BILLERUDKORSNÄS

BillerudKorsnäs – a climate-positive corporation

Forest-based products reduce fossil fuel dependency and help combat global climate change

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Summary

- BillerudKorsnäs is a forest industry corporation specializing in paper and board products, notably liquid packaging products for the food and beverage sector. The present study quantifies the overall corporate contribution to climate change mitigation. While the forest-based sector generally provides large-scale mitigation benefits, the effects of paper and board products have been less researched and has been a focus in the analysis.
- The forest-based sector generates solutions at scale for a fossil-free welfare society. First through active forest management that enhances the carbon sink and stores away large amounts of carbon in the forest. Secondly through renewable forest products that reduce demand for fossil-based alternatives. These are interdependent and mutually reinforcing components of the circular bioeconomy. For Sweden as a whole, the positive climate effect of the forest-based sector has been estimated at 93 million tons of carbon dioxide equivalents in 2018 – in parity with all emissions caused by consumption in the country.
- BillerudKorsnäs is focused on the paper and board segment and thereby fills a key role in the overall integrated forest-based value chain. Procurement of more than ten million cubic meter of wood annually, equivalent to 15% of the total wood harvest in Sweden, provides incentive for sustainable forest management at scale.
- A review of Life Cycle Assessments showed that BillerudKorsnäs’ packaging products displace large quantities of fossil emissions when they replace alternatives made from plastic, metal or glass. This substitution effect was estimated at between 0.5 and 7.8 tC/tC – tons of fossil carbon that remain below ground for each ton of carbon in the company’s fibre-based products. The knowledge base across the range of fibre-based products is not complete, which calls for additional research as well as caution when drawing conclusions based on existing LCAs.
- As a conservative weighted average, the substitution effect across BillerudKorsnäs’ paper and board products and marketed pulp was estimated at 1.25 tC/tC (1.36 tC/tC for paper and board products alone). In 2019, BillerudKorsnäs delivered 2.7 million tons of fibre-based products, thereby ensuring that 5.4 million tons of fossil CO_2 equivalents remained underground.
- The total positive climate effect of BillerudKorsnäs in 2019 was estimated at 5.4 million tons of CO_2 equivalents when all products, the net sink in BillerudKorsnäs’ own forest and the company’s fossil emissions were taken into account. This corresponds to the emissions of the entire steel industry in Sweden, or about one third of all domestic transport in Sweden.
- The study confirms that paper and board products can generate a climate benefit that is considerably higher compared with immediate use of the biomass for energy. Further, the procurement and stable demand for pulpwood incentivize investment in sustainable forest management – accruing further climate benefits.
- Conclusively, forest industry corporations, such as BillerudKorsnäs, that stimulate responsible forest management and ensure that fossil-based products are replaced have a crucial role in the transition towards a climate-neutral society.

Introduction

Quantifying the climate effect of the forest-based sector

The forest-based sector provides solutions at scale for a fossil-free welfare society. First through active forest management that enhances the carbon sink and stores away large amounts of carbon in the forest. Secondly through renewable forest products that eliminate demand for fossil-based alternatives. While the carbon sink in forests is clearly visible in official greenhouse gas inventories (Naturvårdsverket, 2018; UNFCCC, 2020), the eliminated demand for fossils is invisible. From a book-keeping perspective, these displaced fossil emissions are implicitly included through lower emissions in other sectors. On the whole society has lower levels of fossil emissions than what would have been the case without the forest-based sector.

A complete picture of the forest-based sector's effect on the global climate requires an integrated perspective – the circular bioeconomy – where part of the forest growth is harvested for use in renewable products. After the product has been used, recycled and finally, in most cases, generated bioenergy, the wood carbon is released back to the atmosphere, and then returned to the growing forest (Figure 1).

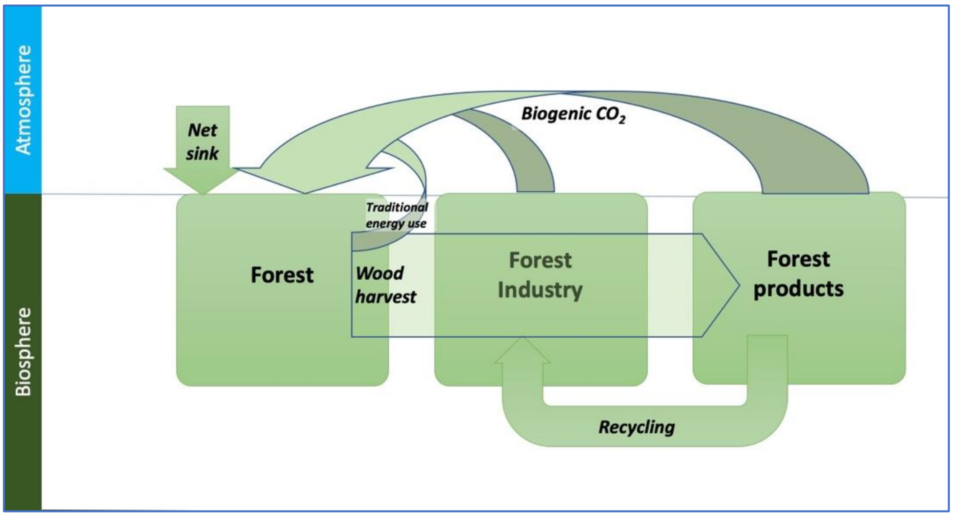

Figure 1. Illustration of biogenic carbon fluxes in the circular forest-based bioeconomy.

Applying this perspective, large positive climate effects of the forest-based sector have been highlighted in recent studies (Holmgren and Kolar, 2019; Leskinen et al., 2018; Södra, 2019; Swedish Forest Industries, 2019) and also documented in corporate annual reports (Holmen, 2020; SCA, 2020; Södra, 2020; StoraEnso, 2020).

The positive climate effect of the Swedish forest-based sector has been estimated at 93 Mt CO_2e (carbon dioxide equivalents) in 2018 (Swedish Forest Industries, 2019) – in parity with the overall greenhouse gas emissions of all Swedish consumption. This illustrates the large scale and already existing contribution made by forest-based products in combatting global climate change. About half the positive effect of the forest-based sector is attributed to increased carbon storage in Swedish forests and in harvested wood products (HWP), with the other half resulting from reduced demand for fossil-based products and energy. Similarly, at the European level the positive climate effect of the forest and forest-based sector is estimated at 800 Mt CO_2e/year (CEPI, 2020), corresponding to 20% of EU fossil emissions. The model applied in these studies, as well as the current, was originally developed by SCA, a forest industry corporation, (Holmgren and Kolar, 2019) defining the climate effect as the sum of three components (Figure 2, Figure 3):

1. Net sink of carbon in the forest and in Harvested Wood Products (HWP) (normally a positive climate effect)
    - These sinks are specifically defined in official Greenhouse Gas Inventory methodologies (IPCC, 2006) and are part of the LULUCF sector in national reporting to the climate convention (Naturvårdsverket, 2018; UNFCCC, 2020). Developments are underway to include sinks (or removals) also in the GHG Protocol used for corporate sustainability reporting (World Resources Institute, 2020a).

2. Fossil emissions in the value chain (a negative climate effect)
    - Fossil emissions are part of both official national reporting of emissions (Naturvårdsverket, 2018; UNFCCC, 2020) and also part of regular corporate sustainability reporting as specified by the GHG Protocol (World Resources Institute, 2020b). For this analysis, upstream emissions (e.g. forest operations), emissions embedded in input goods (scope 3), as well as all direct emissions in the company's value chain are included.

3. Displacement of fossil emissions (substitution) when forest products replace alternatives with a higher climate footprint (a positive climate effect)
    - Displacement/substitution is not an explicit part of current climate reporting, but the effect is implicitly present in national GHG inventories as emissions reported for other, fossil-dependent sectors are lower than what would be the case without a forest-based sector. In other words, this is a real but hidden climate effect of the forest-based sector. Displacement happens mainly through industrial products or large-scale bioenergy solutions, and to a lesser extent through "traditional" wood energy use such as heating of homes with woodstoves.

It should be noted that the model, as applied, is an account for climate effects in one year and does not include any time trends or scenario modeling. That said, the forest-based sector is built on very long-term commitments for sustainable forest management, as well as long term investments in industry-based value chains. The effects calculated for one year can therefore be considered stable over longer time periods.

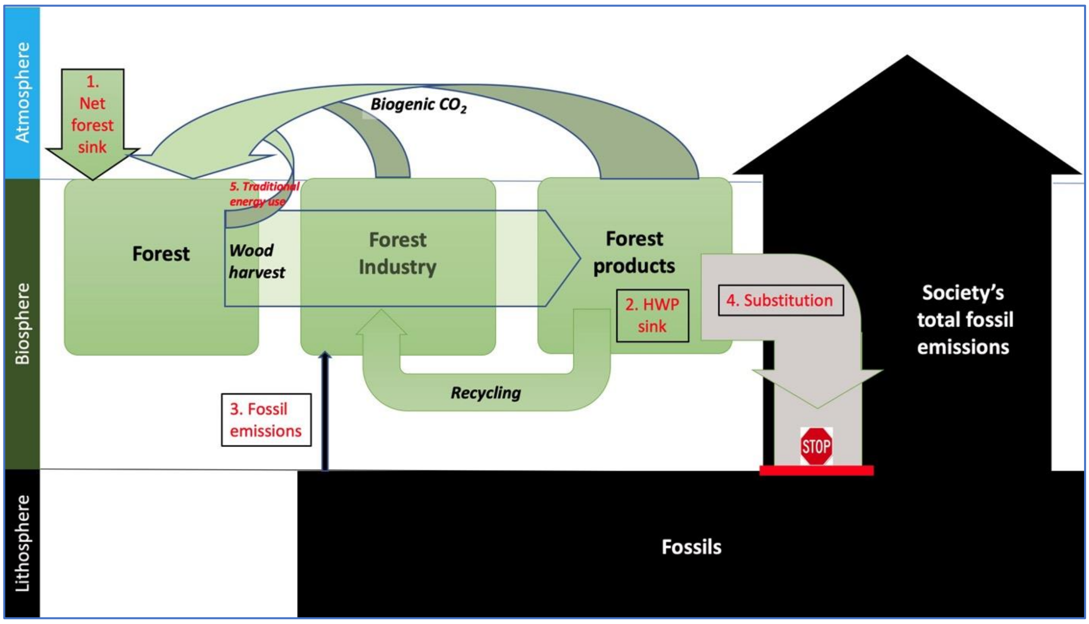

Figure 2. Climate effects of the forest-based circular bioeconomy based on flows introduced in Figure 1: Net sink in forest (1) and Harvested Wood Products (2), Fossil emissions in the value chain (3), Displacement/substitution of fossil emissions (4,5)

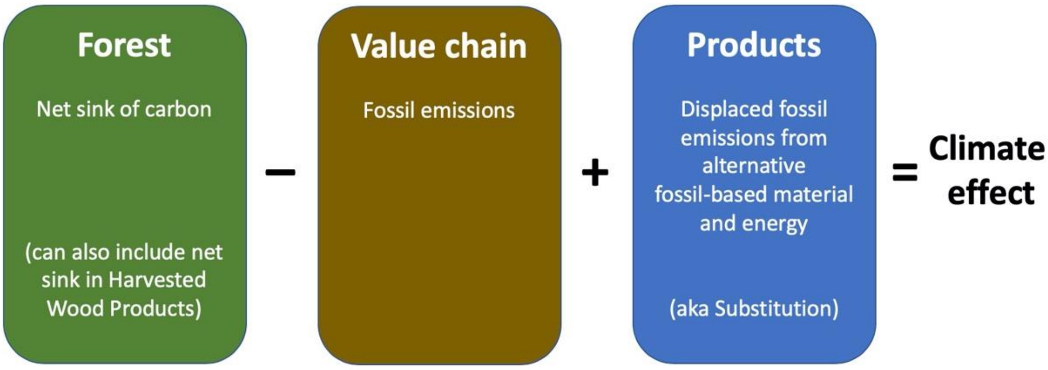

Figure 3. Three components used for calculating the overall climate effect of the forest-based sector, or an individual forestry corporation, derived from Figure 2 and used in previous studies (e.g. Swedish Forest Industries, 2019).

Purpose and boundary of study

The present study aims to use the above described model to detail and calculate the effect on the global climate from the overall business operations of BillerudKorsnäs AB.

In applying the model, a specific analysis of substitution factors for paper-based packaging products has been made, so as to illustrate and calculate the effects of BillerudKorsnäs' product portfolio. The main focus of BillerudKorsnäs' products are high-end paper and board products for packaging, with a large potential to substitute packaging made from plastics, glass or metal.

BillerudKorsnäs owns in full a forest estate (the Marma Skog group). Further, BillerudKorsnäs is a minority owner with full forest management responsibility for Bergvik Skog Öst. In addition, BillerudKorsnäs has long term forest management contracts with private forest owners with full responsibility for all forest management related activities.

Taken together and adding timber procurement from other land owners, the company plays an important role for sustainable forestry through annual appropriation of more than ten million m^3 of wood, corresponding to about 15% of industrial wood harvest in Sweden. That is, the company represents a key segment of the overall forest-based sector, realizing a significant part of the circular bioeconomy

The study focuses on climate effects for the year 2019, to the extent possible using information made publicly available in the most recent corporate annual report (BillerudKorsnäs, 2020). Production levels have not varied significantly in recent years which means that the results are generally valid also in a longer-term perspective.

In relation to the model as described in Figure 2, the current study includes net sink in forests for the estates Marma Skog group and Bergvik Skog Öst for which BillerudKorsnäs has full/partial ownership in combination with full responsibility for forest management (as per above). Traditional wood energy is not included, and neither is the net sink of carbon in Harvested Wood Products. As regards displacement of fossil emissions, these are calculated as the primary (first use) substitution effect of BillerudKorsnäs products, plus residual effects of end-use for energy. Intermittent effects of recycled material are not included.

Quantifying the climate effect of BillerudKorsnäs

Overview of BillerudKorsnäs' operations

BillerudKorsnäs operates in a key segment of the circular bioeconomy, contributing strongly to the large overall positive effect on the global climate by the forest-based sector. While the company has limited corporately owned forests, large quantities of wood are procured from sustainably managed forests in Sweden and other EU countries – forests that due to active management constitute major net sinks of carbon. The company's efficient industries use a very low proportion of fossil energy and fully utilizes the wood raw material, for internal bioenergy as well as a wide range of marketed renewable products. High-end paper products displace large quantities of fossil energy through substitution. Recycling and end-use of products add to the climate benefits. Figure 4 summarizes BillerudKorsnäs' operations, as applied to the above described model.

Production data for 2019 used in the climate effect calculations have been compiled based mainly on publicly available information (Table 1).

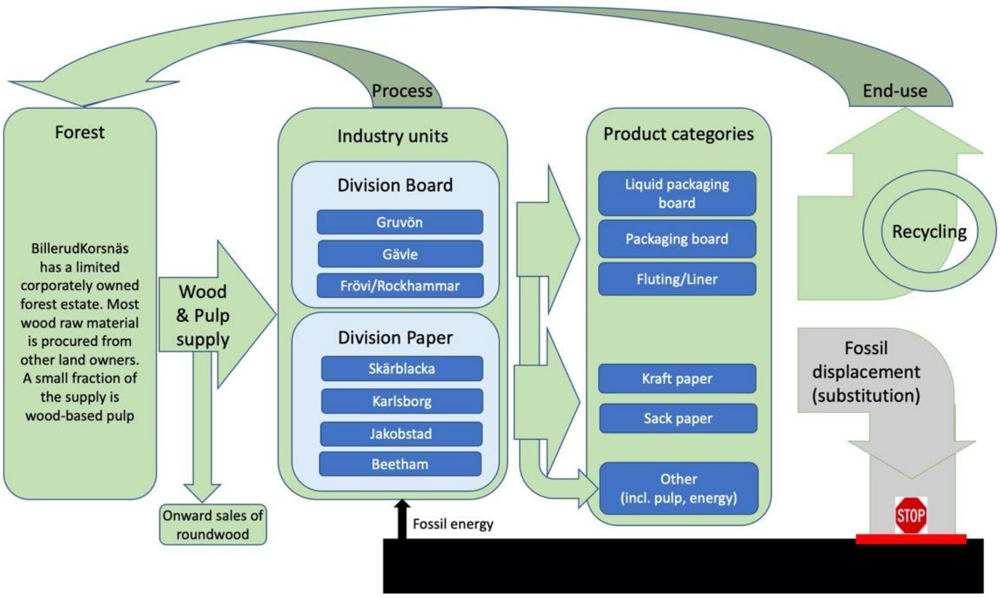

Figure 4. BillerudKorsnäs' operations applied to model in Figure 2.

Table 1. Key production data for BillerudKorsnäs 2019

Product category	Marketed quantity 2019
Roundwood[1]	1.1 Mm^3sub
Pulp for paper	0.44 Mt
Paper and board products	
Board (liquid packaging board, carton board, fluting and liner)	1.66 Mt
Paper (sack and kraft paper)	0.60 Mt
Bioenergy	
Wood for energy	0.036 TWh
Heat	0.94 TWh
Electricity	0.054 TWh
Other	
Crude tall oil, turpentine, etc.	0.077 Mt

[1)] onward sales of wood supply

Fossil displacement by BillerudKorsnäs' products

Fossil displacement (also called substitution) occurs when products/energy based on renewable materials, in this case wood, replace alternatives that have a higher fossil emission footprint, such as plastics, metal, cement or fossil-based energy. In the comparison, biogenic emissions are considered climate neutral under the assumption that these are again absorbed by growing forests. For each analysed product category, the variable of interest – the substitution effect – is the quantity of fossil emissions that is displaced by a given quantity of forest products. The measure used is tons of fossil carbon displaced for each ton of carbon contained in the forest products (tC/tC). As an example, a substitution factor of 0.7 for bioenergy means that 700 kg fossil carbon stays in the ground for each ton of biogenic carbon used for energy production.

For the model applied here, it is important to note that fossil emissions used in the forest product value chain (such as transport, limited parts of industry processes, emissions embedded in input goods) are reported separately and should not be accounted for again in the substitution factor. Therefore, it is the forest product as such that is set against the full range of fossil emissions needed to produce the alternatives. This is important to consider when extracting data from LCA studies where comparisons between products are usually made throughout the entire value chain.

Earlier calculations of the climate effect of forest-based industries have used conservative assumptions on the substitution effect of fibre products. For example, Holmgren and Kolar (2019) applied 0.7 tC/tC resembling the factor for bioenergy products with the assumption that as a minimum the substitution will be at the level of end-use for bioenergy. Leskinen et al. (2018) arrived at 1.2 tC/tC from another review of the literature, although this number was not applied to any specific assessment. Södra (2019) introduced a factor of 1 tC/tC for textile pulp but kept 0.7 tC/tC for all other fibre products. Part of the uncertainties appears to stem from still evolving research in the field. Given that fossil displacement is not yet an explicit part of official or corporate climate reporting, there has been less pressure to develop standards, and as a consequence research studies use slightly different methods.

For this study, a review of Life Cycle Assessments (LCAs) related to BillerudKorsnäs product range was made to enhance the analysis. The expectation was that the high-end paper and board products from BillerudKorsnäs generate a higher overall substitution effect compared to those used in earlier studies.

The review was made in three steps:

1. Calculation of substitution effects for the specific products studied in LCAs (Table 2)
2. Estimation of the proportion of overall product volumes that these products represent (Table 3)
3. Weighing together the results, with assumptions for product categories not covered, into an overall approximate substitution factor for BillerudKorsnäs' products (excluding marketed pulp) (Table 3)

The results indicate that an average substitution effect of 1.25 tC/tC can be applied for BillerudKorsnäs’ products, including marketed pulp. For marketed pulp, the default factor of 0.7 tC/tC was applied as the eventual resulting products are unknown. Excluding marketed pulp, the average substitution factor for BillerudKorsnäs paper and board products was 1.36 tC/tC.

Table 2. Calculated substitution effects based on LCA studies and application in present study. See text for explanation of categories.

Source	BillerudKorsnäs product	Substituted product	Substitution factors			
			Based on LCA tC/tC	Selected for use in study	Energy end-use irt substituted product tC/tC	Applied in study tC/tC
Franklin Associates (2014)	Tetra Recart 0.5l	Plastic pouch	1.9			
		Can	7.8			
	Tetra Recart 0.34l	Can	6.7			
Dahlgren et al. (2015)	Cement sack	Plastic cement sack	1.2	x	0.3	1.5
	Pasta bag	Plastic pasta bag	1.7			
	Paper grocery bag	Plastic grocery bag	0.5	x	0.5	1.0
	Fibreform bottle	PET bottle	2.4			
Markwardt and Wellenreuther (2017)	Recart 390g	Glass jar/Germany	6.5			
		Steel can/Germany	6.4	x	0.7	7.1
		Glass jar/Italy	7.0			
		Steel can/Italy	6.8			
Jelse et al. (2009)	Tetra Brik	PET bottle average	2.6	x	0.0	2.6
		HDPE Bottle average	1.6	x	0.0	1.6
Sturges and Nilsson (2020)	Xpression mailer unbleached/bleached	PE mailer virgin	0.6			
Holmgren and Kolar (2019)	Default factor when relevant LCA not available, corresponding to energy use					0.7

Table 3. Product categories and calculated substitution effects for 2019

Product category	Proportion of delivered quantity linked to LCAs in this study %	Weighted substitution factor tC/tC
Board (liquid packaging board, carton board, fluting and liner)	56	1.51
Paper (sack and kraft paper)	28	1.00
Market pulp	0	0.7
Total fibre products	**44**	**1.25**

Climate effect – considerations, calculations and results

Forest

The net sink in BillerudKorsnäs' forest estates (Marma Skog group and Bergvik Skog Öst) was estimated at 0.58 Mt CO_2e/year (based on Bergvik Skog Öst (2020) and internal data).

As per above, there is a larger indirect net sink effect from annually purchasing 10.8 million m^3 of wood (2019) most of which from other forest owners. The wood procurement generates economic value to forest land, stimulating good forest management and increased forest growth. This, in turn, generates a significant net sink in these forests as is well established for Sweden as a whole at a level of c. 40 Mt CO_2e/yr (Naturvårdsverket, 2018). Using the overall net sink ratio for Sweden this indirect effect of BillerudKorsnäs wood procurement may be in the range 5-7 Mt CO_2e/yr.

Fossil emissions

BillerudKorsnäs caused fossil emissions in their value chain at a level of 0.62 Mt CO_2e in year 2019, including upstream emissions from forest operations as well as emissions embedded in input goods (Table 4). In addition, 4.7 Mt CO_2e of biogenic emissions were emitted from the company's industrial processes, entirely based on residuals of the wood supply (such as bark and branches) and side-products from the industrial processes. This reflects that almost all energy supply to the company is renewable. Energy used in the industry units was to 97% based on biomass with only 3% fossils in the mix. Emissions (Table 4) are declared in the Annual & Sustainability Report (BillerudKorsnäs, 2020) or were calculated for this study using internal data.

Table 4. GHG emissions by BillerudKorsnäs in 2019

Category	**Emissions 2019 Mt CO_2e**
Fossil emissions	
Forest operations	0.07
Wood transport	0.05
Industry scope 1	0.15
Industry scope 2	0.007
Input goods	0.21
Product transport	0.13
Other	0.005
Total fossil emissions	**0.62**

Fossil displacement (substitution)

Fossil displacement of BillerudKorsnäs' products were calculated for three product categories. For each category an average substitution (displacement) factor was applied as per Table 5. While roundwood and bioenergy factors were based on earlier studies, the factor for fibre-based products was reviewed as part of this study (see above).

Applying the substitution factors to product volumes (Table 1) results in a total displacement of fossil emissions of 5.4 Mt CO_2e by BillerudKorsnäs' marketed products in 2019, of which more than half from liquid packaging board (Table 6).

Table 5. Substitution factors applied for BillerudKorsnäs products for year 2019

Product category	Substitution factor tC/tC	Notes
Roundwood	0.5	Approximation based on findings by (Holmgren and Kolar, 2019; Lundmark et al., 2014; Södra, 2019)
Fibre products	1.25	Based on review above. Estimated average across marketed pulp and paper products.
Bioenergy	0.7	Factor based on review by Holmgren and Kolar (2019). Applied to marketed bioenergy plus crude tall oil and turpentine.

Table 6. Calculated displacement of BillerudKorsnäs' products in 2019

Product category	Marketed quantity 2019	Corresponding C content[a]	Substitution factor	Displacement of fossil emissions[b]
		Mt C	tC/tC	Mt CO_2e
Roundwood	1.1 m^3sub	0.28	0.5	0.5
Fibre products	2.70 Mt	1.00	1.25	4.58
Bioenergy	1.03 TWh	0.12	0.7	0.3
Tall oil/turpentine	0.077 Mt	0.009	0.7	0.02
Total		**1.38**		**5.4**

a) Carbon content of wood set to 0.25 tC/m^3sub, of fibre products to 0.37 tC/t product, 1 TWh was set to correspond to combustion of 0.12 Mt biogenic carbon. 1 t of crude tall oil and turpentine was set to contain 0.37 t carbon.

b) Conversion factor from C to CO_2 is 3.67. CO_2 displacement is calculated as C content in product category * Substitution factor * 3.67

Results

Adding the three climate effect components for BillerudKorsnäs results in an overall positive climate effect of the company's operations of 5.4 Mt CO_2e in 2019 (Figure 5).

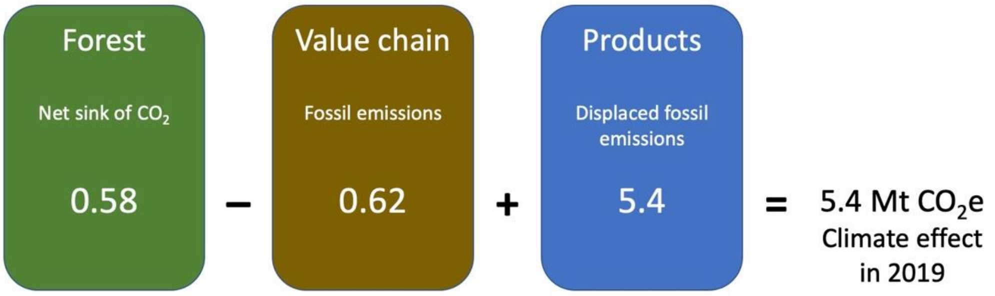

Figure 5. According to calculations for this study, BillerudKorsnäs had an overall positive effect on the global climate corresponding to 5.4 Mt CO_2e in 2019.

Discussion

- The results confirm findings from other studies that forestry corporations make a very significant contribution to mitigating climate change when a complete perspective of the circular bioeconomy is applied;
- The positive climate effect of 5.4 Mt CO_2e for 2019 corresponds to the current level of annual GHG emissions from the entire Swedish steel industry, or about a third of annual GHG emissions from all domestic transport in Sweden in 2018;
- The circular bioeconomy perspective is different compared with the structure of official climate reporting where the forest is considered separate from product value chains and where displacement effects are hidden within other sectors. The model applied here serves to widen the perspective for climate action and climate policy analyses;
- The lack of focus on displacement (substitution) effects means that research is relatively sparse, standards have not developed and, despite presence in IPCC reports, the effects are not yet well acknowledged in policy development. On the contrary, the focus on carbon sinks and storage in forests in LULUCF sometimes leads to a perception that carbon should preferably be left in the forest.
- BillerudKorsnäs' main products are fibre based, specifically within packaging. Additional data on displacement effects of packaging products were presented in this study. This serves to improve the knowledge base of fibre products for substitution. However, the field remains under-researched and a better understanding of the potentials of current and new fibre products is desirable. Currently, the overall substitution factor for BillerudKorsnäs products (1.25 tC/tC) is an approximation as it depends on a small number of LCA studies for selected specific products and the representativity of these for the full product range.

- At the same time, a too detailed focus on LCA analyses of individual products may detract from important systems analyses. As shown in this study, the overall circular bioeconomy is key for generating climate benefits, including positive feedback to enhance the forest sink. Considerable focus is today given to realizing negative emissions through carbon capture of biogenic emissions – which will require large-scale and long-term emission points of the type provided by financially viable forest industries. Further, innovation and new markets may develop the sector in new currently unknown directions. For these reasons, it is clear that additional detailed LCA analyses can only provide a part of the picture concerning climate solutions from the forest-based sector.
- Fossil emissions by BillerudKorsnäs are in relative terms low, e.g. only 3% of industry process energy is fossil-based. However, in absolute terms, annual emissions of 0.62 Mt in a year are still substantial. Transport emissions, in particular, is an area where emissions can be reduced considerably, possibly with introduction of more biofuels in the transport sector.
- The long-term perspectives of the forest-based sector – for forest management as well as industry investments – provides a stable approach towards a fossil-free welfare society, with positive feedbacks for investing in increased growth/sinks in the forest. More shortsighted efforts to compensate emissions in other sectors by reducing wood harvests may be counterproductive, particularly as these may be based on conventional structures of climate reporting and assessments.

Glossary

Bioeconomy or Bio-based economy	The bioeconomy comprises those parts of the economy that use renewable biological resources from land and sea – such as crops, forests, fish, animals and micro-organisms – to produce food, materials and energy. Read more: https://ec.europa.eu/research/bioeconomy/index.cfm
Biogenic emissions	Greenhouse gas emissions caused by conversion of biological material. While this includes all conversions of biological material, it usually refers to emissions caused by human activity, such as production of bioenergy or emissions from land use change
Carbon dioxide equivalents (CO_2e)	Greenhouse gas emissions are mainly in the form of CO_2, but also includes smaller amounts of, e.g., methane and nitrous oxide with higher greenhouse effects per unit. Further, when carbon is stored away from the atmosphere, e.g. in biomass, it takes other chemical forms than CO_2. To make comparisons and calculations easier, all GHG gases and other forms of stored carbon are converted to CO_2 equivalents.
Carbon sink	A process by which CO_2 is removed from the atmosphere. The photosynthesis by plants is the most significant carbon sink. Sometimes "net sink" is used to clarify that more carbon is captured than released in, for example, a forest.
Carbon storage in forest	The amount of carbon in the forest, including living and dead trees, litter and soil. (Should not be confused with "sink" which is the flux of carbon – not the storage)
Embedded emissions	Emissions caused during the production of material or goods. Input goods for the forest industry include various chemicals that have caused emissions before they reach the mill. See also Upstream emissions and Scope 1, 2 and 3.
Forest-based sector	The part of the bioeconomy that manages forests and create value chains based on forest raw material, mainly in forest industries and bioenergy production
Fossil emissions	Greenhouse gas emissions to the atmosphere caused mainly by combustion of fossil energy such as oil, natural gas or coal. Production of cement also cause large scale emissions from the chemical processing of limestone.
Greenhouse Gas Protocol	An established international standard for corporate reporting of climate impact. See also Scope 1, 2 and 3
Harvested Wood Products (HWP)	Harvested Wood Products is a term used in official climate reporting to account for carbon that has been removed from the forest, but not yet reached the atmosphere as it is stored in different products. Especially solid wood products can store the carbon away from the atmosphere for a very long time. HWP storage should not be confused with substitution of fossil emissions. These are two separate and complementary ways that forest products help mitigate climate change.

Land Use, Land Use Change and Forestry (LULUCF)	A “sector” in climate change negotiations, reporting and policy referring to all anthropogenic emissions and sinks that occur in relation to land use. Some issues with this delineation are raised in this report as LULUCF treats the forest in isolation from forest product value chains. This potentially leads to policies that do not consider the integrated potential of the circular bioeconomy.
Life Cycle Assessment (LCA)	A methodology for assessing environmental impacts associated with all the stages of the life-cycle of a commercial product, process, or service. Often an LCA compares products with similar functionality, for example packaging solutions based on paper, glass or metal.
Net carbon sink in forests	When forests absorb more carbon than they lose through natural processing and harvesting, they are considered a net carbon sink. Swedish forests are a large net carbon sink, corresponding to about 80% of the country’s fossil emissions and resulting in a higher carbon storage in the forest.
Scope 1, 2 and 3	Within the Greenhouse Gas Protocol, three scopes of emissions are reported. Scope 1 are direct emissions from owned or controlled sources. Scope 2 are indirect emissions from the generation of purchased energy. Scope 3 are all other indirect emissions that occur in the value chain of the reporting company, including both upstream and downstream emissions.
Substitution (or displacement) of fossil emissions	When products that have caused lower fossil emissions replace alternatives that cause higher fossil emissions. For example when paper-based packaging replace tin, glass or plastic packaging. The result is less fossil emissions.
Substitution factor	A measure of the substitution of fossil emissions. For forest products, it is usually expressed in tC/tC, i.e., the amount of fossil carbon that is substituted per amount of biogenic carbon used instead. When fossil oil is replaced by bioenergy, the substitution factor can be 0.7 tC/tC meaning that for each ton of carbon in the bioenergy fuel, 700 kg of carbon in fossil oil can stay in the ground.
Upstream emissions	Greenhouse gas emissions caused in the value chain prior to the operations of the company in question, for example emissions in forest operations before the wood reaches the forest industry.

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