Fossil displacement and value chain emissions related to primary wood-based products in Ireland

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Commissioned by Coillte

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Contents

Summary

Analysis was undertaken to assess how the global climate is impacted by the domestic forest-based sector (Republic of Ireland and Northern Ireland). Scenarios were then examined to determine the relative magnitude of different climate actions on the daily operations of the sector based on the effects of changes in production levels and efficiency.

Two components were analyzed: (a) displacement of fossil/process emissions and (b) fossil emissions in the forest product value chain. Impacts from changes in composition of the forest were not included. Based on the results, indicative effects of changes in production levels and efficiency were estimated.

The displacement effect is an estimate of downstream effects that is realized by end-users' choices between alternative products. The effect expresses how much fossil/process emissions would be caused if wood-based products were not available on the market, forcing the use of alternative materials or energy. In other words, the displacement effect expresses avoided fossil/process emissions.

In 2019, an overall 4.9 million m³ of wood fibre was processed into a range of wood-based products and bioenergy. On average each m³ of wood led to a downstream fossil/process emission displacement of 0.77 tCO_2e for a total displacement effect of 3.7 million tCO_2e, corresponding to about 6% of reported emissions for the Republic of Ireland.

Fossil emissions in the value chain were estimated at 0.38 million tCO_2e for 2019. This includes forest operations (7% of emissions), transport of wood to mill (17%), emissions resulting from mill processing (25%) and transport of products to customers (51%). Each product produced from our forests was examined and supply chain emissions determined from local data and international forestry supply chain emissions studies.

The largest potential for improved climate performance within current product volumes was associated with maximising utilisation for bioenergy (about 1 million tCO_2e /year) and achieving a higher proportion of construction products (about 0.5 $MtCO_2e$ /yr). Reduced emissions in the value chain could realistically amount to 0.1 $MtCO_2e$ /yr. A 10% increase of product volumes would lead to 0,4 $MtCO_2e$ in improved performance but the overall effect would need to take into account the corresponding changes in forest carbon storage.

1. Background and Scope

The report is a comprehensive desk study commissioned by Coillte — www.coillte.ie — carried out by FutureVistas Inc, / Peter Holmgren during the period July-September 2021, in collaboration with Coillte experts. The study is intended as input to a broader multi-purpose strategy across economic, biodiversity, social & recreation and carbon/climate objectives.

The analysis has three principal components:

1. **Displacement Effects:** Assessment of benefits for the global climate as Irish wood-based products displace fossil/process emissions of greenhouse gases that would otherwise be caused by alternative products.

2. **Value-chain Emissions:** Assessment of fossil emissions caused in the value chain ranging from forest operations through forest industry to delivery of primary forest products to customers.

3. **Potentials for Enhanced Climate Benefits:** Comparison of possible actions towards higher/more efficient/more targeted production and how it could impact climate performance

The above components need to be considered together with developments on the forest estate as harvest levels will determine both the development of carbon storage in the forest as well as the climate performance of delivered products.

Data for the analysis has been provided by Coillte and locally published industry data. For components where local data or model parameters are missing, reference is made to analogous studies in other countries. Overall, the results should be considered as a guide and indicative given (a) unavailability of statistics for some components, and (b) uncertainties in estimations of displacement effects as these have not been part of official climate reporting.

The geographic scope has been the entire island of Ireland, that is the combined forestry and forest industry activity in the Republic of Ireland and Northern Ireland. This was considered relevant as considerable exchange of materials and products are made across the border. Results can be applied to individual product categories, smaller geographic units or individual production units, provided attention is given to possible local variations.

2. Reference Model for Study

The study builds on experiences from forest industry corporations and forest sector studies in Sweden and for the EU as a whole. The motivation for these has been that existing structures in official climate reporting and negotiations separate the forest from wood-based value chains. As a result we see policies (such as the EU LULUCF regulation) that focus on increasing the carbon storage in the forest without considering the benefits of wood-based products. Such policies therefore don't appreciate the full picture of the forest-based sector as a significant part of the climate solutions we need to adopt.

For these reasons, a better starting point is the "Circular Forest Bioeconomy" (Figure 1). The circular forest bioeconomy recognizes (potential) climate benefits through net sink in the forest, through carbon storage in Harvested Wood Products, and through displacement of fossil emissions. Carbon recycling back to the forest underpin the renewable, climate-neutral circular characteristic of wood/biomass from the forest.

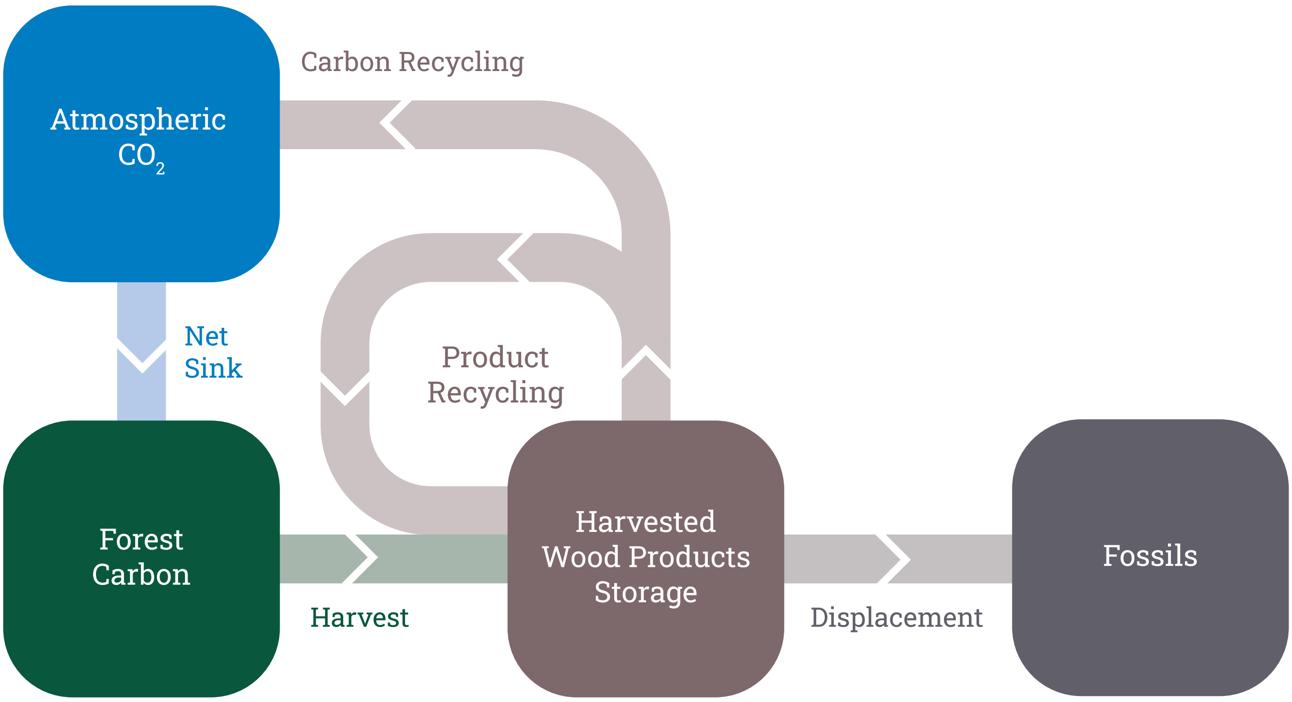


Figure 1: The Circular Forest Bioeconomy

Building on the above, a model for describing and reporting the overall climate benefits of a forest industry corporation (or a national forest-based sector as a whole) has evolved over the past few years (Holmgren and Kolar, 2019). Results are reported in corporate annual reports (e.g., SCA, Södra, Holmen, BillerudKorsnäs and StoraEnso BillerudKorsnäs, 2021; Holmen, 2021; SCA, 2021; Södra, 2021; StoraEnso, 2021). The model has also been used to present the climate effect of the forest-based sector in Sweden and the EU (CEPI, 2020; Swedish Forest Industries, 2019).

The model has three components. The current study considers two of these – Displacement and Value chain emissions (Figure 2):

1. **Net sink in Forest and Harvested Wood Products (HWP) – normally a positive climate effect**

   In European countries forests are currently managed so that the carbon storage increases over time. In addition, increasing storage of carbon in products also keeps carbon away from the atmosphere. Countries report this annually in national inventory reports to the UNFCCC. Forestry corporations usually have a good picture of their carbon storage developments from timber inventories and projections.

2. **Fossil emissions in the Value Chain – a negative climate effect**

   While the forest-based sector has reduced its fossil/process emissions over the past decades through higher process efficiency and also by using more renewable bioenergy, some fossil emissions remain, not least for transport of raw material and products.

3. **Wood-based products displacing fossil/process emissions by alternative products – a positive climate effect**

   Most wood-based products, including bioenergy, lead to a lower level of fossil emissions compared with the use of alternative products. This is a complex component to estimate, as further described below.

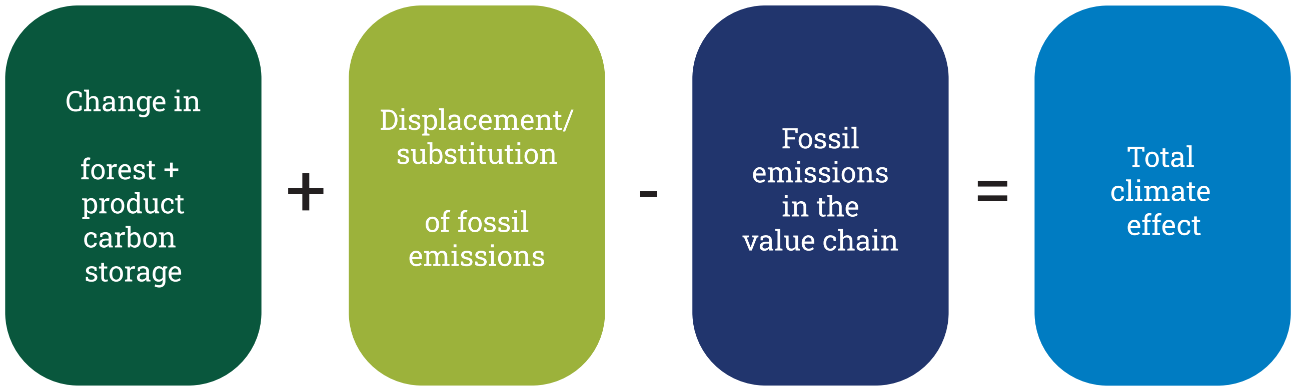


Figure 2: Total Climate Effect Equation

3. Displacement Effect and Displacement Factors

What is Displacement Effect?

The total displacement effect is measured in avoided fossil/process emissions per unit of time (typically tonnes of CO_2 equivalents per year, tCO_2e/yr). They express how much additional fossil emissions that would be made if wood-based products were not available on the market, forcing the use of less climate-friendly materials or energy.

As mentioned above, the displacement effects of forest products are not explicitly reported or included in climate-related negotiations. These effects are real and well established, but the structure of climate reporting hides the displacement effects in other sectors, e.g. construction or energy, where they don't connect to the circular forest bioeconomy concept. Even as the effects are well recognized, they are at the same time often misrepresented in official documents:

- The recent IPCC report on Climate Change and Land (IPCC, 2019) refers to substitution by wood in their analysis of mitigation potentials. The potential is put at a relatively modest level (0.25-1 $GtCO_2e$/yr globally) and refers only to solid wood products replacing cement and steel (IPCC, 2019, p.48). The mitigation potential of Bioenergy with Carbon Capture and Storage (BECCS) is considered much higher at 0.40-11.30 $GtCO_2e$/yr, out of which "up to several $GtCO_2e$/yr" (p.25) relates to the bioenergy as such leading to "avoiding combustion of fossil energy" (p.575), i.e. a displacement effect although not referred to with this wording.
- In 2021, the EC Joint Research Center released a brief on the forest bioeconomy (JRC, 2021) which highlighted the need to consider displacement effects from wood-based products alongside the benefits from the forest. The brief has two distinct problems, however. First it only considers the marginal effect of wood products, which means that already existing volumes and the displacement of fossil emissions that these volumes already deliver are not counted. This appears to be an attempt to conform with the "additionality" principle often applied to climate policy. Secondly, only solid wood products are included, whereas, in reality, also paper and bioenergy products displace substantial amounts of fossil emissions (which JRC has reported on separately).

As a consequence, the forest-based sector's overall contributions to climate solutions are often not well understood or considered. One challenge for the sector is to visualize the displacement effects of its products. This is important both for recognizing the importance of the sector in society's climate efforts and for marketing of wood-based products to climate-conscious customers.

Principles of Displacement

Fortunately, both scientific literature and life-cycle analyses provide data on displacement effects of wood-based products. As there has been no explicit reporting of these effects, there has been no development of formal standards, which still leaves the field somewhat open for interpretation. The above mentioned applications by forest industry corporations have, however, led to something of a de facto approach where the following principles apply:

- The displacement effect is initiated through forest management that allows for sustainable harvest of wood. The effect is then handed down the value-chain in several steps and divided into different product pathways until it is used for construction, packaging, energy or other applications. This is when the effect is realized. This means that all actors along the complex value-chain have a part in making the displacement happen – the effect can't be assigned to any one actor.

- Given the complexity of the value chain, it is not feasible to estimate the actual displacement effect given the wide variety of wood-based products and their uses. Instead, it is practical (and relevant for sector policy purposes) to estimate downstream effects for general product categories delivered by the primary forest industry or bioenergy facilities.

- The full volume of products count – not only additional volumes on the margin as suggested by some (see above). This means that the key question for the analysis becomes "If quantities of wood-based products disappeared from the market - how much fossil emissions would be caused for producing and delivering alternative products?"

- No displacement effect is considered within the value chain, even if theoretically the bioenergy used for industry processes could be seen to replace fossils. Displacement effects are only calculated for products that reach the market.

- Displacement can happen several times for each wood fibre as it is recycled to new products and finally used at end of life for energy. However, cascading displacement effects are even more difficult to estimate, as alternative materials can be recycled – sometimes more times than wood fibre. The recycling process is normally energy-intensive, which reduces the displacement effect of recycled products. To reduce complexity in the analysis and given

limited available data, displacement is only considered (a) for the first order product that is marketed, and (b) for end-use as energy, if applicable.

- Reference data from literature must be chosen with care. Studies of displacement effects have different system boundaries. When obtaining data for displacement effects from the literature, it is important to avoid results where the system boundary of the analysis does not fit the purpose. Some examples of the system boundary considerations are outlined:

- Displacement effects may include modeled impacts on forest carbon storage from harvesting wood. As the forest carbon storage is counted separately in the present model, such results can't be used unless it is possible to separate out the products' specific effects from the development of the forest.

- Some studies compare different mixes of fossil-based and wood-based material. For example, construction of houses may include a higher or lower proportion of wood-based materials. The displacement effects by comparing the more-wood-based-construction with a less-wood-based-construction as a whole does not tell us the specific displacement effects of using wood-based products, say sawn joists.

- Sometimes, only a subset of wood-based products is considered. For example (JRC, 2021) only considered displacement effects by solid wood products, ignoring fibre-based products and bioenergy, both of which also lead to displacement of fossil emissions. In addition, the wood-based value chain is integrated across product categories (partly because trees are round, conical and have bark), so it does not make sense to separate out any subset of products.

- Studies may include assumptions or models of dynamic developments of the displacement factors over time. In most cases, these analysis point to a projected decrease of the substitution effect over time as alternative technologies become less fossil-dependent. Results obviously depend on assumptions, however.

Calculating Displacement Effect

Calculating the total displacement effect (t CO_2e/yr) can be done in different ways. In the model applications referred above, it is done by:

- first establishing a displacement factor (DF) for each product category of interest. The DF is an estimate of avoided fossil emissions by quantity of wood-based product, expressed in tonnes of carbon emissions avoided by tonnes of carbon in the wood-based product (unit: tC/tC, which can also be expressed as tCO_2e/tCO_2e).

- then multiplying each quantity of a wood-based product category with the DF in question, where the volume or weight of products have been recalculated to carbon dioxide equivalents, converted to tCO_2e.

- then adding together the displacement for all product categories.

$$DE = \sum_i DF_i Q_i$$

where

DE = Total displacement effect (tCO_2e)

i = product category

DFi = Displacement factor for product category i (tC/tC)

Qi = Quantity of product category (tCO_2e)

- Note that for presentation purposes, the displacement factors can be converted to tCO_2e/m^3 of wood, as the carbon content of wood is relatively constant. With a wood density of 0.5, relative carbon content of cellulose also of 0.5, and CO_2 to C ratio of 3.67, one m^3 of wood equals 0.5 x 0.5 x 3.67 = 0.9175 tCO_2e.

4. Methodology

Production and trade statistics were obtained from COFORD and internal material provided by Coillte.

Displacement Factors

The set of product categories were consolidated into the list in Table 1. Note 50% recovery for end-use as energy assumed and no pulp/paper products are included as these are not part of the Irish product mix.

Displacement factors (DFs) were averaged based on literature that contain analysis of the specific products categories in the study, excluding studies that have applied a system boundary that is incompatible (see above). Literature consulted: (Bergman et al., 2014; Buchanan and Honey, 1994; Hurmekoski et al., 2020; Leskinen et al., 2018; Rüter et al., 2016; Soimakallio, S. et al., 2016).

As explained above, the DFs were estimated as the sum of primary use of the product plus the effect of end-use as bioenergy, if applicable.

Primary Product Category	Primary Use Displacement Factor tCO_2e/tCO_2e	End-Use Displacement Factor tCO_2e/tCO_2e	Total Displacement Factor tCO_2e/tCO_2e
Construction and Timber frame	1.5	0.35	1.85
Fencing and other	1.22	0.35	1.57
Pallet and Packaging	0.4	0.35	0.75
Posts	1.22	0.35	1.57
Wood Based Panels (OSB and MDF)	1	0.35	1.35
Bioenergy (in CHP)	0.7	n/a	0.7
Bioenergy for heating (eg. Firewood) - assumed	0.4	n/a	0.4

Table 1: Product Categories and Displacement Factors (DF)

Value Chain Emissions

For value-chain emissions, four segments were identified (Figure 3). For each, the fossil emissions were estimated. However, for each of these steps, reliable statistics were not available for the Irish value-chain. Instead, proxy values from other studies were applied.

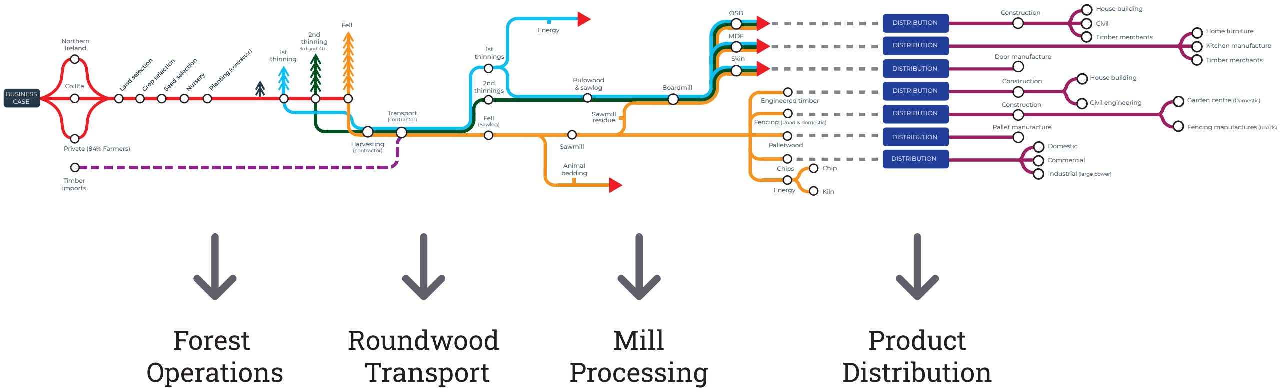


Figure 3: Value-chain of Irish Forest-based Sector and Four Segments Considered in Study
Image: Courtesy Enterprise Ireland

Scenarios/Potential for Improved Climate Effects

Based on the results and data available, a set of changes to product volume/composition and efficiencies in the value-chain were tested with respect to potential impact on the global climate.

5. Results

Displacement Effect

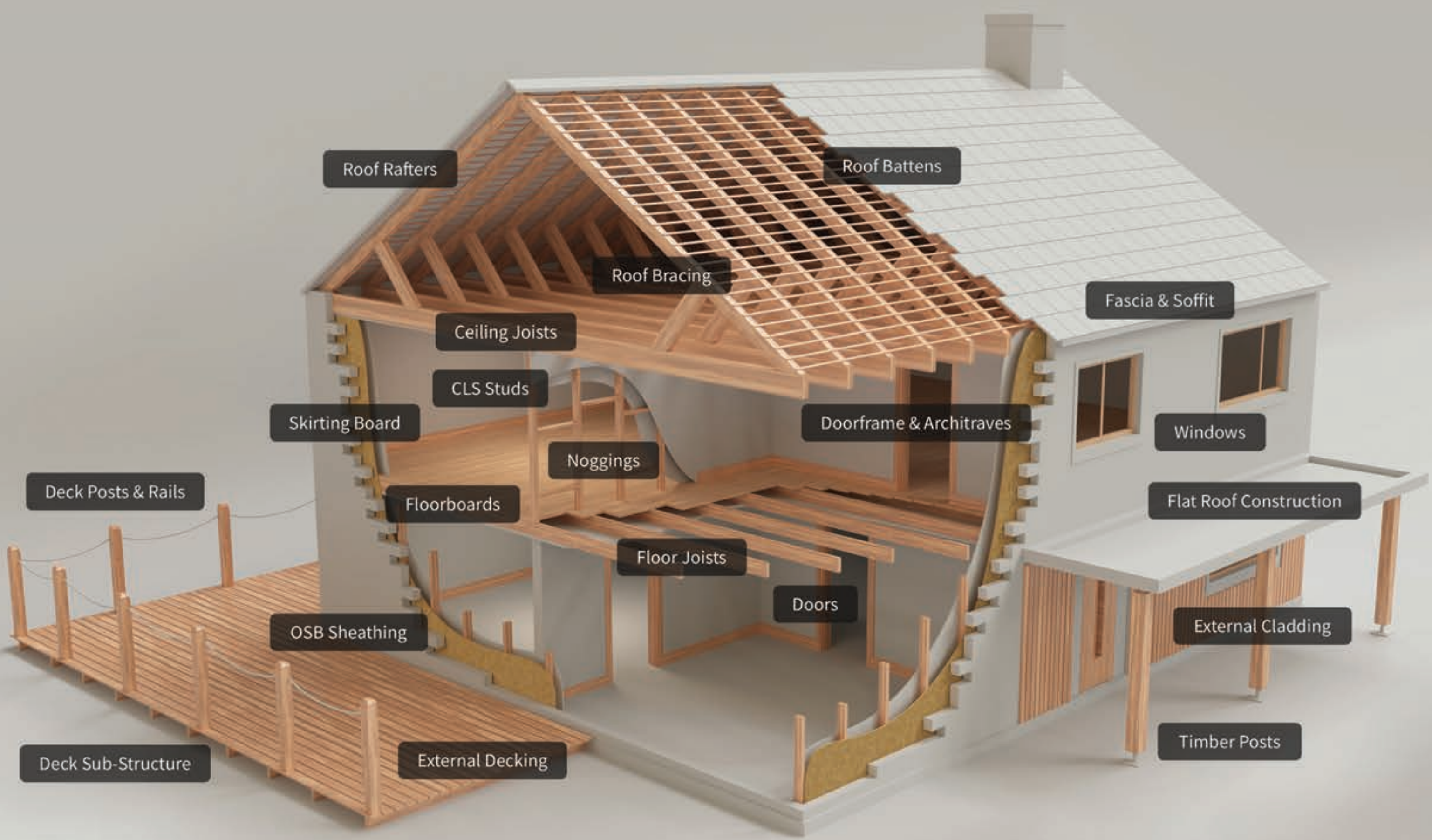
Displacement effects for the Irish forest products sector output were estimated based on a review of international studies of comparable end use product categories (See Table 2). Using estimated production data for the domestic forest products sector, the total displacement effect of domestic forest products is estimated at **3.7 M tCO_2e/yr**. This is the level of avoided emissions from fossil-based products through use of wood-based products and translates to an overall displacement factor of 0.84 tCO_2e / tCO_2e or 0.77 tCO_2e /m^3 at the roundwood stage.

Primary Product Category	Estimated Production 2019 000 m^3	Displacement Factor tCO_2e/tCO_2e	Total Displacement Mt CO_2e
Construction and Timber frame	642	1.85	1.09
Pallet and Packaging	344	0.75	0.24
Fencing and other	436	1.57	0.63
Posts	207	1.57	0.3
Wood Based Panels (OSB and MDF)	919	1.35	1.14
Bioenergy (of which processing sector use)	1315	0	-
Bioenergy for heating	290	0.4	0.11
Other uses	188	0	-
"Export" of residues	362	0.7	0.23
Total	**4699**	**-**	**3.73**
Waste / Unaccounted for	157		

Table 2: Estimated Displacement Effect from Domestic Wood-based Products

Note: The displacement factor for bioenergy can range from 0.4 to 0.8 tCO2e/ tCO2e.

3 million tonnes of CO_2 was stored in long life products made by our sector in 2019.



Fossil Emissions in Value Chain

Four components of the value chain were assessed and comparative data from international studies were applied.

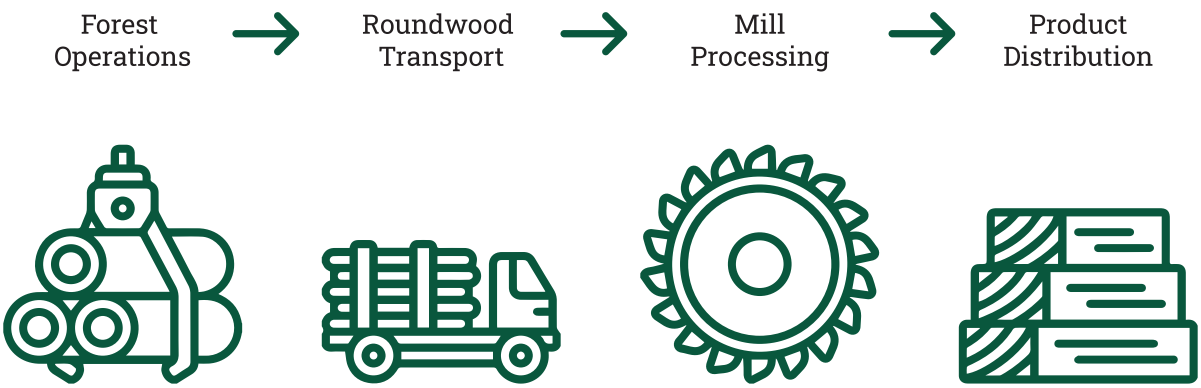


Figure 4: Value Chain Emissions in Forest Products Sector Supply Chain

System Boundary

Each product produced from our forests was examined and supply chain emissions determined from local data and international forestry supply chain emissions studies. Supply chain emissions include harvesting and transport of logs to sawmill, processing and delivery of wood products to main distribution points within the merchant network both in Ireland and the UK. Emissions from the construction of forest roads are excluded. Emissions from any further haulage of the finished product from the merchant network to the point of end use are also excluded. Based on the above system boundaries, value chain emissions were estimated at **0.38 Mt CO_2e/yr** (See Table 3).

Component of Value-chain	Estimated fossil emissions per unit tCO_2e/m^3	Total value chain emissions Mt CO_2e/yr
Forest operations (including harvesting)	0.0059 tCO_2e/m^3 roundwood	0.028
Roundwood transport (to processing mill)	0.0131 tCO_2e/m^3 roundwood	0.063
Processing at mill(s)	0.02 tCO_2e/m^3 roundwood input	0.097
Transport of finished products (to customer)	0.0832 tCO_2e/m^3	0.194
Total	**-**	**0.38**

Table 3: Estimated Value Chain Emissions from Irish Wood-based Products

Scenarios

A range of independent scenarios were examined, based on the above results and data to determine the relative magnitude of different climate actions on the daily operations of the sector based on the effects of changes in production levels and efficiency. All scenarios indicate positive climate effects (ie. a reduction of atmospheric CO_2).

Change in product volume/composition and value-chain efficiency	Potential Climate Impact – Change in atmospheric CO_2 per year $MtCO_2e/yr$
Increase overall production (roundwood + products by 10%)	-0.4
Increase sawn-wood output (from 30% of roundwood volume to 40%)	-0.5
Increase displacement when using sawn wood products for construction (from 1.5 to 2 tCO2e/tCO2e)	-0.3
Increase end-use recovery of wood (from 50% to 80% and use as CHP energy)	-0.3
Maximize bioenergy CHP displacement (80% recovery, only CHP use, Unaccounted waste used)	-1
Maximise bioenergy heat displacement (80% to heat, 20% to CHP, Unaccounted waste used)	-0.7
Reduce transport emissions (by half)	-0.1
Reduce fossil emissions in processing mills (by half)	-0.05

Table 4: Indicative Climate Effects of Selected Scenarios
Related to Displacement and Value Chain Emissions

Notes
- Scenarios are not mutually exclusive and they should not be added up.
- Scenarios do not include the impact the scenario would have on the forest (carbon stocks, carbon sinks and the rate of uptake).
- These scenarios are static estimates given current emissions and displacement effects and do not consider eventual dynamic effects.
- They should be considered indicative of the magnitude of improvements that different actions could have.

All scenarios indicate positive climate effects (a reduction of atmospheric CO_2). The largest potential was noted when maximizing bioenergy displacement. Actions to reduce fossil emissions in the value chain have relatively lower impact, albeit the effects would be large in absolute terms.

6. Discussion and Observations

1. Available data limited the granularity of the study. 2019 statistics were not fully available at the time of writing the report. Value chain emissions are largely based on a review of international studies.

2. The average displacement factor calculated at the stage of roundwood is higher than in other studies (0.77 tCO_2e/m^3 compared with 0.5-0.55 in Swedish studies). The main reason appears to be a higher proportion of solid wood products from the raw material, and concurrently a lower proportion of bioenergy and no fibre products.

3. Overall displacement effect is 3.7 Mt CCO_2e/yr which corresponds to about 6% of ROI overall territorial emissions. This is the level of avoided fossil/process emissions through the use of wood-based products.

4. Looking at possible actions to improve climate performance, efficiency gains in raw material use and recovery can have a considerably higher climate effect than reducing fossil emissions in the value chain. Both types of actions would of course be very useful contributions to the overall climate solution.

For every m³ of roundwood we use in place of another building material, we save 0.77 tonnes of CO_2e.

7. Glossary

Circular Forest Bioeconomy	The circular forest bioeconomy recognizes (potential) climate benefits through net sink in the forest, through carbon storage in Harvested Wood Products, and through displacement of fossil emissions. Carbon recycling back to the forest underscores the renewable, climate-neutral characteristic of wood/biomass from the forest.
CO_2e	Carbon dioxide equivalents. Greenhouse gases other than carbon dioxide (NH_4, N_2O) have a higher warming effect than CO_2. Adding up the total climate impact is made by converting quantities of other gases to the quantity of CO_2 that would cause the same warming, and adding together to the total effect in CO_2e.
Displacement Effect	The quantity of fossil/process emissions that are avoided through the use of material or energy with lower climate footprint. Unit: tons of CO_2e
Displacement Factor	The displacement effect by quantity of, in this case, wood-based products. Unit is usually tC_{fossil} / $tC_{biogenic}$, i.e., the amount of fossil emissions in tC that would be avoided by the quantity of wood-based products that contain one tC (equivalent to about 4 m^3 of solid wood).
Fossil/Process Emissions	Emissions of greenhouse gases from fossil fuels or industry processes – notably cement production.

Harvested Wood Products (HWP)	Term used in climate reporting to express the amount of carbon temporarily stored in manufactured products.
Net Sink (in Forest)	The net increase of carbon stock in the forest, taking into account growth, natural losses and harvesting of wood.
Substitution Effect / Substitution Factor	Sometimes used with the same meaning as Displacement Effect / Displacement Factor.
Value Chain	Here used to express all activities from forest operations to delivery of wood-based products at customer location.
Value Chain Emissions	The total fossil/process emissions caused in the value chain.

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Dr. Peter Holmgren has a long international career within forestry, food security and climate change.

During 14 years at the Food and Agriculture Organization of the UN (FAO) he led the Global Forest Resources Assessment, headed the forest resources development unit and was for five years Director of Climate, Energy and Tenure. He co-founded the UN-REDD programme and led the development of the climate-smart agriculture concept. From 2012-2017 he served as Director General of the Centre for International Forestry Research (CIFOR) where he connected the world of forestry to the SDGs and set up the Global Landscapes Forum placing local communities at the centre of sustainable development. He is now based in his native Sweden as sustainability strategist for the forest industry.

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