Carbon footprint estimates of Finnish wood exports in TOP 25 countries

LAB University of Applied Sciences
Bachelor of Engineering (UAS)
Wood Technology
Energy & Environmental
Spring 2021
Ina Peltonen
Pascal Muhire

LAB University of Applied Sciences

Abstract

Author(s)	Type of publication	Published
Peltonen,Ina Muhire, Pascal	Bachelor's thesis	Spring 2021
	Number of pages 27	

Title of publication

Carbon footprint estimates of Finnish wood exports in TOP 25 countries

Name of Degree

Bachelor of Engineering, Wood Technology, Energy and Environmental (UAS)

Abstract

The thesis was commissioned by Wood from Finland Association, and its main subject was to determine, calculate, and study the carbon footprint of Finnish exported wood products in the top 25 countries. The top 25 countries were discovered in autumn 2020 for another thesis made by students from LAB University of Applied Sciences and most of the information and data is based on that.

The first part of the two-part thesis dealt with a theory that was used to interpret the results of the second part. The second part contained data calculations compiled using Microsoft Excel. For each country, only the most exported wood product, either redwood(pine) or whitewood(spruce) was considered in calculations. All baseline data were reported only for CO_2 emissions, so the other GHG emissions were not taken into account in calculations.

The density of Finnish wood in the calculations was 0,55 t/m^3 for pine and 0,47 t/m^3 for spruce. Possible losses in production of wooden products are 5 to 15 % per m^3 and calculations are made by using the maximum figure. Carbon dioxide emissions were calculated by multiplying distance (kilometres or nautical miles, depending on the type of transport used) CO_2 kilograms per ton kilometres or nautical miles, and the total volume exported with each other.

The results of the study and calculations showed that exports to China, Japan, and Egypt caused most of the CO_2 emissions with the range of 170 000-280 000 tonnes, while exports to the Netherlands, UK and Estonia caused the lowest emissions with the range of 6000-31 000 tonnes. The greatest CO_2 stores were in Egypt, China, and Japan, with the range of 250 000-350 000 tonnes, and the lowest in the Netherlands, Estonia, and France, with the range of 34 000-84 000 tonnes. The longest storage time for CO_2 was in Glulam products and the shortest one in packaging products.

Keywords

Wood from Finland, carbon footprint, logistics, redwood, whitewood

TABLE OF CONTENT

ABBREVIATION

Anthropogenic – man-made

CH_4 – Methane

CO_2 – Carbon dioxide

CO_2 eq – Carbon dioxide equivalent

EPA - United States Environmental Protection Agency

GHG – Greenhouse gas

GHGs – Greenhouse gases

Gt – Gigaton

Km – Kilometre

Luke – Luonnonvarakeskus, Natural Resource Institute Finland

Mt – Million tons

Nm – Nautical mile

NO_2 – Nitrous oxide

UN – United Nations

UNFCCC – UN Framework Convention on Climate Change

1 Introduction

Carbon neutralization, the Carbon footprint and climate change are words we hear almost every day through different channels. More and more countries are working to reduce their carbon footprint, for example through various laws and legal reforms. This inevitably also affects the choices made by individuals. Of the two or several options, it is better to choose the less polluting one. In this way, climate change can be influenced.

Finland has announced that it will strive for carbon neutrality by 2035 (The Ministry of the Environment). As a member of the UN, Finland is committed to complying with the UN Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, and the Paris Agreement. This means that also companies need to be aware of their emissions and are committed to reduce them. Before reducing GHG emissions, it is necessary to calculate and report how they are formed. Environmental awareness and actions affect a company's reliability in the business. A company that visibly strives to offset the CO_2 and other GHG emissions it produces and reduce its carbon footprint probably enjoys greater trust among the customers, employees, and investors than its competitors which do not.

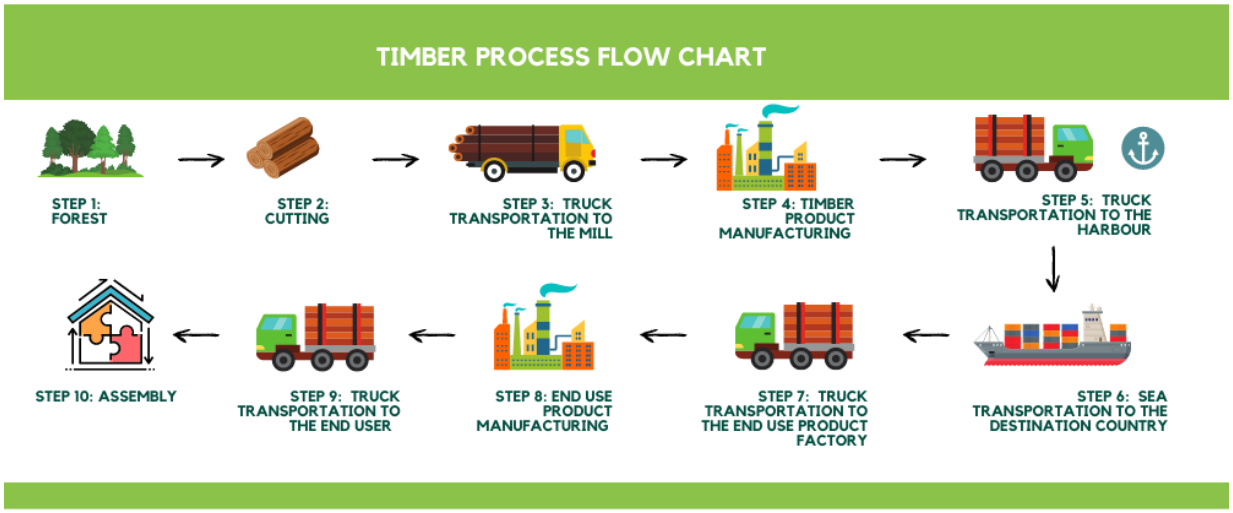
One part of this decision made by Finnish Government concerns public construction. The government has set a target, that 45% of all the public construction will be made from wood by 2025. Public actors are leading the way in the entire construction industry. As a result of public wood construction, the use of wood in the private sector will also increase as construction expertise is strengthened and increasing construction volumes reduce the overall cost level. By choosing wood construction instead of concrete, public actors can reduce climate emissions by binding CO_2 in the buildings and are able to support the domestic economy by favouring local production of building materials as well as local know-how. (The Ministry of the Environment.)

According to the UN Environment Programme's press release (DEC 2020) the CO_2 emissions from the global building sector were 9.95Gt CO_2 in 2019. This accounts for 38% of all energy-related CO_2 emissions when adding emissions from the building construction industry. The best way to reduce CO_2 emissions in this sector is to favour the use of renewable raw materials instead of fossil raw materials. In timber construction, the building itself acts as a carbon storage during the life cycle of the product. The storage time varies from one year to 30-50 years, if not more, depending on the application (Mikkonen 2021).

This thesis is commissioned by Wood from Finland Association. The main purpose is to find out the estimates of carbon footprint in Finnish wood exports in Top 25 countries. The research will focus on calculations of carbon footprint, especially in the logistics and end use products of timber exports countries. Thesis is based on another thesis done in autumn 2020 by students at LAB University of Applied Sciences, in which the Top 25 countries and the end use segments of timber products have been determined. All the information is based on the export figures from 2019.

The first step of this thesis is to become acquainted with the client and the research materials obtained in advance. The calculation of the carbon footprint and the tools used for it also needs to be studied in more detail. Although there are several calculation tools, they are extensively fee-based, so the calculations for this thesis are made by using Microsoft Excel. All baseline data are reported for CO_2 emissions only, so the calculations focus only on these emissions and do not take other GHG emissions into account. The share of the other GHG emissions in relation to CO_2 emissions is small, so the impact on the calculation results is reasonably small. For the calculations, transport routes, transport

equipment and distances need to be determined. In this thesis, only the carbon footprint produced by the finished export product is calculated (steps 5 to 10 in picture 1), the emissions of the wood product manufacturing process in Finland are not considered.



Picture 1. Process flow chart of timber

2 Presentation

2.1 Wood from Finland

Wood from Finland (picture 2) is a national promotion program for Finnish sawn timber. It is operated by Finnish Sawmills Association and Business Finland. The main goal of the program is to form new partnerships between Finnish companies and global timber trade and to strengthen mutual benefits between business partners. Multiple Finnish experts with the technical and commercial expertise work on the Wood from Finland program. (Wood from Finland.)

Wood from Finland Oy is a limited liability company founded in 2007 in Lahti. The company's main business is management consulting. Wood from Finland Oy's CEO is Kai Juha Tapani Merivuori. According to the year 2020 financial statement, the company's turnover was EUR 87 thousand and the result of the financial period was EUR 1 thousand. (Finder.)

Picture 2. Wood from Finland logo (Wood from Finland)

2.2 The Finnish Sawmills Association

The Finnish Sawmills Association (picture 3) has been operating since 1945. The association promotes the business operations of its member companies by representing their interests. The aim of the association is that the independent sawmilling industry is *known in Finland as one of the most vital sectors of the national economy and as a profitable, responsible, and sustainable industry that is based on entrepreneurship.* Their goal is to be known as reliable and forward-looking partners. Their membership base includes approximately 30 companies. Almost all members are family businesses operating nationwide. (The Finnish Sawmills Association.)

Finnish Sawmills Ltd is a limited liability company founded in 2002. The main businesses of the company are organizations, associations, and foundations. Wood from Finland Oy's CEO Kai Juha Tapani Merivuori is also CEO of the Finnish Sawmills Ltd. According to the year 2019 financial statement, the company's turnover was EUR 288 thousand and the result of the financial period was EUR 8 thousand. (Finder.)

Picture 3. The Finnish Sawmills Association logo (The Finnish Sawmills Association)

2.3 Business Finland

The Finnish government organization, Business Finland (picture 4), is for innovation funding and trade, travel, and investment promotion. The organization has 600 employees in 56 offices of which 40 operate globally and 16 across Finland. The organization was created in January 2018 by a merger of two organizations: Finpro and Tekes. Business Finland helps companies to go global and supports and funds innovations. The company aims to *Develop Finland to be the most attractive and competitive innovation environment where the companies can grow, change, and succeed.* (Business Finland.)

Business Finland Oy is a limited liability company founded in 2015. The company's main business is consulting services. Other business areas are foreign trade services and business services. Business Finland Oy's revenue in year 2019 was EUR 82,5 million according to the company's financial statement and the result of the financial period was EUR 1,4 million. Person in charge of the company is general Director Nina Kopola among others. (Finder.)

Picture 4. Business Finland Logo (Business Finland)

2.4 Finnish Forest Industry

More than 75 % of Finland's land area is covered with forest. Of this, about 13 %, 2,9 million hectares are fully protected. This corresponds to an area the size of Belgium. Due to its "green gold" Finland is the most forested country in Europe.

Approximately one-fifth of Finland's merchandise exports consists of the forest product industry. The Forest industry in Finland is a big employer. With its value chains the industry employs over 100 000 Finns and generates more than EUR 3.5 billion in annual tax revenue.

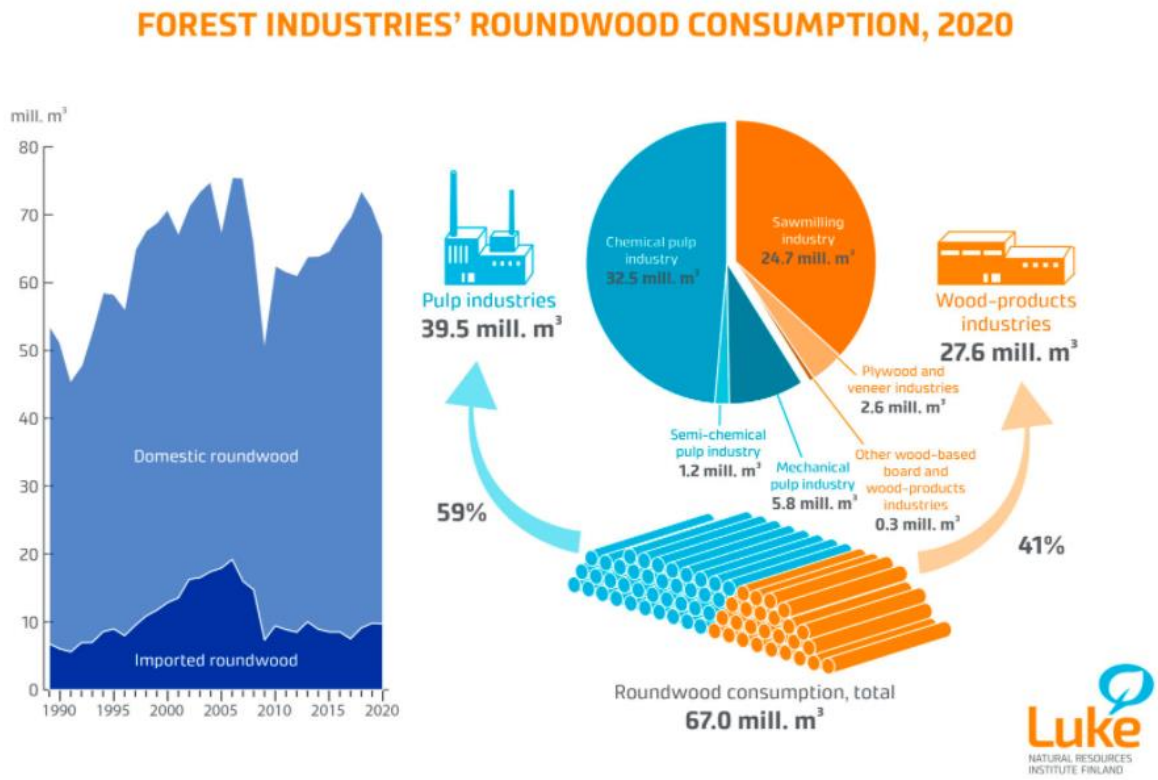
The Finnish Forest Industries Federation is an advocacy organization for forest industry companies operating in Finland. The federation consists of 71 member companies operating in the pulp, paper, board, packaging, and wood product industries. Member companies in the wood product industry are sawmills, wood-based panel manufacturers, and manufacturers of joinery products and wooden houses. The Finnish Forest Industries Federation represents the entire pulp, paper, and board industry, and most of the wood product industry. (Metsäteollisuus.)

3 Wood as a raw material

The sawmill industry handbook (Varis 2018, 37) states that 26,2 million hectares of Finland's land area is used to procure raw materials for the wood industry. 20,5 million hectares of this land is suitable for log procurement. The rest of this is poor-growth wasteland or reserved for another use, such as forest roads. Approximately 9 million hectares of forest land is bogland and half of this is drained. Statistics on these forest areas are based on national forest inventories made since the 1920s.

About 67% of the commercial forest land is owned by private forest owners and 17% by the state. The remaining share is owned by companies, municipalities, parishes, joint forests, and other small community owners. In Finland, two different forest certification systems are used – PEFC and FSC. 85 % of the forests are PEFC certified and 6 % FSC certified. Usually, the FSC certified forests are also PEFC certified.

Referring to Luke's statistics of forest industries' roundwood consumption in 2020 (picture 5), 41 % of roundwood was consumed by wood product industries. Most of it, 59%, was consumed by pulp industries. Even though the amount of roundwood used in Finland is significant, most of it is used for short life cycle products such as paper, board, and packaging materials. The use of wood should be directed more toward long-term uses to maximize environmental benefits.



Picture 5. Roundwood consumption of 2020 (Luke 2021)

3.1 Log yield

Most of the wood used in wood products industry is sourced from private forest owners. in addition to logs, cutting down trees also produce pulpwood and energy wood. In the timber trade, the greatest monetary benefit comes from logs. For this reason, it is important that the amount of log wood is maximized. This has a great benefit to both the seller and the buyer of the wood. Figure 1 shows log prices for week 17/2021. Price information is based on data from Luke. According to Metsä Forest (2021), log percentage is 82,9 for pine and 88 for spruce. Picture 6 shows the approximate breakage of softwood.

First felling

The first felling is forest procedure, which is done when the trees are 12–16 meters high. The best trees are left to grow in the forest, and felling gives them more growth space and the growth of the trees accelerates. First thinning is performed when the forest is 25-40 years old, depending on the location. In Southern Finland, first thinning is done in earlier stage than in Northern Finland. (UPM.)

Thinning

Thinning is performed 15-25 years after the first felling and when the diameters of the trees at a height of 1,3 meters is at least 16 centimetres. In the lower thinning, smaller and poorly growing trees are removed from the forest, while in the upper thinning, the heaviest trees are removed. Between first felling and regeneration felling, one or two thinnings are usually made. (Metsä Forest.)

Regeneration felling

Regeneration felling is carried out when regeneration is of greater benefit to the forest owner than from its management. This usually happens when tree growth begins to decline. Regeneration felling gives the forest owner the greatest profit.

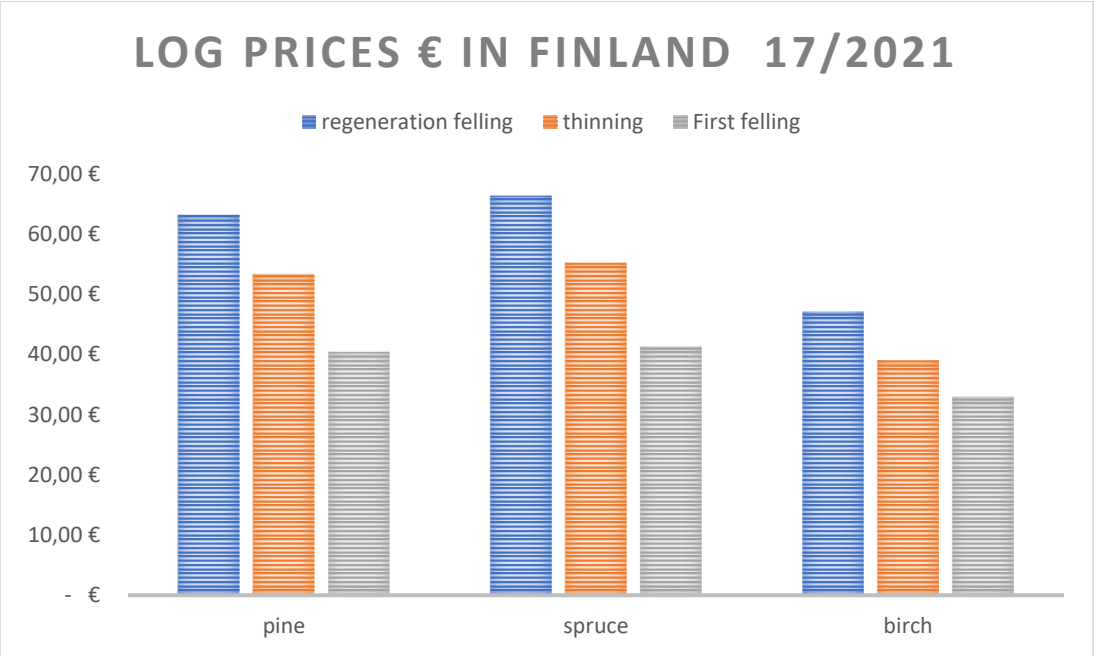
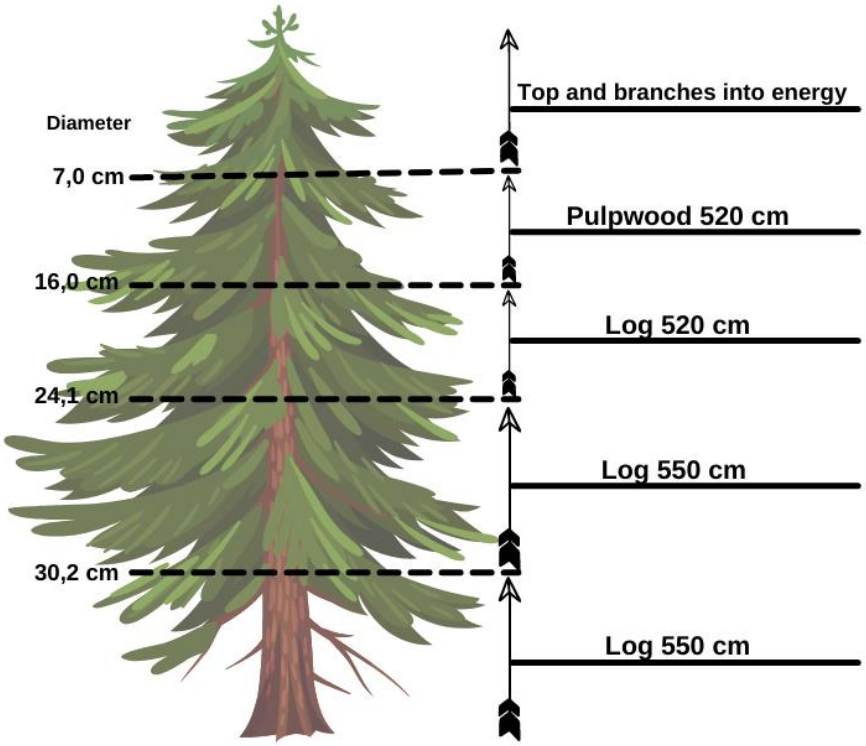


Figure 1. Log prices in week 17/2021



Picture 6. Breakage and log percentage (Adapted from MetsäForest 2021)

The yield from the log

The way the log is sawn in sawmills affects the yield of sawn timber. The most common sawing method used for softwood in the Finnish sawmills is pattern cut (picture 7). In this two-staged method, side boards are first taken from both sides of the log and remaining squared timber can be used as a log blank, or it can be sawn into planks after rotating it 90 degrees. (puuproffa.)

Picture 7. Pattern cut (puuproffa.fi)

3.2 End use products

The Finnish softwood is globally known as an excellent material for various end uses. Its high quality is based on an exceptionally favoured growth area, renewable and certified forest resources, and longstanding forestry. The growing season of Finnish softwood is about 100 days a year, so the three grows slowly. As a result, the trunks are straight, and the branches are small. The wood is tough and hard. The proportion of heart wood is high, and the number of internal cracks is minimal due to the low internal stress of the wood. (Varis 2018, 17.)

The Finnish sawn timber is used for example, in building and construction, interior design, and the packaging industry. In the construction industry, sawn timber is used mostly in structural end use, but also in the joinery industry, such as floors, windows, doors, and stairs. In interior decoration products, Nordic sawn timber has been preferred due to the small number of knots, but as people started to prefer a painted surface instead of a visible wooden surface, it has lost market share to cheaper wood-based substitutes, such as MDF (medium density fibre). For the lower grades of Nordic sawn timber, the packaging industry is the important end user. It is being used for pallets, cable drums, and various boxed applications. (Varis 2018, 221-223.)

4 Carbon footprint

4.1 About carbon footprint

A carbon footprint is the amount of greenhouse gas (GHG) emissions which caused by human activities such as the use of fossil fuels, cutting down trees, transportation, and household energy. GHGs can be expressed as only CO_2 emissions or as CO_2 -eq, which includes other GHG emissions transformed into CO_2 -eq. A carbon footprint is measured by the amount of carbon dioxide (CO_2) of our lifestyle´s actions which released to the atmosphere. (The Nature conservancy 2021.)

In 2007, Finland had 78 million tonnes CO_2 equivalent (CO_2 -eq) of GHG emissions. The emissions were 10% higher than in 1990. According to the data of Finland´s statistics, the total amount of GHGs emissions in 2019 totalled 53 million tonnes of carbon dioxide equivalent, which is equal to 18 million tonnes CO_2 eq less than in comparison year 1990. (Statistics Finland.)

The most significant of Finland´s greenhouse gases (GHGs) are carbon dioxide (CO_2), methane (CH4), Nitrous oxide (NO_2) and Fluorinated gases (figure 2). Carbon dioxide emissions varied for 80% and 85% between 1990 and 2019. The increasing of emissions in the atmosphere changes our climate because each gas has the own ability to heat and make planet warmer. (Good energy 2017).

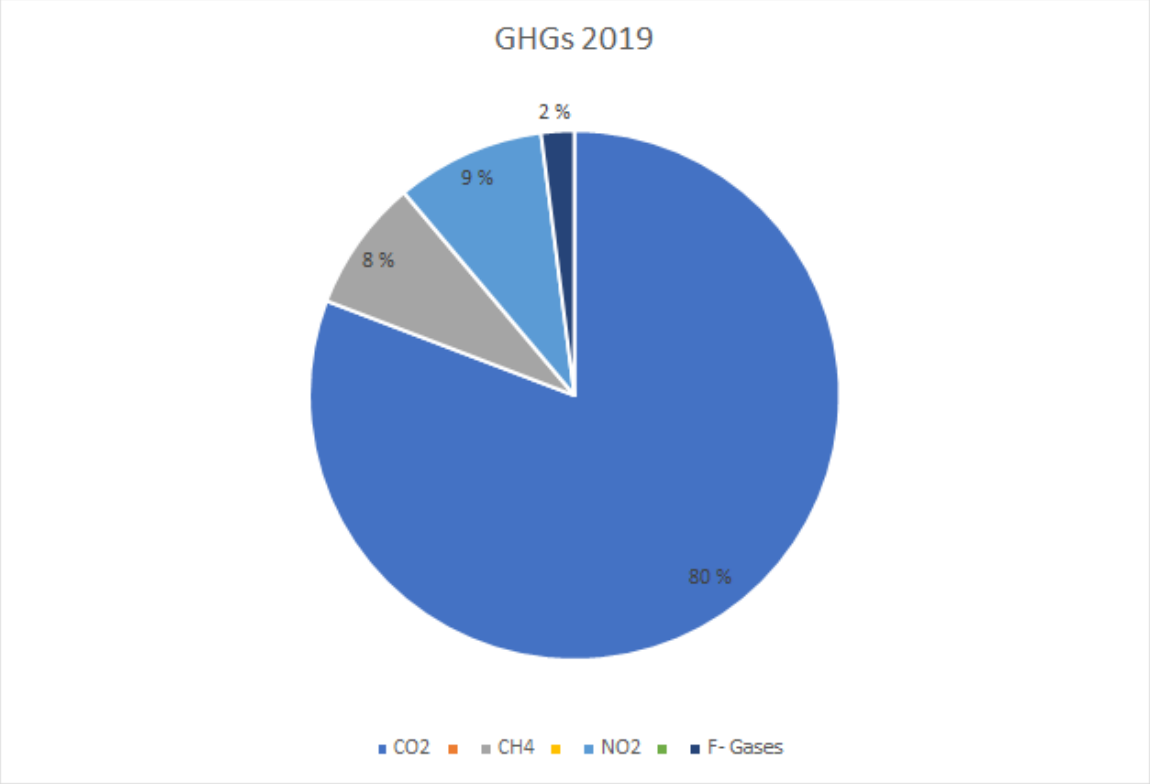


Figure 2. Finland’s Greenhouse gas emissions in year 2019

Anthropogenic CO_2 emissions are the highest compared to other greenhouse gas emissions. The majority is emitted by industry, transport, and electrical use. The people are releasing GHGs to the atmosphere ten times faster than the volcanoes did during the great dying. The cutting and burning of forests to clear space for farming, ranching, settlements, and road building, can add at least 15 percent of global GHGs per year. (Jonathan. S. F. 2019, 92.)

Fossil fuels are fuels created by the fossilization of the biomass of ancient organisms into the soil. These include e.g., coal, natural gas, lignite, and fuels refined from petroleum. Fossil fuels are non-renewable resources which will run out over time. Burning fossil fuels releases a lot of GHGs into the atmosphere and this accelerates global warming. There are also risks associated with the use of fossil fuels, such as explosion and leakage hazards, as well as the risk of collapse in mines when they are procured.

4.2 Climatic impact of GHG emissions

According to the EPA (The United States Environmental Protection Agency) as anthropogenic GHG emissions increase, they accumulate in the atmosphere and warm the climate, which in turn leads to many other changes around the Earth – in the atmosphere, on land and in the oceans. These changes have both positive and negative effects on humans, society, animals, and plants. Because many of the important GHGs remain in the atmosphere for decades, even hundreds of years after the release, their warming effects on the climate will continue for a long time and may thus affect both present and future generations.

As a result of climate change, Finland's weather becomes warmer and more pluvial. Diverse ecosystems and good quality water resources that our nature provides us are under threat. These effects affect agriculture, forestry, the fishing industry, nature tourism as well as land use in urban environments. In Northern Europe, climate change can bring some benefits such as reduced demand of heating, potentially higher yields, and faster growing forests, but globally, however, the adverse effects of climate change outweigh the benefits by far. (ymparisto.fi.)

4.2.1 Mode of Transport

In Finland, transport plays a major role in addition of GHGs. It is the fifth largest emitter in the country. 94 % of transport emissions come from road transport, 4 % are maritime emissions, and 2% are aviary emissions. (Finnish Government.)

Transportation has played the main role in augmentation of the EU´s total emissions where road transport has added 21% of all carbon dioxide emissions in 2017. The road traffic occupied more than 71% in the sector of transportation, 19% of emissions caused by trucks. Maritime transportation was 13.4%. The mode transport taken into consideration in Finnish wood exports countries was maritime and road transport, precisely heavy-duty vehicles (Figure 3).

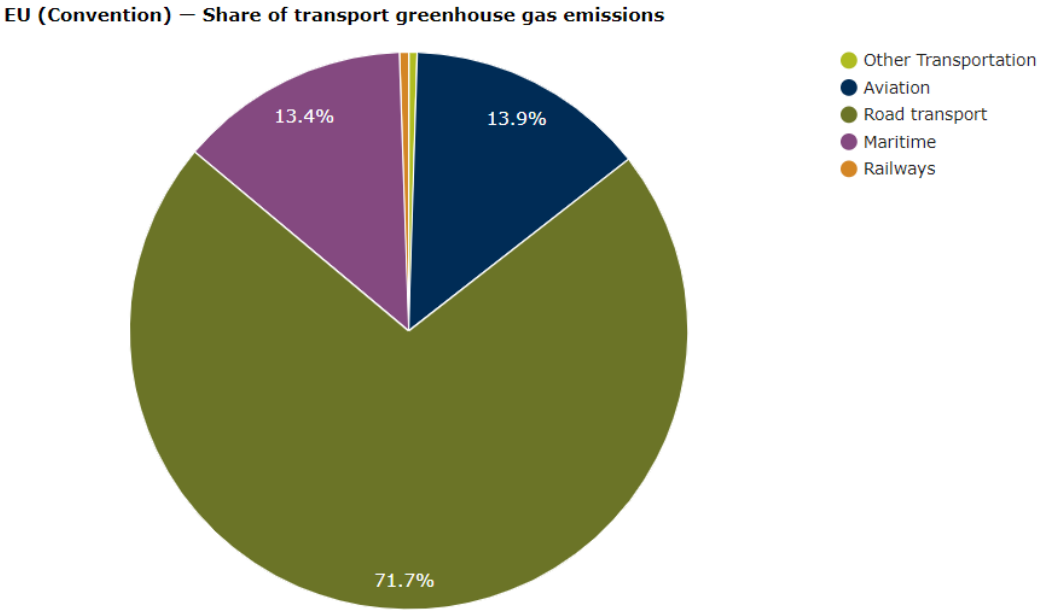


Figure 3. Share of transport greenhouse gas emissions in EU (EEA 2019)

4.2.2 Reducing emissions

The conservation of nature is very crucial for many reasons, for example, the animals and plants are so connected, this means that are dependent on each and other. Human being needs all the time oxygen for respiration, food, trees for construction and other human activities in daily life. If we really need to survive in the long term, we should do our best in reducing emissions. Every sector of the world economy like extraction of raw materials, manufacturing in general and industries' service contributes the emissions in the atmosphere, so all of them must give off from fossil fuels to avoid climate change. (Nunez, C. 2019)

In the manufacturing sector must reduce emissions by remanufacturing. The use of some durable materials can be reused in the future again to reduce new greenhouse gases in the atmosphere. The engineers who design some materials, especially for industry should consider the energy of those products will need to use in production processes by keeping in mind the impact can cause the environment (Industry today 2020).

The Ministry of transport and communications of Finland have suggested the planification to finish the greenhouse gases by 2045 in domestic traffic. The objective will be achieved by using renewable fuels, using more public transport than private transport, improvement of efficiency transport, bicycles when it is possible, and by increasing taxes and fees for activities that are emitting a high quantity of exhaust gases. (The Ministry of transport and communications 2018.)

4.3 Logistics

Finland is the biggest softwood producer in the world where it takes the seventh place and is the world´s number four of exporter of sawn timber. This means that Finland exports 80% of the wood products manufactured and all of them must be transported. The Finnish whitewood and redwood are mostly exported by using maritime transportation (eSawmill 2015). A network of Finnish ports that are specialized in sawn timber are shown in picture 8.

Picture 8. A network of Finnish ports specialising in sawn timber (eSawmill 2015)

The most common used modes of transport in wood products exports are trailers and containers, which replaced the train ferries. These modes of transports are used commonly in Europe. (sahateollisuuskirja 2015.) According to the data from the previous thesis in figure 4, the total amount of the Finnish sawn timber exported in 2019 was 3169389 m3 in logistics. This includes different modes of transportation, such as, door to door, conventional shipment, container shipment and other.

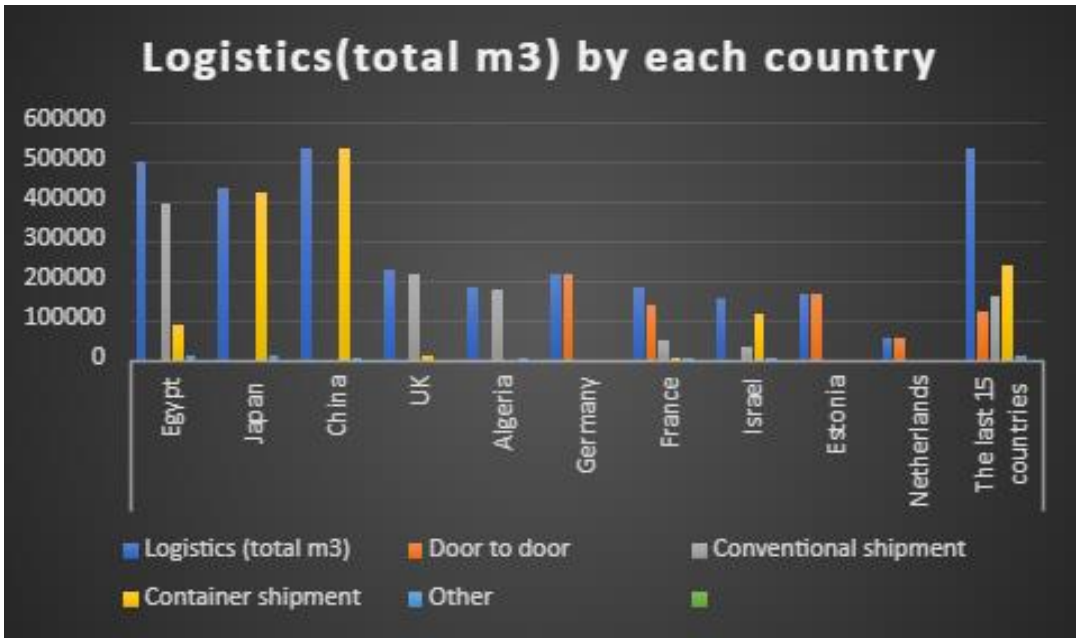
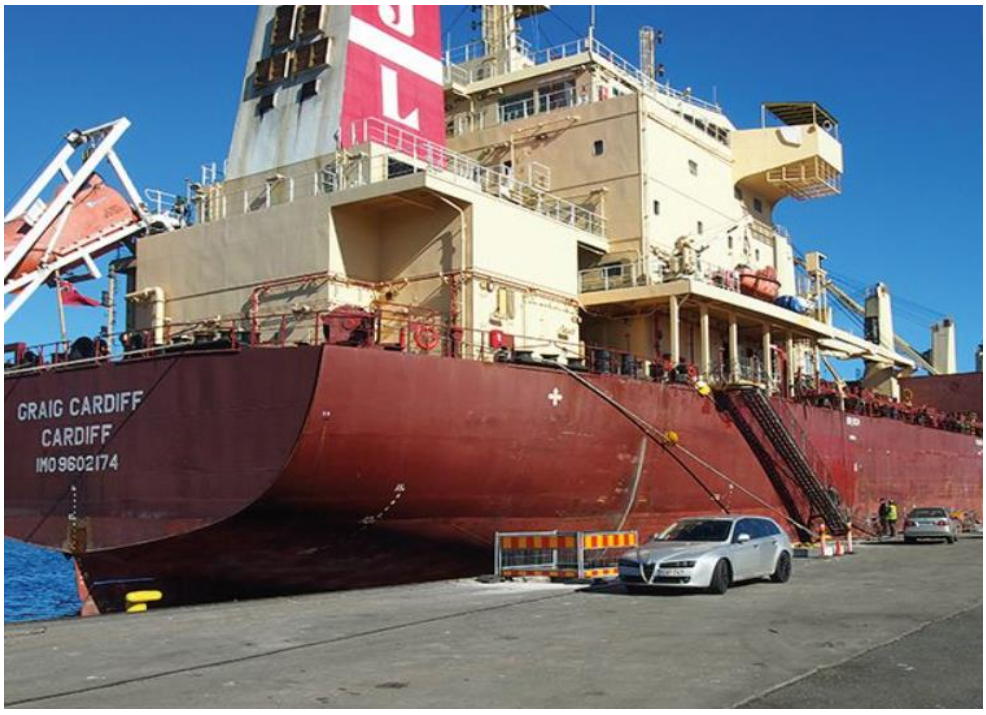


Figure 4. Transport method by country

The logistics of the wood products was changed as the modes of transport was improved. Some European countries, especially those in Northern, Central and Southern Europe and the Nordic countries, mainly use trailers and containers as a method of transport, while to the Middle East and to the North Africa conventional shipments are used as a main transport (picture 9).



Picture 9. A conventional ship (sahateollisuus 2015)

4.4 Calculation standards & methods

There is a different kind of standards and guidelines to determine carbon footprint, such as the product's carbon footprint calculation standard ISO 1467, and GHG Protocols for calculating the company's own emission sources – scope 1, purchased energy emissions – scope 2, and other indirect emissions – scope 3. Legislation can also set targets for reducing the carbon footprint, as has been done in with EU Regulation 333/2014 on CO_2 emissions from passenger cars. (Siitonen 2018.)

The Internet provides several different calculators for calculating carbon footprint. In addition, there are service providers which calculates the organizations carbon footprint of products or services for a fee. Even though there are multiple calculators, it is difficult to find a calculator for a certain product or service.

Typically, the calculation of the carbon footprint considers all GHGs generated by a product or service throughout its life cycle, which are converted to CO_2 equivalents by taking into account their GWP in relation to CO_2, but it can also be calculated for CO_2 emissions alone as in this thesis. In this case, all emissions must be reported in the form of CO_2.

5 Results and analysis

5.1 Information about calculations

In the calculations about carbon footprint made for the thesis, only CO_2 emissions caused by the transport of Finnish export wood have been considered. The calculations were made with Microsoft Excel, and they are rough but give an indication of how much different modes of transport and routs used affect the climate. The emissions were calculated with mathematical formula 1,

$$V * \frac{gCO2}{tnm} * nm \qquad [1]$$

where V is volume, $\frac{gCO2}{tnm}$ is emission figure, and nm is distance in nautical miles (used in maritime transport)

or with formula 2,

$$V * \frac{gCO2}{tkm} * km \qquad [2]$$

where the distance is km (used in road transport).

The formula used depended on whether the emissions to be calculated were from road or maritime transport. The emission figure for maritime transport is 113g CO_2/tnm comes from Finnlines (2021), which is the average emission figure for the cargo vessels used by the company, while the emission figure for road transport for HDW is 900g CO_2/tkm comes from Transport & Environment (2015).

The CO_2 emissions from Heavy-duty vehicles (HDV) are from Transport & Environment (2015), marine emissions used are from Finnlines (2021). Logistic data used are from LAB senior lecturer Esa Mikkonen (2021). Nautical miles have been checked with a website sea-distances.org.

The top 25 export countries, gross volumes, and end use segments comes from a survey made by Eero Kinnunen and Aleksi Turkia in autumn 2020 in part of their thesis. The survey was answered by Finland's 23 largest companies in the wood product industry. The survey was made by using Webropol tool and the 25 largest countries were listed. Wood products were separated into redwood (pine) and whitewood (spruce). A minimum value of responses of 500 m^3 per segment was requested. Each wood product was divided into six different segments: sawn timber for construction, planed goods, packaging material and disposable products used in construction, joinery, and other products. Rough estimates of the volume of wood exported were wanted for the responses. This survey does not cover the whole exported volume, but it gives us a representative sample about 50% Finnish wood product exports.

For each country, CO_2 emissions have been calculated only for the most exported wood product, which is either whitewood (spruce) or redwood (pine). Of the 25 export countries, the 10 largest have been specified. The last 15 have been combined in the same calculation and the averages of the distances of the eight largest countries have been used when the distances were determined.

The density of Finnish dried whitewood is about 470 kg/m^3 and for redwood 550 kg/m^3. About half the weight of wood is carbon, so a cubic meter of sawn timber contains more than 200 kg of carbon. In Europe, a figure around 0,9 tonne of CO_2 is bonded in a one cubic meter of wood. This figure is based on calculations made by Professor Arno Frühwald of the University of Hamburg in the 1990's. This had led to a simplified calculation that one cubic meter of wood binds up a ton of CO_2 from the atmosphere when it grows, and this information is used in several different documents, textbooks, and calculations. (The Federation of the Finnish Woodworking Industries 2021.) This information is also used in this thesis to calculate the carbon stocks maintained by exported wood products. Net carbon storage has been calculated by deducting the losses from wood processing from the gross storage. The loss is 5 to 15 % depending on the end use product, but in this thesis only the highest loss percentage have been taken into account.

When calculating the average storage time of CO_2 in each country, the storage time was obtained by first summing the life cycle of each segment used and dividing the result by the number of segments.

5.2 Redwood

According to the survey made for Finnish timber exporting companies, the amount of exported redwood in 2019 was 1753711 cubic meters. Redwood was exported mostly to Egypt, Japan, Algeria, Israel, and France. Exported volumes based on the survey is shown in figure 5 and total emissions compared to net storage CO_2 is shown in figure 6.

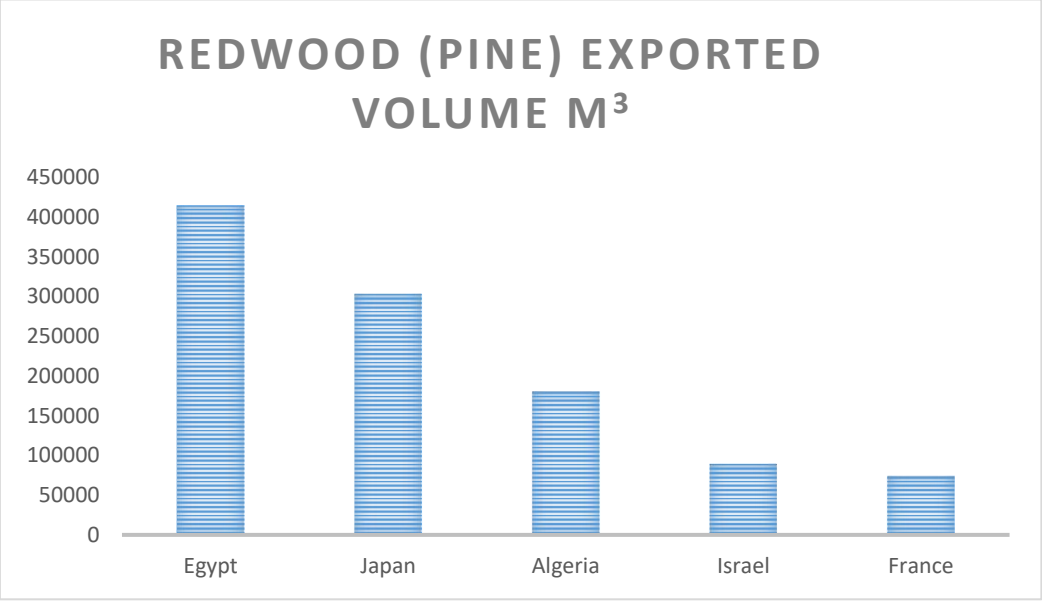


Figure 5. Redwood export volumes obtained from the survey

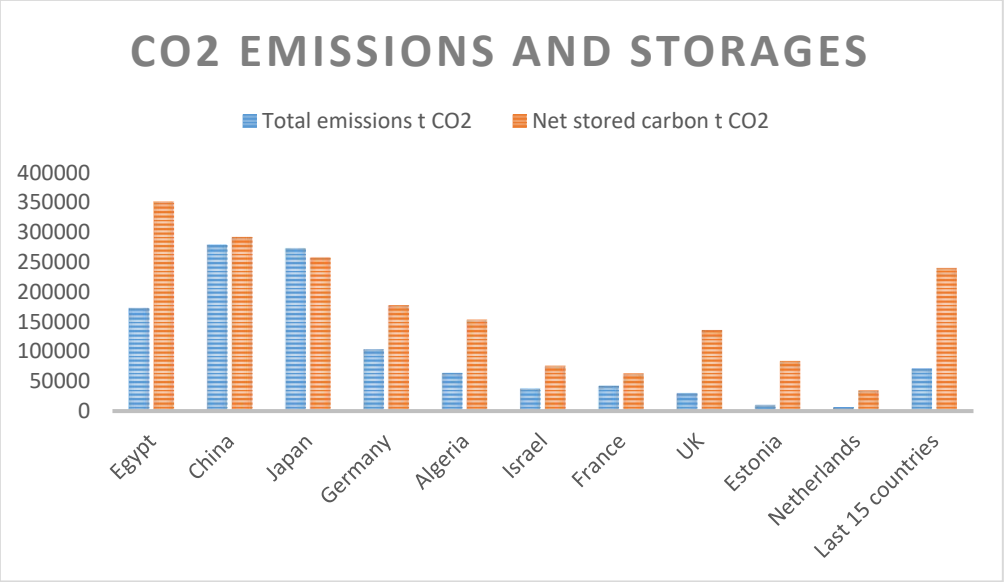


Figure 6. Total emissions and CO_2 net stores of exported redwood

Egypt

Egypt has been Finland's the most significant redwood export country for decades. Due to their environmental conditions and ever-growing population, the law of supply and demand does not meet. In Egypt, redwood is used in all segments, but mostly in construction, joinery, and in packages, pallets, and single use construction materials. The most common mode of transport when exporting products to Egypt was conventional shipment. The total amount of CO_2 emissions, 17283 tonnes, was less than half of the net amount of stored CO_2, which was 352246 tonnes. The storage time for CO_2 is approximately 27,2 years, which is the average of life cycles of all segments used.

Japan

Redwood exported to Japan is mainly used in Glulam beams. The Japanese prefer beams and a visible wooden surface in their buildings, so the Finnish redwood is perfect to this, thanks to its small number of knots. The results of calculations show that the total emissions, 272834 t/CO_2, were slightly bigger than amount of stored CO_2, which was 257814 tonnes. The most common mode of transport to Japan is container shipment. The average life cycle of Glulam is approximately 60 years, during which time CO_2 remains stored.

Algeria

In Algeria, the Finnish redwood is used in joinery, construction and in packaging industry. The net amount of stored CO_2, 153442 tonnes, was twice as big as the CO_2 emissions, which were in total 64204 tonnes. The average storage time of CO_2 in most manufactured

products, such as doors, windows, and kitchen furniture, is 30 years. Conventional shipment was the most common mode of transport when exporting goods to Algeria.

Israel

60% of redwood exported to Israel are used in Glulam and planed goods. The rest of the sawn timber goes to joinery, packaging, and construction. Total emissions when exporting to Israel were 38454 t/CO2 and the net stored CO_2 was 76095 tonnes. The average storage time of CO_2 in the main products is 37,5 years (Glulam 60 years, planed goods 15 years).

France

The most exported products to France were planed goods. It covers 50% of total redwood exports. Most of the shipments, about 70 %, were delivered door-to-door by trucks, the rest with conventional shipment. The average storage time of CO_2 in these products is 15 years. Total amount of CO_2 emissions was 42681 tonnes, and the size of the net CO_2 storage was 63172 tonnes.

5.3 Whitewood

The results of the survey show that in 2019, a total of 1399090 cubic meters of whitewood were exported from Finland. The largest export countries were China, Germany, Estonia, UK, and the Netherlands. Exported volumes based on the survey is shown in figure 7.

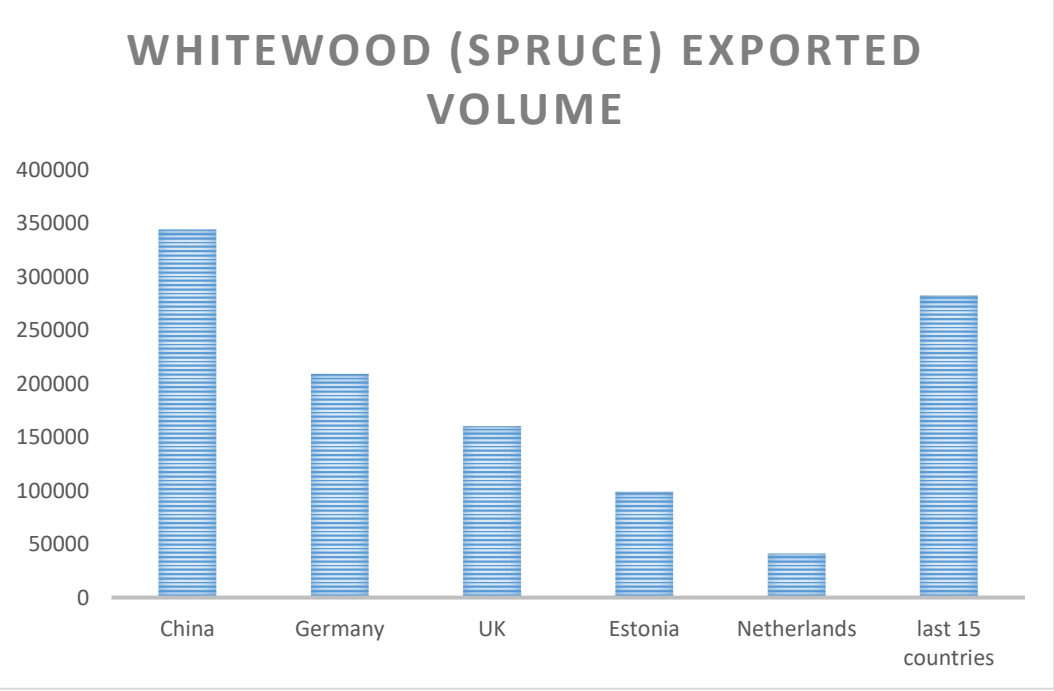


Figure 7. Whitewood export volumes obtained from the survey

The last 15 countries from the survey were added to this category, although the difference in export volumes of redwood and whitewood was not large. The emissions of CO_2 compared to net stored carbon is shown in figure 8.

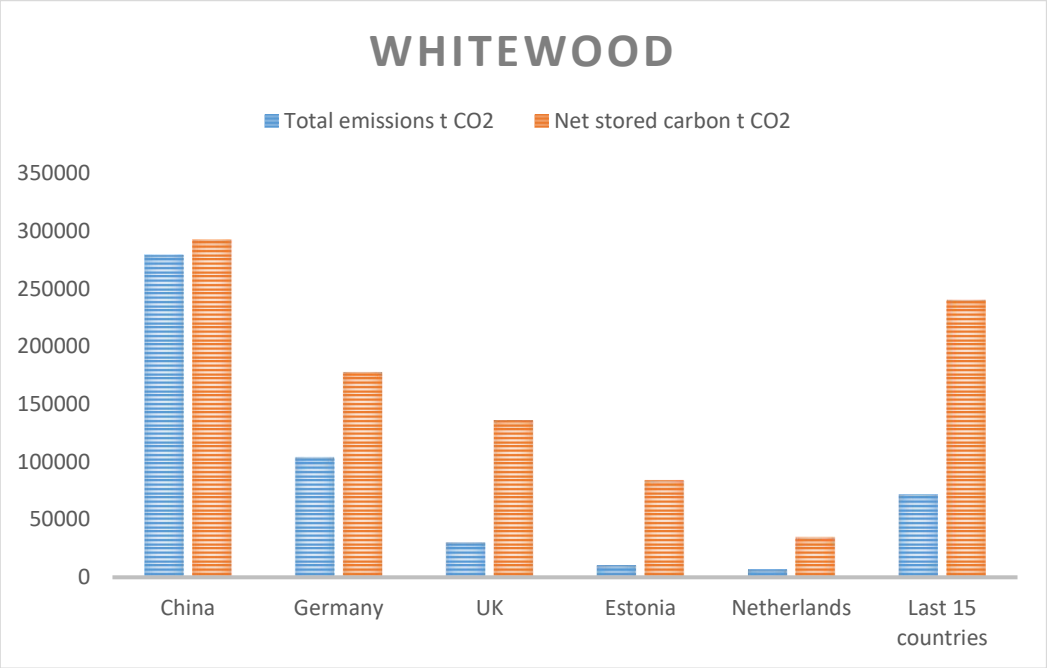


Figure 8. Total emissions and CO_2 stores of exported whitewood

China

From the exported whitewood, over 70 % is used in joinery. The total amount of CO_2 emissions when exporting to China was 279040 tonnes and the amount of stored CO_2 was 292442 tonnes. The most common use mode of transport to China was container shipment. The Chinese prefer furniture made of Finnish wood, especially in children's rooms. The life average life cycle in joinery products is 30 years. The life cycle of well cared solid wood furniture can be decades, so CO_2 stays stored for quite some time.

Germany

Whitewood exported to Germany from Finland mainly as planed goods. The Finnish wood is used, for example, for exterior cladding. The average life cycle of planed goods is approximately 15 years. Door-to-Door transports were the most used mode of transport when exporting goods to Germany. The trucks travel to Germany either via Sweden and Denmark, or directly Finland by vessel. The total amount of CO_2 emissions was 104187 tonnes and the amount of stored CO_2 was 177786 tonnes.

UK

The wood exported to the UK is mostly whitewood. The exported volume consists of sawn timber, joinery, and planed goods. The average life cycle of the products in this segment is 25 years (construction and joinery 30 years, planed goods 15 years). Most common used mode of transport when exporting to UK was conventional shipment, which covered 95 % of all shipments. The remaining 5 % was container transport. The total emissions were 30667 t/CO_2 and the size of the carbon storge was 136286 t/CO_2.

Estonia

Estonia is one of the principal exports of wood products of Finland. In 2019 the total amount of gross volume was 168851 cubic meters. The whitewood occupied 58.7% and redwood was 41.3% of all ordered. The exported whitewood is mainly used in joinery. In joinery products, CO_2 remains bound approximately 30 years. The stored CO_2 was 84184 tonnes, and the total amount of emissions was 10726 tonnes. Door to door was mostly used as a method of transport when goods were exported to Estonia.

Netherlands

At the Netherlands, the most common segment of exported Finnish timber is packaging, pallets, and single use construction material. The average years in use in this segment is one year. Netherlands started doing investment in housing and doing renovation of existing old buildings, due to this plan the exportation of Finnish whitewood was improved. The emissions were 6886 t/CO_2 from Finnish factories to the journey´s end. The size of the CO_2 storage was 34995 tonnes. The total emissions produced from steps 5 to 10 in picture 1 were the lowest of all exporting countries. The door-to-door transport method was mainly used.

The last 15 countries

The last 15 countries exported a total of 530276 m^3, of which 53,3 % was whitewood and 46,7 % redwood. These countries included e.g. Morocco, Saudi Arabia, Poland, Belgium, Spain, and Denmark. The exported whitewood ended up mainly as planed goods, redwood in joinery. Total emissions were 71859 t / CO_2 and net inventories 240109 t / CO_2. Container transport was used as a general mode of transport.

5.4 The average CO_2 storage time

The total volume of exported redwood according to the survey was 1062081 cubic meters. Figure 9 shows how the volume is distributed among different segments. Glulam acts as a long-term carbon storage, and most of the redwood exported from Finland ends up for this very purpose. Redwood is also widely used in joinery products, such as windows, doors, and furniture, which also have a quite long service life. The volume of short-lived products manufactured from Finnish whitewood was lower than the volume of long-lived wood products. There was no more detailed specification for the Other segment, so an exact life

cycle for these products was not available either. Therefore, the storage time of CO_2 in this segment has been set at one year.

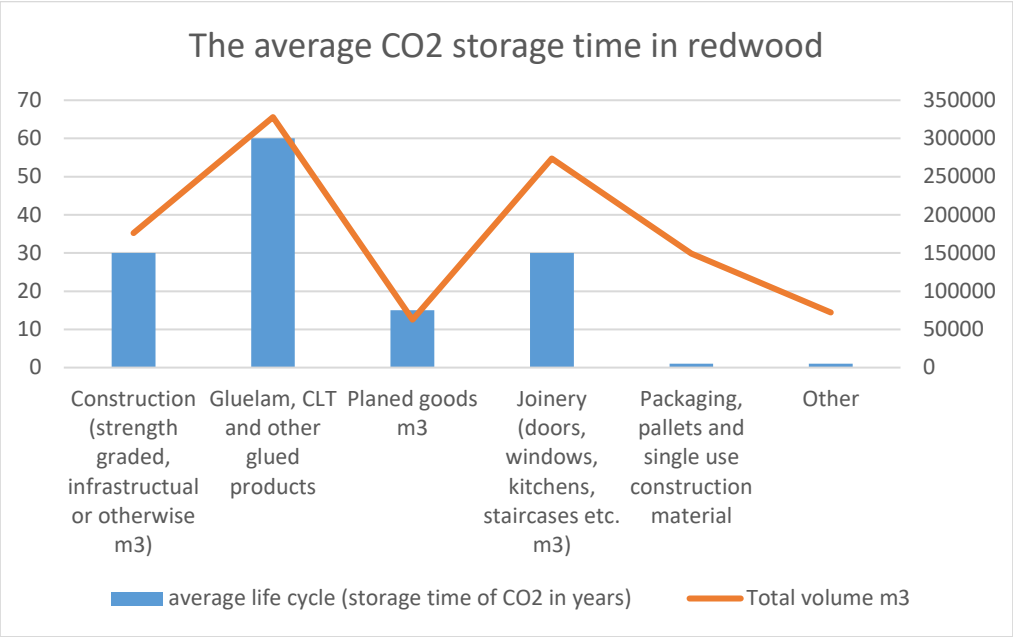


Figure 9. The average CO_2 storage time in redwood products

Figure 10 shows the volumes and average CO_2 storage time of whitewood in different segments. As can be seen from the figure, the use of whitewood in Glulam products was significantly lower than the use of redwood in similar products. The storage time of CO_2 bound to products made from Finnish whitewood is shorter than in redwood products, even though the total export volume, 1136236 cubic meters, was bigger.

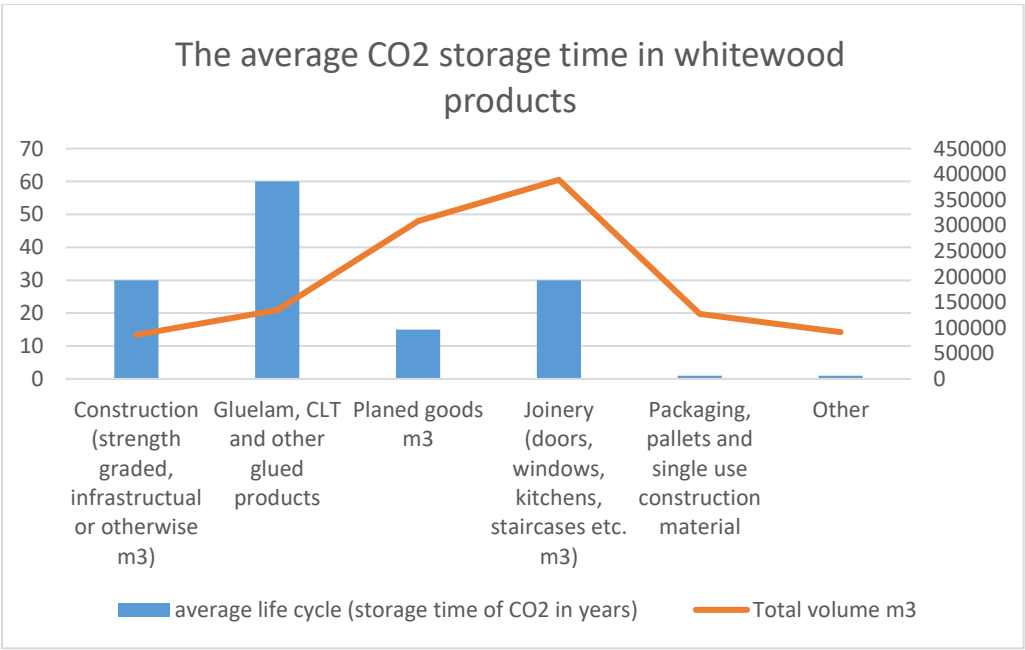


Figure 10. The average CO_2 storage time in whitewood products

6 Conclusions

The main objective of this thesis was to calculate the carbon footprint of the Finnish sawn timber exports in top 25 countries. We used the data from previous thesis which was done in autumn 2020 by Eero Kinnunen & Aleksi Turkia. The more information, such as average life cycles of different segments and other, was given by Esa Mikkonen, a senior lecturer in LAB university of applied sciences.

In calculations we took into consideration only the predominantly between the whitewood(spruce) and redwood(pine) for each country. The distance used to find out the carbon footprint is from Finnish factories to the destination of customers; we did not consider the distance from forests to the product manufacturing. According to the data of logistics the Finnish wood exports in top 25 countries the most used method of transportation is maritime where Egypt, United Kingdom and Algeria are mainly used conventional shipment while China, Japan, Israel and the last 15 countries utilized commonly Container shipment. The rest of countries such as Germany, France, Estonia, and Netherlands used the door-to-door shipping services.

After calculating the total emissions tons of carbon dioxide of all Finnish wood exports countries, we noticed that China, Japan, and Egypt emitted the most CO_2 with the range of 170000-280000 tonnes, while the Netherlands, UK and Estonia have the lowest emissions with the range of 6000-31 000 tonnes.

Countries that export redwood as their main products from Finland have higher and more long-lasting net storages of CO_2 than those countries that export whitewood. According to the results of the calculations, Egypt has a total net storage of 352246 t / CO_2, as it is by far the largest exporter of Finnish redwood. China, on the other hand, controls Finnish whitewood exports in statistics, with a net storage of 292442 t / CO_2.

The greatest CO_2 storages when observing exported Finnish wood products are for redwood in Glulam products and for whitewood in joinery products. With an average life cycle of 60 years in the above-mentioned products and 30 years in the following ones, it can be stated that when exporting wood products, Finland also exports carbon stocks.

In this thesis, we used data from a previous study, as well as additional information from our supervisor, but some of the data we received were not comprehensive enough to provide accurate results for determining carbon footprint estimates. In addition, simplified figures and averages have been used in the calculations, which also contribute to the results. For example, emissions have been calculated from steps 5-10 of Figure 1, which consist of truck transport from the factories to the port, then to the assembly or final destinations. Steps from the forest to Finnish factories were not considered in the calculation because the actual data were not available, although these would be very important steps. In the next possible research, it is necessary to define all the routes used in each country and their mode of transport to obtain more accurate readings.

Controlling emissions is important for the environment. A good way to reduce the release of GHGs to the atmosphere is to favour timber construction over concrete construction. Wood is the only construction material that binds CO_2. It can replace metal, plastic, and brick in a variety of applications, such as load-bearing structures, air barriers, and cladding. In construction and renovation, concrete-based products can be replaced with wood-based products.

REFERENCES

Printed sources

Jonathan. S. F. 2019. We are the weather: Saving the planet begins at breakfast. London: Hamish Hamilton

Kinnunen E. & Turkia, A. 2020. Suomalaiset puutuotteet. Loppukäyttökohteiden ja logistiikkaketjujen kyselytutkimus. Bachelor's thesis.

Varis, R. 2018. The Sawmill industry Handbook. Keuruu: Kirjakaari Oy.

Oral sources

Mikkonen, E. 2021. Senior Lecturer of LAB University of Applied Sciences. Emails from 8.2.2021 & 9.2.2021

Electronic sources

Business Finland. Retrieved on 25 February 2021. Available at https://www.businessfinland.fi/en/for-finnish-customers/about-us/in-brief

European environment Agency. 2019. Share of transport greenhouse gas emissions. Retrieved on 5 May 2021. Available at https://www.eea.europa.eu/data-and-maps/daviz/share-of-transport-ghg-emissions-2#tab-googlechartid_chart_13

Federation of the Finnish Woodworking Industries. Puutuoteteollisuus. 2021. Perustietoa puusta. Retrieved on 24 May 2021. Available at https://puutuoteteollisuus.fi/tietoa-puusta-ja-tuotteista/mita-puu-on

Finder: Business Finland Oy. Retrieved on 5 May 2021. Available at https://www.finder.fi/Konsultointipalvelut/Business+Finland/Helsinki/yhteystiedot/133795

Finder: Finnish Sawmills Ltd. Retrieved on 5 May 2021. Available at https://www.finder.fi/J%C3%A4rjest%C3%B6t+yhdistykset+ja+s%C3%A4%C3%A4ti%C3%B6t/Suomen+Sahat+Oy/Helsinki/yhteystiedot/933112

Finder: Wood from Finland Oy. Retrieved on 5 May 2021. Available at https://www.finder.fi/Liikkeenjohdon+konsultointi/Wood+from+Finland+Oy/Helsinki/yhteystiedot/1620262

Finnish Government. 2020. Transport emissions halved by 2030. Retrieved on 5 May 2021. Available at https://valtioneuvosto.fi/en/-/transport-emissions-halved-by-2030-requires-an-extensive-range-of-options

Finnish Ministry of Environment. International climate change negotiations. Retrieved on 5 May 2021. Available at https://ym.fi/en/international-climate-change-negotiations

Good energy. 2017. What is a carbon footprint? Retrieved on 3 March 2021. Available at https://www.goodenergy.co.uk/blog/2017/11/20/what-is-a-carbon-footprint/

Industry today. 2020. 5 Ways Manufacturers Can Reduce Carbon Emissions. Retrieved on 6 May 2021. Available at https://industrytoday.com/5-ways-manufacturers-can-reduce-carbon-emissions/

Metsä Forest, 2021. Katkomme tukit tarkasti käyttöön. Retrieved on 10 May 2021. Available at https://www.metsaforest.com/fi/Puukauppa/Pages/Katkomme-tukit-tarkasti-kayttoon.aspx

Metsä Forest. Harvennushakkuu turvaa puuston elinvoimaisuuden. Retrieved on 24 May 2021. Available at https://www.metsaforest.com/fi/Metsanhoito/Pages/Harvennushakkuu.aspx?cid=1250&utm_source=google&utm_medium=cpc&utm_campaign=Harvennukset%20ja%20hakkuu&utm_term=harvennushakkuu&gclid=CjwKCAjw47eFBhA9EiwAy8kzNORaBhchSdTnDX4V8WfLjmVjIL3jNRk8GGCyWyy4PodQ_ssLRO2emBoCUYkQAvD_BwE

Metsä Forest. Uudistushakkuusta kertyvät suurimmat tulot. Retrieved on 24 May 2021. Available at https://www.metsaforest.com/fi/Metsanhoito/Pages/Uudistushakkuu.aspx?cid=1250&utm_source=google&utm_medium=cpc&utm_campaign=Harvennukset%20ja%20hakkuu&utm_term=p%C3%A4%C3%A4tehakkuu&gclid=CjwKCAjw47eFBhA9EiwAy8kzNHnImXPASBMLW2t9olBK_8uqU5ttUkOvDDuRlH8coo37Eo1JO_n99RoCBT8QAvD_BwE

Metsäteollisuus. Retrieved on 6 May 2021. Available at https://www.metsateollisuus.fi/metsateollisuus-ry

Ministry of transport and communications. 2018. Transport emissions to zero by 2045. Retrieved on 6 May 2021. Available at https://www.lvm.fi/-/transport-emissions-to-zero-by-2045-990384

Natural Resources Institute Finland. LUKE. 2021. Forest industries' roundwood consumption, 2020. Retrieved on 6 May 2021. Available at https://www.luke.fi/en/news/forest-industries-roundwood-consumption-continued-to-decrease-in-2020/

Nunez C. 2019. National Geographic. Carbon dioxide levels are at a record high. Here's what you need to know. Retrieved on 6 May 2021. Available at https://www.nationalgeographic.com/environment/article/greenhouse-gases#:~:text=Greenhouse%20gases%20have%20far%2Dranging,change%20caused%20by%20greenhouse%20gases.

Puuproffa. Sahaustapoja. Retrieved on 14 May 2021. Available at https://puuproffa.fi/puutieto/puun-sahaus/sahaustapoja/

eSawmill. 2015. Sawn timber logistics. Retrieved on 7 May 2021. Available at https://sahateollisuuskirja.fi/en/markkinat-ja-myynti/sahatavaralogistiikka/

Sahateollisuus RY. Finnish Sawmills Associations. Retrieved on 25 February 2021. Available at https://sahateollisuus.com/finnish-sawmills/?lang=en

Siitonen S., Advisor, Climate Leadership Coalition. 2018. Miten laskea hiilijalanjälkiä? Retrieved on 25 February 2021. Available at https://clc.fi/fi/2018/03/12/miten-laskea-hiilijalanjalkia/

Statistics Finland. 2020. Greenhouse gas emissions fell in 2019, emission reduction targets for 2013 to 2020. Retrieved on 3 March 2021. Available at http://www.stat.fi/til/khki/2019/khki_2019_2020-12-21_tie_001_en.html

Statistics Finland. 2013. Greenhouse gas emissions in Finland by gas in 2012. Retrieved on 5 May 2021. Available at https://tilastokeskus.fi/til/khki/2012/khki_2012_2013-12-12_kuv_003_en.html

The Nature conservancy. Calculate Your Carbon Footprint. Retrieved on 3 March 2021. Available at https://www.nature.org/en-us/get-involved/how-to-help/carbon-

footprint-calculator/#:~:text=A%20carbon%20foot-print%20is%20the,is%20closer%20to%204%20tons.

Transport & Environment. 2015. Too big to ignore – Truck CO_2 emissions in 2030. Retrieved on 3 March 2021. Available at https://www.transportenviron-ment.org/sites/te/files/publications/2015%2009%20TE%20Brief-ing%20Truck%20CO2%20Too%20big%20to%20ignore_FINAL.pdf

UN Environment programme. December 2020. Building sector emissions hit rec-ord high but low-carbon pandemic recovery can help transform sector. Retrieved on 5 May 2021. Available at https://www.unep.org/news-and-stories/press-re-lease/building-sector-emissions-hit-record-high-low-carbon-pandemic

United States Environmental Protection Agency. Retrieved on 6 May 2021. Availa-ble at https://www.epa.gov/climate-indicators/greenhouse-gases

UPM. Milloin on ensiharvennuksen aika? Milloin päätehakkuun? Retrieved on 24 May 2021. Available at https://www.upmmetsa.fi/tietoa-ja-tapahtumia/artik-kelit/hakkuun-aika/

Wood from Finland. Retrieved on 25 Februray 2021. Available at https://woodfrom-finland.fi/wood-from-finland/about/

Ymparisto.fi. August 2019. Ilmastonmuutoksen vaikutukset. Retrieved on 6 May 2021. Available at https://www.ymparisto.fi/fi-FI/Ilmasto_ja_ilma/Ilmas-tonmuutoksen_vaikutukset