UNIVERSITY OF TURKU

Backcasting Finnish energy and forest sector futures to meet the EU Green Deal in 2050

Normative Scenario development for Finnish energy and forestry sector to understand the business and regulatory environment of the European Union Green Deal climate targets in 2050.

Futures Studies
Master's thesis

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16.5.2024
Helsinki

Master's thesis

Subject: Futures Studies

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Title: Backcasting Finnish energy and forest sector futures to meet EU Green Deal in 2050

Supervisors: PhD Hanna Heino

Number of pages: 79 pages

Date: 16.5.2024

The discourse on sustainability transition has gathered global attention, with pressing issues like climate change, global warming, and biodiversity losses prompting a call to action. While corporate strategies today state to prioritize sustainability, actual implementation falls short, with a focus on incremental rather than transformative change. Understanding the effects of regulatory environment, market dynamics, and technological development on sustainability transformation aligns corporate actions providing an understanding of how large-scale complex transformation can be enabled.

In Finland energy and forest sectors present two large industries, whose emissions and carbon storage capabilities affect the EU Green Deal and thus national climate goals. These two sectors represent two sides of the coin. Where the energy sector is urging to cut down greenhouse gas emissions, the forest sector needs to act in increasing the natural carbon storage.

Fostering a climate-neutral economy is the key goal of the EU Green Deal. The long-term goal of being the first climate-neutral continent by 2050 provides many ambitious sub-targets to EU countries and their industries. The emission-cutting plan has been divided into three middle points: in 2030 EU net emissions should be reduced by 55% compared to the year 1990, in 2040 the emissions should be decreased by 90% and in 2050 the goal is to be climate neutral. The EU Green Deal guides Finnish climate politics and thus also Finnish energy and forest sectors.

The goal of the research is to understand how the EU Green Deal targets could be reached in certain industries. To understand alternative possible routes to reach the target I used normative scenarios to illustrate the possible futures of net-zero economy. Normative scenarios and backcasting techniques provide answers to "*How can a certain future be reached*?". In this research, this question is relevant, as the long-term goal is set. The empirical part of the research consists of qualitative research in which I interviewed a total of nine experts in the fields of energy and forestry. These experts represent various perspectives: political, economic, social, technological, and environmental.

Based on the research interviews the understanding of the dynamics of a socio-technical transformation was seen. The scenarios are created from three perspectives: regulation-driven change, market-driven change, and technology-driven change. Where the regulatory environment is pushing the change towards a climate-neutral economy, the transformation is not possible without market development and technological innovations. These three combine a landscape for the large-scale sustainability transformation.

Key words: EU Green Deal, Sustainable Development, Normative Scenarios, Energy Sector, Forest sector

Pro Gradu -tutkielma

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Keskustelu kestävän kehityksen siirtymästä on saanut laajaa huomiota, kun kiireelliset ilmiöt, kuten ilmastonmuutos, maailmanlaajuinen ilmaston lämpeneminen ja luontokato ovat kannustaneet toimimaan kestävästi. Vaikka yritysten strategiat tänään kertovat kestävyyden olevan tärkeää, jää toteutus vaillinaiseksi, kun yritykset keskittyvät ennemmin pikemminkin inkrementaaliseen kuin transformatiiviseen muutokseen. Regulaation, markkinadynamiikan ja teknologisen kehityksen vaikutusten ymmärtäminen kestävyysmuutoksen edessä tarjoaa näkemystä siitä, miten suuria monimutkaisia muutoksia voidaan mahdollistaa.

Suomen energia- ja metsäsektorit edustavat kahta suurta teollisuutta, joiden sekä päästöt että hiilen sidontakyky vaikuttavat EU:n ilmastotavoitteisiin ja siten kansallisiin ilmastotavoitteisiin. Nämä kaksi sektoria edustavat kolikon kahta puolta – energia-ala painottaa kasvihuonekaasupäästöjen vähentämistä, kun taas metsäalalla kriittistä on hiilensidonta luonnon monimuotoisuusarvot toteuttaen.

Hiilineutraalin talouden edistäminen on EU Green Deal -paketin keskeinen tavoite. Pitkän aikavälin tavoite on olla ensimmäinen päästöneutraali maanosa vuoteen 2050 mennessä. Tämä asettaa monia kunnianhimoisia alatavoitteita EU-maille ja niiden teollisuudelle. Päästöjenvähennysstrategia on jaettu kolmeen välietappiin: vuoteen 2030 mennessä EU:n nettomääräisten päästöjen on vähennyttävä 55 % vuoden 1990 tasosta, vuoteen 2040 mennessä päästöjen on vähennyttävä 90 % ja vuoteen 2050 mennessä tavoitteena on olla hiilineutraali. EU Green Deal ja ilmastolaki ohjaavat Suomen ilmastopolitiikkaa ja siten myös suomalaisia energia- ja metsäsektoreita.

Tutkimuksen tavoitteena on ymmärtää, miten EU Green Deal -sopimuksen tavoitteisiin voitaisiin päästä näillä aloilla. Ymmärtääkseen vaihtoehtoisia mahdollisia reittejä tavoitteen saavuttamiseksi käytin normatiivisia skenaarioita kuvatakseni mahdollisia tulevaisuuksia ilmastoneutraalille taloudelle. Normatiiviset skenaariot ja backcasting-menetelmä antavat vastauksia kysymykseen "*Miten tietty tulevaisuus voidaan saavuttaa?*". Tässä tutkimuksessa kysymys on relevantti, kun pitkän aikavälin tavoite vuoteen 2050 on asetettu. Tutkimuksen empiirinen osa koostuu laadullisesta tutkimuksesta, jossa haastattelin yhteensä yhdeksää asiantuntijaa energia- ja metsäaloilta. Nämä asiantuntijat edustavat eri näkökulmia: poliittisia, taloudellisia, sosiaalisia, teknologisia ja ympäristöön liittyviä.

Tutkimushaastatteluiden perusteella saatiin näkemyksiä sosioteknisen muutoksen dynamiikasta. Skenaariot luotiin kolmesta näkökulmasta: regulaatioon perustuva muutos, markkiavetoinen muutos ja teknologiapohjainen muutos. Siinä missä egulaatio työntää muutosta kohti ilmastoneutraaliutta, ei muutos ole mahdollinen ilman markkinoiden kehitystä tai teknologisia innovaatioita. Nämä kolme yhdessä luovat kehyksen laajamittaisen kestävyysmuutoksen onnistumiselle.

Key words: EU Green Deal, Kestävä Kehitys, Normatiiviset Skenaariot, Energiasektori, Metsäsektori

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1 Introduction

1.1 Background of the topic

Sustainability is a topic that is widely discussed all around the world. Over the past decade, sustainability transition has gained significant attention, with research delving into socio-technical transitions across various energy, agriculture, and automotive sectors (Farla, Markard, Raven & Coenen 2012). Global warming and biodiversity losses are floating in news headlines and scientists are telling us that the time to act is now. Today also companies around the world are building on sustainability agendas and hiring sustainability managers to work with emerging climate issues. In 2023 the International UN Climate Change Conference COP 28 was held in the United Arab Emirates. The historical conference stated for the first time that we should globally detach from fossil fuels. Yet the historical agreement was criticized for being too vague and not having clear action points on how the detachment is supposed to happen and by whom (The Guardian, 2023). This has been the tone of sustainability discourse in recent years: there’s a common understanding that we need to act, but the ways of action are still widely lacking.

While individual companies are urged to participate in sustainability transitions, progress has been slow (Dyllick & Muff, 2015). Despite the commitment made by all United Nations (UN) members in 2015 to achieve "The 2030 Agenda for Sustainable Development," as outlined by the 17 Sustainable Development Goals (SDGs), the pace of implementation falls short (United Nations). UN General Secretary António Guterres emphasized the urgent need for accelerated action, urging collaboration across all sectors (2019). The Brundtland Commission's (1987) definition of sustainable development underscores the necessity for companies to revamp their operations to meet present needs without compromising future generations' ability to do the same. While companies recognize the need for change, the transition remains sluggish (Shevchenko, Lévesque & Pagell, 2016, 912). Achieving sustainable development requires innovation, technological advancements, and societal shifts (Hall, Daneke & Lenox 2010). To truly embrace sustainability, companies must embed it into their core operations rather than merely meeting stakeholder expectations (Dyllick & Muff, 2015).

In 2023 we followed the middle point of the United Nations Sustainable Development Goals (SDG) and how those are progressing. The depressing news was that out of 17 SDG’s only two are on the desired progress track, and the rest 15 SDG’s are failing to be achieved (United

Nations (2023). Also the headlines told us that large global oil companies have reversed their sustainability goals and invested in fossil fuels instead (Helsingin Sanomat, 2023). The current climate discourse does not provide much hope but at the same time, it’s an opportunity to review and understand further what the key challenges of the green transition for companies are, and what is slowing companies down with the subject. The common tone of climate activities globally sounds slow and by following the news one could think that there’s no hope for achieving the sustainable development goals.

Yet, the corporate strategy papers tell a different story. When reading corporate strategies, sustainability is often mentioned or even lifted as one of the core elements of the corporate strategy, yet the sustainability reports talk a different language. Corporates end up focusing on incremental change instead of macro-level transformation (Manninen & Huiskonen, 2022). With this research, I wanted to understand the sustainability actions of the companies, and how those are put into action. I also wanted to understand the possibilities of using future thinking in advancing companies’s sustainable business transformation. When starting to read the background materials I soon understood that Finnish politics and goals for Finnish companies are coming from European Union (EU) law and EU’s climate targets. Therefore, I chose the topic of normative scenarios in corporate climate actions, stating the end year to the year 2050, which is the EU’s net zero emission goal. Middle points for the scenarios were also chosen from the EU’s Green Deal goals: in 2040 the goal is to reduce 90 % of the Greenhouse gas (GHG) emissions compared to the year 1990, and in 2030 the goal is to reduce GHG emissions by 55 %. (European Commission, 2019, European Commission, 2024).

To reach these rather ambitious goals, the EU has launched a program called The Green Deal. The Green Deal is a comprehensive plan and set of policy initiatives aiming to make the EU’s economy more sustainable and climate-neutral. It aims to ensure possibilities to make business in a healthier world and be a forerunner in climate climate-neutral economy and thus improve the competitive advantage of the EU region. The Green Deal program was launched in 2019 by the European Commission’s president Ursula von der Leyen (European Commission, 2019). In the EU policy-making process flows from EU policies and directives to national legislation. Therefore, Finnish climate targets are strongly linked to EU Green Deal targets and directives (Työ- elinkeinoministeriö, 2021).

1.2 Energy and forest sectors – two sides of sustainability challenges

The Paris Agreement, established in 2015 under the United Nations Framework Convention on Climate Change (UNFCCC), is a landmark international treaty aimed at combating climate change. Its primary goal is to limit global warming to well below two degrees Celsius above pre-industrial levels, with efforts to limit the temperature increase even further to 1.5 degrees Celsius. The agreement encourages countries to set and achieve nationally determined contributions (NDCs) to reduce greenhouse gas emissions and adapt to the impacts of climate change. Through collective action and cooperation, the Paris Agreement represents a crucial step towards a sustainable and resilient future for our planet. (IPPC, 2023).

When delving into research within such a vast and complex subject area, it is challenging to define a relevant and informative scope without becoming overly intricate or superficial. Initially, my objective has been to explore how major industries contributing to pollution could transition towards sustainability. In 2019, around 79% of global greenhouse gas (GHG) emissions stemmed from the energy, industry, transport, and buildings sectors combined, while 22% were attributed to agriculture, forestry, and other land use (AFOLU) (IPPC, 2023, p. 5). To narrow the focus to the sectors most crucial for emission reduction, emphasis was placed on the energy sector, whose impact extends across various other sectors such as transportation and steel production, where emission reductions are closely linked to adopting cleaner energy sources.

The energy sector discussed in this research includes activities related to energy production, transformation, transmission, and consumption. In the greenhouse gas inventory, when looking at the energy sector, both primary and secondary energy production are considered the emissions and evaporative emissions generated by burning all fuels (Sanastokeskus, 2020).

While the energy sector plays a significant role in global emissions reduction efforts, I wanted to have another sector to compare if the backcasting works also in other than energy sectors. In Finland forest sector also holds major importance in this regard, as being the other side of the coin – the one increasing and maintaining carbon storage. A pivotal moment for Finnish forest sector occurred in 2022 when Natural Resources Institute Finland (LuKe) released new calculations revealing a significant decrease in carbon storage within the country (Helsingin Sanomat, 2022, Luonnonvarakeskus, 2022).

Finland has traditionally taken pride in its forest sector's management practices and utilization methods. However, a notable shock occurred in 2021 when Russia initiated a war against Ukraine, prompting all EU countries to impose sanctions on Russian trade. Consequently, wood imports from Russia to Finland were halted, placing increased pressure on the utilization of Finnish wood in the forest industry. Simultaneously, research findings indicated that the decline in carbon storage within Finland was primarily attributed to excessive logging activities in its forests (Forest.fi, 2022).

Forestry refers to livelihoods related to forests, such as growing and harvesting wood and forests, forest industry, services for forest owners, nature tourism, and forest research. The forest sector is a part of forestry. It means forest economy and forest industry together. The forest sector is one of the key pillars of the Finnish economy. In 2017, it directly employed nearly 64,000 individuals, according to estimates from the Natural Resources Institute Finland. Forest industry products accounted for 20 percent of Finland's merchandise export revenue in 2017. (Forest.fi, 2019)

Both the energy and forest sectors are actively engaged in combating climate change, although through distinct strategies. While the energy sector primarily focuses on reducing greenhouse gas (GHG) emissions, the forest sector is tasked with maintaining adequate carbon storage levels and preserving natural ecosystems to ensure their functionality. This dichotomy presents an intriguing research subject, as the objectives of these sectors diverge significantly. Although these sectors may be perceived as two sides of the same coin, their goals are also interrelated, and their actions can impact each other's objectives.

1.3 Normative scenarios provide routes to the goal

In Futures studies, scenario building is one of the key methods. When exploring the area of sustainability the scientific fact is that the time for action is running out, and therefore nations and companies have made goals that have a clear date when issues like carbon neutrality are supposed to happen. This type of date-based goal setting opens up a possibility to create normative scenarios that often answer the question "*What is supposed to happen to X to be reached?*". In comparison to explorative scenarios that often explore the question "*What are the possibilities that can happen within the time frame of X?*" (Holmberg & Robert, 2000).

According to Holmberg & Robert (2000, 5) backcasting is a methodology for planning under certain circumstances. In the context of sustainable development, it means to start planning from a description of the requirements that have to be met when society has successfully become sustainable, then the planning process proceeds by linking today with tomorrow in a strategic way: what shall we do today to get there? (Holberg & Robert, 2000). This methodological choice felt natural for this thesis research, as the European Union has made the Green Deal target setting to try and reach carbon neutrality in 2050. This set the schedule for the transformation and also created the environment for Finnish energy and forest sectors to transition under the European and national legislations. For industries and companies normative scenarios provide hypothetical sets of events that provide alternative ways to reach a certain goal or target. It also reveals what causalities there are and how certain goals could be met. Usually, there are several ways to reach the goals, and policymakers must make decisions based on the best understanding.

1.4 Research questions

In this thesis research, I wanted to understand what the goals from international and national levels for energy and forest sectors are that push these sectors to diminish global warming and to hold global warming under 1,5 °C. I was also interested in understanding are the regulations and policies are strong enough to make changes in large business entities, and why the change is constantly too slow. After several careful iteration rounds my research questions formed into the following:

1. **What kind of transition is required from the Finnish energy and forest sectors to meet the goals of the EU Green Deal?**
    - **What is the role of regulation and policies in the transformation?**
    - **What market-led business opportunities may arise?**
    - **What is the role of technologies in transition?**
    - **How are regulation, markets, consumers and technology related to each other in a large-scale business transformation?**
2. **What kind of new perspectives can transformative normative scenarios provide for energy and forest sector to enable the transformation?**

2 Landscape today

In this chapter, I'll discuss the intricate interplay between global climate policies and the Paris Agreement, regional initiatives such as the EU Green Deal, and national legislation, particularly in the context of Finland's energy and forest sectors. I'll also sum up the key goals of the EU Green Deal in target years 2030, 2040, and 2050, as these goals work as middle points and targets for the normative scenarios created through this research. On the national legislation guiding the transformation, I'll sum up the strategic objectives and discuss also the low-carbon roadmap work as well as the biodiversity roadmap work on both energy and forest sectors, and how the sectors themselves have defined the road to meet the Green Deal targets. At the end of the chapter, there's also a snapshot of the Finnish energy and forest sectors today, to give a better perspective on how the transition gap towards a sustainable future looks like.

2.1 EU Green Deal

As a party to the Paris Agreement, the European Union has made commitments to reduce its greenhouse gas emissions and enhance climate resilience. The Paris Agreement was negotiated under the United Nations Framework Convention on Climate Change (UNFCCC) and concluded in December 2015 at the 21st session of the Conference of the Parties (COP21) and entered into force in November 2016. Ultimately, the agreement was endorsed by 196 parties, making it the most universally supported treaty in the history of the United Nations (United Nations, 2024). The objective of the Paris Agreement is to keep the global average temperature increase well below 2°C and to limit the average temperature increase to 1.5°C compared to pre-industrial times. The aim is also to strengthen the adaptive capacity and climate resilience of the parties to the agreement and to direct financial flows to low-emission development. To achieve the temperature target, global greenhouse gas emissions must be reversed as soon as possible and reduced rapidly thereafter to ensure that anthropogenic greenhouse gas emissions and sinks will be balanced in the second half of this century. (IPCC AR6, European Commission, 2019, European Commission, 2024).

The EU Green Deal provides the legislative framework and policy initiatives necessary to implement the EU's obligations under the Paris Agreement (European Commission, 2019). This includes proposals to revise existing legislation and introduce new measures across various sectors, such as energy, transport, agriculture, and industry, to align with the objectives of the Paris Agreement. The EU aims to lead by example in the global fight against climate change by demonstrating its commitment to the goals of the Paris Agreement through the EU Green Deal. By implementing ambitious climate policies and promoting sustainability and innovation, the EU seeks to inspire other countries to take similar actions and enhance global cooperation on climate issues (European Commission, 2019). EU Green Deal is guiding also Finnish national climate legislation through EU law and common policies (Työ- ja elinkeinoministeriö, 2024). Therefore, the main literature research material for emission reduction and climate target setting in this study is based on the European Commission's official climate goals, which act as the key driver for national policies and act as guidance towards lower emissions. (European Commission, 2024).

The vision of European Union at the end of the next decade is an ambitious one: it aims to remain a prime destination for investment opportunities that bring stable, future-proof quality jobs, with a strong industrial ecosystem (European Commission, 2024, 2). Europe should be the leader in developing the clean technology of the future, and markets where all major countries and businesses seek to benefit from the opportunities. Becoming a continent with clean, low-carbon, affordable energy and sustainable food and materials, Europe will form itself resilient against future crises, such as those currently caused by disruptions in the supply of fossil fuels and those caused by climate change. By remaining a global leader and a trusted partner in climate action, Europe will strengthen its open strategic autonomy and diversify its sustainable global value chains to be the master of its fate in a volatile world. (European Commission, 2024).

European Union's Green Deal climate targets are divided into three goals: 2030, 2040, and the year 2050 (European Commission, 2019; European Commission, 2024). By 2030 EU aims to reduce greenhouse gas emissions by at least 55% compared to 1990 levels (European Commission, 2019). In February 2024, the European Commission unveiled its proposal for a 2040 climate target, which advocated for a reduction of the EU's net greenhouse gas emissions by 90% by 2040 compared to 1990 levels (European Commission, 2024, 6). This target is crucial in ensuring that the EU stays on course to achieve its 2050 climate neutrality target. The EU aims to achieve climate neutrality by 2050, meaning that the EU's net greenhouse gas emissions will be reduced to zero. This objective is stated in the European Green Deal and requires a comprehensive transformation of the EU economy towards sustainability, including decarbonization of energy systems, transport, industry, agriculture, and buildings, as well as increased carbon sequestration through natural and technological means. (European Commission, 2024)

2.1.1 EU Green Deal 2030 climate target "Fit for 55"

In September 2020, the European Commission unveiled a proposal to enhance the 2030 greenhouse gas (GHG) emission reduction target. The previous target was to decrease GHG emissions by 40 % compared to the level of 1990, yet the revised proposal proposed an intensified target, advocating for a reduction of net greenhouse gas emissions by at least 55%. This highlights the inadequacy of the previous 2030 target in effectively realizing climate neutrality at the European Union level by 2050. (European Commission, 2020, 2).

The new 2030 target, branded as "Fit for 55" is a legislative package that proposes reforms to align EU policies with these goals, emphasizing social fairness, industry innovation, and global leadership in combating climate change. It enhances the EU emissions trading system (EU ETS) by extending its scope, reducing emission allowances, and incorporating international aviation schemes. Additionally, a new emissions trading system for buildings, road transport, and fuels is introduced. The Environment Council and the European Parliament have reached provisional agreements to increase emissions reduction targets and update rules for the aviation sector within the EU ETS. These agreements were adopted formally in 2023 (European Council, 2024).

Making the green transition happen will require major transformation and investments. For the current long-term budget, running until 2027, EU countries have decided to devote up to 30% of all EU funding to climate-related action – this amounts to almost €550 billion. Additional funds, such as the Innovation Fund and the Modernisation Fund under the EU ETS, as well as the Social Climate Fund, will also contribute to the shift to greener policies (European Council, 2024).

2.1.2 EU Green Deal 2040 target proposal

In February 2024, the European Commission presented its assessment of a 2040 climate target for the EU. The 2040 target will reaffirm the EU's determination to tackle climate change and will shape our path after 2030, to ensure the EU reaches climate neutrality by 2050. The 2024 target requires a 90% net GHG emissions reduction compared to 1990 levels as the recommended target for 2040 (European Commission, 2024, 6).

This target was proposed because in 2023 the world faced a strong acceleration in climate disruption when global warming reached 1.48 °C above the pre-industrial level for the first time. Also, ocean temperatures and Antarctic Ocean ice loss were breaking records by a wide margin (European Commission, 2024, 2). Thus the European Commission (2024, 2) stated that it's clearer than ever that achieving a stable climate and safeguarding a liveable planet for current and future generations means cutting global greenhouse gas (GHG) emissions sharply and rapidly. Therefore the Commission recommended reducing the EU's net greenhouse gas emissions by 90% by 2040 relative to 1990 (ibid). The 2040 climate target is the EU's next intermediate step on the path to climate neutrality.

The following actions will be needed to achieve the 90% reduction target by 2040:

1. Fully implement existing EU laws to reduce emissions by at least 55% by 2030
2. Decarbonise the industry by relying on existing strengths like wind power, hydropower, and electrolyzers. To step up this work strand, the Commission has put forward new measures to manage carbon emissions by industry in the EU that will see investment in technologies that can capture and store carbon, and re-use it
3. Increase domestic manufacturing in growth sectors like batteries, electric vehicles, heat pumps, solar cells, and others
4. Keep fairness, solidarity, and social policies at the core of the transition, helping vulnerable citizens, regions, businesses, and workers through tools such as the Social Climate Fund and Just Transition Fund
5. Have an open dialogue with all concerned, including farmers, businesses, social partners and citizens

(European Commission, 2024, 6-7)

The establishment of the EU's 2040 target signals the EU's commitment to leading global efforts in expanding dedication to the Paris Agreement and multilateral cooperation, setting an example for other nations to follow the example. The 2040 target communication initiates a political discourse among European citizens and governments, informing future legislative proposals, including the incorporation of the 2040 target into the European Climate Law and the development of a post-2030 policy framework. The period between 2024 and 2029 will shape Europe's trajectory towards 2040 and beyond, necessitating a balanced and cost-effective approach across all sectors to achieve greenhouse gas emission reductions and carbon removal objectives. (European Commission, 2024, 26-27).

2.1.3 EU Green Deal 2050 climate vision

The EU Green Deal Climate Vision 2050 embodies a visionary agenda, aspiring to achieve climate neutrality by 2050. At its core is an ambitious commitment to significantly reduce greenhouse gas emissions, aiming for net-zero levels by 2050. This bold vision underscores the urgency of addressing climate change and environmental degradation, guiding policy actions toward sustainable energy practices, carbon mitigation strategies, and ecological resilience. The Green Deal's climate vision seeks to transform economies, industries, and societies, promoting innovative solutions and international cooperation to safeguard the planet for future generations. It represents a landmark initiative signaling the EU's commitment to combat climate change and leading the global transition towards a sustainable, low-carbon future. (European Commission, 2019).

At the introduction of the Climate Vision strategy European Commission states the vision with the following words:

"In November 2018, the European Commission presented a long-term strategic vision to reduce greenhouse gas (GHG) emissions, showing how Europe can lead the way to climate neutrality – an economy with net-zero GHG emissions. The strategy explores how this can be achieved by looking at all the key economic sectors, including energy, transport, industry and agriculture. A portfolio of options was explored to underline that it is possible to move to net-zero GHG emissions by 2050, based on existing – though in some cases emerging – technological solutions, empowering citizens and aligning action in key areas such as industrial policy, finance or research, while ensuring social fairness for a just transition." (European Commission, 2019, p.2)

The seven main building blocks for Climate Vision 2050 are:

1. Maximise the benefits of energy efficiency, including zero-emission buildings;

2. Maximise the deployment of renewables and the use of electricity to fully decarbonize Europe's energy supply;

3. Embrace clean, safe and connected mobility;

4. A competitive EU industry and the circular economy as a key enabler to reduce GHG emissions;

5. Develop an adequate smart network infrastructure and interconnections;

6. Reap the full benefits of bioeconomy and create essential carbon sinks

7. Tackle remaining CO2 emissions with Carbon Capture and Storage (CCS).

(European Commission, 2019, 6)

The Climate Vision 2050's building blocks are widely linked to the energy and forest sectors. Enhanced energy efficiency in buildings reduces energy demand, impacting the need for forest biomass in energy production. Increased deployment of renewables and transitioning to clean mobility may reduce demand for biofuels. A circular economy promotes sustainable forest management and encourages biomass utilization affecting the natural carbon sinks in forests. Developing smart grid infrastructure facilitates renewable energy integration. Leveraging the bioeconomy and creating carbon sinks involve forests, while CCS technologies develop. Collaboration across sectors is vital for achieving climate goals.

Table 1: Key components of the EU Green Deal target initiatives

(Sources: European Commission, 2019; European Commission, 2024; European Council, 2024)

Key components of the EU Green Deal target initiatives			
	2030	2040	2050
Energy sector revolution	• Energy sector reform • EU Emission Trading System (ETS) reform • Expansion of Carbon Pricing Renewable energy	• A resilient and decarbonised energy system for our buildings, transport and industry. • Energy taxation reform • An industrial revolution with competitiveness based on research and innovation, circularity, resource efficiency, industrial decarbonisation and clean tech manufacturing at its core.	• A competitive EU industry and the circular economy as a key enabler to reduce GHG emissions; • Develop an adequate smart network infrastructure and interconnections;
Emission reduction	• Member state's emission reduction targets • Carbon border adjustment mechanism (CBAM) • Reducing methane emissions in the energy sector	• Enhanced emissions reductions in agriculture.	• Maximise the deployment of renewables and the use of electricity to fully decarbonise Europe's energy supply;
Energy Efficiency	• Energy efficiency • Energy performance of buildings	• Continued energy efficient improvements to reduce needs for energy	• Maximise the benefits of energy efficiency, including zero emission buildings;
Transportation & Fuels	• CO2 emission standards for cars and vans • Sustainable aviation fuels • Decarbonised fuels in shipping Alternative fuels infrastructure (AFIR)	• Development of a smart integrated energy infrastructure at the distribution level, including for the recharging and refuelling of vehicles	• Embrace clean, safe and connected mobility;
Hydrogen	• Hydrogen and decarbonised gas market package	• Infrastructure to deliver and to transport and store hydrogen and CO2.	• Tackle remaining CO2 emissions with Carbon Capture and Storage (CCS).
LULUCF	• Emissions and removals from land use, land use change and forestry (LULUCF)	• The implementation of the Kunming-Montreal Global Biodiversity Framework and of the EU Biodiversity Strategy • Innovations in bioeconomy and food system at large.	• Reap the full benefits of bioeconomy and create essential carbon sinks
Fairness of green transition	• Social Climate fund	• Fairness, solidarity and social policies at the core of the transition. • Climate policy as an investment policy.	
Diplomacy and partnerships		• EU climate diplomacy and partnerships to encourage global decarbonisation.	

2.2 National climate and energy strategy in Finland

The long-term goal of the Finnish energy and climate strategy is to be a carbon-neutral society by 2035, which would be 15 years before the European Union's target (Energiateollisuus, 2023). Finland's national climate and energy strategy are subsidiaries of the European Union's climate goals and thus much of the direction is related to EU law and EU's Green Deal goals (Työ- ja elinkeinoministeriö, 2022). Finland has been actively working on its climate and energy strategies to meet the commitments of the Paris Agreement and EU.

Table 2: Key points of Finland's national climate and energy strategy

(Source: Työ- ja elinkeinoministeriö, 2022)

Carbon Neutrality Goal	Finland aims to achieve carbon neutrality by 2035. This means that the country's net greenhouse gas emissions should be zero or negative by that year, with any remaining emissions offset by carbon removal or absorption.
Renewable Energy	Finland has been increasing its use of renewable energy sources such as wind, solar, biomass, and hydroelectric power. The government has set targets to increase the share of renewable energy in its energy mix.
Energy Efficiency	Improving energy efficiency is a key aspect of Finland's strategy to reduce emissions. This includes measures to enhance the efficiency of buildings, transportation, industry, and appliances.
Phasing Out Coal	Finland has committed to phasing out coal as a source of energy by 2029. This involves transitioning to cleaner alternatives such as renewable energy and natural gas.
Transportation	Finland is also focusing on reducing emissions from the transportation sector, which accounts for a significant portion of its greenhouse gas emissions. This includes promoting electric vehicles, improving public transportation infrastructure, and incentivizing low-emission fuels.
Research and Innovation	Finland invests in research and innovation to develop new technologies and solutions for combating climate change and transitioning to a sustainable energy system.
International Cooperation	Finland collaborates with other countries and participates actively in international forums to address climate change and promote global efforts to reduce emissions.

Overall, Finland's climate and energy strategy is aimed at achieving its carbon neutrality goal while ensuring energy security, affordability, and sustainability. The country recognizes the importance of taking decisive action to mitigate climate change and transition to a low-carbon economy.

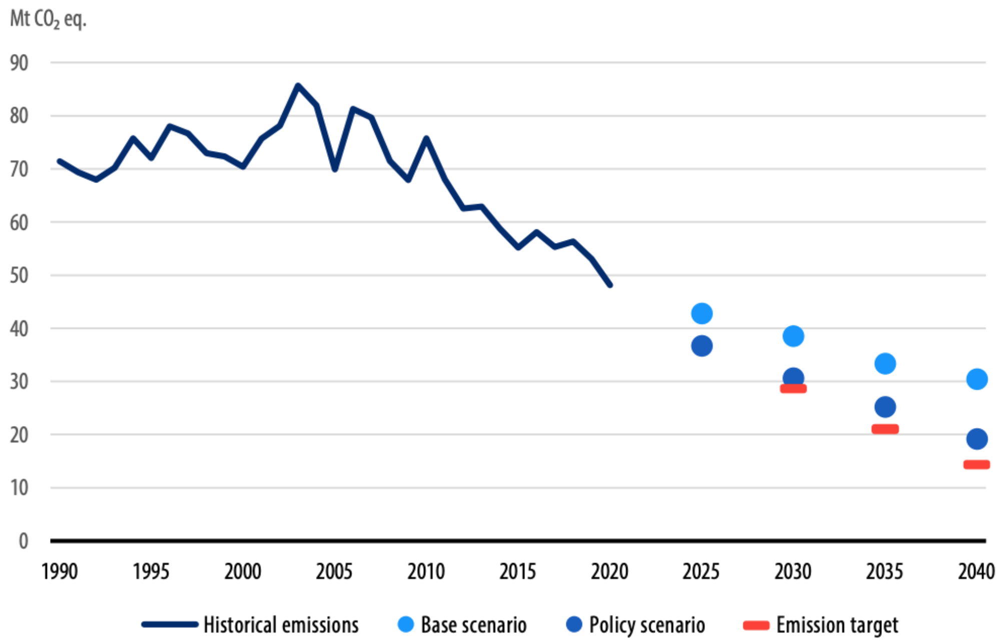

Figure 1: Total actual emissions 1990–2020

Emission trends in the base and policy scenarios 2025–2040 and emission targets for 2030, 2035 and 2040. (Source: Työ- ja elinkeinoministeriö, 2022)

2.2.1 Industry low-carbon roadmaps

In 2019 Finland's Prime Minister Antti Rinne's and later Sanna Marin's government published a program for creating low-carbon roadmaps for major industries in Finland. These roadmaps outline the strategic plans and measures for various sectors to transition towards a low-carbon economy. Overall, the Finnish industry's low-carbon roadmaps provide a strategic framework for reducing emissions, fostering innovation, and promoting sustainable industrial development in alignment with national climate and energy goals. Altogether 13 industries made low-carbon roadmaps including energy and forest sectors. The first round of low-carbon roadmaps was published in 2020, and the work continued during Prime Minister Petteri Orpo's government. The next versions of low-carbon roadmaps are supposed to be ready during the spring of 2024 (Työ- ja elinkeinoministeriö, 2024).

The initial findings from low-carbon roadmap work were that it is possible to reduce carbon emissions significantly in Finland and reach carbon neutrality in by 2035. Another key finding was, that to reach the 2035 carbon neutrality goal, carbon emission reductions must be made in each sector at the same time (Työ- ja elinkenoministeriö, 2020). Therefore the low-carbon roadmaps need to be ambitious yet realistic (Työ- ja elinkeinoministeriö, 2024).

The energy sector's low carbon roadmap is considered one of the most crucial ones, mainly due to the interdependencies within different sectors. Especially the electrification of the industrial sector will require massive increases in renewable and emission-free electricity and energy production. The estimates state that the energy needs may increase by 100% in industrial sector electricity usage, and a 50 % increase in the electricity usage of Finland as a whole (Työ- ja elinkenoministeriö, 2020, 30). Low carbonization of the energy industry is part of a wider energy transition, where energy production emissions drop sharply. Smart sector integration, changing the role of energy users into energy stores and producers, and new innovative technical and business solutions, such as hydrogen or energy as a service are the enablers of the energy revolution. Integration in the energy sector refers to the connection of industry, transport, and heating to each other via electricity, district heating, and gas networks. The low-carbon road maps offer the industries' assessments of future energy demand and the energy industry conditions to meet demand Työ- ja elinkenoministeriö, 2020:52). Key technological solutions in the energy sector are described to be onshore and offshore wind power, extending the service life of nuclear power plants, combined heat and biogas plants for electricity production, geothermal heat energy technology, solar energy technology and battery technology (Työ- ja elinkenoministeriö, 2020; Energiateollisuus, 2022).

The forest sectors' low-carbon roadmap reveals that the carbon dioxide emissions relative to forest industry production have decreased 64 percent since the year 1990 (Metsäteollisuus Ry, 2020, 10). Factories operating in Finland can almost completely detach themselves from fossil fuels as early as 2035, and shortly thereafter they can even be carbon-negative. According to the road map, the carbon stock of Finland's forests can be further increased at the same time as the use of forests is increased (Metsäteollisuus Ry, 2020, 12). One of the greatest concerns within the forest sector is the observed passivity in forest management. The industry perceives this passivity as potentially detrimental, foreseeing a scenario where Finland's forests undergo significant changes leading to a reduction in their carbon sink capacity. Over time, this could even transform forests into sources of emissions. Furthermore, the industry anticipates that such passivity would diminish economic benefits, as the mere presence of forest resources does not directly translate into job creation. (Metsäteollisuus Ry, 2020)

This perspective – that forest usage could be increased while the carbon sinks would grow – has been criticized widely among scientists and nature organizations. Also in 2022 NGOs WWF and Luonnonsuojeluliitto left and a dissenting opinion of the National Forest Strategy.

(Suominen & Nordman, 2023). In 2020 research group BIOS explored how the first version of low-carbon roadmaps was too heavily leaning on the usage of biomass. When all biomass needs from different sectors were summed up, the amount of wood needed exceeded the current maximum amount of wood logged, which would have decreased the carbon storage and natural habitats (Majava et al., 2022).

2.2.2 Biodiversity roadmaps

Climate change and low-carbon roadmaps act as important devices for reaching the national and EU-level climate targets. Yet, biodiversity and natural conditions are a rising topic in the climate discussion, especially in the forest sector. Scientists have proven that climate change and biodiversity losses are tightly connected (United Nations, 2024). Even a hypothesis occurs, that by solving the problem of biodiversity losses we can also solve climate change (Pfenning-Butterworth et al., 2024). Therefore, it's relevant for this research to study also the biodiversity roadmaps created by major industries in Finland. Like low-carbon roadmaps, biodiversity roadmaps are a device for improving the natural conditions in Finland. The energy and forest sectors have created their biodiversity roadmaps that propose scenarios for increasing biodiversity while reducing emissions (Metsäteollisuus Ry, 2023; Energiateollisuus Ry, 2022).

The energy industry was the first industry to publish its biodiversity road map in the summer of 2022 (Energiateollisuus Ry, 2022). The starting point of the roadmap is that "the energy sector solves the climate challenge by promoting biodiversity" and the goal is that the loss of nature caused by the energy industry will be halted by 2035 (Energiateollisuus Ry, 2022, 3). The roadmap has assessed the nature impacts of the following activities and the necessary measures to promote biodiversity: hydropower, forest energy, other for burning-based production, nuclear power, wind power, solar, earth and geo-energy, energy networks, stocks, hydrogen and new fuels and peat production (Pantsar, 2023). Forest energy has a dual role in both low-carbon and biodiversity roadmaps. It is an important part of the renewable energy palette, but forest energy is continuously moving towards using only sidestreams from the forest industry and thinning wood that is too small to be utilized in other uses (Energiateollisuus Ry, 2022). Whereas the official statement is, that only side streams and small thinning wood are used for energy, the reality is that still today also logs and fiber wood are used for energy purposes (Riikilä, 2024).

The forest sector's biodiversity roadmap proposed 5 + 5 actions for increasing biodiversity in the forest sector, especially in economic forestry. Five core actions in the forests are increasing in wood types, increase in the amount of rotten wood, protecting valuable areas when logging wood, recognizing and caring of grove forests, increasing fire habitats and burning as a renewing method for forests. In addition, this roadmap indicates five supporting activities for increasing biodiversity in the forest sector. These actions are increases in education, collaboration, technologies and data, research, and increase in motivation for the transformation. The forest industry's biodiversity roadmap also indicated that an increase in logging and forest usage can be possible at the same time when biodiversity and carbon storage in the forests increase (Metsäteollisuus Ry, 2023).

A new research project called FORTRAN exploring the safe borders for forest usage in Finland was launched at the Jyväskylä University in 2023 (Fortran, 2024). At the opening presentation of the FORTRAN project Member of European Parliament Ville Niinistö together with scientists Matti Mönkkönen and Teppo Hujala discussed how forests' carbon storage capabilities cannot be explored without understanding the biodiversity and ecosystem effects at the same time. The key message was, that forests can't be calculated only based on the amount of wood or biomass, but the biodiversity and rich environment must also be considered. Therefore, the amount of wood per area doesn't tell enough of the carbon storage of the forest but requires a holistic approach to understanding the sustainable level of logging. (Jyväkylä University, 2023). Many scientists state that logging should be decreased, and this is one of the key research questions the FORTRAN program is researching. The difficulty with the forest sector's biodiversity roadmap is, that the concrete actions or means of control for fitting the increase in logging and increasing biodiversity are lacking. The biodiversity maps have also been criticized for not specifying any target dates or timelines for its actions (Pulliainen, 2023).

2.3 Snapshot of the Finnish energy sector

In Finland, the total energy consumption was heavily growing until the latter half of 2000 and then decreased slightly remaining at a steady level. In 2021 the total consumption in Finland was 1357 PJ (Statistics Finland, 2022, 3). The primary source of energy in Finland in 2021 was renewable energy sources by 52% of the total energy supply. The main renewable energy sources in 2021 were wood fuels in industry and energy production (30%), Black liquor (29%), small combustion of woods (11%), hydropower (10%), and others (20 %) including wind power, biofuels for traffics, heat pumps, recovered fuels, other biofuels and solar power (Statistics Finland, 2022, 11

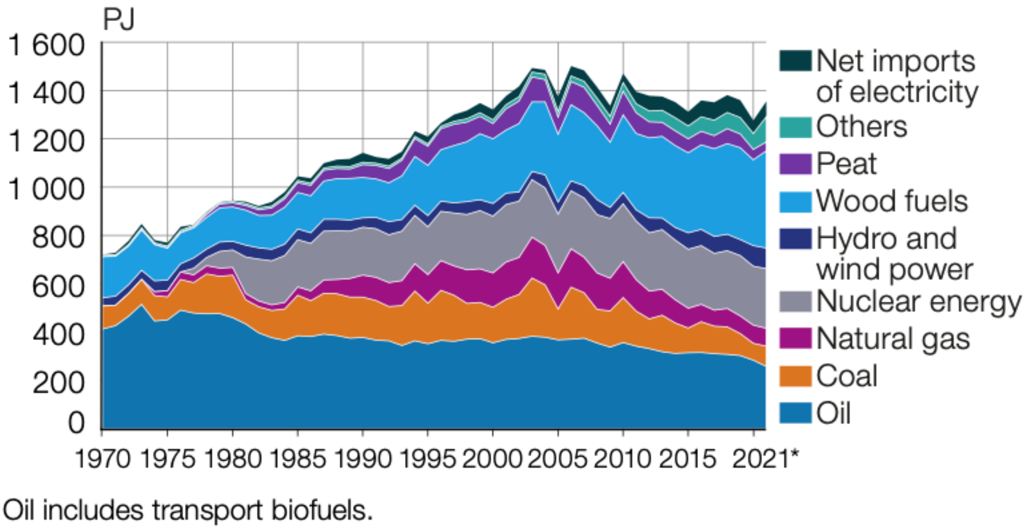

Figure 2: Total Energy consumption in Finland by energy source 1970-2021 (PJ)

(Source: Statistics Finland, 2022)

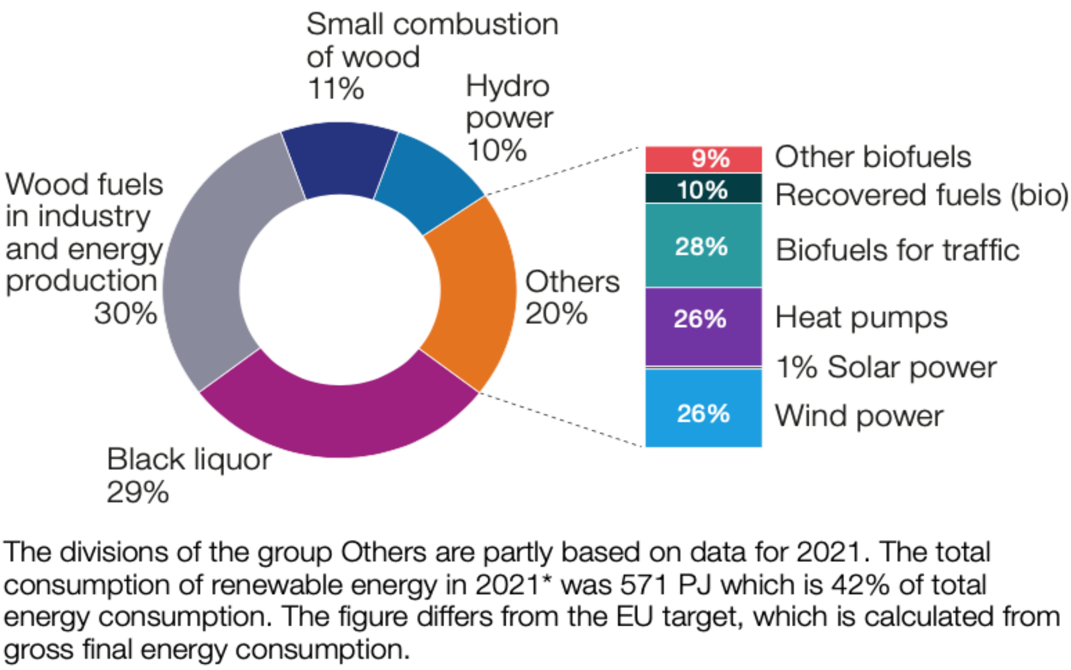

Figure 3: Renewable energy in Finland in 2021 (%)

(Source: Statistics Finland, 2022)

In 2021 out of the total energy, the consumption industry and consumption sector were the main consumers of energy with 45 % share of total consumption. The second largest consumer was households and agriculture with 28 % share and the third largest public sector with 25 % share of total consumption (Statistics Finland, 2022).

2.4 Snapshot of the Finnish forest sector

According to the Natural Resources Institute Finland, the value added by the forest sector constituted 4.4 percent of the total value added to the national economy in 2017. Of this value added, 45 percent originated from forestry, 16 percent from wood product manufacturing, and 39 percent from pulp and paper manufacturing. (Forest.fi, 2019).

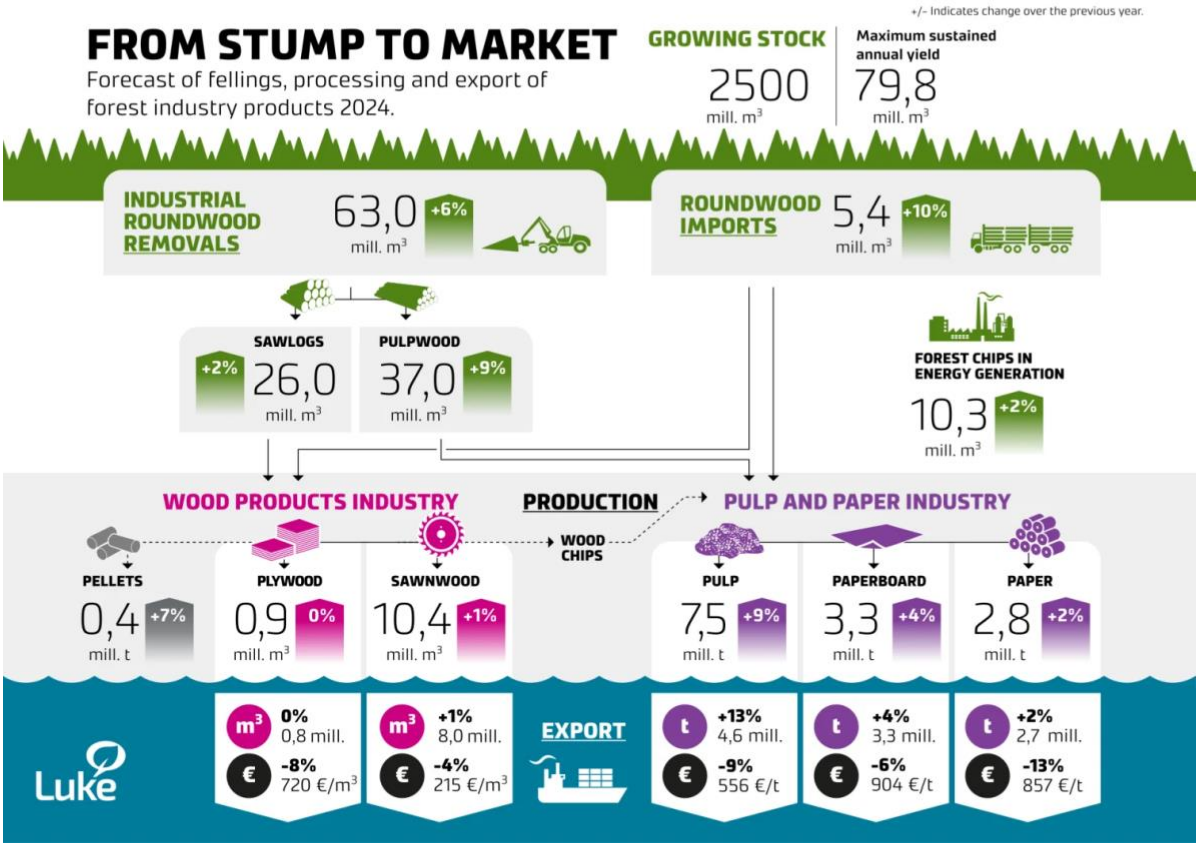

Figure 4: Forecast of Fellings, processing and export of forest industry products 2024 (Forest.fi, 2024)

In 2023, the Finnish forest industry experienced a decline in demand for its products in key markets after two consecutive years of peak performance. This downturn is attributed to various factors, including inflation, high interest rates, and general uncertainty affecting the construction sector, which diminishes interest in wood-based construction. Consequently, this trend adversely affects domestic production, exports, felling volumes, and roundwood trade within the Finnish forest industry. However, projections from the Finnish forest sector economic outlook, as reported by the Natural Resources Institute Finland (Luke), suggest a modest recovery in demand for forest industry products in the following year. (Forest.fi, 2019).

In 2023, both Finnish sawn wood exports and production are predicted to decrease by eight percent from the previous year. Also, cardboard production and export volumes will decrease by more than a fifth from last year, demand for printing papers is sluggish, and profitability of the forest industry is declining. Amidst weak economic growth, Finland anticipates an 11% growth in chemical pulp exports in 2023. This growth is driven by lower production levels in the previous year and the commissioning of Metsä Group's new mill. However, overall production volumes of chemical and mechanical pulp are expected to decline due to decreased paper production. Looking ahead to 2024, Finnish chemical pulp exports are projected to increase further, driven by expanded production capacity, despite continued weak demand. . (Luonnonvarakeskus, 2023a; Luonnonvarakeskus 2023b).

While this growth is anticipated to boost total pulp production volumes significantly, average export prices are forecasted to decline. In autumn 2023, significant uncertainties arise from Russia's ongoing war in Ukraine and its potential ripple effects. Concerns persist regarding the duration of the conflict, the possibility of its escalation into a broader conflict, and its impact on energy availability and prices in Europe, particularly during the upcoming winter months. Although global inflation rates are expected to decelerate, unforeseen events such as heightened conflict in the Middle East could trigger inflation spikes, hindering central banks' plans to lower key interest rates. Economic downturns may fuel political unrest and protectionism, potentially leading to heightened tensions between major global powers like China and the United States. Additional uncertainty looms with the outcome of the US presidential election in late 2024. (Luonnonvarakeskus, 2023b).

3 Theoretical framework

3.1 Sustainable business transformation

Sustainability, as a megatrend, forces business organizations to transform from business-as-usual to sustainability level (Sankak, 2023). Several scientists have theorized sustainable business models and multicapitalistic and regenerative business models. Many of these theories have modelled sustainable businesses very ambitiously considering different perspectives on sustainability: environmental, social and economical. Yet those still lack a clear definition of how the business profit or economic growth are fitted to sustainable innovations (Sankak, 2023).

In sustainable transition, the business perspective is often battling with the rising expenses and the emerging, yet not large-scale, needs of the customers. Especially within the existing companies' investments in processes, supply chains and machines, and changing those creates costs. In business calculations, the return on investment (ROI) has been a basic metric for how much can a change cost and when it is supposed to return the investments put into it. The issue with sustainable business is to balance society's desire for environmental protection with the economic burden on industry (Porter & van der Linde, 1995, p. 97).

3.1.1 Regulation as a catalyst for innovation

In order to balance the issue of society's desire to balance environmental protection to the economic burden of the industry Porter and van der Linde (1995) propose that environmental regulation works as a catalyst and affects positively green business strategy. According to them, green business strategy affects positively responsible innovation, and therefore, we can expect that environmental regulation affects responsible innovation. As an example of regulation-driven innovation Porter & van der Linde (1995) used earlier phase tighter recycling standards in Germany, which pushed German companies to develop less packaging-intensive products and thus created an early-mover market advantage for them.

The study by Chen (2024) has empirically tested Porter's hypothesis, and their findings are consistent with the hypothesis. According to Chen environmental regulation significantly affects green business strategy, which is positively related to responsible innovation. This postulates that environmental regulation has an "innovation compensation" effect that promotes proactive responsible innovation to enhance differentiation.

When possible regulations should include the use of market incentives, including pollution taxes, deposit-refund schemes and tradable permits. Such approaches often allow considerable flexibility, reinforce resource productivity and also create incentives for ongoing innovation. Regulations should also encourage product and process changes to better utilize resources and avoid pollution early. Yet the regulators should also consider the technological capabilities and resources available at each stage, as it affects the likelihood that innovation will occur. If the market, technology or resources are not ready the probability for innovation to succeed decreases (Porter & van der Linde, 1995, 111).

3.1.2 Markets and customers in interrelation with policies

Huisman et al. (2024) have done research related to the combined effect of regulators's and retailers's actions to simulate consumer inertia in energy markets. European Commission (2021) has recognized consumer inertia being one of the largest market barriers in European energy markets. Especially at the Finnish energy market consumers's interest towards energy prices and green energy has grown due to the increase in consumer electricity prices and households's heating prices (Tolvanen, 2023). Understanding the interactions within regulators, market players, and consumers creates a theoretical framework. Huisman et al. (2024) have been analysing the mutual effects of the regulator's and energy retailers' actions in dynamic systems models that capture the inter-dependencies between actors and the dynamic nature of the effects. The conceptual model (fig. 5) presents the interrelations between regulators, retailers and consumers. Whereas regulator has power to retailers and consumers, the retailers have power over consumers and vice versa.

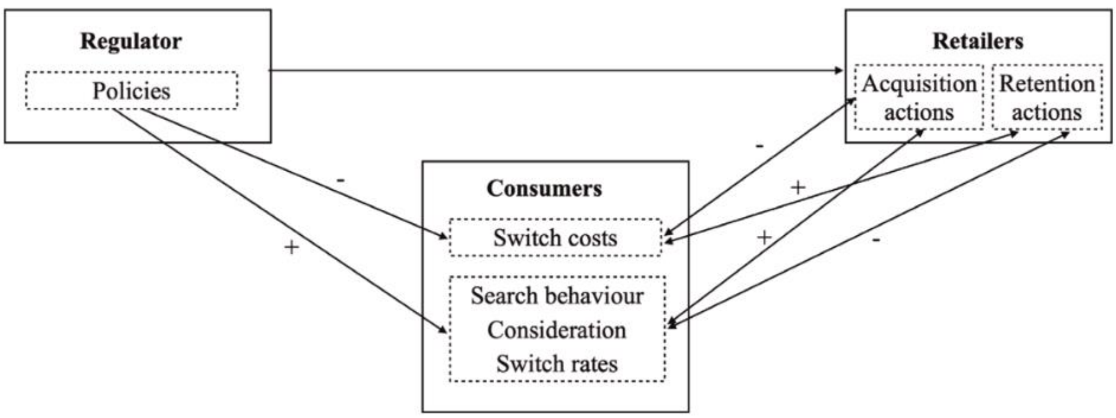

Figure 5: Conceptual model

(Source: Huisman et. al. 2024)

The findings of the research revealed that the policies implemented by regulators have distinct effects on the different forms of active consumer participation. The regulator affects consumer participation either directly or indirectly through energy retailers' actions. Huisman et. Al. (2024) conclude that retailers' acquisition and retention actions do not counteract the regulator's efforts to increase active consumer participation. While retention actions lead to decreased switching behavior, they concurrently decrease perceived switch costs while increasing search behaviour and the consideration to switch. This underscores the importance of considering a broader range of active participation forms beyond just switch rates. Regulators aim to enhance consumers' ability to actively participate in retail energy markets, which may as well result in staying with the same energy retailer or changing contracts within their current energy retailer.

3.1.3 Multi-level perspective on socio-technical transformation

The multi-level perspective (MLP) offers a framework for understanding transitions by examining interactions across three levels: niche innovations, landscape changes, and regime destabilization (Geels & Schot, 2007, 3). At the niche level, innovations gather momentum through learning, price/performance improvements, and support from influential groups. Changes at the landscape level exert pressure on existing regimes, while destabilization of the regime creates windows of opportunity for niche innovations to emerge. It explores how these processes align to enable the breakthrough of novelties into mainstream markets, challenging existing regimes. The MLP integrates empirical, analytical, and agency-focused critiques to refine its conceptualization. When these processes align, novelties can break through into mainstream markets, challenging the existing regime (Geel & Schot, 2007).

However, this conceptualization of transitions has faced constructive criticism on several fronts. Firstly, there's ambiguity regarding the application of these conceptual levels empirically. Scholars like Berkhout et al. (2004) argue that defining sociotechnical regimes at different empirical levels can lead to varying interpretations of regime shifts. What may seem like a regime change at one level could be viewed as merely incremental change at another. Secondly, there's a relative neglect of agency in representations of the MLP. Critics like Smith et al. (2005) contend that the MLP tends to be overly functionalistic, emphasizing regime transformation as a monolithic process dominated by rational action while overlooking contextual differences. They advocate for a deeper analysis of agency within the framework. (Geels & Schot, 2007).

Lastly, there's a critique of the MLP's focus on technological niches as the primary locus for regime change. Scholars such as Berkhout et al. (2004) argue that MLP approaches are unilinear, disproportionately emphasizing processes of regime change originating within niches and neglecting broader sociotechnical landscape features. To better understand these dynamics, it's crucial to consider the stability and articulation of rules within regimes and niche innovations. While regimes adhere to stable and well-articulated rules, niche innovations operate within unstable and evolving rule sets. These rules encompass regulative, normative, and cognitive dimensions, influencing behavior, values, and problem-solving approaches within sociotechnical systems. (Geels & Schot, 2007). Integrating these insights can refine the MLP framework and enhance our understanding of socio-technical transitions.

3.2 Scenario planning

Futures studies pioneer Peter Schwartz describes scenarios as ‘‘tools for ordering one’s perceptions about alternative future environments in which one’s decisions might be played out’’ (Chermack, 2005, 61). In futures studies scenario method has been hailed as “the tool par excellence” or “the archetypical product of futures studies” (Adreescu et al., 2021, 2). According to Chermack (2005) organizational leaders are constantly trying to understand the environments they are operating and thus seeking tools to explore the phenomena that affect their operating field. Scenario planning appears to have utility in planning for the future and is therefore gaining interest within the past decades. In a world that changes too rapidly for prediction to be accurate, scenarios are gaining credibility as effective tools to prepare for an uncertain future, alter mental models, test decisions, and improve performance in a dynamic environment (Chermack, 2005, 60).

At his theory of scenario planning Chermack (2005) presents five units of scenario planning: (1) scenario stories, (2) learning, (3) mental models, (4) decisions, and (5) performance. Chermack (2006) states that all scenario planning processes should have these five elements included as together they build a coherent scenario narrative that serves the purpose as a strategic decision-making device. Although scenario planning is one of the most basic, although contested, concepts in the field of futures studies the theoretical description of scenarios varies within different descriptions, and thus one definition or approach to scenarios is unavailable. Various typologies have been suggested in attempts to make the field of futures studies easier to overview, but not one typology has been defined. Börjesson et al. (2006) state that it can be useful to have more than one typology for futures studies, since different typologies have different objectives.

Börjesson et al. (2006) present a typology of scenarios that is based on the description presented by Amara dividing futures into three categories: possible, probable and/or preferable futures. According to the typology, scenarios can denote both descriptions of possible future states and descriptions of developments, and thus have divided scenarios into three main categories and their subcategories, see fig. 1. The main reason for these categories is the different approaches towards the future. They have classified scenarios as prescriptive, explorative, and normative. The classification is based on the principal questions they believe a user may want to pose about the future. These are *What will happen?, What can happen?* and *How can a specific target be reached?* (Börjesön et al., 2006, 725).

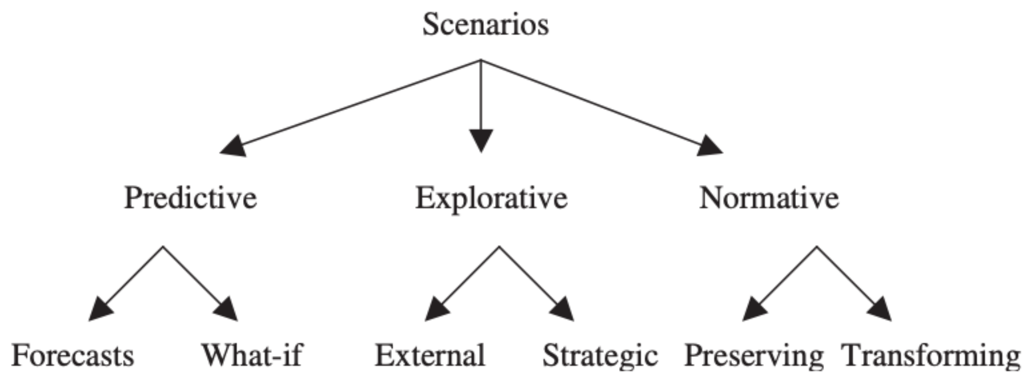

Figure 6. Scenario typology with three categories and six types.

(Source: Börjeson et al., 2006)

3.2.1 Normative scenarios

At Börjeson et al. (2006) scenario typology normative scenarios are the ones that answer the question "*How can a specific target be reached?".* They have also classified normative scenarios to consist of two different types, distinguished by how the system structure is treated. Preserving scenarios respond to the question: *How can the target be reached, by adjustments to the current situation?* Transforming scenarios respond to the question: *How can the target be reached when the prevailing structure blocks necessary changes?*

In normative **preserving** scenarios the key question is how a certain target can be met efficiently. The normative preserving scenarios are often made with quantitative modelings, but can also be done in a qualitative manner using planners or experts to make judgments on the most efficient paths to the desired future state. The outcome of this type of qualitative preserved normative scenario is a path of events creating a normative scenario. (Börjeson et al., 2006, 728-729). One risk with preserving normative scenarios, especially when observed through optimation modeling is that the thinking might be entrenched in present solutions, possibilities, and limitations. When an optimizing model is used in a normative way, the model might miss solutions that are just a little more expensive but better in some other respect, e.g. the environmental or the security performance. (Börjeson et al., 2006, 733).

In **transforming** normative scenario studies, the starting point is on a high level and with highly prioritized targets, but, typically, this target is unreachable if the ongoing development continues. (Börjeson et al., 2006, 729). In transforming normative scenarios generating techniques form the basis of the the study. Those are techniques of generating and collecting ideas, information and opinions regarding some parts of the future. Examples of such techniques are workshops, panels, and surveys. Interviews or parts of interviews can be elements in all of these techniques. Such techniques can be used for generating additional information to quantitative models. They can also be used for generating and reviewing model structures, assumptions, input data, model calculations and model results. (Börjeson et al., 2006, 730).

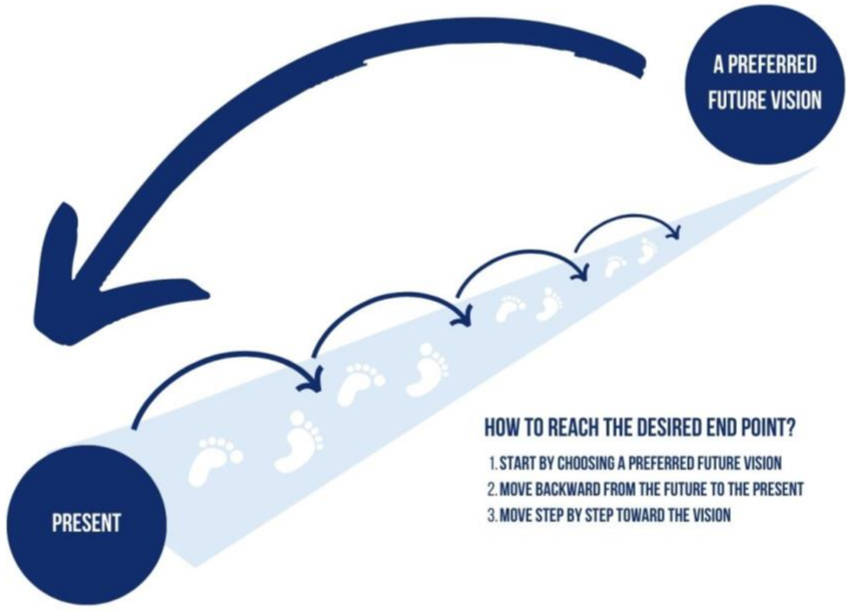

Figure 7: The idea of backcasting

Backcasting is a method used in transforming normative scenarios (Börjeson et al., 2006). Backcasting originated by John B Robinson who initially used it in his energy scenarios (Robinson, 1982). Robinson has been a prominent critic of energy forecasting, proposing the backcasting technique for energy policy analysis in multiple research articles. He argues that even with advancements in forecasting techniques, energy forecasts remain unreliable. Backcasting focuses on achieving desirable futures rather than their probability. It involves normative scenarios starting from a future endpoint, and then identifying policy measures to reach it. The aim is to explore policy implications for a preferred future, such as energy efficiency. According to Robinson backcasts are not intended to indicate what the future will be but to indicate the relative implications of different policy goals. Good backcasts can be expected to diverge, to reveal the relative policy implications of alternative energy futures. (Robinson, 1982, 337-338). Backcasting involves visioning and analyzing future alternatives, followed by pathways and strategies to reach the preferred target. (Robinson, 1982).

The major distinguishing characteristic of backcasting analysis is a concern, not with what futures are likely to happen, but with how desirable futures can be attained. It is thus explicitly normative, involving working backward from a particular desirable future end-point to the present in order to determine the physical feasibility of that future and what policy measures would be required to reach that point. (Dreborg, 1996, 814). the point of backcasting is to encourage searches for new paths along which development can take place (Börjeson et al., 2006, 729).

According to Dreborg (1996) backcasting is particularly useful approach when:

- The problem to be studied is complex.
- There is a need for major change.
- Dominant trends are part of the problem.
- The problem to a great extent is a matter of externalities.
- The scope is wide enough and the time horizon long enough to leave considerable room for deliberate choice.

The result of a backcasting study is typically several target-fulfilling images of the future, which present a solution to a societal problem, together with a discussion of what changes would be needed to reach the described images. It has a rather long time perspective of 25–50 years (Börjeson et al., 2006, 729).

3.2.2 Relevance of normative scenarios in climate change

In understanding potential future development, scenario methodology is essential to illustrate plausible pathways. Scenario analysis serves as an approach to create alternative futures, designed to capture inherent uncertainties in future system development. Given the inherent unpredictability of the future, it necessitates a conceptualization as emergent and only partially knowable. A participatory, iterative learning-by-doing approach is crucial for gaining deeper insights into the complex interplay of trends and uncertainties in foresight endeavors. (Van der Voorn, 2012, Börjeson et al., 2006)

In climate change discussions scenario analysis embraces a forward-looking perspective, flexibly envisioning potential futures, thereby addressing a departure from past and present constraints. While past events may inform future developments, major discontinuities can lead to unforeseen shifts. Discontinuous futures, though unpredictable, can be explored through context scenarios or normative scenarios, offering insights into both desirable and undesirable outcomes. Backcasting, a method focused on learning from envisioned futures to achieve management objectives amidst uncertainty, complements adaptive strategies for understanding and providing alternative routes on how the green transition can be made. Van der Voorn (2012).

Scenario development encompasses three main types: trend extrapolation, exploratory, and normative. Exploratory scenarios aim to delineate a range of potential conditions, generating alternative futures to outline a "possibility space" for societal navigation. These approaches have been valuable across various research domains, notably in transition studies. In climate change research, the IPCC's emissions scenarios, such as those in the Fourth Assessment Report, underpin long-term climate projections. These scenarios serve the dual purpose of informing IPCC assessments and providing a basis for broader analyses by the research and policy community. They aim to advance understanding of climate change impacts, adaptation, and mitigation options while facilitating analysis of environmental issues beyond climate change. (Van der Voorn, 2012)

The key impact of backcasting studies is to make change happen through visioning (Van der Voorn et al., 2017). Normative scenarios have also been considered highly suitable for addressing the potential to mobilize resources for future change (Van der Voorn et al., 2023). In climate adaptation and mitigation transformative change is required instead of adaptive change. Van der Voorn et al. (2023, 2) describe transformative change as a process that fundamentally (but not necessarily irreversibly) results in change in the biophysical social or economic components of a system from one form function or location (state) to another thereby enhancing the capacity for desired systems states to be achieved given perceived or real changes in the present or future environment.

The aim of backcasting for long-term climate adaptation is to develop long-term visions and robust adaptation pathways that could lead to such visions in a participatory manner. In contrast to other futures methods, focusing on likely or possible futures, the key distinction with backcasting is its explicit normative nature, based on setting normative goals and envisioning (un)desirable but radically different futures, by thinking radically differently about these futures and exploring how the required changes can be achieved incrementally. According to Dreborg (1996), backcasting is particularly useful when applied to complex and persistent problems, when dominant trends (climate change) are part of the problem, when externalities are at play, when there is a need for major change and when time horizon and scope allow development of radical alternative options. Climate adaptation obviously combines all these characteristics.

4 Research Design

4.1 Methodology

4.1.1 Qualitative energy and forest sector expert research

To gather the most recent signals and to fully understand the sectoral development and how the climate targets are visible inside the forest and energy sectors I decided to use the method of qualitative research to understand the phenomena and development paths of the transition. Qualitative research, especially in business research is often compared to quantitative research methods. Quantitative research has been dominating the business research field, and it's considered as the ones that provide the more rigorous results and deal with explanations of what has happened (Eriksson & Kovalainen, 2016, 4). Qualitative research methods are those providing answers to the question ***why*** something is happening, whereas quantitative methods, especially those leaning on mass data, are rather exploring ***what*** happens. The complexity of qualitative research methods is that the analysis is sensitive to the social and cultural contexts aiming at a more holistic understanding of the issues studied (Eriksson & Kovalainen, 2016, 42).

This research was conducted as semi-structured qualitative interview research. Before the research, I made extensive literature research to understand what aspects affect the transition. The qualitative research method was selected because in addition to the existing materials and policies I wanted to understand what the signals and ideas within the experts from different organizations and companies are related to the energy and forest industries. The qualitative research aimed to understand the most recent hints and thoughts that are not yet documented or reported. I also wanted to understand the thoughts and aspirations of the interviewees on their preferred future images and listen to how different the ambition and actions are perceived among the scientists and policy-makers compared to the energy and forest industries.

4.1.2 Target group sampling

I started to map out the interview target group by structuring the interviewees using PESTE framework. PESTE is a commonly used framework for horizon scanning, especially in strategic planning. PESTE covers the areas of political, economic, social, technological and environmental perspectives of the research subject (Washington State University, 2024). There are different ways to conduct PESTE analysis depending on the research subject and context. Sometimes it is seen in the form of PEST analysis, where environmental aspects are embedded into other categories, sometimes in the form of PESTEC when the sixth variable is cultural dimension and often in the form of PESTLE where legal aspects are excluded to separate inspection area (Washington State University, 2024). For this research, I decided to use the form of PESTE analysis, as the legal aspects are embedded strongly in political and thus regulative perspectives due to EU legislation and directives. Also in this research cultural variables were embedded in social variables. This framework was selected to get a wide and coherent understanding of the current topics and used for mapping out the relevant organisations for interview candidate scanning.

Table 3: PESTE Framework for interviewees

Political	Economical	Social	Technological	Environmental
Interview participants				
Ministry of Economic Affairs and Employment Sitra	Energy company’s new businesses Forest company's R&D	University of Jyväskylä	Nature and technology consulting	Forest company's nature department Forest company's corporate responsibility department

I wanted to interview experts from various fields, including political decision-making, economic perspectives from companies and policy-makers, social transitions, technological innovations, and environmental aspects. I first interviewed people who are not working in energy and forest companies to get a better picture of how transition looks from outside of the industries. The latter half of the interviews was with experts working inside the companies. Organizing the interviews in such order provided me growing understanding of the questions, hypotheses and assumptions that experts outside of the companies had that could later be discussed further with the industry experts.

The sampling of the interviewees was considered successful as I managed to find a good representation of different perspectives of experts who are working in Finnish energy and/or forest sector. The interesting finding with the sampling was, that many experts were working on both industries and that in Finland Energy and Forest sectors are strongly interlinked.

Table 4. Interviewee perspectives

Sector	Title/position	Organisation	PESTE Perspectives
Energy/Forest	Researcher	University of Jyväskylä	Economic, Social, Environment
Energy/Forest	Researcher	University of Jyväskylä	Economic, Social
Forest	Consultant	Consulting agency	Social, Technology
Energy	Senior Specialist	Ministry of Economic affairs and employment	Political, Economic, Technology
Forest/Energy	Senior Specialist	Innovation fund	Political, Economic, Environmental
Forest	R&D Manager	Forest Company, New business	Technical, Economical
Forest	Leading Nature Expert	Forest Company, Nature solutions	Economic, Environment
Energy	Head of New Business	Energy Company, New business	Economic, Social, Technological,
Forest	Sustainability manager	Forest company, Sustainability	Economic, Environment

4.1.3 Fieldwork

The data collection process began on October 2023 and the interviews took place between 23.10.2023 and 22.1.2024. The interview material consists of a total nine interviews consisting experts from both the energy and forest sectors. Many of the interviewees had experience from both sectors, and despite the interviewees being selected to represent all aspects of PESTE framework, many of them represented more than one category. All interview data has been recorded and transcribed. Interviews were conducted as semi-structured qualitative interviews mainly using video-conferencing tools. Several interviews were conducted face to face, and one interview through telephone. The average duration of an interview was a bit over an hour, ranging from 60 minutes to two hours.

The starting point for all interviews was the same, but the implementation was initially tailored to suit each interview according to the experts' profile and substance knowledge. The interview sessions were very calm and conversational, and each interview deepened my knowledge of the subject beyond the initial interview script. I rarely followed the interview script as such, but followed my intuition when something interesting came up during the discussions.

4.1.4 Additional sources of information

In my research, I incorporated also recent webinars, podcasts and reports to gain a wider understanding of various perspectives related to the topic at hand. These platforms served as valuable additions to initial qualitative interviews, offering diverse viewpoints and nuanced insights that complemented the discussions. One notable observation was the opportunity to explore emerging research initiatives through webinars and podcasts. For instance, while investigating the optimal level of wood harvesting in Finnish forests without compromising carbon storage, I discovered that two research projects related to sustainable forestry were about to begin at institutions like Sitra and the University of Jyväskylä. The opening webinar of the University of Jyväskylä's FORTRAN research program revealed that many of the questions I wanted to understand were just about to be started to research (Fortran, 2024) Webinars and podcasts provided early insights into upcoming studies, allowing me to anticipate future findings and integrate them into my research framework. During the interviews I was also guided to reports and podcasts in which the interviewees were discussing deepen about certain topics. Through these additional sources, I was able to understand how leadership in the energy and forest industry considers climate actions and what solutions they believe in.

Moreover, webinars proved instrumental in accessing the latest research outcomes and industry developments. For example, attending sessions hosted by organizations such as IBC-Carbon enabled me to stay on the map of recent findings and incorporate them into my research inquiries. By engaging with experts and scholars in real-time discussions, I gained access to timely and relevant information that enriched the depth and breadth of my research. (IBC-Carbon, 2023). Leveraging webinars, events and podcasts alongside qualitative interviews offers a multifaceted approach to knowledge acquisition in organizational research. These multimedia platforms provide access to diverse perspectives, emerging research trends, and up-to-date findings, thereby enhancing the comprehensiveness and relevance of the research outcomes.

Table 5: List of additional sources utilised for information gathering

Name of the content	Speakers	Format	Date utilised
FORTRAN lounaskollokvio	Professor Matti Mönkönen/ Univeristy of Jyväskylä, Ville Niinistö / Europeam Parliament, Annina Kostilainen / Sahateollisuus Ry	Webinar recording	12.11.2023
IBC-Carbon End Seminar	Professor Martin Forsius / Finnish Environmental Institute, Professor Markku Ollikainen / University of Helsinki	Webinar	9.11.2023
Tiedekulma: Miksi Kaikki puhuvat Vedystä	Professor Timo Räty/University of Helsinki	Webinar	17.11.2023
Fingrid visiopodcast: Pienydinvoima	Ville Tulkki / VTT	Podcast	6.2.2024
Fingrid visiopodcast: Vetytalous ja vedyn siirto	Sara Kärki / Gasgrid Finland Oy	Podcast	23.11.2023
Futucast: Mitä puusta pystyy tekemään?	Katariina Kemppainen, Head of RDI, Metsä Spring Oy	Podcast	5.1.2024
WEC Finland: puhdas siirtymä ei odota	Juha-Pekka Weckström / Ilmatar, Jukka Leskelä / Energiateollisuus Ry, Emma Kari / Kari & Pantsar Oy, Sirpa Pietikäinen / Auropeam Parliament, Joona Turtiainen / Energiateollisuus Ry, Heli Virkki / Gasgrid Finland Oy, Juho Romakkaniemi / Keskuskauppakamari, Mari Pantsar / Kari & Pantsar Oy, Petteri Laaksonen / LUT University, Sami Oksa / UPM Forest, Sakari Puito / Member of parliament, Elina Kärkimaa/ Ilmatar Energy	Event	18.3.2024
Tiedekulma: Mitä metsille pitäisi tehdä?	Raisa Mäkipää / Luonnonvarakeskus, Jyri Seppälä / Ilmastopaneeli, Annamari Laurén / Helsingin yliopisto	Webinar	25.10.2023

4.1.5 Thematic and content analysis

I conducted the research using semi-structured personal interviews. The interviews were recorded, and the recordings were transcribed into text using MS Word transcript tool. The interviews followed a daisy chain method at which the questions evolved throughout the interview process. Therefore, earlier phase interviews had a bit more limited set of questions, whereas the last ones were more rich and focused on deeper details.

The interview material has been analysed using content analysis and thematic analysis. This practice allows the material to be classified into larger entities later if needed. In qualitative data analysis, categorising the materials is not just about the data processing, or understanding the majority of the voices, but rather exploring and analysing the ideas to find new ideas and structures (Eriksson & Kovalainen, 2016). An interesting element in qualitative analysis is also to understand the elements of which the interviewees have consensus, but even more the ideas from which there's dissensus. Especially when analyzing the material for building scenarios the elements on which the interviewees are not fully agreeing on spark the questions and thoughts of alternative futures.

According to the goals of the research and the initial research questions I find that the content and thematic analysis fits into the context of normative scenario building, especially when the intention is to bring out wider narratives and understand the experiences. It should also be stated that the analysis inevitably includes the researcher's own interpretation of things and can not be fully objective.

4.1.6 Normative scenario backcasting

Out of the research material I decided to create normative transforming scenarios, as they serve as a powerful tool for advancing sustainability and achieving the goals outlined in the EU Green Deal initiatives. Unlike other types of scenarios, which focus primarily on predicting or exploring potential future development, normative scenarios are explicitly designed to articulate desirable futures and identify pathways for achieving them. By envisioning and articulating a set of aspirational goals and values, transformative normative scenarios provide a framework for guiding decision-making and policy development towards a more sustainable future.

In the context of reaching the EU Green Deal 2050 targets, the normative scenarios can play a crucial role in shaping the transition towards a climate-neutral and environmentally sustainable economy. Articulating ambitious targets and outlining pathways for achieving them helps normative scenarios to understand different development paths and how those are linked to each other. They can also catalyze mobilizing stakeholders and fostering collective action towards sustainability goals. By presenting a compelling vision of a desirable future, normative scenarios inspire to collaborate and work towards common objectives. I see that ultimately, normative scenarios empower decision-makers to chart a course towards a more sustainable, resilient, and inclusive future in alignment with the principles and objectives of initiatives like the EU Green Deal.

Based on the research material I created three alternative scenarios: regulation-driven, market & customer-driven and technology-driven using backcasting method. The regulation-driven scenario has an emphasis on the ambitious and tightening climate and nature regulation, in Finland, affected especially by the EU. Market and customer-driven scenario was inspired by several interviewees discussing the hen and egg dilemma, whether the market signals come first and how would the intentions turn into actual investments. The third, technology-driven scenario is an ode to everyone who considers themselves believing that technological solutions will solve the green transition. All scenarios follow the structure of three images of the future, which are based on the EU Green Deal climate targets and vision the years 2030, 2040 and in 2050.

4.2 Validity, reliability, and limitations

The key question when assessing the validity of qualitative research like the one conducted in this research lies in the overall perspective: whether the research is thoroughly conducted and whether the results are relevant and coherent. (Eriksson & Kovalainen, 2016). In this context it means that the discussions are not described as such, but the validity aspects appear in the form of interaction: how well my interpretations correspond to those produced by the interviewees and how well I produce these findings for others to understand. However, a single study can never produce a complete understanding of the issue. The validity question in a study like this is, in my opinion, about the accuracy of the interpretation. In the qualitative research interviews, the researchers' hypotheses and own understanding guide the research, especially at the beginning (Eriksson & Kovalainen, 2016).

One of the most challenging areas of qualitative research is to choose the optimal set of participants for the interviews. During the research interviews the ethical considerations apply to the formulation of the questions, common understanding of the terminology, and interpretations of the researcher and interviewee. If the questions are formed poorly so that the interviewee doesn't understand them fully would cause difficulty in understanding the questions. Therefore I often offered a chance to define different terms and ensure we both understand that we speak about the same thing. After all analysis of the qualitative research also depends on various things, and thus the interpretations might be different considering who is conducting the research and analysing the material. If another researcher had conducted the research the end results might be somewhat different.

5 Results

5.1 Summary of the results

The research highlights the important role of the Finnish energy sector in emission reduction efforts, both domestically and on a global scale. Interviews underscore the sector's significance in driving down greenhouse gas emissions, particularly within industrial contexts, and its profound impact on emissions across other sectors. While industrial contributions are notable, the role of households in energy transformation, particularly in areas such as demand elasticity and renewable energy production are significant.

Key technological innovations discussed include hydrogen solutions and Small Modular Reactors (SMR), with hydrogen touted as a transformative technology for clean energy but facing challenges in scaling up safely. SMR development is considered promising but still under development, and heavily influenced by regulatory frameworks and geopolitical factors. Additionally, the importance of energy networks, infrastructure, and new business models like energy-as-a-service providers are highlighted as integral components of future energy systems.

In the forest sector, interviewees recognize its dual role in climate change mitigation and biodiversity conservation. Regulatory pressures, particularly from the EU's green deal, are seen as driving sustainability initiatives, albeit with concerns about short-term disruptions. The discussion also delves into the industry's responsiveness to market demands for value-added wood products and the need for greater innovation and commercialization.

The integration between energy and forest sectors emerges as significant, given the reliance on wood biomass for energy production. However, questions arise regarding emissions accounting for new innovations and the balance between energy needs and forest conservation. While renewable energy sources present alternative revenue streams for forest owners, challenges such as the burning of wood for energy and land use changes are evident.

5.2 Energy sector results

Throughout the interviews Finnish energy sector was considered as one of the most remarkable sectors when it comes to emission cutting both globally and in Finland. The energy sectors' influence on GHG emissions decrease has been understood especially among the industrial businesses as it also has significant effects on the emissions of other sectors. Although the industrial side is remarkable, also households play a big role in energy transformation. Households are considered for example to be the area from which the largest demand elasticity can still be found. Also, the role of households as renewable energy producers, especially in solar energy production can be remarkable in the new energy equation.

"Of course, the role of the energy sector is absolutely central, yes, the majority of Finland's climate emissions still come from there. The energy sector is still a significant source of emissions, and therefore its role is also large on a Finnish scale." (E1)

In the energy sector, one of the biggest concerns is the continuous increase in total energy consumption and overall energy usage. Especially now when transportation, industries, and heating are electrifying at a rapid pace the total energy consumption should decline. During the past years, total energy consumption in Finland has decreased by a few percent, but those have been rather due to the strikes and stoppages in the forest industry in 2021 and due to the decrease in both households' and industries' energy consumption after the war between Russia and Ukraine started in 2022. Yet these changes in total consumption, especially within households saving energy in 2022 were considered as signals, that Finnish people find energy solidarity when it's incentivized properly. Otherwise, energy solidarity would require sufficiency from people on how we use energy, especially in heating.

The key technological energy innovations that were discussed in the interviews were hydrogen solutions and small modular reactors (SMR). Hydrogen solutions are considered as the core technology of the future of clean energy by all interviews. Although hydrogen isn't energy sources but rather energy storage and distribution solution it represents an existing yet developing technology. One interviewee described how *"hydrogen solutions are always ten years from now",* meaning that hydrogen has been estimated to mainstream our energy system already for decades. The consensus of the hydrogen solutions was that on the timeline it's a solution beyond 2030, as to scale it would require market signals from either the supply or demand side. The big question about hydrogen was, also how it could be scaled up in safe way. In Finland the Russian war has highlighted the security questions and uncertainties related to that. In the future Finnish energy system will be based on renewable energy sources, it is very elastic, and it's not based on burning fossils or biomass.

"Various safety-related questions are already being emphasized. Not only those related to security of supply, but also many safety questions related to hydrogen, for example, which have yet to be resolved." (E2)

Small Modular Reactors (SMR) development is considered to be currently an emerging technology yet it's still much on the drawing table. Both technologies and regulation related to SMR development are waiting to be realised in certain format. Regulation was considered to even decide the future of SMR development, as it can either start it or kill it or at least define how fast it comes to market. Like hydrogen solutions, also SMR regulation development are heavily related to safety and geopolitics. At this situation, having war in the neighboring country the security reasons are very strong in different technical developments.

Energy networks and infrastructure require, and enable new investments. With an electrifying society, the networks need to be strong and cover the entire country. Also the hydrogen network is crucial for scaling up the hydrogen solutions in the future. Future energy system is built to consider biodiversity effects, as the renewable energy system will increase land use. Also the landscape changes require sufficiency from Finnish citizens as the amount of windmills and solar energy will change how the countryside would look. The desired energy system is based on circular models and produces no waste energy. Everything that is produced to energy will be captured and reused as long as possible.

The new energy system is also expected to provide new business models like energy as service providers, who in collaboration with companies provide whole energy infrastructure, supply and reporting. Also sector integration and fading borders between different industrial players will be more common in the future. Sufficiency and how much are us humans willing to decrease well-being, like decreasing the heating at homes. This thought provoked different opinions, whether people are willing to change their habits or not. Some thoughts were given on smaller consumer behavior trends like self-sufficiency, but in general the larger changes in the energy sector will come from industrial needs and regulation.

"Instead of regulation, the force of change can be, for example, a geopolitical upheaval or how the US elections or how the reality of NATO-Finland starts to affect the green transition. In a normal situation, regulation can be the most effective, but in terms of effectiveness, external surprising changes accelerate the change, so regulation is not the only thing to look at." (E3)

In the green energy discussion, the notable fact is that nuclear energy doesn't have many opposing voices in the current landscape. In the interviews and in public discussion especially the SMR development was considered mostly interesting and attractive, even though nuclear energy has faced largely critique in the previous years.

5.3 Forest sector results

All interviewees stated that the Finnish forest sector's role is remarkable or at least somewhat remarkable at climate change. There was some discussion about the size of Finland and does that really matter in the discussion, yet the agreement was that Finnish Forest plays an important role and that sector should take climate change and global warming seriously. Another thing interviewees discussed a lot was, that the forest sector’s climate effects shouldn’t be discussed without discussing the nature effects as well. Biodiversity losses were widely understood as a large theme, and the forest sector’s role in enhancing the rich biodiversity was considered remarkable.

"Of course, global warming is a global issue, so in that big context it is not that significant. But as a large business sector, forests are one of the most important sectors, both through their end products and the growth of forests and carbon sequestration." (F1)

"What is good is that the forest industry uses renewable raw material. The flip side is that even renewable raw material cannot be used too much." (F2)

The largets pressure of sustainability transformation at the forest sector was seen to come from regulation, especially from the EU’s green deal. Market reactions were mainly considered as reactions to increasing regulations and thus considered being under the influence of those. In the forest sector regulation was seen as one of the strongest enablers for climate activities, as it forces the different players to change, but in the short term, it was also seen as a way to slow the sustainability transformation, due to increased workload and focusing on wrong things. From the regulative directives, the ones that will be affected most would be Corporate Sustainability Reporting Directive (CSRD), Deforestation Directive (EUDR), Corporate Responsibility Due Diligence Directive (CSDDD), and Packaging Material Directive.

"The biggest problem (with the Forestry sector) is that we cut down too much forest. The most significant reason that Finland is under threat is related to forestry. In practice, we should cut down less and get better value from wood-based products." (F3)

Other change drivers lifted at the interviews were increasing the value of the products created from wood. Whereas this is a discussion widely in public conversation also, the opposite opinion was that the forest industry in Finland is already very agile in developing new, more value-adding products if there’s a market demand for those. This discussion is something that would be interesting to dig deeper into and discuss with a wider group of forest industry experts, as from outside of the forest companies the whole industry was considered rather slow to change and a bit old-fashioned in their thinking and especially when thinking about climate and nature activities. A somewhat opposite opinion was from the interviewees from inside the forest industry, who considered the industry as an agile innovator who can save our national forest treasury and convert that into something valuable.

Ideas regarding the forest sector's innovations are also divided. From outside the industry, the interviewees were longing for a stronger approach to new wood-based materials innovations and especially from a business perspective innovation that would create added value to wood as a resource. From inside the forest industry, the innovation potential was seen as agile and fast-moving, yet dependent of the commercial potential of the innovations. The question left unanswered was why the forest industry hasn't been able to commercialize new innovations wider. According to one interviewee the major innovations visible outside of the industry hadn't really developed between 2007 and 2019 when they had conducted research regarding to the development of forest industry. One hypothesis presented was that it could be because of lack of diversity inside the companies. Discussion about technological innovations is full of contrasts, as digitalization has been a major theme in the forest sector and in Finland we have one of the most advanced inventories of the forest assets (Source). Yet the current solutions towards forest owners are focused mostly on presenting the financial value of the forest asset, as that has been considered as the main interest area for both forest owners and forest companies.

"The forest industry, at least in the Nordic countries, has internalized the role of a producer of sustainable solutions. It also radiates to research and product development. Serious companies enable new innovations to be made." (F4)

When asking the interviewees about their desired future of the forest sector, again the consensus aligns. All of the interviewees wish to see a forest sector that balances the nature protection and industrial use of forests. Ways to achieve that future include higher processing of wood to innovative products so that more of the value from wood would stay in Finland. Examples of that would be producing pulp for fabrics and the wood-based construction industry. In the future, the wish was that only a small minority of wood would be used for energy, and that bio-based energy would be the last adjustment force in energy production. Instead the forest industry would consist of smaller and more agile players constantly innovation new value adding products from wood and wood-based materials and industry side streams. Large forest companies could provide an ecosystem or platform to support the smaller players.

"If there are more forms of use aimed at increasing carbon sinks, the availability of wood in the market will decrease. In other words, there will be alternative forms of use where you can get the same income by leaving the trees standing, so it will be more interesting for forest owners." (F5)

In the future nature would be more valued as a provider of wellbeing and other products than wood. This would require a change in attitudes towards the forest and variation within the different voices who are discussing publicly about the forests. Now the loudest voices are within the large industrial players, but in the future also in wider groups who use and benefit from nature and forests, like artists, nature traveling companies, and the users of everyone's rights – the common people. In addition to that, in the desired future the forest would be understood and valued better as a provider of collecting items, such as mushrooms and berries, and also a provider of these. Forest ecosystems can provide many other things than just wood, and that element plays in minor role in the current forest discussion. Understanding the health benefits, diversity benefits, and consequences in case of losing it and public commodities like fresh air produced by forests require a new type of discourse in policy-making, public discussion, and industrial-level discussion of forests.

5.4 Sector integrations between energy and forest sectors

Energy and forest sectors were seen as interlinked, especially because today wood and biomass are a large part of Finnish energy production. Several interviewees also had background and experience from both sectors.

Sector integration between energy and forest sectors was considered important and strengthening in the future presenting opportunities for synergy and sustainability. Utilizing forest biomass for renewable energy production reduces reliance on fossil fuels, mitigating climate change. However, careful and sustainable forest management is crucial to balance energy needs with forest conservation goals, ensuring long-term environmental and economic benefits. Sector integration raises interesting thoughts and questions. New innovations are being developed, but it's still unclear in which sector those emissions count. If wood based textiles are created, will the emission be calculated on forest of textile industry, or both? The same dilemma applies to several new innovations, especially at the era of carbon credits.

Restrictions in forest usage and wood biomass were considered to also affect the energy sector, as there would be a need for alternative renewable energy sources. Yet with the wood energy the largest problem was considered the burning of wood, as it's the lowest value for wood so far. Whereas the side streams from forest industry were considered as tolerable to be used as energy the rest of the biomass was strongly considered more valuable as rotten wood. On the other hand, forests are already today facing changes when the energy sector changes. Renewable energy sources like wind and solar energy would require changes in land use and provide alternative revenue source for forest owners by renting the land for windmills or solar park.

In general energy sector was considered to be clearly ahead of forest sector in green transition initiatives. This was discussed to be mainly through ETS which has created market conditions for GHG emissions. Also the collaboration between different actors and coalitions around hydrogen and renewable energy sources have accelerated the change. Energy sector in Finland is also considered to be remarkable in creating a positive handprint in the climate, meaning that the solutions created in Finland could be exported and scaled in other countries.

6 Scenarios

6.1 Regulation-driven scenario

6.1.1 Costly and slow transformation through regulation

In 2050 Finnish energy sector is one of the most efficient and modern ones in the world. The clean industrial revolution has been thriving mainly due to the energy reform. ETS has forced Finnish energy sector to cut emissions and become fossil-free through increased carbon pricing. In the forest sector carbon goals have also been able to be reached, but the progress has been difficult and slow. In 2050 sanctions and restrictions on wood usage have worked and forests remain as carbon sinks again. The problem with the regulation-led transformation has been its costs and slow pace as companies are playing time with the investments required.

Table 6: Key variables in regulation-driven scenario

Sector	Key variables in 2024-2030	Key variables in 2030-2040	Key variables in 2040-2050
Energy sector	ETS reform	Resilient and decarbonised energy system	Maximise energy efficiency
	Energy efficiency	Industrial revolution to circularity	Decarbonized energy supply
	Renewables	Hydrogen and CO2 infrastructure	Smart network and interconnections
	Regulatory environment for hydrogen infrastructure and markets		Maximize renewables
	Carbon Border Adjustment Mechanism (CBAM)		
Forest sector	LULUCF emission removals	Risk management and resilience through biodiversity	Full benefits of bioeconomy
	Nature restoration law	Carbon removals and carbon farming certificate (CRCF)	Carbon capture and storage (CCS)
	Deforestation directive		Carbon capture and utilisation (CCU)
	Packaging materials directive		

6.1.2 Regulation-driven image of the future in 2030

Strong political push towards increases in renewable energy

In 2030 EU has reached the ”Fit for 55” goal meaning that the GHG emissions in the EU region have decreased by 55 % compared to the year 1990. The key player in succeeding with the goal was the European Emission Trading System (ETS) which has created functioning markets for carbon emissions. Heavy industries and transportation have been able to cut their emissions in Europe and investments in renewable energy have grown slowly. Since 2025 the newly elected European Parliament has pushed for a comprehensive political agenda favoring hydrogen energy. Member states collaborate to establish robust frameworks incentivizing investment in hydrogen infrastructure, research, and development. Tax incentives and subsidies are introduced to encourage businesses to transition to hydrogen-based technologies. Additionally, stringent regulations are enacted to limit carbon emissions, further driving the adoption of hydrogen. Through diplomatic channels, the EU actively promotes international cooperation on hydrogen initiatives, fostering a global transition towards a greener and more sustainable energy landscape.

Whereas in 2030 the green hydrogen plants in Finland are technologically still in the pilot phase due to the lack of investments from the private sector. The carbon reductions in the energy sector lean strongly on an increase in renewable energy production. In 2027 the new government decided that it was time to speed up the actions to reach the climate goals. Years of active influencing from environmental organizations had affected the industries and through that also whole business sector started demanding stronger climate politics. During 2020s Finland had lost several massive green investment projects to other EU countries and the business world got frustrated. The pressure from the business sector finally changed the political environment so that the legislation was changed to support climate and nature-friendly solutions.

To reach the carbon reduction goals set by the EU, the Finnish government has decided to increase the amount of renewable energy significantly. Yet the new nature law has clearly stated that green energy investments should be fitted to nature's reserves and cannot override nature law. For example, the marine wind energy legislation and practices are still under development in 2030 in the Finnish energy portfolio as those have faced problems with the marine ecosystem and biodiversity protection in the Baltic Sea. The sensitive nature of the

Finnish Coastline requires further research and thus marine wind energy investments have been delayed. Instead, the Finnish government has created policies and incentives to increase wind energy investments and distribution networks on the land, and solar energy investments especially in the large cities have accelerated.

In 2030 one of the Finnish government's policies for increasing renewable energy is to increase solar energy. In that initiative, households play a significant role. All major cities in Finland have accelerated the adoption of solar energy to individual households by providing tax reductions. While by 2030 this development is still progressing, the direction is towards a vast increase in solar energy. In addition to solar energy supply, many households have started to heat their houses with geothermal energy. Together ground heating, solar energy, and heat recovery solutions create new, energy-efficient households. Households can apply for support from the government, and due to the increasing energy prices, this option is attractive to many consumers. Changes in energy taxation support maximum energy production and selling the surplus energy back to the grid with reduced taxation.

In 2024, the government led by Petteri Orpo introduced tax incentives aimed at promoting large-scale clean energy transition projects. The incentive, totaling up to €150 million in tax reduction per project, was designed to encourage investments in clean energy initiatives in Finland (Valtioneuvosto, 2024). This initiative garnered significant attention, positioning Finland as an attractive destination for clean energy investments. While hydrogen solutions are still in the piloting and planning phase, by 2030 EU has created a regulatory environment for larger-scale hydrogen solutions.

Forest sector prepares for stringent nature restoration law

In the Forest sector, the pressing regulative directive from the EU is regulation and law on nature restoration. The restoration bill was declined by right-wing opposition in February 2024 and returned back to the drawing table. The key elements of the bill require action to improve biodiversity across 20% of all EU land and sea by 2030 and the incremental restoration of all degraded ecosystems by 2050. Watering down of the bill means that the nature restoration law was delayed and accepted only in 2025 after the new parliament managed to make an agreement that fit all member states. (Ympäristöministeriö, 2024).

This has left the Finnish government mostly with regulative tools of incentives. Increasing the budget by offering private forest owners incentives for protecting their forests voluntarily has been able to increase the forest carbon sinks. The pace of the nature restorations is not fast enough and to increase the forest carbon sinks the newly elected government in 2027 has decided to triple the budget for temporary protection, as it's the fastest way to retain the forest assets as carbon sinks. In Finnish regulatory discussion, one hot topic is wood-based energy. Biomass plays an important role in transforming Finnish energy systems towards renewable energy sources, yet the pressure to stop burning wood is strong and the debate continues throughout the decade.

6.1.3 Regulation-driven image of the future in 2040

Energy sector politics pushing towards emission-free energy solutions

In 2040 EU has reached the goal of reducing 90 % of GHG emissions compared to the year 1990. This has been possible with the European-wide Industrial Alliance launched and fostering collaboration among stakeholders across the EU. By 2040 European industrial sector has faced a revolution. Energy efficiency, circular processes, and renewable energy sources are the backbone of the industries. ETS has been the main tool to create demand for renewable energy, as fossil energy has simply become too expensive for industries. EU Green Deal and politics have continued the path of increasing the price of GHG emissions and tightening legislation for nature restoration and deforestation. Many of the directives set during the 2030s are now applied also to national legislation. This means energy efficiency directive, carbon border adjustment mechanism (CBAM), and deforestation (DF) directive. The countries that fail to reach the goals set are facing sanctions and even personal fines for their actions.

In Finland, this decade means expansion and scaling of hydrogen solutions. Finnish energy politics is aiming to reach carbon neutrality by 2035 (työ- ja elinkeinoministeriö, 2019), and green hydrogen solutions were key in reaching this goal. The first pilot plants in Vuosaari and in Porvoo have been able to scale up their green hydrogen production, with the support of tax initiatives set in 2030. Having the markets for hydrogen in action means that supply and demand are starting to find their balance. Investment intentions are finally turning into reality and both SSAB and a new investor from outside the EC area have decided to invest in green steel production plants in Raahe and Inkoo. By 2040 these plants will be up and running and have generated a need to increase hydrogen storage and thus renewable energy production in Finland. Due to this development, Finland will be able to cut the emissions in the Finnish energy system significantly reaching both national and EU-level targets.

The forest sector is having an era of innovations

In the forest sector, the main regulatory driver for the decade has been the newly formed and finally approved nature restoration law that forces EU countries to restore and protect 20 % of their land and forests. With the implementation of the Nature Restoration Law in Finland, the forest sector undergoes a transformative shift. Strict regulations prioritize biodiversity preservation and sustainable forestry practices. Logging in sensitive ecosystems decreases, allowing natural habitats to regenerate.

In 2030 Jyväskylä University's FORTRAN forest transition project has successfully developed advanced simulation models for Finnish forest ecosystems. The project accurately predicts the impacts of climate change, logging practices, and biodiversity conservation efforts on forest dynamics. These models provide invaluable insights for forest management strategies, balancing ecological preservation with economic sustainability. Furthermore, the project has fostered collaborations with governmental agencies and environmental organizations, leading to evidence-based policy recommendations for sustainable forest management. To safeguard Finland's rich forest biodiversity and the long-term resilience of its forest ecosystems the policy recommendations have concluded that the overall logging amount should be decreased from the current 80 million m3 to 70 million m3 and that protected areas need to be connected to ensure movement for species between forest areas. Also, the forest biomass needs to be kept at a sufficient level to ensure the biodiversity in the forest. This means that forests need to be let grow longer and that logging wood for energy or fiber use is allowed only with an exceptional permit.

In the wake of regulatory restrictions, Finland's forest management and industry undergo a paradigm shift, driving a surge in innovation. By 2040, forest companies will be at the forefront of pioneering research and development, continually launching new pilots to commercialize innovative fiber-based materials. Fuelled by EU regulations and market demands, these companies seek added value from their products, driving the transformation of the industry. With restrictions on wood usage, the focus shifts towards maximizing value from wood resources. Pulp innovations, such as textile fibers and battery materials, scale up to commercialization. Simultaneously, the Finnish government places restrictions on biomass use in energy production, leading to the emergence of valuable side-stream material innovations.

In 2040 private forest owners who in 2024 were in their 50's are now owning the forests. Their understanding of the environmental impact of the forest as well as the public commodity values has increased. Also, forest owners are wealthier than ever and thus want to protect their forests rather than sell the wood. The Finnish government has also created new initiatives through which private forest owners can create value from their forests as carbon sinks. The mechanisms that make forest growing more attractive for forest owners have transformed forest management towards a more restoring one.

6.1.4 Regulation-driven image of the future in 2050

The Finnish energy system is one of the most efficient ones in the world

By 2050, the urgency to decarbonize the energy system drives an ambitious roadmap. A comprehensive approach is essential. The regulatory environment is pushing with both incentives, restrictions and sanctions toward integrating all zero and low-carbon energy solutions including renewables, nuclear, energy efficiency, storage, CCS, CCU, carbon removals, geothermal and hydro-energy, and all other current and future net-zero energy technologies. EU outlines a strategy, emphasizing the deployment of CCS and CCU technologies for hard-to-abate sectors like agriculture and land use sectors.

In 2050, the European Union finally celebrates a monumental achievement as it officially reaches carbon neutrality. Decades of collective effort, innovation, and collaboration have culminated in this historic milestone. In Finland, carbon neutrality was achieved already in 2035 with stringent energy and forest politics and sufficient incentives for renewals. These activities have made Finland an attractive place for green investments.

In 2050 Finnish energy sector is one of the most modern in the world. It runs fully on renewable and emission-free energy and combines new technologies on both energy distribution and storing but also on the demand elasticity. This was all possible through the ambitious climate politics between 2030 and 2040 that created a favorable environment for green investments. One of the key things Finland managed to solve before other countries were energy efficiency. Market price and volatility in energy prices have led to a situation where Finns are very price-aware about the energy and demand elasticity has been found through dynamic pricing. Our rather small nation was among the first ones to create an energy distribution system in which households play a key role in the elasticity of the peak hours.

Especially during the winter, the automated heating solutions are programmed to drop the temperature by a degree or two, and households will get compensation for that.

The deployment of Small Modular Reactors has been sluggish mainly due to the economic downturn and uncertainties in geopolitics in Europe. It has been pending on the regulatory repository due to the prolonged war in Russia. The emphasis is on ensuring the highest standards of nuclear safety, environmental sustainability, and industrial competitiveness. As a result, the EU will witness the fruition of its efforts with the deployment of the first SMR projects. This milestone signifies a great leap towards achieving the decarbonization goals, propelling the EU into a sustainable and resilient energy future.

Where ETS has been one driver of the green transition it wouldn't have been able to happen without functioning energy markets. The balance between demand and supply of renewable energy as possible with tariffs, and functioning ETS reform created a price and markets for emissions, but only after the business and market balance the scaling of the system was possible.

Forest politics in favor of the nature restoration

In response to stringent regulations aimed at combating climate change, Finland's forest industry has undergone a profound transformation towards sustainability and carbon storage by 2050. The government implemented strict policies mandating sustainable forestry practices, including reduced deforestation rates, increased reforestation efforts, and the protection of old-growth forests. Forest management guidelines prioritize carbon sequestration, encouraging the growth of diverse, resilient forests with high carbon storage capacities.

The forest industry was forced to change its practices at a fast speed. They embraced innovation and invested in advanced technologies such as precision forestry, which optimizes tree growth and carbon capture. The companies that had started the development and innovation were winning. Due to the tightened regulation, wood supply was restricted and the forest industry had to create more value with less wood. Government incentives and subsidies incentivized forest owners and industry players to adopt carbon-focused practices. Carbon credits and payments for ecosystem services further incentivized forest conservation and restoration efforts. International collaborations with the EU and global partners facilitated knowledge exchange and funding opportunities for sustainable forestry initiatives. Finland emerged as a global leader in carbon-positive forestry, exporting expertise and sustainable products worldwide.

Forest management strategies prioritize ecosystem health and resilience over intensive timber production. Collaborative initiatives between government, industry, and environmental organizations promote reforestation and habitat restoration efforts. Indigenous communities gain greater recognition and involvement in decision-making processes regarding forest management. While the sector faces adjustments, the long-term benefits include enhanced biodiversity, carbon sequestration, and resilience to climate change, positioning Finland as a global leader in sustainable forest management.

As a result, Finnish forests have become significant carbon sinks, actively mitigating climate change while supporting biodiversity and rural livelihoods. The forest industry's transition to sustainability not only aligns with regulatory requirements but also positions Finland as a model for sustainable land use and climate action on the global stage.

6.2 Market-Driven Scenario

6.2.1 Decoupling economic growth and increase in emissions

In 2050 Finland is the leading European Country with its advanced green energy system. Finland has successfully managed to decouple economic growth from GHG emissions, which has been possible by renewing the whole energy system. Key drivers for the success have been large clean energy investments in the 2030s, that have revolutionized the Finnish industrial sector. The Finnish forest sector has also transformed itself cellulose provider into a new, value-adding high-end biomaterial producer. The main export products from the forest sector in 2050 are packaging materials, textile fibers, and wood-based building elements. These materials haven't just increased the value of wood but are also designed to store more carbon.

Table 7: Key variables in market-driven scenario

Sector	Key variables in 2024-2030	Key variables in 2030-2040	Key variables in 2040-2050
Energy sector	Investments in green hydrogen RDI	Green hydrogen commercial use	Green energy based industrial sector
	Investments in energy network improvements	Reductions in wood energy	Smart energy networks
	Increase in renewable energy building	Marine wind energy	CO2 synthetic fuels
	Heat pump	Increase in solar energy	
		Demand elasticity	
		Energy as a service solutions	
Forest sector	RDI of value adding products	Biomaterials innovation cluster	Revolution in forest industry
	Investments in sustainable and regenerative forestry methods development	Bio-CO2	Carbon markets for CO2
		PFO attitudes moving towards sustainable forestry	
		Remote forest ownerhip	

6.2.2 Market-driven image of the future 2030

Green hydrogen solutions are rising

In 2030 the first green hydrogen pilot plants are running in Helsinki and in Porvoo. Helen's hydrogen pilot plant 3H2 Helsinki Hydrogen Hub in Vuosaari started to operate in 2026 and in 2030 through leveraging advancements in electrolysis technology and scaling up renewable energy capacity, the plant was able to increase its capacity significantly. Where Helen's Pilot plant was the first to be running, competition has been rising as Plug Power's green hydrogen plant started their pilot plant a bit later than Helen, in 2027. While Plug Power lost the race of the first pilot plant they were faster to scale the production due to the established demand by Porvoo Kilpilahti circular economy cluster (Helen, 2024; Kilpilahti 2024; We Circle 2024) .

The successful scalability has been possible via long collaboration with industrial companies, and with investments from outside of Finland. The strategic partnerships with research institutions have also played a role and created credibility in the market. The green hydrogen economy has been in the Finnish government's agenda since the early 2020s (Työ- ja elinkeinoministeriö, 2022), and the expectation is, that after 2030 it seems to be finally breaking. Hydrogen solutions play an important role in cleaning the Finnish industries, but they require large investments from the private sector. Steel production, chemical industry, and transportation are the estimated beneficiaries of the hydrogen network. Market signals of the functioning and economically viable hydrogen plants have expanded the production of renewable energy production in Finland. In 2030 marine wind energy investments are growing, and Finland's energy independence is getting closer.

While investments in renewable energy are growing, energy consumption is decreasing and energy efficiency, especially within households is increasing. Due to the volatility in energy production and energy prices during the 2020s, in addition to the economic downturn, Finnish citizens have become very aware of the energy prices and increased energy efficiency. New digital applications are good at predicting energy production and prices, and the new normal for Finns is to plan their energy consumption days. This has made households an important player in the demand elasticity of the energy sector. Finnish households have also invested to ground heating, which has made buildings change their heating systems and by 2030 most Finnish houses will be heated and electrified by renewables. Due to the increased demand, new buildings are by default planned with ground heating, solar energy roofs, and enhanced energy efficiency.

The forest sector is facing changes in customer behavior

In 2030 Finnish forest sector is facing several market challenges. After the Russian border closed due to the war with Ukraine, the wood supply from Russia was diminished, and by 2030 it hadn't still opened, even if the war had ended. This has led to a situation where Finnish forests have been under the public eye for a decade. The key challenges are the loss of biodiversity and the decreasing carbon sinks. In the forest sector, the demand for fiber wood remains relatively high until the end of the decade, yet in 2030 the carbon sinks have decreased to an alarming level and global warming is increasing the pesticides in the economic forests.

After the closing of the Russian border, the market demand for FSC-certified wood has increased significantly as the big packaging buyers like retail chains demand more sustainable products. In 2030 wood used for packaging and buildings needs to be FSC-certified by default. This has put pressure on forest companies to increase FSC-certified forests and thus sustainable wood supply. In 2024 only 11 % of Finnish Forests are FSC certified (Forest.fi, 2022), but with active sales operations in 2030 already 50 % of Finnish Forests are within the FSC certification This has not just increased the amount of protected forest areas, but also grown the understanding of sustainable forestry among the private forest owners.

Private forest owners who in 2030 are selling 80 % of the wood to the forest industry have been following the discussion of the forests closely and the new generation of forest owners have understood how large their role in the climate change battle is. Forest ownership is renewing, generation by generation. The new ownership generation is more educated than the previous one, they live more often in the cities and are detached from their forest assets, and hold smaller forest compartments. This transition is increasing the amount of private forest owners who are no longer interested only in the financial value of their forest, but want to understand the different, more sustainable ways of forest management and how it affects the financial status of the forests. Forest owners are no longer leaning on individual forest expert's advice, but searching for information online from various sources. These changes have forced forest companies to innovate and provide new sustainable forest management solutions and create new digital services for forest management.

6.2.3 Market-driven image of the future 2040

Energy Sector is scaling the hydrogen solutions

The big question of the energy market in the 2020s was which came first – the supply or the demand. Finnish business sector was eager to see the investment intentions realized, as the industrial revolution to a zero-emission economy expected the energy sector to provide zero-emission solutions to the market. In 2030 the supply side finally won the race, with investment from multinational hedge funds. The first hydrogen energy pilot plants built in Helsinki and Porvoo started to turn investment intentions into reality, and in 2034 the Porvoo region was already using green hydrogen widely. The success story was enabling circular solutions at the regional industries and energise the Ports of Kilpilahti and Tolkkinen. As this coalition, organized and built by several rather small players surprised the business world as being the fast mover in circular energy production, the reasons were simple. The We Circle project in the Porvoo region had started to collaborate with the regional industrial companies to change not just the infrastructure but most importantly the attitudes toward circular economy. Where companies had learned to collaborate, it accelerated the pace of the transition setting an example for successful circular transition and economic growth. In 2032 SSAB finally made an investment decision to renew the Raahe Steel Factory. For Finland, this is great news, as the previous round of investment intentions was lost to Sweden and the Luulaja Steel factory in 2024 (Helsingin Sanomat, 2024).

After the first commercialized hydrogen plants, there begins to be several others, especially at the west coast of Finland. Investments in hydrogen plants have created demand also for a safe and reliable distribution network. Gasgrid was supposed to develop the Finnish hydrogen grid already at the latter half of 2020s, but the slow economic growth and lack of investments slowed the process down. Due to the increase in green hydrogen plants Gasgrid and Fingrid are in a hurry to develop the distribution networks for hydrogen, gas, and electricity. By 2040 the network covers Finland's west coast and South of of Finland all the way from Oulu to Kotka.

The forest sector is learning to collaborate

Changes in the operating environment in the Finnish forest sector have led to a situation where the forest industry requires radical and fast renewal. Changing behavior in Private forest owners as well as within the customers demanding more sustainable forest-based products are putting forest companies to face the new era. To meet the changes in bioeconomy, and still maintain the competitiveness of Finnish forest sector, the government has launched an initiative for a bioeconomy innovation cluster led by companies from different sectors interested in bioeconomy. This cluster, inspired by the success of the Hydrogen Cluster Finland (2024) aims to seek and commercialize new biomaterial-based solutions. This cluster doesn't just innovate new products from wood-based materials but also promotes Finland as a country of sustainable forestry and biomaterial producers.

In 2040, Finland's forest sector emerges as a global leader in sustainable innovation, mainly through the bioeconomy cluster. Leveraging its abundant forest resources and cutting-edge technologies, Finland pioneers a new paradigm in forest-based innovation. The initiative begins with collaboration between government, industry, and research institutions, fostering a fertile ecosystem around bioeconomy. Recognizing the forest sector's potential to address global challenges, stakeholders unite to create a shared vision for sustainable growth. Key developments include breakthroughs in wood-based materials, biorefining processes, and ecosystem services. These innovations attract investment and talent, fueling the cluster's expansion and influence. As the cluster matures, Finland becomes synonymous with forest-based innovation, exporting solutions worldwide and shaping the future of sustainable development.

In 2040 the bioeconomy innovation cluster covers over 100 Finnish companies from large forest companies to small bioeconomy startups. The first commercialized products are from the field of packaging. While the urge to reduce the amount of plastics in packaging materials is still growing due to the increasing micro- and nanoplastics problem, the wood-based packaging materials are rising. Also, the online shopping trend keeps the demand for packaging materials high. Collaborations with car manufacturers and chemical industries are providing success to the commercialization of cellulose-based medical solutions and for lignin-based carbon in electric vehicle battery material.

Woody biomass presents versatile opportunities, with byproducts like lignin and sawdust finding applications in various industries. The forest products market shows promise for growth, buoyed by consumer demand for renewable alternatives and supportive policies. Environmental considerations, including recyclability and biodegradability, are central to product development, with companies navigating barriers through policy support for bio-based alternatives. Balancing environmental impact across the product lifecycle is crucial, emphasizing the importance of sustainability measures. The decade between 2030 and 2040 means a great shift for the Forest sector. In the previous decade, pulp was the main product and its side stream of black liquor was one of the key renewable energy sources in the Finnish energy system. Now forest assets have multiple roles: the wood and wood-based renewable material production, but also an increasing role as carbon storage, a resource for biodiversity balancer, the land for renewable energy like solar and wind parks, and as a habitat for recreational and tourism practices.

Typically private forest owners in 2040 want to maximize both, the environmental and financial benefits of the forest during its lifetime. With advanced digital forest asset management solutions, forest owners can decide how they want to use their forests, and incentive models are wider than in previous decade. New service innovations have also risen throughout the forest life cycle. While forests are in the fast growth phase, the land can be protected or rented as carbon storage which was made possible by legislative changes in 2030. Continuous growth and softer harvesting practices provide financial cash flows for forest owners but also the possibility to retain the carbon storage and use the forest for recreational purposes. The forest markets are moving in the direction that both wood sellers and the buyers of wood-based products require more responsible and regenerative forest management and logging methods.

6.2.4 Market-driven image of the future 2050

Energy sector is flexibly balancing demand and supply

In 2050, Finland has achieved a groundbreaking transition in its energy system, setting an example for sustainable and flexible power generation worldwide. The shift is driven by investments in renewable energy and green hydrogen pilots. EU ETS and market demand have made the fossil-free energy system possible and economically viable. Renewable energy sources, such as wind, solar, and hydropower, dominate Finland's energy landscape, providing a significant portion of its electricity needs. These sources are complemented by hydrogen production facilities powered by renewable energy, enabling the storage and utilization of excess energy during peak production periods.

SMR's play also a role in Finland's energy mix, providing reliable and low-carbon baseload power. These advanced nuclear reactors offer flexibility in operation, allowing for rapid adjustments to match fluctuations in energy demand. Furthermore, Finland has developed a sophisticated grid infrastructure that integrates smart technologies and energy storage solutions. Demand-side management programs incentivize consumers to adjust their electricity usage based on supply availability, optimizing energy consumption and reducing waste. The flexibility of Finland's energy system enables the seamless integration of intermittent renewable energy sources while ensuring stable and reliable power supply for industries, households, and transportation. This holistic approach not only reduces carbon emissions but also enhances energy security and resilience to external disruptions. Through collaboration with international partners and continuous innovation, Finland has successfully transitioned to a renewable, hydrogen-based, and flexible energy system, serving as a beacon of sustainable energy transition for the global community.

Carbon capture technologies are rising, as the fuel industry is demanding fossil-free fuels for aviation and transportation. CCU technologies are found as a solution to transform the fuel industry toward more synthetic. Where CCU is captured from industries and utilized in synthetic fuels, it has been battling with energy efficiency issues for a long. The investments in RDI from large industrial corporations speed up the development and are now part of the energy equation.

Forest sector faces ownership and forest management changes

In 2050 forest ownership in Finland remains largely in private hands. In 2050 60 % of the forests are still owned by private forest owners, but the amount of forest owners has increased by 20% due to fragmentation of forest areas that have been inherited. In 2050 almost 800 000 Finns own forest assets, which has changed also the wood trade as the owners' values have become more and more environmentally oriented. Also, the forest assets have scattered to smaller pieces and the financial value no longer remains as the key driver for selling wood. Instead, the new forest owner generation wants to know how their wood is used. They choose to sell to a company that can provide evidence that the wood remains as a carbon sink as long as possible and that it is not used for short-term products or energy. Forest owners use digital tools to track the financial and environmental value of their forest assets. They are more educated than the previous generation, live in the cities within longer distances from the cities, and understand much better the environmental and social value of their forests.

In 2050, Finnish private forest owners find themselves at a crossroads amidst mounting pressure to preserve forest ecosystems and combat climate change. Faced with increasing awareness of the importance of forest conservation and carbon sequestration, many private forest owners across Finland choose to reject open-area logging practices. Driven by a collective commitment to environmental stewardship and sustainability, these forest owners opt instead for selective logging methods that prioritize biodiversity conservation and carbon storage. They embrace innovative forestry techniques such as continuous cover forestry and agroforestry, maintaining forest cover while harvesting timber responsibly. This shift is fueled by various factors, including evolving consumer preferences for sustainably sourced wood products, government incentives promoting forest conservation, and growing societal awareness of the climate crisis. Forest owners recognize the long-term benefits of maintaining intact ecosystems, including enhanced carbon sequestration, improved soil health, and increased resilience to climate change impacts such as extreme weather events.

While the transition away from open-area logging poses challenges for some forest owners, including potential economic impacts, many see it as an opportunity to future-proof their forests and contribute to global efforts to mitigate climate change. The decision to prioritize forest conservation over short-term gains reflects a broader shift towards sustainable land management practices, positioning Finland as a leader in responsible forestry and environmental stewardship.

6.3 Technology Driven Scenario

6.3.1 Hype and technological pilots but sluggish scalability

By 2050, Finland leads in green energy technologies, especially in green hydrogen production. Advanced technologies power massive electrolysis facilities, producing hydrogen at scale from renewable sources and driving sectoral decarbonization. Smart grid technologies optimize energy consumption, ensuring grid stability and elasticity. Technological innovations in forest management enhance sustainability, utilizing remote sensing and AI-driven analytics. Integrated biorefineries maximize resource efficiency, promoting sustainable land management. Finland emerges as a global leader in technological advancements for a sustainable future. Technological leadership has been gained by investing in research and innovations on both public sector and in private sector operators.

Table 8: Key variables in technology-driven scenario

Sector	Key variables in 2024-2030	Key variables in 2030-2040	Key variables in 2040-2050
Energy sector	Development of Green Hydrogen technologies	SMR technology development	Smart, connected and elastic zero carbon energy system
	Energy sector digitalisation and AI solutions	Commercialization of green hydrogen solutions	Advanced energy efficiency
	Service pilots for energy efficiency and demand elasticity	Demand for green hydrogen from Green steel	
Forest sector	Digital forest asset management	Advanced Precision forestry technologies utilizing AI and machine vision	Nationwide real-time forest asset data covering biomass and biodiversity
	Remote forest management solutions for PFOs	Real-time forest asset data	New technologies for efficient harvesting for continuous growth forests
	Value adding wood-based products	Commercialization of value adding wood innovations	
	Nanocellulose innovations	AI based forest biodiversity scanning and simulation	
		CCS & CCU	

6.3.2 Technology-driven image of the future 2030

Energy sector innovates at a fast pace

In 2030, the European Union has reached its Fit for 55 goal and the GHG emission in the EU region have decreased by 55 %. Finland's energy sector celebrates a significant milestone as it successfully reduced emissions, marking an essential moment in the nation's journey towards a zero-emission energy system. The key factors that contributed to this achievement were technological breakthroughs in energy storage technologies, such as advanced battery systems and hydrogen storage solutions, enabling better integration of intermittent renewables into the grid. During the 2020s Finland witnesses a substantial expansion of renewable energy, including wind, solar, hydro, and biomass. Government incentives and investment programs spur the development of new wind farms, solar parks, and hydroelectric plants, boosting renewable energy capacity across the country.

Rigorous energy efficiency measures are implemented across industries, buildings, and transportation. Retrofitting existing infrastructure with energy-efficient technologies, promoting energy-saving practices, and incentivizing the adoption of electric and hybrid vehicles contribute to reducing overall energy consumption and emissions. Transitioning to cleaner alternatives like natural gas and biogas for power generation helps lower emissions while ensuring energy security and affordability. The increasing heating costs have made ground heating attractive for households. This development has decreased the use of district heating and the new district heating system is based on thermal storage and heat recovery mechanisms. New heating innovations and electrification are decreasing GHG emissions strongly in households, and have been adopted well by Finnish people. Increased public awareness of climate change and the importance of sustainability drives demand for cleaner energy solutions. Strong public support for new renewable energy and energy efficiency technologies as well as climate action initiatives encourages policymakers and businesses to prioritize emission reduction efforts.

On the industrial side, larger-scale technological innovations like hydrogen plants and SMR development are facing new threats from national security. The extended war between Russia and Ukraine has highlighted the security aspects of especially hydrogen to the next level and extended the scale-up time of hydrogen technologies. Pilot plants have been built and are running smoothly, but the insecurity of geopolitical tensions reflects negatively in the acceptance of the new technologies.

Despite the geopolitical tensions and insecurities Finnish government is investing heavily in new energy technologies. Stringent carbon pricing mechanisms and regulations incentivize businesses to invest in cleaner technologies and practices. Carbon taxes, emissions trading schemes, and environmental regulations create economic incentives for companies to lower their carbon footprint and transition towards cleaner energy alternatives. As a result of these combined efforts, Finland's energy sector achieves a significant reduction in emissions by 2030, surpassing national targets and contributing to global climate mitigation efforts.

Forest sector innovations are taking the first steps toward commercialization.

In 2030, Finland's forest sector finds itself at the cusp of transformative technological advancements, poised to revolutionize traditional practices. While the main products of the forest sector are still pulp and increasingly packaging materials and wood construction elements, innovations are starting to arise. Emerging from the challenges of the past decade, innovative pilots are now entering the production phase, promising to redefine the industry landscape. One such innovation is the development of advanced biocomposite materials derived from wood fibers. These materials, boasting superior strength, durability, and sustainability, are set to revolutionize various sectors, from construction to automotive manufacturing. Pilot projects demonstrate the feasibility of mass-producing these biocomposites, offering a renewable alternative to conventional materials.

Simultaneously, breakthroughs in nano cellulose technology are unlocking new possibilities in product design and manufacturing. Nanocellulose-based materials exhibit remarkable properties, including lightweight, flexibility, and biodegradability, paving the way for innovative applications in electronics, textiles, and medical devices. Pilot production facilities are now scaling up to meet the growing demand for these futuristic materials.

Furthermore, advancements in digitalization and automation are streamlining forest management practices. From precision forestry techniques using drones and remote sensing to AI-driven predictive analytics for optimized harvesting, these technologies are enhancing efficiency while minimizing environmental impact. Pilot projects showcase the seamless integration of digital solutions into forestry operations, heralding a new era of sustainable resource management. As these innovative pilots are in transition into full-scale production, Finland's forest sector stands on the brink of a technological renaissance. With a commitment to sustainability and a spirit of innovation, the industry is poised to lead the way towards more sustainable forestry.

6.3.3 Technology-driven image of the future 2040

The energy sector reaches carbon neutrality through technological investments

After the successful decade of GHG emission reductions, it's time to increase the speed. As the target for the EU in 2040 is to decrease GHG emissions by 90 % compared to the year 1990, it creates a lot of pressure to continue the green transition path. In 2040 Finland's energy landscape undergoes a profound transformation driven by strategic investments and innovative research initiatives. These investments are strategically directed towards renewable energy technologies, bioenergy innovations, offshore wind farms, energy storage solutions, and smart grid infrastructure, with the overarching goal of achieving carbon neutrality by 2040.

After the economic downturn, Finland has been focusing largely on energy efficiency technologies, as the financial benefit of those are the fastest to reach. Investments in new efficient energy storage technologies, smart grid infrastructure, and digitalization solutions aim to optimize energy distribution and facilitate demand-side management. Battery storage, thermal storage, and hydrogen storage systems play a crucial role in enhancing grid stability and enabling the integration of variable renewables into the energy system. Advanced sensors, IoT platforms, and machine learning algorithms enable the development of a resilient and efficient energy network capable of accommodating renewable energy integration at scale.

The first focus is on offshore wind energy, recognizing the vast potential of the Baltic Sea. Research projects are dedicated to developing innovative wind turbine designs, floating platforms, and monitoring systems, enabling the deployment of large-scale offshore wind farms. The second investments head towards advanced solar power solutions to pave the way for the widespread adoption of solar energy across Finland. Breakthroughs in solar cells and solar panels technologies significantly enhance the efficiency and affordability of solar power generation, positioning it as one of the mainstream energy sources. The impact of these investments is multifaceted. Energy efficiency technologies together with renewable energy sources become the primary driver of Finland's electricity generation, reducing reliance on fossil fuels and lowering carbon emissions. The declining costs of renewable energy technologies make clean energy more accessible and affordable for both consumers and businesses.

In 2040, Finland embarks on a transformative journey towards a hydrogen-powered future. With increasing global demand for clean energy solutions, hydrogen plant pilots are spreading across the country harnessing Finland's abundant renewable resources. First pilot plants are now undergoing commercialization paving the way for a hydrogen grid as a key part of the Finnish energy mix. Simultaneously, Small Modular Reactor (SMR) technology takes its inaugural steps, offering a promising alternative for emission-free energy generation.

Bioenergy emerges still as a key pillar of Finland's energy transition supported by investments in biomass processing, biogas production, and biofuel technologies. By optimizing bioenergy conversion processes and utilizing diverse feedstocks such as forestry residues and agricultural waste, Finland achieves greater energy independence while reducing greenhouse gas emissions. By 2040 the strategic investments catalyze a transformative shift towards a cleaner, more resilient, and sustainable energy system in Finland. Through innovation, collaboration, and strategic planning, Finland not only achieves carbon neutrality by 2040 but also establishes itself as a frontrunner in the global clean energy transition.

Digitalization and automation technologies increase cost efficiency in the forest sector

In 2040, Finnish forest innovations and smart forest technologies have reached unprecedented heights, revolutionizing the forestry sector. A new generation of forest experts have taken over the leadership in big forest companies and the change is happening at a fast pace. After a decade of trying to advance digitalization and new technologies inside each company, the Finnish forest sector created a new alliance for automated forest management. The new alliance, led by VTT and funded by major forest companies has paved the way to monitor, manage, and innovate around forests. This new alliance is also integrating into the chemistry and energy sectors and thus providing fuel to sustainable and nature-preserving technologies.

Through relentless research and development, Finland has become a global leader in sustainable forest management practices. Advanced technologies, such as artificial intelligence, drones, and IoT sensors, are extensively utilized to monitor forests in real time, enabling precise decision-making and optimization of harvesting operations. New technologies in forest asset management and forest inventory have brought sustainable forest management to the hands of private forest owners.

Moreover, Finland's commitment to sustainability has led to the emergence of eco-friendly wood-based materials and products. Innovative companies have successfully commercialized novel solutions, including timber construction materials, bio-based textiles, and advanced packaging materials, all derived from sustainably managed forests. The integration of digital platforms and AI technology has further enhanced transparency and traceability across the forest value chain, increasing consumer confidence and bolstering Finland's reputation as a trusted supplier of forest products. Finland's smart forest initiatives have attracted significant investments and collaborations from both domestic and international partners. Finland is again at the top of the forestry expertise on the global level. Multinational corporations, research institutions, and startups flock to Finland to harness its expertise in smart forest technologies, driving economic growth and fostering innovation ecosystems.

Carbon capture & Storage (CCS) and Carbon Capture & Utilisation (CCU) are developing. The energy efficiency problems in both technologies have been solved through efficient research and innovation, and these technologies have undergone significant evolution. CCU advancements have led to the efficient conversion of captured carbon into valuable products like fuels and building materials, contributing to a growing circular economy. Meanwhile, CCS technologies have become more streamlined and cost-effective, enabling large-scale carbon capture and storage in underground reservoirs, thereby playing a crucial role in mitigating greenhouse gas emissions and combatting climate change on a global scale. These developments mark a pivotal step towards achieving sustainability and a low-carbon future, yet, notably, these technologies don't replace forests as carbon sinks. Instead, CCU and CCS technologies act as an addition to the carbon storage mix.

6.3.4 Technology-driven image of the future 2050

Finland is the leading hydrogen economy in Europe

By 2050, Finland emerges as a global powerhouse in green energy innovation, particularly in the realm of hydrogen production and utilization. Advanced technological innovations propel Finland to the forefront of the hydrogen economy, with massive electrolysis facilities utilizing abundant renewable energy sources to produce hydrogen at scale for a myriad of applications. This shift not only reduces reliance on fossil fuels but also drives sectoral decarbonization efforts, contributing significantly to Finland's ambitious climate goals.

Moreover, Finland's adoption of smart grid technologies and demand-side management strategies revolutionizes its energy infrastructure. Through the deployment of cutting-edge AI-driven energy management platforms, real-time monitoring and optimization of energy consumption become possible, ensuring grid stability and efficiency. Additionally, flexible demand-response programs incentivize consumers to adjust their energy usage patterns, further enhancing grid balancing efforts and reducing overall energy consumption.

Technological breakthroughs also extend to forest management practices, where digitalization and IoT solutions revolutionize sustainability and productivity. Remote sensing technologies, drones, and satellite imagery provide real-time data on forest health, while AI-driven predictive analytics optimize timber harvesting schedules. These innovations, coupled with advanced biomass conversion technologies and integrated biorefineries, maximize resource efficiency and promote sustainable land management practices, solidifying Finland's position as a global leader in technological advancements for a sustainable future.

In 2050 Finland is a global leader in green energy innovation, attracting global investments, creating high-quality jobs, and fostering economic growth in the clean energy sector. The accelerated deployment of renewable energy and energy storage solutions contributes significantly to Finland's ambitious climate goals, positioning the country as a model for sustainable energy transition on the international stage. Technological advancements in wind, solar, and hydroelectric power have significantly increased energy efficiency and reliability. Energy storage solutions, including advanced battery technologies and grid-scale hydrogen storage, ensure uninterrupted power supply and grid stability.

Finland has also become a global leader in green hydrogen production and utilization. Massive electrolysis facilities are built to be elastic, powered by abundant renewable energy sources, and produce hydrogen at scale for various applications. Hydrogen fuel cells power not only vehicles but also industrial processes, heating systems, and heavy-duty machinery, further reducing reliance on fossil fuels and contributing to sectoral decarbonization.

The deployment of smart grid technologies and demand-side management strategies has transformed Finland's energy infrastructure. Advanced energy systems, coupled with AI-driven energy management platforms, enable real-time monitoring and optimization of energy consumption. Flexible demand-response programs incentivize consumers to adjust their energy usage patterns, contributing to grid balancing and reducing overall energy consumption.

By 2050 Finland acts as the global frontrunner in smart and renewable energy systems, leveraging its innovative power to develop cutting-edge technologies. With a strong commitment to sustainability, Finland establishes itself as a hub for renewable energy research and development, attracting top talent and investments from around the world. Finnish companies pioneer breakthroughs in energy storage, grid optimization, and renewable power generation, they export their technological knowledge abroad, collaborating with international partners to build resilient and sustainable energy solutions. Finland's leadership in the renewable energy sector not only enhances its energy security but also contributes to the global transition towards a more sustainable future.

Smart AI-based forest management is the new normal

In 2050 digitalization and IoT solutions revolutionize forest management practices, enhancing sustainability and productivity. Remote sensing technologies, drones, and satellite imagery provide real-time data on forest health, enabling precise monitoring of carbon sequestration, biodiversity, and ecosystem dynamics. AI-driven predictive analytics optimize timber harvesting schedules, minimizing ecological impact while maximizing resource yield. The breakthrough in advanced forest monitoring technologies was possible by collaboration between public sector investments in technological development and private forest sector companies's funding.

Finland's circular bioeconomy continues to thrive, with innovative technologies driving resource efficiency and waste recycling. Biorefineries produce a diverse range of bio-based products, including advanced biofuels, biochemicals, and biomaterials, from forestry and agricultural residues. Closed-loop systems maximize resource utilization, minimize waste generation, and promote sustainable land management practices, enhancing ecosystem resilience and biodiversity.

In 2050, Finland achieves a significant carbon storage increase through advanced forest asset management and innovations in continuous growth harvesting methods. A new understanding of forest management and ecosystem services together with high-class digital asset management and monitoring has developed smaller but more cost-efficient harvesting machines. Automated smaller lightweight harvesters are using machine vision, and can smoothly travel in the forest and cut trees remaining the biodiversity at its fullest. In difficult conditions, drone-harvesting is utilized to prevent the forest land from breaking. The new technologies are making harvesting more cost-efficient for smaller areas, and thus enable continuous growth methods to mainstream in Finnish forests.

By 2050, Finland's forest industry undergoes a transformative shift, with smart utilization of the wood resources. Wood is primarily used for long-term carbon-storing materials, which doesn't just increase the capacity but also advances the biodiversity in the forests. Advanced processing techniques unlock the full potential of wood fibers, enabling their use in a diverse range of applications. From sustainable packaging materials to high-tech textiles and advanced composites for construction and manufacturing, wood fibers become indispensable in various sectors. This evolution is fueled by Finland's commitment to sustainability and innovation, driving research and development in fiber technology. With forests carefully managed for optimal production, Finland establishes itself as a global leader in sustainable materials, contributing to a circular economy and mitigating environmental impact.

Collaborative efforts between the energy and forest sectors drive the transition towards a circular bioeconomy. Bio-based materials derived from sustainably managed forests replace fossil-derived counterparts in construction, packaging, and textiles, reducing carbon emissions and promoting resource efficiency. Advanced biomass conversion technologies enable the efficient utilization of forest resources for energy production. Integrated biorefineries maximize resource efficiency by producing a range of bio-based products alongside energy generation.

In addition to healthy biological carbon storages in forests, the advanced CCU systems efficiently capture CO2 emissions from industrial power plants, utilizing it for various applications and storing it underground. Finland surpasses its climate goals, becoming a global leader in carbon capture innovation. These initiatives inspire global efforts in combating climate change, positioning Finland on the top of sustainable bioeconomy innovations.

7 Discussion

The need for different views stands high as we are on our way to a new state of social and economic development: the new era is not here yet and the old era is not yet left behind (Wilenius 2017). Futures studies exploring the possible ways to reach certain targets face many dilemmas that need to expand our thinking and creativity towards the unimaginable. The transitions in socio-technical systems involve more than just changes in technology. They are multi-actor processes that have interactions with policies, consumer practices, infrastructures, cultural meanings, and business models in addition to technological changes (Geels & Schot 2010 in Grin et al. 2010, 11). The sustainability transition is a complex, radical transformation of society towards new established socio-technical system. (Grin et al. 2010, 1).

The research revealed that complex sustainability transformation cannot be explored through one lens but needs to be perceived in a multi-dimensional way. During the research process, the key dimensions: regulation, market demand, and technological development, started to appear from the interview data revealing the relationship and dynamics of the dimensions. Integration between energy and forest sectors emerged as crucial for synergistic and sustainable development. While forest biomass remains a significant component of energy production, concerns were raised regarding the environmental implications of wood burning. Possible restrictions on forest usage and biomass extraction could necessitate alternative renewable energy sources, potentially impacting energy sector operations. Furthermore, the transition to renewable energy sources like wind and solar energy may necessitate changes in land use, offering new revenue opportunities for forest owners.

For both energy and forest sector transformation, the market demand plays a big role. Whereas regulation pushes both sectors towards more sustainable development by forcing the players to change, and new technologies act as enablers for the transition to take place, it's the market demand and customers' behavioral change that provide and make the large-scale change possible. If the transformation is forced through regulations, the lack of funding will most probably make the change slow and painful. New technologies easily rise and are full of promises, but without market demand, those will stay in the pilot phase and won't scale. Market demand alone rarely happens without a reason from either regulatory push or from new technologies and innovations that provide cost efficiency and thus replace the old ones. Efficient and rapid transformation would require actions from all three dimensions.

Based on the different materials it's evident that the green transition is in a hurry, yet both energy and forest sectors are rather slow in the changes, mainly due to the nature of the sectors and industries. Both industries would require major investments in technologies, plants, and processes to transform operations in a new direction. Typically, these processes, like building a new plant would require years or even a decade from idea to production. In that light, the year 2030 comes soon, just six years from today. Overall, sector integration poses challenges and opportunities for both energy and forest industries, necessitating careful consideration of environmental and economic implications.

Scenario thinking and different images of the future force us to contemplate alternative futures by challenging conventional modes of thinking and encouraging foresight into plausible yet divergent forms. Through scenario analysis envisioning a spectrum of potential outcomes takes form, each image facing a distinct set of assumptions, drivers, and uncertainties. This process disrupts linear thinking patterns and forces us to explore multiple pathways that deviate from historical trends or current projections. The big question in scenario building is "What if?". The normative transforming scenarios as an approach made me think of necessary steps and goals to meet the middle points to be able to go further in the development. One of the most difficult parts of the scenario-building process was to fill the gaps and search for the known unknowns. Also, the scenarios at which the middle points wouldn't be reached proposed interesting thinking patterns and further questions. Normative scenarios serve as valuable tools for challenging assumptions and biases, prompting stakeholders to question entrenched beliefs and explore new perspectives. As the end goal is set, alternative routes to that need to be found. By exploring diverse scenarios, the researcher is forced to confront inherent uncertainties and acknowledge the complexity of future dynamics, thereby fostering a more nuanced understanding of potential challenges and opportunities.

8 Conclusions

This thesis has provided perspectives on alternative future scenarios of how Finnish energy and forest sectors could meet the EU Green Deal targets for zero emissions by 2050. In understanding the different development paths this method of different experts interviewed and additional sources of research and discussions followed has provided an understanding of the alternative pathways to reach the targets set. In a complex research topic, such as sustainable development the transformative normative scenarios provide multiple possibilities to reach the targets.

To the research question: What kind of transition is required from the Finnish energy and forest sectors to meet the goals of the EU Green Deal? The research provided clear answers. The transition is ongoing and requires large changes in both the energy sector and forest sector. In the energy sector, the key is to cut down emissions. The current transition is on a good track, enabled by EU ETS. The next big move is to get market signals for new technological energy production and storage systems, especially for green hydrogen. Technological development is an ongoing process that supports and balances the dynamics of regulation and markets. In the forest sector current development is defined largely by markets, as the production of pulp is the only product growing. Forest sector is expected to face stronger regulation and restrictions on forest use in the forthcoming decades. In the forest sector technical innovations are focused on nature friendly forest management practises and value adding product innovations. The forest sector is also in the urge to innovate ways to create better value from fewer wood.

My other research question was: What kind of new perspectives can transformative normative scenarios provide for the energy and forest sector to enable the transformation? This question also provided insights through creative scenario building. In futures studies creativity plays a big role, and creating alternative pathways to the same end result is possible. The different scenarios enabled to understand the complexity of the topic, and to reveal the dynamics between the perspectives of regulation, market demand and technologies. In public discussion transformation is often simplified to one of the three, and for example the role of technology in transformation is often overemphasised, yet the role of market demand is large. Whereas regulation can shape the markets, and technologies can create new innovations to support the transition, it's after all the market players who by providing funding are in the key role for the transformation to happen in a large-scale. Scenarios providing different perspectives were able to highlight the interconnectedness of several elements and how they affect each other. The research also revealed the sector integration and dependencies of energy and forest sectors, and how these two sectors influence each other is the dynamics change.

In a complex topic, such as sustainability and climate change mitigation, one often encounters a lack of singular, definitive solutions. In qualitative interview research it became obvious, that each participant provided different perspective to the topic. The starting point and perspectives of sustainability in general and understanding of the level and speed of activities made varied among the participants. Variability in starting points, perspectives on sustainability, and approaches to meeting climate targets underscores the necessity for extensive discussion and collaboration across sectors. During the qualitative interviews, it became evident that participants possess varying understandings of sustainability, levels of urgency regarding mitigation activities, and diverse views on the ways of meeting climate targets. This diversity underscores the need for comprehensive dialogue and cooperation to develop strategies for achieving climate goals across different sectors.

However, while this research can provide insights into future development paths, it lacks a participatory element and fails to engage stakeholders in meaningful discussions about potential solutions around the same table. The potential of participatory backcasting lies in its capability to support adaptation in a participatory manner for building more resilience of socio-ecological systems in different contexts e.g., water, mobility, and forest management (Van der Voorn et. al, 2023, 16). By involving stakeholders in the process of scenario creation, decision-makers could gain insights into diverse perspectives, identify potential barriers and opportunities, and develop more robust and inclusive strategies for achieving climate goals.

Overall, while the research provides valuable insights into complex topics, such as sustainability and climate change mitigation, it would be essential to complement this research with participatory approaches that engage stakeholders in the process of scenario development and decision-making. By fostering collaboration and dialogue among stakeholders, participatory backcasting could help build resilience and adaptive capacity in the face of environmental challenges.

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Appendices

Appendix 1: Key components of the 2030 EU Green Deal "fit for 55" targets

Key components of the 2030 "Fit for 55" target	
EU Emission Trading System (ETS) reform	ETS is EU's main tool in addressing the carbon removals. New provisions of ETS include extension to emissions from maritime transport, faster reduction of emissions allowances in the system and gradual phasing-out of free allowances for some sectors, implementation of the global carbon offsetting and reduction scheme for international aviation (CORSIA) through the EU ETS, increase of funding for the modernisation fund and the innovation fund, and revision of the market stability reserve.
Social Climate fund	Ensuring a just and socially fair transition is a priority, addressing the socio-economic impacts of climate policies and supporting affected communities and workers. Proposed social climate fund will provide support to vulnerable groups most affected by this new system.
Carbon border adjustment mechanism (CBAM)	Maintaining and strengthening innovation and competitiveness of EU industry while ensuring a level playing field with third-country economic operators is emphasized. The carbon border adjustment mechanism (CBAM) aims to ensure that the emissions reduction efforts of the EU are not offset by increasing emissions outside its borders.
Member state's emission reduction targets	EU sets binding annual greenhouse gas emissions targets for member states in sectors that are not covered by the EU emissions trading system (EU ETS) or the regulation on land use, land use change and forestry (LULUCF). These sectors include: road and domestic maritime transport, buildings, agriculture, waste and small industries
CO2 emission standards for cars and vans	The regulation introduces progressive EU-wide emissions reduction targets for cars and vans for 2030 and beyond, including a 100% reduction target for 2035 for new cars and vans.
Reducing methane emissions in the energy sector	The proposal aims to track and reduce methane emissions in the energy sector. The proposal follows from the strategic vision set out in the EU Methane Strategy in 2020.
Sustainable aviation fuels	The ReFuelEU Aviation proposal aims to reduce the aviation sector's environmental footprint and enable it to help the EU achieve its climate targets by increasing the uptake of sustainable aviation fuels (advanced biofuels and electrofuels).
Decarbonised fuels in shipping	The goal of the FuelEU maritime initiative is to reduce the greenhouse gas intensity of the energy used on-board of ships by up to 80% by 2050. The new rules promote the use of renewable and low-carbon fuels in shipping.
Alternative fuels infrastructure (AFIR)	The main objective of the regulation on alternative fuels infrastructure (AFIR) is to ensure that citizens and businesses have access to a sufficient infrastructure network for recharging or refuelling road vehicles and ships with alternative fuels.
Expansion of Carbon Pricing	A new emissions trading system is introduced for additional sectors like buildings, road transport, and fuels
Emissions and removals from land use, land use change and forestry (LULUCF)	The new rules set an increased EU-level target for LULUCF of at least 310 million tonnes of CO2 equivalent net removals of greenhouse gases for 2030. Binding national targets are defined for each member state.

Renewable energy	The proposal is to increase the current EU-level target of at least 32% of renewable energy sources in the overall energy mix to at least 40% by 2030.
Energy efficiency	The new rules will accelerate energy efficiency efforts by member states by increasing annual energy savings obligations and decreasing the energy consumption of public sector buildings aiming to reduce final energy consumption by 11,7 % by 2030.
Energy performance of buildings	The main objectives of the new rules are: all new buildings should be zero-emission buildings by 2030 and existing buildings should be transformed into zero-emission buildings by 2050
Hydrogen and decarbonised gas market package	The goal is to shift from natural gas to renewable and low-carbon gases and boost their uptake in the EU by 2030 and beyond. The package consists of a regulation and a directive. The two proposals set common internal market rules for renewable and natural gases and hydrogen. They aim at creating a regulatory framework for dedicated hydrogen infrastructure and markets and integrated network planning. They also set rules for consumers protection and strengthen security of supply.

Source: European Council, 2024

Appendix 2: EU Green Deal 2040 targets

EU Green Deal 2040 targets	
A resilient and decarbonised energy system for our buildings, transport and industry.	All zero and low carbon energy solutions will be necessary (renewables, nuclear, energy efficiency, more sustainable bioenergy, storage, CCU, carbon removals, and all other current and future net-zero energy technologies). The transition away from fossil fuels will increase the EU's independence and open strategic autonomy and reduce the risk of price shocks. Solid fossil fuels should be phased out. In line with REPowerEU, gas and oil use should decrease over time in a way that guarantees the EU's security of supply. A renewable and low carbon hydrogen supply chain should contribute to seasonal storage and hard to decarbonise sectors. Electrification will be at the heart of the transition, through the deployment of recharging infrastructure, heat pumps and building insulation. The electricity sector should come close to full decarbonisation in the second half of the 2030s, with increased flexibility through smart grids, energy storage, demand response and low carbon dispatchable power energy storage. This will require an important reskilling effort in the manufacturing and servicing sectors. The 2040 climate target will require substantial expansion and upgrades of the EU's power grids and storages. Changes in the energy mix will require significant investments over the coming 10-15 years and hinge on the ability to establish the right regulatory framework, integrated infrastructure planning, competitive manufacturing and incentives for resilient supply chains.
An industrial revolution with competitiveness based on research and innovation, circularity, resource efficiency, industrial decarbonisation and clean tech manufacturing at its core.	Need for a comprehensive investment agenda to attract private capital and ensure the EU remains an attractive destination for investment for research, innovation, deployment of new technologies, circular solutions and infrastructure. An enabling framework for decarbonised industry should complement a strengthened EU industrial policy with resilient value chains, notably for primary and secondary critical raw materials, and increased domestic manufacturing capacity in strategic sectors and principle of competitive sustainability fully incorporated in public procurement. This would require well-resourced funding mechanisms at EU level and the creation of lead markets, including through public procurement rules, market-based incentives, standards and labels to steer consumption towards sustainable, near-zero carbon materials and goods. Strategic approach to securing strategic commodities on the global market through joint purchase mechanisms, as well as measures addressing competitiveness of European exports on global markets. Along targeted investment support, carbon pricing will remain a principal driver for change. The current Emission Trading Systems will need to be supplemented with the efficient use of energy taxation and the phase out of fossil fuel subsidies which do not address energy poverty or just transition.
Infrastructure to deliver and to transport and store hydrogen and CO2.	Targeted public intervention can act as a catalyst to accelerate investment, including at European level. Particular attention should be paid to the development of a smart integrated energy infrastructure at the distribution level, including for the recharging and refuelling of vehicles, and for industrial clusters, including to supply hydrogen and low-carbon feedstock to substitute fossil-based input. Urban and city planning will allow citizens and business to decarbonise their environment, be it via recharging infrastructure or district heating.
Enhanced emissions reductions in agriculture.	Agriculture plays a vital role in ensuring food security. Like other sectors, agriculture alsohas a role to play in the green transition. With effective policies that reward good practices there is room to decrease emissions from the sector faster while enhancing carbon removals in the land sector, in soils

	and forests. The agri-food value chain should be involved in order to create synergies and exploit the maximum mitigation potential. Clear policies and incentives should be put in place to realise the innovation potential in the food system and the bioeconomy at large as well as to deliver healthy and sustainable food to EU citizens.
Climate policy as an investment policy.	An additional 1.5% of GDP compared to the 2011-2020 decade should be invested annually in the transition – moving resources away from less sustainable uses like fossil fuel subsidies. A strong mobilisation of the private sector will be pre-requisite to make this possible. The private sector will deliver most of these investments if the policy framework incentivises low carbon investment and discourages carbon intensive investment, provided there is a strong business case for these investments. Dedicated policies are needed to promote the EU as a leading destination for sustainable investments. This requires a comprehensive reflection on all elements: from taxation to access to finance, from skills to regulatory burdens, and from a deepening of the Single Market to energy costs. This is a crucial element for the future success of the EU agenda and should be coordinated with EU Member States. The transition also requires smart use of public support and financial schemes to leverage private investment at scale. Public support at scale in the sectors faced with high business risks and for households, where equity is a concern, will be essential. This will require a more active engagement and less risk-aversion from institutional financial actors and notably the EIB. At the same time, public support remains crucial, and the effective use of adequate resources, including through EU funding , should form part of a reflection, to make zero and low carbon industrial projects commercially viable.
Fairness, solidarity and social policies at the core of the transition.	A climate neutral, inclusive and resilient economy will ensure the long-term prosperity and well-being of EU citizens. However, public policy and funds, as well as social dialogue, will have to tackle challenges for certain groups and regions, supporting decarbonisation investments by households. Addressing social concerns will require a clear policy focus on fairness, solidarity and social policies that not only alleviate the direct impact of carbon pricing where needed, but also allow low-income households to make the effective transition towards no carbon emissions.
EU climate diplomacy and partnerships to encourage global decarbonisation.	The EU should continue to lead by example and provide a wide-ranging contribution to achieving the Paris Agreement goals and broaden and deepen its international partnerships. It should deploy an active global carbon pricing diplomacy in synergy with other EU climate policy instruments such as CBAM.
Risk management and resilience.	The EU's natural resources are crucial to fully provide their ecosystem services, in particular in terms of controlling climate change and enhancing carbon sequestration. The implementation of the Kunming-Montreal Global Biodiversity Framework and of the EU Biodiversity Strategy will be key to achieve the EU's climate objectives, including the 2040 target. Climate change will nevertheless impact our societies for years to come, so we must prepare and adapt in parallel. Stepping up risk prevention and preparedness measures and implementing policies like water-efficiency or nature-based solutions in a coordinated manner will improve the resilience of the whole of our economy and reduce the costs.

Source: European Commission, 2024

Appendix 3: Original interview quotes in Finnish

"Tietysti, energiasektorin rooli on ehdottoman keskeinen, kyllä, suurin osa Suomen ilmastopäästöistä tulee edelleen sieltä. Energia-ala on yhä merkittävä päästöjen lähde, ja siksi sen rooli on myös suuri Suomen mittakaavassa." (E1)

"Erilaisia turvallisuuteen liittyviä kysymyksiä korostetaan jo. Eivät vain niihin, jotka liittyvät toimitusvarmuuteen, vaan myös moniin turvallisuuskysymyksiin, kuten esimerkiksi vetyyn liittyviin, jotka ovat vielä ratkaisematta." (E2)

"Muutosvoima voi olla regulaation sijaan esimerkiksi geopoliittinen murros tai miten Yhdysvaltain vaalit tai kuinka Nato-Suomen todellisuus alkavat vaikuttaa vihreään siirtymään. Normaalitilanteessa regulaatio voi olla vaikuttavin, mutta tehokkuudeltaan ulkoiset yllättävät muutokset nopeuttavat muutosta joten regulaatio ei ole ainoa jota katsoa." (E3)

"Tietenkin ilmastonlämpeneminen on globaali juttu, joten siinä isossa kontekstissa se ei ole niin merkittävä. Mutta isona liiketoiminnan alana metsä on yksi keskeisimpiä sektoreita, sekä niiden lopputuotteiden, että metsien kasvun ja hiilensidonnan kautta." (F1)

"Mikä on hyvää on, että metsäteollisuudella on käytössä uusiutuva raaka-aine. Kääntöpuoli on se, ettei uusiutuvakaan raaka-ainetta voida käyttää liikaa." (F2)

"Isoin ongelma (Metsäsektorilla) on se, että me hakataan liikaa metsää. Merkittävin syy siihen, että Suomessa on uhanalaisuutta liittyy metsätalouteen. Käytännössä pitäisi hakata vähemmän ja saada puupohjaisista tuotteista parempaa arvonlisää." (F3)

"Jos hiilinielujen lisäämiseen tähtääviä käyttömuotoja tulee lisää, niin puun saatavuus markkinoilal vähenee. Eli jso tulee vaihtoehtoisia käyttömuotoja jolloin saat samanlaista tuloa jättämällä puut pystyyn niin se tulee kiinnostavammaksi metsänmistajille." (F4)

"Metsäteollisuus ainakin pohjoismaissa on sisäistänyt roolin kestävien ratkaisujen tuottajana. Se säteilee myös tutkimukseen ja tuotekehitykseen. Vakavaraiset yhtiöt mahdollistavat uusien innovaatioiden tekemisen." (F5)

Appendix 4: Research interview questionnaire

Energia/metsäsektorin asiantuntija

1. **Haastateltavan tausta ja kokemus energia- ja/tai metsäsektorilta**

2. **Millaisena näet Suomen energiasektorin roolin ilmaston lämpenemisen hidastajana?**

    a. **Mitä haasteita ilmastonlämpeneminen aiheuttaa toimialalle?**
    b. **Mitä mahdollisuuksia ilmaston lämpeneminen avaa toimialalle?**

3. **Millaisena näet Suomen metsäsektorin roolin ilmaston lämpenemisen hidastajana?**

    a. **Mitä haasteita ilmastonlämpeneminen aiheuttaa toimialalle?**
    b. **Mitä mahdollisuuksia ilmaston lämpeneminen avaa toimialalle?**

4. **Mitä toimenpiteitä energia- ja metsäsektorilla tulisi tehdä, jotta ilmastonlämpeneminen pysyy alle 1,5 celciusasteen?**

    a. **Mitä toimenpiteitä on jo tekeillä/tulossa?**
    b. **Mitä toimenpiteitä mielestäsi tulisi tehdä lähitulevaisuudessa?**

5. **Mitä kansallisia tai kansainvälisiä poliittisia päätöksiä on vireillä jotka vaikuttavat energia- ja metsäteollisuuden tulevaisuuteen?**

6. **Millainen olisi sinun näkemyksesi mukainen ”ideaali energiasektori” 20 vuoden päästä? Entä ”ideaali metsäsektori”?**

Appendix 5: Sources for alternative sources of information

FORTRAN lounaskollokvio	https://fortran.fi/11-10-2023-metsasektorin-oikeudenmukainen-kestavyysmurros-lounaskollokvio/
IBC-Carbon End Seminar	https://www.ibccarbon.fi/fi-FI/Ajankohtaista/IBCCarbonhankkeen_tutkimustyon_tulokset_(66594)
Tiedekulma: Miksi Kaikki puhuvat Vedystä	https://www.youtube.com/watch?v=_Ry7NaRBnfE
Fingrid visiopodcast: Pienydinvoima	https://podtail.com/fi/podcast/fingrid-visiopodcast/
Fingrid visiopodcast: Vetytalous ja vedyn siirto	https://podtail.com/fi/podcast/fingrid-visiopodcast/
Futucast: Mitä puusta pystyy tekemään?	https://www.youtube.com/watch?v=wUGHhhh_bXE
WEC Finland: puhdas siirtymä ei odota	https://wecfinland.fi/tapahtumat/puhdas-siirtyma-tarvitsee-nyt-ymmarrysta-ja-hyvaksyntaa/
Tiedekulma: Mitä metsille pitäisi tehdä?	https://www.helsinki.fi/fi/tiedekulma/ohjelma-ja-sisallot/tapahtumasarjat/ymparisto-nyt/ymparisto-nyt-2023/mita-metsille-pitaisi-tehda