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REVIEW OF LITERATURE ON FOREST PRODUCTS-RELATED AVOIDED GREENHOUSE GAS EMISSIONS

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About this report:

This report examines research on forest products-related avoided greenhouse gas (GHG) emissions in the context of existing guidance on calculating and reporting these avoided emissions. It confirms that forest products, and wood products in particular, generally release less fossil fuel-related GHGs over their life cycle than fossil fuel-intensive alternatives and have the capacity to store carbon over long periods of time. With regards to calculating and reporting avoided emissions, the report finds that different organizations have used different approaches and there is no standard approach for doing so to date.

About NCASI:

NCASI (National Council for Air and Stream Improvement, Inc.) is a non-profit environmental research organization that seeks to create credible scientific information required to address the environmental information needs of the forest products industry in North America. NCASI conducts surveys, performs field measurements, undertakes scientific research, and sponsors research by universities and others to document the environmental performance of industry facility operations and forest management, and to gain insight into opportunities for further improvement in meeting sustainability goals.

REVIEW OF LITERATURE ON FOREST PRODUCTS-RELATED AVOIDED GREENHOUSE GAS EMISSIONS

SUMMARY

Over many years, a body of research has been developed examining the greenhouse gas (GHG) and carbon attributes of forests and forest products. This research has demonstrated that forest-based products, particularly building materials, provide long-term GHG mitigation benefits when they substitute for more GHG-intensive alternatives. This report examines research on forest products-related avoided emissions in the context of existing calculating and reporting guidance. The report confirms that forest products, and wood products in particular, generally release less GHG over their life cycle than fossil fuel-intensive alternatives and have the capacity to store carbon over long periods of time. NCASI found that different organizations have used different approaches in calculating avoided emissions. Approaches typically involve consideration of the full life cycle (i.e., from raw material extraction to final disposal) of forest products and their alternatives but use different metrics for reporting. In addition, net biomass CO_2 removals are sometimes aggregated with avoided fossil fuel emissions, making the results less transparent.

KEYWORDS

forest products, substitution effects

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REVIEW OF LITERATURE ON FOREST PRODUCTS-RELATED AVOIDED GREENHOUSE GAS EMISSIONS

1.0 INTRODUCTION

Over many years, a body of research examining the greenhouse gas (GHG) and carbon attributes of forests and forest products has been developed. This research has demonstrated that forest-based products, particularly building materials, provide long-term GHG mitigation benefits when they substitute for more GHG-intensive alternatives. In this context, when undertaking GHG inventories, some companies may wish to report the emissions avoided as a result of use of their sold products. However, there is no standard guidance on how to do so, and relatively few suggested approaches have been established to date. This report examines research on forest products-related avoided emissions in the context of existing reporting guidance.

2.0 DEFINITIONS

Allocation: Partitioning input or output flows of a process or a product system between the product system under study and one or more other product systems (ISO 2006).

Attributional Approach: An approach to life cycle assessment (LCA) or GHG inventories where emissions and removals are attributed to the studied product by linking attributable processes along its life cycle (adapted from WRI and WBCSD 2011b).

Avoided Emissions: Emission reductions that are indirectly caused by the studied product or a process that occurs in the studied product's life cycle (WRI and WBCSD 2011b); that is, emissions reductions that occur outside a product's life cycle or value chain but as a result of the use of that product (Draucker 2013). Alternative terminologies include climate positive, net-positive accounting, scope 4 emissions, and substitution effects. It seems that the "avoided emissions" terminology is mainly used by the WRI/WBCSD GHG Protocol, whereas the forest products sector has largely referred to these as "substitution effects".

Consequential Approach: An approach to LCA or GHG inventories where processes are included in the life cycle boundary to the extent that they are expected to change as a consequence of a change in demand for the studied product (adapted from WRI and WBCSD 2011b)

Harvested Wood Products (HWPs): Wood-based materials harvested from forests that leave forest sites and are used as products. HWPs include forest products in use (wood products and paper products), woody biomass used for energy purposes, and woody biomass in solid waste disposal sites (adapted from IPCC 2006, 2019).

Substitution (or Displacement) Factor: Factor that expresses the efficiency of using a wood-based product to reduce GHG emissions to the atmosphere compared to a non-wood-based equivalent alternative product (Sathre and O'Connor 2010a; Leskinen et al. 2018).

3.0 ACCOUNTING FRAMEWORKS FOR AVOIDED EMISSIONS

3.1 WRI/WBCSD GHG Protocol Corporate/Scope 3 and Product Standards

Avoided emissions are not addressed in the Corporate Accounting and Reporting Standard ("Corporate Standard") but are discussed in its companion Corporate Value Chain (Scope 3) Accounting and Report Standard (WRI and WBCSD 2004, 2011a). Under the Scope 3 Standard, companies are not allowed to claim avoided emissions as a deduction to their Scope 3 inventory but may report them separately. Companies that report avoided emissions are encouraged to provide data to support the claim that emissions are avoided and to report methodology, data sources, system boundary, time period, and other assumptions used to calculate these emissions. Companies are referred to the Protocol for Project Accounting ("Project Protocol") for quantification of avoided emissions[1]. Examples of activities within a company inventory that are listed under the Scope 3 Standard as potentially resulting in "avoided emissions" include recycling activities and use of sold products.

Similarly, under the Product Life Cycle and Accounting Standard ("Product Standard") (WRI and WBCSD 2011b), companies are not allowed to deduct avoided emissions from their products' total GHG inventory results because they are considered to be occurring outside the boundary of a product's life cycle. However, they may be reported separately. In calculating and reporting avoided emissions, companies are encouraged to also consider any <u>positive and negative</u> indirect emissions caused by market responses to the studied product or its life cycle. The Product Standard also underlines that "avoided emissions" or "substitution" is an allocation approach used in LCA; if avoided emissions are calculated in this context, these cases are not considered to be avoided emissions as defined by the standard and therefore are not required to be reported separately from inventory results (if the Product Standard allocation guidance is applied).

3.2 WRI/WBCSD GHG Protocol for Project Accounting

The Project Protocol (WRI and WBCSD 2005) does not provide guidance on reporting avoided emissions but instead provides principles, concepts, and methods for quantifying and reporting GHG reductions (i.e., decreases in GHG emissions or increases in removal and/or storage) from climate change mitigation projects. Thus, to apply the Project Protocol to quantify avoided emissions, one must consider emission reductions indirectly caused by the studied product as a "GHG project", which consists of a "specific activity or set of activities intended to reduce GHG emissions, increase the storage of carbon, or enhance GHG removals from the atmosphere", making it difficult to apply in the context of avoided emissions. Therefore, it appears that applying the Project Protocol for quantifying emissions in the context of corporate inventories might be of limited utility and that more guidance would be needed in order to do so.

3.3 WRI "Estimating and Reporting the Comparative Emissions Impacts of Products"

In 2018, the World Resources Institute (WRI) provided guidance specifically to account for "[c]omparative product GHG impacts" (Russell 2018). Comparative product GHG impacts are described as the "emissions impact of a product (good or service) relative to the situation where that product does not exist". These differences can be negative or positive, with positive differences frequently referred to as avoided emissions.

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[1] Tool for quantifying GHG benefits of climate change mitigation projects.

In accounting for comparative emissions impacts, WRI distinguishes between attributional and consequential accounting approaches (see definitions in Section 2). The attributional approach is relatively easy to apply to a large product portfolio but ignores market effects. The consequential approach considers market-related effects, but its application might be constrained due to data availability and can be labor intensive. WRI indicates that companies typically apply the attributional approach but that the consequential approach is probably better suited to decision-making if data are available.

3.3.1 Calculating Avoided Emissions Using the Attributional Approach

As shown in Figure 1, when using the attributional approach avoided emissions are estimated as the difference between the attributional, life cycle GHG inventory of a company's product (the "assessed" product) and an alternative (or "reference") product that provides an equivalent function (Russell 2018).

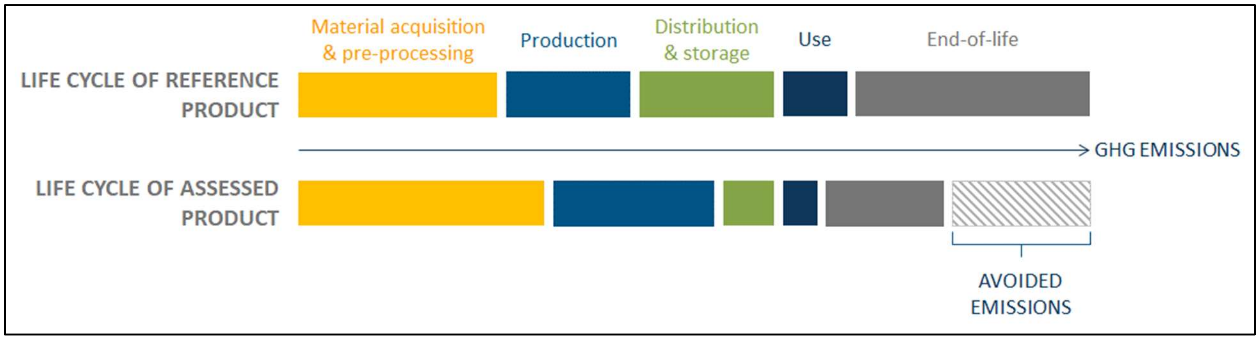


Figure 1. Calculating Avoided Emissions Using the Attributional Approach
[Source: adapted from Russell 2018]

3.3.2 Calculating Avoided Emissions Using the Consequential Approach

To calculate avoided emissions using the consequential approach, one must consider the total, system-wide change in emissions and removals that results from a given decision, such as the decision to produce one extra unit of the assessed product. Avoided emissions are estimated by subtracting emissions in a scenario under which the extra unit of the assessed product is produced from those in a scenario under which the extra unit of the assessed product is *not* produced and another product is needed to achieve the same function.

3.3.3 Key Recommendations

WRI reviewed major existing guidelines or standards applicable to avoided emissions (Russell 2018). These guidelines apply to all sectors (WRI 2014; ILCAJ 2015), information and communication technologies (GeSI and BCG 2010; ITU 2014), chemicals (ICCA and WBCSD 2013), and electrical and electronic products (IEC 2014). In reviewing these guidelines and documents, WRI (Russell 2018) made a series of recommendations. The most significant ones are summarized in Table 1.

Table 1. Summary of WRI 2018 Recommendations on Avoided Emissions

Category	Recommendations
General principles	Avoided emissions should not be used to adjust (e.g., "net") scope 1, 2, and 3 emissions. Instead they should be reported separately and should not detract from a company's GHG inventory.
	Avoided emissions should include all life cycle GHG emissions (under an attributional approach) or all changes in emissions arising from the assessed product (consequential approach) in the assessment and should be derived using consistent methodologies for the assessed and alternative products.
	Any identified trade-offs with other (non-GHG) environmental impact categories should be disclosed.
Accounting approach	If feasible, the consequential approach should be used when avoided emissions are employed to inform decision-making and whenever market effects are significant.
	The attributional approach should be used only to help customers understand the scope 3 implications of their purchasing decisions.
Definition of the reference product or baseline scenario	A reference product or baseline scenario that represents what is most likely to be sold in the market in the absence of the assessed product, rather than what already exists on the market, should be selected.
	The reference product or baseline scenario should be clearly defined and justified.
	When assessing the avoided emissions associated with renewable energy products, "marginal" emission factors should be used to define the emissions profile of the comparable product.
Uncertainty	Uncertainty should be discussed.
	Particularly for long-lived products, sensitivity analyses of key parameters and assumptions in the assessment should be undertaken.
	In cases where uncertainty is high, avoided emissions should be reported using the most conservative assumptions.

Note that under the GHG Protocol, if avoided emissions are reported they would typically be reported in units of CO_2 eq. [avoided] per year.

3.4 CEPI "10-Toe Framework"

In 2007, the Confederation of European Paper Industries (CEPI) published a carbon footprint framework applicable to paper and board products; it was updated in 2017 (CEPI 2007, 2017). The framework consists of ten reporting elements (or "toes" of the footprint), the tenth one being avoided emissions. In this toe, a company is allowed to report "information on emissions that do not occur (i.e., are avoided) because of an attribute of the product or an activity of the company making the product," but CEPI underlines that the credibility of avoided emissions is "directly dependent on that of the scenario used to describe what would have happened in the absence of the product attribute or company activity". CEPI also specifies that whether netting out avoided emissions with other emissions is acceptable depends on the use of the reported information and recommends that assumptions and methods be transparently communicated to users of the information.

CEPI lists these examples of cases where reporting avoided emissions might be interesting for forest products:

- Sale of electricity or heat that displaces energy that would have been produced by more GHG-intensive methods;
- Paper recycling[2];
- Use of sold products if it reduces life cycle GHG emissions compared to alternative fossil-based products;
- Beneficial use of mill residuals that avoids emissions associated with production of other materials (e.g., fertilizers) that would have been used instead;
- Burning of used products or waste materials as a source of biomass energy, avoiding emissions associated with fuels that would have been used otherwise; and
- Production of co-products that avoids their alternative production elsewhere.

CEPI underlines that depending on the type of carbon footprint (or GHG inventory) applied, care is needed to avoid inconsistent application of LCA allocation methods and reporting of avoided emissions (see Section 3.6).

3.5 Substitution (Displacement) Factor

Sathre and O'Connor (2010a) introduced a metric to quantify the difference between GHG emissions resulting from use of wood and a predominantly non-wood alternative – the displacement factor. The metric was renamed the Substitution Factor (SF) by the European Forest Institute (Leskinen et al. 2018). It is calculated thus:

$$SF = \frac{GHG_{non-wood} - GHG_{wood}}{WU_{wood} - WU_{non-wood}}$$

$GHG_{non\text{-}wood}$ and GHG_{wood} are the GHG emissions (in units of carbon) resulting from use of non-wood and wood alternatives. WU_{wood} and $WU_{non\text{-}wood}$ are the amounts of wood used (in units of carbon) in wood and non-wood alternatives. A positive SF value indicates that using a wood product causes less GHG emissions than using the non-wood product if the wood product contains more wood than the non-wood product, which is expected to be the case.

The SF is derived using the attributional life cycle approach. Calculation of SF typically excludes biomass CO_2 emissions but sometimes includes biomass carbon stored in use and in landfills. Thus, an SF is only one component of the GHG balance of wood products. To estimate the overall climate impact of wood products, one also must consider the biogenic carbon balance, including changes in forest carbon stocks and storage in HWPs in cases where these are not already included in the calculation of the SF.

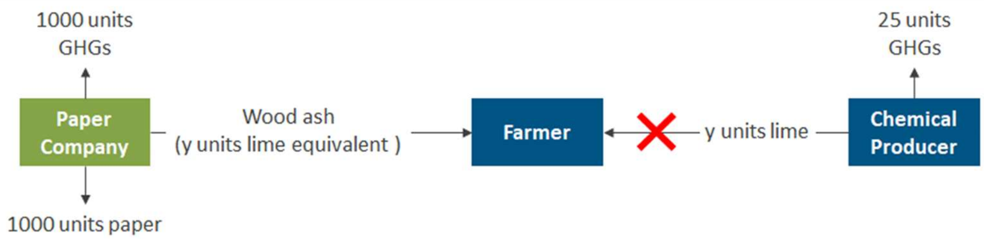
[2] CEPI notes, however, that avoided emissions associated with paper recycling are extremely dependent on local conditions and are especially significant in situations where the paper would have been landfilled if it was not recycled. Avoided emissions also depend on whether the alternative use of the used paper is burning for energy to displace fossil fuels for heat and electricity production.

The SF cannot be deducted from a company's GHG inventory, which can be seen as an advantage. However, this will also prevent a better understanding of the magnitude of avoided emissions relative to a company's total GHG emissions.

3.6 LCA "Avoided Burden" or "Substitution" Allocation Method

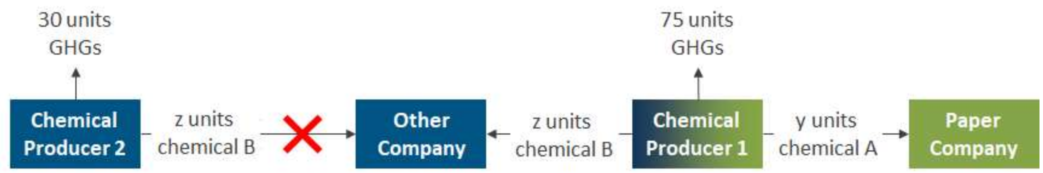
One of the difficulties in quantifying the LCA profile or GHG inventory associated with a given product is in isolating GHGs attributable specifically to that product in a system that produces more than one. Although less common in corporate inventories, there may also be situations where it is necessary to attribute GHG emissions to one reporting company versus another. These situations require use of an "allocation" method to attribute GHG emissions (or any other environmental load) between the assessed product and other products that would be outside the studied boundary.

There are several different allocation methods, one of which is referred to as the "avoided burden" or "substitution" method. With this approach, GHGs that are attributable to the assessed product (and hence need to be reported in the inventory) are calculated by subtracting GHGs that would have been generated if other products had been produced by other means from the total. The method shares the same concepts as the quantification of avoided emissions but serves a different purpose. As noted, the Scope 3 Standard allows a GHG inventory to be developed by applying the avoided burden allocation approach as long as it is acceptable for the specific allocation situation, but does not allow avoided emissions to be deducted from the total GHG inventory. The difference is subtle and confusing. Figure 2 provides an example.



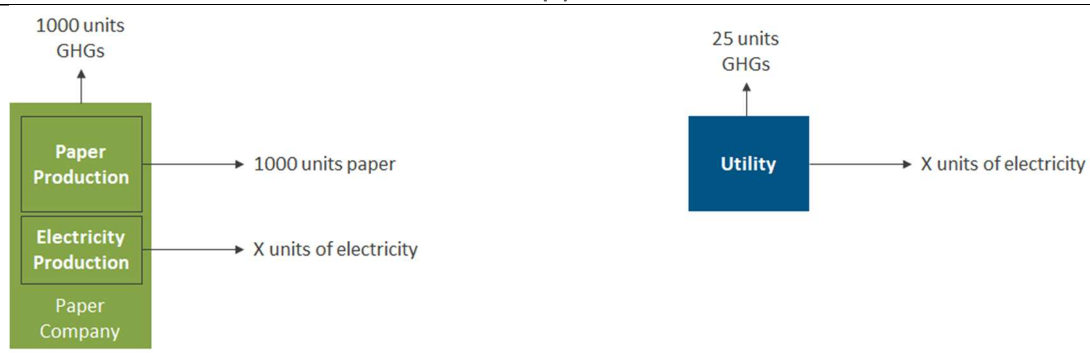
In a given year, a paper company released 1000 units of GHGs. Instead of landfilling its wood ash, the company sold it to a local farmer that used it to replace y units of lime, the production of which would have emitted 25 units of GHGs. In reporting its corporate inventory, the paper company needs to report the full 1000 units of GHGs as Scope 1 emissions and is not allowed to deduct 25 units from its inventory. However, it may be able to declare 25 units of avoided emissions as a separate item. That said, in this case the paper company would also have to report the Scope 3 emissions associated with the land application of the ash.

(a)



A paper company purchased y units of chemical A from chemical producer 1. In producing this amount of chemical A, chemical producer 1 emitted 75 units of GHGs but also produced z units of chemical B in a shared process. Chemical B was sold to another company, which otherwise would have had to purchase it from chemical producer 2. Production of chemical B by chemical producer 2 would have released 30 units of GHGs. In calculating its Scope 3 emissions, the paper company might use the avoided burden approach to allocate emissions of chemical producer 1 between chemical A and chemical B. In doing so, the paper company would report 45 units (75 – 30) of GHGs as Scope 3 emissions. Note that another allocation method might be applied leading to different Scope 3 emissions for the paper company.

(b)



A paper company released 1000 units of GHGs. The company sold X units of electricity to the local grid which, to produce X units of electricity would have emitted 25 units of GHGs. In reporting the carbon footprint of paper, the company can use the avoided burden method. As such, the carbon footprint of paper is 0.975 (1000 – 25)/1000 units of GHGs/unit of paper. Alternatively, the company could have applied process knowledge to determine that out of the 1000 units of GHGs, 10 units were due to the production of sold electricity and hence the company could report a carbon footprint of 0.990 units of GHGs/unit of paper instead. Irrespective of the method selected, the company should not claim avoided emissions in addition, as this would be double-counting the benefits of sold electricity production in the context of the product carbon footprint.

(c)

Figure 2. Example Illustrating the Difference between "Avoided Burden" Allocation Method and "Avoided Emissions": (a) Corporate GHG Inventory of a Paper Company Selling its Residuals; (b) Corporate GHG Inventory of a Paper Company Purchasing Chemicals from Shared Processes; (c) Carbon Footprint of Paper

4.0 EXISTING FOREST PRODUCTS CASE STUDIES

Here we review published studies investigating the substitution effects associated with forest products. The review is not intended to be exhaustive, but rather as representative of the findings of a few major review studies as well as more recent work on this topic.

4.1 FPInnovations

In 2010, FPInnovations undertook a review of the scientific literature investigating GHGs avoided by substituting wood for non-wood materials, excluding energy applications (Sathre and O'Connor 2010a, 2010b). Of 66 studies reviewed, 21 contained enough information to allow them to compute SFs. The studies varied in terms of system boundaries used. Hence, depending on the study, calculation of SFs could have included fossil fuel emissions from material production and transport, process emissions such as cement reactions, fossil emissions avoided due to using biomass by-products and post-use wood products as biofuel, carbon stock dynamics in forests and wood products, and carbon sequestration and methane emissions of landfilled wood materials. Carbon stocks in products in use were more often discussed than mathematically included in calculations of SFs.

FPInnovations reported SFs varying from –2.3 to 15 kg C/kg C, with most values lying between 1 and 3 kg C/kg C and an average of 2.1 kg C/kg C. Thus, on average, there was a reduction of approximately 2 kg of carbon per kg of carbon in wood product (or 3.9 kg CO_2 eq. per dry kg of wood). The authors found that the main driver for the result was lower consumption of fossil fuels in manufacturing wood products than in manufacturing alternative materials, as well as in other aspects of the wood products life cycle. Avoided process emissions from cement production were another driver. They also found that the substitution effect of avoiding fossil fuel-related emissions was significantly more important than the carbon stored in wood products. FPInnovations indicated that, while negative SFs indicating higher GHG releases from wood products were found, these were generally obtained through unrealistic worst-case scenarios.

4.2 CORRIM

In 2019, CORRIM produced a technical note summarizing the latest research on use of forest-derived products in terms of impacts of forests, forest products, and biofuels on carbon mitigation (Lippke et al. 2019). It reported SFs varying from 0.21 to 3 kg C/kg C. These numbers include biomass carbon stored, in contrast to a recommendation by Leskinen et al. (2018) to report these separately for greater transparency. The numbers reported by CORRIM assumed stable forest carbon stocks.

4.3 European Forest Institute (EFI)

Leskinen et al. (2018)[3] analyzed 51 studies providing information on 433 separate SFs. The primary focus of the reviewed studies was on the construction sector, with substantially fewer SFs available for other product types (i.e., furniture, packaging, and textiles), particularly for paper and chemicals (Figure 3). While the figure is specific to studies reviewed by Leskinen et al. (2018), we believe it is representative of the general body of research on the topic.

[3] The report is published by EFI but comes with this disclaimer: "The views expressed in this publication are those of the authors and do not necessarily represent those of the European Forest Institute, or of the funders."

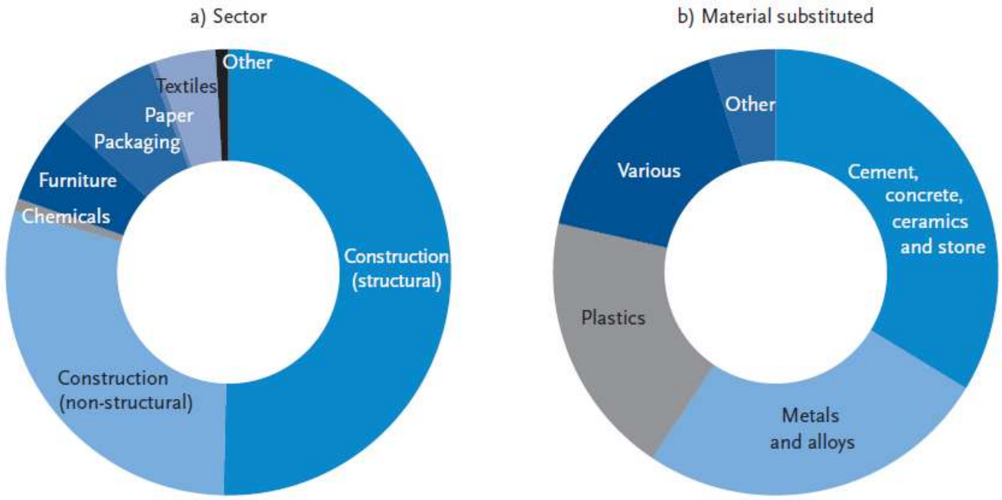


Figure 3. Overview of Research Available Related to Substitution Effects of Various Forest Products [taken from Leskinen et al. 2018]

In calculating SFs, the authors did not include any biogenic carbon dynamics (i.e., change in forest carbon, products in use and, storage in landfill stocks were excluded).They found that most studies indicated that the use of wood and wood-based products from sustainably managed forests (i.e., where there would be no decrease in forest carbon stocks) were associated with lower fossil and process-based emissions compared to non-wood products, and found an average SF of 1.2 kg C/kg C. However, SFs were quite variable, with 95% of values ranging from -0.7 to 5.1 kg C/kg C. As with the study by FPInnovations, the authors found that substitution benefits were largely obtained from reduced fossil fuel-related GHG emissions during the production stage of the wood product. The largest SFs were found for substituting materials in the textile sector, but this finding was based on a limited number of available studies.

The authors underlined that SFs alone are insufficient for understanding the carbon profile of wood products and that forest and forest soil sinks, harvested wood products carbon storage, permanence of forest sinks and forest disturbances, and potential carbon leakage effects also need to be considered.

4.4 SCA and Swedish Forest Industries Federation

In 2019, the Swedish Forest Industries Federation published a report investigating the role of the Swedish forestry sector in global climate change in 2017 (Holmgren and Håkansson 2019). It used a framework that included an evaluation of the forest carbon sink, fossil emissions in the value chain, and reductions of fossil emissions by substitution that arise when forest products replace fossil-based alternatives such as cement, steel, plastic, and fossil fuel combustion (Figure 4). The method used by the Swedish Forest Industries Federation was based on a proposal by SCA (Holmgren and Kolar 2019), although Holmgren and Kolar proposed using the full value chain emissions while the Swedish Forest Industries Federation seems to have excluded end-of-life. Potential climate benefits from temporary carbon storage were not accounted for.

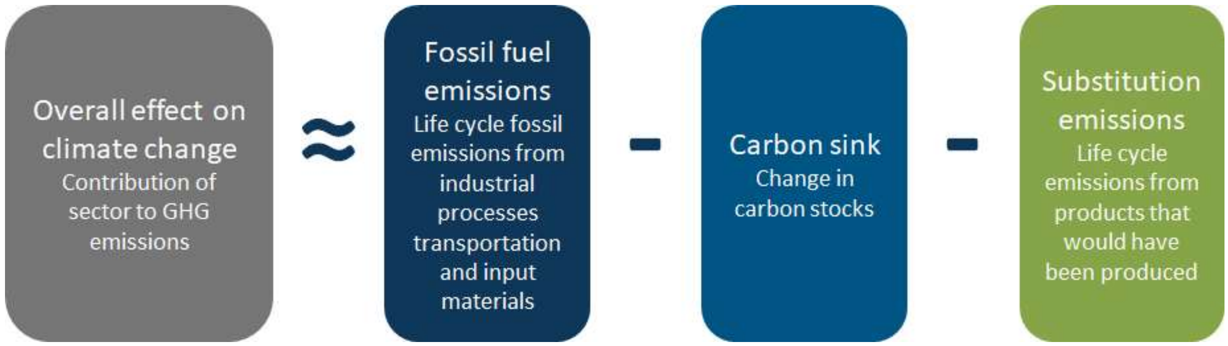


Figure 4. Swedish Forest Industries Federation Framework for Evaluating the Contribution of the Sector to Global Climate Efforts [adapted from Holmgren and Håkansson 2019 and Holmgren and Kolar 2019[4]]

With regards to substitution emissions, Holmgren and Kolar (2019) reviewed the literature to define average SFs that exclude biomass CO_2 for three categories of products: bioenergy, pulp and paper products, and solid wood products. They found that available research presented reasonably similar SFs for bioenergy, although they vary depending on different levels of conversion efficiency in bioenergy production and different assumptions on the mix of fossil fuels it replaces (SFs varied from 0.47 to 0.89 kg C/kg C). They assumed an average substitution factor of 0.7 kg C/kg C. SFs were found to be more variable for solid wood products, probably because of the range of products and their substitutes (SFs varied from 0.45 to 2.4 kg C/kg C). They used an average SF of 1.73 kg C/kg C. They found that very few studies tried to develop SFs for pulp and paper products, but that it was clear there are some substitution effects (e.g., compared to plastic). They elected to use the same SF as for bioenergy. In a recent study, NCASI (2020) found that the relative GHG emissions of paper compared to plastic are highly variable and depend on the type of product in question, as well as a series of other factors. In the absence of information specific to the product being evaluated, a more conservative approach would be to assume no substitution effects of paper compared to alternatives.

In summary, SCA and the Swedish Forest Industries Federation used an approach in which the SFs excluded biogenic CO_2. They also published their products substitution effects results as CO_2 eq. per year rather as kg C/kg C.

5.0 CONCLUSIONS

Research indicates that forest products, and wood products in particular, generally release less fossil GHGs over their life cycle than their fossil fuel-intensive alternatives and have the capacity to store carbon over long periods of time. Different methods have been used to compute the mitigation potential of forest products. While biomass carbon dynamics, including forest and forest soil sinks, harvested wood products carbon storage, permanence of forest sinks, and forest disturbances and potential carbon leakage effects, should not be ignored, the most transparent approach would involve quantifying these dynamics separately from avoided fossil fuel-related GHGs.

[4] The convention has been updated from Holmgren and Håkansson (2019) and Holmgren and Kolar (2019) to be more consistent with existing reporting frameworks such as that of the GHG Protocol. Thus, a positive contribution means that the sector has net GHG emissions, while negative emissions means that the sector has net reductions in GHG emissions due to either increasing carbon stocks or substitution of fossil emissions-intensive alternatives.

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