Natural resources and bioeconomy studies 15/2024

2035 Vision: Doubling the Value Added of Finland´s Forest sector

Jussi Lintunen, Johanna Kohl, Johanna Buchert, Antti Asikainen, Tuula Jyske, Jyri Maunuksela and Jani Lehto

Luke
NATURAL RESOURCES
INSTITUTE FINLAND

Natural resources and bioeconomy studies 15/2024

2035 Vision: Doubling the Value Added of Finland´s Forest sector

Jussi Lintunen, Johanna Kohl, Johanna Buchert, Antti Asikainen, Tuula Jyske, Jyri Maunuksela and Jani Lehto

Natural Resources Institute Finland, Helsinki 2024

Referencing instructions:

Lintunen, J., Kohl, J., Buchert, J., Asikainen, A., Jyske, T., Maunuksela, J. & Lehto, J. 2024. 2035 Vision: Doubling the Value Added of Finland´s Forest sector. Natural resources and bioeconomy studies 15/2024. Natural Resources Institute Finland, Helsinki. 21 p.

NATURAL RESOURCES
INSTITUTE FINLAND

ISBN 978-952-380-620-7 (Online)
ISSN 2342-7639 (Online)
URN http://urn.fi/URN:ISBN:978-952-380-881-2

Publisher: Natural Resources Institute Finland (Luke), Helsinki. 2024
Year of the publication: 2024

Authors: Jussi Lintunen, Johanna Kohl, Johanna Buchert, Antti Asikainen, Tuula Jyske, Jyri Maunuksela and Jani Lehto
Cover picture: Erkki Oksanen
Graphics: Jouni Hyvärinen
Layout: Saara Pönkkö

Foreword

The forest sector has always been an important industry in Finland, and we believe it will continue to be so in the future. However, the value added to the national economy per cubic meter of processed wood produced by the forest sector has decreased since the golden age of paper. The Finnish bioeconomy strategy has set ambitious goals for increasing the value added of bio-based products.

With this discussion opener, we want to consider doubling the value added of the forest sector and calculate the significance of the bioeconomy strategy's goals for the forest sector. In Finland and other Nordic countries, there is active and high-quality R&D activity related to the refining of forest biomass. However, the challenge is to ensure the formation of industrial activity and longer value chains in Finland.

We invite decision-makers, industry, financiers, and the research world to consider how this would be done. We thank numerous partners for enlightening discussions. In particular, we thank Pia Qvintus, Lauri Pehu-Lehto, Matti Mikkola, Heikki Vuorikoski, Katariina Kemppainen, Kirsi Mikkonen, and Jaakko Paju for their valuable views. Thanks also to Petri Kilpeläinen, Jouni Hyvärinen, Miitta Eronen, John Kettle and Saara Pönkkö for their active contribution to the preparation of the discussion opener.

The original paper was published in 2023 (http://urn.fi/URN:ISBN:978-952-380-620-7) in Finnish, and this is a direct translation of that paper. The additions to this version of the paper are clearly marked.

Johanna Buchert, CEO, Natural Resources Institute Finland (Luke)

Image: Erkki Oksanen

Summary

The forest sector plays a significant role in Finland's national economy. Finland and other Nordic countries have very high-quality forest sector research and innovation activities. Finland's bioeconomy strategy has set the goal of doubling the value added of the bioeconomy. In this discussion paper, we examine the opportunity to achieve of the objectives of Finland's bioeconomy strategy in terms of increasing the value added of the forest sector.

The forest sector's research has created and is creating highly potential wood biomass innovations on an industrial scale. At the moment, the value added of Finland's forest bioeconomy is created at the beginning of the value chain. To advance our position in this chain, also national investments are needed.

In this study, we focus on the value added of pulp fiber, the mechanical wood product industry, and the further processing of their by-products. We present two scenarios in which the forest sector achieves the €50 billion value added target set in the Finnish bioeconomy strategy by 2035 for its part.

This study concentrates on economic variables, factors such as biodiversity or carbon sink impacts, which play a crucial role in the real world future prospects and targeting of measures in the forest sector, are not assessed.

For the pulp industry, we examine the conversion of pulp fiber into textile fiber and the further processing of lignin, extracted as a by-product of cooking, into a concrete plasticizer. We also examine the growing production of new types of packaging materials that replace plastics. These products were selected as examples for our review because sufficient information was available for value added calculations. Our review shows that significant value appreciation can already be achieved by refining pulp into textile fiber, but there would be much greater potential in moving further up the value chain to textile materials and consumer products. There is great potential in further processing the by-product lignin, and in this work we assume it is utilized as a concrete plasticizer with relatively high value added, although volumes are small. It should be noted that lignin already has very high end-use potential in for example battery materials, but there was insufficient information available for value added calculations.

For the mechanical wood product industry, we anticipate that the proportion of further processed sawn timber products would increase relative to traditional sawn timber. This implies that emergence of a technologically advanced CLT and other wood product value-added ecosystem would emerge in Finland. For sawdust, a by-product from sawmilling, we assume it is used to produce carbohydrate-based emulsifiers, which have relatively high value, although volumes are small.

Significant domestic value addition of bioproducts would require potentially tens of billions of euros of investment from industry. Despite national product development, industrial-scale production investments will not automatically be allocated to Finland. It is a "billion euro question" how Finland can become a more competitive and attractive destination for corporate investments. Companies base their investment decisions on their own criteria, but the public sector and the country's industrial policy can influence these decisions. Is Finland an appealing enough for companies producing, for example textile fibers or other high value-added products? Do we have competitive industrial ecosystems that would encourage investments here?

Advancing up the value chain would require investment in expertise enhancement, experimental environments, and scaling up. Success would also require increased R&D efforts, investments and renewed training. Automation and digitalization can be keys to improving productivity.

Finland has the potential to significantly increase forest-based value added. There is hope, but the question remains: can we create a positive enough operating environment that both domestic and international companies are willing to invest in Finland?

Content

1 Operating environment is changing

1.1 Towards green transition

The role of the forest sector is central from the perspective of our country's economy, security of supply and the longer-term green transition. Geopolitical tensions and the tightening of the security environment as well as the depletion of natural resources can lead to new kinds of conflicts and emphasize the importance of self-sufficiency and security of supply in forest policy. The transition of the forest sector is linked to the sustainability transition[1] and the goal of reducing dependence on fossil raw materials. The frameworks for sustainability in the forest sector are not detached from global megatrends and transitions across sectoral boundaries[2] [3] (Figure 1). The increasing material use of the bioeconomy and the substitution of fossil economy products with bio-based ones, the requirements to maintain and increase carbon sinks, and halting biodiversity loss require reconciliation. From the perspective of the national economy and security of supply, the use of forests for high value-added products should be increased. At the same time, however, climate change and biodiversity loss and related policy measures set restrictions on increasing the use of forests.

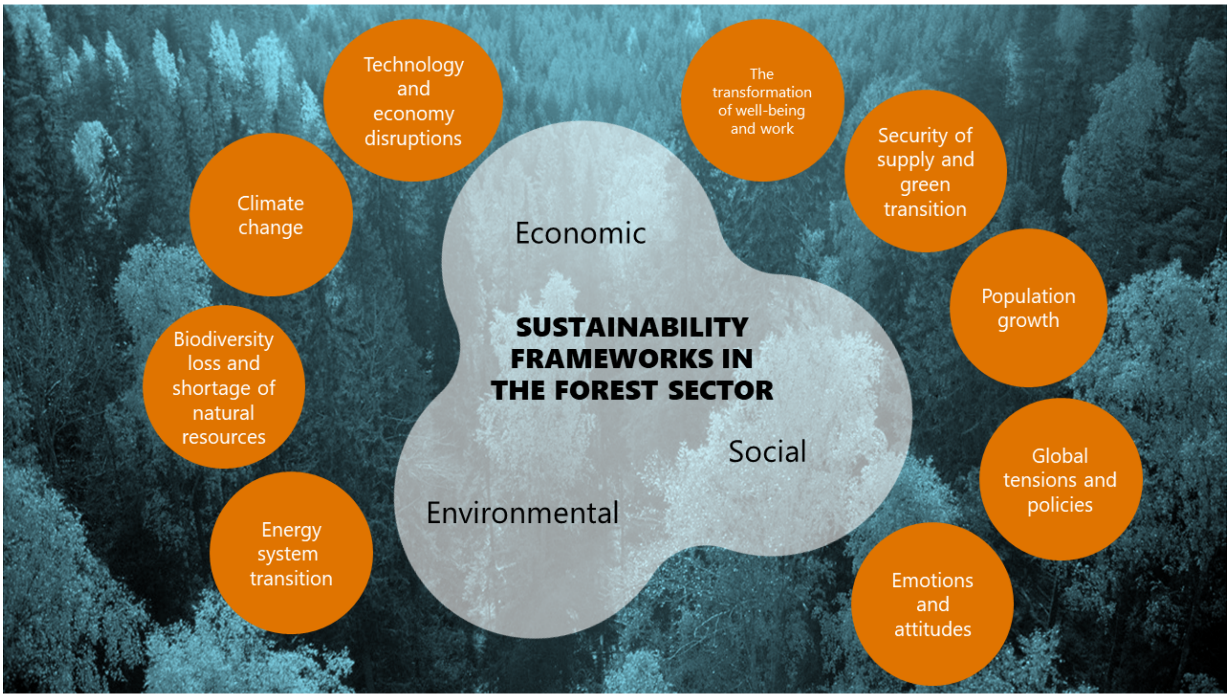


Figure 1. The forest sector is not detached from global megatrends and transformations.

With less and optimized use of bio-based raw materials, more high value-added products should be obtained and dependence on fossil raw materials reduced. This means extending and also expanding value chains, further processing of by-products, and even forming completely new types of industrial ecosystems. The circular bioeconomy and digitalization can, at best, accelerate the formation of regional raw material flows and value chains[4].

1 Vehmasto, et al. 2022. Frameworks for Sustainability – Natural Resources Research in the Sustainability Transition: Synthesis Report. (In Finnish). http://urn.fi/URN:ISBN:978-952-380-502-6
2 Kärkkäinen et al. 2022. Background study for the preparation of the National Forest Strategy 2035 – Scenario-based review. (In Finnish). http://urn.fi/URN:ISBN:978-952-380-474-6
3 Megatrends 2023. Sitra. https://www.sitra.fi/en/publications/megatrends-2023/
4 Jyske, T., Rasa, K., Korkalo, P. ja Kohl, J. (eds.) 2023. Cascade vision : Regionally adaptive circular bioeconomy - added value, wellbeing and resource wisdom with cascade processing. http://urn.fi/URN:ISBN:978-952-380-608-5

1.2 Growth for the forest bioeconomy

-- Added text, differs from the original publication-- European forests are pivotal in the green transition: providing the supply of renewable raw materials, preserving biodiversity, and serving as carbon sinks and storages. According to Eurostat data, about 65% of the net annual increment is harvested in the EU. Since 2000, annual roundwood production in the EU has increased by 25% to roughly 500 million m^3/ year. In addition, to secure a stable energy supply in the EU, the demand for wood for energy is increasing. At the same time, the ageing of forests combined with additional forest protection and restoration as well as large scale forest disturbances such as drought, insect outbreaks, and fires, may reduce the area of forest available for wood supply. These changes form the foundation for current and future sustainable forest-based bioeconomy strategies and practices, which must also fulfill broad and diversified range of social and cultural forest values linked to European forests. Not all forest-related policy goals set by the EU can be achieved simultaneously especially in the short term. Therefore decision makers will need to prioritize the uses of forests.

The growth in value added in the forest sector cannot rely solely on the increased use of raw materials. This is because the growth of EU's forests is saturating, while the utilization rate of forests is already high. Furthermore, national and international climate and diversity goals for forests may impose varying degrees of restrictions on increasing wood use.--- Addition ends.

In Finland, the bioeconomy refers to an economy that utilizes renewable biological natural resources in a resource-wise way to produce food, energy, products and services. The national bioeconomy strategy "Sustainably towards higher added value"[5] aims for 4% annual growth in the value added of the bioeconomy[6]. his would almost double the total value added of the bioeconomy by 2035 compared to the 2019 level. At the same time, Finland should be carbon neutral by 2035. The use of forests is challenged by global agreements. The UN Biodiversity Conference reached an agreement to halt biodiversity loss by 2030, giving the world's states 30% protection and restoration targets. The equation is not easy to solve nationally or globally. In addition to techno-economic reviews, this is about responsibility, policy choices and prioritizations as well as a temporally and locally just transition.

Forest is the most important renewable biological natural resource in Finland. The benefits provided by the forest are mainly based on growing and utilizing wood biomass as raw materials, refined products and energy. The ecosystem services provided by the forest are also an important part of the bioeconomy. In addition, forest biotechnology can include the development and production of technologies, applications and services based on the sustainable use of natural resources.

In this discussion paper, we want to especially highlight the entire value chain of wood-based bioeconomy and its role in achieving the objectives of Finland's bioeconomy strategy. The focus of this discussion paper is on wood-based products and related product entities. The growth of the forest bioeconomy should be based on increasing the value of production and, correspondingly, more efficient use of production inputs. A larger share of value added should also be realized in Finland.

5 National Bioeconomy Strategy - Sustainably towards higher added value. 2022. http://urn.fi/URN:ISBN:978-952-383-579-5

6 See also Arasto, A. et al. 2021. Finnish bioeconomy on the global product market in 2035. https://www.vttresearch.com/sites/default/files/2021-02/Bioeconomy-products-2035-whitepaper-VTT-Luke.pdf

The aim of this work is to consider whether, relying especially on the research investments made in the SHOK programs and projects funded by Tekes/Business Finland, we can meet the growth targets set in the national bioeconomy strategy. The work evaluates new forest-based bioproducts, their production volumes and values, and the plant investments needed to increase value added. A product portfolio was selected for the work that allowed estimating production volumes and production value added based on available data. The figures and estimates presented in this work are very rough and should be seen as indicative of direction and order of magnitude, as their industrial production does not yet exist to any significant extent. However, we want to open up a discussion on what achieving high value added could require from us and what order of magnitude we are talking about. It should be noted that this discussion paper focuses solely on considering economic variables, and issues related to biodiversity or carbon sinks have been excluded from the review. In reality, these variables are key influencing variables for the future.

Finland has strong research on wood-based bioeconomy. Examples of this are entities focused on close cooperation between companies and research institutes. The Forestcluster FIBIC Ltd. operated in 2008-2011 and had, for example, the national Fubio cellulose program of stakeholders. The Design Driven World of Cellulose (DWoC) project was a strategic initiative by VTT funded by Tekes in 2013-2018. FinnCeres, in turn, is a 2018-launched flagship project funded by the Academy of Finland to promote innovative bioeconomy, jointly implemented by Aalto University and VTT.

Individual projects in research institutes and universities, such as VTT, Luke, Aalto University, University of Helsinki, LUT University, Åbo Akademi University, University of Jyväskylä, and various universities of applied sciences, as well as companies' own R&D have advanced innovative forestry. We have good examples of innovations in the forest industry as well as piloting environments built by research institutes and spin-offs from research. For example, VTT[7] is launching five research investments to support sustainable industrial growth, with the Jyväskylä investment aiming to build a piloting environment for responsible fiber products to significantly reduce the forest industry's energy and water consumption and enable new product innovations.

7 https://www.vttresearch.com/en/news-and-ideas/vtt-launching-5-research-investments-supporting-sustainable-industrial-growth-and

2 Value addition to the bioeconomy and the role of the forest sector

2.1 How did we get here

The value added of the bioeconomy has grown by about 6 billion euros over the past decade (2010-2019) or about 32%[8]. During the review period, the value added of the forest sector grew by 1.4 billion euros or about 20%. The growth in the forest sector has been achieved mainly by increasing production volumes and wood use, which has been reflected in increasing wood harvesting volumes and also the use of imported wood. The value added per cubic meter of pulp and paper has decreased since the turn of the millennium[9]. As a result of the war in Ukraine, the import of wood from Russia has dried up and it has been difficult to find substitute raw material sources. In 2019, the total value added of the forest sector was about 8.5 billion euros[10].

2.2 Target of the forest sector´s value addition to bioeconomy in 2035

The ambitious goal of Finland's bioeconomy strategy is to create sustainable growth and jobs by producing products and services with the highest possible value added. The strategy aims to increase the value added of the bioeconomy from 26 billion euros (2019) to 50 billion euros by 2035. In this work, we assumed that the relative share of the forest sector in value added formation would remain the same in relation to other bioeconomy sectors. In that case, the target state for the forest sector's value added in 2035 would be about 17 billion euros (Figure 2).

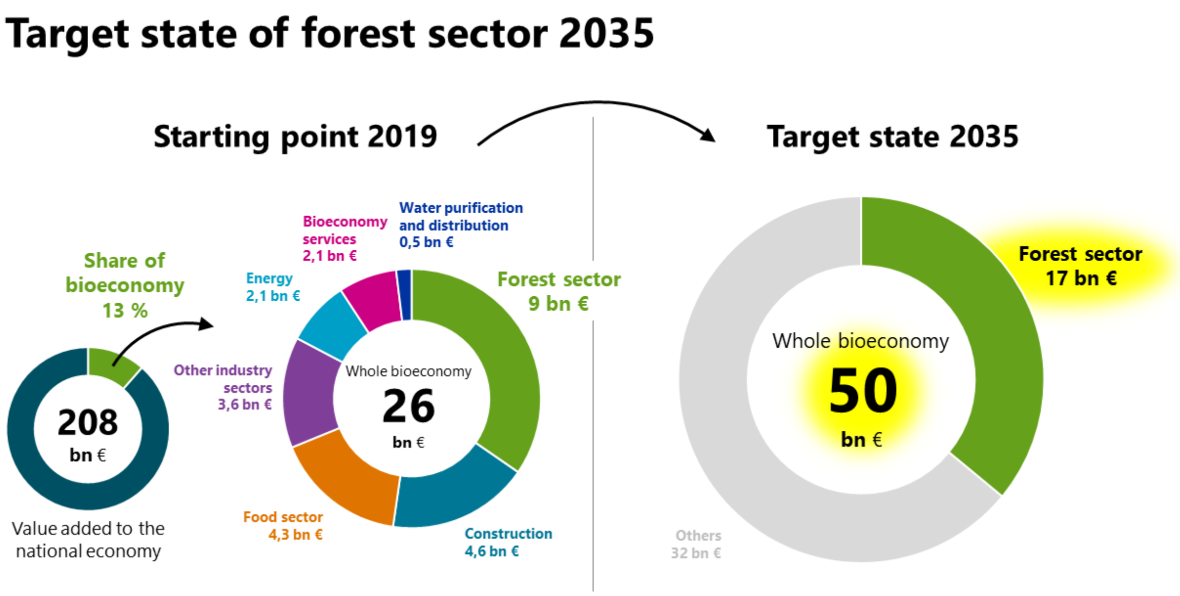


Figure 2. The bioeconomy strategy's target state for 2035 and the share of the forest sector

8 https://www.luke.fi/en/statistics/indicators/bioeconomy-innumbers
9 Finnish Statistical Yearbook of Forestry 2021 http://urn.fi/URN:ISBN:978-952-380-325-1
10 https://www.luke.fi/en/statistics/indicators/bioeconomy-innumbers

The innovation potential of new products currently lies mainly in pulp, lignin and by-product streams. It is also possible to create added value based on the mechanical wood product industry and its by-product streams. In addition to these, there is still demand for traditional paper and cardboard products. Currently, cardboard has become the most important export product of the forest industry (Luke 2022[11]).

In simple terms, harvested wood is further processed through the mechanical or chemical forest industry or utilized for energy production, resulting in fiber products, wood products or energy. A significant proportion of wood biomass is utilized for energy production through by-product streams from the forest industry's own processes or through direct combustion. In addition, part of the fiber and timber ends up in energy production or releases carbon dioxide in biological processes after use.

The formation of value added in the forest sector is illustrated in more detail in Figure 3. In this review, we assumed that the 2035 target level of 17 billion euros in value added for the forest sector would be achieved by tripling the value added of the chemical forest industry compared to 2019. This assumption is supported in particular by the R&D investment made in Finland in innovations in the chemical forest industry. We also assumed that the value added of the wood product industry would double. In the wood product industry, five high value-added products have been identified: planed sawn timber, birch plywood, cross-laminated timber (CLT), laminated veneer lumber (LVL) and glued wood products[12]. Of these, CLT was included in this scenario.

In our view, it is not possible to significantly increase value added in forestry and wood harvesting.

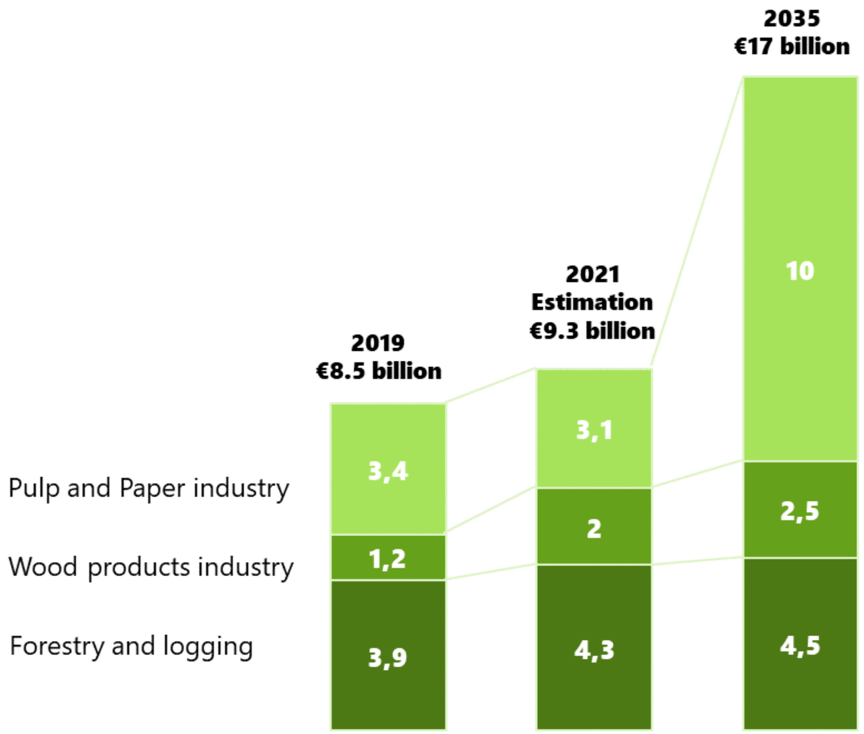


Figure 3. Value added of the forest sector in 2019 and estimate for 2035

11 Paperboard became the most important exported forest industry product. News 4.4.2022 https://www.luke.fi/en/news/paperboard-became-the-most-important-exported-forest-industry-product

12 Viitala, E.-J. & Mutanen, A. 2020. Increasing the processing value of wood products behind hard work. In: Finnish Forest Sector Economic Outlook 2020-2021. (In Finnish). Natural resources and bioeconomy studies 71/2020.

We aimed to achieve a value added of 17 billion euros with the following measures:

1. Diversify and extend the value chains of the chemical forest industry's product portfolio in terms of innovative packaging materials and textile products.
2. Refine 20% of the lignin contained in the black liquor of pulp cooking into a functional process chemical (concrete plasticizer).
3. Further process the products of the sawmill industry into various engineered wood products for construction (CLT and products with corresponding value added).
4. Refine emulsifiers from the by-products of the sawmill industry for use in e.g. the food and cosmetics industries. We assumed that 10% of the hemicellulose from spruce sawdust would be separated for further processing.
5. The use of cardboard is diversified to increasingly replace products such as plastics ("PackagingPlus").
6. The amount of biomass directed to energy production is determined by the chosen processing methods with energy unit prices remaining at the current level.

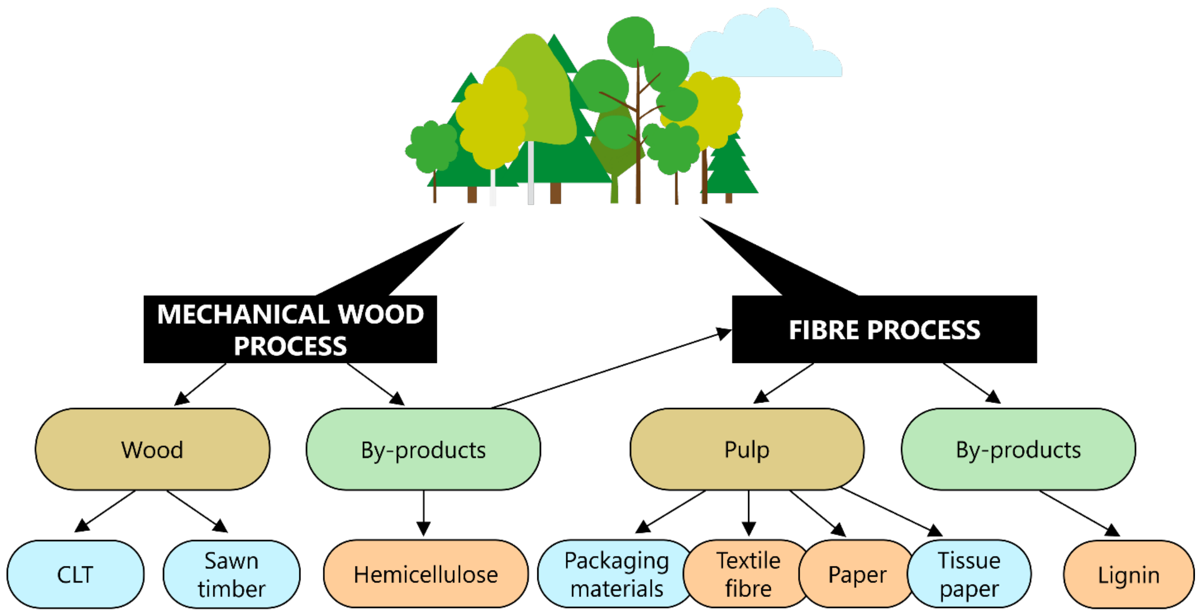
Image: Erkki Oksanen

3 Future production and products

3.1 Starting point for the scenario work

A future scenario is a projection of the future, not a forecast. The realization of a scenario is influenced by several uncertainties, such as technological breakthroughs, changes in business logic, changes in attitudes, policy changes both nationally and internationally, and many other actions and events that cause uncertainty, which were briefly reflected in the description of the operating environment in Chapter 1.1. In this work, the scenario review was carried out using the production process descriptions of our FinFEP sector model[13].

The forest industry has two main value-generating streams, the changes of which are used to examine the future (Figure 4). The wood product industry mechanically processes wood, while the chemical forest industry pulps wood for the production of paper, cardboard and their further processed products. Both processes generate significant amounts of by-products. Depending on the sector, only about 19–57% of the procured wood ends up in end products and 24–56% in by-products[14]. Further processing of by-products into high value-added but low-volume products provides a good addition to the development of the forest sector's value added.



Picture 4. Sectors of the forest industry.

In this work, we examined two scenarios. In the first, the forest industry's wood use remains at the 2019 level (71 million m^3) and the product portfolio was selected so that the forest sector meets the value added target of Finland's bioeconomy strategy in 2035. In the second scenario, the forest industry's wood use decreases by 20% from the 2019 level, but we still kept the bioeconomy strategy's value added target the same. We will refer to these as the base scenario and the lower wood use scenario.

The starting point for the scenarios is the situation in 2019. The value added of the industries forestry and logging (TOL 2008 category 02), wood product manufacturing (16) and pulp and paper manufacturing (17) were 3.9, 1.2 and 3.4 billion euros. The total value added of the forest sector formed by these industries was therefore 8.5 billion euros. The target level for the forest sector's value added in 2035 was thus 17 billion euros.

13 Lintunen, J. ym. 2015. Finnish Forest and Energy Policy Model (FinFEP) – A Model Description. Natural resources and bioeconomy studies 59/2015. https://urn.fi/URN:ISBN:978-952-326-119-8
14 https://www.luke.fi/en/news/82-million-cubic-metres-roundwood-consumption-2019

In the scenarios, the increase in value added was allocated in different proportions to the different industries. Since our main focus is on pulp and paper manufacturing, its target was set at 10 billion euros in value added. Correspondingly, of the increase in value added, 4.5 and 2.5 billion were allocated to forestry and wood product manufacturing. In the scenarios, the increase in value added in forestry is moderate, while in wood product manufacturing the value added doubles and in pulp and paper manufacturing it triples.

In pulp and paper manufacturing, the increase in value added was implemented through expanding the product portfolio with by-product processing and further processing of pulp. The scenario examined extracting lignin from the cooking liquor of pulp and refining it into a concrete plasticizer, manufacturing new advanced packaging boards and processing part of the export pulp into textile fiber. The shift from paper production to cardboard production was also taken into account, which was thought to continue in the future as well.

In the wood product industry, the increase in value added was considered to take place through the further processing of sawn timber and sheet products into e.g. cross-laminated timber (CLT), laminated veneer lumber (LVL) and carpentry products. Of these, only the potential of CLT to increase value added was examined in the scenario. CLT represents here more broadly the value-adding product portfolio of mechanical forest industry, whose market price and required investments for processing are at the same level. In addition, we examined the separation of hemicellulose from spruce sawdust. As the flow of spruce sawdust, and thus the yield of hemicellulose, is relatively small in the biomass flows of the forest industry, the amount of produced hemicellulose remained relatively small (60,000 t).

3.2 Setting up the scenarios

The base scenario consists of a set of assumptions that enable the pulp and paper industry, and thus the entire forest sector, to achieve the value added growth target. With the production shift from paper to pulp in the scenario, paper production was halved and the released pulp was used for cardboard production.

Regarding the actual new products, we made the following assumptions: 20 percent of the cooking liquor lignin was extracted during pulp cooking. This can be considered feasible without disrupting the cooking process. The scenario equipped all pulp cooking taking place in Finland with lignin extraction technology, resulting in just under one million tons of lignin extracted for further processing. In the scenario, all lignin was refined into a concrete plasticizer.

In cardboard production, there is a shift to more advanced packaging boards, which require modifications to cardboard machines. Advanced packaging boards were assumed to have a 50 percent higher price than conventional cardboard. Correspondingly, the energy demand and other manufacturing costs are higher for advanced cardboard. Pulp usage was assumed to remain unchanged. The production volume of advanced packaging board was assumed to be 3 million tons per year.

To achieve the value added target, part of the export pulp was refined into textile fiber in the scenario. There are various kinds of textile fiber production processes, and the scenario examines a whole that covers several processes. Although we estimate the value added of textile fiber to be high per tonne produced, the amount of textile fiber produced still has to be very high (3 million tons) to achieve the value added target, requiring 70 percent of export pulp volume.

In the wood product industry, the possibilities for increasing value added through further processing of sawn timber were assessed. In the scenario, half of the spruce sawn timber produced was directed to further processing into cross-laminated timber (CLT). In the review, CLT represents more broadly the value-adding product portfolio of the mechanical forest industry, whose market price and required investment for processing are at the same level.

Spruce sawdust generated in the wood product industry was directed to an extraction process, where the hemicellulose of the wood was separated from other substances. The spruce sawdust stream and thus also the yield of hemicellulose is relatively small in the biomass streams of the forest industry, which is why the amount of hemicellulose produced remained relatively small (60,000 t).

To achieve the value added target, the scenario also took into account other products of the industrial sectors that were not described here. In the chemical forest industry, these other products are especially pulps used as intermediates, the production of which was assumed to remain unchanged. In the mechanical forest industry, however, the value added of the unmodeled products was assumed to increase. In practice, these products are further processed products of sawn timber and panels, such as carpentry products.

In the lower wood use scenario, production levels were calculated so that the 20% lower roundwood volume (57 million m^3) was sufficient to cover the wood demand of production. In practice, production levels decreased by 20%, except for textile fiber, the production of which is based on the amount of export pulp (which also decreased by 20%). To maximize value added with the lower wood use, all export pulp was used for the production of textile fiber in this scenario. The lower wood use scenario does not account for possible changes in the prices of wood or forest industry products.

The required investment and production costs were estimated very roughly based on investment and stock exchange releases, techno-economic assessments published in literature, and expert assessments. The product values used in the calculations are based on e.g. our views on various fossil products and their prices that these new products are expected to replace. Therefore, it is good to be aware that the numbers used in the calculations, and hence the results obtained, are thus based on the estimates formed by the authors of this work.

3.3 Scenario results

The production volumes, product prices and production trends of the key product groups in the basic scenario are presented in Table 1. It should be noted that the calculation contains very rough assumptions about production costs.

Table 1. Summary table of the base scenario. Trend vs current shows the magnitude of change compared to the current situation. The minus and plus signs indicate direction, i.e., decrease or increase. The number of signs indicates the intensity of the change trend.

Fibre Process	Volume (million. t) or (million. m³)	Current Trend	Prics (€/t) or (€/m³)	Value Addition (million. €)
Paper	3,4	--	725	450
Carton Board	2,2	-	715	350
Value added Packaging	3,1	++	1 270	1 600
Textile fibre	3,1	++++	3 000	5 000
Lignin	0,8	++	1 500	800
Other products		+/-		1 800
Mechanical Wood Process				
Sawn timber	6,9 (not CLT)	+/-	290	660
CLT	5,5	++	600	900
Hemicellulose	0,06	+	2 000	90
Other products		+		850

In order to achieve the set value added target, it was assumed that 70% of export pulp would be used for the production of textile fiber in the basic scenario. This assumption was chosen because the innovations in this value chain have been significant in recent years, and sufficient information was available for value added calculations. Producing textile fibers to this extent generated a value added of 5 billion euros (Table 1 and Figure 5). This corresponds to half of the value added of pulp and paper manufacturing in 2035. Correspondingly, the value chains of advanced packaging board ("PackagingPlus") and concrete plasticizer together produced a value added of 2.4 billion euros. Their production replaced the production of regular cardboard and reduced the burning of lignin for energy. As the amount of hemicellulose extracted from sawdust remained low in terms of volume, its value added remained relatively low at 100 million euros compared to the other value chains examined. However, we believe that the future product portfolio in the forest sector will include both high-volume products and specialty products with very high added value but small production volumes.

For the wood product industry, the situation was examined as an example where half of the spruce sawn timber is processed into CLT boards. The value added from this production was 900 million euros, which alone would cover 70% of the additional need for value added in the wood product industry.

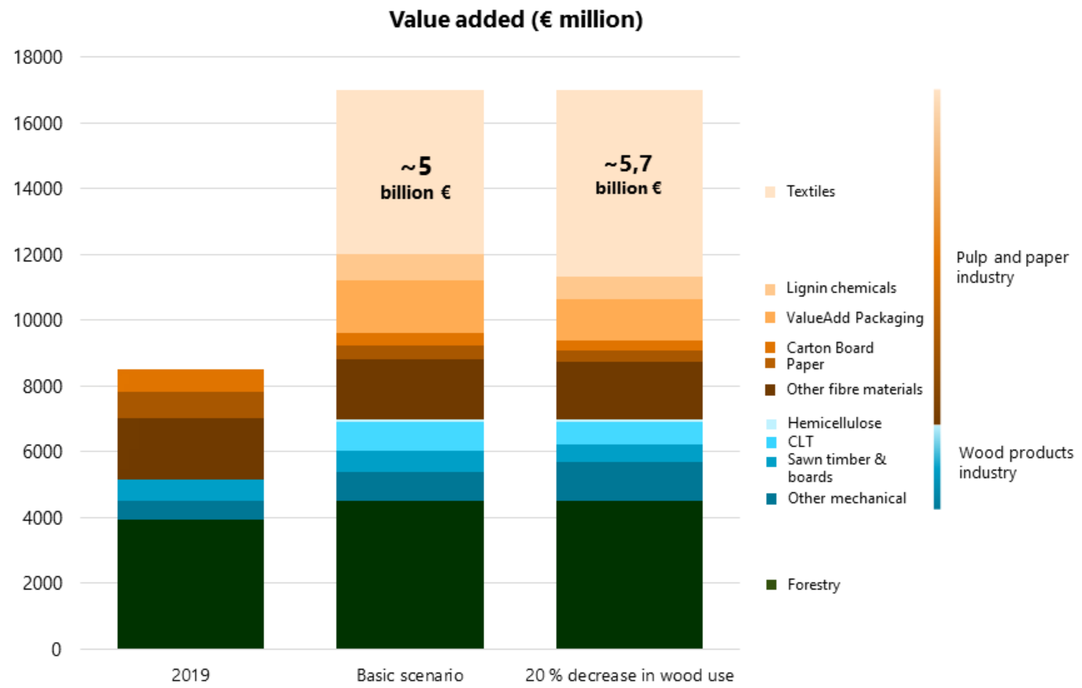


Figure 5. Value added of the forest sector at the starting point (2019) and in the scenarios (Base and Wood -20%).

In the lower wood use scenario, the 20% decrease in wood use was distributed evenly to wood-using production, resulting in a 20% decrease also in production levels based on by-products and wood pulps. Correspondingly, value added from production decreased by the same proportion. The scenario responded to the lowered wood use by increasing the production of textile fibers from export pulp. By using all export pulp for manufacturing textile fiber, 3.5 million tons of textile fiber was obtained, with a value added from this production of 5.7 billion euros. However, this was not quite enough to achieve the 10 billion euro value added target for pulp and paper manufacturing. The target was missed by only 300 million euros. To achieve the target, the value added from other products of the industrial sectors would also have to increase by raising the degree of processing. In the scenario, 60% of the value added of pulp and paper manufacturing comes from the production of textile fibers.

The transition to high value added products can be illustrated by relating the forest industry's value added to the amount of roundwood it uses. In the base scenario, the forest industry's value added was 175 €/m^3 and in the lower wood use scenario 210 €/m^3. In 2019, this ratio was 65 €/m^3 for the forest industry. The change compared to the current situation is thus significant.

Refining a by-product currently ending up in combustion, such as lignin, directly leads to a decrease in energy production. On the other hand, the new wood and pulp products need energy in their production processes. As a result, the energy balance of pulp and paper manufacturing weakens significantly. The sector's electricity balance weakens by 12 TWh and its heat balance by 24 TWh. The changes are significant in relation to the forest industry's electricity (19 TWh) and energy (88 TWh) use in 2019. In this work, we did not examine the impacts of these scenarios on energy in more detail.

The new products examined are still in the development phase and thus only estimates were available on the prices and production costs of their end products. Therefore, the estimates of the value added from producing the products are, at best rough magnitude estimates. For example, if the value added of textile fibers per produced unit turns out to be lower than estimated here, achieving the value added target will be more difficult, and may not even be achievable with the examined product portfolio. In that case, the portfolio needs substitute products with high production volumes and high value added as well as further processing of existing products. In addition, the pressure to increase value added will be partly transferred to other bioeconomy sectors as well, such as services and nature tourism.

3.4 Towards the future

The "What Wood Can Do" map[15] published by the Confederation of European Forest Owners (CEPF) and also translated into Finnish[16] gives an idea of the future potential for the use of wood. In this discussion paper, we only examingives an idea of the future potential for the use of wood. In this discussion paper, we only examined a very limited product portfolio. However, wood biomass can be shaped into very diverse bulk and extremely high value-added products[17]. At best, the forest sector of the future is a combination of high-volume production that is further processed domestically as far as possible, and the production of specialty products formed from the by-product streams of this production. For example, pharmaceutical products bring high value added but their volumes are very small. The industrial use of wood biomass must be optimized to have a balanced product portfolio of high-volume but lower-value products and high-value but lower-volume products. Both product lines support each other.

Developing a diverse product portfolio and industrial ecosystems requires significant research, development and innovation efforts as well as a renewed industrial policy. And very often the consumer is the one making the final choice.

15 https://www.cepi.org/wp-content/uploads/2021/02/What-a-tree-can-do-final_compressed.pdf
16 Image 2 as part of a broader background report: Kärkkäinen, L. et al. 2022. Background study for the preparation of the National Forest Strategy 2035: Scenario-based review. http://urn.fi/URN:ISBN:978-952-380-474-6
17 See also The National Forest Strategy 2035 http://urn.fi/URN:ISBN:978-952-366-748-8

4 Value chains at the core of success

4.1 Need for the entire value chain in Finland

New bioproduct production requires mutually supportive processes and research, especially in finding end-use applications for new final products. By examining bioproduction from the end product perspective, processes can be balanced and combined according to which products find markets. Process integration requires scaling up first to pilot phases and from there testing the best concepts at demonstration scale using techno-economic calculation.

Simply put, from the national perspective, only those bioproduction products and production concepts that lead to production or service investments in Finland generate value added for Finland. The challenge for investments is that their location must be optimal from the perspective of the entire value chain. Therefore, in the current situation, processing of raw material is typically done in Finland, whereas further processing into final products have been done closer to the consumer in export countries.

Although new bio-based products are actively developed and piloted in Finland at the moment, it does not guarantee their industrial-scale manufacturing here in the future. When companies make investments, they look for the best possible return for their investment and seek for optimal environment for that. Good investment targets are often countries and locations where the stakeholders of the whole value chain in question are widely present and form functional entities, i.e. ecosystems.

In this work, in connection with the scenarios presented in Chapter 3, we also estimated at a very rough level the amount of investment required to increase value added as targeted in the bioeconomy strategy. According to our calculations, the investment need grows, even at its most conservative, to well over 20 billion euros. The required amount is enormous, so the question of whether Finland is an attractive country for bioeconomy investments is extremely relevant.

4.2 Textile value chain of the future as a case example

In this work, we looked specifically at the textile value chain. Globally, polyester and cotton account for the largest share of global fiber production. A total of approximately 113 million tons of different textile fibers are used annually in the world (2020)[18]. Of this, the share of natural fibers has been approx. 32 million tons, of which cotton alone has been approx. 26 million tons. Global production and consumption of textile fibers have almost tripled over the past 30 years. The production of natural fibers has not grown significantly, but growth has come almost exclusively from the rapid growth in the production of man-made fibers. Wood-based textile fibers could replace cotton, the production of which is often not ecologically sustainable. In our scenario, the production volumes of wood-based textile fibers could rise to as much as 3.5 million tons, which would correspond to over 10% of global cotton production. Wood-based textile fibers could potentially also replace synthetic fibers. Consumer decisions play a key role in the textile market, and of course the use of wood fibers must also be based on sustainability.

A responsible and competitive wood-based textile value chain has good future prospects (see Kamppuri et al. 2021[19]). Several wood-based textile fiber innovations have already been developed in Finland, some of which are at the pilot stage. However, refining pulp fiber into textile fiber is only the first step in the textile value chain, and the further processing chain from fiber to yarn and fabric with processing steps is almost completely missing from Finland. The textile value chain would enable real value added to be generated.

Building a wood-based textile value chain in Finland would be possible if the availability of raw materials, energy and logistics also work is cost-effective. Finland's competitive advantages for the entire textile value chain lie above all in education, digitalization and responsibility (see Growth spots in the textile and fashion industry 2022[20]). With good industrial policy and R&D investment, this value chain could be achievable in Finland in the future. Increasing expertise through training is also essential, especially at the end of the value chain.

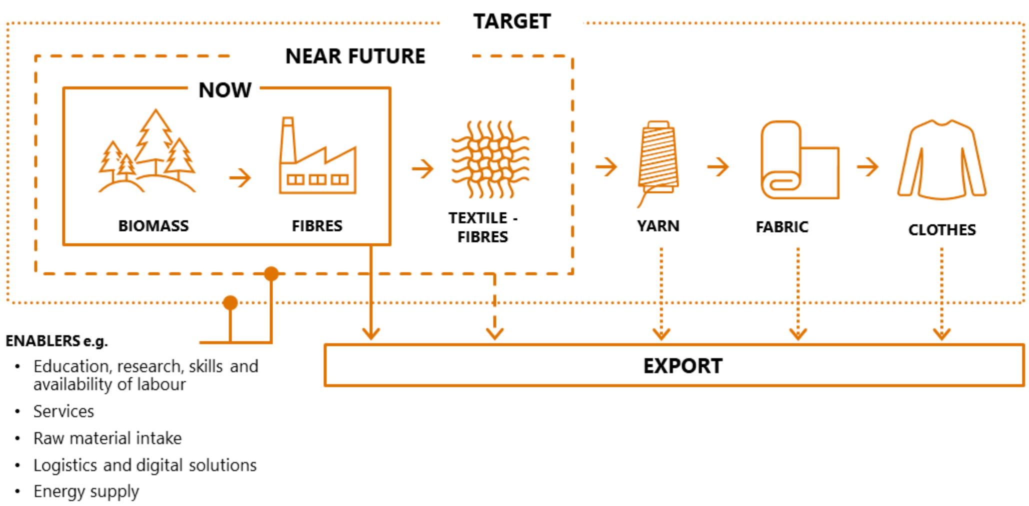


Figure 6. The future textile value chain and its enablers in Finland. The value added in the textile chain is to a large extent only created at the end of the chain.

---

18 Textile fiber guide 2021. (In Finnish). https://www.stjm.fi/wp-content/uploads/2022/02/Tekstiilikuituopas_korjattu.pdf

19 Kamppuri et al. 2021. Finland as a forerunner in sustainable and knowledge-based textile industry – Roadmap for 2035. https://cris.vtt.fi/en/publications/finland-as-a-forerunner-in-sustainable-and-knowledge-based-textil

20 Places of growth in the textile and fashion industry 2022. (In Finnish). https://www.stjm.fi/wp-content/uploads/2022/05/Tekstiili-ja-muotialan-kasvun-paikat-raportti.pdf.

5 Conclusions

Finland's forest sector: A vital component for economic recovery

Recently, Finnish public debate has been dominated by concerns about the difficult state of our national economy and its future outlook. As a solution to our indebtedness, various public spending cut lists have been proposed. While streamlining public finances certainly has its place, maintaining our welfare society in the future will, in our view, also require productive investments, competitive export companies, improved labor productivity, and a thriving forest sector.

Structural changes needed to achieve bioeconomy strategy

Finland's bioeconomy strategy sets an ambitious goal for value added growth by 2035. To achieve this we believe significant structural changes are needed in forest industry's value chains. The push to increase value added also partially extends to other bioeconomy sectors such as services and nature tourism.

The crucial role of pulp processing in high value-added products

To achieve the bioeconomy strategy targets, further processing of pulp plays a decisive role. This is because we need to produce large quantities of high value added products. If the industry's available raw material significantly decreases in the future, the challenge of increasing value added product will intensify as well.

The need for bold R&D investment in product piloting and demonstration

The emergence of new bioproducts is imminent, but it will not happen automatically. Numerous innovations have emerged through research and they are transitioning to commercial production. However, R&D funding in Finland has lagged behind our competitors for years. In 2022, the political parties have set a joint target of raising R&D funding to four percent of GDP. It remains to be seen how and in what way these objectives and their implementation will be implemented in the forest sector. In our view, bold R&D investment in piloting and demonstrating new products is crucial if we aspire to get industrial-scale investments in Finland as well.

Tens of billions of investment are needed to transform current product portfolio into higher value-added products

We estimate that the investment need for industrial forest bioeconomy would be in the range of tens of billions putting Finland in a tight global competition. We need to enhance our national competitiveness and business environment to attract companies to invest in our country. Increasing value added products significantly requires renewing the current product portfolio and extending value chains closer to consumer products, enabling ecosystems and services.

Finland needs Industrial and Innovation Policy

The next step is transitioning to an industrial and innovation policy for the circular bioeconomy. This would support the emergence and operation of industrial ecosystems across the value chain, promoting industrial investments in Finland. A functional and competitive Finland would also provide businesses with support services that enable their operations. This policy would also boost regional activity and employment.

Systematic and comprehensive review is needed

We hope that this discussion paper will spark further dialogue both within and outside the forest sector. We need a shared vision for the forest-based bioeconomy, the conditions for its success, and the construction of innovation ecosystems for that success. A comprehensive review should systematically examine the impact of restoration, carbon neutrality, biodiversity loss prevention and forest recreation objectives on the prerequisites for forest bioeconomy.

Hope vs will: The national question

Our review reveals a promising message: that there is hope! Research in the field and new product development are making progress, and even more valuable products loom on the horizon. However, the most significant question at the national level is whether we have the collective will to seize these opportunities. Are we ready to get on board?

You can find us online

luke.fi

Natural Resources Institute Finland (Luke), Latokartanonkaari 9, 00790 Helsinki