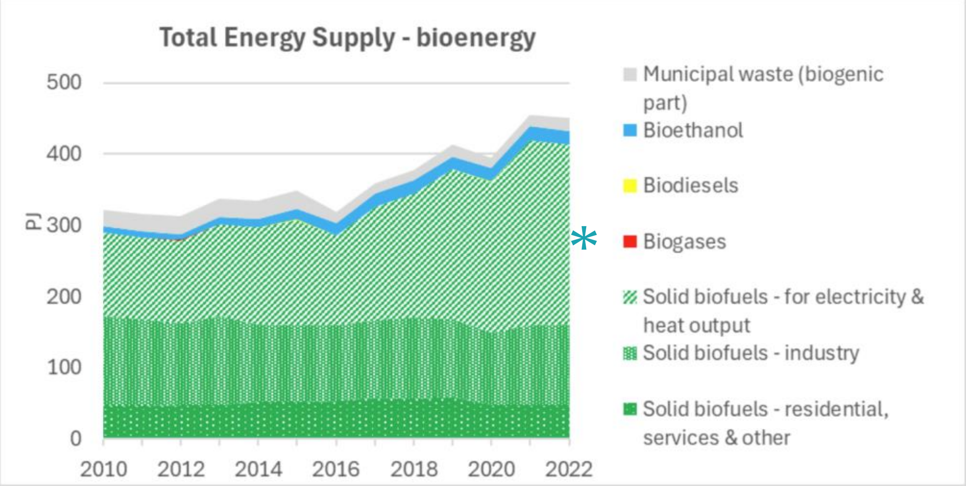
The FIT system guarantees a fixed purchase price for electricity generated from renewable sources. The Feed-In Premium (FIP) scheme incentivises power producers to use low-carbon fuels by providing a premium on top of the market electricity price, encouraging biomass electricity generation when market prices are favourable.



The FIT/FIP scheme acknowledges the following certifications:

- **Sustainable Biomass Program (SBP)**
- International Sustainability and Carbon Certification (ISCC)
- Roundtable on Sustainable Biomaterials (RSB)
- Green Gold Label (GGL)
- Roundtable on Sustainable Palm Oil (RSPO)

Since April, 2023 lifecycle GHG emissions must also be reported.



1 - https://www.ieabioenergy.com/wp-content/uploads/2024/12/CountryReport2024_Japan_final.pdf

SUSTAINABLE BIOMASS PROGRAM

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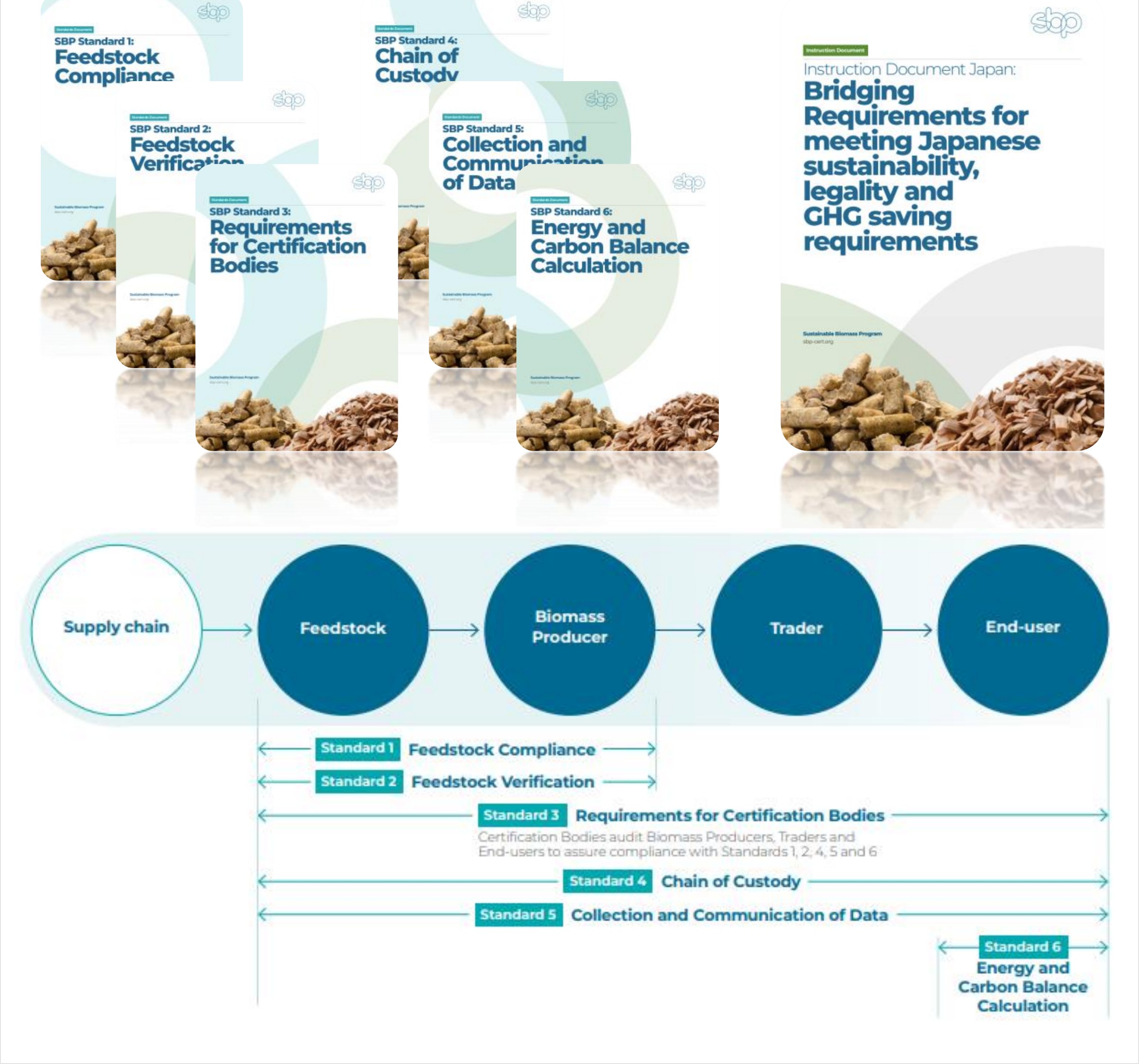


To qualify for Japan's FIT or FIP subsidies using woody biomass fuels, one of the ways power producers can demonstrate compliance is through the Sustainable Biomass Program (SBP).

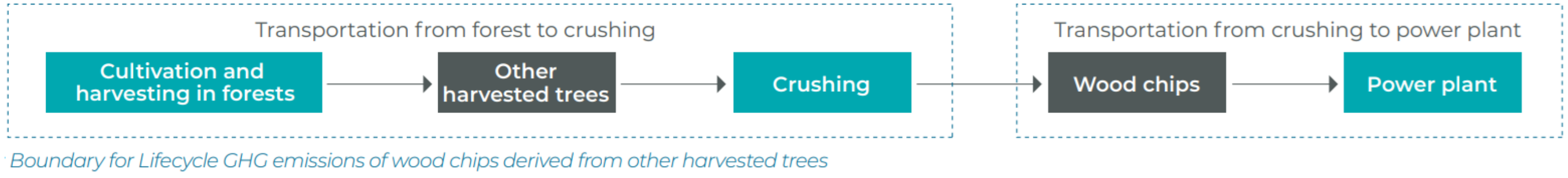
In addition to the six core documents of the SBP, there is a bridging document[1] for Japan outlining additional requirements for FIT/FIP eligibility beyond its core standards. These include:

- Acceptance of FSC and PEFC certification as proof of legal and sustainable origin,
- A Chain of Custody (CoC) system to track biomass from source to end user,
- A GHG lifecycle emissions report aligned with Japanese methodology, and
- Third-party auditing to verify compliance.

With New Zealand's extensive base of FSC and PEFC-certified plantation forests, there is strong potential to supply SBP-compliant biomass to the Japanese market.

1 – https://sbp-cert.org/documents/

SBP GHG LIFECYCLE APPROACH



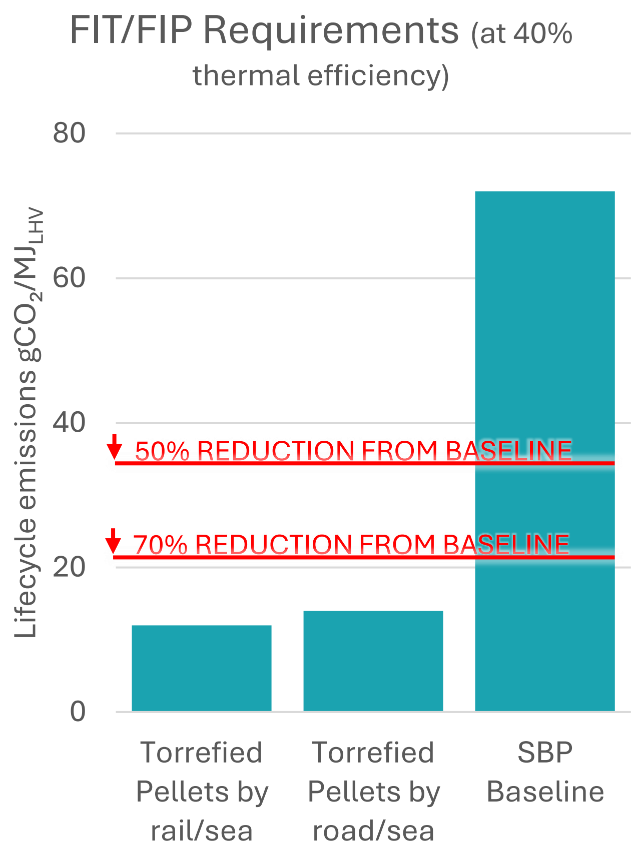
This study was developed using a methodology that aligns closely with the Sustainable Biomass Program (SBP) Standard 6, which governs energy and carbon balance calculations for woody biomass. The lifecycle assessment (LCA) includes all major stages—feedstock sourcing, manufacturing, transport, and combustion—and accounts for both biogenic and fossil emissions, including methane and nitrous oxide, in line with SBP and Japanese regulatory expectations.

While the study is not a certified SBP submission, it supports the potential for future certification of NZ-made wood pellets and briquettes.

The FIT/FIP requirements includes a baseline emission rate of 180 $gCO_2e/MJ_{electricity}$. To be eligible for the scheme, a 50% reduction below this baseline must be achieved prior to 2030, and a 70% reduction after 2030.

For a power station with an overall thermal efficiency of 40%, the baseline value of 180 $gCO_2e/MJ_{electricity}$ translates to a fuel with 72 gCO_2e/MJ_{LHV}. Achieving the 50% and 70% reduction targets will require lifecycle fuel emissions below 36 gCO_2e/MJ_{LHV} and 22 gCO_2e/MJ_{LHV} respectively.

Again, the chart to the right is using **torrefied wood pellets** as a representative example.



1 - https://sbp-cert.org/wp-content/uploads/2023/05/SBP_Standard_6_v2.0_final.pdf

7 CONCLUSIONS

CONCLUSIONS

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Torrefied and white wood pellets have very similar lifecycle GHG emissions, and significantly lower than coal. Briquettes offer a very slight benefit in lifecycle GHG emissions.

With Japan's thermal power plant efficiency of >40%, it should be achievable for NZ-made wood pellets and briquettes to be compliant with both the current and post-2030 lifecycle GHG requirements for Japan's FIP certification scheme; regardless of rail transport use.

The most significant reduction in lifecycle emissions can come from switching diesel-powered harvesting machinery, logging trucks, and bulk trucks to low-carbon alternatives. These sources account for almost 60% of the fossil fuel emissions for torrefied wood pellets transported by road.

Delivering product to port by rail instead of by road reduces the modelled transportation emissions by almost 30%, resulting in an overall emissions reduction of around 10%.

Torrefied pellets have enhanced properties (such as moisture resistance), making them ideal for efficient storage and long-distance transport.

APPENDIX A - DEFINITIONS

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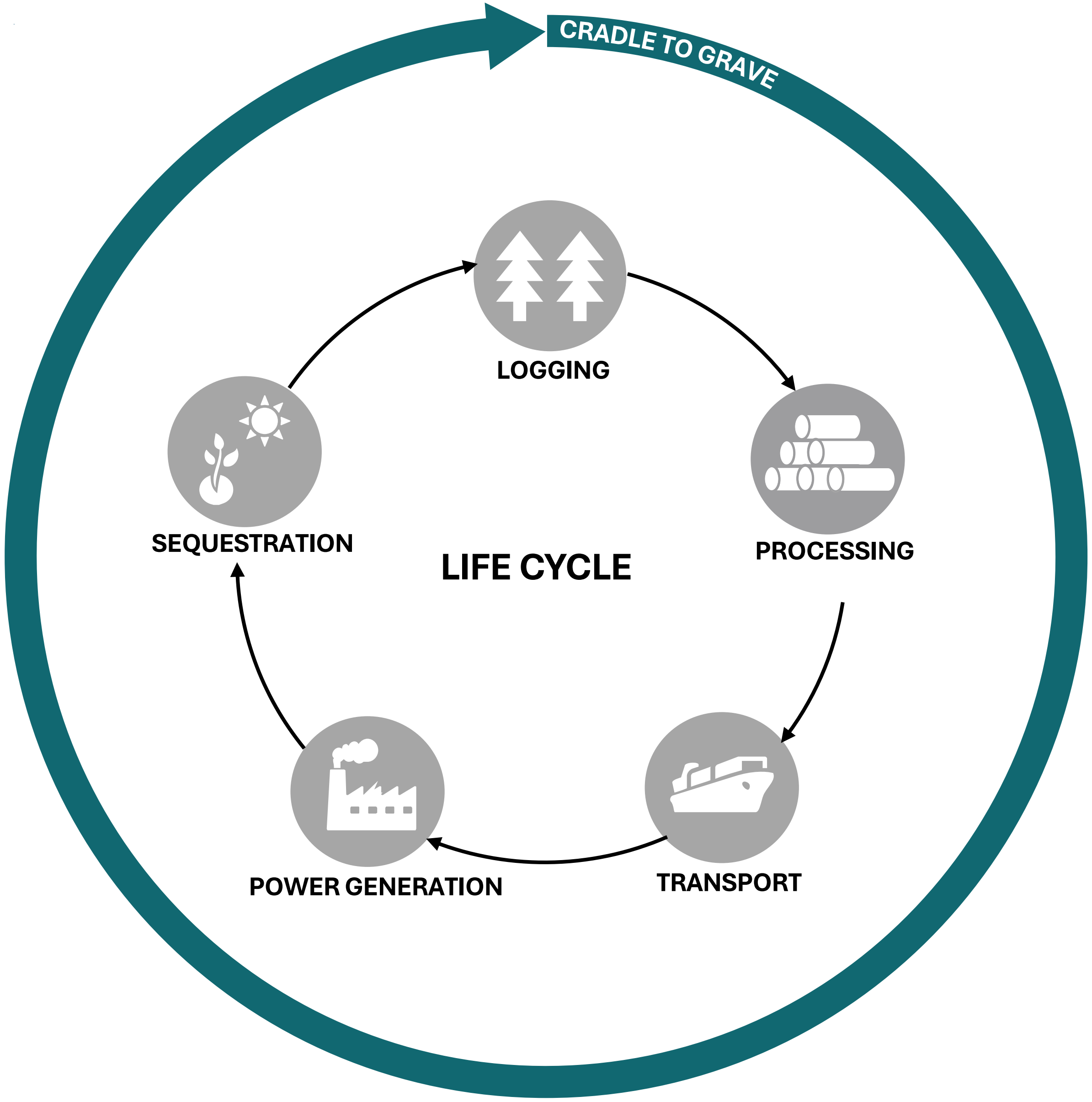
DEFINITIONS

- **Biogenic emissions:** Greenhouse gases released from the combustion or decomposition of biological materials such as plants and trees.

- **Lower Heating Value:** The LHV of a fuel, also known as the net calorific value, is the amount of heat released when a fuel is completely combusted, assuming that the water released in the combustion process remains in a gaseous state and its heat of vaporisation is not recovered.

- **Cradle to Grave:** refers to all the stages in a product's life cycle from raw material extraction (the "cradle") through to its use and disposal.



B

ASSUMPTIONS, REFERENCES & LIMITATIONS

ASSUMPTIONS

Logs – The wood feedstock was assumed to have an average moisture content of 55% (wet basis) and 50% carbon content by oven-dry weight.

Moisture content – Torrefied pellets and briquettes were assumed to have an average moisture content of 4% (wet basis) and white wood pellets and briquettes, 8% (wet basis).

Carbon content – White wood pellets and briquettes were assumed to have 50% carbon content by oven-dry weight, while torrefied material was assumed to have 65% carbon content by oven-dry weight.

Sea freight – All sea freight was assumed to be done using a vessel representative of a bulk carrier with dry weight tonnage (DWT) between 60,000 and 99,999.

Transport to and from port – The study assumed a total of 280 km road freight including both the distance from the production facility to Port of Tauranga, and the distance from the destination port to the consumer.

Log transport – Assumed 100 km road freight from harvesting location to the production facility.

EXCLUSIONS

Additives: Additives such as starches and binders were excluded as their low contribution to the total mass of the product likely leave them well below the significance threshold.

Plant and Equipment Construction: Embodied emissions from facility and infrastructure construction are spread over the service life of the facility, and with high production volumes, their impact per unit falls below the study's significance threshold.

Consumables and staff equipment: The consumables and staff equipment required during the operations were deemed to be minimal and therefore falling below the significance threshold.

Maintenance and repair: Maintenance emissions are minor because replacement parts, spread over high production volumes, do not significantly affect the products' greenhouse gas balance.

Non-harvested woody biomass: Non-harvested biomass (e.g. litter, roots, branches, etc.) are excluded because the forest system is assumed to be in dynamic equilibrium where carbon inputs (e.g., from plant growth, litterfall, residues, roots etc.) are balanced by outputs (e.g., decomposition, respiration, and harvesting).

Packaging: Packaging is excluded since pellets are usually shipped in bulk or reusable bags, making its impact negligible and below the study's significance threshold.

Water supply: Due to the design utilising a thermal oil heat plant rather than a boiler, the operational water requirement for the modelled facility was determined to be immaterial.

Wastewater treatment: Process emissions from wastewater treatment was excluded as the low volumes of wastewater associated with the production are unlikely to produce emissions beyond the significance threshold.

Waste disposal: Due to the hypothetical facilities being assumed to combust all biological waste for heat generation, the remaining waste volumes are low enough that no reasonable end-of-life scenario would not fall below the significance threshold.

EMISSIONS FACTORS

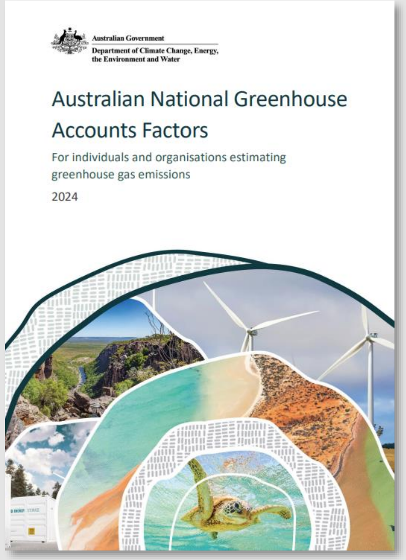
GHG emission factors were sourced primarily from:

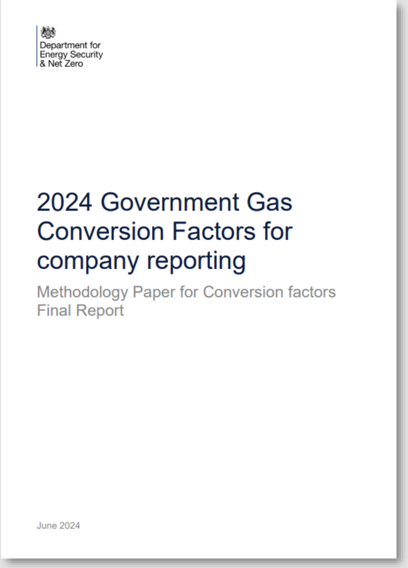
- 'Measuring emissions guide 2025', published by Ministry for the Environment,

Supplemented with well-to-tank (WTT) emission factors from the:

- 'National Greenhouse Accounts Factors: 2024', published by Department of Climate Change, Energy, the Environment and Water
- 'Greenhouse gas reporting: conversion factors 2024', published by the Department of Energy Security and Net Zero

All emission factors used are cradle-to-grave (i.e. including WTT) where applicable.





LIMITATIONS

Purpose and Reliance

The scope of Wood Beca's work for the Wood Pellet Life Cycle Greenhouse Gas (LCGHG) Emissions Modelling is to estimate the lifecycle greenhouse gas emissions of New Zealand made wood pellets and briquettes (torrefied and white) based on a hypothetical plant and to prepare a report for Invest New Zealand (the "Purpose"). As this is an estimate of lifecycle emissions associated with a hypothetical plant (not actual production data), the outcome of this study cannot be used as a guarantee of GHG emissions intensity, but as an indication of the potential magnitude and range of emissions which can be compared against other fuel sources.

The contents of this report may not be used for any other purpose other than in relation to the Purpose, nor may this report be relied on by any other party other than Invest New Zealand. Wood Beca accepts no liability to any person other than to Invest New Zealand for issues arising out this report.

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Invest New Zealand should take its own legal advice on the legal effect and requirements of the standards, guidelines, legislation, codes, policies, plans, rulings, determinations, or common law. Unless special arrangements are made, the advice provided will not be updated to take account of subsequent changes to any standards, guidelines, legislation, codes, policies, plans, rulings, determinations, or common law, and it is Invest New Zealand’s responsibility to take further advice, if it is to rely on this report later.

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