Publications of the Ministry of Economic Affairs and Employment • Energy • 2021:9

Summary of sector-specific low-carbon roadmaps

Ministry of Economic Affairs and Employment of Finland

Publications of the Ministry of Economic Affairs and Employment 2021:9

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Ministry of Economic Affairs and Employment, Helsinki 2021 Finland

Ministry of Economic Affairs and Employment

ISBN PDF: 978-952-327-796-0

Layout: Government Administration Department, Publications

Helsinki 2021 Finland

Description sheet

Published by	Ministry of Economic Affairs and Employment		February 2021
Authors	Mikko Paloneva and Saana Takamäki		
Title of publication	Summary of sectoral low-carbon road maps		
Series and publication number	Publications of the Ministry of Economic Affairs and Employment 2021:9		
Register number		**Subject**	Energy
ISBN PDF	978-952-327-796-0	**ISSN (PDF)**	1797-3562
Website address (URN)	http://urn.fi/URN:ISBN:978-952-327-796-0		
Pages	133	**Language**	English
Keywords	energy, greenhouse gas emissions, sectors, road maps, low carbon, greenhouse gases		

Abstract

Both the Government Programmes of Prime Minister Antti Rinne and Prime Minister Sanna Marin stated that sector-specific low-carbon roadmaps would be developed in cooperation with operators in each sector. The roadmaps' purpose was to provide a more accurate picture of the scale, costs and conditions of the measures needed to move to a carbon neutral Finland.

A total of 13 sectors prepared their own roadmap. In support of the sectors, the Ministry of Economic Affairs and Employment coordinated the project as a whole, provided guidance and held regular discussions and seminars.

The roadmaps show that the Government's goal of a carbon neutral Finland in 2035 is achievable for industry and other sectors with existing or upcoming technologies. However, the realisation of road maps requires that the investment environment is favourable and that a number of conditions are met.

The results of the roadmap work will be utilised in the preparation of the Government's climate and energy policy, the targeting of RDI investments and the preparation of a sustainable recovery. Several sectors are planning or preparing further steps on their road maps, including more thorough reviews and means to put the results into practice.

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Publisher	Ministry of Economic Affairs and Employment
Distributed by/ publication sales	Electronic version: julkaisut.valtioneuvosto.fi Publication sales: julkaisutilaukset.valtioneuvosto.fi

Kuvailulehti

Julkaisija	Työ- ja elinkeinoministeriö		helmikuu 2021
Tekijät	Mikko Paloneva ja Saana Takamäki		
Julkaisun nimi	Yhteenveto toimialojen vähähiilitiekartoista		
Julkaisusarjan nimi ja numero	Työ- ja elinkeinoministeriön julkaisuja 2021:9		
Diaari/ hankenumero	TEM105:00/2019	**Teema**	Energia
ISBN PDF	978-952-327-796-0	**ISSN PDF**	1797-3562
URN-osoite	http://urn.fi/URN:ISBN:978-952-327-796-0		
Sivumäärä	133	**Kieli**	englanti
Asiasanat	energia, toimialat, tiekartta, vähähiilisyys, kasvihuonekaasut kasvihuonekaasupäästöt		

Tiivistelmä

Pääministeri Antti Rinteen ja pääministeri Sanna Marinin hallitusten ohjelmissa linjattiin, että yhteistyössä alan toimijoiden kanssa laaditaan toimialakohtaiset tiekartat vähähiilisyyteen. Tiekarttojen avulla haluttiin saada tarkempi käsitys hiilineutraaliin Suomeen siirtymiseksi tarvittavien toimenpiteiden mittakaavasta, kustannuksista ja edellytyksistä.

Oman tiekarttansa valmisteli yhteensä 13 toimialaa. Toimialojen tukena työ- ja elinkeinoministeriö koordinoi kokonaisuutta, tarjosi ohjeistusta sekä järjesti säännöllisesti erilaisia keskustelutilaisuuksia ja seminaareja.

Tiekartat osoittavat, että hallituksen tavoite hiilineutraalista Suomesta 2035 on teollisuuden ja muiden toimialojen osalta saavutettavissa olemassa olevilla tai näköpiirissä olevilla teknologioilla. Tiekarttojen toteutuminen edellyttää kuitenkin, että investointiympäristö on suotuisa ja useat reunaehdot toteutuvat.

Tiekarttatyön tuloksia hyödynnetään hallituksen ilmasto- ja energiapolitiikan valmistelussa, TKI-panosten suuntaamisessa ja kestävän elvytyksen valmistelussa. Useat toimialat suunnittelevat tai valmistelevat tiekarttatyölle jatkoaskeleita, joihin kuuluvat erilaiset syventävät tarkastelut ja keinot tulosten jalkauttamiseksi.

Työ- ja elinkeinoministeriön yhteyshenkilö: Juhani Tirkkonen, p. 029 506 2140

Kustantaja	Työ- ja elinkeinoministeriö
Julkaisun jakaja/myynti	Sähköinen versio: julkaisut.valtioneuvosto.fi Julkaisumyynti: julkaisutilaukset.valtioneuvosto.fi

Presentationsblad

Utgivare	Arbets- och näringsministeriet		februari 2021
Författare	Mikko Paloneva och Saana Takamäki		
Publikationens titel	Sammandrag av sektorspecifika färdplaner för ett koldioxidsnålt samhälle		
Publikationsseriens namn och nummer	Arbets- och näringsministeriets publikationer 2021:9		
Diarie-/ projektnummer		**Tema**	Energi
ISBN PDF	978-952-327-796-0	**ISSN PDF**	1797-3562
URN-adress	http://urn.fi/URN:ISBN:978-952-327-796-0		
Sidantal	133	**Språk**	engelska
Nyckelord	äxthusgasutsläpp, energi, branscher, färdplaner, koldioxidsnålhet, växthusgaser		

Referat

I regeringsprogrammen för statsminister Antti Rinnes och statsminister Sanna Marins regeringar fastställs att sektorspecifika färdplaner för ett koldioxidsnålt samhälle kommer att utarbetas i samarbete med branschaktörer. Syftet med färdplanerna är att ge en närmare uppfattning om omfattningen av samt kostnaderna och förutsättningarna för de åtgärder som omställningen till ett klimatneutralt Finland kräver.

Sammanlagt 13 branscher beredde sin egen färdplan. Arbets- och näringsministeriet stödde branscherna genom att samordna helheten, ge anvisningar och regelbundet ordna olika diskussionsmöten och seminarier.

Färdplanerna visar att regeringens mål om ett klimatneutralt Finland 2035 kan nås i fråga om industrin och andra branscher med befintlig teknik eller teknik som är under utveckling. Genomförandet av färdplanerna förutsätter dock att investeringsmiljön är gynnsam och att flera specialvillkor uppfylls.

Resultaten av arbetet med färdplanen utnyttjas vid beredningen av regeringens klimat- och energipolitik, vid inriktningen av satsningarna på forskning, utbildning och innovationer och vid beredningen av en hållbar återhämtning. Flera branscher planerar eller bereder fortsatta steg i arbetet med färdplanen, bland annat olika fördjupade analyser och metoder för att förankra resultaten.

Kontaktperson vid arbets- och näringsministeriet: Juhani Tirkkonen, tfn 0295 062 140

Förläggare	Arbets- och näringsministeriet
Distribution/ beställningar	Elektronisk version: julkaisut.valtioneuvosto.fi Beställningar: julkaisutilaukset.valtioneuvosto.fi

Contents

Summary

"The government will work to ensure that Finland is carbon-neutral by 2035 and carbon negative soon after that."

This objective of a carbon-neutral Finland by 2035 was announced in the programme of Antti Rinne's government on 3 June 2019 and restated in the programme of Sanna Marin's government on 10 December 2019. The government programmes also stated that sector-specific roadmaps to low-carbon operation would be prepared in cooperation with the sector's operators. The roadmaps would be used to achieve a better understanding of the scale, costs, and conditions of the required actions.

A total of 13 sectors produced their own roadmaps in coordinated cooperation. In addition, bio energy association and one labour organisation published reports to contribute to the roadmap project. The sectors had independent control over the drafting and execution of their roadmaps – the guiding principle was that each sector would know their field the best.

The sectors coordinated the production of their roadmaps internally by engaging with and listening to different operators at different stages of the process. In addition to project managers and steering groups assembled by the sectors, consultants and trade association committees were particularly important actors. Some sectors also organised workshops, discussions, avenues for comment, and member surveys to enable them to extensively listen to their membership and stakeholders.

The Ministry of Economic Affairs and Employment (MEAE) supported the sectors by coordinating the whole project, offering guidance, and arranging regular discussions and seminars. Additionally, the sectoral ministries participated in monitoring the roadmap efforts and/or the utilisation of the results in their sectors.

The MEAE prepared instructions for the basis and recommended content at the start of the roadmap project. This was done to make the roadmaps comparable and their results useful. The same questions arose repeatedly during the work's planning, and in the autumn of 2019, the MEAE published a list of frequently asked questions to support the work of the sectors.

The MEAE emphasised repeatedly that the roadmaps should be as ambitious as possible while remaining realistic. Only realistic roadmaps would be relatable for the sector's operators and make their results useful for follow-up.

Typically, the roadmaps include a comprehensive description of the current situation, an evaluation of emission-reducing technologies and measures, and an estimate of achievable reductions. The roadmaps also use scenario analysis to assess coming developments. The scenarios include a baseline that depicts the effect of the current operating environment, and nearly all roadmaps included one or two low-carbon scenarios.

Roadmap results

The electrification of industry and the rest of society makes significant greenhouse gas emission reductions possible in several sectors. According to the roadmaps, electrification could mean a 100 per cent leap in industrial electricity consumption and an increase of over 50 per cent in Finland's national energy consumption by 2050. Major investments will be required to build low-emission electricity production capacity and to expand the transmission network.

As a result of electrification, emissions from other sectors will largely depend on the climate measures taken by the energy industry. Reducing emissions from energy production will significantly lower the indirect emissions from purchased energy in other sectors.

The low-carbon trend in the energy industry is part of a larger transformation in energy that is drastically cutting the emissions of energy production. This energy transformation is made possible by the smart integration of sectors, energy consumers changing their roles to become energy storers and producers, and innovative solutions. "Sector integration" refers to the coupling of industry, transport, and heating through electrical, district heating, and gas networks.

Realising the roadmaps will require considerable investment. The investment cycles in industry are long, and the effect of today's investments will be seen for decades to come. Some investments will be made as part of normal development, but less-profitable investments will require government support.

In most cases, the roadmaps include either quantitative or qualitative assessments of future investment needs. Low-carbon energy production, fundamental changes in processes, energy efficiency upgrades, and investments in technology were highlighted in the investment needs identified by the sectors. The roadmaps avoid speculating on specific investments for which companies have not released information.

Technological solutions, some of which are still in development or not yet commercialised, are the focus of emission reductions in many sectors. The roadmaps repeatedly mention technological solutions related to low-emission energy production, energy and materials efficiency, alternative power sources (e.g. biofuels, hydrogen, and electrification), the exploitation of waste heat, and the capture and utilisation or storage of carbon dioxide (CCU and CCS, respectively). Many roadmaps also recognised the potential of various smart solutions and digitalisation. The examples used included the use of IoT and AI, smart automation and control systems, robotics, and cloud services. Several roadmaps also emphasised low-carbon materials and changes in the raw material pool.

The allocation of research, development, and innovation (RDI) investments is one of the essential questions for promoting reduced carbon emissions. Typically, the roadmaps suggested that the need for RDI investments would increase. Some roadmaps underlined the even distribution of development investments over the stages of the RDI process: basic research, pilots, commercialisation, and the development of new business models.

A fair transition is important as society becomes low-carbon. This includes society supporting the opportunities of workers to update their skill sets and retrain. A fair transition also means a comprehensive policy of adjustment that takes a wide view of the structural changes in society and aims to build a society with social and regional viability.

Key conclusions

The following important conclusions can be drawn from the roadmaps:

- The roadmaps show potential for significant reductions in greenhouse gas emissions in different sectors. The government's objective of a carbon-neutral Finland by 2035 can be achieved in industry and other sectors with existing technologies or those on the horizon, assuming favourable conditions for investment.
- The objective of a carbon-neutral Finland by 2035 is so ambitious that emissions need to be reduced in every sector. Although the emissions vary widely in scale by sector, having all of them contribute is necessary and valuable.
- The impact of individual investments on future emissions is great, and hence, emission reductions often happen in steps rather than in a linear fashion.
- Many conditions must be satisfied for the roadmaps to be realised. A friendly and predictable business environment, RDI investments, available skilled labour, and smooth regulation are essential. Furthermore, success requires the sectors to commit firmly to follow-up efforts.
- The energy transformation required for the objective of carbon neutrality depends on the availability of affordable and reliable electricity. Integrating various sectors, developing energy networks, and dismantling administrative obstructions are key to accelerating the energy transformation. The coupling of sectors will enable significant reductions in emissions as the electrification of society progresses.
- The allocation of RDI investments is an essential question for a low-carbon future, as it will decide future development. Investment cycles in industry are long, and carbon lock-in must be prevented.
- The technological solutions recurring in the roadmaps are related to low-emission energy production, energy and materials efficiency, alternative power sources (e.g. biofuels, hydrogen, and electrification), the exploitation of waste heat, and the capture and utilisation or storage of carbon dioxide (CCU and CCS, respectively).
- In future, the boundaries between sectors and operators will blur, interdependence will increase, and seamless cooperation with decision-makers will become more important.

- The "carbon handprint", meaning positive climate impact, of current and emerging products is immense, and clean solutions offer export opportunities and new business. Finland can punch above its weight as a provider of solutions for climate change mitigation.
- Profitable business and solving the climate crisis are not mutually exclusive – on the contrary, the business community sees carbon-neutral solutions as a competitive advantage for Finnish industry.
- The roadmaps include several uncertainties, as the analysis concerns a long period of time and many factors are not controlled by Finnish operators. Additional limitations were imposed by the lack of initial data and the quick pace of the production.

The next steps

The results of the roadmap project will be used as direct input for the government's climate and energy strategy, which is currently being prepared under the MEAE, and many other government plans related to energy and climate policy. Furthermore, the roadmaps will guide the allocation of RDI investments and the preparation of sustainable recovery measures, for example.

Multiple sectors are planning or preparing follow-ups for the roadmaps, which include various indepth analyses and ways to use the results. The plans also include developing tools for members (e.g. carbon handprint and Scope 3 emission calculators) and beginning a systematic dialogue with stakeholders. Many sectors find it challenging to make use of the results – and to reach small and medium enterprises in particular – which further underlines the need for follow-up.

1 Introduction

"The government will work to ensure that Finland is carbon-neutral by 2035 and carbon negative soon after that."

This objective of a carbon-neutral Finland by 2035 was announced in the programme of Antti Rinne's government on 3 June 2019 and restated in the programme of Sanna Marin's government on 10 December 2019. The government programmes also stated that sector-specific roadmaps to low-carbon operation would be prepared in cooperation with the sector's operators.

An enormous transformation is needed to make society low-carbon. This transition is also a great opportunity for Finland, as the same solutions will be necessary in other countries as well. A better understanding of the scale, cost, and conditions of the required actions was sought through the roadmaps.

The production of the roadmaps was based on the principle of each sector knowing their field the best. Sector-driven production offered a new perspective for the government and elucidated the scope of the required change. Furthermore, this strengthened the sectors' commitment to reducing emissions.

Roadmaps were produced in coordinated cooperation by 13 sectors: energy, chemical, forest, technology, food, logistics and transport, agriculture, hospitality, commerce, textile, sawmill, construction and built environment, and property owners and developers. In addition, the Bioenergy Association of Finland and the Central Organisation of Finnish Trade Unions SAK published reports to contribute to the roadmap project.

The Ministry of Economic Affairs and Employment (MEAE) supported the sectors by coordinating the whole project, offering guidance, and arranging regular discussions and seminars. Additionally, the ministries responsible for these sectors monitored and participated as appropriate in the preparation of the roadmaps in their respective areas. The target for completing the roadmaps was June 2020, which was set to ensure that their results could be fully utilised in the preparation of the government's climate and energy policy.

Some sectors had begun planning their roadmaps prior to the announcement of prime minister Antti Rinne's government programme or started it soon after that. For most of the sectors, the work started in autumn 2019 or in early 2020. The coronavirus pandemic that broke out in the spring of 2020 posed its own challenges, as specialists started working from home en masse and many events became webinars.

Despite the demanding schedule and the coronavirus pandemic, nearly all roadmaps were completed on time. The majority of the roadmaps were published in May or June 2020, and the final project seminar was held as a webinar on 9 June 2020.

Multiple sectors are planning follow-ups for the roadmaps, which include various indepth analyses and ways to use the results. The government is using the roadmaps in preparing its climate and energy policy, industrial policy, RDI policy, and recovery measures.

This report describes the content of the roadmaps and how the project progressed. Chapter 2 explains the role of the government and gives a general overview of the sectors' processes. Chapter 3 covers the project's premise and methodology. Chapter 4 is a summary of the primary results, while chapter 5 has abstracts of each roadmap. Chapter 6 describes the preliminary plans the sectors have for roadmap follow-ups. The appendices go into more detail about the original MEAE instructions for the basis and content, as well as the sectors' internal processes for producing the roadmaps.

2 Roadmap production

2.1 Government support and coordination

The ministries responsible for the sectors participated in the monitoring of their sector's roadmap efforts and/or the utilisation of the results as follows:

- **Ministry of Transport and Communications:** logistics and transport industry
- **Ministry of Agriculture and Forestry: a**griculture and parts of other food supply chain sectors (food industry, commerce, and hospitality industry)
- **Ministry of Economic Affairs and Employment:** energy, chemical, forest, technology, food, hospitality, commerce, textile, and sawmill industries
- **Ministry of the Environment:** construction industry, property owners and developers.

The Ministry of Economic Affairs and Employment was in charge of coordinating and monitoring the roadmap project as a whole. The method used was light coordination, where the MEAE offered instructions and arranged regular discussions and seminars. The sectors had independent control of the drafting and execution of their roadmaps.

The sectors were divided into two groups for light coordination by the MEAE. One group included large, energy-intensive sectors – energy, chemical, forest, and technology – who prepared their roadmaps in close cooperation and were the first to start the work. The other group consisted of nine sectors, which started later. The energy industry was also invited to participate in the second group, as the production structure and specific emissions from energy production have a substantial impact on the greenhouse gas emissions of purchased energy.

The MEAE organised meetings for both coordination groups every one to two months. Early in the project, the meetings of the energy-intensive sectors in particular focused on technical questions, such as how to limit the analysis and define scenarios. As progress was made, the meetings increasingly focused on the results of the roadmaps and their publication.

The other sectors' meetings explored questions regarding the preparation of the roadmaps more broadly. Some meetings included a detailed presentation from one of the sectors, but the main emphasis was on tour-de-table rounds and discussion. The participants thought the events were useful[1], which is likely explained in part by the fact that climate issues and a scenario-based approach were less well known in some sectors. The sharing of plans, experiences, and learning were also considered valuable, along with the opportunity to network.

The all-sectors communication group prepared the MEAE seminars and the publication of the results. The group would typically meet before the seminars.

In November 2019, the MEAE organised a discussion on the topic of a fair transition. This discussion delved into the impact of climate action on employees and the skill requirements related to climate change mitigation. Representatives of both employee and employer associations were invited to the event.

The progress of the roadmaps was reported to the Ministerial Working Group on Climate and Energy Policy and to the contact network for the sector's civil servants. The roadmap results were presented in the government's evening session on 24 June 2020.

2.2 Seminars and communication

The progress of the roadmaps was presented to the stakeholders in four seminars. The first two were held in the restaurant of the Helsinki Music Centre, which was completely filled on both occasions. The last two events were webinars due to the coronavirus situation, which further increased the number of participants. Better

1 Ministry of Economic Affairs and Employment interviews with roadmap authors, summer 2020.

media coverage was achieved due to the work being publicised by the sectors in addition to the government.

The seminars and other stakeholder events were seen as one important reason for the project's success[2]. First, the social discourse inspired by the project and the acquisition of knowledge were essential, considering the scale of the required low-carbon transition. Second, the media coverage and the participation of multiple sectors in the roadmap project generated positive peer pressure. This has encouraged new sectors to prepare roadmaps and potentially motivated the current participants. Third, the broad exposure supported the post-completion phase of the roadmaps: their deployment into companies.

The chemical, technology, forest, and energy industries (the first to start their roadmaps) presented their plans for executing the roadmaps at the starting seminar of the roadmap project on 23 September 2020. The "Change Paths to Success" panel at the seminar also discussed different viewpoints on decarbonisation.

A review of the progress in creating the roadmaps was heard on 28 January 2020 in the "Toward Low-carbon Technologies" seminar. Technical solutions were presented by various sectors, from export to construction and commerce. Panels discussed the role of the private and public sectors. Many speakers emphasised the importance of technological solutions in reducing greenhouse gas emissions, as well as the opportunities they may create for exports and new business.

The "How Much Energy is Enough?" seminar was postponed by over a month because of the coronavirus pandemic, and finally held as a webinar on 5 May 2020. The seminar revolved around the supply of and demand for clean energy in a low-carbon society. This theme had been prominent in the preliminary results of multiple roadmaps. Many spoke of the role of electrification in reducing greenhouse gas emissions and the resulting surge in electricity consumption.

The 13 sectors that had prepared their own roadmaps presented their key findings in the final seminar of the roadmap project on 9 June 2020. The presentations suggested

2 Ministry of Economic Affairs and Employment estimate and interviews of roadmap authors, summer 2020.

that the roadmaps showed potential for widespread emissions reduction, but that realising them would require the government and companies to work together.

2.3 Internal sector roadmap coordination and process

The sectors coordinated the production of their roadmaps internally by engaging with and listening to different operators at different stages of the process. Aside from the steering groups assembled by the sectors, consultants and trade association committees were important actors (see Figure 1). Appendix 3 goes into detail about the process of producing the roadmaps..

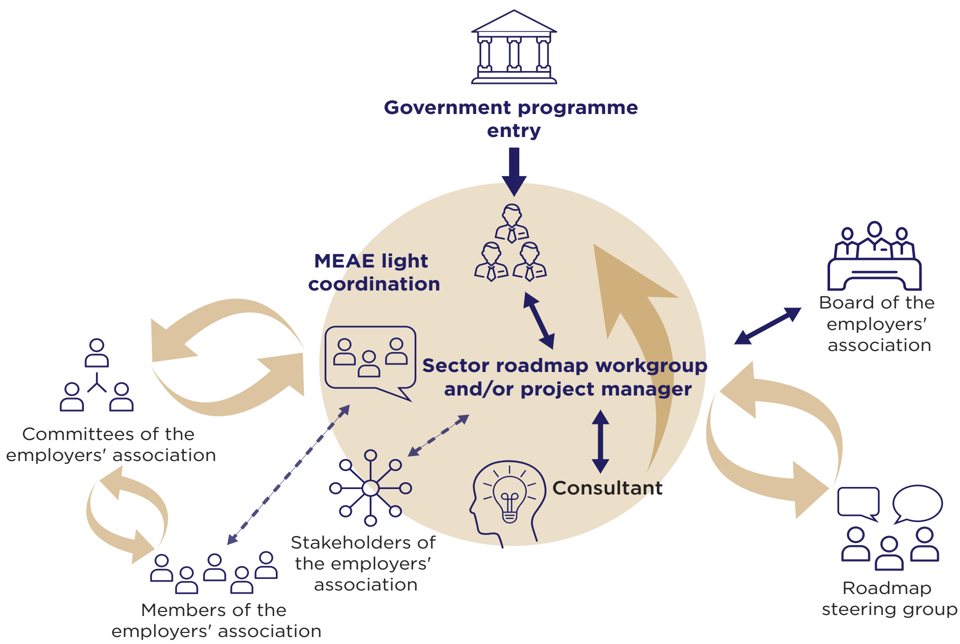


Figure 1. Roadmap coordination and the roles of different operators.

Typically, the steering groups included representatives of member companies and key stakeholders, and the steering group was coordinated by the roadmap project's project manager. The size, activity, and role of the steering groups varied between sectors. Their core task was to provide viewpoints and comments from companies in the sector on the roadmap's content. The committees were used to inform, and they were effective in reaching people responsible for themes inside the industry, such as future needs for knowledge and skills. Some sectors also organised workshops, discussions, avenues for comment, and member surveys to enable them to extensively listen to their membership and stakeholders.

The sectors prepared the roadmaps in close cooperation with a consulting firm of their choice. The consultants were either partially or fully responsible for collecting and analysing the data as well as creating scenario models, depending on the sector, and also for background studies in some cases. Many sectors chose to use the same consultants, which made the roadmaps more comparable and their methodologies more compatible. In addition, some sectors met outside the discussions organised by the MEAE to avoid their roadmaps overlapping.

The MEAE interviews indicated that functional cooperation with the consulting firm, a shared commitment to decarbonisation, and clear but sufficiently unrestricted instructions from the MEAE were seen as the most important factors for the success of the roadmap project. The scope of the roadmap project and how to limit it, the tight schedule, and the various challenges posed by the coronavirus pandemic were seen as the biggest challenges for the work.

3 Methodology

3.1 Central premise

Each sector prepared their own roadmap. The MEAE emphasised repeatedly that the roadmaps should be as ambitious as possible while remaining realistic. Only realistic roadmaps could be adopted and deployed by operators in the sector. A realistic approach was also required for the results to be useful in climate and energy policy scenarios and for the groundwork for the policy environment.

In general, companies will only carry out emission reduction measures if they are profitable, financially feasible, or a statutory requirement. For the preparation of future policy measures, the MEAE and other ministries need to identify the conditions for realising the investments required to transform the sectors.

Typically, the roadmaps include a comprehensive description of the situation at present, an evaluation of emission-reduction technologies and measures, and an estimate of achievable reductions. The roadmaps also use scenario analysis to assess coming developments. The scenarios include a baseline that depicts the effect of the current operating environment, and nearly all roadmaps included one or two low-carbon scenarios. The scenarios are analysed further in subchapter 3.3 and Appendix 2.

The time span of most roadmaps extended to 2050[3] . Particular attention was paid to 2035 – the government's target year for Finland to be carbon-neutral. In addition,

3 The baseline scenario ended in 2035 in two roadmaps, in 2040 in one roadmap, and in 2050 in ten roadmaps. Eleven roadmaps presented at least one quantitative low-carbon scenario. Their time spans reached 2035 in three roadmaps, 2040 in one roadmap, and 2050 in eight roadmaps.

some sectors evaluated 2030 and 2040 for government programme targets for the path to carbon neutrality, due to be set in the amended Climate Change Act.

The goal of carbon neutrality by 2035 is for Finland as a whole, but not every industry may need to be carbon neutral by this deadline. The MEAE instructed the sectors to evaluate how much and how soon they could reduce their greenhouse gas emissions.

Due to the analysis reaching all the way to 2050, the results include significant uncertainty. Furthermore, how the scenarios play out depends on multiple factors, many of which are not in the hands of a given industry's Finnish operators. This underlines the role of the roadmaps as guidelines, not commitments.

3.2 Content and scope definition

The content and scope of the roadmaps vary between the sectors. Topics covered in particular by multiple roadmaps:

- Description of the current situation. For example, a categorisation of sector operators in practical clusters, sources of greenhouse gas emissions, and the structure of energy consumption.
- Measures for reducing greenhouse gas emissions, including but not limited to technological solutions.
- Baseline and low-carbon scenarios for estimating potential developments from the perspective of energy consumption, greenhouse gas emissions, and investment needs, for example.
- Conditions for the scenarios. For example, these include the climate and energy policy environment, RDI investments, and the availability of skilled labour.
- The Greenhouse Gas Protocol (GHG Protocol) categorisation of emission sources [4]. These are the direct greenhouse gas emissions of the sector (Scope 1), emissions from purchased energy (Scope 2), and indirect emissions created in the sector's value chain (Scope 3).

4 For more information on GHG Protocol emission calculations and reporting, see https://ghgprotocol.org/

- Carbon handprint, meaning positive climate impact that can be achieved with current or emerging products.

The MEAE prepared instructions for the basis and recommended content at the start of the roadmap project. The aim was to make the roadmaps comparable and to maximise the usefulness of their results for the government's climate and energy scenarios, as well as the preparation of policy measures in general. The basis is described in the previous chapter and the list of recommended content is included in Appendix 1.

The same questions arose repeatedly during the planning of the work. They concerned the boundaries of analysis in functions that are related to multiple sectors (energy production and logistics), geographical scope, and the required scenarios. The MEAE published a list of frequently asked questions in autumn 2019 to answer those questions in more detail. The original instructions are included in Appendix 2. The appendix also includes subsequent comments that compare the original instructions and the methods used in the roadmaps.

The results of the post-process interviews showed that some sectors felt that the MEAE instructions mostly applied to large-scale sectors, and that they wished smaller sectors and non-industry sectors had been acknowledged more. On the other hand, many sectors found the instructions helpful for requesting quotations from consultants and during the whole roadmap preparation.

3.3 Scenario analysis

The roadmaps reflect the sectors' perceptions of alternative future developments through scenario analysis. Typically, one baseline scenario and one or more low-carbon scenarios are used for the analysis. The baseline scenario describes the expected development in a situation where policy measures, technology, and the operating environment develop while the current policy instruments remain the same and certain assumptions are true. The low-carbon scenarios can then be compared to the baseline.

The background assumptions of the baseline scenario regarding a predictable operating environment and international competitiveness also serve as the starting point for the low-carbon scenarios. The background assumptions of the scenarios also include production volume growth or change in total output, improvements in energy and materials efficiency, and the energy and emissions intensity of different forms of production, for example. Typically, the baseline scenario for each sector assumes that the energy industry will cut its emissions drastically, which is in line with the baseline scenario of the energy industry's roadmap. The estimates of future volume growth and energy efficiency improvements in many roadmaps are based on historical development and the industry's characteristics.

Most sectors also prepared one or two alternative, more ambitious scenarios where emissions are reduced more than in the baseline scenario as a result of active emission reduction measures. Alternative scenarios allow for a more fruitful review of the investment and business environment than the baseline scenario. Favourable changes in the business environment include more rapid emergence and successful commercialisation of technologies; more available, more affordable, and low-emission electricity; and investments in infrastructure, for example. "Active emission reduction measures" typically include electrification, replacing fossil energy sources with bioenergy, and carbon capture, among other things. In the baseline scenario, they are implemented more slowly, or perhaps not at all. The realisation of the low-carbon scenarios will require significant investment in research, development, pilot, and demonstration projects in most cases.

For example, the most ambitious scenarios call for rapid technological development, available low-carbon raw materials, innovative circular economy solutions, the adoption of unproven technologies, fundamental changes in the international operating environment, or the wide-scale adoption of carbon capture technology. The roadmaps state that the most ambitious emission reductions are subject to the highest costs, which would weaken competitiveness and their market-based realisation.

The investments required for carbon neutrality depend on identifying the changes in the sectors' operating environments, which is further explored in subchapter 4.8. The background assumptions of the scenarios may include the assumption of positive development in the Finnish business and investment environment with regard to international competitiveness and the predictability of the operating environment. The availability of electricity and district heating, along with their emissions factors and price, have a major effect on the development of several sectors due to emissions from purchased energy.

The scenarios of different roadmaps may vary in their background assumptions and calculation methods. The differences are the result of industry characteristics, roadmap emphases, and methodological choices, for example. It should also be noted that the scenarios are not predictions and that their realisation depends on many factors.

The bases for the scenarios are also analysed in Appendix 2.

4 Roadmap results

4.1 Principal conclusions

The following important conclusions can be drawn from the roadmaps

- The roadmaps show potential for significant reductions in greenhouse gas emissions in different sectors. The government's objective of a carbon-neutral Finland by 2035 can be achieved in industry and other sectors with existing technologies or those on the horizon, assuming favourable conditions for investment.
- The objective of a carbon-neutral Finland by 2035 is so ambitious that emissions need to be reduced in every sector. Although emissions vary widely in scale by sector, having all of them contribute is necessary and valuable.
- The impact of individual investments on future emissions is great, and hence, emission reductions often happen in steps rather than in a linear fashion.
- Many conditions must be satisfied for the roadmaps to be realised. A friendly and predictable business environment, RDI investments, available skilled labour, and smooth regulation are essential. Furthermore, success requires the sectors to commit firmly to follow-up efforts.
- The energy transformation required for the objective of carbon neutrality depends on the availability of affordable and reliable electricity. Integrating various sectors, developing energy networks, and dismantling administrative obstructions are key to accelerating the energy transformation. The coupling of sectors will enable significant reductions in emissions as the electrification of society progresses.

- The allocation of RDI investments is an essential question for a low-carbon future, as it will decide future development. The investment cycles of industry are long, and carbon lock-in[5] must be prevented.
- The technological solutions recurring in the roadmaps are related to low-emission energy production, energy and materials efficiency, alternative power sources (e.g. biofuels, hydrogen, and electrification), the exploitation of waste heat, and the capture and utilisation or storage of carbon dioxide (CCU and CCS, respectively).
- In future, the boundaries between sectors and operators will blur, interdependence will increase, and seamless cooperation with decision-makers will become more important.
- The "carbon handprint", meaning positive climate impact, of current and emerging products is immense, and clean solutions offer export opportunities and new business. Finland can punch above its weight as a provider of solutions for climate change mitigation.
- Profitable business and solving the climate crisis are not mutually exclusive – on the contrary, the business community sees carbon-neutral solutions as a competitive advantage for Finnish industry.
- The roadmaps include several uncertainties, as the analysis concerns a long period of time and many factors are not controlled by Finnish operators. Additional limitations were imposed by the lack of initial data and the quick pace of the production.

4.2 Emissions development

The development of emissions depicted in the roadmaps describes the sectors' opinions of potential future development paths for greenhouse gas emissions. The roadmaps describe emissions development in the baseline scenario and emission reductions in the low-carbon scenarios. They also outline the conditions for more ambitious reductions [6].

5 Carbon lock-in refers to a situation where investments with along service life or societal structures force society onto a high-emissions course. If carbon lock-in occurs, moving away from high emissions will be difficult due to high costs, for example, which will hinder the transition to a low-carbon society.

6 Subchapter 3.3 and Appendix 2 – Frequently Asked Questions have more information on scenario modelling and the background assumptions used in it..

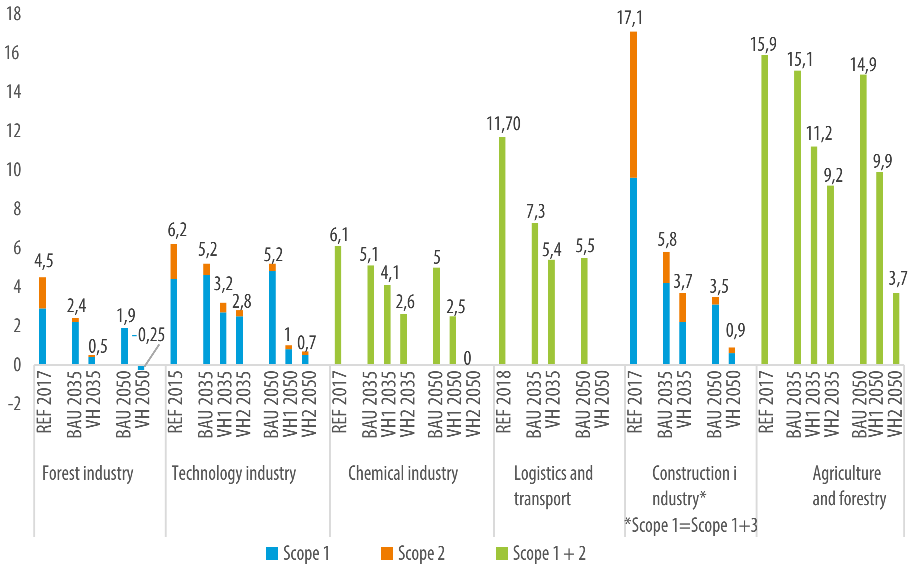
Figure 2 shows the Scope 1 and Scope 2 emissions[7] reported by the sectors in the baseline and low-carbon scenarios in their roadmaps. The figure is a visualisation of emissions development in different scenarios and illustrates the future prospects of the sectors.

The bases and assumptions of the scenarios vary between the different roadmaps, and some of the energy industry's emissions are included in the Scope 2 emissions reported by the other sectors. For this reason, the greenhouse gas emissions and emission reductions of different sectors have not been added together. A comprehensive background study will be commissioned to support the climate and energy strategy currently in preparation and the medium-term climate policy plan. The study will analyse the development of Finland's greenhouse gas emissions in different scenarios.

Figure 3 presents the potential emissions development scenarios of the energy industry, based on the background study of the energy industry's roadmap. The industry's greenhouse gas emissions are included as a separate picture, as some of the energy industry's emissions are included in the Scope 2 emissions reported by other sectors, making comparison inadvisable.

The decarbonisation of energy production will significantly reduce the Scope 2 emissions from other sectors, which has been taken into account in their scenario calculations. The energy sector's major emission reductions are due to the coming coal ban, the phasing out of natural gas and oil capacity, and reduced use of peat. At the same time, the use of biomass for fuel is expected to grow.

7 The Greenhouse Gas Protocol emissions categories are described in subchapter 3.2..



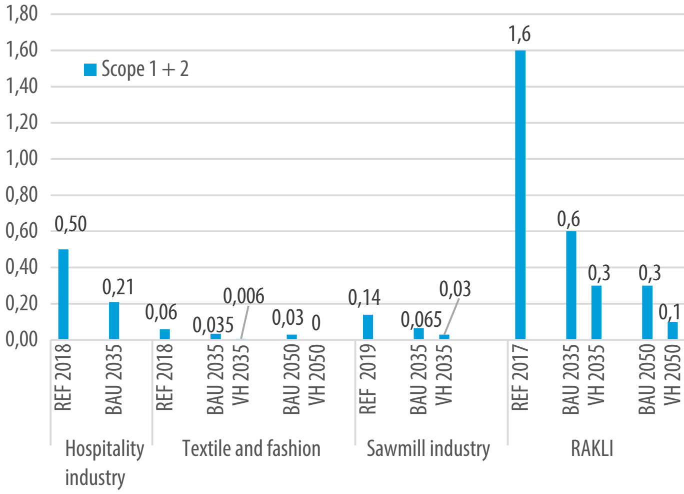


Figure 2. **Greenhouse gas emission development in different scenarios (million tonnes CO2 equivalent per year, m t CO2e/a). The current state – the reference year (REF) – is between 2015 and 2019, depending on the sector. BAU is "business as usual", meaning the baseline scenario. VH is the low-carbon scenario (the background assumptions may vary by sector). For sectors with two low-carbon scenarios in their roadmap, these are indicated by VH1 and VH2, where the latter is more ambitious.**

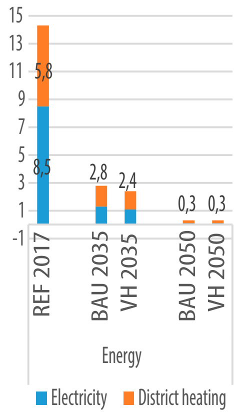


Figure 3. Potential development of greenhouse gas emissions (m t CO2e/a), according to the energy industry's background study for their roadmap.

4.3 Energy demand

The sectors largely depend on the decarbonisation of the energy industry, as the electrification of society and industry in particular can be expected to increase significantly in the coming decades. The low-carbon trend in the energy industry is part of a larger transformation in energy that is drastically cutting emissions from energy production. This energy transformation is made possible by the smart integration of sectors, energy consumers changing their roles to become energy storers and producers, and innovative solutions. "Sector integration" refers to the coupling of industry, transport, and heating through electrical, district heating, and natural gas networks. The roadmaps include the sectors' own future energy demand and the energy industry's capacity to meet the demand.

According to the roadmaps, the electrification of society could result in industrial electricity consumption increasing by 100 per cent and Finland's consumption increasing by more than 50 per cent by 2050 (Figure 4). The sectors have estimated their future electricity demand in their roadmaps, and the figures of the energy industry roadmap are based on calculations from AFRY Management Consulting about how the energy industry will be able to respond to a growing demand for electricity.

The background study of the energy industry roadmap also analysed different electricity production methods for meeting the increased demand. In the low-carbon scenario, the answer to increased electricity consumption is to use nuclear and wind power, which would see their share of production grow significantly. Furthermore, the low-carbon scenario posits that the net energy imports and CHP production will shrink compared to the current level.

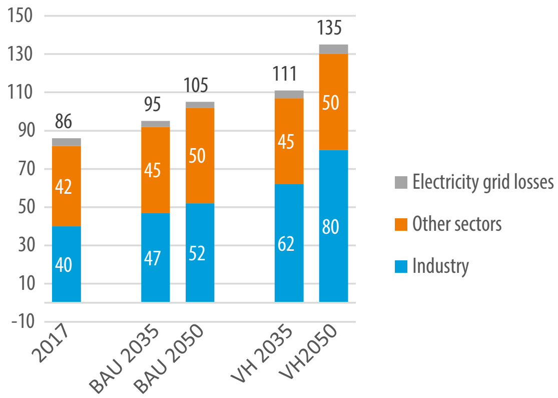


Figure 4. Electricity demand for industry and other sectors according to the scenarios of the energy industry roadmap background study.

The development estimate for industrial electricity consumption varies between sectors. In their low-carbon scenario, the electricity demand from the forest industry will decrease as a result of energy efficiency measures. Meanwhile, the chemical and technology industries expect their demand to increase. The increased demand in the chemical industry for electricity in the low-carbon scenario is explained by the electrification of processes and the use of power-to-x technologies. In addition to the above, electricity demand will increase in the ambitious scenario due to carbon capture technology and modified processes. The electricity demand in the technology industry will grow due to increasing consumption in data centres and the electrification of the metal processing industry.

Major investments will be required to increase low-emission electricity production capacity and extend the transmission network to ensure that future electricity production will be zero-emission, reliable, and competitive.

The energy industry's background study puts the need for new electricity production capacity at 80 TWh per year in its low-carbon scenario. This would enable 135 TWh of electricity production by 2050. This new capacity of 80 TWh would include 50 TWh for increased electricity demand and 20 TWh to compensate for a trade deficit. The background study also took into account the aging CHP plants that are responsible for 10 TWh of production.

4.4 Investment need

In their roadmaps, the sectors have identified essential low-carbon investment needs and measures for the public sector to support the investments. Among other things, investments are needed to replace obsolete production capacity with low-carbon technology and due to fossil fuels being phased out. Some of the investments also concern the redirection of unavoidable investments into low-carbon alternatives.

The investment cycles in industry are long, and the effect of today's investments will be seen for decades to come. Some investments will be made as part of normal development, but less-profitable investments will require government support. For example, the roadmaps of the chemical and technology industry raise long investment cycles and carbon lock-in, underlining the urgency of the investments.

Emissions will not be reduced linearly, but in steps, due to the investments cycles of industry. Processes often cannot be changed while large plants are in operation, and maintenance shutdowns may only take place once a decade. A research, development, and commercialisation project may take a decade before the investment decision can be made. According to the chemical industry, another five to ten years may pass from the investment decision before the investment reaches production use. Because of this, the changes in the operating environment must be predictable and consistent, and emission reductions must be considered in the long term. At the same time, long investment cycles highlight the urgency of taking action and starting comprehensive RDI programmes.

The roadmaps emphasise the importance of a favourable investment environment for profitable, market-based investments that are driven by companies' individual operating conditions and ambitions. The term "favourable investment environment" means, among other things, the availability of low-carbon and competitively priced electricity, consistent policy, and seamless regulation (e.g. expedited environmental permit procedure). A favourable investment environment also benefits from a predictable operating environment, stable market conditions, and reliable market signals.

The public sector can promote the development of a favourable investment environment by subsidising investments in innovative technology, through public procurement, by having streamlined permission processes, and with sufficient investments in RDI. The roadmaps also indicated a need for supporting demonstration and pilot projects that allow technologies to be commercialised. The EU's coronavirus recovery measures may offer new financing mechanisms for the sectors' investment needs. Other forms of public sector support could be loan guarantees and a price guarantee system, for example. The focusing of support on industry leaders or operators with connections to multiple operators' emission reductions is important for their effectiveness. Investment subsidies can also accelerate the creation of the market.

In most cases, the roadmaps include either quantitative or qualitative assessments of future investment needs. Low-carbon energy production, fundamental changes in processes, energy efficiency upgrades, and investments in technology were highlighted in the investment needs identified by the sectors. The roadmaps avoid speculating on specific investments for which companies have not released information.

The roadmaps of major export industries emphasise investments in commissioning new technologies (e.g. low-carbon production processes, power-to-x, and CCU/CCS), improvements in energy and materials efficiency, RDI, expanding product ranges, and offering bio-based raw materials.

The logistics and transport roadmap describes the need for investment in rail transport, the core road network, and public transport in urban areas. The agriculture roadmap specifies the investment subsidies needed for biogas production capacity by year. The investment needs of buildings are related to promoting self-sufficient electricity production, smart energy systems, and improvements in heat recovery. Some roadmaps also identified an investment need in developing skills.

Quantitative estimates of investment needs for low-carbon operation were given by the following sectors:

- Construction industry
  - Converting the current building stock to be energy-efficient and low-emission: EUR 10–20 billion by 2050
- Chemical industry
  - Baseline scenario: EUR 34 billion between 2015 and 2050
  - First low-carbon scenario: EUR 50 billion between 2015 and 2050
  - Second low-carbon scenario: EUR 58 billion between 2015 and 2050
- Logistics and transport
  - Railway network electrification and targeted investments in freight transport (EUR 400 million)
  - Extensive railway projects to increase the market share of railway transport (EUR 5–10 billion)
  - Urgent improvement needs of the core road network, EUR 2–3 billion
- Agriculture and forestry
  - Peatland measures (investments, incentives and loss of profit): EUR 300–500 million between 2021 and 2050
  - Poor-quality land afforestation (40,000–80,000 ha): EUR 140–230 million between 2021 and 2050
  - Sustainable intensification of agriculture (e.g. technological development and field soil fertility): no less than EUR 2.1–3.3 billion between 2021 and 2050
  - Biogas plant investments, total:
    - Baseline scenario (WEM): EUR 265 million by 2050
    - Low-carbon scenario 1 (WAM1): EUR 1,070 million by 2050
    - Low-carbon scenario 2 (WAM2): EUR 1,900 million by 2050
- Sawmill industry:
  - approximately EUR 100 million over the next ten years[8].

The challenges and obstacles to investment identified in the roadmaps are related to the profit risk of the investments, a high debt-to-equity ratio for the companies, the investment-intensive nature of some sectors, and susceptibility to economic

8 The sawmill industry estimate includes members of the Finnish Sawmills Association, who are responsible for approximately half of the timber produced in Finland..

fluctuations. Weak global competitiveness due to high production factor prices and the sector's low capacity for renewal were also seen as obstacles to investment. One roadmap also stated that the scale of some industrial low-carbon investments is such that not all of them are feasible at the current emission allowance price.

To clear the obstacles to investment, the roadmaps suggested identifying losing industries and companies in the design of financing options, identifying sufficient low-carbon demand signals, creating markets, and guaranteeing a predictable operating environment. Some roadmaps also recognised a need for sharing financial risks between the public and the private sector, for example by using a Public Private Partnership (PPP) model.

Major investments or other measurements are needed in every sector to make Finland carbon neutral. Although some investments, such as SSAB's investments in hydrogen reduction for metal processing, have a large impact on the overall situation, it is important for every operator to cut their greenhouse gas emissions.

4.5 Technological solutions

Technological solutions, some of which are still in development or not yet commercialised, are the focus of emission reductions in many sectors. The roadmaps repeatedly mention technological solutions related to low-emission energy production, energy and materials efficiency, alternative power sources (e.g. biofuels, hydrogen, and electrification), the exploitation of waste heat, and the capture and utilisation or storage of carbon dioxide (CCU and CCS, respectively). The potential of various smart solutions and digitalisation was also recognised in multiple roadmaps. These solutions include the use of IoT and AI, smart automation and control systems, robotics, and cloud services. Several roadmaps also emphasised the production of low-carbon materials and changes in the raw material pool. Changes in the raw material pool require new technologies in metal processing, for example.

Some roadmaps had a clearer emphasis on technology compared to others, and they stressed the importance of technological solutions for enabling emission reductions. For example, the chemical and energy industry roadmaps had overviews of key technologies, and they explored the applicability and emission reduction potential of technology in their sector, the maturity of the technology, barriers to its implementation, and the expected price development. Non-industrial sectors put less emphasis on the development of technological solutions in their roadmaps.

The sectors are highly interconnected. For example, the decarbonisation of the chemical, energy, and technology industries will have a major impact on emissions throughout the value chain, affecting commerce and the hospitality industry, among others. Low-carbon raw materials (e.g. steel and concrete) will require the use of alternative production methods, which has a direct impact on emissions upstream, such as those of the construction industry. Technological solutions can advance decarbonisation as well as connections to the circular economy and carbon handprint potential.

Examples of the technological solutions identified in the roadmaps for promoting decarbonisation:

Technology industry	Plant and process planning, IoT utilisation in manufacturing, specialised robotics, cybersecurity technologies, 5G applications, optimising harbour operations, and bioenergy technology.
Energy industry	Onshore and offshore wind power, extending the service life of nuclear power plants, biogas plants for combined heat and electricity production, geothermal energy technology, solar power technology, and battery technology.
Chemical industry	Chemical and mechanical recycling, Power-to-Chemicals, synthetic biology and biochemistry, CCU/CCS, and process changes.
Forest industry	New production technology for pulp, paper, and mechanical wood products, methods of optimising wood use, and water efficiency solutions.
Logistics and transport	Low-emission vehicles, remote technologies substituting for transport, autonomous cars, electricity distribution and recharging infrastructure, alternative sources of motive power, and synthetic fuels.
Food industry	Heat pump technology and biogas plant integration into biowaste processing.
Textile industry	RFID technology for textile identification, textile recycling technologies, and textile fibre technologies.
Sawmill industry	Sawing and drying technologies.
Agriculture	Farming technologies, manure processing technology, biogas plants, and alternative motive power sources for machines.
Construction industry	Insulation technologies, low-carbon building materials technology (e.g. for cement and steel), CCU, and smart thermostats and gauges.
Buildings	Smart automation and control systems, IoT solutions, and virtual power plant (VPP) technology.
Hospitality industry	Heat pumps and energy efficiency upgrades.
Commerce	Automation and recovery related to energy use, low-carbon refrigeration technology.

Although important technological solutions may exist, there can be numerous obstacles to their adoption, according to the roadmaps. Financial obstacles are often related to excessive costs, customers' reluctance to pay for emission reductions, and the poor predictability of the market (continuity). In addition, the availability of sustainable raw materials and bioenergy may be uncertain. Legislation must make it possible to seamlessly adopt technology.

4.6 RDI investments and the need for skills and training

Statistics Finland defines "research and development activity" [RDI] as "systematic work undertaken to increase the stock of knowledge and use it to devise new applications" [pilots]. Research and development activity also "includes basic research, applied research and experimental development.[9]

Some roadmaps use a broader definition of RDI: the term “RDD&D” refers to research and development, but also includes demonstration and deployment. RDI investments can also be used to support scaling up to an industrial scale. RDI is often a major part of a company's business, but the role of public funding (national and EU) is increasingly important to subsidise RDI for decarbonisation.

The allocation of RDI investments is an essential question for a low-carbon future, as it will decide future development. One way to identify technological solutions, products, and services that enable new technology is to identify key solutions and bottlenecks for innovations. One solution to this problem was the approach of Technology Industries of Finland: they analysed ten technology industry clusters and identified their key technologies for RDI investment. Using network analysis, Technology Industries of Finland suggested influential technologies and "enabling technologies" that pave the way for other technology. Multistage analysis is one example of cost-effective RDI investment and identifying bottlenecks.

Some roadmaps emphasised the consistent distribution of development investments over the stages of the RDI process. Investment is needed in basic

9 As defined by Statistics Finland. https://www.stat.fi/meta/kas/t_ktoiminta_en.html

research, where it is important to identify opportunities for cooperation and to develop broad commercial and academic competence. In the next phase of RDI activities, it will be necessary to evaluate what development paths could be accelerated through public sector demand and the sharing of financial risks, for example. The modelling, piloting, and demonstration stages are crucial for industry, and they will decide if and how technologies will be commercialised. The public sector can support these stages through public procurement and by making the operating conditions more favourable for commercialisation. In addition, the development of new business models and the focusing of RDI investments on them was identified as essential for achieving a low-carbon result.

The roadmaps typically considered it necessary to focus RDI investments in low-emission energy and materials. Some of the RDI investments identified in the roadmaps are highly specific, such as the energy industry pilots for geothermal heat production, which is why sectoral roadmaps offer the most comprehensive overview of RDI investments.

Typically, the roadmaps recognised a growing need for RDI investments for decarbonisation. The sectors named potential investments either in general or in detail.

The technology industry's roadmap stated that the need for RDI investments is great in fundamental process changes in particular, as they enable critical individual emission reductions (e.g. the SSAB HYBRIT project). On the other hand, the sawmill industry's roadmap emphasised that deploying existing technology at sawmills is more important than developing new technology. It also suggested that research into wood products should concentrate on increasing the value of side streams.

The roadmaps made the following suggestions for supporting RDI, reducing risks, removing obstacles to adoption, and accelerating decarbonisation:

- A push–pull model. Direct funding of technology development and demand creation through public procurement.
- Public–private partnership. A flexible model to support investments between different operators.
- Review of bottlenecks to technology adoption.

- Boosted technology commercialisation. Financial instruments available at all stages of RDI activities.
- Promotion of synergies and cooperative models between sectors.
- Survey of skill and training needs. Investments in multidisciplinary competence are critical already in the short term.

The roadmaps also named some skill and training needs, some of which are listed below.

Energy industry	A focus on scientific and mathematical subjects from comprehensive school onwards; skill development for understanding business and technology, etc.; digitalisation; data analytics; and customer orientation. A growing need for cross-disciplinary and multiple skills.
Chemical industry	Immediate investment in multidisciplinary education for low-carbon technology development, private and public incentives for education and retraining, and attracting skilled workers from abroad.
Forest industry	Include the needs of business as a starting point in education policy and support the specialisation of universities.
Food industry	Develop life cycle calculation methods that account for nutritional value.
Textile industry	Improve technical skill and promote apprenticeships and pay subsidies.
Sawmill industry	Development across all levels of education for both the quality and quantity of participants, update the content of education, and increase options for supplementary training.
Buildings	Improve skills in reconstruction and life cycle calculation. Improve the skills of public procurement entities regarding life cycle sustainability and low-carbon aspects.
Agriculture	Special skills related to solar power and biogas production, business management training for farmers, competences in climate-friendly use of peatlands, and support for the adoption of carbon farming methods.

In the skill analysis, the Central Organisation of Finnish Trade Unions SAK stated that a fair transition is important as society is made low-carbon. This includes society supporting the opportunities of workers to update their skill sets and retrain.
A fair transition also means a comprehensive policy of adjustment that takes a wide view of the structural changes in society and aims to build a society with social and regional viability. SAK covered the fair transition in their contribution to the roadmap project[10].

10 AK (2020): A Fair Climate Policy for Workers. https://www.sak.fi/en/serve/fair-climate-policy-workers-implementing-just-transition-various-european-countries-and-canada a

4.7 Carbon handprint

"Carbon handprint" refers to how much a company, process, or product helps other operators reduce their emissions. A larger carbon handprint is therefore better. The carbon handprint does not include the sector's emission reductions – only those achieved by others.

According to the VTT and LUT University carbon handprint calculation guide, an operator generates a carbon handprint by reducing the carbon footprint of another operator, either by way of a low-carbon alternative or by reducing the carbon footprint of their process[11] . In the first case, the operator who generates the carbon handprint offers a new low-carbon solution to replace a previous baseline solution, eliminating some of the carbon footprint. In the latter case, the operator helps their customer create a new way of reducing emissions by developing the production process, reducing the carbon footprint from the baseline. The simplest formula is therefore "the baseline carbon footprint less the carbon footprint of the carbon handprint product (as CO2e)".

The carbon handprint calculation methods have not been fully established, so the carbon handprints reported by the sectors may not be comparable.

In particular, the companies at the forefront of low-carbon technology development have a high carbon handprint potential and therefore likely a great potential for exports. Operators can increase their carbon handprint by scaling their innovations to the global marketplace. For example, the chemical industry's roadmap includes an alternative analysis, which explains how much export profits can prevent emissions ("green ratio").

11 Further information on carbon handprint calculations: Vatanen et al. (2018). The Carbon Handprint approach to assessing and communicating the positive climate impact of products. VTT. LUT University. Retrieved from: https://www.vttresearch.com/sites/default/files/pdf/technology/2018/T346.pdf

Quantitative estimates given by the largest industries about the scale of their carbon handprint:

- Climate impact of the forest industry's annual production:
  - 2017: 16m t CO2e
  - 2035: 18m t CO2e
- Potential carbon handprint impact of the chemical industry's exported products:
  - Current products: 21m t CO2e
  - Developing technologies: 26m t CO2e
- Potential carbon handprint impact of the technology industry's exported products
  - Current products: 20m t CO2e
  - Developing technologies: 50m t CO2e

In their roadmaps, the above industries have divided their carbon handprint among clusters, key technologies, and product groups. This is done to identify key solutions and maximum multiplier effects for maximum carbon handprint potential.
The industries' carbon handprints are substantial compared to Finland's total greenhouse gas emissions, which were 52.8 million tonnes CO2e in 2019 [12].

The agricultural sector's roadmap includes quantitative estimates of emission reductions in transport and heat production by integrating biogas production into agriculture to replace fossil fuels.

The roadmaps typically recognise a need to increase the sector's carbon handprint. However, it is challenging to determine the carbon handprint of an entire sector, which is why industries other than those named above discuss it in qualitative terms at most in their roadmaps. For example, the roadmaps of the construction and textile industries describe opportunities and suggestions for measures that the industries can employ to increase their carbon handprint in different stages of life cycles and in connection to other industries' roadmaps.

12 Source: Statistics Finland, 2020. http://www.stat.fi/til/khki/2019/khki_2019_2020-05-28_kat_001_fi.html

4.8 Summary of conditions and policy measures

According to the roadmaps, a competitive and favourable operating environment is based on the availability of reliable and competitively priced energy, which requires the development of energy networks and flexible energy markets. The financial viability of investments is also key if the emission reduction measures are to be market-based.

The public sector can support market-based low-carbon development through predictable and consistent policy measures that reinforce the continuity of the operating and investment environment. Market-based emission reductions are achieved when low-carbon alternatives are more profitable than high-emission alternatives.

The factors that drive the operating environment influence future developments. The important driving factors towards carbon neutrality identified in the roadmaps are related in particular to electrification, low-carbon raw materials, improvements in materials and energy efficiency, and the availability of low-emission and competitively priced electricity. Almost all of the roadmaps also identified potential for exploiting waste heat and side streams, automation and digitalisation, circular economy operating models, and new business models.

Multiple roadmaps also state that the easiest and most profitable solutions have already been largely deployed. The roadmaps state that some products and technological solutions are subject to legal hurdles, including the use of recycled materials, CCU, and natural gas-fuelled cars. In most cases, the major obstacles are related to a lack of profit or financing instruments at different stages of RDI. Factors standing in the way of emission reduction measures also include the state of the global economy, predictable market signals, and recent large investments. Technical obstacles include fundamental process changes in the technology industry, for example, which may necessitate running down old processes.

The roadmaps put forward several policy measures for achieving the desired development. Many of the policy measures are specific to a sector. However, the policy measures listed below were among those suggested in multiple roadmaps, or they will serve the carbon-neutrality objectives of multiple industries as the sectors become more interlinked.

- Reform energy taxation and reduce the energy tax on business to the EU minimum.
- Develop the electricity market through joint European legislation.
- Increase the blending obligation for biofuel and extend it to fuel oil and/or raise the fuel tax.
- Create an extensive recharging and refuelling network for alternative motive power sources for transport.
- Improve the conditions for biomethane (vehicle fuel) production and use, including a distribution obligation, taxation, infrastructure development, investment subsidies, and purchase subsidies (incl. moving agriculture transport to biogas).
- Adjust the terms of the energy aid granted by Business Finland and the MEAE to include projects with conventional technology in the emissions trading sector.
- Set ambitious energy efficiency targets for and improve the conditions for using renewable energy in new construction.
- Review the damage factor for electric heating energy in energy certificate calculations.

5 Summaries of the sectors' roadmaps

This chapter gives a brief summary of each roadmap. The estimates, assessments, and suggestions are directly based on the sector roadmaps and/or their background studies.

5.1 Energy industry

> *"District heating systems offer many ways to make the energy system more flexible."*

The energy industry's roadmap reflects on the transformation currently sweeping the energy system and its impact on the electricity system in particular. It also identifies measures to accelerate the change. The effects of electrification are a particular focus in the roadmap's background study.

Finnish Energy is committed to advancing policies that will halve emissions by 2030, as well as meeting the objectives of the Paris Agreement. Finnish Energy is also committed to steering the energy system towards low-carbon operation without compromising energy security or economic competitiveness. According to the energy industry roadmap, a low-carbon energy industry requires effective cooperation between companies and society.

The current situation and an estimate of future development: Electricity production

Electricity has been identified as one of the most cost-effective means of reducing emissions in industry and transport, for example. Based on the roadmaps for energy-intensive industries, the industrial demand for electricity may double between 2017 and 2050. Investments in the electrification of process heat and hydrogen production will have a particularly significant impact on Finnish electricity demand by 2035, increasing further by 2050.

The roadmap's background study concludes that new electricity production capacity will require major investments. For this to occur, the investments require a demand signal, which can be created through climate policy. The transmission network also requires investments in order to shift zero-emission electricity production from generation sites to consuming applications and to utilise the flexibility of a larger market area in balancing supply and demand. The rapid growth of weather-sensitive wind power production and electricity demand require extremely robust cross-border transmission connections and effective electricity markets between countries to maintain system balance at different times and in different weather conditions. Transmission network investments take a long time to realise, and various flexibility options should be considered for potential bottleneck situations.

The current situation and estimate of future development: District heat production

District heating and cogeneration will play a major role in a carbon-neutral society. The marked increase in demand for electricity puts more emphasis on cogeneration in securing the electricity supply in low-carbon scenarios.

District heating systems offer many ways to make the energy system more flexible. Cogeneration is flexible on many timespans, as the profile of electricity production correlates closely with electricity consumption on annual and daily bases. Heat pumps and electric boilers can take advantage of low electricity prices and offer demand response for balancing the system. District heat stores add further potential for flexibility.

New, low-carbon production methods and storage options look to offer new opportunities for emission reductions in district heating systems. The background study of the roadmap estimates that waste heat, geothermal heat pumps, and industrial heat pumps could cover one third of district heating demand. According to the industry, the system would still rely on wood-based fuels, but a large portion of heat production could use non-burning technology.

The current situation and estimate of future development: Other issues

Replacing natural gas with biogas and (from 2030 onward) hydrogen will slowly make the fuel gas cleaner. The current development suggests that the main uses for gas in the 2030s will be in industry and potentially transport. The use of natural gas for energy is responsible for three per cent (1.6 million tonnes) of Finland's total emissions (55 million tonnes).

Even today, oil is in marginal use as a starting and emergency fuel, mostly on cold winter days. The development of low-carbon production, demand response, and other new services for the district heating network will further reduce the use of oil-fired boilers. CO_2-free replacement liquids for oil may change things, but the roadmap makes no such assumption.

The development of emission allowance prices is estimated to reduce peat use to 10 to 30 per cent of the current level by 2035. Its use will also be reduced by the winding up of domestic peat production for energy generation. In the 2030s, emissions from district heating and electricity production will come from fuels used to ensure the security of supply (oil, peat, and natural gas) and waste incineration.

The current situation and an estimate of future development: Energy industry emissions

There will be a marked reduction in emissions from the energy industry by 2035 due to the drastic cutting of the specific emission factors of electricity and heat production (see Table 1). The emission reductions by 2035 will mainly come from the ban on coal, but the phasing out of current natural gas and oil capacity and the reduction in peat use will also play an important part. The remaining emissions will mainly come from the use of natural gas and peat.

In 2050, emissions will only be generated in the production of waste and mixed fuels. The advancement of the circular economy also affects the generation of these emissions. The production of electricity and district heating are nearly emission-free.

In the roadmap's background study, the specific emission factor for district heating will be reduced from 148 kilograms of CO_2 to 34 kilograms per megawatt-hour of heat produced. The roadmap calculates specific emission as an average for all of Finland. It should be noted that district heating is always local, and production methods vary between the individual district heating networks. A significant number of district heating networks are already low-emission.

Table 1. The development of energy production specific emission factors, according to the energy industry roadmap background study.

		Baseline scenario		Low-carbon scenario	
	2017	2035	2050	2035	2050
Electricity, kg CO2/MWh	131	14	1	10	1
District heating, kg CO2/MWh	148	38	6	34	6

The development of district heating and cogenerated electricity emissions is shown in Figure 5 below.

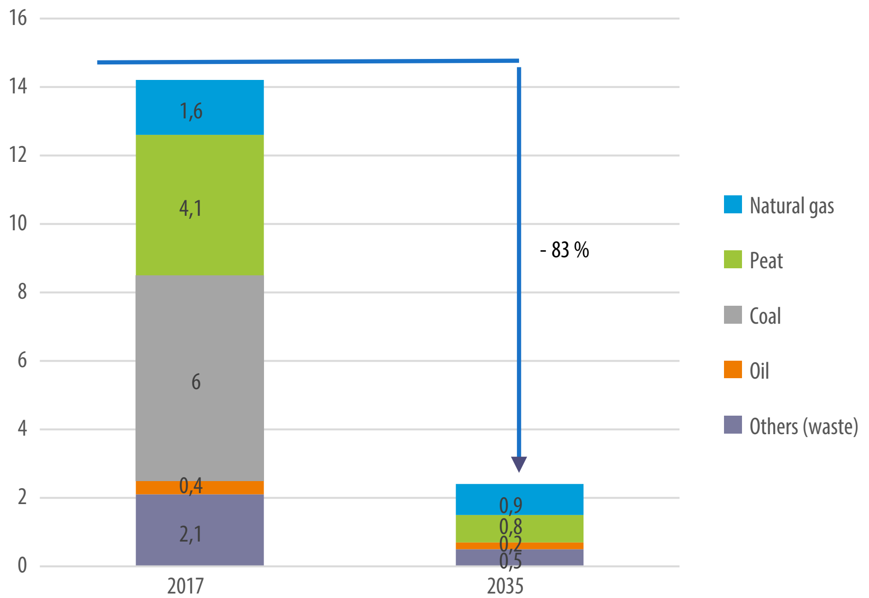


Figure 5. The emissions development of district heating and cogenerated electricity, according to the energy industry's roadmap. Unit: million tonnes CO2. Source: Finnish Energy.

Main solutions for achieving low-carbon operation

Finnish electricity and district heating production are included in the EU's emission trading scheme for the most part, and emission allowance prices act as an incentive to reduce emissions. Joint climate policy is used to achieve emission reductions for industries deemed vital for EU member economies in order to maintain equal and fair competition in the internal market (emissions trading). A lowering emission cap has been set for energy production and heavy industry included in emissions trading, and the target level is reviewed periodically.

The development of technologies, increasing cost pressure from emissions trading, and demand for new services are pushing energy companies to seek new solutions as competition stiffens.

The streamlining of administrative processes and procedures is highlighted year after year in the development of the business environment. Efforts must continue to settle the conflicting requirements of different administrative branches (e.g. radar operations) and streamline the permission process, according to the industry.

If national climate policy is to be made in emissions trading, Finnish Energy suggests it should focus on technological developments. For example, the reduction of emissions from heavy industry could be aided by electrification and the promotion of clean gases, as stated in the roadmap. Additional policy that overlaps emissions trading should therefore aim to improve the industry's ability to compete globally and produce new products for export.

The roadmap suggests that society must help with the following:

- General development of the business environment
- Sharing the technological risk of new technologies
- Building skills.

The roadmap underlines that there is no need to channel public money into market-based investments. For example, building the new and clean electricity production capacity modelled in the background study is estimated to happen without subsidies, as long as administrative obstacles are removed. The scale of climate change mitigation requires the use of private-sector funds and the mobilisation of markets. Subsidies will be required, but in a limited and targeted capacity.

According to the sector, technology development and piloting should be promoted in the following industries, among others: low-carbon district heating, biogas, diverse bioeconomy, circular economy, and industrial electrification.

Cross-sector integration is a large-scale phenomenon that will require revisions in legislature and taxation to develop (see Figure 6). Integration makes it possible to work across sectors in order to reach low-carbon targets.

According to the industry, the economic operating conditions of the energy networks (electricity, heating, cooling, and gas) must be secured to successfully integrate the sectors. Networks enable flexibility and the distribution of low-emission production. In practice and according to the industry, the existing networks are viable only if the competitiveness of existing production is not compromised by increased taxation. The industry suggests that emissions from peat, natural gas, and waste used for energy generation can be reduced by developing the technical and economic maturity of new solutions.

The review of business and skill requirements will be carried out as a follow-up to the roadmap, but it is already clear that new skills will be required to achieve the targets..

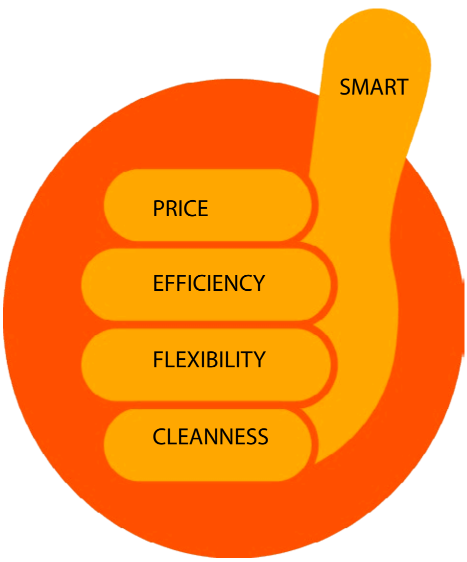


Figure 6. The integration of sectors in energy production and large-scale energy use is a major system-level transformation that will result in cost-effective emission reductions. It will require updates to legislation and taxation to develop (source: Finnish Energy).

5.2 Chemical industry

”The chemical industry has competence, products, and solutions that make it possible to reduce greenhouse gas emissions on a global scale.”

The Chemical Industry Federation of Finland decided in 2018 to study what carbon neutrality, meaning the significant cutting of greenhouse gas emissions, would mean for the chemical industry in Finland. The result was a roadmap published in June 2020, which includes multiple paths to a future low-emission chemical industry.

The objective of the Chemical Industry Federation of Finland was to create a realistic but ambitious path for future emission reductions. An additional objective was to cover all the essential systems for emission reductions, which is why the work focused on direct process emissions, indirect energy emissions, and raw materials emissions in the value chain. The roadmap includes three scenarios with separate energy needs, investment needs, primary technologies, and the resulting development of emission reductions. The scenarios are a baseline scenario, a fast development scenario, and a carbon neutrality scenario.

The current state in the chemical industry

In Finland, the chemical industry employs some 34,000 people directly and nearly 100,000 people indirectly and through income effects. The chemical industry is one of Finland's largest export businesses: it exports EUR 12 billion worth of goods annually. Numerous individual companies make up the chemical industry's value chain. In the climate neutrality roadmap, the chemical industry was divided into the following clusters:

- Energy-intensive chemical industry: high-capital production plants and complex processes.
- Reaction chemistry: medium-sized special chemistry and advanced materials plants.
- Inorganic chemistry: plants specialising in inorganic chemistry products.
- Formulators: plants that manufacture end products by mixing ingredients.
- Converters: plants that make consumer products and intermediate products.

Main products of the Finnish chemical industry at the time of analysis: oil products (38 per cent), basic chemistry (23 per cent), plastics and plastic products (11 per cent), pharmaceuticals (10 per cent), rubber products (4 per cent), paints and varnishes (2 per cent), cosmetics and detergents (1 per cent), and other products (12 per cent).

The chemical industry processes raw materials into materials and products for society. This is energy-intensive by nature, but the industry states that the materials and products create benefits and well-being seen in all of modern society. Among other things, the Finnish chemical industry produces renewable fuels for transport, battery chemicals for mobile devices and electric cars, fertilizers to meet the food demand of a growing populace, light and durable construction industry materials, pharmaceuticals and protective equipment for healthcare, and municipal water treatment solutions.

The Finnish chemical industry uses 26 terawatt-hours of energy a year at the time of analysis – 19 for heat and seven for electricity. Its plants process 23 million tonnes of raw materials, which include some 4.5 million tonnes of recycled and renewable materials. In 2019, the chemical industry's greenhouse gas emissions were equivalent to approximately 5.7 million tonnes of CO2. These comprised some four million tonnes of direct emissions from chemical industry processes and 1.7 million tonnes of indirect emissions from energy consumption.

Estimate of future development: Carbon footprint

The Climate Neutrality roadmap has two main parts: the carbon footprint and the carbon handprint of the chemical industry. The carbon footprint analysis surveyed the emissions generated by operations (Scope 1) and purchased energy (Scope 2). As the work only concerned the companies' Finnish operations, the carbon footprint includes emissions relevant for Finland's carbon neutrality pledge by 2035.

Figure 7 illustrates the carbon neutrality scenario of the roadmap. The roadmap includes a second scenario that is less ambitious than the carbon-neutral scenario. To achieve major emission reductions, the chemical industry must increase its use of electricity fivefold while emissions from energy use are reduced. Meanwhile, investments in new technology will increase on average by 70 per cent annually. Both emission reduction scenarios reach the same conclusion: In Finland, it is of critical importance to invest in innovation projects, and pilots and demonstrations in particular. They are means to develop and accelerate new competence, attracting top talent and increasing national potential for exports. The integration of sectors to use energy and other resources with maximum efficiency is important for large projects and plants in particular.

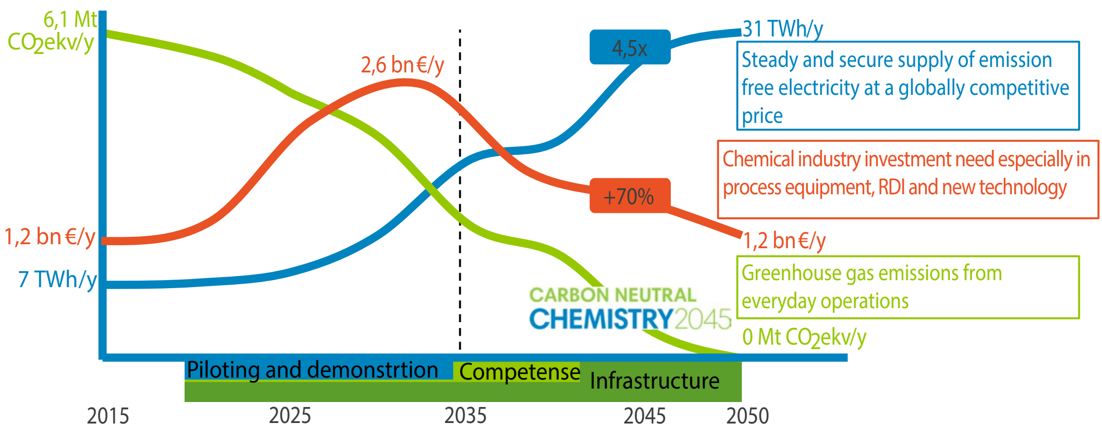


Figure 7. Greenhouse gas emissions, investment needs, and electricity demand for operations (sources: Chemical Industry Federation of Finland, AFRY Management Consulting).

The roadmap also analyses emissions from raw material source to the chemical plant's outgoing gate. The sector's raw materials and their feedstock emissions in different scenarios are included in Figure 8 below.

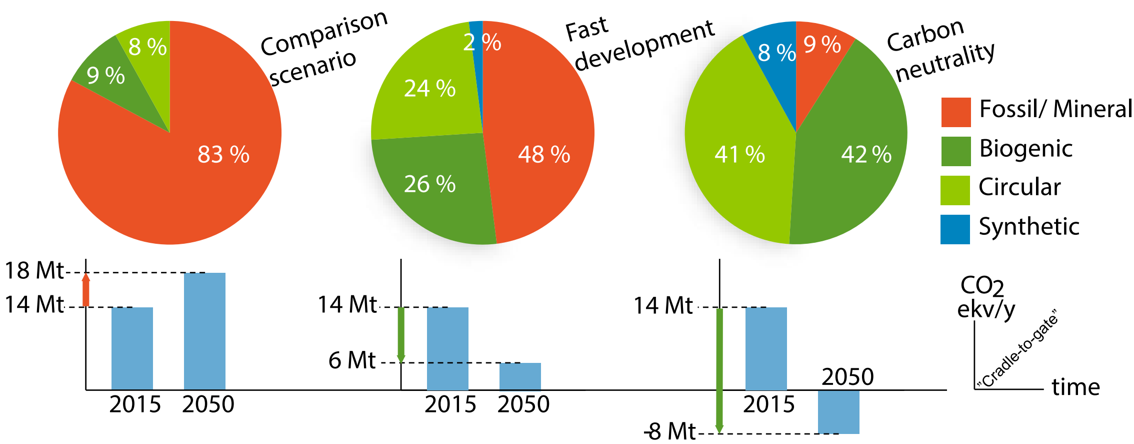


Figure 8. Raw materials used by the sector (pie charts) and raw material supply chain emissions (bar charts) in 2050, according to different scenarios (source: Chemical Industry Federation of Finland, AFRY Management Consulting).

As the above figure shows, the raw material feedstock emissions highly depend on replacing fossil raw materials with primarily renewable but also recycled raw materials. Fossil raw materials can also be replaced with synthetic raw materials through widespread utilisation of hydrogen and carbon dioxide. This would allow the chemical industry to significantly reduce the greenhouse gas emissions from its purchased raw materials and reduce emissions throughout the whole value chain of a material or product by replacing high-emission products.

The emissions at the end of the life cycle are not included, as they are more difficult to influence – many products and solutions are shipped out of Finland. The roadmap examines the opportunities for exploiting end-of-life cycle products in the abstract through circular economy thinking.

Estimate of future development: Carbon handprint

There is great potential in the chemical industry's carbon handprint. Low-emission Finnish products and solutions can be created by using low-emission alternatives for raw materials, which will then reduce customers' emissions. At the very core of the chemical industry's carbon handprint are products, and solutions that have potential to reduce greenhouse gas emissions globally through exports..

The roadmap examined the carbon handprint and export potential. By investing in ten cutting-edge technologies and exporting these around the world from Finland, the products and solutions of the chemical industry can exponentially reduce emissions from other countries and sectors. The Finnish chemical industry currently generates 5.7 million tonnes CO2e of greenhouse gas emissions, and the chemical industry's estimated carbon handprint could be up to five times its domestic emissions (25 million tonnes CO2e).

According to the roadmap, exports of low-emission products and solutions (ten key products) would increase Finnish chemical industry exports by EUR 5 billion.

Objectives and preferred outcomes

The objective for the chemical industry is to reduce its domestic carbon footprint in the next 25 years by eliminating as much as possible of its current 5.7 million tonnes of greenhouse gas emissions. This would be done by reducing emissions from processes and energy use. The chemical industry's carbon handprint could be significantly increased at the same time.

The carbon handprint could be increased by using low-emission raw materials in production to make materials and products for export to the global market. The main means for transforming raw material operations are more effective use of bioeconomy side streams, acceleration of the circular economy, and growing the green hydrogen economy. The chemical industry's targets for reducing its carbon footprint, increasing its carbon handprint, and promoting exports are included in Figure 9.

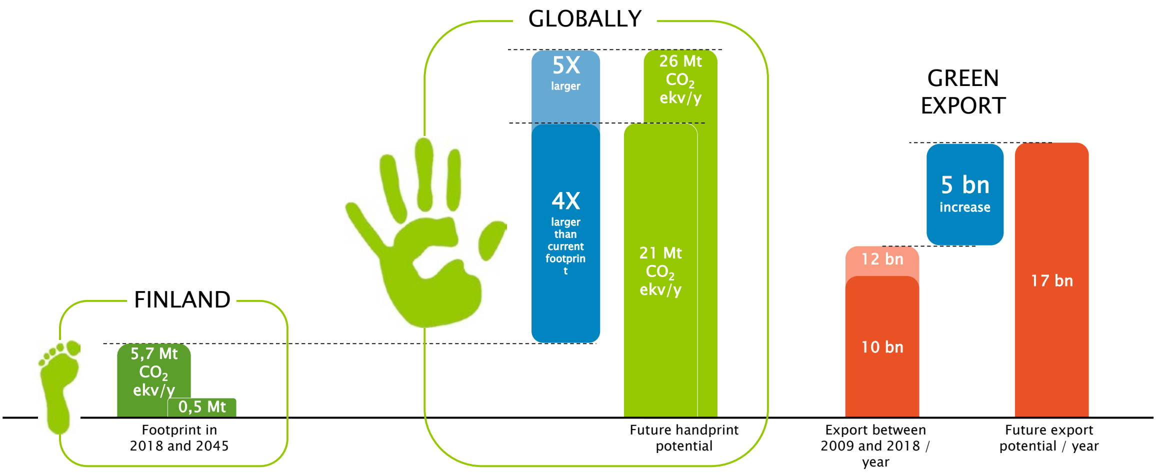


Figure 9. "Climate Neutral Chemistry" in summary: carbon footprint reduction, carbon handprint increase, and the resulting growth in export potential (sources: Chemical Industry Federation of Finland, AFRY Management Consulting).)

The roadmap suggests that electricity will play a major part in both reducing the carbon footprint and increasing the carbon handprint. Energy consumption will rise considerably if significant emission reductions are to be achieved. The roadmap also mentions employment prospects: in particular, highly skilled research, development, and innovation functions will require more workers. The industry states that talent must be trained in Finland and attracted from abroad.

The roadmap lists a large number of new technologies and raw materials that the transformation will bring. Safety should always be top priority when handling these.

The roadmap's results are based on a long list of assumptions, making the results somewhat sensitive to changes in these assumptions. The roadmap is not a prediction of the future, but an evaluation of what the future can be if multiple critical pieces fall in place. An additional objective was to identify the essential means for promoting the transition to a low-emission future. The scenarios are tools that illustrate a complex whole with many interdependencies.

Main solutions for achieving the objectives: Technology

If the chemical industry is to be made carbon neutral, this will require a comprehensive toolkit of technological solutions and policy measures. It will take more than a few key technologies to reduce emissions. Policy will be needed to create a marketplace where low-emission solutions can compete and succeed. If the solutions are approached from the same angle – reducing the carbon footprint and increasing the carbon handprint – the following conclusions can be drawn:

For reducing the carbon footprint, the most important thing is to adjust chemical industry production to use zero-emission energy and utilise all side streams, be they energy, raw materials, or heat, as efficiently as possible. Processes can also be changed and enhanced by using various catalytic solutions.

One of the biggest challenges for the chemical industry is that its processes often require high temperatures and reactions take place under high pressure. Currently, furnaces that burn different fuels are used to generate high temperatures, which results in carbon dioxide emissions. The burning processes must be used less or the current fuels need to be replaced with zero-emission fuels to reduce the emissions.

The electrification of production is key. Heat could be generated by electricity, for example with electric furnaces. For fuel replacement, the critical first move is to find low-emission fuels, such as natural gas, biogas, or biomass. In the long term, fuel could be produced with power-to-X technologies, which are suitable for making hydrogen. Hydrogen can be refined into hydrocarbons by combining power-to-X technology with carbon capture and utilisation (CCU). The hydrocarbons are also suitable for use as fuel. Carbon dioxide can also be captured for storage (CCS) in geological formations, preventing it from ending up in the atmosphere.

In addition to fuel replacement and power-to-X technologies, sector integration is also highly important. This refers to high-level resource efficiency and presents many opportunities for energy-intensive industries in particular. The aim is to make the use of electricity, heat, and different side streams as efficient as possible between the energy sector, industry, and the municipal sector. For example, industrial waste heat can be used to heat cities. There are many opportunities for the chemical industry in sector integration. New business opportunities include energy storage and flexibility in energy demand, for example.

Main solutions for achieving the objectives: Raw materials

For increasing the carbon handprint, it is essential to reduce the use of virgin fossil raw materials in the chemical industry and society as a whole. Fossil raw materials will be necessary in future, but more of them will be recycled and reused. The following three key solutions can change how the chemical industry produces vital materials and products for society:

1. Circular economy raw materials
   - The modern society is enormously wasteful in different parts of the value chain and towards the end of material life cycles. Circular economy solutions aim to exploit this waste and circulate it back into use. Current methods can recover some of the waste for use, but technological development is needed to recycle the maximum amount of materials.
   - Chemical recycling is the missing piece in this puzzle. For example, chemical recycling can be used to reduce old plastic products back into their constituents, meaning gaseous and liquid hydrocarbons, which can be used as raw materials in the chemical industry's processes. The circular economy offers new business opportunities that companies can use to significantly improve the resource efficiency of their value chains. Particularly important raw material streams that should be utilized are plastic waste, textile waste, composite waste, battery materials, concrete waste, plaster, and mining waste.
2. Sustainable bioeconomy and biotechnology
   - There is potential for using natural biomass as a raw material in the chemical industry. Among others, these methods include different biomass-based oils and waste oils, hemicellulose utilisation, lignin and sugar raw materials, and the exploiting of side streams and waste from agriculture and the forest industry. Natural biomass always comes with the question of sustainability, which must be considered in emission calculations.
   - The bioeconomy is also in need of technological development, particularly in industrial biotechnology and synthetic biology. Biomass can be grown artificially, and great potential is seen in algal oils as a replacement for other plant and fossil-based oils, for example. Synthetic biology may open completely new doors by combining biotechnology with digitalisation. These technologies are still in early development phases, however.

3. There is incredible export potential in the hydrogen economy.
   – Due to the versatility and huge volume of oil, few substances exist today to replace fossil hydrocarbons. This could be achieved by a combination of green hydrogen and carbon dioxide utilisation. Not only is hydrogen important for fuel and energy storage, but also for raw material manufacturing, i.e. the production of hydrocarbons. The hydrogen economy must use low-emission hydrogen to be sustainable. Electrolysis and methane pyrolysis are key technologies in this regard. The use of hydrogen as a base for raw materials is also very energy-intensive, which makes it important to ensure that the hydrogen can be produced with zero-emission energy.

The roadmap's calculations for carbon handprint and export potential are based on ten identified cutting-edge technologies. These are not the only opportunities for the chemical industry, but in the case of Finnish expertise, they possess the greatest potential. These cutting-edge solutions are renewable fuels, low-emission water treatment, bioresins, bioethanol, chemical recycling of plastic, pyrolysis oil-based bioplastics, battery chemical recycling, synthetic fuels and chemicals, biotechnology, gaseous raw material use, and the use of gypsum in fertilizers. Other potential solutions include exploiting waste heat, low-emission packaging, and low-emission logistics.

Operating environment conditions

According to the industry, the main policy measures for reducing the carbon footprint and increasing the carbon handprint include different financing mechanisms and programmes that support pilots and demonstrations of new technologies, the building of sufficient infrastructure, and energy policy measures that promote electrification or emission free heat.

The industry also underlines the importance of public procurement in boosting the competitiveness of low-emission products and technologies compared to conventional options. The industry would also like to emphasise that Finland needs to maintain a high level of expertise as a society and attract foreign top talent to Finland.

5.3 Forest industry

"The Finnish forest industry is capable of bringing increased added value, tax income, and new jobs to the Finnish economy while working to mitigate climate change."

The current state of decarbonisation in the forest industry

The direct emissions of the forest industry's plants (Scope 1) were some three million tonnes of carbon dioxide at the time of analysis (see Figure 10). The plants could be free of fossil fuels soon after 2035.

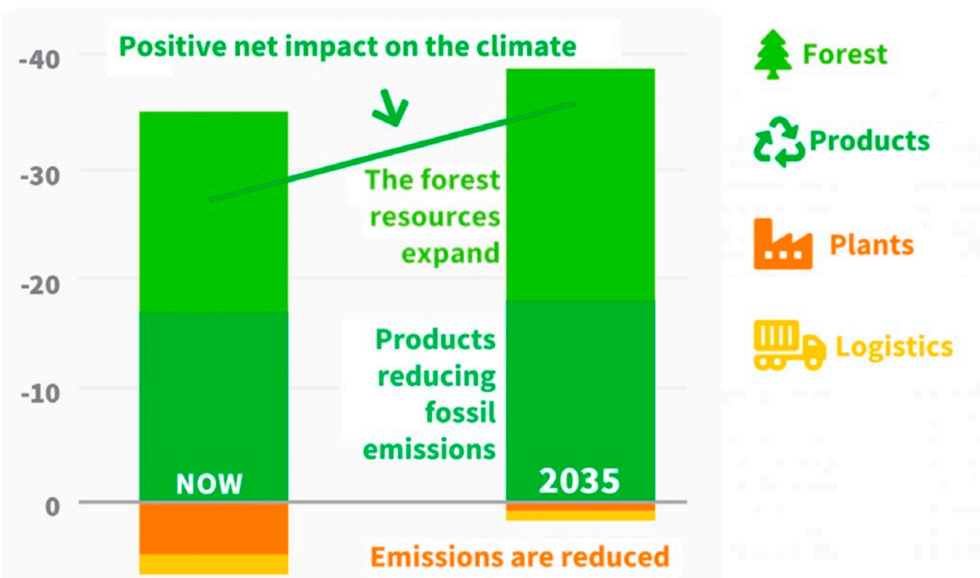


Figure 10. **The forest industry's net impact on the climate (source: Finnish Forest Industries Federation).**

The forest industry's products actually reduce carbon dioxide emissions globally. In 2017, the annual climate impact of the forest industry was estimated to be 16 million tonnes, which is the result of wood-based products replacing products that generate more fossil emissions.

At the time of analysis, there are an estimated 3,200 million tonnes of carbon dioxide stored in Finland's forest resources. Active forest economy will be required to accelerate the growth of forest resources, including the use of cultivated crops, forest fertilisation, and increased seedling tending.

The forest industry's annual additional value to the national economy is EUR 12.1 billion (2017). The industry estimates that it is capable of producing even more in future.

Estimate of future development: Climate impact

According to the forest industry, global megatrends, people's values, and the expectations of decision-makers support a view of the future where forest industry products offer climate-friendly alternatives. The industry sees strong support in European climate visions and the market prospects of renewable products for change in consumption habits that accelerate climate change.

The European Commission's 2018 climate vision, A Clean Planet for All, highlights the role of manufactured wood products in mitigating climate change and the need for wood raw material for many industrial products (e.g. for construction, fibre products, textiles, composites, bioplastics, renewable energy, and chemicals). The market for wood-based products is estimated to grow globally by nearly EUR 200 billion between 2017 and 2030 (Pöyry, 2018).

Estimate of future development: Factory emissions

In proportion to its production, carbon dioxide emissions from the forest industry have shrunk by 64 per cent since 1990. Finnish plants can replace fossil fuels almost completely by 2035, and may even become carbon negative thereafter. The industry states that to replace fossil fuels, Finland must be a favourable operating environment for wood processing activities.

So far, the industry has reduced its carbon dioxide emissions more than the rest of Finland, and they express a strong desire to continue the trend. Fossil fuels can be replaced completely with the proper investments. The industry's plants currently generate some three million tonnes of carbon dioxide emissions, which can be reduced to 0.3 million tonnes in a favourable operating environment (see Figure 11)..

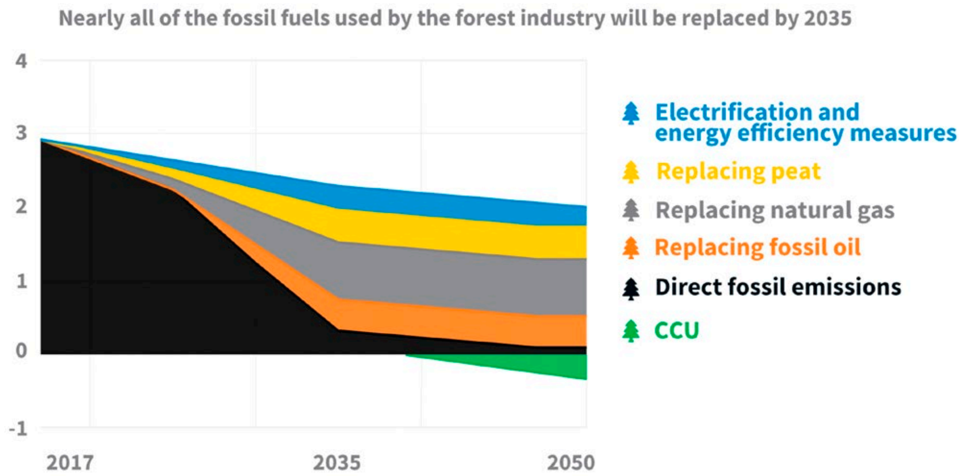


Figure 11. Fuels used by forest industry plants. In this scenario, the use of fossil fuels can be eliminated, except for small amounts of emergency fuel, by plant investments and electrification. The remaining fossil fuels would be eliminated by upgrading incineration plants and through new plant investments. Even today, fossil fuels only account for 14 per cent of the fuels used in forest industry plants (sources: Finnish Forest Industries Federation, AFRY Management Consulting).

Compared to other countries, Finnish forest industry products are manufactured from well-managed forests and with minimal fossil energy. At the same time, domestic production adds major value to Finnish society.

Estimate of future development: Forest resources

The positive prospects of Finnish wood processing have long served as motivation for forest owners to care for the forests' health and to increase forest resources (see Figure 12). To continue, this trend will rely on active forest owners and confidence in the future of the forest economy and forest industry, according to the industry. The roadmap suggests that it is possible to further increase the carbon reservoir of Finnish forests while increasing their utilisation.

In the industry's view, passive forest management will negatively impact the capacity of Finland's forests to sink carbon, and they could become an emission source in the long term. Furthermore, the industry suggests that economic benefits will be squandered through passivity, as forests offer no employment by their existence alone.

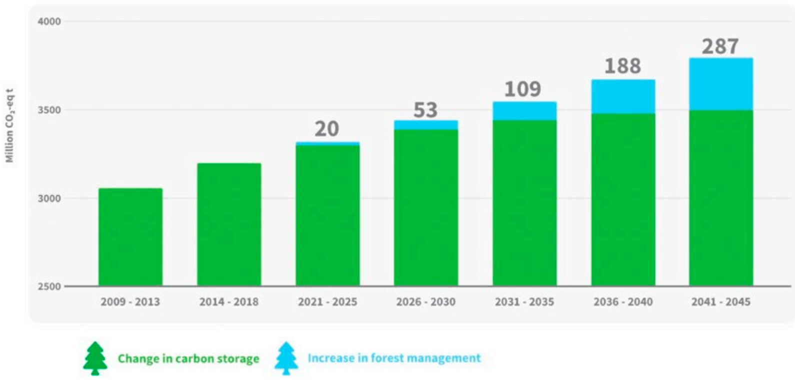


Figure 12. In the scenario prepared by the Natural Resources Institute Finland (Luke) for the Finnish Forest Industries Federation, the forest carbon reservoir will continue its strong growth thanks to well-timed forestry. The capacity of forests as a carbon sink can be maintained despite increased harvesting by carrying out growth-boosting measures. The scenario estimates that harvest volumes will increase from the current level towards the maximum possible harvest volume (source: Natural Resources Institute Finland).

The roadmap concludes that forest management to enhance vitality and growth is a cost-effective and functional climate policy that reaches all the way to the products. The sector's position is that forest owners should continue to be encouraged into active forest management. Improving the growing capacity of forests and the increasing use of wood are required for the products to yield climate and economic benefits, meaning that the overall picture reaches beyond the development of forest resources.

Estimate of future development: Added value

According to the forest industry, the industry's products have good prospects on the global market. The industry states that forest industry companies are willing to invest in Finland, and that the plants are ready to compete for market share. It is the view of the industry that good cooperation with decision-makers will allow the development of business with higher added value and new export products (see Figure 13).

The Finnish bioeconomy already generates considerable added value to the economy – over EUR 200 for every cubic metre of wood. The majority of this comes from the forest industry: EUR 176. In future, every cubic metre of wood processed by the forest industry could yield well over EUR 200 in added value.

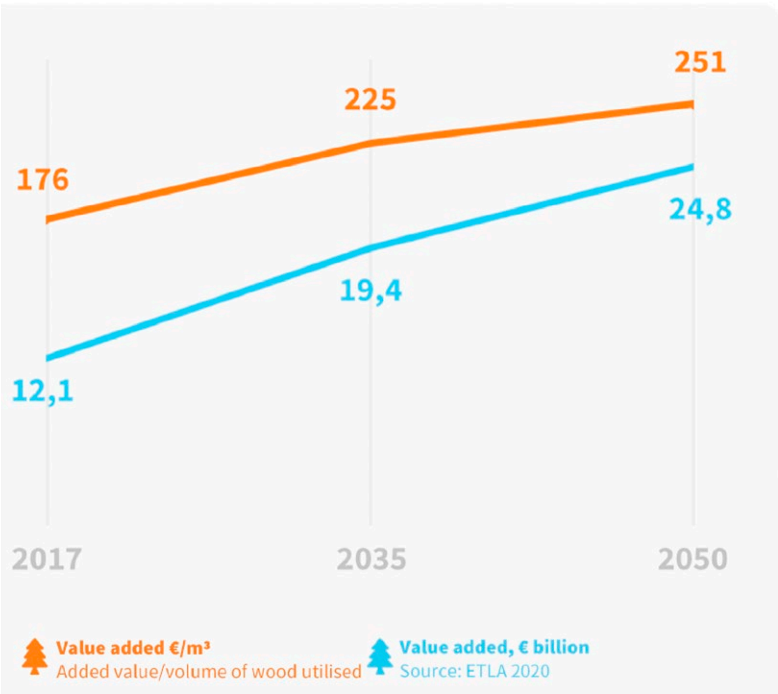


Figure 13. The forest industry's added value may increase by over EUR 7 billion by 2035 and double by 2050. It is possible to generate over EUR 200 of added value for every cubic metre of processed wood in 2035 and even more by 2050 (source: ETLA Economic Research).

The Finnish forest industry estimates that it is capable of bringing increased added value, tax income, and new jobs to the Finnish economy while working to mitigate climate change. The industry states that it will take investment-orientated and cost-competitive policy in Finland to exploit the full potential of wood processing.

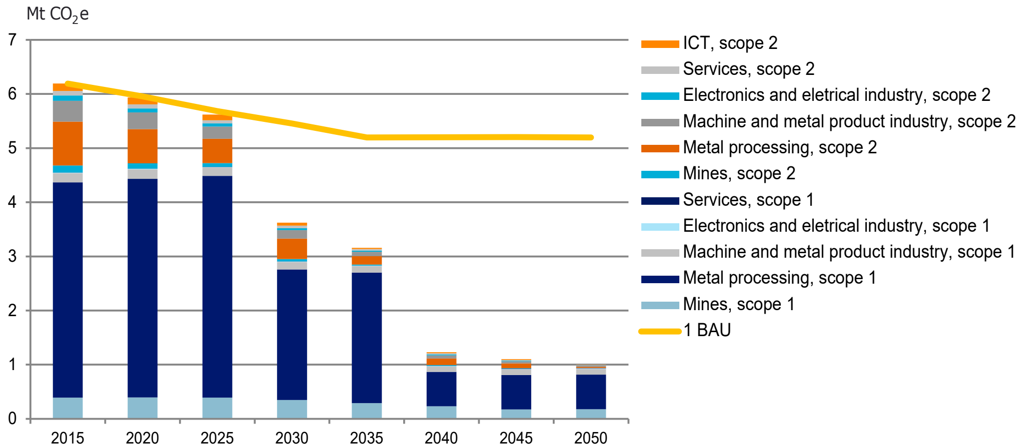
5.4 Technology industry

"The circular economy and energy efficiency have been competitive advantages for Finland's technology companies for decades."

Technology Industries of Finland is committed to mitigating climate change and limiting the rising of the global average temperature to a maximum of 1.5 °C by 2050. The technology industry's roadmap, prepared by consulting firm AFRY Management Consulting, supports Finland's objective of carbon neutrality by 2035 and the EU's objective of the same by 2050.

The current situation and an estimate of future development:

The technology industry comprises multiple sectors with highly varying emissions (see Figure 14). The direct emissions (Scope 1) of different sectors amounted to approximately four million tonnes of CO2 equivalent in 2018. The majority of these were generated by metal processing and the mining of metal ores and industrial minerals. The direct emissions from the machine and metal product industry, electrical and electronic industry, design and consulting industry, and information technology industry only amounted to 2 per cent of the sector's total emissions. The use of purchased energy results in additional emissions (Scope 2) of over two million tonnes of carbon dioxide.



The graphs show the direct greenhouse gas emissions of the sectors (Scope 1) and the indirect emissions from purchased energy (Scope 2) as CO2e.

Figure 14. Development of technology industry emissions in the low-carbon, accelerated technological development scenario (sources: Technology Industries of Finland, AFRY Management Consulting).

Greenhouse gas emissions can be reduced substantially across all sectors of the technology industry. In the accelerated technological development scenario included in the roadmap, direct emissions will be reduced by 38 per cent by 2035 and 80 per cent by 2050.

Most of the emission reduction measures are based on the electrification of processes and machines, improved energy and materials efficiency, the circular economy, and the use of digital solutions. The single largest emission reduction will be achieved when SSAB's hydrogen reduction-based steel manufacturing process is put into production in the 2030s.

The need for zero-emission electricity will increase significantly as a result of the technology industry's low-carbon transformation (see Figure 15). It is estimated that the sector's demand for purchased energy will increase by some 50 per cent by 2035 and double by 2050. Most of the technology industry's energy demand is for electricity, which is needed to process metals. Electricity is also required to make hydrogen for processes and for converting machines to electrical drive. The electricity consumption of data centres and data communications is estimated to increase significantly due to growing volumes.

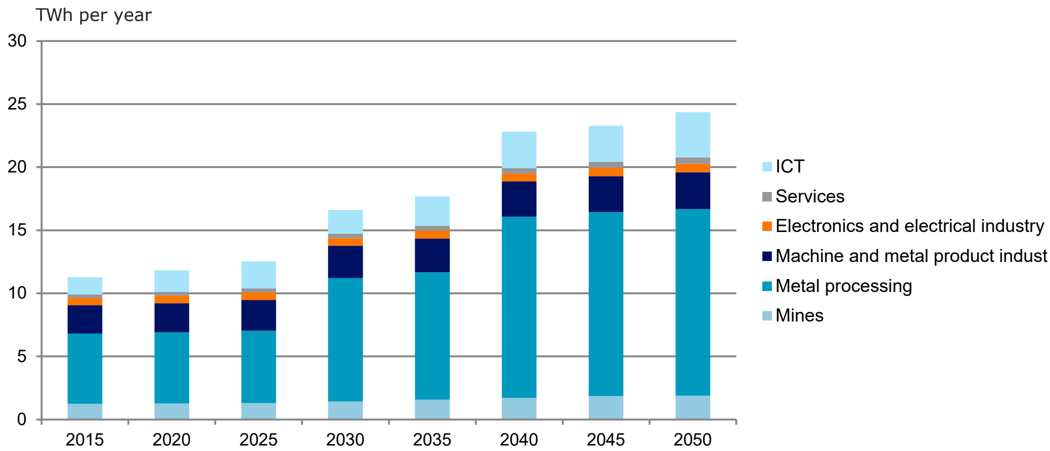


Figure 15. The demand for zero-emission electricity will double in the technology industry (sources: Technology Industries of Finland, AFRY Management Consulting).

The technology industry has limited potential for demand response due to the continuous nature of industrial processes. New opportunities for improved energy efficiency, local production, storage, and elasticity will open up in the service sectors. The emissions from the manufacturing industry can be reduced by replacing fossil fuels (natural gas and oil) with bio-based and carbon-neutral fuels (power-to-X), as well as electrification. Waste heat is available in data centres, for example, but its exploitation is restricted by their location. The energy efficiency of data centres is constantly improving. The roadmap assumes two technological breakthroughs will occur by 2050 that will reduce energy consumption by 20 per cent and 30 per cent.

Estimate of future development: Carbon handprint

Investments in decarbonisation are notable opportunities for business and export for Finland. To exploit these requires that the government and companies invest in research, development, and innovation activities. Some of the industry's key technologies will enable other low-carbon solutions through its network – their investments therefore multiply their benefits for both business and climate. This is why ecosystems will be the most effective way to promote innovations and open up new markets for the solutions. All in all, the roadmap analysis identified nearly 200 products or technologies that are either current export products, areas for development, or openings in the marketplace. The key technologies with major carbon handprint impact are included in Figure 16.

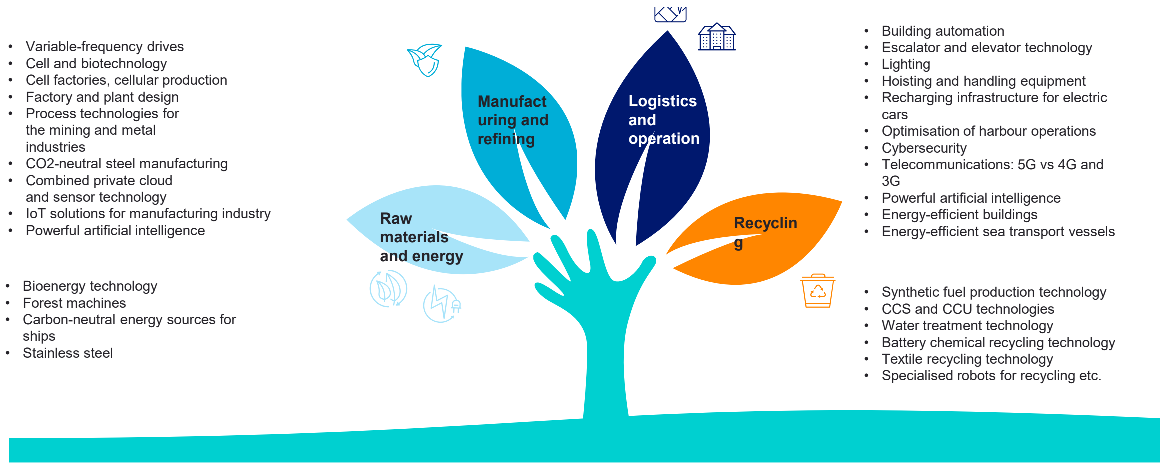


Figure 16. The complete list of key technologies includes currently successful products and new key exports in different parts of the value chain (sources: Technology Industries of Finland, AFRY Management Consulting).

The carbon handprint of the technology industry's current emission and energy consumption-reducing export products and services is estimated to be 20 million tonnes CO2e per year at a minimum, which is nearly five times the technology industry's direct greenhouse gas emissions in Finland. The carbon handprint of emerging technologies was also estimated. According to the technology industry, these solutions could increase the handprint by over 50 million tonnes CO2e per year.

International estimates suggest that the global demand for low-carbon solutions will increase by 20 per cent from the current level in order to achieve the currently agreed climate goals. The technology industry estimates that this would increase Finland's annual exports of investment goods by over EUR 3 billion. In addition, a large number of parties, both domestic and international, have promoted green recovery measures as an important tool in managing the aftermath of the coronavirus crisis. The recovery measures may increase the demand for low-carbon solutions twofold, which would increase Finland's annual export potential to over EUR 30 billion.

Operating environment conditions

The roadmap makes the general assumption that Finnish society will continue to trust that industry can deliver prosperity and will support it appropriately. The industry views the requirement of decarbonisation as a favourable development in the marketplace and operating environment, which include stable and predictable regulation, long-term climate and energy policy, and investment-friendly authorities and permit processes. The technology industry also considers a national hydrogen strategy and its implementation roadmap to be essential.

5.5 Food industry

> *”The food industry is able to reach its target of reducing greenhouse gas emissions by 75 per cent by 2035 through open information exchange and cooperation in the food supply chain, assuming a predictable and stable business environment”*

Work on the food industry low-carbon roadmap started in March 2020, and it was completed in August 2020. The membership of the Finnish Food and Drink Industries' Federation (ETL) was actively engaged during the project. From the start, the aim was to achieve continuity for decarbonisation and the related roadmap work.

The current state of decarbonisation in the food industry

For now, there is no unified information source for the current state of decarbonisation in the food industry, which made it challenging to evaluate the sector's decarbonisation. The evaluation of the current state in decarbonisation is largely based on interviews with food industry companies and an electronic survey of ETL member companies conducted in May 2020.

Food industry operations typically generate little if any direct greenhouse gas emissions (Scope 1). What little direct emissions there are from production processes are typically related to the use or generation of carbon dioxide (e.g. stunning, smoking, roasting, and fermenting).– Direct emissions are also generated by the plants' internal or adjacent energy production. For most companies, the direct greenhouse gas emissions of food production amount to between zero and 30 per cent of the product's life cycle emissions. The majority, 60 to 80 per cent, are related to situations where the company produces its own energy. Self-sufficiency in terms of energy production is rare in the industry, and purchased energy is often used.

Companies in the industry have carried out energy efficiency measures to reduce direct emissions, such as developing heat recovery and reducing energy consumption. In addition, many companies have adopted low-carbon energy production methods, with biosteam plants and biogas use on the rise in particular.

The operations of food industry companies generate much more indirect than direct greenhouse gas emissions. The majority of a food product's life cycle greenhouse gas emissions are generated during primary production or energy production (Figure 17). To a lesser extent, indirect emissions are generated by logistics and packaging materials. Additional greenhouse gas emissions are generated in different parts of the value chain, including consumer food waste..

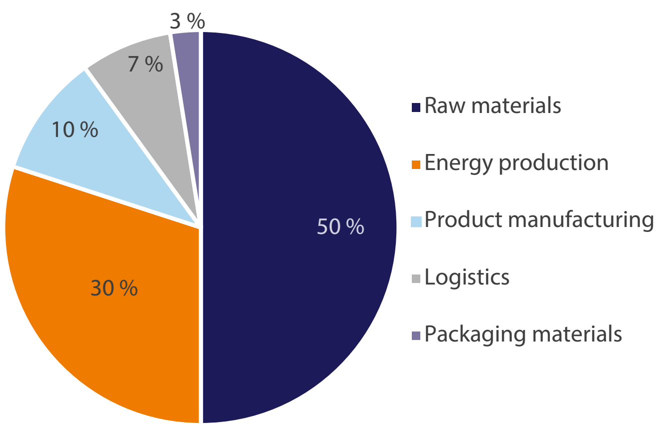


Figure 17. The major life cycle carbon footprint impacts of products are the result of raw material manufacturing (sources: Finnish Food and Drink Industries' Federation, Ecobio).

The roadmap suggests that Finland's national legislation, financing and incentive systems, and high level of technology have resulted in large-scale adoption of the best available technology (according to the BAT conclusions of the Industrial Emissions Directive) among food industry companies. In Finland, responsibility and climate change mitigation have been recognised as a competitive advantage in time, which is why large companies in particular are already widely implementing emission mitigation techniques. Statutory conformity requirements have also ensured that small and medium-sized enterprises have a good level of readiness for emission reductions in general.

Energy and materials efficiency solutions are in widespread use in Finland, especially in large food industry companies. This is due to government-subsidised systems (including energy performance contracting) and direct government influence on energy use costs in companies.

Objective and goal state conditions

The vision of the food industry low-carbon roadmap for 2035 is that low-carbon solutions will have been widely adopted in the sector, and that climatic effects will be well-managed in the food industry value chain. The Finnish Food and Drink Industries' Federation is aiming for carbon neutrality in cooperation with companies in the industry. Their 2035 target is to reduce the sector's greenhouse gas emissions by 75 per cent relative to net sales. The food industry is firmly committed to advancing the entire food supply chain's efforts to reach carbon neutrality.

A predictable and stable operating environment is essential for promoting decarbonisation in companies. The industry states that the government must support low-carbon operating methods in a predictable manner between 2020 and 2035. In this, the different starting points of companies and the opportunities and obstacles posed by the food industry's diversity should be taken into consideration. In particular, the restrictions and special features brought on by food industry regulations must be noted when assessing food industry operations.

Main solutions for achieving the objective

As a whole, the food industry generates relatively few direct emissions, which is a good starting point for a low-carbon future.

The roadmap lists a number of measures for realising the low-carbon vision and goal state, included in Figure 18. The essential measures are related to predictable government measures to support low-carbon operating methods and the availability and adoption of low-emission energy. Shared and harmonised, LCA-based calculation methods will also need to be developed based on scientific facts. One suggested measure is the continuation and deepening of the roadmap work.

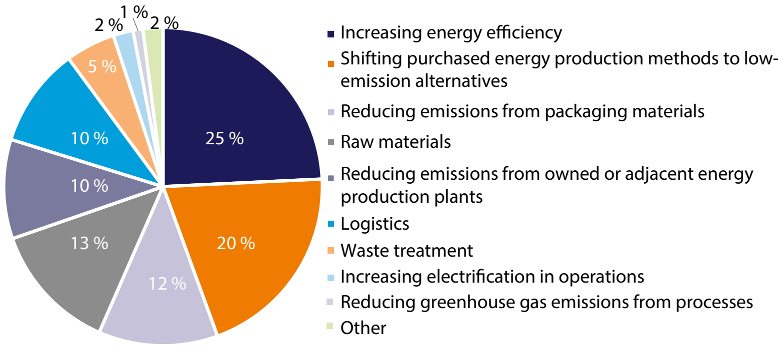


Figure 18. Primary means identified by companies for reducing the operational carbon footprint (sources: Finnish Food and Drink Industries' Federation, Ecobio).

Energy production is one of the most significant emission sources in the life cycle of food products. According to the roadmap, the transition to alternative fuels and zero-emission energy will require government direction and initiative from the companies themselves.

The emissions of energy production can also be reduced by increasing the share of renewable energy and by accelerating energy efficiency measures considerably across all member companies of the Finnish Food and Drink Industries' Federation regardless of size. This requires investments in energy-efficient systems, energy audits, and the sharing of best practices and information. Pioneering companies have a major influence on the building of the food industry knowledge base and toolkit for decarbonisation.

Most companies in the industry estimate that a further reduction of 10 to 30 per cent in energy consumption can be achieved with energy efficiency measures. Furthermore, many food industry companies consider it possible to replace most or all energy used with renewable, low-carbon energy at some point in the future.

Solutions related to the utilisation of production side streams and the prevention of production losses should be adopted more widely, as there exists a lot of unused potential.

The calculation of greenhouse gas emissions and product carbon footprint calculation are core elements in transitioning to low-carbon business. This requires harmonised scientific and LCA-based calculation methods, as well as emission factors that take into account the nutritional value of the food products. The calculation methods must be compatible at national and international levels. This will ensure that the product emissions are comparable and that they remain competitive on the international market.

In the case of food, the majority of emissions are generated during primary production, which is outside the scope of the food industry's roadmap. This is why cooperation in the value chain is of paramount importance for decarbonisation. Existing cooperation must be strengthened, particularly between primary production and the food industry, to reduce greenhouse gas emissions and harmonise the calculation of emissions from raw materials. To this end, open information sharing will be necessary, along with identifying the impacts of the different operators in the value chain.

5.6 Commerce

> ***"Carbon-neutral commerce can be expedited by 15 years by reducing the tax on electricity and supporting the small-scale production of renewable energy, for example."***

Commerce is the largest sector of the economy, with nearly 300,000 employees. There are some 40,000 companies operating in commerce who serve the rest of the business world, the public sector, and consumers. Operating in proximity to consumers and companies, commerce has a strong position socially and economically to enable climate change mitigation.

Commerce is a major economic investor with a large volume of domestic purchases. Its investments and purchases also create jobs in other sectors. Commerce will continue to reinforce its role and added value in the transition to a carbon-neutral society. This is aided by the servitisation of commerce, new business models (including leasing and life cycle solutions), and the trend towards carbon-neutral and carbon-negative investments.

Companies in the sector are endeavouring to bring together climatically sustainable products and services with sellers and buyers throughout the value chain in a resource-efficient manner. The aim of the commerce sector's low-carbon roadmap is to put Finnish commerce at the forefront of its industry in climate action by achieving carbon neutrality by 2035 and near-zero emissions by 2050.

The current situation

The transition to carbon neutrality is a cornerstone in the strategies of industry companies. The industry has worked for a long time to protect the climate, and companies have made determined efforts to transition to low-emission and renewable energy sources. Staff skills and customer solutions have also been future-proofed. Direct emissions from commerce account for less than 1 per cent of Finland's greenhouse gas emissions. Associations in the sector have also signed voluntary agreements and commitments to mitigate climate change. One example of this are the voluntary Green Deal agreements signed by the industry and the Ministry of the Environment.

The present in numbers: emissions, 502 tonnes CO2 (2017); energy purchased, 3,993 GWh (2017); heat purchased, 2,365 GWh (2017); workforce, 287,000 (2019).

Estimate of future development: Carbon handprint

According to the industry, its companies' climate action has a large positive carbon handprint. The carbon handprint impact concerns the entire value and supply chain, and customers' opportunities to act and live in a sustainable, carbon-neutral way. The commerce sector is actively offering solutions that reduce its customers' carbon footprint and emissions, as well as tools for measuring and reducing consumption in the industry.

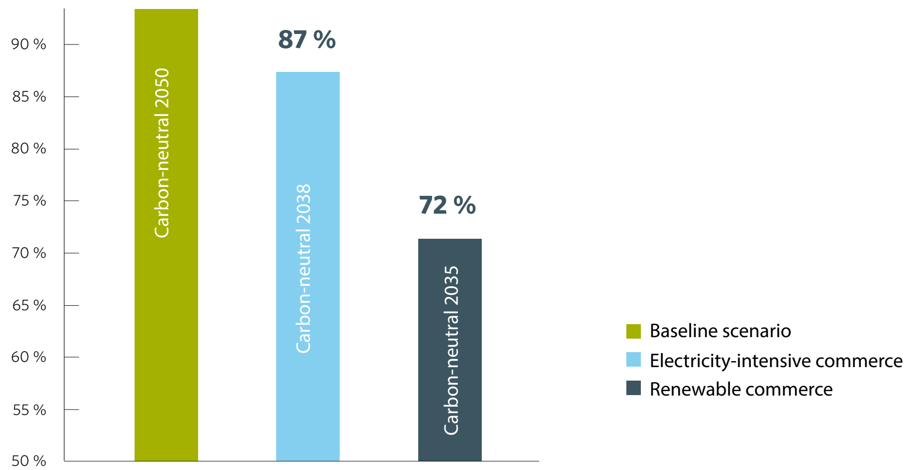
Convenience goods and specialty goods are an interface into private consumption and can reduce key emission sources from consumption by offering alternatives. The technical goods trade can have an unexpectedly large carbon handprint as an accelerator, enabler, and realiser of customer transformations in industry, infrastructure investments, housing, and more. The wholesale trade maintains the availability of essential products for industry and controls their quality.

Estimates of future development: Carbon footprint

According to the roadmap, the determined emission reduction efforts of the commerce sector will require more extensive statistics for different industries and functions. The statistics for electricity and heat use in particular, as well as transport and circular economy, must be greatly improved. Reliable material produced by the authorities would enable more effective and congruent targeting of measures and comparable reporting of impacts between sectors.

Due to the shortcomings of statistics for the commercial sector, a completely new and comprehensive emission reduction monitoring model was created for the industry's low-carbon roadmap. The low-carbon index of commerce enables the changes of the roadmap's scenarios to be tracked (see Figure 19).

The three scenarios of the roadmap enable the monitoring of emissions in from members of the Finnish Commerce Federation as follows: The baseline scenario depicts the continuation of the current style of change, mostly through the internal activities of companies. The electricity-intensive scenario describes a rapid reduction in heat use and increasing electricity consumption by the companies in the commercial sector. The renewable commerce scenario is based on electrification and dedicated, small-scale production methods of renewable energy in commerce, which will substantially reduce the use of purchased electricity and heat.



The "renewable commerce" scenario promises significant cumulative reductions in emissions in the next 15 years and carpon neutrality by 2035. The scenarios reguire compensation.

Figure 19. Total carbon-indexed emissions in the scenarios between 2020 and 2035 (cumulative; source: Finnish Commerce Federation).)

The roadmap uses the carbon index of commerce to track the development of emissions generated by commerce. The index was created for the roadmap, as official sources could not provide enough information to form an overall picture.

The index includes a comprehensive selection of available information from various official sources about the direct and indirect emissions of commerce, such as the use of electricity and heat. Furthermore, member companies were surveyed for the state of refrigerant emissions and future predictions. The index is also based on the specific emission factors used by the energy industry for the situation at present and the future factors of different scenarios. They were used to standardise the effects of different scenarios on the industry.

Statistical methods were used to index the standardised CO2 emissions of the present and the different scenarios, which enabled the tracking of changes. The Finnish Commerce Federation will monitor the progress of the roadmap's scenarios and the impacts of policy and company measures. The components of the carbon index of commerce are included in Figure 20.

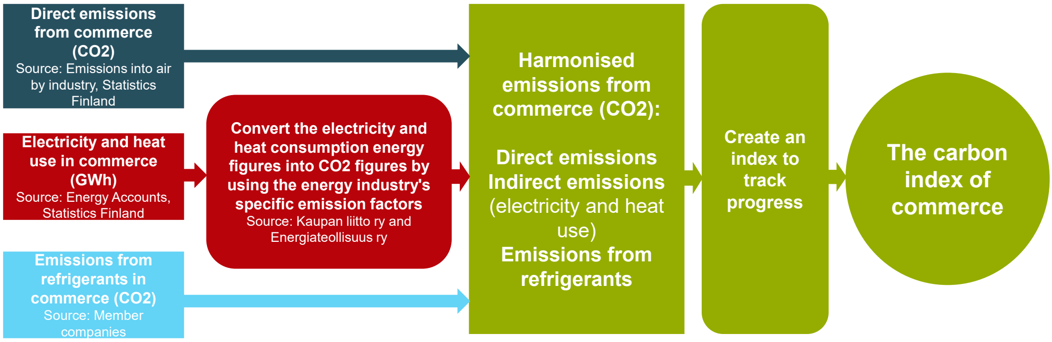


Figure 20. **The carbon index of commerce (source: Finnish Commerce Federation).**

Main low-carbon solutions

Commerce is at a crossroads with regard to climate change and several other global megatrends with cumulative and multiplicative effects. According to the roadmap, domestic commerce is in an unfair competitive position in comparison to international e-commerce and non-EU operators. The role of market and regulatory control is important in achieving a level playing field.

The current electricity taxation puts a threefold tax on the electricity used by the service sector compared to industry. The global nature of e-commerce and distance selling have introduced extensive changes to the commercial operating environment. For example, automated commercial logistics hubs are energy-intensive, which means that gradually lowering the electricity tax on domestic commerce to the level of industry will, according to the sector's estimate, support the sector's climate efforts and improve their international cost competitiveness. This will promote emission reductions and reduce dependency on district heating, which will continue to be generated with coal and peat for some time to come.

In order to transition to carbon neutrality by 2035 and near-zero emissions by 2050, machines and production capacity will need to be upgraded extensively. According to the industry, this will require support for the acquisition of new clean and energy-efficient energy sources, machines, and equipment, as well as sustainable, high-quality life cycle solutions. The roadmap suggests that a purchase subsidy for companies based on climate objectives could help overhaul the Finnish industry, construction, and retail businesses, along with their ability to change and compete.

The roadmap also states that it is important to quickly adjust the procurement criteria of the public sector, cities, and towns. Construction and maintenance services are responsible for a sizable portion of the emissions from cities and towns. According to the industry, carbon neutrality and zero-emission objectives necessitate the inclusion of carbon footprint in the procurement criteria and support for the competitive offering of solutions that are in line with the climate policy.

The energy consumption of commerce will increase significantly in the coming years as processes are electrified. The sector possesses vast unutilised roof and land areas that could be used to produce renewable energy. The commercial sector is able to increase its own production of renewable energy, which would contribute to the security of Finland's energy production (distributed generation). The investments of the commercial sector in zero-emission energy production can be increased by raising the lower limit of small-scale production.

5.7 Logistics and transport

"The government's goal of halving emissions from traffic by 2030 is achievable with de-termined measures."

Low-carbon objective and current situation for the logistics and transport industry

About one fifth of Finland's emissions come from transport, which makes the industry's emission reductions an important factor. The Finnish government has decided to cut transport emissions in half by 2030, relative to the level of 2005, and to eliminate emissions by 2045. These are ambitious targets, as emissions from domestic transport were reduced by approximately 10 per cent between 2005 and 2018.

The baseline scenario published by the Ministry of Transport and Communications and VTT on 22 April 2020 estimates that current policy measures will reduce greenhouse gas emissions from transport by 37 per cent by 2030, relative to 2005, without additional measures[13]. The roadmap prepared by logistics and transport operators suggests that transport emissions can be halved by 2030. The logistics and transport industries are committed to pursuing the emission reduction targets of the roadmap.

The roadmap was jointly authored by Service Sector Employers Palta, Finnish Freight Forwarding and Logistics Association, Finnish Information Centre of Automobile Sector, Association of Logistic Enterprises in Finland, Finnish Public Transport Association, Finnish Bus Association, and Intelligent Transportation Society of Finland – ITS Finland. Put together, these organisations represent a large portion of Finland's passenger traffic and goods traffic sector. The work was carried out in cooperation with AFRY Management Consulting. The roadmap covers domestic road, water, and rail transport in Finland. The 2030 objective of reducing emissions by half is achieved in the roadmap without carbon offsets.

Estimate of future development

The logistics and transport industry's roadmap estimates that it is possible to halve transport emissions by 2030. In the estimate, the emissions are reduced by 51 per cent by 2030 and by 59 per cent by 2035, relative to 2005.

The additional measures suggested by the roadmap will drastically reduce greenhouse gas emissions from transport between 2020 and 2030 (see Figure 21). The emissions will be 6.3 million tonnes of CO2 per year in 2030 and 5.4 million tonnes of CO2 per year in 2035. Compared with the baseline scenario published by the Ministry of Transport and Communications, the additional measures of the logistics and transport industry roadmap can, according to the roadmap's estimates, achieve a reduction of 1.85 million tonnes of CO2 by 2030.

13 https://api.hankeikkuna.fi/asiakirjat/d99a3ae3-b7f9-49df-afd2-c8f2efd3dc1d/1ab511f1-aa06-45c0-b3ef-9ac9650838c9/MUISTIO_20200422120412.pdf

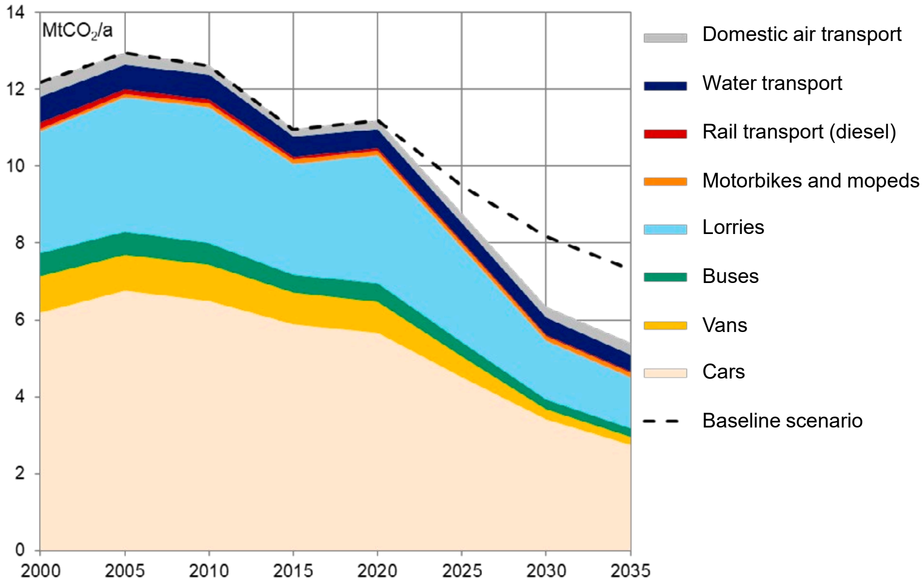


Figure 21. Greenhouse gas emission development, according to the roadmap (source: AFRY Management Consulting).

The emission development described by the roadmap is not a certainty – the measures listed below must be taken immediately and with determination, according to the industry. Incentives and investments will be required from the sector and the government to maintain the competitiveness of logistics and transport.

Main solutions for achieving the objectives

Although greenhouse gas emissions from transport have barely budged in the last 30 years, the industry can be made low-carbon in the appropriate conditions.

There is no single solution that would achieve the required reductions – reducing emissions from transport must be accomplished through a combination of measures (see Figure 22). The roadmap identified 18 measures, which can be divided into five categories:

1) Accelerated replacing of old cars with new cars
    - Use policy instruments to accelerate the modernisation of Finland's cars and the spread of low-emission cars.
        - Shift the focus of motor vehicle taxation from the point of sale to an annual vehicle tax.
        - Utilise a scrapping incentive.
        - Utilise a purchase subsidy for heavy vehicles.
        - Adjust the taxation of company cars.
2) Public transport and sustainable modes of transport in cities
    - Develop the traffic systems of cities to be sustainable through comprehensive land use and transport system planning.
    - Use low-emission vehicles for local transport services.
    - Constantly develop the level of service in public transport to create a base for a sustainable transport service system. Take measures to promote walking and cycling (including transport pricing).
3) Renewable fuels
    - Raise the distribution obligation for renewable fuels to 35 per cent by 2030. No noteworthy alternatives are in sight for diesel fuel in the next ten years in the case of heavy transport.
        - Potentially target goods traffic, increase the incentive for the distribution obligation, and utilise a production subsidy.
        - Make the distribution obligation of biogas 65 per cent by 2030.
        - Synthetic, carbon-neutral fuels are also an option.

4) Sustainable transport services and digitalisation
    - Accelerate the digitalisation and servitisation of logistics and transport, and develop the trip chains, transport chains and delivery logistics.
        - Investments and RDI funding: smart infrastructure, static and dynamic data, analytics, and data transfers.
        - Policy instruments: pricing, incentives, taxation, land use, public procurement, etc.
        - Information-driven steering and reliable emissions reporting (e.g. standards).
        - Promotion of remote connection technologies as a replacement for transport.
5) Infrastructural investments in the transport system
    - Promote a transition to low-carbon modes of transport. Carry out electrification of the railway network and make targeted investments in freight transport (EUR 400 million). Increase the market share of railway transport through major rail projects (EUR 5–10 billion).
    - Invest in the Saimaa Canal (EUR 80 million) to increase the market share of inland water transport in the 2020s.
    - Remove bottlenecks from the road infrastructure to enable more energy-efficient transport, high-capacity transport vehicles, etc. Urgent improvements are needed in the core road network, EUR 2–3 billion.
    - Improve the condition and maintenance of the road network.
    - Invest in urban rail transport.

The logistics and transport industry's roadmap suggests, among other things, that over a quarter of the new mandated emission reductions could be achieved through the increased use of renewable fuels and biogas, compared with the current progress. One fifth could be achieved by adjustments in taxation to modernise the cars on Finland's roads, and one tenth could be achieved by digitalising goods traffic (e.g. transport optimisation). Replacing old cars with new models will accelerate the electrification of transport that started last decade.

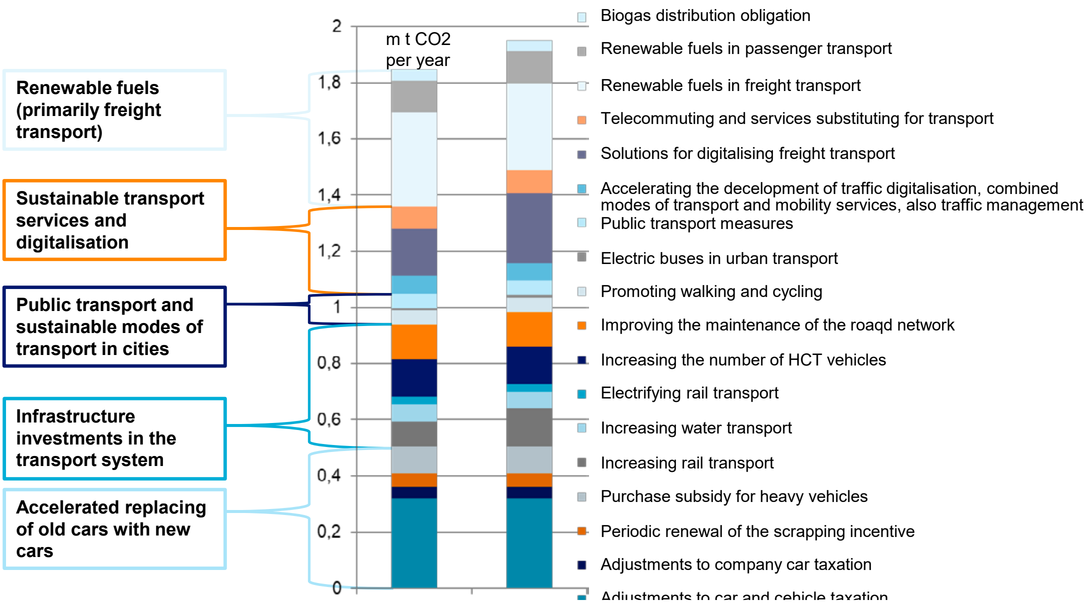


Figure 22. The impact of the measures presented in the roadmap as compared to the baseline scenario by sector (source: AFRY Management Consulting).)

Additionally, the logistics and transport roadmap states that low-emission transport solutions have major export potential. The global market for electric cars, traffic control systems, ride-sharing services, etc. is estimated to grow by 20 per cent each year between 2017 and 2022, according to the MEAE's National Growth Programme for the Transport Sector. Exports of sustainable solutions will also increase the sector's carbon handprint.

In the end, the choices of customers and consumers dictate emission reductions. Zero-emission alternatives must be made attractive to customers and consumers in order to reduce emissions.

5.8 Agriculture

"Climate measures must be targeted where they have the most impact: in emission reductions for peatlands, mineral soil carbon sequestration, and the energy transformation of farms."

Agriculture will need extensive measures to reduce emissions from peatlands, increase carbon sequestration in mineral soil, and change agricultural energy use and production. These changes call for more soil surveys as well as new guidelines and incentives for farmers. It must be noted that the farmers' primary mission is to produce domestic food that meets consumers' needs and preferences.

Different farms have vastly different capacities for reducing greenhouse gas emissions. Significant reductions must be planned carefully and executed with versatile tools in order to allow every farmer to implement whichever measures suit them, in cooperation with other farmers and operators. The roadmap aims to improve the sustainability of Finnish agriculture in all areas, including profitability.

The roadmap raises uncertainties and the need for additional research into climate action, particularly in the case of peatland and verifying carbon sequestration in different farming methods.

The current situation

Greenhouse gas emissions from Finnish agriculture were approximately 16 million tonnes CO2e in 2018. This is close to the level where emissions from agriculture have remained for the past ten years. According to the greenhouse gas inventory, calculated greenhouse gas emissions from agriculture come from the soil and field use (75 per cent), farm animals and manure processing (19 per cent), and energy consumption (6 per cent).

Estimate of future development and scenario descriptions

The agriculture roadmap analyses future development by using three scenarios: the baseline scenario (with existing measures, WEM) and two more-ambitious scenarios (with additional measures, WAM1 and WAM2). The base level for the roadmap's measures are the averages of greenhouse gas emissions from agriculture between 2017 and 2018.

The WEM scenario depicts a continuation of current policy with no additional measures or policy instruments deployed to reduce greenhouse gas emissions from agriculture. At their predicted rate, the calculated greenhouse gas emissions from agriculture will fall by 5 per cent by 2035 and by 6 per cent by 2050 (see

Figure 23). This translates to a reduction of less than 1 million tonnes of CO2e by 2050, mainly due to a nominal reduction in cattle and no major changes to agricultural production or field use.

The development paths of the WAM1 and WAM2 scenarios are different: various policy instruments are used to steer agriculture into reducing greenhouse gas emissions. The measures in the WAM scenarios aim to reduce net emissions from agricultural peatlands, increase carbon sequestration in mineral soil, and increase the production of biogas and solar power in conjunction with agriculture. In peatlands, this will involve a number of measures, such as reduced cultivation of annual crops, adjustable subsurface drainage, restoration, and paludiculture to maintain a high water level, all aimed at reducing greenhouse gas emissions.

In the WAM1 scenario, the greenhouse gas emissions will be reduced by 29 per cent by 2035 and by 38 per cent by 2050 (see Figure 23). This is equivalent to a reduction of some 6 million tonnes of CO2e by 2050. Emissions can be reduced by approximately 1.9 million tonnes of CO2e with measures specific to peatlands, and by approximately 2.2 million tonnes by adjusting field use and target-oriented mineral soil carbon sequestration. Slight reductions in greenhouse gas emissions can also be achieved by changing the production and use of energy and reducing the number of cattle, which is the same in the WEM scenario and the WAM scenarios. The WAM1 scenario is feasible already if the problems related to the policy instruments can be solved. In particular, these concern the terms for compensating farmers in full for any profits lost due to a loss of agricultural subsidies on low-profit peatlands taken out of farming use, as well as reforested peatlands and mineral soils.

In the WAM2 scenario, greenhouse gas emissions will be reduced by 42 per cent by 2035 and by 77 per cent by 2050 (see Figure 23). This is equivalent to a reduction of some 12 million tonnes of CO2e by 2050 (with a reduction of 6.8 million tonnes of CO2e by 2035). Approximately 3.1 million tonnes CO2e of the reduction will be accounted for by the wide-scale application of measures specific to peatland, particularly the restoration of peat soil fields, adjustable subsurface drainage, and the reforestation of shallow-peat fields. This scenario's target for mineral soils is sizable: a carbon sink of up to 5 million tonnes of CO2e by 2050 (2 million tonnes of CO2e by 2035). This must be considered a highly goal-oriented and ambitious scenario, and evaluating the target's feasibility will require heavy investment in research. Achieving this target is a long-term challenge that calls for new solutions – of particular interest are the absorption of carbon output into soil, its stability in the soil, and how to verify carbon sequestration

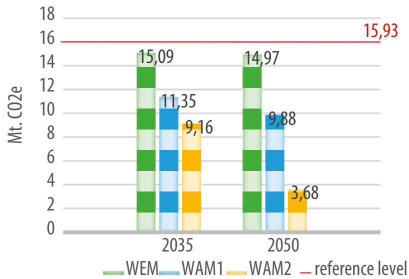


Figure 23. Net agricultural emissions in different scenarios. In addition to the Agriculture class, the bars include greenhouse gas emissions from calculated energy consumption, emissions from agricultural functions, and carbon sequestration in the land use sector (sources: Central Union of Agricultural Producers and Forest Owners, Natural Resources Institute Finland).

In the WAM scenarios, harvests will first increase by 10 per cent and then by more than 15 per cent by 2035 and 2050, respectively. This will be achieved with new cultivars and their appropriate farming, targeted resourcing, as well as more diverse improvements to soil fertility through crop rotation and increased soil organic matter. The above will diversify field use considerably, as some grain fields and low-yield grassland will be converted to oil plant farming, grasslands for biogas production and green fertilizing, restoration plant growing, and into various environmental set-asides.

On the whole, the carbon sequestration of mineral soils will be improved significantly, and mineral soils will be converted from a greenhouse gas emission source to a carbon sink by 2035. The creation of the carbon sink will be enhanced by increased growing of catch crops and multi-crop harvest grassland, both production and fallow. Biogas and solar power will be promoted with new policy instruments and additional subsidies based on the utilisation of the energy produced and the nutrient cycle, in cooperation with various operators. The renewable energy produced on farms will be used at the farms and in the transport sector to replace fossil fuels.

Objective and goal state conditions:

The emission-reduction measures of the WAM scenarios require a setting where farmers benefit from reducing greenhouse gas emissions and the related measures. If these conditions cannot be met and farmers face a loss of profit, it will not be possible to reduce greenhouse gas emissions as outlined by the WAM scenarios.

Based on the analysis, EUR 300 to 500 million in new resources will be needed between 2020 and 2050 to realise the WAM1 measures. Additional resources will be required to develop technology and to deploy methods, such as precision agriculture, new climate-proof high-yield cultivars, mineral soil carbon sequestration and its verification, adjustable subsurface drainage, and the restoration of peatlands. Some of these resources would see minimal use initially, but they would increase considerably by the 2030s at the latest. Additional resources and market development are also necessary for the energy production of farms to expand and mainstream the production of solar power and biogas, as well as the nutrient recycling of the latter.

The majority of these additional resources should come from market-based activities. Overall, agriculture will become significantly more sustainable, as measured by many sustainability indicators, so the use of public funds to aid the transformation is justified. Fitting new policy instruments on top of existing policy will be challenging and may require adjusting the conditions of existing methods (such as farming subsidies) for the instruments to have the correct effect, such as stopping the farming of low-yield lands.

Social impact assessment

The emission reduction measures and the policy instruments for their universal promotion will have major social and cultural impacts. In the WAM1 and WAM2 scenarios, food production will be increasingly integrated into climate action. The changes predicted by the scenarios in the operating environment and social expectations will affect both skill requirements and the professional image of farmers.

Large grain growing and livestock farms have better financial capacity implementing the new technologies and production methods required for climate measures. Operations based on cooperative networks will become more commonplace. In the WAM2 scenario, this will enable large-scale biogas production when distributed and centralised solutions are combined successfully. Keeping small and remote farms on board with development that is based on efficient division of work, cooperation, and a technological breakthrough will be difficult, but it is possible in a network model.

Farmers will inevitably be in different positions based on their farm's production focus, size and geographical location, as well as their number of peatland fields and prior climate measures. Therefore, the occurrence of different social and cultural impacts must be carefully analysed beforehand, as with economic impacts, when planning climate action in more detail.

The progress predicted by the WAM2 scenario is only possible if the climate policy measures leave all farmers feeling like they are working towards a shared objective. If farmers feel left out of the new objectives and operating culture of agriculture, this may cause confusion or conflict about roles, or their professional image.

Natural diversity and assessing the impact on water

The analysed measures for reducing greenhouse gas emissions both decrease and increase emissions into water systems and the natural diversity of fields. Reducing active farming, replacing traditional fields with new farming methods, and some land use changes will create more diverse field environments and leave more room for wild species. These changes will also reduce emissions into water systems in the long term.

However, land use changes will be a major strain on local waters in the short term. The measures will change the landscape of the countryside and reduce the area available for cultivated plants. It is not self-evident that society as a whole will understand and appreciate the change in the agricultural landscape and field use that will result from a significant reduction in greenhouse gas emissions.

5.9 Hospitality industry

"By 2035, the carbon footprint of the hospitality industry is estimated to decrease to one quarter of the current figure as emissions from district heating and electricity production are reduced."

The Finnish Hospitality Association MaRa prepared the roadmap for the hospitality industry in collaboration with Gaia Consulting Ltd, a consulting firm for sustainable business.

The aim was to reduce the industry's carbon footprint from the current level and estimate the development of emissions until 2035. Further objectives included determining the main emission sources and investigating what action the industry could take to reduce emissions.

Roadmap project bases

The current state calculations are based on consumption figures from 2018 that were collected from companies in the sector. The survey was sent out to 35 companies or chains in three industries: restaurants, hotels and amusement parks. Only 12 companies responded due to difficulties caused by the coronavirus pandemic starting at the time of the survey. These results are therefore only indicative and not a comprehensive description of the sector.

The carbon footprint was calculated in accordance with the Greenhouse Gas Protocol, which is the most common international calculation and reporting standard used for carbon footprint. The results were scaled to match the sector's total carbon dioxide emissions. The following scaling factors were used: restaurants according to their turnover, hotels according to nights stayed, and amusement parks by visitors per year.

The hospitality industry roadmap included direct emissions (Scope 1), indirect emissions from purchased energy (Scope 2), and electricity and heating production emissions from rented premises (part of Scope 3). The last set of emissions was included because the companies should have decent control over them. Other indirect emissions were not included in the calculation.

The current situation and estimate of future development:

The majority of the sector's current and future emissions, 93 per cent, come from the consumption of district heating and electricity at owned and rented premises (Figure 24).

The roadmap suggests that the sector's greenhouse gas emissions will fall radically in the coming years even in the baseline scenario as Finland's production of electricity and district heating moves to other fuels. The sector's emissions may be reduced by up to 77 per cent between now and 2035. The baseline scenario assumes that the sector's volumes remain at their 2018 level and no special emission reduction measures are undertaken.

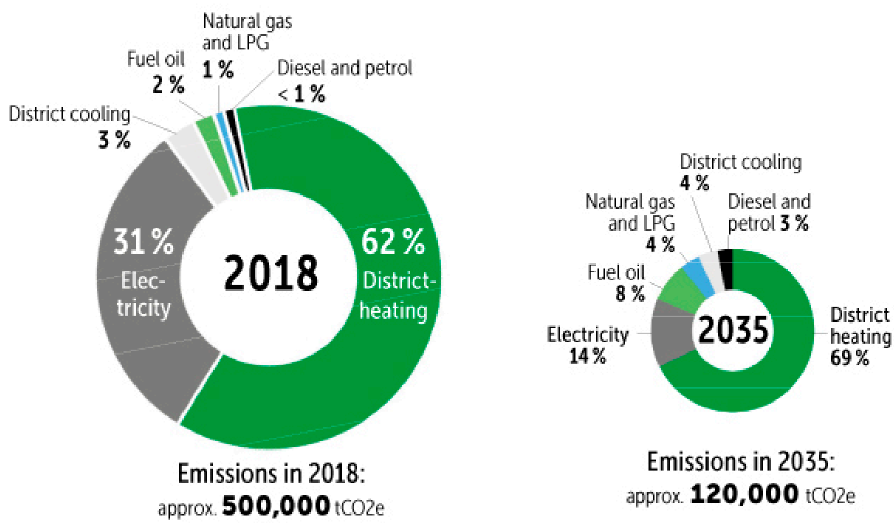


Figure 24. Emissions from hospitality industry services in the baseline scenario between 2018 and 2035 (sources: Finnish Hospitality Association MaRa, Gaia Consulting).

The proportion of electricity will reduce from 31 per cent to 14 per cent by 2035. This will be due to changes in electricity production. The proportion of district heating will increase, and so will the proportions of fuels.

Main solutions for achieving emission reductions

The majority of the sector's emissions come from district heating and district cooling, so reduction measures should focus on these. Figure 25 includes measures identified in the hospitality industry roadmap that operators can take to reduce their emissions.

Energy upgrades (e.g. changes in heating types) and centralised control will have an effective and permanent impact on emissions. Large investments are often necessary to make energy upgrades, and they can only be implemented in owned properties. On the other hand, these investments are often cost-effective and available from energy service companies (ESCO), for example. The above example is a business where an external operator finances the energy investment and the buyer repays them with funds from cost savings.

In 2035, electricity will have a medium share of the sector's total emissions, and hence measures targeting electricity will have a medium impact at best. Emissions from electricity can be effectively reduced with energy upgrades, for example by starting local renewable energy production. Equipment choices and centralised control will also have an effect on emissions.

The proportion of fossil fuels will be approximately 15 per cent of the sector's total emissions in 2035, and any measure targeting them will have an equally low impact. Emissions from petrol and diesel can be eliminated with alternative equipment and fuels, but as their share of emissions will be only 3 per cent in 2035, the effect on total emissions would be minimal.

How can industry companies reduce their emissions?

The following grades were used for the emission reduction measures' impact on the sector's total emissions:

- Major
- Moderate
- Minor

The following criteria were used:

- The impact of the measure on the source's emissions in 2035
- The emission source's proportion of the sector's total emissions in 2035
- The following criteria were used to assess the feasibility of measures:
  Major: easily implemented by everyone, no obligation or subsidies necessary, or they exist already.
  Moderate: moderately priced, but limited application.
  Minor: expensive or difficult, and requires investment subsidies or technological development.

District heating and district cooling

Major

– Energy upgrades (e.g. modern doors and windows, extra floor and roof insulation)
– Carrying out energy upgrades: from district heating to geothermal heat

Moderate

– Moving to more energy-efficient buildings
– Curbing temperatures and cooling with centralised control
– Saving hot water with water-efficient taps and showers
– Improving the recovery of waste water
– Reducing the consumption of district heating with air source heat pumps

Minor

– Reducing water consumption through instructions for employees and customers
– Adopting green rental agreements, splitting the cost savings between the owner and the tenant

Electricity

Major

– Producing solar power (+ micro-generation of wind power, <50 kWh)

Moderate

– Replacing lights with energy-efficient LED lights
– Energy-efficient kitchen equipment (preparation and serving, i.e. dish warmers, ovens, grinders, mixers)
– Energy-efficient washing equipment (dishes, laundry)
– Energy-efficient refrigeration equipment (cooling and freezing)

Minor

– Energy-efficient machines, vehicles, and devices (e.g. amusement park rides, game arcades)
– Instructing the use of electricity (hotel guests)

Fuels

Moderate

– Replacing fossil fuel local heating with heat pump solutions (larger sites may use biomass or biogas)

Minor

– Replacing internal combustion engine cars or fossil fuels with low-emission vehicles
– Offering electric bicycles etc. to staff (image considerations)
– Replacing diesel-powered generators with electricity or biodiesel (e.g. amusement parks)
– Replacing oil in other solutions (e.g. large saunas)
– Replacing gas-powered machines and devices with low-emission alternatives (electricity, biogas) or giving them up altogether (patio heaters)
– Replacing gas-fired kitchen equipment with low-emission alternatives (induction, electricity, biogas)

Figure 25. How can industry companies reduce their emissions? A selection of tools for emission reductions in hospitality industry services (sources: Finnish Hospitality Association MaRa, Gaia Consulting).

The majority of the sector's total life cycle emissions come from company value chains. Indirect emissions are generated by food production, logistics, consumer transport and construction, among other things. Companies have limited opportunities to influence the above, as the sector is subject to the choices made in the value chain.

5.10 Construction industry

"The greatest potential exists in reducing the energy consumption and emissions from existing building stock."

Roadmap project bases

The Confederation of Finnish Construction Industries RT prepared the roadmap for a low-carbon built environment in cooperation with its stakeholders. The built environment has a wide-ranging effect on society and the economy. Of the construction industry's fixed capital, 83 per cent is tied up in buildings and infrastructure. The construction and property business is responsible for 15 per cent of Finland's GDP and has over 500,000 employees.

The built environment is one of the biggest sources of CO2 emissions, and its importance for climate change mitigation is undeniable. More than a third of the energy consumed in Finland goes to the built environment, and it is responsible for about one third of Finland's greenhouse gas emissions from consumption. Today, the majority of the sector's emissions come from the use-phase energy consumption of buildings.

The construction industry roadmap is the first calculation of the annual carbon footprint for construction and the built environment in all of Finland, measures for reducing their emissions, and the conditions for the above. The roadmap also includes future emission reduction scenarios up to 2050. The aim was to identify the major areas for reducing emissions, low-carbon measures, and the main uncertainties.

The roadmap also analysed how the 2021–2022 reform of the Land Use and Building Act and the related building life cycle and low-carbon assessment could be included in the broader future roadmap work. Particular attention was paid to potential overlap with existing legislation (regarding EU emission trading and the energy efficiency of buildings, for example). An important aspect was to identify the coupling of sectors, which are presented in Figure 26.

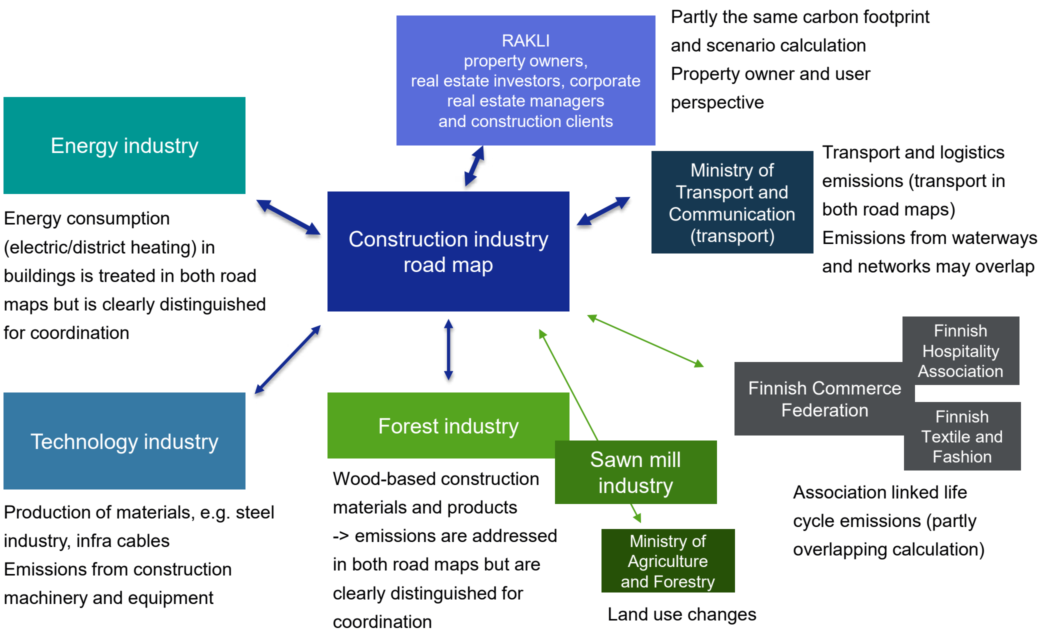


Figure 26. **Cross-sectoral coupling of the the Confederation of Finnish Construction Industries RT roadmap with other sector roadmaps (sources: Confederation of Finnish Construction Industries RT, Gaia Consulting).**

The current situation

The analysis of the built environment's current greenhouse gas emissions reveals that the use-phase energy consumption of buildings accounts for three quarters of the total carbon footprint of Finland's built environment. The final quarter is evenly divided between emissions from construction materials and emissions from worksite functions, transport, etc. The current emission situation is included in Figure 27.

The most important thing for rapidly reducing emissions is to shrink the energy consumption of existing buildings through various energy efficiency measures and to develop low-carbon energy options for them.

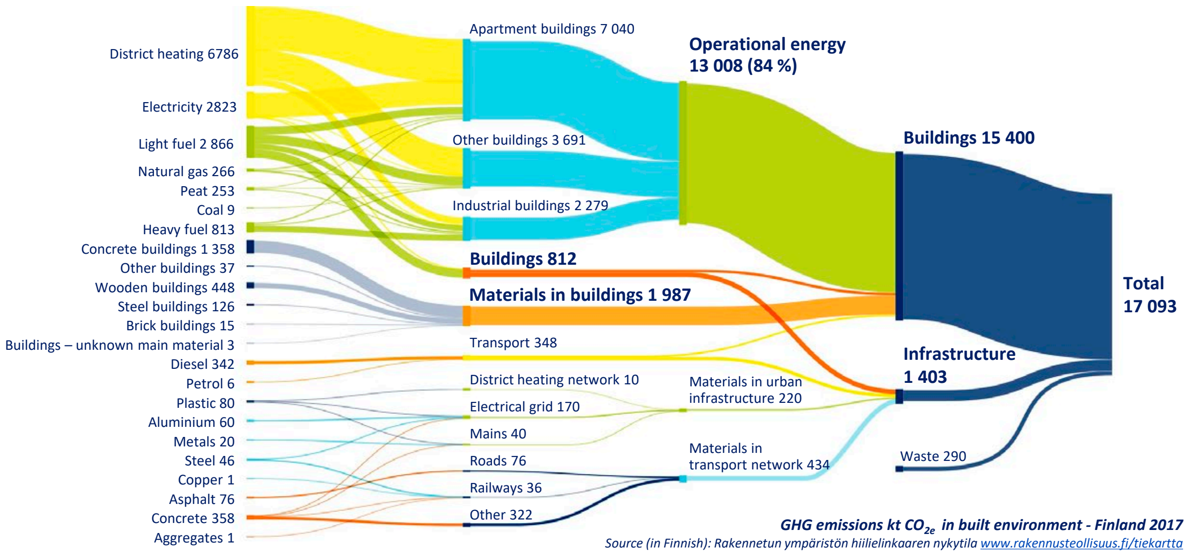


Figure 27. Built environment life cycle carbon footprint (thousand tonnes CO2), total calculated (includes the emissions of energy used in the operating phase; sources: Confederation of Finnish Construction Industries RT, Gaia Consulting).

Estimate of future development and main solutions for achieving emission reductions

The emissions of the built environment and the construction industry will be reduced by 66 per cent by 2035 (see Figure 28). In this case, the technological leaps that were identified can even achieve emission reductions of around 80 per cent. Near-total carbon neutrality will be possible by 2050 with emissions reduced by 95 per cent compared to the current level.

In the built environment, 76 per cent of emissions come from the energy consumption of buildings during their use. The greatest potential for reducing emissions lies in curbing the energy consumption of existing buildings with upgrades to their energy efficiency and heating, among other things. According to the industry, making low-emission energy available for other uses would be a major boon to energy-intensive sectors.

The main potential for reducing emissions from infrastructure construction is found in worksite functions, the use of regional rock materials to reduce transport, and the use of recycled and recovered materials. The majority of emissions (90 per cent) are set at the planning stage, which means that the effects of construction and planning will be felt for a long time over the built environment's life cycle. The public procurement entity has the principal role in making these choices and decisions.

Electrification and biofuels are important for reducing emissions from worksite functions.

During construction, the focus is on technological developments in the manufacturing of construction materials, such as cement and steel. At the building level, emissions from different materials differ only by a few parts in a thousand.

Major emission reductions will require determined action from all parties, including the public sector. The following are the sector's assessments of the measures required. The government must reform the industry's low-carbon regulations in a consistent and realisable manner. In their land use decisions, municipalities must account for the traffic emissions that result from the locations of buildings and structures, including the additional emissions caused by the difficulty of construction. Public actors must prioritise low-carbon options without any material or technology bias and in a predictable manner.

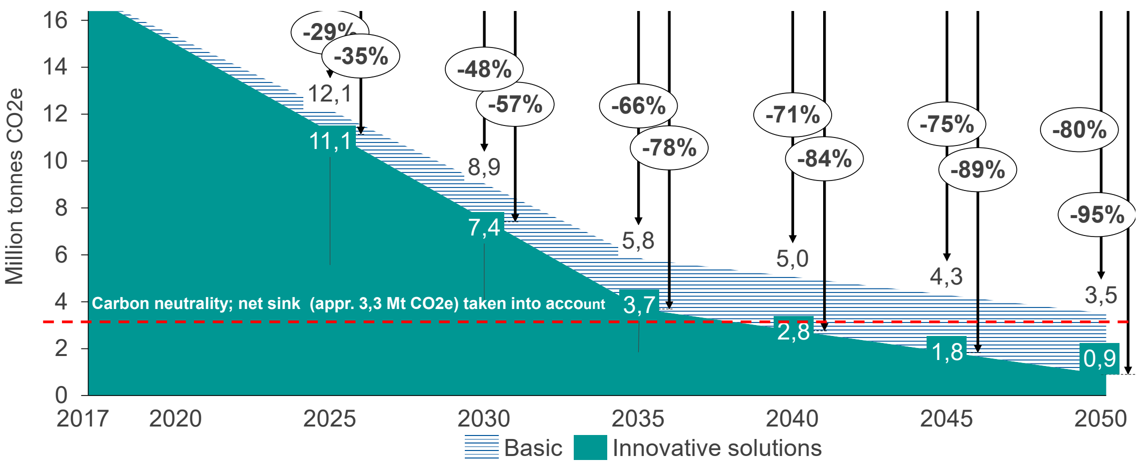


Figure 28. **Built environment life cycle carbon footprint (thousand tonnes CO2), total calculated (includes the emissions of energy used in the operating phase; sources: Confederation of Finnish Construction Industries RT, Gaia Consulting).**

The baseline scenario in the above figure reflects the reductions in emissions that can be achieved with the current distribution of construction materials and if the currently known norms and plans for the operating environment are implemented. The "innovative solutions" scenario depicts the possible reductions in a situation with nearly limitless resources. If the requirements for Finland's long-term renovation strategy (2020–2050) are met, its execution alone will result in significant emission reductions in the baseline scenario (a reduction of 24 per cent by 2035 compared to the current level).

The striped section of the figure indicates the range of emission reduction targets for the construction industry and the built environment based on the aforementioned scenarios. The range is given as a percentage of the current level for 2025, 2030, 2035, 2040, 2045 and 2050. These percentages describe the range and scale of the preliminary emissions targets for the industry and the built environment in the coming years. The measures and objectives will be specified further in stakeholder dialogue over the rest of 2020.

Roadmap project follow-up: Carbon neutrality dialogue

The second stage of the roadmap will be carbon neutrality dialogue between the stakeholders in the construction and property sector. The goal of the dialogue is to deploy proposals based on the roadmap as action over the coming years. The four topics in the dialogue will be zoning and urban development, property ownership and use, infrastructure, materials and their use, and worksites. The work will start in autumn 2020 with assembling the interest groups, and the value chain dialogue will be undertaken over the rest of 2020. The results will be published in early 2021.

5.11 Property owners and developers

"The property and construction business can reduce its emissions significantly by 2025 through more efficient utilisation of resources and space, as well as the circular economy, all without requiring additional investment."

RAKLI ry prepared its low-carbon roadmap in collaboration with Gaia Consulting Ltd in spring 2020. The aim of the roadmap was to analyse the carbon footprint components of owners and users of the built environment, and how the carbon footprint could be reduced in different building segments. The roadmap uses scenarios to analyse the role of building use as an emission source and in reducing emissions both today and by 2050.

RAKLI ry is Finland's largest association of professional property owners, property investors, commercial property managers and developers.

The current situation

The carbon footprint of RAKLI ry members is 1.592 million tonnes of CO2e (2017). The energy consumption of buildings comprises 70 per cent of the carbon footprint, while construction and waste account for 27 per cent and 3 per cent, respectively.

Finland's total emissions in 2017 were 55.4 million tonnes of CO2e, and the built environment was responsible for 30 per cent of this. By carbon footprint, the members of RAKLI ry account for 2.9 per cent of Finland's total emissions and 9.3 per cent of the carbon footprint of the built environment.

The baseline scenario of the RAKLI ry roadmap describes how the emissions from members' property stock will develop if the currently known emission reduction measures and impact of current legislation are used.

The "innovative solutions and resource efficiency" scenario includes measures that could be used for more ambitious progress towards the carbon neutrality target of 2035. The measures were analysed for their cost-efficiency, effectiveness, and other aspects resulting that many of the measures require major investments at the moment

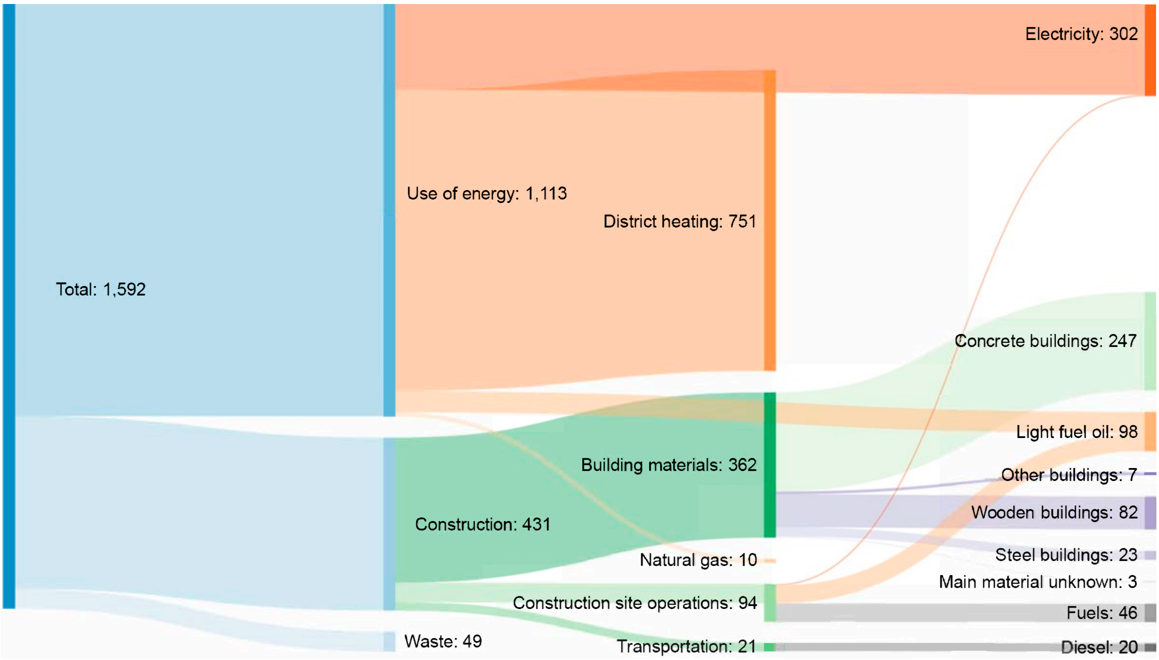


Figure 29. Rakli ry member carbon footprint in 2017 millions of tonnes of CO2 (Sources: RAKLI ry, Gaia Consulting).

Roadmap project approach: Case calculations

The RAKLI ry roadmap includes calculations for three cases of resource-efficient urban development and effective property use. They represent cost-neutral measures for significantly reducing emissions. With these measures, emissions could already be reduced considerably by 2025.

The first case concerned demolition and infill construction in optimally located areas, the second enhanced property use, and the third the converting of empty office space to residential use. The purpose of the analysis was to calculate actual figures for the emission reduction potential of the above measures, which are cost-neutral.

The measures used in these cases can be implemented immediately, and they require no technological advances from the current level.

In addition to the case studies on property development and the efficiency of use, the roadmap evaluates technical measures for reducing emissions in the existing building stock, and what can be achieved by material choices and by reducing the emissions from materials production. Some of the technical measures are already available, while others will take major investments to develop.

Estimate of future development

In the baseline scenario, emissions will be significantly reduced through the reduced emission factors of energy and the execution of the long-term renovation strategy (2020–2050) in particular (see Figure 30).

The "innovative solutions" scenario takes into account all technical measures for reducing emissions, particularly in material choices (emissions from materials production), worksite functions, purchased and self-produced zero-emission energy, and the cost-effective resource efficiency measures used to support the above..

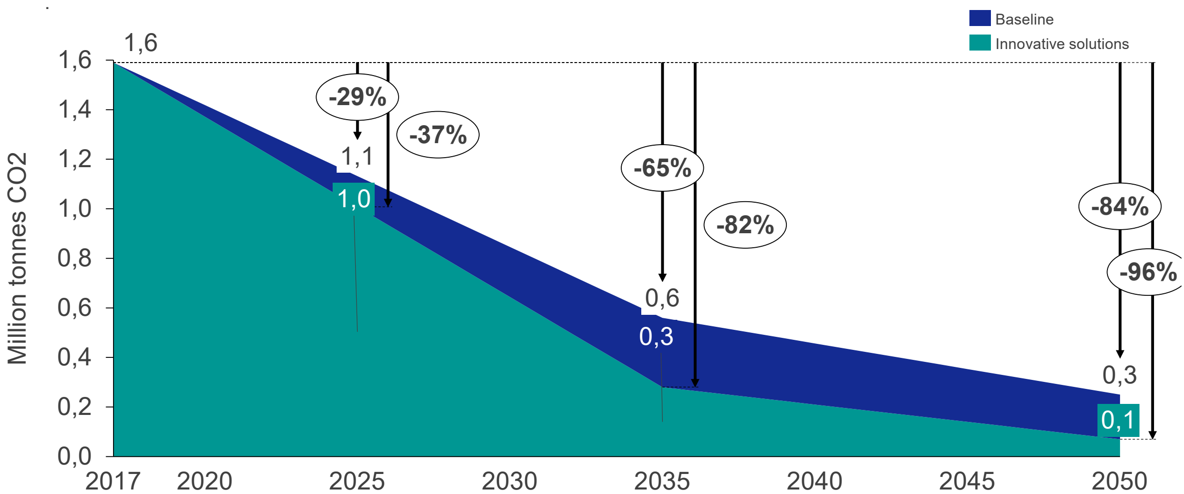


Figure 30. **RAKLI ry low-carbon emission reduction scenarios (Sources: RAKLI ry, Gaia Consulting).**

The roadmap's results show that the resource efficiency, space utilisation, and circular economy measures raised by RAKLI ry can achieve rapid and considerable reductions in emissions by 2025 already without sizable additional investments. In addition to the above, the roadmap includes technical solutions and measures related to construction measures for reducing emissions.

Economic operating conditions and main solutions for achieving the desired progress

According to the industry, implementing the roadmap will require clear changes in zoning culture and regulations on land use. Major emission sources are set already in regional planning, city planning and the planning of individual properties. For example, the industry states that using unoccupied spaces according to current demand should be allowed, and zoning should be more flexible. The role of land use in reducing greenhouse gas emissions should not be overlooked.

The energy use of properties is still the single largest emission source, but shrinking emissions from energy production also reduce the share of energy consumption in the total emissions of RAKLI ry's members. If affordable zero-emission energy will not be available for purchase in the near future, one solution is to invest in local energy production on properties or in energy communities.

Significant additional reductions can be achieved with innovative technical solutions, but many still require major investments at the moment. To achieve the emission targets, it will be important to exten-sively utilise solutions that are already cost-effective, in addition to resource efficiency measures.

For its realisation, the RAKLI ry roadmap requires that the measures listed in the roadmaps of major stakeholders, such as the energy industry and the construction industry, are also realised. Property owners can make choices that advance the development of critical emission-reduction technology.

The members of RAKLI ry have a wide selection of tools available for reducing their carbon footprint. These include emission planning in new construction projects and renovation projects, energy efficiency measures to control emissions from property throughout the life cycle, carbon-neutral operating models, and maximising the efficiency of property use. The roadmap also includes a database of measures that the member organisations can use to draw up their own low-carbon plans. Many pioneering organisations already have plans ready.

5.12 Sawmill industry

> ***"The carbon footprint of the Finnish Sawmills Association can be reduced by over 80 per cent by investing in resource-efficient production equipment and low-carbon transport solutions."***

The sawmill industry depends heavily on exports. Timber was Finland's sixth most exported product in 2019. The sector's net sales are approximately EUR 4 billion, and it produces 12 million cubic metres of timber and manufactured products. Exports account for 75 per cent. All production inputs were domestic in origin.

The sector's carbon footprint in 2019 was 421,000 tonnes of CO2e, of which 141,000 tonnes (34 per cent) were generated on plant premises. The difference, 280 thousand tonnes (66 per cent) was from the start of the chain – raw material (log) purchasing and transport to plants. The largest emission sources at plants were electricity (18 per cent) and machine fuels (11 per cent of the total carbon footprint; see Figure 31).

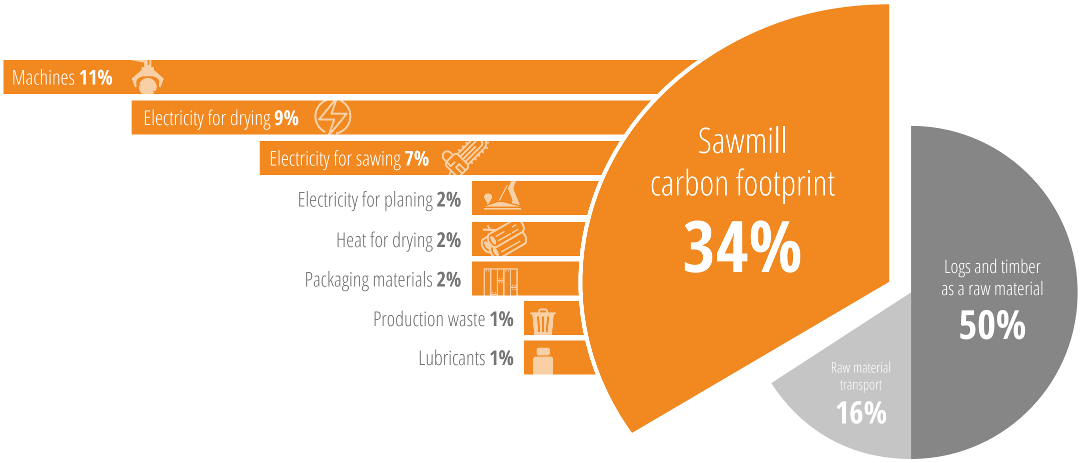


Figure 31. Distribution of the sawmill industry's carbon footprint (sources: Finnish Sawmills Association, Natural Resources Institute Finland).

Currently, sawmill industry processes use 3,230 GWh of heat energy per year. This heat is generated with industry by-products (sawdust and bark). Excluding woodchips, which are sold to the chemical forest industry, the potential heat energy of excess by-products is approximately 3,200 GWh. Currently, by-products are used in fiberisation and as a raw material for wood panels and bioenergy.

Sawmills produce 768 GWh of energy per year. The industry's machines burn 16.4 million litres of fuel oil per year. In total, 110 million litres of fuel oil are used in the entire chain from the forest to domestic customers or ports.

Estimate of future development: Carbon footprint

The sawmill industry's carbon footprint will largely depend on the development of emissions from logistics and machines. The machines used in plants can mostly be replaced with electric models, but external heavy transport and logging will remain diesel-powered in the near term. As such, emissions development will be heavily influenced by the biocomponent ratio of the diesel fuel.

In the sawmill industry's low-carbon scenario, the carbon footprint of plant premises will be reduced by 82 percent by 2040, totalling 25,000 tonnes of CO2e (see Figure 32). Major updates will be required to the sawmills' equipment to realise this target. Modernising equipment to use the best available technology will reduce energy consumption and increase sawmill output. This will both shrink the carbon footprint of sawmills and improve the industry's international competitiveness. As this equipment is largely designed and built in Finland, these investments will have effects on income and employment, as well as the competitiveness and profitability of the equipment suppliers. An estimated EUR 100 million per year will be needed for ten years for the investments.

In the low-carbon scenario, the energy and heat consumption of sawmills will be reduced to 624 GWh and 2,500 GWh per year, respectively. The energy capacity of the excess by-product stream from sawmill production that is suitable for bio-based energy production is 4,500 GWh.

The sawmill industry is rather evenly distributed across Finland. In some towns, sawmills offer the only major industrial jobs, which further highlights the impact of individual sawmills on the economies of their regions. The sawmill industry currently has about 6,000 direct employees, with many times that number employed indirectly. The low-carbon scenario predicts moderate growth for timber production, mostly as a result of improved production process efficiency. The number of jobs in the sawmill industry will stay the same in this scenario.

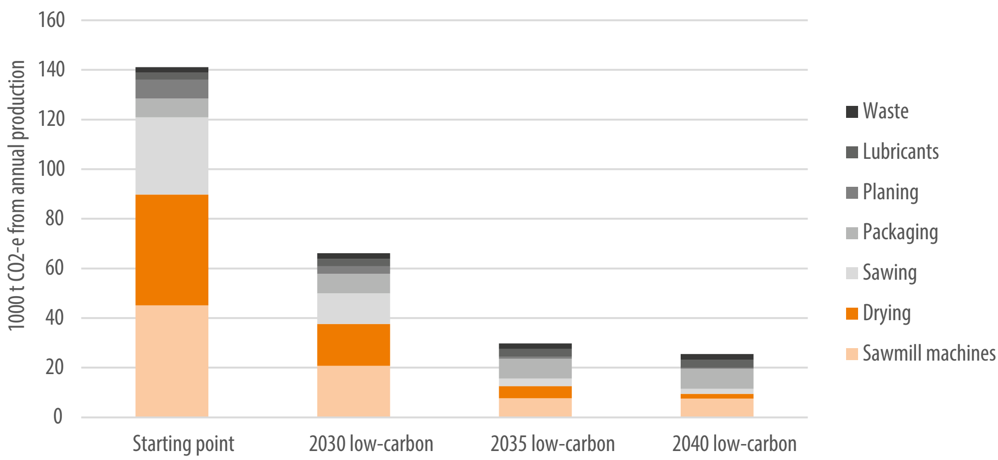


Figure 32. Timber production carbon footprint in the "inside the sawmill gates" low-carbon scenario (sources: Finnish Sawmills Association, Natural Resources Institute Finland).

Estimate of future development: Carbon handprint

In addition to reducing the sector's carbon footprint, it is important to note the substantial carbon handprint potential of the sawmill industry. For example, increasing wood construction will reduce carbon dioxide emissions from construction materials. The use of timber in domestic construction will also increase the volume of long-term carbon reservoirs.

Every year, over 9 million tonnes of carbon dioxide are sequestered in sawmill industry products. This is twenty times more than the carbon dioxide emissions from production and manufacturing.

Main solutions for achieving the objectives

How the carbon footprint of sawmills will develop is in many ways dependent on the progress of other sectors. The assumption was made regarding the specific emissions of electricity production that these emissions will be reduced by 90 per cent from the current level by 2035, and a further 90 per cent between 2035 and 2050. This progress was assumed to be linear.

For reducing emissions from logistics, solutions that enable the use of bio-based fuels will be essential. Emissions from logistics comprise over 60 per cent of the carbon footprint of timber production. The fleets can be electrified to an extent, but reducing carbon dioxide emissions from heavy equipment will largely depend on transitioning from fossil fuels to biofuels. Replacing fossil fuels with renewable, bio-based fuels will require more competitive prices for the latter.

Modern technology will improve production efficiency considerably and enable low-carbon development. There is an urgent need in the sawmill industry to modernise sawlines (sawing machines), to build new, energy-efficient kilns, and to transition into using low-carbon fuels in material transport, mostly by shifting to electric machines. According to the industry, these investments must be accelerated with an investment programme that promotes decarbonisation as well as energy and materials efficiency. The programme must include general investment subsidies, specific investment subsidies for modernising basic production equipment, and government loan guarantees.

5.13 Textile industry

”Finland's textile industry can not only become carbon-neutral itself, but can also offer solutions for the global climate challenges of the textile industry.”

The textile and clothes industry is estimated to produce about one tenth of global carbon dioxide emissions. The Hiilineutraali tekstiiliala roadmap prepared by Finnish Textile and Fashion analysed the Finnish textile and fashion industry's greenhouse gas emissions for the first time. The roadmap also investigated measures to make the Finnish textile industry carbon-neutral and solutions that could reduce emissions globally.

The current situation:

The roadmap estimated greenhouse gas emissions from Finnish textile and fashion industry companies that are generated within Finland. The textile industry has a moderate carbon footprint: 59,300 tonnes of CO2e. This is equivalent to the carbon dioxide emissions of 5,440 Finnish citizens and amounts to 0.1 per cent of Finland's total emissions.

These emissions include the textile companies' direct greenhouse gas emissions from production in Finland (Scope 1) and the indirect emissions from purchased energy (Scope 2) that is used in production, sales, storage, office and other facilities. Most of the textile industry's carbon footprint comes from the use of natural gas for industrial textile production and textile maintenance services, as well as the emissions from purchased electricity and heat.

The roadmap's carbon footprint calculation focused specifically on emissions from company operations, i.e. their carbon footprint in Finland. It should be noted that a significant portion of the life cycle emissions of Finnish textile products are probably generated in the supply chain before Finnish company operations, or later during use by customers and end users (figure 33).

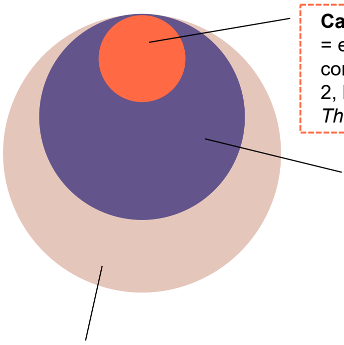


Figure 33. Areas and opportunities for climate action impact in the Finnish textile industry (sources: Finnish Textile and Fashion, Gaia Consulting).

Estimate of future development: Carbon footprint

The Finnish textile and fashion industry has excellent potential for becoming carbon neutral in its own activities. If the government supports the transformation, the industry can realistically be made carbon-neutral by 2035.

The key factors for carbon neutrality are the availability and competitiveness of zero-emission commercial electricity and heat, as well as replacing natural gas with biogas (figure 34). For example, replacing the natural gas used for industrial production and textile maintenance would reduce the industry's emissions by 44 per cent by 2035. Additional requirements include the use of zero-emission vehicles and replacing fuel oil. It may not be cost-effective or technically possible to completely avoid all emissions generated by the textile industry. Unless every operator becomes a completely self-sufficient producer of renewable energy, some emissions from purchased energy will remain.

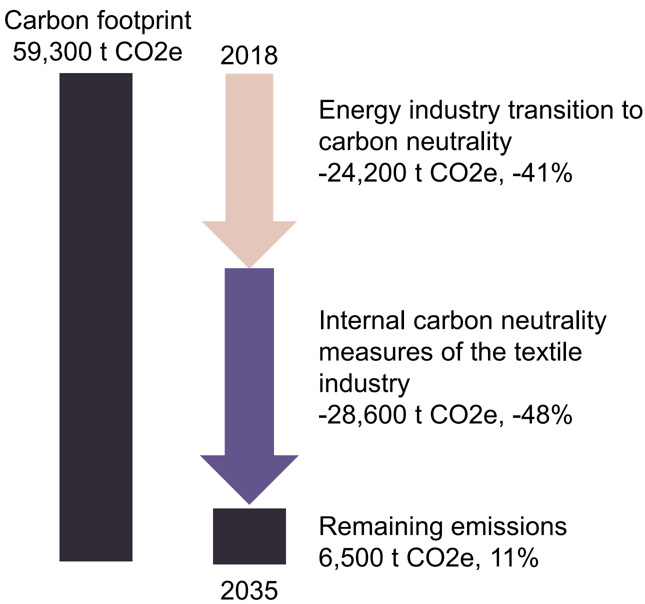


Figure 34. Reduction of the carbon footprint of Finland's textile industry (sources: Finnish Textile and Fashion, Gaia Consulting).

Estimate of future development: Carbon handprint

The global textile and fashion business is in the midst of a great change, and companies are actively looking for solutions to reduce greenhouse gas emissions. Finland's textile industry can not only become carbon neutral itself, but also offer solutions for the global climate challenges of the textile industry. The domestic production of recycled and cellulose-based textile fibres and the exporting of their production technology are examples of the Finnish textile industry's emission-reducing carbon handprint.

New fibres and their production technologies are being developed in Finland by Spinnova, Infited Fiber Company, Ioncell (owned by Aalto University and Helsinki University), BioCelSol (owned by VTT and Tampere University of Technology), Metsä Spring, Stora Enso, and Fortum, among others. The new fibre technologies being developed in Finland have the advantage of neutral raw materials: wood is a stable raw material that is easy to process, but other cellulose-based raw materials are also compatible with the process.

The new Finnish textile fibres can replace cotton, for example, the production of which is a heavy consumer of natural resources. So far the operators have pilot-stage plants in Finland, but many companies are looking to establish their first industrial-scale plants in the early 2020s.

In 2025, the above plants in Finland would have a potential total production capacity of approximately 150,000 tonnes of fibre, based on the interviews with operators. If the new fibres produced in Finland in 2025 were to replace 150,000 tonnes of cotton, this would reduce the global emissions from the textile industry by 285,000 tonnes of CO2e per year. The positive carbon handprint would be nearly five times greater than the industry's current carbon footprint in Finland.

Main solutions for achieving the objectives

As changes towards carbon neutrality will take resources to implement, companies will require consumer and government support to realise them. There must be demand for carbon-neutral solutions – so far, responsibility and carbon neutrality have yet to drive the decisions of the industry's customers and consumers.

The workshops of the roadmap's active participants – companies and stakeholders – raised the fact that the textile industry's carbon neutrality could be advanced by increasing the demand for carbon-neutral solutions in public procurement, by changing the operating environment to favour carbon-neutral solutions, and by subsidising the changes made by companies.

An important factor for the transformation was also the availability of knowledge and expertise. For companies and customers to make better climate choices in future, it will be essential to produce reliable and comparable information regarding textile materials, production methods and the life cycle emissions of products. It will also be essential to ensure that Finland has skilled workers to develop future solutions for carbon neutrality in the textile industry.

5.14 Bioenergy industry

"In future, side stream biomasses can be used to make electricity, heat, and also fuels, for example."

A summary of the Bioenergy Association of Finland report Bioenergia-alan panos hiilinegatiiviseen tulevaisuuteen Suomessa.

Approach

The operations of Bioenergy Association of Finland member companies are linked to multiple sectors, in particular the energy, forest, technology and transport industries. Each of these has prepared their own low-carbon roadmap. The report prepared by Bioenergy Association of Finland titled Bioenergia-alan panos hiilinegatiiviseen tulevaisuuteen Suomessa (The Contribution of the Bioenergy Industry to a Carbon-Negative Future in Finland) is aimed at supplementing the overview of the roadmaps regarding future development from the perspective of bioenergy and the Bioenergy Association of Finland. The report discusses the impact of the sector, additional potential for utilisation, and the role of skills and technology.

The current situation

Approximately 90 per cent of Finland's bioenergy is renewable wood energy. Wood energy comes from various forestry and forest industry side streams, more of which will be created in the coming decades. There is no industrial-scale logging purely for fuel in Finland. The side streams can be exploited for energy and to create additional value as biomass materials, or they can be left unutilised.

The energy systems of Finland and the EU still use plenty of imported fossil energy, which bioenergy has a significant role in replacing. There are limits to the potential of bioenergy: it is restricted by how fast biomass will grow. Currently, bioenergy is largely a domestic energy source and will therefore increase investments and employment in Finland.

The electrification of society is picking up speed and domestic capacity will be needed. Therefore, the industry believes that it is important to recognise the value of bio-based heat generation and cogeneration from side streams as energy-efficient and adjustable production capacity. In future, it will be possible to use side stream biomasses to produce electricity, heat and also fuels, for example.

Estimate of bioenergy sustainability

As part of climate action, the carbon reservoirs of forests must be increased and their stability ensured. If bio-based side streams are not used but left in nature, this will create temporary carbon reservoirs that release their carbon to the atmosphere at different rates without economic, employment or compensation benefits. The industry states that the controlled use of bioenergy, including increasing the amount of decaying wood (which is vital for natural diversity) is a better alternative to fossil energy in the long term and a good fit for a transition to a bio-based and circular economy.

In Europe, the sustainability of biomass has been defined in the Renewable Energy Directive (RED II). The minimum levels of sustainability for biomass are determined in sustainability legislation. The criteria for sustainability are part of social discourse and the acceptability of biomass. This is why they are governed by more than static legislation. It is to be expected that some operators will adopt more stringent criteria in the future through voluntary sustainability certification systems.

Estimate of future development: utilisation and employment

The use of bioenergy will increase in the 2020s, according to the industry, as coal is banned, the use of peat for energy is reduced, and biogas and liquid biofuels become more widely used. To ensure the availability of wood energy, it is important to sustain competitive economic operating conditions for the forest and sawmill industry, as well as to secure the sustainable future exploitation of forests. Agricultural biomass holds significant additional potential compared to existing use. In particular, increasing the growing of energy crops and short-rotation ligneous plants will require support programmes.

According to the industry, the use of bioenergy should be increased in a controlled fashion, for example by 10–20 per cent by 2030 compared to 2019.

The use of peat for energy will be reduced faster than the government programme's target and at the current level of taxation through emissions trading measures and company initiatives. The future of peat for energy after 2030 should be discussed in the 2020s as the understanding of the rate of change of the energy system becomes more apparent. Reducing the use of peat for energy will negatively impact employment by approximately 1,000 person-years over the next five years, according to the industry. Based on 2018 figures, this would be a loss of 1,800 person-years when accounting for indirect impacts. The people who are affected by this change deserve a fair transition into new operations inside the industry or in entirely new industries. At the same time, the bioenergy production and utilisation chain has potential for 2,400 person-years worth of direct employment by 2030 in the above case, according to the industry.

Main solutions for achieving the objectives:

Below are some solutions identified by the industry:

1. Sustainably replacing imported fossil energy with
   – side streams and recycled wood from forestry and the forest industry
   – transport biofuels
   – biogas
   – suitable field biomasses.
2. Cogenerating electricity and heat by energy-efficient and adjustable production capacity, in future also including parallel fuel production and hybrid systems (e.g. coupled with solar heat).
3. Correcting neglected forest management with targeted measures. Reducing the use of peat for energy and the increasing demand for energy wood should be considered in the Temporary Act on the Financing of Sustainable Forestry and its supplementary decree.
4. The use of biomass with carbon capture (BECCS/BECCU/PyCCUS) is an emerging opportunity for Finland while the market is in its infancy. Sustainable – and even carbon-negative – biomass-based products could be created.

Estimate of future development: carbon handprint

Finnish technology and innovations (e.g. bio-boilers and renewable transport fuels) have already reduced global carbon dioxide emissions by millions of tonnes. The more global emission reductions are desired, the more demand there will be for sustainable and modern bioenergy technology. The carbon handprint of Finnish operators can be expected to continue its growth.

Radical slashing of emissions will be required to meet climate objectives, but even they will not be enough on their own. Carbon sequestration from the atmosphere with natural carbon sinks and technology will be required in addition to reduced emissions. Innovative solutions that effectively combine different technologies and energy sources will be required. The most important conditions for developing new technology are expertise and references. High-quality education is a must for maintaining Finland's world-class level of expertise.

Many methods are available for carbon sequestration, and the industry suggests that no option should be ruled out while the technologies are being developed. These technologies have global export potential and their market is only just forming.

6 Follow-up plans by the sectors

The interviews conducted by the MEAE in the summer of 2020 included the follow-up plans in the sectors regarding the roadmaps and decarbonisation. The responses clearly indicated that creating the roadmaps was seen as only the first step in the process. Preparing a roadmap was seen as the starting point for more meaningful work.

The interviews also revealed that deployment, and especially reaching SMEs, was a core challenge, which highlights the importance of follow-up efforts. Some sectors also considered it important to act on the lack of information identified during the roadmap project in order to identify accurate overall figures. The follow-up plans reflect the sectors' initial intentions at the time of the interviews.

In the interviews, roadmaps were described as a means of lowering the barrier for climate action cooperation. Several roadmaps were aimed at the operators in their sector, but also at decision-makers, and hence the follow-up plans not only concern the development of the sectors' readiness, but also that of the external operating environment.

Typical plans concerned promoting deployment, reaching SMEs, continuing cooperation between the industries, and utilising existing tools (e.g. energy performance contracting) to follow up the roadmap. Some industries also stated that they would actively update their roadmaps and prepare supplementary publications. Figure 35 includes follow-up plans described by the sectors in the interviews.

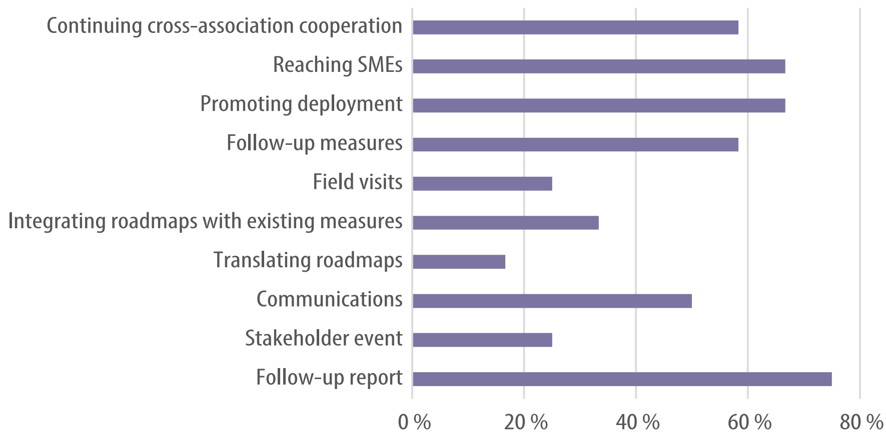


Figure 35. Roadmap follow-up plans by the sectors. The figures are proportions and they are based on the MEAE roadmap interviews.

Some of the industries raised tangible follow-up measures, which included developing tools for members (e.g. carbon handprint and Scope 3 emission calculators) and initiating systematic dialogue with stakeholders. Furthermore, some industries also felt that it would be important to promote the identified themes by visiting companies to discover regional synergies.

One industry plans to assemble interest groups as part of their Hiilineutraaliusdialogi ("Carbon Neutrality Dialogue"), and then dividing these groups into smaller groups for workshops on the groups' life cycle emission reduction measures and objectives. This industry aims to communicate the results of its value chain dialogue and the progress of the measures. They also aim to hold a high-profile announcement event.

The topics of follow-up investigations included surveys of needed skills, plugging identified gaps in knowledge, new technologies (e.g. CCS, CCU, and power-to-X), and regional analysis. Follow-up plans with communication objectives concerned the collecting and sharing of good practices in particular. Some sectors have already translated, or are planning to translate, their roadmaps into English, which will help in communicating the roadmap to international export firms, stakeholders, etc.

7 Closing words

The drafting of low-carbon roadmaps for sectors was first included in the government programme published in June 2019. At that point, few could have guessed how influential this declaration would be.

The sectors that prepared roadmaps took to the task with determination and enthusiasm. The roadmaps were mostly completed on time, despite a tight schedule and the coronavirus pandemic, and their content was surprisingly comprehensive. The published roadmaps offered fresh perspectives into climate action and a great deal of new information. They also reinforced the commitment of the sectors and their companies to climate action.

The above benefits will be highly useful, as stronger measures are needed to reduce greenhouse gas emissions in accordance with the EU's stiffening energy and climate objectives and Finland's goal of carbon neutrality by 2035. Action is required from actors big and small, and every deed counts.

The results of the roadmap project will be used as direct input for the government's climate and energy strategy, which is currently being prepared under the MEAE, and many other government plans related to energy and climate policy. Furthermore, the roadmaps will guide the allocation of RDI investments and the preparation of sustainable recovery measures, for example.

Although the roadmaps have been published, the work is not over. Companies and state administration are only beginning their efforts in many areas. Ultimately, success will be decided by how well the measures raised in the roadmaps can be translated into actual investments and changes in operating methods. The commitment of the sectors and companies will be essential. The government must simultaneously work to facilitate massive investments and other measures.

Several sectors are considering or preparing steps to follow up on the roadmap project, and the MEAE wishes to support them here as well. The roadmap project has shown how cooperation can yield fantastic results – whether between the public and private sectors or between different industries. This cooperation was exceptionally strong and exemplary, even internationally speaking, and we will need to continue it.

The Ministry of Economic Affairs and Employment extends its warmest thanks to everyone who participated in the roadmap project! Marvellous work should be celebrated. Afterwards, it will be time to roll up our sleeves and implement the roadmaps..

Appendices

Appendix 1: Government requirements for the content of the roadmaps

At the start of the roadmap project, the Ministry of Economic Affairs and Employment prepared the instructions for the basis for and recommended content of the roadmaps. A general description of the instructions is given in chapter 3.

This appendix includes the MEAE's detailed list of recommended content in its original form. As the sectors had varying resources available for the work, the MEAE also gave its impression of the relative importance of different types of content. Particularly important information is highlighted in yellow, and the other information was to be included where possible.

Background, descriptions of the following **scenarios**

1. Future development with existing measures and based on current development (baseline scenario)
2. Development with additional measures (low-carbon scenario); minimum one, but preferably multiple

Descriptions and quantitative information where possible regarding the following (current situation and expected development in different scenarios):

1. Global competitive conditions (supply, demand)
2. Production processes and technologies in Finland
3. Production volumes or other activity indicators in Finland
4. Energy use (electricity, heat, fuels; specify process use, buildings, transport, machines, etc.)
5. Energy production (by the sector or in adjacent plants)

6. Greenhouse gas emission development (total emissions, emission trading/emissions not included in emission trading, separate emissions from processes and energy)

Required measures and changes that will accelerate progress towards the low-carbon scenario (including the next steps, intermediate targets, and priority):

1. Technological development
2. Investment needs (description, in euros)
3. Changes to regulations, taxation solutions, incentives, etc. (Finland/EU)
4. Investments in research and education (government/sector/others)
5. Other requirements

An estimate of impact on employment for different scenarios and/or measures. The employment impact estimates are especially useful in the case of requests for government involvement.

Risks and uncertainties.

Needs and opportunities for supporting companies' internationalisation.

Appendix 2: Frequently asked questions

In autumn 2019, the Ministry of Economic Affairs and Employment published a list of frequently asked questions (versions 1.0 and 1.1). Below is version 1.1 in its entirety. This appendix also includes a comparison of the original instructions with the approaches chosen by the sectors.

1) Emissions from logistics – who estimates them and how?

1. Government requirements

The sector roadmaps only need to estimate the need for logistics (tonne-kilometres). The greenhouse gas emissions from logistics (i.e. indirect emissions for the sector) or the potential for reducing them need not be estimated, as these will be included in the fossil-free transport roadmap being prepared by the Ministry of Transport and Communications.

If the sector would like to weigh in on the need for changes in transport methods (e.g. from road to rail), these should be included in their roadmap. Estimates may prove a difficult task, and they are not mandatory.

In the previous strategies of the Ministry of Transport and Communications, the evaluation of logistics needs has been the task of Traficom (or its predecessor). The sectors' roadmaps will offer a new basis of knowledge for the evaluation.

Estimates of logistics needs should be submitted to the Ministry of Transport and Communications. The ministry should be contacted early on to relay preliminary findings.

The roadmap and any communication regarding the results should clearly define the scope of the analysis

2. Other needs

If they wish, the sectors may present an estimate of their carbon footprint in the roadmap, including the indirect greenhouse gas emissions from logistics.

An estimate of these emissions can be requested from the Ministry of Transport and Communications. Please note that the workgroup preparing the fossil-free transport roadmap will continue to work until 30 October 2020.

Instructions in comparison with the roadmaps' choices (reviewed afterwards)

The roadmaps mostly adhered to the definition of scope given under "government requirements". The roadmaps did not typically include the indirect emissions from logistics.

2) Emissions from energy production – who estimates them and how?

1. Government requirements

For electricity and district heating purchased from external sources, the sectors' roadmaps need only estimate consumption (and potential for reducing or restricting consumption, as applicable). The greenhouse gas emissions from purchased energy and district heating or the potential for reducing them in production need not be estimated, as these will be included in the energy industry's roadmap.

The internal energy production of industrial processes (e.g. heat generated by the process and locally generated electricity) must be included in the sector's roadmap. This also applies to all energy production plants owned by a separate energy company located on industrial premises or in their immediate vicinity ("adjacent plants"). The running of adjacent plants is typically controlled by the needs of their industrial plant.

If the sector's roadmap includes an estimate of emissions from the use of externally purchased gas, it must include an estimate of the emission factor of the gas. This depends on the proportion of biogas being used. We recommend using the energy industry roadmap (due in spiring 2020) or another source (with justification) to estimate the emission factor.

Please contact Finnish Energy regarding the estimates for electricity, district heating, and gas consumption, in addition to the emission factor of the gas.

The roadmap and any communication regarding the results should clearly define the scope of the analysis.

2. Other needs

If they wish, the sectors may present an estimate of their carbon footprint in the roadmap, including the greenhouse gas emissions from externally purchased electricity and district heating.

We recommend using the energy industry roadmap (due in spring 2020) or another source (with justification) to estimate the emissions from electricity and district heating production.

Instructions in comparison with the roadmaps' choices (reviewed afterwards)

Very few sectors analysed their greenhouse gas emissions purely on the basis of "government requirements", i.e. limiting the scope to only direct emissions (and including the consumption of purchased energy).

Most sectors chose to include both direct emissions (Scope 1) and indirect emissions from purchased energy (Scope 2) in their greenhouse gas emission analysis. Some sectors declared their Scope 1 and Scope 2 emissions separately, and some as a total.

3) How many scenarios are required and what should they be?

Ideally, the roadmap should include the three scenarios described below. If it is impossible to use them all, the sector can choose to forgo one or both of the two latter scenarios. The baseline scenario should always be included.

- The baseline scenario describes future development in terms of the current operating environment and policy measures of the public sector. Specifically, this means the legislation in effect on 1 January 2020 and the decisions made by the indicated date (e.g. the General Government Fiscal Plan for 2020–2023, approved on 7 October 2019). We recommend not including in the baseline scenario any measures from the government programme that are yet to receive their final decisions. The baseline

> scenario must include measures to improve energy efficiency that companies can be expected to undertake in any case, for example. The baseline scenario should not assume that emission reduction measures will stop or that technological development will halt completely. For this reason, the baseline scenario has also been referred to as the "free-breathing" scenario.

The rapid progress scenario describes a situation where known low-carbon technologies and other emission-reducing measures develop and come down in price quickly. Other measures for reducing emissions may include more efficient ways of using and operating buildings, for example. This scenario assumes a broader selection of tools for reducing emissions. The measures and technologies for reducing emissions must be at least mature enough to be realistic to implement.

The target level scenario describes a situation where emissions are reduced to a predetermined target level, regardless of how high the costs of doing so would be.

Instructions in comparison with the roadmaps' choices (reviewed afterwards)

All but one roadmap includes a quantitative baseline scenario. One roadmap used a qualitative baseline scenario.

The number and bases of the low-carbon scenarios varied by roadmap. Four roadmaps included two quantitative low-carbon scenarios with the following general bases: rapid and very rapid progress scenarios (I and II), rapid progress and target level scenarios (III), and two scenarios relating to various government policy measures (IV).

In total, eight roadmaps included one quantitative low-carbon scenario. One of these is a target level scenario. The others are close to the rapid progress scenario in principle, but the scenarios are often based on government policy measures in addition to, or instead of, technological development. One roadmap includes no low-carbon scenario.

4) Geographical scope – just Finland or other countries as well?

1. Government requirements

For the purposes of the project, it is sufficient to limit the analysis to emissions in Finland.

The need for logistics should be estimated for air and sea freight, both from Finland to other countries and to Finland from other countries. Although the greenhouse gas emissions from these are not included in Finland's emission inventory, the estimates will serve to inform the roadmap work of the Ministry of Transport and Communications. Furthermore, the use of LNG in ships is relevant for the energy industry's roadmap, for example

2. Other needs

If they so wish, the sectors or their companies can estimate the emissions generated outside of Finland to determine their carbon footprint.

For example, one sector is planning to first prepare a roadmap for the government's information and schedule needs, and then a separate review of global impacts.

The point was raised in some discussions that many measures for reducing emissions are shared by plants in Finland and abroad. Even if the scenarios only concern Finland, the technology surveys could be used to benefit the companies' overseas plants.

Instructions in comparison with the roadmaps' choices (reviewed afterwards)

Most roadmaps restricted their analysis to the greenhouse gas emissions generated in Finland in accordance with "government requirements". Some roadmaps did include emissions from materials, regardless of their country of manufacture, in their carbon footprint.

From the beginning, one sector planned to first prepare a roadmap for the greenhouse gas emissions generated in Finland and then continue the work by reviewing global raw material chains.

Appendix 3. Roadmap project methodology

1.Basis

The roadmap should describe the phases required to achieve the selected objective. The roadmap is a means of communicating long-term strategy. This can be done through analysing the current situation and the goal state, for example. The sector-specific roadmap-style analysis stipulated by the government programme is a good fit for Finland, with its active industry associations.

In particular, the sectors took to drafting the roadmaps because they were seen as an opportunity to comprehensively study future low-carbon questions and to relay sector-specific needs for achieving a low-carbon result. Overall, the roadmap project was seen as a meaningful and interactive form of cooperation between the government and private sector operators.

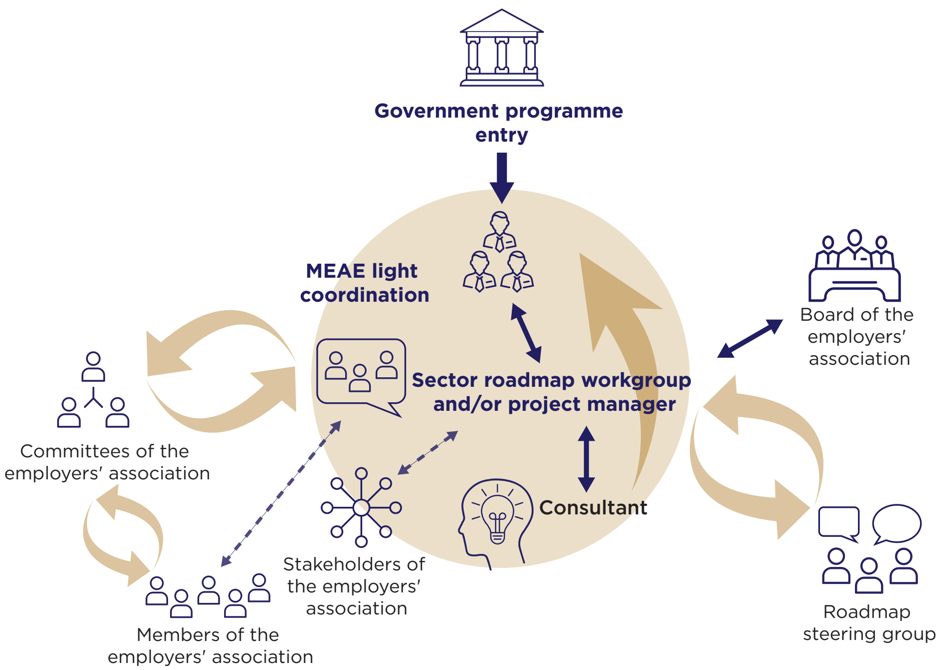
Many sector representatives also mentioned that the 1.5 °C special report of the Intergovernmental Panel on Climate Change motivated their industry to integrate low-carbon measures into their strategy . Some sectors considered the roadmap to be a proactive tool that offers a cross-sectional view of industry-specific climate discussion and is particularly useful for operators who are only now starting their climate measures. One of the sectors was instructed by the government to find out what decarbonisation means for their industry, whereas many of the sectors were attracted to the roadmap project through MEAE roadmap events or at the behest of their member companies or investors.

The methodology, good practices and main lessons of the roadmap project were gathered in interviews conducted by MEAE in the summer of 2020. Sector representatives, often the roadmap's project coordinators, described the different stages of the roadmap process, the roles of different operators, follow-up plans for the roadmap project, the roadmap's reception, and internal successes and issues. The interviews were also used to collect feedback on the MEAE's light coordination and any future requests for the MEAE's roadmaps.

2. Sector-specific roadmaps and the roles of different operators

One or more project coordinators from the employers' association or the consulting firm worked on the roadmap, depending on the sector. Association coordinators often acted as go-betweens for consultants and the steering group, in charge of planning the work, setting objectives, deciding schedules, and communicating with various operators. Some sectors also chose to supplement the steering group with an internal association roadmap team that supported the internal coordination of the roadmap project. Many sectors also had discussions with committees, key stakeholders and association members as part of their roadmap project.

Figure 35 is a general description of the operators and their roles in the roadmap project. Every sector had a unique internal coordination process, so the illustration may not reflect the division of tasks or cooperation relationships in any one sector. The roles of different operators are discussed in more detail in later subchapters.



Kuvio 36. Roadmap coordination and the roles of different operators

Figure 37 illustrates the working plan and scheduling of the construction industry. In the first stage, the construction industry drafted a description of their current situation with the help of a consulting firm. Their aim was to describe the industry's carbon life cycle and determine their carbon footprint and carbon handprint. This required analysing the operators and functions of the built environment, as well as essential materials, technologies and production processes.

In the second stage, the industry delved into their potential and risks regarding carbon neutrality, both horizontally and vertically. One method used was to analyse the maturity of production processes and technologies. This stage also included a review of the changes required in the industry and from the government to achieve carbon neutrality. In the third stage, the consulting firm modelled the industry's baseline scenario and low-carbon scenario with help from the industry.

The last two stages involved two separate workshops organised by the industry. The first workshop discussed the validation of measures for reducing carbon footprint and the results from the first and second stages. The second workshop discussed how the industry and the government were going to implement their emission-reduction measures. Both workshops were arranged as webinars due to the coronavirus pandemic, and the Howspace platform was used for commenting on the results. A third workshop was replaced with extended stakeholder comments, as the schedule was changed due to the coronavirus pandemic.

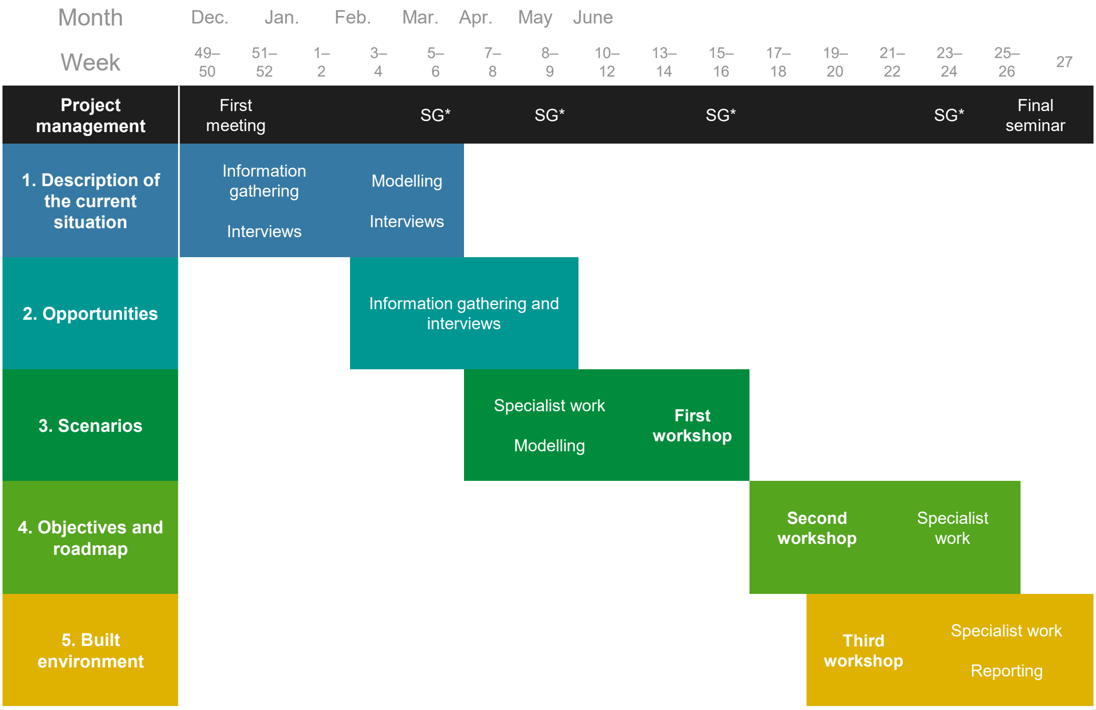


Figure 37. Construction industry roadmap with schedule by work units (sources: Confederation of Finnish Construction Industries RT, Gaia Consulting).

2.1 Steering group

The principal task of the steering groups was to act as the voice of the association's member companies in their roadmap project and to relay messages. The steering groups ensured that the roadmaps were in line with the views of the companies. The steering groups were typically assembled from the directors and managers of significant companies in their sector, and they had between four and twenty members. Some steering groups also included representatives from the public sector or key stakeholders. The steering groups met between three and ten times during the roadmap project, depending on the sector.

The roles, decision-making power, and activity of the steering groups varied considerably between the sectors. The active steering groups participated in setting targets, arranged comment rounds in the member associations, and communicated with and engaged their sector's companies, gathering their viewpoints.

The importance of the steering group's composition was stressed in the MEAE roadmap interviews. One sector stated that it was useful to have managers in the steering group, as they knew the strategies as well as field work and practical solutions. One large but fragmented sector was torn between a compact steering group and engaging a wide variety of operators – they ended up with a large, yet highly functional, steering group. On the other hand, one sector lamented the lack of more critical members in their steering group, as these could have better challenged issues and pointed out crucial bottlenecks and obstacles.

2.2 Consultant

Many sectors wished to emphasise the importance of seamless collaboration with their consulting firm, which was seen as a principal factor for success. The consultants were largely in charge of writing up the roadmaps, carrying out background studies and modelling the scenarios. Some sectors supported the consultants in data gathering by engaging their member companies.

The same consulting firm was used for the roadmaps of the forest, energy, chemical, technology, and logistics and transport industries, which introduced major synergy into the roadmaps' preparation, according to the sectors. One sector argued that using the same consulting firm was beneficial because not all information could be shared openly due to concerns over data protection. This allowed connections between the industrial roadmaps to be utilised and the industrial energy needs to be harmonised between the roadmaps. On the other hand, one sector stated that using different consultants enabled the exchange of different views and sparring.

2.3 Association committees

Committees were used in addition to steering groups to find ideas and views for the roadmap content. Depending on the association, the committees included representatives from member associations and member companies, as well as employee representatives. Typically, the committees were assembled around themes (e.g. environmental committees), which made it possible to request targeted input for different parts of the roadmap.

2.4 Alternative hearings

Some sectors organised workshops, discussions and comment opportunities to support their roadmap work. Among other things, these alternative working methods concerned the identifying of change factors, the acceptability of measures, and the opportunities for decarbonisation. Some sectors also met with each other outside the MEAE discussions to discuss roadmap connections, sector limits, etc. Some sectors gathered views and feedback regarding the intermediate results of the roadmap from a broader audience of experts and stakeholders.

Some roadmap coordinators also actively gave speeches about decarbonisation efforts at their industry events and in other places (e.g. schools, chambers of commerce, embassies and corporate management teams).

3. Cornerstones and key issues for success

The interviews conducted by the MEAE revealed that the scope of the roadmap project and how to limit it, the tight schedule, and the various challenges posed by the coronavirus pandemic were seen as the biggest challenges for the work. Typically, the sectors considered this project to be the first phase of their roadmap, and that they would now start the work proper. The issues were often seen to stem from future deployment and reaching SMEs.

One sector also stated that it would have benefited from a shared, in-depth training day on how to calculate carbon footprint and carbon handprint. This could have been organised by a specialised consultant, for example, to give a shared introduction into the work's methodology. This lines up with the views of several sectors that it was difficult for them to write up a request for quotation to the consulting firms. Likewise, multiple industries found that many more hours had been spent on the roadmap project than were initially planned.

Some sectors also identified substantial gaps in their industry's statistics, which restricted information gathering and created problems in determining carbon footprints, in particular. Some small and medium-sized sectors also felt that the MEAE instructions were a poor fit for them, and that they had hoped the instructions would take into account the differences between the sectors and the internal heterogeneity of the operators. One sector also expressed concern over the lack of references, as no study of this kind had been done in their sector before.

One consultant mentioned that the methodological choices and carbon footprint calculation standards should have been discussed more in the shared discussions, as this would have made the roadmaps more comparable. From the perspective of methodology, it was generally considered good that the energy industry's specific emission factors were available to all sectors at an early stage. Another consultant felt that the MEAE instructions had sufficient leeway and that no methodological specifications were necessary, as each sector was highly different and the roadmap objectives were clearly defined.

The MEAE interviews indicated that functional cooperation with the consulting firm, a shared commitment to decarbonisation, and clear but sufficiently unrestricted instructions from the MEAE were generally seen as the most important factors for the roadmap project's success. The dialogue between different operators allowed the sharing of best practices and increased synergies between the sectors. The sectors also commended each other on open and transparent conduct in terms of both working methods and problems. In addition, the strong commitment of the steering group and membership were seen as crucial support for the work. Multiple sectors found the roadmaps to be a meaningful and rewarding working method for the government to request sector contributions for the preparing of policy measures.

The important aspects for project management were the choice of consultant, the defining of objectives, and the limiting of scope. For time management, many sectors found it useful to reserve enough time for free discussion and to set, and keep to, firm meeting schedules far into the future. One sector also felt that it was necessary to proceed with the work on the basis of consensus, time limits allowing. Another sector saw that it was important to keep ambitions in check and divide the work into smaller pieces for a better focus on the core content and an increased chance of success.

Multiple sectors found that putting the roadmap in an easily accessible and absorbed format was useful. This helps ensure that the roadmap reaches the maximum number of readers possible, which results in more input for its preparation. It was also deemed necessary to invest in communication materials and legibility – promoting decarbonisation was not enough, the style of communication matters. One sector pointed out that professional jargon should be used sparingly, as it may not reach some member companies.

The sectors stated that it was vital for the MEAE to participate actively during the roadmap project. Multiple sectors deemed it crucially important that the government elevated the roadmaps into a high-priority project. This motivated the operators to invest more time and economic resources into the work. One sector stated that they would have opted out of the roadmap project if the MEAE had not expressed such interest in what the businesses had to say. The MEAE strived to update its instructions and answer the questions posed by the sectors in a timely and comprehensive fashion, which left an easy and pleasant impression of cooperation with the government.

Appendix 4. Links to the roadmaps

Energy industry
Roadmap
Background study

Chemical industry
Summary
Roadmap (includes phases 1 and 2)

Technology industry
Summary
Technological study of low-carbon solutions
Scenarios and carbon handprint analysis

Forest industry
Roadmap and other materials

Food industry
Food industry low-carbon roadmap

Logistics and transport
Summary
Roadmap

Agriculture
Agriculture climate roadmap (MTK and SLC)

Hospitality industry
Roadmap website

Commerce
Roadmap

Textile industry
Roadmap

Sawmill industry
Roadmap

Construction industry
Osa 1: Rakennetun ympäristön hiilielinkaaren nykytila
Osa 2: Vähähiilisyyden mahdollisuuksien tarkastelu
Osa 3: Vähähiilisyyden skenaariot
Osa 4: Rakennusteollisuuden ja rakennetun ympäristön vähähiilisyyden tiekartta 2020-2035-2050

Property owners and developers
Summary
Roadmap website

Bioenergy industry
Roadmap

Appendix 5. Contact persons

- Energy industry: Jukka Makkonen and Petteri Haveri (firstname.lastname@energia.fi)
- Chemical industry: Rasmus Pinomaa (firstname.lastname@kemianteollisuus.fi)
- Technology industry: Helena Soimakallio and Marjo Ollikainen (firstname.lastname@teknologiateollisuus.fi)
- Forest industry: Ahti Fagerblom and Fredrik Blomfelt (firstname.lastname@forestindustries.fi)
- Food industry: Anna Vainikainen and Pia Pohja (firstname.lastname@etl.fi)
- Logistics and transport: Petri Laitinen (firstname.lastname@huolintaliitto.fi) and Tatu Rauhamäki (firstname.lastname@palta.fi)
- Agriculture: Jukka Rantala (firstname.lastname@mtk.fi)
- Hospitality industry: Veli-Matti Aittoniemi (firstname.lastname@mara.fi)
- Commerce: Marja Ola and Bate Ismail (firstname.lastname@kauppa.fi)
- Textile industry: Satumaija Mäki (firstname.lastname@stjm.fi)
- Sawmill industry: Anniina Kostilainen (firstname.lastname@sahateollisuus.com)
- Construction industry: Pekka Vuorinen (firstname.lastname@rakennusteollisuus.fi)
- Property owners and developers: Mikko Somersalmi (firstname.lastname@rakli.fi)
- Bioenergy industry: Harri Laurikka (firstname.lastname@bioenergia.fi)
- Employment and employees: Pia Björkbacka (firstname.lastname@sak.fi)

Summary of sector-specific low-carbon roadmaps

PDF
ISSN 1797-3562
ISBN 978-952-327-796-0

Sähköinen versio: julkaisut.valtioneuvosto.fi
Julkaisumyynti: vnjulkaisumyynti.fi