WHAT ROLE FOR FOREST-BASED INDUSTRIES IN A CLIMATE-NEUTRAL FUTURE?

FINDING THE RIGHT BALANCE BETWEEN SINKS, PRODUCT SUBSTITUTION, RENEWABLE ENERGY AND BIODIVERSITY

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Abstract

Climate neutrality in the European Union and globally will lead to a deep transformation of existing industrial value chains, bringing new and lower-carbon products, processes and novel business models. This transformation will affect the entire industrial sector, notably including all energy-intensive industries, forest-based industries among them. The sector represents a full value chain, from forest owners and managers, to industries transforming the forest products and recycling. While the exact routes for this transformation remain uncertain, the technological pathways for decarbonisation are known: electrification, hydrogen, energy efficiency, circular economy, carbon-neutral liquids, carbon capture and negative emissions.

For policymakers, the transition of forest-based industries raises the task of finding the right balance between the sector's contribution to sinks, product substitution (including recycling), renewable energy and biodiversity, in addition to carbon accounting issues, especially if international trade is included in the analysis. Possible trade-offs – food versus feed, fibre versus fuel, and land versus ecosystems – will most likely become more acute after 2030 as the deadline for climate neutrality approaches.

More knowledge will be required to make the most appropriate choices, such as which energy crops have the potential to deliver the highest negative emissions, which forest management practices are optimal from a biodiversity perspective, and what role forests will play more generally in climate change mitigation and adaption. Low-carbon 'lead markets' can in theory support demand for climate-neutral products, including for wood-based products, but policy-driven demand is not equivalent to market-driven demand. Climate-neutral products are not necessarily of higher value to consumers, nor do they offer better functionality. Consumer preferences for bio-based products in, for example, the materials or textiles sectors will matter.

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1. Introduction

Achieving climate neutrality by 2050, as has been proposed by the European Commission in its European Green Deal, will ultimately lead to a profound transformation of industrial value chains across the European economy. New products, processes and business models, often supported by IT and artificial intelligence, will become essential in achieving emissions reductions. All industries, including notably energy-intensive industries, will have to make very significant contributions to the low-carbon transformation. Options for energy-intensive industries include a shift to electrified processes, the use of low-carbon gaseous fuels (e.g. hydrogen) for high-temperature heat and feedstocks currently supplied by natural gas, and the deployment of carbon capture and storage (CCS). Together with energy-efficiency measures, these options can provide significant emissions reductions.

A particular role will be played by what is generally referred to as the forest-based industries, encompassing the full value chain of forest-based products, from forest owners and managers to industries that transform forest products and recycling. The industry can contribute to the climate-neutrality objective via sinks, by material substitution, renewable energy and recycling. The forestry process industry produces low-carbon materials, by-products and residues across the various parts of the value chain, while improving its efficiency through re-use and recycling. In doing so, the circular bioeconomy offers sustainable alternatives to fossil-based materials and fossil energy, and is able to process waste and side-streams into circular added-value products. At the same time, this requires finding a balance between the various contributions that the value chain can make to public policy objectives, including climate, biodiversity and the circular economy.[1]

The objective will need to be ensuring the optimal use of bio-based resources, for example to use biomass as a feedstock in industry, thereby substituting carbon-intensive inputs. Such a trade-off is similar to those of other types of resources. However, biomass carries a particular opportunity cost as a result of its impact on land use, for which there are many potential alternative uses. As both the IPCC's report on climate change and land (2019) and the EU's long-term strategy (2018) make clear, land is a critical resource due to its role as a carbon sink, as well as in food production, bioenergy and biodiversity.[2]

Politically, finding the right balance between sinks and product substitution including recycling, renewable energy and biodiversity is particularly interesting, as in the EU the forest-based sector falls under three climate-related EU regulatory frameworks alone: the EU emissions trading system (ETS); effort sharing; and land use, land use change and forestry (LULUCF); in addition to numerous EU laws such as the waste framework directive and the timber regulation, and various national laws. The climate-related regulatory framework also raises a number of carbon accounting issues, especially if international trade is included in the analysis.

[1] As acknowledged by the Circular Economy Action Plan (EC, 2020d), which refers to the importance of material efficiency.

[2] See also the IPCC's press release on the special report on Climate Change and Land: www.ipcc.ch/2019/08/08/land-is-a-critical-resource_srccl/.

This CEPS Policy Insight will describe and assess the sector's challenges from both an industrial and policy perspective. It will then highlight key areas for finding the right balance and will suggest a number of possible steps to take.

Following this introduction, chapter 2 provides a sector description. Chapter 3 examines the meaning of climate neutrality, before chapter 4 discusses the principal analysis on challenges and opportunities. The penultimate chapter 5 examines issues in adapting the framework to climate neutrality, while the concluding chapter 6 makes a number of suggestions for the way forward.

2. The forest-based industry: a sector description

The forest-based industry usually refers to woodworking, furniture, pulp and paper manufacturing and converting, and printing. These sectors bridge urban, peri-urban and rural areas, amounting to 3.5 million workers and 7% of the EU's manufacturing GDP.[3] Forests cover about 42% of EU land area,[4] with the forest cover varying significantly between member states: Sweden and Finland have the largest proportion of forested land, while the least densely wooded countries in the EU are Malta, the Netherlands, Ireland and the United Kingdom.

Wood represents the main financial resource from forests, and the main raw material used in the sector. It is, in principle, renewable, re-usable and recyclable.[5]

Figure 1 provides a simplified illustration of the forest-based industry value chain. The wood extracted from forests is a heterogeneous material, with varying attributes according to its species, dimension and quality. Based on the different types of wood fibres and their available volumes, the material can be used for obtaining a large range of products across the value chain, which differs from one EU and EEA member state to another. Nonetheless, it generally extends from sustainable forestry upstream, to industrial and consumer applications and recycling of materials and fibres downstream.

In some installations and wood-processing units, electricity and heat are produced across the entire value chain, using both wood-based inputs and some of the by-products resulting from the processes of the sub-sectors. This is, however, not the case for all. The best carbon outcomes in the forest-based industries can be achieved by a value chain perspective, from the forests to the end-consumer with a good understanding of the specific challenges of the sub-sectors. Bottlenecks or inefficiencies in certain sub-sectors usually negatively affect the entire value chain, from either a socio-economic or carbon perspective, or both.

[3] European Commission (2013b), "A blueprint for the EU forest-based industries (woodworking, furniture, pulp & paper manufacturing and converting, printing)", SWD(2013) 343 final, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52013SC0343&from=EN.

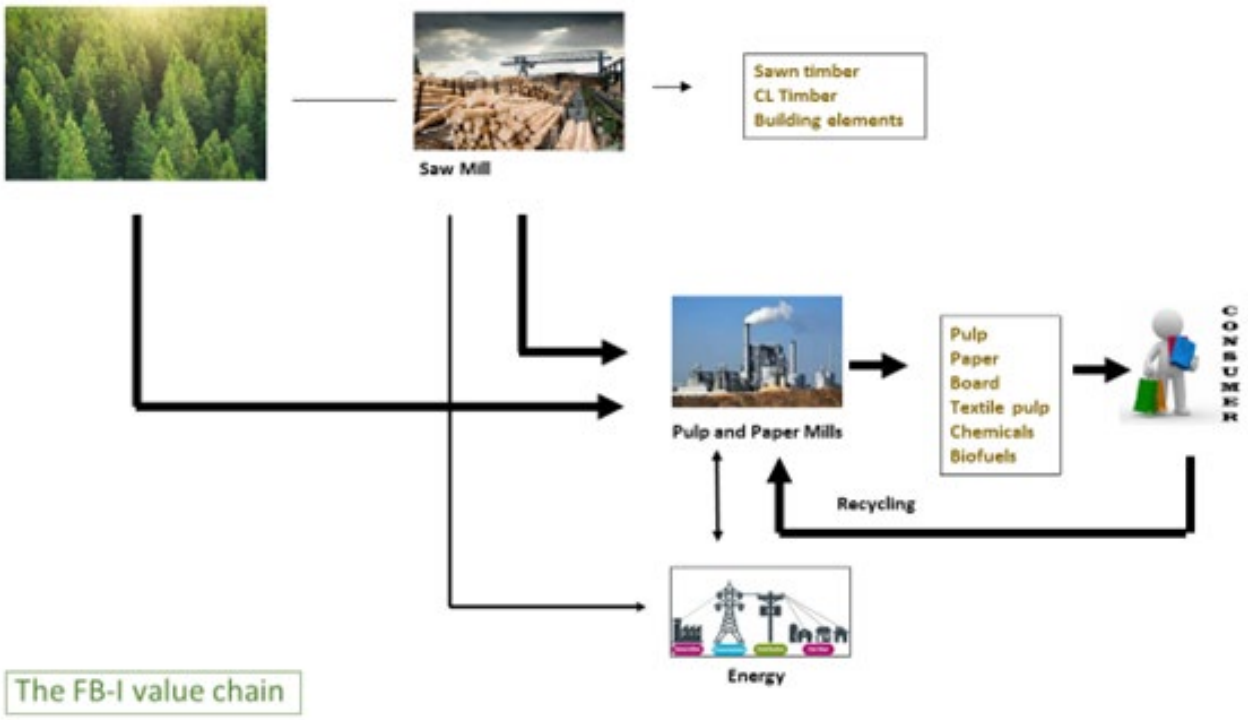
[4] European Commission (2013a), "A new EU Forest Strategy: for forests and the forest-based sector", SWD(2013) 342 final, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52013SC0342&from=EN.

[5] European Commission (2013b), "A blueprint for the EU forest-based industries (woodworking, furniture, pulp & paper manufacturing and converting, printing)", SWD(2013) 343 final, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52013SC0343&from=EN.

In principle, through sustainable forest management practices, the economic, ecological and social functions of wooded areas can be exploited at the same time as maintaining biodiversity, productivity and regeneration capacity.

The forest-based sub-sectors rely to different extents on *wood* for their material input, 90% of which comes from EU forests.[6] Woodworking – including sawmilling, the manufacture of wooden panels, carpentry and wooden packaging – rely almost entirely on the processing of wood for the production of roundwood, sawn wood and other wooden products, such as panels, wood fuels and cork. Consequently, its challenges mainly stem from the supply side, linked to the legal, economic and sustainable availability of raw material. The diversity of types of wood and fibre limits the substitutability and the ability to fully standardise products.

Figure 1. The FB.I value chain



Source: Own assessment.

Pulp, paper and paperboard manufacturing and converting use both raw wood and recycled material to produce pulp and paper, as well as graphic, hygienic, packaging and speciality paper grades and products. The processes are both energy and raw material intensive, usually characterised by high capital costs and very long investment cycles.

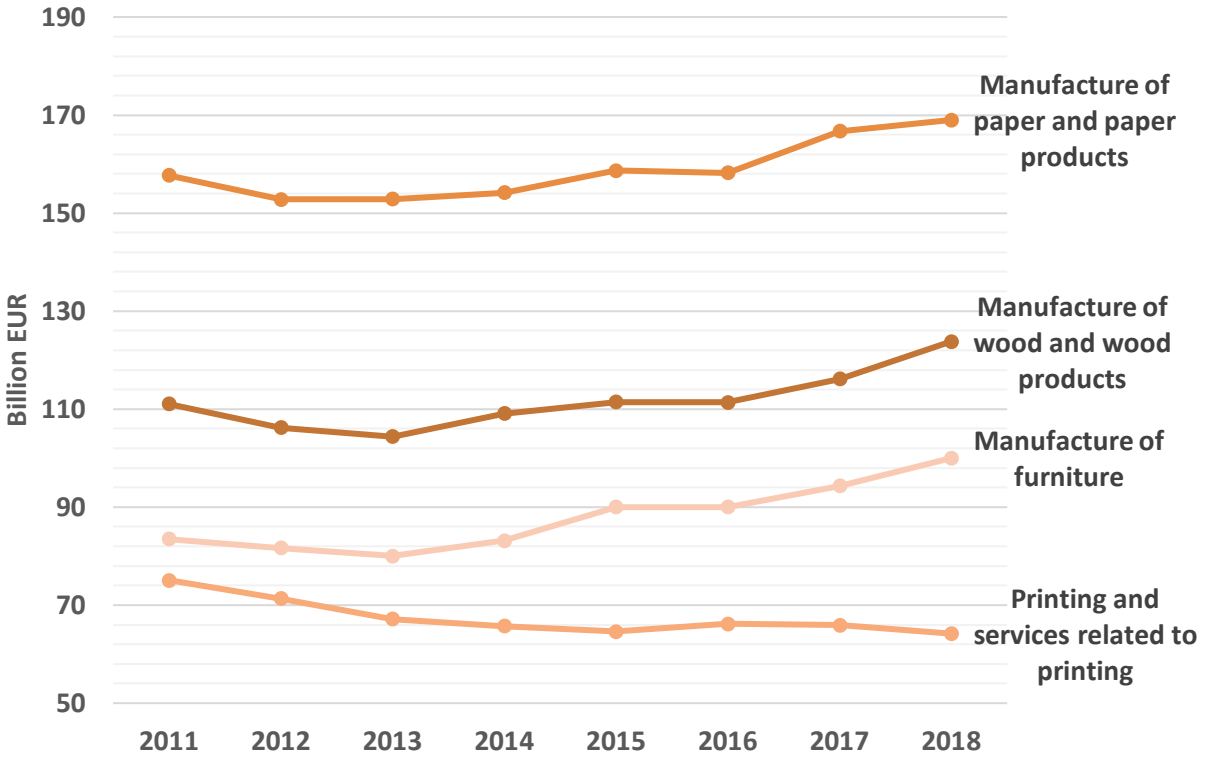
Over the past years, pulp and paper producers have significantly reduced their environmental impact through innovations that have increased resource efficiency and reduced emissions,

[6] Ibid.

water and energy usage. The industry currently runs a 72.5% paper recycling rate,[7] but fully decarbonising their energy use remains a challenge. Nevertheless, the industry has no process-related greenhouse gas (GHG) emissions. It operates in growing markets such as packaging material, hygiene products, textile products and building materials, offering low-carbon alternatives to fossil fuel-based products.

The *furniture and printing* industries produce consumer goods using wood alongside a range of other materials. The furniture and wood furnishing industries rely on labour-intensive activities to produce kitchen, office, bedroom and other specialist types of furniture. Therefore, especially in the low-end market segments, competitiveness is reliant on low labour costs. Meanwhile, the printing and paper-media publishing industries are characterised by a high fragmentation of business, facing changes in reading habits in the EU. Figure 2 shows the evolution in the production value of forest-based industries.

Figure 2. Production value of forest-based industries



Source: Eurostat data.

[7] CEPI (2018), "The challenge: decarbonising whilst being recycling pioneer: Summary for policy makers", Policy Briefing, European Forest Institute, www.cepi.org/system/files/public/documents/publications/CEPI%20policy%20briefing%20-%20Challenges%20in%20decarbonising%20whilst%20being%20recycling%20pioneer%20-%20final.pdf.

Wood is also used in bio-refineries to refine ligno-cellulose into transport *biofuels*, *composite materials* and *chemical feedstocks and products*, which could further drive up demand in a low-carbon economy. This competition for the supply of sustainably extracted wood is likely to increase in the future. With fluctuating wood prices, any increases can squeeze the margins of businesses; margins which are difficult to replace elsewhere in the process. Currently, this is one of the main bottlenecks.[8]

A major bottleneck in the value chain of forest-based industry is linked to the economics of the saw mill, which, to a large extent, determine the quantity of wood supply from harvested EU forests. This, in turn, can significantly affect the viability of production across the entire value chain, given the subsequent impact it can have on the price of wood. The saw mill needs to obtain at least break-even price from the sawn timber it produces for the construction and furniture industries, which usually yields the highest return, as well as from the side products used in pulp and paper mills, and from the by-products that go into energy generation, which usually have the lowest value.

Future demand for wood: forests as carbon sinks and material substitution

In the future, the availability and price of the wood processed by saw mills will also be affected by the role that forests play in balancing EU GHG emissions in the long term. Forests and their products reduce emissions, enhance sinks, store carbon and provide a continuous stream of ecosystem services, including wood products, energy and biodiversity conservation.[9] A report by the European Paper Industry Confederation (CEPI) estimates the overall climate contribution by European forests and the forest-based sector at a reduction of 806 million tonnes of carbon dioxide equivalent ($MtCO_2$) annually, corresponding to around 20% of all fossil emissions in the European Union (Holmgren 2020).[10]

These climate benefits may be expanded through the substitution of fossil energy and materials with wood-based alternatives. Wood has become more versatile through practices that have extended its range of uses in construction, bio-foam, bio-plastic, bio-polymer paints and pharmaceutical casing.[11] Many of these uses are currently marginal, usually restricted to by-products of pulp mills. In the future, however, given the potential to mitigate emissions, such applications may become more mainstream, which would further drive up demand. To date, it is not clear how this will affect the future economics of the sector and therefore the long-term economic sustainability.

[8] As the characteristics of FB.I are to an extent country specific, the bottlenecks and challenges presented in this paper vary from one EU country to another.

[9] Nabuurs, G.J. et al. (2015), "A new role for forests and the forest sector in the EU post-2020 climate targets", From Science to Policy 2, www.efi.int/sites/default/files/files/publication-bank/2019/efi_fstp_2_2015.pdf.

[10] www.cepi.org/cepi-study-climate-effects-of-the-forest-based-sector-in-the-european-union/.

[11] Wood can be produced with less energy and pollution than artificial materials such as steel and plastic. Solid wood items, such as furniture or wood used in construction, can also have extremely long working lives of up to 100 years or more. See WWF (2012), "Chapter 4: Forests and Wood Products", *WWF Living Forests Report*, https://d2ouvy59p0dg6k.cloudfront.net/downloads/living_forests_report_ch4_forest_products.pdf.

The future role of forests and harvested wood products – both to sequester increasing amounts of CO_2 emissions through forest growth and sustainable management, and to substitute carbon-intensive materials and fuels – is also recognised in the European Commission's long-term strategy.[12] According to this document, in the 2050 perspective, carbon sinks will be as important as a reduction in emissions, given that any remaining GHG emissions in certain sectors will need to be compensated for by absorption in other sectors. However, according to the 2018 long-term strategy baseline scenario, with current trends, the EU sink capacity is projected to decrease from about 300 $MtCO_2$ in 2015 to 260 $MtCO_2$. According to more recent analysis presented in the Commission's 2020 impact assessment for increasing the EU GHG emissions target, sink capacity could even fall to 225 million by 2030.[13] Increasing the sink capacity will require afforestation (or reforestation, although the EU potential may be limited here), as well as an improvement to forestry management practices. In sustainably managed forests in Sweden, for example, the trees capture more carbon than they release 20 years after plantation, and reach the 'peak of carbon capture' at about 60 years.[14]

According to the European Commission, a net-zero emissions economy will also require increasing usage of biomass compared to today's consumption. The highest projections of the long-term strategy show an increase in bio-energy consumption of around 80% by 2050 compared to today. Higher rates of wood replacement of durable goods will also further reduce biogenic carbon releases into the atmosphere. Measuring the substitution effect still represents a subject of debate.[15]

Part of this increasing demand for wood can be met given the current growth rate of the EU's forested area. Over the past few decades, EU forests have been expanding constantly by about 0.4% annually, while only about 60-70% of the increment is cut for use in the forest-based sector.[16] However, the long-term strategy shows that the current trends would be insufficient to cover all future EU needs. Extending the areas where sustainable management practices are implemented will also be a challenge, given the current fragmented ownership structure and protected natural areas. Some 60% of forests are owned by several millions of private owners,[17] and nearly a quarter of the EU's forest area is protected under Natura 2000, which limits the supply potential.

[12] European Commission (2018), "A Clean Planet for all: A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy", COM (2018) 773 final, Brussels, 18 November 2018.

[13] See page 11 of the 2030 Communication: https://ec.europa.eu/clima/sites/clima/files/eu-climate-action/docs/com_2030_ctp_en.pdf.

[14] Pöyry (2017), "Carbon Capture: Project double loop", Final Report.

[15] For example, Pöyry (2017) has estimated that substituting a cubic metre of wood with other building materials saves on average 0.8 tCO_2, compared to a study by Peter Holmgren (2020) commissioned by the Swedish Forest Industry Federation, which uses a 1.5 tC/tC substitution factor for solid wood products.

[16] European Commission (2013a), "A new EU Forest Strategy: for forests and the forest-based sector", COM(2013) 659 final, https://eur-lex.europa.eu/resource.html?uri=cellar:21b27c38-21fb-11e3-8d1c-01aa75ed71a1.0022.01/DOC_1&format=PDF.

[17] Ibid.

As the EU decarbonisation commitments become more stringent, energy use may also represent a bottleneck in some regions. Currently, energy is a significant cost item, especially for the paper and pulp sectors. Since 2005, the related carbon emissions have been reduced by 26% and energy consumption decreased by 11%, with 60% of the final energy coming from renewable sources.[18] However, some mills still use natural gas or even coal or oil for energy production, without a viable low-carbon alternative to date. This tends to be the case in countries where the paper-based industries use fewer virgin fibres, for example due to lack of availability, and rely to a larger extent on recycled fibres.

Countries that have integrated mills for processing sawn wood into multiple products across the value chain have the advantage of being able to generate renewable heat and electricity necessary for their processes by burning side-stream residues such as bark, lignin and other wood biomass components. By contrast, based on several factors such as cost efficiency, local and national conditions and lack of viable alternatives, mills that rely on recycled fibres usually resort to the use of natural gas.

This could technically be replaced through the use of electrical boilers to produce steam, but would require significant asset replacements, higher energy costs and an increase in the industry's baseload demand by an estimated factor of 2.5.[19] In a climate-neutral future, combustion of unabated natural gas is most likely not a long-term solution for paper recycling, so viable decarbonisation solutions will need to be found, especially as EU allowance (EUA) prices will likely increase and subsequently drive up the costs associated with using natural gas for energy production.

3. Implications of climate neutrality

In order to reach net-zero GHG emissions, significant efforts will be required across the EU economy and society. It will rely on the radical transformation of the energy, transport, industrial, land and agricultural sectors, as well as the modernisation of cities and the adjustment of individual mobility patterns and consumer behaviour. Given the extent of these transformational changes, a determining factor in the success of decarbonisation efforts will also be the ways in which the most vulnerable are affected and protected during the transition.[20]

The European Green Deal, with its reiteration of the climate neutrality objective, its emphasis on just transition, and its framing as a growth strategy – especially in the wake of the ongoing pandemic – shows the importance of climate policy being broadly understood for long-term economic development in the EU. The EU climate law should legally clarify some of the definitions and implications of a climate neutrality objective. However, the European

[18] CEPI (2019), "The challenge: decarbonising whilst being recycling pioneer, https://www.cepi.org/policy-briefing-decarbonising-whilst-being-recycling-pioneer/

[19] Ibid.

[20] European Commission (2018), "A Clean Planet for all: A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy", COM (2018) 773 final, Brussels, 18 November 2018.

Commission's long-term climate strategy remains the most comprehensive attempt to assess possible pathways.

The long-term strategy identifies some no-regret measures for enabling this process, such as electrification; increased use of renewable energy, including advanced biofuels; improvements in energy efficiency; circular economy expansion; and more widespread use of hydrogen. However, all of these actions combined will still be insufficient to reach net-zero emissions. Some sectors will still have residual emissions, which will likely need to be compensated by, among others, the forest-based industry sector. Consequently, the sector may be unable to count on the use of offsets to cover its own remaining emissions. Forest-based industries will more likely have to become a source of negative emissions to compensate for remaining difficult or impossible-to-decarbonise processes in other sectors of the economy.

According to the long-term strategy, a net-zero economy will need to reap the full benefits of the bioeconomy and enable carbon sinks. This implies, among others, the large-scale increase of the natural sink capacity of forests, agricultural land and coastal wetlands to offset residual emissions. Sustainable biomass will be required for direct heat supply, to be transformed into biofuels and biogas, to substitute carbon-intensive materials and for power generation with the potential for negative emissions when used concomitantly with CCS. BECCS (bioeconomy and CCS) and afforestation are considered by the long-term strategy as one of the most significant options for carbon removal. Consequently, achieving net-zero emissions by 2050 will be reliant on the use of higher amounts of biomass, by up to 80% compared to today.[21] As EU forests will not be able to deliver these increased amounts while also providing carbon sinks and wider ecosystem benefits, imports will be needed to cover the deficiency. In turn, there is a risk that this may indirectly increase emissions in non-EU countries through land-use change.

The circular bioeconomy will also create new opportunities for the agricultural sector, according to the long-term strategy. The increased demand for woody biomass could provide farmers with opportunities for using abandoned land and for land-use conversion from the production of food-based biofuels, which can diversify farming business by up to 10%. Nonetheless, the sector will also have to reduce its own GHG emissions through the digitalisation of its processes to increase energy and resource efficiency, through the conversion of waste into biogas through anaerobic digestion,[22] and through soil sequestration and carbon storage. Some of the pressure on the sector may be relieved through the enhanced use of aquatic and marine resources for carbon capture, for example algae cultivation.

In deciding which land-use practices will deliver the most sustainable outcomes, there will be trade-offs based on the different carbon sequestration potentials, as well as distinct impacts on the ecosystem, especially on water resources, soil quality and biodiversity. For example, afforestation or reforestation of non-forest land, increased forest cover, and the restoration of

[21] Ibid.

[22] Biogas can be purified into biomethane, which can be used as a replacement for natural gas in gas grids without retrofitting the infrastructure.

degraded forests[23] have the ability to both increase carbon absorption and protect biodiversity. However, in some instances, increased afforestation can increase GHG emissions in other sectors if it displaces the agricultural production of food, feed, fibre or energy. In other cases, afforestation may prove the more effective form of land use. Another example relates to the quantities of extracted wood. If wood extraction is limited, it may increase the forest carbon sink, but it may simultaneously inhibit fuel and material switches to biomass in other sectors, which can in turn limit the emissions reduction potential of these sectors.

4. Challenges and opportunities for the sector

Market overview forest-based industries

When measured by some basic economic and trade indicators, the EU's forest-based industries have seen continued growth.[24] The total production value of the wood-based industries grew from just over €60 billion in 2005 – the starting year of the EU ETS – to just under €100 billion by 2018. While imports still exceeded exports in 2005, the trade balance has been positive since 2010, with trade representing about a quarter of the EU production value. For the paper and paper-product part of the value chain, growth has likewise been sustained in terms of both volume and value, bar a correction at the time of the economic crisis in 2009. Imports and exports are higher in 2018 than they were in 2005, although the export market is about two thirds larger than imports in terms of value.

According to official data, GHG emissions intensity has been in consistent decline since the creation of the EU ETS, yet due to the economic growth of the forestry sector, emissions in absolute terms have stayed stable.[25] Sub-sectors of the forest-based industries have received free allocations under the EU ETS. Since 2017 the sectors have received fewer allowances than they emit annually, thereby increasing the direct exposure to the ETS price.

Long-term challenges and opportunities for forest-based industries

The EU's long-term strategy for 2050 of November 2018 presents a number of technical and economic pathways to reach long-term climate targets in line with either the 2°C or 1.5°C temperature targets of the Paris Agreement. The overarching message is that all technological/socio-economic options should be pursued simultaneously if the objective of 'net-zero' GHG emissions (considered necessary for the 1.5°C objective) is to be achieved. In

[23] See chapter 4 of the IPCC Special Report on Climate Change and Land. It defines forest degradation as "land degradation that occurs in forest land" and land degradation as "a negative trend in land condition, caused by direct or indirect human-induced processes including anthropogenic climate change, expressed as long-term reduction or loss of at least one of the following: biological productivity, ecological integrity, or value to humans" (Section 4.1.3.).

[24] Based on Eurostat (Annual detailed enterprise statistics) and Comext (Europroms DS-056120) data, using the NACE codes 16.00-17.29.

[25] According to the forestry sector, the data from the EU Transaction Log is not fully representative of the sector as some emissions are attributed to the power sector instead of the FB.I sectors. Including these energy installations as well would show continued emissions reductions in absolute terms.

addition, negative emissions will be required by 2050 to compensate for remaining emissions to reach a net-zero balance.

These pathways include electrification, hydrogen, energy efficiency, circular economy, carbon-neutral liquids, carbon capture and negative emissions.

Forest-based industries are central to many of these pathways. They have fossil fuel emissions to reduce in their own production processes, but also manage forest lands that can release CO_2 but mostly absorb it as a carbon sink. Additionally, harvested wood products have the potential to substitute some energy-intensive materials and therefore contribute to emissions reductions in other (mainly ETS) sectors.[26] Forest-based products lend themselves well to the circular economy dimension of the European Green Deal.

The EU net sink[27] stood at 263 million tonnes in 2018, with the expectation that it will shrink to 225 million by 2030.[28] Total gross removals of CO_2 in 2016 were 424 million tonnes per annum. By comparison, total EU GHG emissions in 2018 were just over 4 billion tonnes of CO_2 equivalent, with 1.69 billion coming from ETS sectors. The long-term strategy notes that this net sink is not expected to be sufficient to compensate for residual emissions by 2050, while the 2030 Communication refers to the need for a growing sink if climate neutrality is to be reached.

Residual emissions are most likely to occur in the agricultural sector,[29] where non-CO_2 GHGs are difficult to eliminate. This is also true in aviation[30] and certain energy-intensive industries, where some process emissions may prove difficult to eliminate. Additional measures will therefore most likely be required to reinforce the EU's carbon sinks and the role of land in mitigating climate change.

As at late 2020 a precise, legal definition of 'net-zero greenhouse gas emissions' does not yet exist. The Climate Law proposed by the European Commission in March 2020 offers an opportunity to define in particular the 'net' side of the equation: how many negative emissions is the EU expected to need to reach net-zero in 2050? Much will depend on the balance between pursuing negative emissions in greater amounts, and reducing emissions.[31]

The potential of bio-based products to displace more energy and carbon-intensive alternatives is well acknowledged in the long-term strategy. At the same time, the volumes of materials that

[26] e.g. steel and cement in construction, or plastics. Most basic materials are produced by ETS sectors, although some of the impacts may also occur in non-ETS sectors, e.g. reduced transport demand or more efficient buildings.

[27] i.e. the balance between GHG emissions and absorption from land.

[28] See page 11 of the 2030 Communication: https://ec.europa.eu/clima/sites/clima/files/eu-climate-action/docs/com_2030_ctp_en.pdf.

[29] Emissions in agriculture in 2017 are 520 million tonnes (EEA greenhouse gas data).

[30] Emissions in aviation in 2018 are 61.7 million tonnes (EEA greenhouse gas data).

[31] See Sabine Fuss et al (2014), "Betting on Negative Emissions".

in principle can be substituted are so high that bio-based products cannot substitute all of them due to scale limitations or the specifications of current products.

The displacement of carbon-intensive materials by low-carbon or carbon-neutral alternatives, irrespective of whether they are bio-based or not, will require market demand. Currently such demand does not exist as most low-carbon alternatives have higher costs. The European Commission acknowledges this in its Green Deal and comes forward with a proposal to create 'lead markets' for climate-neutral industrial products.

Will general climate policy be enough to create demand for bio-based materials sufficient to meet the net-zero objective, or should there be targeted policies for different categories of products, including bio-based ones? This raises the broader question of to what degree a policy aimed at increasing the market prospects of climate-neutral products should be technology neutral. If the answer is that it is important, defining technology neutrality in the context of a lead markets proposal, and in the role of wood-based products becomes necessary.

In addition to the potential substitution effects of bio-based materials, their contribution to circular economy objectives by reducing demand for the inputs of conventional materials, as well as the role of forests in maintaining and enhancing carbon sinks, are critical factors in answering the question above.

Substitution potential exists for many basic materials. Biochemicals and textiles offer further potential. In the energy supply sector, a major challenge for climate neutrality is delivering decarbonised molecules, i.e. gas. Biomass energy can help generate negative emissions through BECCS. For example, the European Commission's long-term strategy foresees 80% growth in bioenergy consumption (including BECCS) by 2050. As this market grows, there may be competition for land used to produce this biomass.

A similar issue regarding competition for land may arise in the agricultural sector, especially in scenarios when energy crops are pursued. The agricultural sector has some of same attributes as forest-based sectors in its contribution to, and mitigation of, climate change or other environmental objectives; both can contribute to negative emissions – by enhancing soil carbon – and to afforestation and reforestation. They can also protect biodiversity.

The long-term strategy emphasises the importance of maintaining and enhancing the EU's carbon sink. It also sees nature-based approaches as desirable due to the additional benefits they bring, for example not just biodiversity but also health and leisure. The opportunities for foresters are obvious. In combination with a desire to grow the market for wood-based products, however, some tensions may arise. The sector itself sees no issues with enhancing both the sink and other 'ecosystem services', while at the same time growing the market for wood-based products. Nevertheless, from a land-use perspective, there can be an opportunity cost on whether a unit of land should be optimised for its sink effect, biodiversity or economic activity. At its core this is a political choice.

Management of carbon sinks can also have a different impact on the short term versus the long term. Likewise, this can have implications for forest-based industries when policies for climate neutrality are being deployed.

The EU sink has declined in recent years, after a period of expansion from 1990 to 2010. Losses from harvests and forest decays have increased, as has biomass production. While an expansion of wood-based production need not necessarily come at the expense of maintaining the sink, it can nevertheless pose a challenge. Furthermore, if the goal is to grow the sink considerably, the competition effects as described above may still present limitations.

Afforestation can in some cases increase overall GHG emissions if the new forest for example displaces food, fibre, or energy production, which then move elsewhere. This may in some cases constrain prospects for turning additional land into forest.

Perceptions of what constitutes short and long term may also differ considerably between policymakers, climate scientists, regular industry and forest managers.

Which markets and uses can be pursued by forest-based industries?

The primary opportunity for forest-based industries is the growth of markets compatible with a more circular, bio-based and climate-neutral economy. There may nevertheless be limits to the growth of these markets, for example because of resource constraints, competition for resources or consumer demand.

In the construction industry,[32] wood as a construction material has been estimated to represent around 8-10% of the market share for detached houses, with large variations across member states.[33] This share differs considerably across regions, for example with northern Europe as well as some other member states having more experience using wood. The forest-based industries themselves expect that this market share could be quadrupled by 2050, when climate neutrality should be achieved. This translates into some 4% growth per annum. While this represents solid growth for the forest-based sectors, the 70% market share for 'conventional' materials leaves a large share of construction materials to be decarbonised or their demand reduced by other means.

In the global plastics market, bio-based plastics currently hold just a 1% market share. However, for this market the growth potential is considered to be very large, according to the European Commission's long-term strategy. For the world to transition to bioplastics would also increase the demand of that sector for biomass. The long-term strategy expects 5% of global biomass to be needed for bioplastics production.

[32] The construction industry will also be affected by the Circular Economy Action Plan; see e.g. https://ec.europa.eu/environment/eussd/buildings.htm.

[33] Hurmekoski, E. (2016), "Long-term outlook for wood construction in Europe", Dissertationes Forestales 211, School of Forest Sciences, Faculty of Science and Forestry University of Eastern Finland; DOI: 10.14214/df.211.

Other opportunities exist in the textiles and cosmetics sectors; here consumer preferences are likely to be decisive.

Delivering negative emissions: can forest-based industries meet competition?

Planting trees is a straightforward way to increase the EU's carbon sink and to deliver negative emissions. The forestry sector may, however, find itself in competition with other means to deliver negative emissions, such as BECCS. Trees also require land.

The long-term strategy estimates that demand for biofuels in the aviation, maritime and freight sectors would require 29 million hectares of energy crops. This is roughly similar to the landmass of Italy. More sustainable practices in agriculture can help to meet some of this demand. Likewise, the type of feedstock and biomass used can affect the size of the carbon sink. Nevertheless, demand for energy crops to satisfy BECCS would need to be added to the 29 million hectares of land.

This illustrates the difference between two 1.5°C scenarios developed in the long-term strategy. The so-called 1.5CTECH scenario assumes a higher contribution of BECCS to negative emissions, therefore requiring additional energy crops. The 1.5CLIFE scenario prioritises nature-based negative emissions, with a greater share of natural land used for forests and non-productive (i.e. non-agricultural) grasslands and shrubs. The long-term strategy assumes an implicit carbon price of between €70 and €150 per tonne for enhancing the LULUCF sink through expanded forests. If BECCS is pursued, the costs of enhancing LULUCF are lower, at €30 per tonne, because the total land required for the sink would also be lower. However, this does not take into account the additional costs to deliver BECCS.

The view from the IPCC: land is a critical resource and well managed forests are essential

Two recent major reports from the Intergovernmental Panel on Climate Change (IPCC) confirm the importance of forest-based industries, but also of the land they use. The IPCC special report on the 1.5°C target emphasises the importance of short-term action up to 2030 if the temperature limit is to be met. Globally, CO_2 emissions should be cut roughly in half by 2030 and reach net-zero by 2050. In addition, global net-negative emissions are required.

With their activities to maintain and enhance carbon sinks, the forest-based industries can contribute to negative emissions, especially longer term. For the short term, the potential to displace carbon-intensive products with bio-based alternatives provides an opportunity to contribute, although this would require a rapid scale-up in production and acceleration of market shares for these products.

The IPCC special report on climate change and land[34] adds that all "pathways that limit warming to 1.5°C or well below 2°C require land-based mitigation and land-use change, with most including different combinations of reforestation, afforestation, reduced deforestation, and bioenergy". It continues with further detail on the importance of various land uses for climate

[34] See IPCC (2019), Summary for Policymakers.

policy. First, it states that it is hard to separate anthropogenic and natural drivers of emissions from land and removals by sinks. This may explain why accounting of certain land-based activities needs to be kept simple.

The special report also acknowledges the many services that good forest management provides. "Sustainable forest management aimed at providing timber, fibre, biomass, non-timber resources and other ecosystem functions and services, can lower GHG emissions and can contribute to adaptation."

It furthermore acknowledges the positive impact that harvested wood products can have, as by transferring carbon to wood products the issue of sink saturation is addressed. Once transferred to wood products, these can substitute emissions-intensive materials in other sectors, reducing these sectors' emissions. Compared to biomass for energy, this also represents a longer-term contribution to the carbon sink, as carbon from biomass is released back into the atmosphere more rapidly.

While acknowledging this positive substitution effect, the report also highlights that the accounting for the substitution effect is challenging, as it difficult to assess the totality of alternative futures. In the EU the main impact would be reduced output, and therefore reduced emissions for certain energy-intensive industries covered by the EU ETS.

The UN carbon accounting principles to prevent double counting do not include substitution effects, as the counterfactual is difficult to establish (i.e. what exactly is being substituted). As such, substitution effects cannot be recognised in a formal carbon (compliance) accounting sense, even if the positive contribution to emissions reductions is acknowledged. The accounting principles for harvested wood products are similarly well established in international rules and have been transposed in EU regulations. As such, harvested wood products are either assigned half-life values to determine when they release half of the embedded CO_2, or it is assumed that all CO_2 is released the moment a tree is cut (instantaneous oxidation).

5. Adapting the policy framework to climate neutrality

The value chain of forest-based industries, perhaps uniquely so among different industries, straddles all three main climate policy frameworks in the EU: the EU ETS, the effort sharing regulation, and the LULUCF legislation. The emissions arising from its own activities are mostly covered by the EU ETS (bar some smaller sites). The challenge is to reduce these emissions towards zero by 2050.

To reduce direct emissions from its own activities, energy-inputs need to be addressed. In some regions where paper mills do not run on biomass, alternatives to natural gas need to be developed. This is a similar challenge faced by other energy-intensive sectors and one where the EU's agenda on decarbonised gases will play an important role.

The non-ETS effort sharing legislation is not so important for the sector because its wood-based products can affect emissions more broadly, for example in the buildings sector, even if the

amount of direct forest-based industry emissions included in the non-ETS sector is limited. More importantly, there has been some interaction between the effort sharing legislation and LULUCF framework in terms of accounting, with the annual emission allocation (AEA) accounting unit from the effort sharing legislation also eligible to comply with LULUCF accounting. Additionally, a member state may decide to transfer a limited number of tonnes from LULUCF compliance to effort sharing compliance. Similarly, some exchange for flexibility reasons is possible between the EU ETS and non-ETS. However, trade in wood products can lead to some accounting issues as only part of this sub-sector is covered by the ETS.

Under the European Green Deal, the intent to increase the EU's GHG reduction target for 2030 has already been announced. If this transpires, it will also lead to a reopening of the various 2030 climate policy frameworks. Besides changes to the operation of the climate policies, this may also entail a rebalancing of the relative efforts of the three main policy frameworks.

Rather than the "no-debit" rule currently included in the LULUCF legislation, a separate target for negative emissions (possibly as part of the proposed climate law) can affect the maintenance and enhancement of the forest sink. ETS sectors may be expected to do more (or less) to achieve the additional reductions required to reach a 50-55% target by 2030. The suggestion to extend the ETS to other sectors such as transport and buildings could further affect this balance.

In the EU ETS itself, the interaction between a net-zero target and the current trajectory of the cap going to zero could lead to changes such as the introduction of negative emissions credits. Without an external supply of credits for compliance, it would not be possible for any residual emissions to exist in ETS sectors, even if they are currently expected to occur in e.g. some process industries and aviation.

As trade-intensive sectors, the proposal to investigate border carbon adjustments (potentially through the inclusion of imports in the ETS) could also have an impact on the forest-based industry's competitiveness.

New policies beyond the core climate policies

The European Green Deal explicitly links the climate agenda to other environmental and sustainability objectives. Most prominently, a circular economy is seen as essential to manage material and resource demand, increase efficiency and thereby reduce emissions. Forest-based industries also pursue a high degree of circularity within their own value chain (e.g. by processing waste streams) and are as such well aligned with this objective. Nevertheless, circularity does not as a general rule reduce emissions. Rebound effects in recycling stages can lead to increased energy use and therefore emissions. Outside of the forest-based industries themselves, a higher degree of circularity can increase material and energy efficiency, although the same caveats on the rebound effect apply. Increasing circularity can help resolve some of the tension with land use and biodiversity.

Among other aspects of sustainability, safeguarding biodiversity stands out, as evidenced by the EU biodiversity strategy for 2030[35] and the first global assessment report[36] of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES – which can be described as a biodiversity counterpart to the IPCC). The EU's biodiversity strategy stresses the need to link the management of forests for biomass to biodiversity considerations, while highlighting the fact that the EU's primary and old-grown forests are to be strictly protected. Forest-based industries are in a position to have considerable impact here, but different development pathways for the sector may come with different co-benefits and impacts on biodiversity. Conversely, future policy by the EU in this area could also constrain the choices available to the sector if this results in stricter requirements to protect biodiversity in forests.

One element that could play a role in future policy is the pricing of ecosystem services – which so far is absent. Pricing of ecosystem services could have significant impacts for forest-based industries, as one of their key resources and inputs could then yield returns in potentially different ways.

After 2030, the potential trade-offs related to forestry and land use could become more acute as the net-zero target date approaches. These can be summarised in three categories:

- food versus feed
- fibre versus fuel, and
- land versus ecosystems.

More knowledge will be required to find the right balance. This includes knowledge on which energy crops have the potential to deliver the highest negative emissions, forest management practices to optimise biodiversity, avoiding monocultures[37] with afforestation,[38] and the role of forests in climate adaptation.

Challenges for policy are how to create lead markets and, more generally, the use of public procurement instruments. These can in theory support demand for climate-neutral products, but policy-driven demand is not equivalent to market-driven demand. Climate-neutral products are not necessarily of higher value to consumers, nor do they offer better functionality. Consumer preferences for bio-based products in, for example, the materials or textiles sectors will matter.

[35] European Commission, "EU Biodiversity Strategy for 2030: Bringing nature back to our lives", COM(2020) 380 final, Brussels, 20 May 2020.

[36] See the Summary for Policymakers of the Global Assessment Report of IPBES: https://ipbes.net/sites/default/files/2020-02/ipbes_global_assessment_report_summary_for_policymakers_en.pdf.

[37] See page 98 of the full text of the Special Report on Climate Change and Land, which states that reforestation with monocultures of fast-growing, non-native trees has little benefit to biodiversity.

[38] Avoiding monocultures is described as an example of unsustainable forest management in the European Environment Agency (EEA) Briefing "Forest dynamics in Europe and their ecological consequences". See also www.eea.europa.eu/themes/biodiversity/forests.

6. Conclusions

From the perspective of the forest-based industries, product substitution towards bio-based products is desirable for the market opportunities it represents. Likewise, from a climate policy perspective, displacing highly carbon-intensive products is desirable. However, accounting uncertainties make it difficult to translate this into policy action as it is inherently unclear what exactly would be displaced. Moreover, there are instances where substitution by bio-based products could be expected to lead to a net-reduction of carbon stocks. Looking further ahead into the future of a (partly) decarbonised industrial economy, substitution could also displace more low-carbon industrial products, further complicating the calculations on exact impacts on emissions and carbon stocks.

A specific challenge for wood-based manufacturing is that one way of increasing the sink in the short to medium term is precisely by limiting or reducing wood extraction. The trees will then continue to absorb CO_2 for some time. While in the longer term this is not an issue as harvested trees regrow, some (net-zero) GHG targets may create an incentive to increase the sink in the short term. However, limiting wood extraction in this way could also have an adverse impact on the substitution effect of wood-based products; for example, older trees are less resilient, increasing the risk of losing the sink by losing the forest.

Amidst this complexity several concrete conclusions can be formulated:

- Recent indications show the EU net sink to be shrinking. This reinforces the importance of accurate data and monitoring. Likewise, an EU biodiversity policy with indicators and monitoring should inform forestry practices and estimates of biomass availability.
- Closely linked is the need to monitor and enforce compliance with sustainable forestry management practices.
- To ensure coherence between climate and forestry policies, perspectives on different timeframes need to be considered and aligned as closely as possible. The optimal use of forests to contribute to climate neutrality and negative emissions is likely to be different for shorter timeframes – decades in the forestry context – than for longer timeframes, where the role of forestry (for example for negative emissions) adds further complexity. Policy will need to consider this and eventually take decisions.
- A negative emissions strategy is essential for the EU, and its formulation will have a great impact on forest-based industries. Such a strategy should clarify expected/desired volumes over different timeframes – including in the very long term (end of century); and interact with the ETS & LULUCF frameworks.
- An immediate task for policymakers will be to consider the need for dedicated instruments for lead market creation for wood-based products. Is there a need for dedicated policies for wood-based products or does the current policy framework provide sufficient incentives for product substitution?
- Sustainable forestry management for imports: Given the strong international trade dimension of the bioeconomy, it will be necessary to address the sustainability of forestry management for imports.

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