

ROADMAP FOR FOSSIL
FREE COMPETITIVENESS

Forest Sector



A close-up photograph showing a person's hand holding a rectangular, transparent wood sample. The wood is clear and allows light to pass through, revealing the underlying wood chips and shavings scattered on a light blue background. The hand is positioned at the bottom left, with the thumb and index finger gripping the edges of the wood sample. The wood chips are of various sizes and orientations, some showing the natural wood grain. The overall scene is brightly lit, emphasizing the clarity and texture of the materials.

Swedish researchers have succeeded in producing transparent wood, a strong material that lets light through. Windows and solar panels are some possible uses.

How the forest sector increases climate benefits in society

The forest sector contributes to climate change mitigation in three overriding ways: by *substitution*, whereby biobased products replace products that are produced from fossil raw materials or which cause major fossil emissions during production, by *carbon capture* in the forests and in biobased products, as well as by *reducing the sector's own use of fossil energy sources*.



Foreword

Sweden will be one of the world's first fossil free welfare nations. This is not just a vision but a firm reality, with several business sectors now presenting their roadmaps for fossil free competitiveness.

This is crucial work in a time when greenhouse gas emissions are decreasing far too slowly to limit global warming to below 2 degrees Celsius. It is the task of the Fossil Free Sweden initiative to accelerate Sweden's climate mitigation and adaptation efforts, and it has therefore invited business sectors to produce their own roadmaps for fossil free competitiveness – and the response has been overwhelming. In the spring of 2018 nine roadmaps have been produced, and more will be launched during the autumn.

These roadmaps are unique initiatives. The fact that various corporate networks show their plans for becoming fossil free is certainly a good thing, but entire sectors drawing up their own roadmaps for being fossil free by 2045 is an initiative that brings hope for the future. It is not just the actual document that is important, but also the fact that it has entailed a far-reaching process involving many other players through various workshops and seminars. Since there are so many roadmaps, producing them creates a momentum in Sweden, with more and more players taking steps towards being fossil free.

These roadmaps jointly make up a 'Jigsaw Puzzle of Sweden', showing how Sweden can become fossil free while welfare increases. The sectors are, however, owners of their own roadmaps' narratives, and of the policy demands necessary to enable them to realize their ambitions of the roadmaps. Fossil Free Sweden has worked with the sectors in various ways to support them in producing their roadmaps. This has included joint debate articles, participation in workshops, and occasionally giving concrete tips and advice. It should however be emphasised that the roadmaps are products of the sectors' inherent drive and commitment, and that the results and the various political suggestions highlighted are owned by the sectors themselves.

Through these roadmaps a Swedish national team for

fossil free development has been created. It has come together to show others that another world is possible. When we demonstrate that a fossil free country is also the way to a better life, there will be a global race to leave the fossil-based society.



Svante Axelsson

National Coordinator, Fossil Free Sweden

Contents

Foreword		3
Summary		5
1	Introduction	7
1.1	The Swedish climate goals	7
1.2	Climate work from a forest sector perspective	7
1.3	Definitions and delimitations in the roadmap	9
1.4	Approach and organisation	9
2	The Forest Sector's Vision and Goals	10
3	Vision and goals for the roadmap for fossil free competitiveness	11
3.1	The forest sector's vision and goals for the roadmap	11
3.2	The roadmap's targets for 2030	11
4	Analysis of Obstacles	14
4.1	Growth in the bioeconomy	14
4.2	Phasing out fossil energy	15
4.3	What is needed to implement the roadmap?	15
5	The Current Situation	17
5.1	The Swedish forest sector	17
5.2	Energy use	17
5.3	Bioenergy	20
5.4	Growth and felling	20

Summary

How can the forest sector create increased profitability, competitiveness and jobs across the country, while at the same time phasing out the use of fossil energy sources up to 2045? The forest sector's roadmap for fossil-free competitiveness, shows how the sector can create even more climate benefits than it already does today.

The roadmap is developed by the trade association *The Swedish Forest Industries Federation (Skogsindustrierna)*.

THE VISION OF THE ROADMAP IS:

»The forest sector drives growth in the global bio-economy«.

The vision goes beyond its own sector by including a transformation of society to a bio-based economy. In a growing bioeconomy, the forest sector today already contributes to climate change mitigation in three overall ways: by *substitution*, whereby biobased products replace other products that are produced from fossil raw materials or which cause major fossil emissions during production, by *carbon capture* in the forests and in biobased products as well as by *reducing the use of fossil energy sources*.

THE GOAL FOR THE ROADMAP IS:

The overall climate benefits of the forest sector and its contributions to a fossil-free society will have increased by 2045 by contributing with more bio-based products and by phasing out fossil energy sources in its own operations.

TARGETS FOR 2030

To increase the overall climate benefits of the forest sector and its contributions to a fossil-free society, The Swedish Forest Industries has defined goals to be reached by 2030. The goals are divided between the two focus areas: *climate benefits and competitiveness through growth in bioeconomy* on one hand, and *climate benefits through phasing out of fossil energy sources in the operations*, on the other.

Climate benefits and competitiveness through growth in bioeconomy

- The forest sector's share of the Swedish GDP has doubled, from 3 percent in 2013 to 6 percent in 2030.
- The market for wood products has expanded and the value of deliveries has increased – at least 50 percent of all new homes are built with wooden frameworks and an increasing proportion of other buildings are built with wooden frames.
- Investments in research, innovation and demonstration facilities linked to forestry and forest industry have doubled to SEK 8 billion per year.
- The forest sector's deliveries of bioenergy have increased.
- The production of biofuels based on forest raw material has increased – an estimate is an increase from 1 TWh to 10 TWh.

Climate benefits from the phasing out of fossil energy sources

- The use of fossil energy sources in processes within forest industries has decreased further. Today, processes in sawmills are almost entirely free of fossil energy sources and the processes in the paper and pulp industry are 96 percent free of fossil energy sources.
- No fossil fuels are used in Non road Mobile Machinery in forest industries or in forestry.
- Fossil emissions from domestic transportation in the forest sector have been reduced.

GOAL WHAT IS NEEDED FOR THE IMPLEMENTATION OF THE ROADMAP?

Measures are needed in many areas if the forest sector is to fulfil the roadmap's vision and goals. Here is a list of those we consider to be the most important and where politics need to contribute.

- **A clear political ambition to create a biobased society**

A growing bioeconomy requires an increase in the production of forest industry products, bioenergy and biofuels. Politics must create conditions for this by, for example, removing the uncertainty with respect to views about forestry, taxes and fees linked to biobased products, transportation etc. There is also a need for increased state funding for R&I, at least in line with the industry's own initiatives.

- **Competitive conditions for the forest sector**

The forest industries operate in global markets. This places high demands on competitive conditions when it comes to, for instance, electricity costs, permit processes, the investment climate and the burden of fees and taxes, which should be in line with the conditions that international competitors face.

- **Assured access to biomass from sustainable forestry**

For the forest sector to contribute to a fossil-free Sweden, there must be an assured access to biomass from the forests. The ability to pursue efficient and sustainable forestry is crucial. The industry will demand more raw materials to enable an increase in current production of wood products, cardboard, paper and pulp. This is essential for increasing side streams to energy, fuels and new bio-based products. Political instruments and subsidies that distort competition or control the use of raw materials must not be introduced.

- **Increased focus on freight transportation**

Freight and the transportation of goods must be given higher priority when investing in infrastructure. Infrastructure initiatives based on the needs of the sector are also key, for example initiatives for transfer of goods to other modes of transport. Many of the member companies of The Swedish Forest Industries are able and willing to transfer more goods to rail and maritime shipping if the Swedish Transport Administration sorts out transportation bottlenecks and other obstacles. The measures presented in the National Freight

Transport Strategy, adopted by the Swedish Government in June 2018, need to be implemented.

- **Improving efficiency of transportation**

Improving efficiency can, for example, be achieved by permitting trains and lorries that are both heavier and longer. A first measure in the near future would be to ensure that the entire road network is adapted for lorries with a maximum weight of 74 tons. The potential for improving efficiency through the possibilities of digitization, e.g. horizontal cooperation, increases if authorities push for digitization in transport and infrastructure.

- **Electrification**

Electrification of road traffic can be increased, for example, by battery operated small lorries and passenger vehicles. The electrification of major roads, such as the E-road network with lots of heavy traffic, or shorter distances with shuttle services should also be carried out.

- **Continued investments in research and innovation**

Investments in research and innovation from the state and the private sector must be intensified further. This is crucial to enable development towards a growing bio-based economy. Research needs to be targeted at the areas presented in the research agenda from the forest industries (*Skogsnäringens Forskningsagenda 4.0*).



1 Introduction

Sweden has an explicit ambition to become one of the world's first fossil free welfare nations. As part of this vision, Fossil Free Swedenⁱ has been created as a platform for dialogue and cooperation between businesses, local authorities and other stakeholders with a desire to make Sweden free from fossil fuels. Fossil Free Sweden has encouraged various sectors to produce roadmaps to show how their particular industries will create fossil free competitiveness. The aim is for these roadmaps, jointly, to provide an idea of what a fossil free Sweden might look like, and how it can create competitive advantages for Swedish trade and industry on an international market. The roadmaps also aim to identify obstacles along the way and contains suggestions for decision-makers on how government authorities and political bodies can enable and facilitate the process of achieving the goals.

The Swedish Forest Industries Federation (*Skogsindustrierna*, a trade organisation) and several individual companies in the forest sector have decided to join Fossil Free Sweden. The Federation has also decided to produce a roadmap for fossil free competitiveness in the Swedish forest sector, within the framework of Fossil Free Sweden. The aim of the roadmap is to map how the forest sector can bring about higher growth, competitiveness and jobs across Sweden, while achieving fossil free energy use by 2045.

1.1 THE SWEDISH CLIMATE GOALS

Swedish efforts to achieve climate neutrality are based on the long-term, dated emission target set by Swedish Parliamentⁱⁱ:

Sweden will have no net emissions of greenhouse gases into the atmosphere by 2045, and will thereafter achieve negative emissions. Negative emissions mean that emissions of greenhouse gases from businesses in Sweden will be lower than, say, the amount of carbon dioxide absorbed by nature as part of the circularity, or lower than the emissions Sweden contributes to decrease abroad by investing in different climate projects. The remaining emissions from businesses in Swedish territory will however be at least 85 per cent lower than emissions in 1990. According to the Swedish Environmental

Protection Agency (EPA), climate-affecting emissions in Sweden have fallen by 26 per cent between 1990 and 2016. Emissions in Sweden in the sectors to be encompassed by the EU's effort sharing regulation should be at least 63 per cent lower than 1990 levels by 2030, and at least 75 per cent lower by 2040. The main emissions covered by the regulation are from transport, Non-road Mobile Machinery, small industrial and energy plants, housing and agriculture. These emissions are not part of the EU Emission Trading System (ETS), which encompasses most emissions from industrial, electricity and district heat production, along with aviation taking off and landing within the European Economic Area, EEA. As with the long-term goal, there are also opportunities to achieve parts of the goals by 2030 and 2040 through supplementary measures, such as higher absorption of carbon dioxide in forests, or by investing in various climate projects abroad. Increased absorption in forests will be reported in line with internationally accepted reporting standards, which at present means that it will only pertain to absorption in relation to a national reference level. The reference level includes carbon stored in wood products. Such measures may be used to achieve a maximum of 8 and 2 percentage points respectively of the emission reduction goals for 2030 and 2040.

Emissions from domestic transport, excepting domestic aviation, will decrease by at least 70 per cent by 2030 compared to 2010 levels.

1.2 CLIMATE WORK FROM A FOREST SECTOR PERSPECTIVE

The forest sector contributes to climate change mitigation in three overriding ways: by *carbon capture* in bio-based products and in the forests, by *substitution*, whereby biobased products replace fossil-based products or products which cause major fossil emissions during production, as well as by *reducing the sector's own use of fossil energy sources*.

Carbon capture

Growing forest absorbs carbon dioxide from the atmosphere through photosynthesis. If the growth stays in the forest, this benefits the climate as the carbon

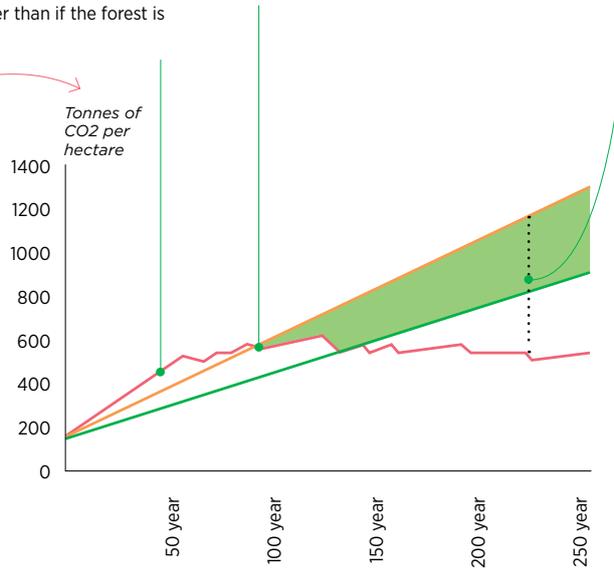
MANAGED FOREST WINS IN THE LONG RUN

If a previously managed forest is left untouched, to begin with it will grow well, which means a large annual increase in the stock of carbon. Since there are no emissions during forest management or production of forest products, the climate benefits are somewhat higher than if the forest is harvested and used.

At somewhere around 80 years old the managed »future forest« overtakes the unmanaged forest, because growth has started to slow down in the unmanaged forest.

The difference between the carbon stock in an unmanaged forest and the accumulated climate benefits of a managed forest increases year on year, since the unmanaged forest continues to decline in growth, while growth in the managed forest is high and stable.

Figure 1: Carbon stock change over 250 years in managed vs. unmanaged forests^{iv}. The calculations assume that all products for which the forest is used are substitutions for fossil based products.



Managed forest – future
The raw material is used in the same way as today, but also for new products that reduce the need for fossil raw materials even more.

Managed forest – today
The raw material is used for wood products, paper and as a replacement for fossil raw materials, primarily in the form of energy.

Unmanaged forest
After the growth phase comes a saturation phase, when the absorption and release of carbon dioxide are roughly equal. This makes the forest a static carbon stock.

The hypothetical calculations assume that when forestry stops in one country this does not lead to increased felling in another country.

dioxide in the air is bound and stored in the trees and ground. Climate benefits arise as long as the trees continue to grow and the timber volume increases. When the forest grows, is managed and harvested to be used for products, this also creates climate benefits since the carbon dioxide is sequestered in the products. This is *carbon capture*. According to Swedish EPA statistics, the Swedish forest and forest land bind around 41 million tonnes of carbon dioxide equivalents, and wood products bind around 8 million tonnes of carbon dioxide equivalents every yearⁱⁱⁱ. This can be compared to emissions from domestic transport, which was just under 17 million tonnes of carbon dioxide equivalents in 2016.

Substitution

When the forest is harvested and used to replace fossil raw materials, climate benefits arise. This is because carbon dioxide is first absorbed from the atmosphere by the trees and then re-released – a circularity to which no new carbon dioxide is added. If, however, we use fossil raw materials such as oil, coal or natural gas, new carbon dioxide is added to the atmosphere. When the forest's

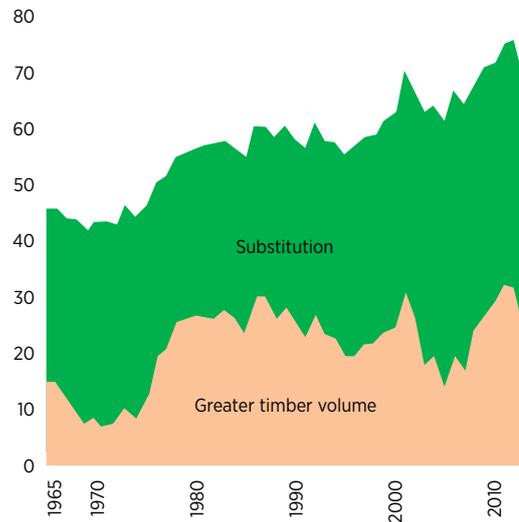


Figure 2: Millions of tonnes of carbon dioxide bound in timber volume and as substitution^{vi}.

products are used as energy or as an alternative to fossil-based products, we prevent new carbon dioxide being added to the atmosphere. This is *substitution*. For products with a long life span, such as wooden buildings and furniture, the carbon dioxide is bound for a long time. A study published in *forests* 2104 analyses the overall climate impact of forests and forest products in Sweden based on three different scenarios. The study shows the effect of forest product substitution in Sweden to be approximately 40 million tonnes in 2016. It also shows a substitution effect of between 500-800 kg of carbon dioxide per cubic metre of stem wood when the tree is used for products^v. Swedish climate policy is based on the possibility to use forest products for substitution of fossil-based products.

Reducing the sector's own use of fossil energy sources

The processes in forest industry at pulp and paper mills are already 96 per cent fossil fuel free. The sawmill industry is almost completely free of fossil fuels^{vii}. Reducing and in the long run totally phasing out the use of fossil energy sources in the processes is an obvious part of the forest sector's climate work. Another important and challenging aspect of this work is to reduce the use of fossil energy in Non-road Mobile Machinery and in transport.

1.3 DEFINITIONS AND DELIMITATIONS IN THE ROADMAP

This roadmap is produced by the trade organisation Swedish Forest Industries Federation and outlines the sector's joint plan for fossil free competitiveness. The roadmap's starting point is the question: How can the forest sector increase profitability, competitiveness and jobs across Sweden, while also phasing out the use of fossil energy sources by 2045?

Assuming that the obstacles and suggested measures described in chapter 4 can be dealt with, the roadmap will mean that the forest sector will contribute to the climate goals set by parliament to an even greater extent than it already does. The roadmap encompasses the entire chain, from forest to finished products. The focus is on society's climate-related benefits of products from the forest, and on the phasing-out of fossil energy sources within the forest sector's own operations.

When it comes to climate benefits for society, there are as mentioned before, two main components:

- Carbon capture
- Substitution

When it comes to the phasing-out of fossil energy sources, the goals in the roadmap are to phase out fossil energy sources in the forest sector's domestic transportation, Non-road Mobile Machinery and industrial processes.

- Domestic transport refers to transportation of the forest sector's forest raw materials and finished products within Sweden.
- Non-road Mobile Machinery refers to the machines used in forestry, and in the forest industry's Swedish production plants.
- Industrial processes refer to the Swedish production plants of companies in the forest sector.

The crucial questions in the roadmap are how these aspects of climate work can be combined, and how the total scale of climate benefits created in the forest sector and in society can be maximised.

For the forest sector, there are both cost and market-related aspects to consider when implementing a roadmap for fossil free competitiveness. Production processes in the forest sector are already virtually fossil free. What remains to be rectified is the fossil energy supply in Non-Road Mobile Machinery and transport. The sector has the potential to action this by manufacturing biofuels from logging waste and side flows in the industry. This will require significant investment in new production plants, which will limit the scope to carry out other vital investments. Some of the actions that may be required by the goal of phasing out fossil energy sources or producing biofuels could also lead to higher costs compared to abroad. Conversely, however, measures that lead to energy efficiencies could also increase competitiveness.

1.4 APPROACH AND ORGANISATION

At the Swedish Forest Industries Federation board meeting in December 2017, it was decided to produce a sector-wide roadmap for fossil free competitiveness. Work on the roadmap has been managed by a working group at the Swedish Forest Industries Federation. Two

reference groups were also linked to the work in seminars on 14 February and 27 February 2018. Participating in reference groups has enabled different stakeholders and representatives of other roadmaps to let their views be known on various aspects of the forest sector's roadmap – whether on the subject matter or on the goals and vision. The roadmap was ratified and adopted at the Swedish Forest Industries Federation board meeting in March 2018. During the process, separate discussions have also been held with representatives of other sectors' roadmaps.



2 The Forest Sector's Vision and Goals

The forest sector drives growth in the global bioeconomy^{viii}. This vision, adopted in 2015, is based on a necessary transformation of society to a biobased economy. A biobased economy entails a transition to using products that are based on renewable raw materials used in a sustainable way. The vision means that the bioeconomy's, and in particular the forest industry's, share of the overall economy grow faster than other parts of the economy. The roadmap for fossil free competitiveness is therefore a vital and natural part of the process of achieving the adopted vision.

The vision has been clarified by four goals:

- Increased production of renewable products
- Increased value added for biomass
- Efficient use of resources
- Increased expertise

These goals were also adopted in 2015 and are mostly based on accomplishment in 2030. The goals entail active forestry that takes responsibility for production as well as biodiversity and the forest's social values. The goals also describe measures to develop existing and new products, processes and markets, along with measures to give the sector access to the right expertise to secure its competitiveness in the future.



Everything you can make from oil you can make from trees. Here is a 3D printed ear in nanocellulose. Its tissue is very similar to human tissue, and can be used for drug tests.

3 Vision and goals for the roadmap for fossil free competitiveness

3.1 THE FOREST SECTOR'S VISION AND GOALS FOR THE ROADMAP

The forest sector's roadmap for fossil free competitiveness has the same vision as the vision adopted in 2015: *The forest sector drives growth in the global bioeconomy.*

As described previously, the vision entails a transformation of all of society to a biobased economy. The major contribution from the forest sector to climate change mitigation is through active and sustainable forest management and production of today's and tomorrow's biobased products. This way the sector can play a crucial role in the transition to a biobased society.

The goal of the roadmap for fossil free competitiveness is: *The overall climate benefits of the forest sector and its contributions to a fossil free society has increased by 2045.*

The roadmap clarifies how the forest sector contributes to climate change mitigation through carbon capture, substitution and reduced use of fossil energy. To achieve the greatest possible climate benefits, actions in these areas must be combined.

Fundamentally, it is the access to biomass that limits the size of the forest sector's contribution to secure a fossil free Sweden. Carbon capture and substitution are made possible by active forest management, and by manufacturing and using biobased products and different forms of bioenergy. Bioenergy is generated as side-streams from forest and downstream production processes. This means that the amount of energy used in-house in the sector and supplied to society is governed by the harvesting volumes and the industrial production rates. Continued resource and energy efficiency contributes to enlarging the scope for energy deliveries,

but fundamentally it is the development of industrial production rates that determines the forest sector's ability to create long-term climate benefits.

Other key requirements for the forest sector's climate contribution are competitive conditions for the industry in terms of electricity costs, permit applications, investment climate, pressure from charges and taxes, competitively priced transportation, robust efforts in research and development, and access to skills and expertise at every stage.

3.2 THE ROADMAP'S TARGETS FOR 2030

To concretise the vision and goals, the Swedish Forest Industries Federation has defined a number of targets which the forest sector strives to achieve by 2030.

CLIMATE BENEFITS AND COMPETITIVENESS THROUGH GROWTH IN THE BIOECONOMY

The forest sector's share of GDP has doubled

Sweden's transformation to a fossil free society means that the bioeconomy needs to grow. This target entails a doubling of the forest sector's share of GDP from 3 per cent in 2013 to 6 per cent in 2030.

According to a report by the Stockholm Environment Institute, SEI, the bioeconomy's share of Sweden's GDP could be tripled by 2050^x. In a 2014 report on the future of the forest industry, consulting company Pöyry identified the greatest potentials for the sector. The conclusion is that in the long term, new bioproducts and advanced biofuels could be important components for increased growth and profitability. In the shorter term, the main contributors are investments in advanced or evolved wood products, paper and pulp^x. Since the report was published the sector has invested more than

SEK 40 billion; in 2017 alone investments totalled almost SEK 17 billion. These investments contribute to the described development in both the short and the long term.

The market for wood products has expanded and the value of deliveries has increased

By 2030, new wood-based materials and wood products have guaranteed properties that enable them to compete on equal terms with other construction materials.

The proportion of timber frames in apartment buildings has increased from 13 per cent in 2015 to at least 50 per cent in 2030, and other buildings are increasingly built using timber frames. Sweden is a leading exporter of timber construction elements and systems for other countries in Europe and is a world-leading exporter of input materials for construction and housing.

According to a report by Linköping University, increased industrial timber building could for example deliver 50 per cent of apartment buildings built on the Swedish market by 2025^{xi}. Exploiting the potential of wood to reduce climate impact compared to other construction materials reduces climate impact in construction by 0.7–0.8 millions of tonnes of carbon dioxide equivalents. Adding the carbon capture of the wood to the substitution effect, the calculated saving is 2–4 million tonnes of carbon dioxide equivalents.

The forest sector's investments in research, innovation and demonstration facilities has doubled

Forest research and industrial forestry research in Sweden is in many cases internationally leading. Annual investment in forest research totalled more than SEK 4 billion in 2017, the forest sector and foundations accounting for two-thirds and government initiatives the remaining third. Investments in Swedish research need to double on 2017 figures, in order to strengthen the Swedish forest sector's competitiveness and to ensure that Sweden successfully manages the transition to a fossil free, circular and biobased society.

The research agenda for the forest sector highlights areas where investment in research and innovation is necessary^{xii}. Initiatives are needed both to strengthen competitiveness in existing processes and products, and to ensure that new biobased products reach the market.

The forest sector's deliveries of bioenergy have increased

Bioenergy currently accounts for just over 30 per cent, i.e. 130 TWh, of the energy use in Sweden today, with around 110 TWh coming from forest biomass^{xiii}. A large proportion of this is used in-house within the forest industry, but the sector also delivered just over 26 TWh of biofuel externally in 2015. The majority of the energy from forest management and forest industry that was sold externally was bark, branches and tops, but there were also other residues such as dry chips and shavings. In other words, the majority of the energy produced is used in the forest industry.

The potential exists to harness more forest residues, such as branches, tops and stumps. If the forest industry's production of other products increases, there is also the potential to produce more bioenergy from side-streams. According to a 2017 report entitled *Bioenergi på rätt sätt (Bioenergy done right)* by the Swedish Energy Agency, the Swedish Board of Agriculture, the Swedish EPA and the Swedish Forest Agency^{xiv}, the annual provision of sustainable bioenergy from agriculture and forestry in Sweden could increase to around 200–220 TWh up to 2050. A year earlier, in 2016, the Swedish Forest Industries Federation commissioned consulting company Pöyry to analyse the potential extraction of bioenergy from forest and forest industry in several different scenarios. In the *Maximum biofuel extraction* scenario, Pöyry concluded basically the same as the »done right» report above, i.e. that the potential exists to extract some 200 TWh of forest based bioenergy by 2050, given maximum extraction levels of branches, tops and stumps in line with the Forest Agency's recommendations. However, improved logistical solutions will also be required if this potential is to be realised. A likely more realistic development can be found in Pöyry's *Developed bioeconomy* scenario, which indicates bioenergy potential of about 129 TWh from the forest sector in 2050. Even in this more modest assessment of potential bioenergy extraction from the forest sector, there is relatively large potential to increase the proportion of bioenergy in a sustainable manner. Higher deliveries of bioenergy do, however, assume favourable developments when it comes to means of control, market prices, demand, efficiency measures, attitudes towards forestry and so on.

The production of biofuels based on forest raw materials has increased

Access to biofuels is a key factor in reducing fossil emissions, particularly in the transport sector. The forest sector's production of biofuels has the potential to increase. In 2015, approximately 1 TWh of biofuel was produced from forest sector raw material^{xvi}. There are already plans in place to increase production to about 5 TWh in the near future, and by 2030 it is believed that production of 10 TWh of biofuel is possible. The vision in the even longer term is that it will be possible to produce 20 TWh.

The 5 TWh per annum in the near future is based on official information on planned production capacity for biofuels from forest raw material in Sweden. The Swedish Forest Industries Federation will shortly be initiating a new investigation into the potential of producing biofuels from forest raw material, the aim being to quantify the potential and clarify under what conditions that potential can be realised.

The Swedish Forest Industry Federation's most recent study was in 2006, when consultancy ÅF was commissioned to conduct an analysis specifically of the production potential of vehicle fuels from forest sector raw material. The analysis showed that by 2020, producing 9 TWh of biofuel from the forest sector should be viewed as a good result^{xvii}. This presupposed, however, that all the recommended measures were taken. But the situation did not develop in the way ÅF deemed possible.

Energy use in the entire Swedish transport sector in 2016 totalled around 87 TWh, according to Swedish Energy Agency statistics^{xviii}. In the road sector biofuels accounted for around 19 per cent, equating to 17 TWh, of fuel use in 2017. This was either in the form of pure biofuels, or as additives. Energy use in the forest sectors' domestic road transport has been estimated at about 5 TWh a year. This estimate is based on the Swedish Government Official Report; *Fossilfrihet på väg*, SOU 2013:84, Fossil Free Vehicle Traffic, stating that heavy road transport in Sweden uses about 20 TWh a year. Statistics from Transport Analysis indicates that of all commercial road transport in Sweden, the forest sector accounts for roughly 25 per cent. When it comes to the production and use of biofuels, this means that in the near future the forest sector will produce, or deliver raw

materials for, roughly the same amount of biofuel as the volume of fuel used in the sector.

Access to and production of bioenergy are affected by a range of factors, and the same is true for the potential to produce biofuels. Preconditions for increased production of biofuels is favourable development overall when it comes to opportunities for cost-effective transportation, market prices, demand, efficiency measures and attitudes towards forest management. It is also important that means of control and subsidies are not introduced that distort competition or govern the use of the raw material.

CLIMATE BENEFITS THROUGH PHASING OUT OF FOSSIL ENERGY IN THE FOREST SECTOR:

The use of fossil energy sources in the forest industry's processes has decreased further

Long-term successful efforts to replace fossil energy sources in the forest industry's in-house processes mean that fossil energy now comprises just 4 per cent of the fuels used. Therefore, the remaining measures required to achieve completely fossil free energy use must be dealt with by the individual companies. The overall objective for the sector, according to earlier set goals, is that the processes should be completely free of fossil fuels in the long term.

Non-Road Mobile Machinery in forestry and the forest industry uses no fossil fuels

In purely technical terms, this target can be achieved by 2030. There are already good experiences of electrifying Non-Road Mobile Machinery at various industrial plants and of using biodiesel in the form of HVO (Hydrotreated Vegetable Oil) in forest machinery. If this target is to be achieved, it is however crucial that there is enough biofuel available, and that the costs and tax regulations do not counteract the transition.

Fossil emissions from the forest sector's domestic transport have decreased

Swedish Parliament's climate goal means that fossil emissions from domestic transportation has decreased by at least 70 per cent in 2030 compared to 2010. The goal relates to all modes of transport apart from air, i.e. private cars, buses and light and heavy goods vehicles,



shipping and rail. Reducing transport-related emissions is a challenge for society as a whole, since it calls for the transformation of the entire transport sector.

The forest sector is one of Sweden's biggest purchasers of transport services, and the vast majority of domestic transportation takes place by lorry and railway. The forest sector is also cost sensitive when it comes to transport, and heavily reliant on cost-effective transportation in all modes of transport. The forest sector's goal of re-

ducing its transport-related emissions is a contributor in achieving Parliament's goal.

Various measures need to be taken to ensure that the forest sector can reduce transport-related emissions in line with the parliamentary decision. This applies to regulations that enable efficiencies, clear initiatives in electrification, and investments in infrastructure for freight transport. This area is covered further in Chapter 4, Analysis of Obstacles.



Cross laminated timber is a form-strong and lightweight building material that is used as frame in modern high-rise buildings.

4 Analysis of Obstacles

4.1 GROWTH IN THE BIOECONOMY

One precondition for a growing bioeconomy is the possibility to increase extraction of biomass from the forest. Efficiency measures will be taken, meaning that the same volume of raw material can yield a larger quantity of finished products, but the general view is that the industry will increase its raw material demand. This is also crucial to keep in mind when calculating the potential for bioenergy from the forest sector, since biomass for energy is only produced when the traditional forest industry has a demand for raw material in the form of stemwood. Virtually all the energy from the forest and forest industry today comes from side-streams in the forest sector. When the industry produces products with high value added, side-streams can be utilised for e.g. energy production, and this jointly brings great climate benefits. Producing only energy products from forest raw material would demand considerably higher prices for such products as well as lower felling and logistics costs, since felling purely for energy purposes is neither economically nor environmentally sustainable. It is therefore more effective to continue striving for efficiency and new technology in the industry, which can then offer even more side-streams than at present, flows which can be used for energy production.

Political obstacles

- Lack of a clear political ambition to create the right conditions for a growing bioeconomy with biobased products of high value added.
- Uncertainties regarding taxes, fees and general conditions for the production and sale of bioenergy, biofuels and other biobased products.
- Long and resource consuming environmental permit processes for developing existing production, and on establishing the manufacture of new biobased products.
- Uncertainties as regards attitudes towards forest management, and whether long-term, growth-promoting conditions for active and sustainable forest management will be in place.

Technical obstacles

- New techniques for more efficient production of existing and new products need to be further developed.
- Technology for producing biofuels needs to be further developed for efficient domestic production, both in relation to imported biofuels and fossil fuels.
- New plus evolved technical solutions for more efficient, gentle harvesting and transportation of forest raw material out of the forest.
- Continued development of reliable digital solutions for efficient logistical chains, information flows and horizontal collaborations.

Economic obstacles

- Few business operators are prepared to take a financial, political and technical risk for large-scale investment in the production of biofuels. The forest industries have an objective to increase the production of traditional and new products by 2050. There is potential to produce more fuels, but there are few business operators who are individually prepared to take a large risk for such an investment.
- High costs for converting production and sales when changing from one product type to another.
- Generally high costs for producing bioenergy and biofuels compared to fossil alternatives.
- High costs for transporting bioenergy from the forest.
- When making investment decisions, the choice is between producing new products, and developing existing products. Investment funds are limited and will be spent on whatever brings the highest return.

4.2 PHASING OUT FOSSIL ENERGY

The phasing out of fossil energy in Non-road Mobile Machinery will primarily be possible by electrifying the machinery in industry, and by using biofuels in machinery in the forest. This means that the obstacles to phasing out fossil energy in Non-road Mobile Machinery are much the same as for phasing out fossil energy in the transport sector.

The Swedish climate policy goal of reducing emissions from the transport sector by 70 per cent by 2030 is a challenge. Such a reduction requires transformation of the whole of society. The forest industries are primarily transport purchasers, and companies in the sector will be dependent on society clearly backing the transformation to a fossil free society. It is also crucial that representatives of each mode of transport invest and take measures to achieve fossil free transportation. For the forest sector, it is crucial that the measures taken to reduce emissions from the transport sector do not lead to an increase in overall transport costs, since this will have an adverse impact on competitiveness. This in turn will reduce the possibility to extract biomass from the forest for products and energy.

Phasing out fossil energy from forest industry transport requires measures in three main areas: efficiency, electrification and biofuels. Of these, the efficiency measures are the most important as they can be taken immediately and have a positive impact both on reducing emissions and on the companies' competitiveness. Electrification and the increased use of biofuels are also important but are to some extent more difficult and involve more far-reaching measures.

Political obstacles

- Proposals for a road-wear tax and already approved indexation of fuel tax put together, mean increasing transport costs.
- Freight and freight transport generally have low priority in transport and infrastructure policy.
- Socioeconomic calculations undervalue the transportation of freight.
- Efficiencies from a decision on roads for heavier trucks will not have their full effect until the entire road network has been opened to 74-tonne vehicles.

- A lack of regulations promoting transport efficiency with longer vehicles on the road, and longer and heavier rolling stock on the railways.
- A lack of investment in electric roads.

Technical obstacles

- Too low a percentage of electrically powered private cars and light lorries.
- The development of electric roads is proceeding too slowly.
- The development of electrically powered heavy vehicles is proceeding too slowly.
- The development of fossil free Non-road Mobile Machinery, electricity or gas, for industrial operations is proceeding too slowly.

Economic obstacles

- Access to biofuels (see also 4.1.2 on the production of biofuels).
- Fossil free alternatives are more expensive to purchase and manufacture.

4.3 WHAT IS NEEDED TO IMPLEMENT THE ROADMAP?

If the forest sector is to meet the roadmap's vision and targets, action is needed in many areas. Below we highlight the ones we feel are most important and where policies need to contribute.

- **A clear political desire to create a biobased society**

A growing bioeconomy needs increased production of forest sector products, bioenergy and biofuels. The policies must create the right conditions for this, partly by removing the uncertainty felt by the industry regarding policy and attitudes towards forest management, taxes and fees linked to biobased products, transportation and so on. Increased state funding for research and innovation is also needed, matching that of the industry's own investments as a minimum.

- **Competitive conditions for the forest sector**

The forest sector operates on a global market. This places high demands on competitive conditions

for e.g. electricity costs, permit applications, the investment climate, and tax and fee pressure, in line with the conditions for international competitors.

- **Reliable access to biomass from sustainable forest management**

If the forest sector is to contribute to a fossil free Sweden, there must be good, reliable access to biomass from the forest. The ability to conduct efficient, sustainable forest management is crucial. The industry will demand a higher amount of raw materials in order to increase its current production of wood products, cardboard, paper and pulp. This is a precondition for also achieving increased side-streams for energy, fuels and new biobased products. It is important that means of control and subsidies that distort competition or govern the use of the raw material are not introduced.

- **Increase focus on freight transportation**

Freight and freight transport must also be made more of a priority when investing in infrastructure. Infrastructure investments based on the needs of industry are pivotal. For example, more initiatives are needed for transfer of goods to other modes of transport; many Swedish Forest Industries Federation member companies want to and can transfer more goods to railways and shipping, provided the Swedish Transport Administration deals with bottlenecks and other obstacles. The measures outlined in the National Freight Transport Strategy need to be implemented.

- **Making transport more efficient**

Efficiencies can be achieved for instance by permitting trains and lorries that are heavier and longer. A first step in the near future is to ensure that the entire road network is adapted for lorries with a maximum weight of 74 tonnes. The potential for efficiencies by harnessing digital opportunities, for example horizontal collaborations, will increase if government authorities push for digitalisation in transport and infrastructure.

- **Electrification**

Increased electrification in road transport can be achieved for instance through battery power in

small lorries and passenger transport. Larger roads such as the European highways, which have a lot of heavy traffic, or shorter stretches with a lot of shuttle traffic, should also be electrified.

- **Continued investments in research and innovation**

Investments in research and innovation from the government and private sector must be further intensified. This is crucial to enable development towards a growing biobased economy. Research should be focused on the areas presented in the Swedish Forest-based Sector Research Agenda 4.0.



5 The Current Situation

5.1 THE SWEDISH FOREST SECTOR

The Swedish forest sector is comprised of companies engaged in forest management and in forest industry. It is a smoothly functioning sector based on responsible, sustainable forest management, functional, efficient logistical chains, and competitive, energy-efficient production plants. Global demand for forest industry products is growing, and today's products can also be further developed and supplemented with new products and materials that can not only replace today's fossil based products, but also meet needs in new areas of use. The potential for the Swedish forest sector to develop and grow is good.

Half of Sweden's forest land is owned by around 330,000 private owners as individuals or families. A quarter of the forest land is owned by private limited companies, and one quarter by the state and other public and private owners. The Swedish forest industry is comprised of companies in pulp and paper production, sawmills as well as bioenergy companies. Some of the forest industry companies are also owners of forest land, others are not. The sector also includes companies with close business links to pulp, paper or wood product manufacturing.

The forest industry accounts for one-tenth of employment, exports, turnover and added value in Swedish industry overall. The forest sector's direct and indirect added value was equivalent to around SEK 112 billion in 2015. The forest sector employs some 120,000 people in Sweden, both directly and indirectly. In several counties, the forest industry is responsible for 20 per cent or more of industrial employment. The Swedish forest industry is strongly focused on exports, with an export value of SEK 132 billion in 2017. Since the source for raw material is largely domestic and there is relatively limited import of forest industry products, the sector is a major contributor to Sweden's trade balance.

The majority, around 80 per cent, of Swedish forest industry production is exported and sold on an international market, with global pricing. On these markets,

and in Sweden as well, the forest industry companies encounter competition from forest industry products made in other countries, as well as products made from other materials. On the marketing side, high environmental performance, such as low climate impact, is often an advantage.

Swedish forest industry products have long had a very low carbon footprint thanks to well-established fossil free electricity production in Sweden (hydro power, nuclear power, biopower and wind power), and thanks to efforts made in the industry to replace fossil fuels with biofuels. To the extent that low climate impact is an advantage on the market, this is therefore something that companies in the Swedish forest industry already benefit from.

5.2 ENERGY USE

The description of the current situation with regard to energy use encompasses the forest sector's domestic transport, Non-road Mobile Machinery in industry and in the forest, as well as industrial processes at pulp and paper mills and sawmills in Sweden.

The forest sector's domestic transport

For the sector's vision »the forest sector drives growth in the global bioeconomy» to be realised, access to cost-effective transportation for the sector's raw materials and finished products is a pre-requisite. The forest industry purchases transport worth approximately SEK 25 billion annually and is reliant on all modes of transport. For the forest sector, the optimum transport solution is often a combination of several modes. The sector is therefore dependent on efficient, well-developed transportation by lorry, train and ship.

The sector is highly cost sensitive when it comes to transport, and costs for transport and logistics are a vital part of the product value. Case studies show that transport costs for a sawmill can be nearly 20 per cent of the product value. Cost-effective transportation is therefore crucial to the companies' competitiveness. Working for more rational transportation is a constantly ongoing process that fits in very well with the sector's climate

change mitigation, since more efficient transport leads to lower emissions per transported unit.

The forest sector's total domestic transportation (amount of goods moved) is currently about 41 per cent by rail, about 57 per cent by lorry, and around 2 per cent by shipping. The average transport distance per load for domestic transport is 322 km for rail, 99 km for lorry and 275 km for shipping. The current energy use in the forest industry's road transportation has been estimated at around 5 TWh annually.

Lorry

For transportation of raw material, a lorry is always needed for the initial part of transport, and truck is therefore the predominant means of transport for raw materials. To streamline and minimise this transport, the sector has for a long time been working to optimise individual transports, routes and flows. Thanks to a well-developed collaboration system for exchange of raw material between forest industry companies, the raw material is transported to the closest plant that can use it, regardless of who owns the plant.

Several research initiatives for heavier and longer vehicles show that emissions can be reduced significantly by using fewer and more efficient transport runs without increasing road wear. A decision to permit vehicles of up

to 74 tonnes has been made, and the first road network for these vehicles was opened during the summer of 2018.

Rail

The forest industry buys more rail transport than any other sector in Sweden. The trains are primarily used to transport wood and paper products to the continent but also domestic raw material and other transportation. Rail is the mode of transport that produces the lowest emissions of carbon dioxide, and the sector has the ambition to increase the share of freight transported by rail. The forest industry has developed its transport systems for raw material on the railway, for instance by investing in new terminals. Rail transportation plays a key role for the sector and is an integral part of production and further refinement. For the forest industry's roundwood (raw material), rail transport often takes place in a westerly-easterly direction to plants along the coast, and also from south to north. Traditionally speaking, rail is the preferred option when transporting large volumes long distances, which combined with the environmental benefits gives the railway its main competitive advantages.

Shipping

When exporting the forest industry's finished products, shipping is the most important mode of transport. For

PERCENTAGE DISTRIBUTION OF TONNE-KILOMETRES

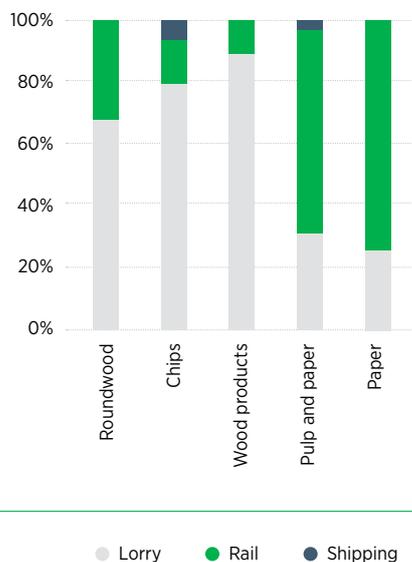


Figure 3: Percentage distribution of transport work between different modes of transport and by product (tonne-kilometres)

domestic transport, shipping accounts for 2 per cent and is used mainly for fuel deliveries to heating plants. When there is an imbalance regarding raw material within Sweden, shipping is sometimes used to transport roundwood and pulp.

THE FOREST SECTOR'S NON-ROAD MOBILE MACHINERY

Non-road Mobile Machinery in forest management

In forest management, Non-road Mobile Machinery is used to fell and cut trees into shorter lengths, for terrain transport of the logs to the road (forwarding), for scarification, and to chip forest fuel. The machines must be mobile and be able to move over big areas. The number of machines is relatively limited, and they are used in shifts, which means they are used intensively and that the rate of exchange is high.

Operational work in the forests is largely carried out by contractors. There is an ongoing endeavour to reduce fuel use, and there are ongoing efforts to monitor fuel consumption. According to statistics from the Swedish Energy Agency^{xx}, fossil energy use in machines for logging and forwarding in 2016 amounted to approximately 1.6 TWh.

Non-road Mobile Machinery in forest management is only used in outdoor environments and has to work in both high and very low outdoor temperatures. They are used in areas which, geographically, are far away from the standard fuel supply infrastructure, which means that a system of internal logistics has been developed to supply the machines with fuel. Biofuel can be used in

forest management's Non-road Mobile Machinery. Technological development of this machinery could to some extent be limited for these types of machines by the fact that the world market is very niched. All in all, around 3,500–4,000 forest machines are produced every year by ten or so manufacturers, Komatsu and Rottne being two major Swedish suppliers^{xxi}. In Sweden, between 300 and 350 new forwarders are registered every year, and deliveries of new harvesters are roughly of the same level. These figures can be compared to tractors and excavators, which number in the hundreds of thousands.

Non-road Mobile Machinery in industry

Several types of Non-road Mobile Machinery are used in forest industry, primarily trucks and wheel loaders. The Non-road Mobile Machinery is largely restricted to a limited area. This means that the environment for the machines can often be controlled. Another characteristic of Non-road Mobile Machinery used in industry is that it is stationary, i.e. it usually spends the majority of its lifespan in the same place.

Unlike the Non-Road Mobile Machinery used in forest management, there are technical solutions for electrification of some of the industrial machines. This may be a way of achieving fossil free machinery. Non-road Mobile Machinery in industry can also be run on biofuel to a greater extent than at present. According to statistics from the Swedish Energy Agency, fossil energy use in 2016 totalled 0.3 TWh in the Non-road Mobile Machinery of companies in the forest industry^{xxii}.

The forest sector's industrial processes

Production of paper and pulp consumes a lot of electricity. Energy consumption accounts for a large part of

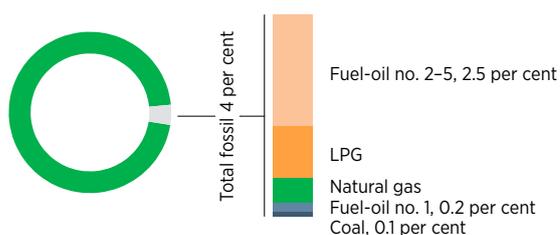


Figure 4: Fuel consumption by type of fuel in the pulp and paper industry and paper products industry, as well as printing and other repro industry, 2016.

Source: Statistics Sweden

the industry's costs, which is why energy efficiency is a constantly ongoing process in the industry. By using residual energy and side-streams in its own processes, the industry has vastly reduced its dependence on fossil energy.

In 2015, the Swedish Forest Industries Federation set a long-term target of making its processes totally free from fossil fuels. In 2016 the sawmills were virtually fossil free, and 96 per cent of fuel use in the pulp and paper industry was generated from biofuels. Pulp and paper mills together with sawmills use approximately 21 TWh of electricity annually, which equates to just over 15 per cent of all electricity use in Sweden.

The forest industry currently self-generates around 40 per cent of the electricity used in the processes, and this is fossil free. In addition, there is electricity from wind power on company owned forest land as well as hydro-power generation owned by forest industry companies. The electricity is primarily used internally but can also be delivered to the power grid.

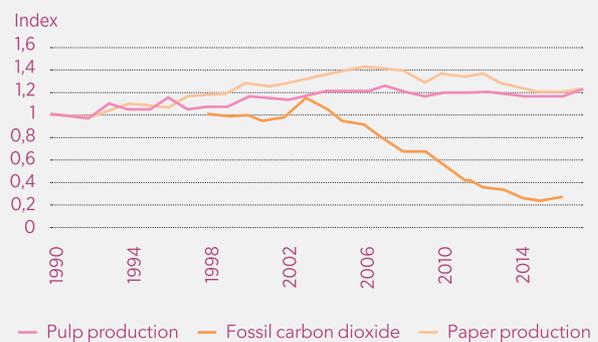
The small amount of remaining fossil energy in the forest industry is used in the lime kilns of pulp mills, and a minor amount in paper production. In recent years, several mills have invested in measures to enable the use of pellets and other biofuels rather than fossil oil in the lime kilns. A small amount of fossil energy is also used for starting up boilers at the mills



HISTORY-THE FOREST INDUSTRY'S ENERGY EFFICIENCY AND ENVIRONMENTAL WORK

DURING THE second half of the 20th century, the Swedish forest industry carried out comprehensive work in the fields of energy efficiency and the environment. Greenhouse gas emissions from the forest industry equate to around 1 per cent of all emissions in Sweden. The graph below shows the reduction in fossil carbon dioxide emissions from Swedish pulp and paper mills in relation to the increase in production between 1990 and 2015.

Figure 5: Fossil carbon dioxide emissions from Swedish pulp and paper mills in relation to production



5.3 BIOENERGY

The forest industry is Sweden's largest user of bioenergy, and companies have come a long way in their efforts to replace oil and other fossil energy sources in internal processes. The forest industry is also the biggest supplier of biofuels to society. There are significant amounts of bioenergy delivered to other areas of society, such as district heating, different types of forest fuels for heating plants, as well as biofuels.

The flow of bioenergy from the forest to the forest industry and the rest of society is a complex system, and energy deliveries to society are affected by harvesting volumes and the industry's production rates. Raw material from the forest is transported to forest industrial plants, where it is refined into different products. Residues arise in the sawmills in the form of e.g. bark, chips and shavings. The chips are used as a raw material in pulp mills, while bark and shavings become bioenergy. In chemical pulp mills, forest raw material is processed and divided

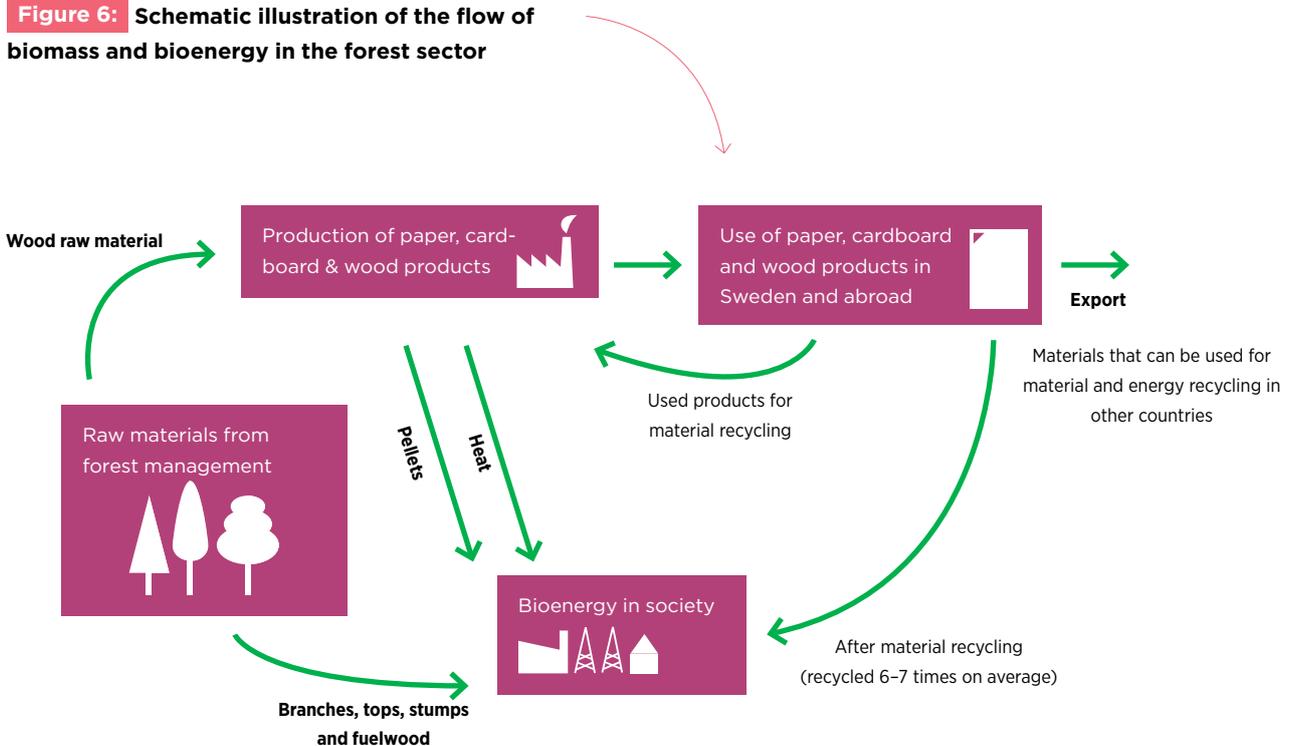
so that the cellulose is used for pulp production and the remaining parts of the raw material become energy for internal processes. Electricity, heating and bioenergy are also produced for the rest of society. When the forest sector's products are exported, climate benefits are also exported thanks to substitution effects, and because materials and energy can be recycled in other countries. The increased forest growth and harvesting that have taken place since the early 20th century has been used for higher production rates in the forest industry. The product mix in the industry has changed, but the growth and the greater harvesting potential have enabled industrial development and expansion. Major investments in the industry in recent years entail an industry that continues to grow, and this in turn calls for increased growth in the forests. In parallel with growing industrial production, the sector has been able to provide society/the heating sector with raw materials in the form of branches, tops, bark, pellets and residual heat.

5.4 GROWTH AND HARVESTING

The forest absorbs carbon dioxide as it grows. Therefore, the forest acts as a carbon sink. The larger the growth, the more carbon dioxide is absorbed. As the forest gets older growth decreases, and the risk of damage due to storms and insect infestations, for example, increases. Since the beginning of the 20th century, the volume of standing trees, annual harvesting and annual growth in Sweden's forests have almost doubled. This is thanks to better forest management and improved plant material.

According to Riksskogstaxeringen (official statistics on Sweden's forests), growth is currently 121 million forest cubic metres a year^{xxiv}. Annual harvesting is about 90 million forest cubic metres a year, which means that less forest is felled every year than grows. This means that the standing volume is constantly increasing. The reason that not all growth is harvested is that some of the growth takes place in areas exempted from forest management, such as nature reserves, where forest management is not carried out.

Figure 6: Schematic illustration of the flow of biomass and bioenergy in the forest sector



Swedish Forest Agency analyses show that with current forest management and current climate change, growth will continue to increase gradually over the next 100 years^{xxv}.

In the short term it might be good for the climate to leave the forest to only grow and not harvest, and thereby let carbon stocks increase. This is, however, only possible to a certain extent. When the forest grows older, net growth decreases. Trees die and biodegrade, and carbon dioxide is released back into the atmosphere. In a very old forest, the absorption and release of carbon dioxide are roughly equal. A forest which is no longer growing does not yield any further climate benefits. If we stop managing the forests, we must also ask ourselves what materials we will use instead of paper, wood and biofuels. If the answer is plastic, oil, coal and concrete, then the climate loses.

So, in the longer term, it is better for the climate to actively manage and use the forest. The more forest that grows, the more carbon is sequestered, and more wood can be used for substitution. A managed forest landscape contains both harvested areas that release carbon dioxide, and growing forest that absorbs carbon dioxide. As long as growth is higher than harvesting the growing stock expands, while also producing a substitution effect. By harvesting trees with decreased growth and replacing them with new trees, the high rate of growth can be maintained. This means that harvesting trees is a way of ensuring high growth.

Swedish forest policy equates production targets with targets on preserving biodiversity. This lays a good foundation for a sustainable forest sector. It is important that the forest sector, alongside government agencies and non-profit organisations, reach a consensus on goals related to our forests, and how to achieve positive environmental consideration.

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