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# Summary of Sectoral Low-Carbon Roadmaps 2024

Ministry of Economic Affairs
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# Summary of Sectoral Low-Carbon Roadmaps 2024

Katja Tuokko, Adele Silver

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## Summary of Sectoral Low-Carbon Roadmaps 2024


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**Abstract**

The Programme of Prime Minister Petteri Orpo's Government outlines that the low-carbon roadmaps prepared in 2020 will be updated. In accordance with government programme, the same 14 sectors that were part of the first roadmap process participated in the update, which was coordinated by the Ministry of Economic Affairs and Employment. The Ministry provided guidance and organised discussions to support the sectors.

It is a relevant time to update the roadmaps, because the coronavirus pandemic, Russia's invasion of Ukraine, the energy crisis and the unstable economic outlook have caused changes in the operating environment. It is also important to maintain a situation picture of the measures that will be sufficient for Finland to meet its emission reduction obligations and targets.

The roadmaps show that the sectors have made progress in their emission reduction measures compared to 2020, and that emissions from energy production, in particular, have decreased faster than anticipated. However, achieving these reductions requires investments that could be slowed down by an unpredictable regulatory environment, for example.

The results of the work will be used in the preparation of the energy and climate strategy and the industrial policy strategy. The roadmaps have made the linkages between sectors apparent. The flexible process has produced roadmaps that reflect the special characteristics of the sectors and to which they have strong ownership.



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## Yhteenveto toimialojen vähähiilitiekartoista 2024


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**Tiivistelmä**

Petteri Orpon hallituksen ohjelmassa linjataan vuonna 2020 laadittujen vähähiili-tiekarttojen päivityksestä. Linjauksen mukaiseen päivitykseen osallistuivat työ- ja elinkeinoministeriön (TEM) koordinoimana samat 14 toimialaa, jotka olivat mukana ensimmäisessä tiekarttaprosessissa. Toimialojen tukena TEM tarjosi ohjeistusta sekä järjesti keskustelutilaisuuksia.

Tiekarttojen päivityksen tarve on ajankohtainen, sillä esimerkiksi koronapandemia, Venäjän hyökkäyssota Ukrainassa, energiakriisi ja epävakaat talousnäkymät ovat aiheuttaneet muutoksia toimintaympäristössä. Lisäksi on tärkeää ylläpitää tilannekuvaa Suomen päästövähennystavoitteiden ja -velvoitteiden saavuttamisen kannalta riittävistä toimista.

Tiekartat osoittavat, että toimialat ovat edenneet päästövähennystoimissaan verrattuna vuoteen 2020 ja etenkin energiantuotannon päästöt ovat vähentyneet ennakoitua nopeammin. Toteutuakseen päästövähennykset edellyttävät kuitenkin investointeja, joita voi jarruttaa esimerkiksi vaikeasti ennustettava sääntely-ympäristö.

Työn tuloksia hyödynnetään energia- ja ilmastostrategian sekä teollisuuspoliittisen strategian valmistelussa. Tiekartat ovat tuoneet näkyväksi yhtymäpintoja toimialojen välillä. Joustava prosessi on tuottanut tiekarttoja, jotka heijastelevat toimialojen erityispiirteitä ja joihin niillä on vahva omistajuus.



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# Sammanfattning av de sektorspecifika färdplanerna för koldioxidsnålhet 2024


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**Referat**

I regeringsprogrammet för statsminister Petteri Orpos regering fastställs att de sektorsspecifika färdplaner för koldioxidsnålhet som utarbetats 2020 ska uppdateras. I uppdateringen i enlighet med regeringsprogrammet deltog under samordning av arbets- och näringsministeriet de 14 sektorer som deltog i den första färdplansprocessen. Arbets- och näringsministeriet har stött sektorerna genom att ge vägledning och ordna diskussionsmöten.

Behovet att uppdatera färdplanerna är aktuellt bland annat på grund av förändringarna i omvärlden till följd av covid-19-pandemin, Rysslands anfallskrig mot Ukraina, energikrisen och de osäkra ekonomiska utsikterna. Dessutom är det viktigt att upprätthålla en lägesbild av tillräckliga åtgärder för att Finlands mål och åtaganden för utsläppsminskning ska uppfyllas.

Färdplanerna visar att sektorerna har gjort framsteg i sina åtgärder för att minska utsläppen sedan 2020 och att i synnerhet utsläppen från energiproduktionen har minskat snabbare än väntat. För att utsläppen verkligen ska minska krävs det investeringar, men till exempel en svårförutsägbar regleringsmiljö kan bromsa nödvändiga investeringar.

Resultaten av arbetet används vid beredningen av energi- och klimatstrategin och den industripolitiska strategin. Färdplanerna har synliggjort kontaktytorna mellan olika sektorer. Den flexibla processen har resulterat i färdplaner som återspeglar sektorernas särdrag som de är starkt engagerade i.



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# 1 Finnish sectoral low-carbon roadmaps 2024

This summary, produced by the Finnish Ministry of Economic Affairs and Employment (MEAE), presents the findings of the 2024 update of the Finnish sectoral low-carbon roadmaps. The conclusions and views presented here are based on the sectoral roadmaps and/or their background research. A more extensive summary of the roadmaps is available in Finnish.

# 2 Introduction

In 2020, 14 Finnish sectors produced their own sectoral roadmaps, outlining pathways for sector specific decarbonization. In autumn 2023, in line with the Programme of Prime Minister Orpo's Government, the sectors began updating their sector-specific low-carbon roadmaps. All 14 sectors are committed to this work. The Ministry of Economic Affairs and Employment (MEAE) supports the sectors by coordinating the project, offering guidance, and arranging regular discussions.

Sectors which have drawn up low-carbon roadmaps:

- Energy industry
- Chemical industry
- Forest industry
- Technology industries
- Construction industry
- Agriculture
- Bioenergy industry
- Food and drink industry
- Hospitality sector
- Property owners
- Sawmill industry
- Service sector
- Commerce
- Textile and fashion sector

# 3 Roadmap process and methodology in Finland

All sectors prepare the roadmaps on a voluntary basis and are responsible for funding the work themselves. MEAE acts as the coordinator and provides the sectors with a methodological guidance, describing the elements it deems useful to include in the sectoral roadmaps.

Each sector prepared its own roadmap, typically through internal processes involving member organisations and companies. Sectors used interviews, workshops, and surveys as tools to gather grassroots-level views on the emission reduction actions discussed in the roadmaps and on how realistic the scenarios are. Typically, sectors used consultants to support the scenario work.

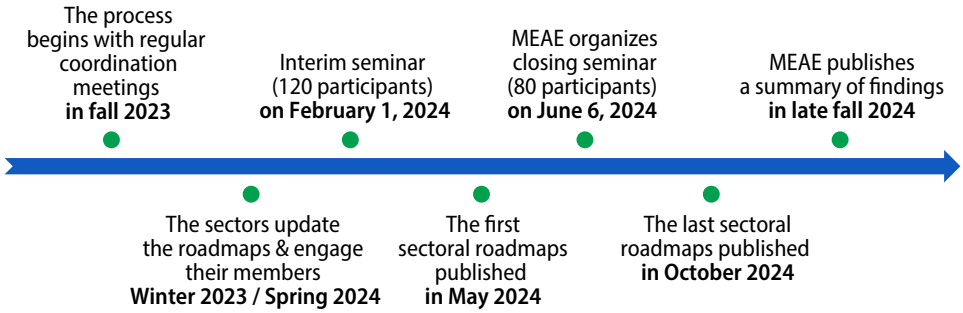
MEAE emphasized that the work should be as ambitious as possible, yet realistic enough for sectoral stakeholders to take ownership and commit to implementation. Realistic expectations are also important for MEAE and other ministries to understand the conditions under which the investments required in each sector would take place. MEAE requested that sectors present both a baseline scenario and a low-carbon scenario in their roadmaps. The baseline scenario assumes the continuation of existing measures under current operating conditions, while the low-carbon scenario includes additional measures. Almost all sectors have included such scenarios, and many roadmaps incorporate several different low-carbon scenarios. MEAE also requested that the roadmaps include both scope 1 and scope 2 emissions, as defined in the GHG Protocol. Some sectors have also taken a step further by analyzing scope 3 emissions.

Regarding the timeline, MEAE asked sectors to focus on emission developments for the years 2030, 2035, and 2050.

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. Scenario analysis is used to assess future developments.

MEAE coordinated the process by organizing regular coordination meetings with the sectors starting from autumn 2023. The first meeting focused on discussions about the methodology. Following this, the sectors presented their drafts, provided updates on the progress, and shared knowledge. Additionally, MEAE organized a seminar in February 2024 that brought together over 120 stakeholders interested in the sectoral roadmap process. In June 2024, MEAE organized a final seminar where the sectors presented their outcomes. Almost all sectors also held their own events around the publication of their roadmaps.

**Figure 1.** Roadmap process in Finland



# 4 Main findings

## 4.1 Significant changes in the operating environment play a central role

Since the previous round of Finnish sectoral roadmaps in 2020, there have been several unexpected and significant changes in the operating and investment environment. These changes have affected the sector's operational capacity and their ability to progress with emission reductions. The fast pace of societal changes has demonstrated the need to update the low-carbon roadmaps. In particular, the COVID-19 pandemic, Russia's war of aggression in Ukraine, the energy crisis, the unstable economic outlook, and difficulties in the procurement of raw materials and components have caused disruptions in the operating environment. Additionally, the negative effects of climate change have increasingly started to pose challenges for certain industries.

## 4.2 Emission reductions in sectors are advancing

The following graphs[1] present the emission reduction scenarios in different sectors compared to the current situation, i.e. the reference year, which varies depending on the sector between 2017 and 2023.

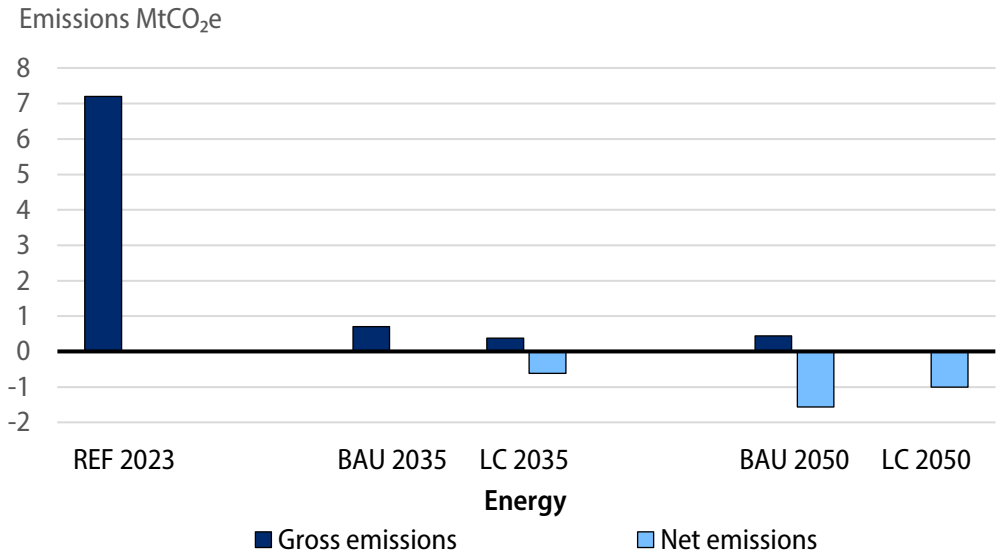
No direct comparison with the emission scenarios of the 2020 roadmaps has been made, as the definitions and methods have partly changed in the sectoral roadmaps. The energy industry's scenarios are presented in a separate graph, as emissions in the energy industry are included in scope 2 emissions reported by other sectors and should therefore not be compared with each other. On the other hand, emissions from other sectors are not necessarily comparable, as different methods have been used in the calculation of emissions, and the limitations of the emissions analysis vary. This is why the indicators are indicative, not commensurate. The data points of emission reduction paths also differ by industry. Some industries have estimated emissions for 2035 while others have used 2040, 2045 or 2050.

Emissions reductions have advanced more rapidly than expected in several sectors. Faster reduction of energy production emissions plays a central role.

On the other hand, the challenges posed by an unstable operating environment have weakened the investment outlook, which has reduced the possibilities of some companies to invest in the green transition. Emission reduction measures have not advanced in all sectors as swiftly as anticipated in 2020. This development is present in some sectoral scenarios, which indicate more moderate emission reduction potential compared to 2020. In the big picture, however, the roadmaps demonstrate an array of different measures and showcase concrete emission reductions have taken place between the 2020 roadmap process and the 2024 update.

1 Depending on the sector, the reference year (REF) is 2017-2023. The BAU scenario refers to the business-as-usual scenario, the baseline scenario. The starting points of the BAU scenarios vary by sector, and in many sectors the baseline scenarios already contain considerable emission reduction measures. LC refers to a low-carbon scenario and their underlying assumptions differ across sectors. If the sector has presented two baseline or low-carbon scenarios in its roadmap, they are presented as BAU1 and BAU2 as well as LC1 and LC2, the latter of which are more ambitious. The hospitality sector and the bioenergy sector have not presented scenarios in their roadmaps. The scope 3 emissions are not included from all sectors.

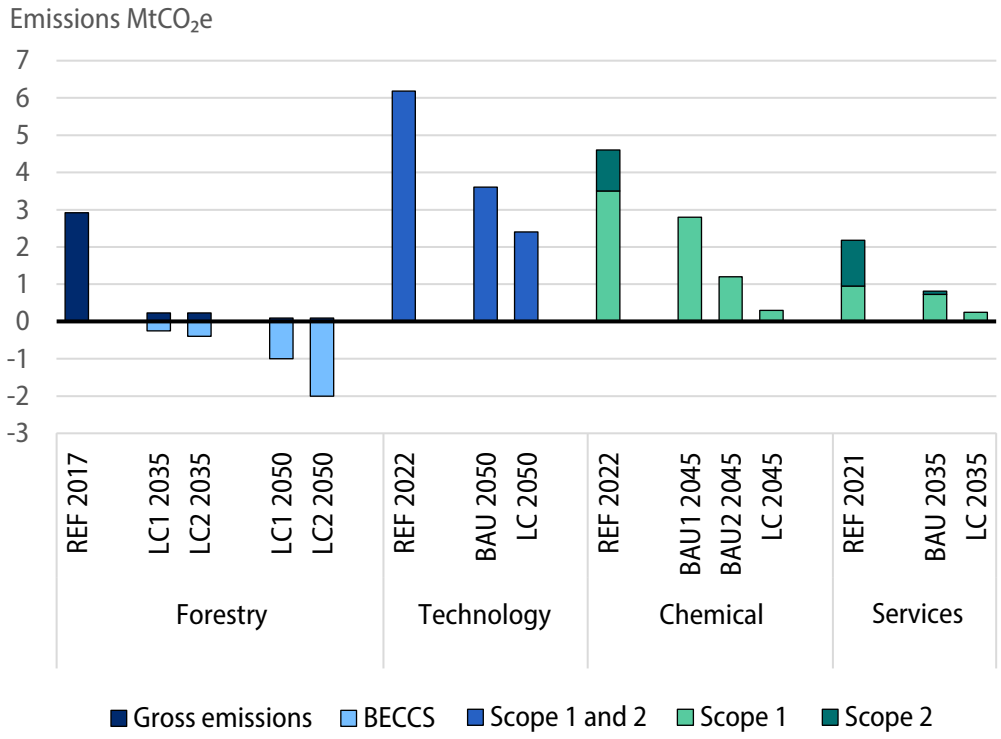
**Figure 2.** Development of greenhouse gas emissions from electricity and district heating production in different scenarios according to the energy industry Roadmap.
Net emissions are obtained by deducting recovered carbon dioxide from gross emissions.[2]




The roadmap for the energy industry indicates that gross emissions from electricity and district heating production could reach zero by 2050 in the low-carbon scenario (Figure 2). Figure 3 outlines the emission trends in the forest industry, technology industry, chemical industry and service industries across different scenarios, highlighting significant potential for emission reductions. In an uncertain investment climate, it is important to note that part of this potential depends on the deployment of technologies that are not yet widely adopted. Therefore, changes in the investment environment and the cost of new technologies will greatly influence emission trends. The rapid reduction of emissions from energy production is also reflected in decline of indirect emissions (scope 2) in other sectors.

2 The less ambitious vision also leads to significant emission reductions, even though it is referred to here as the BAU scenario. The more ambitious vision includes significant growth, for example by producing high value added products for the European and global markets. It should also be noted that in addition to the LC scenario, carbon dioxide is captured also in the BAU scenario in 2035, which means that the net emissions of the industry will be zero in that year, even though this is not indicated in the graph.

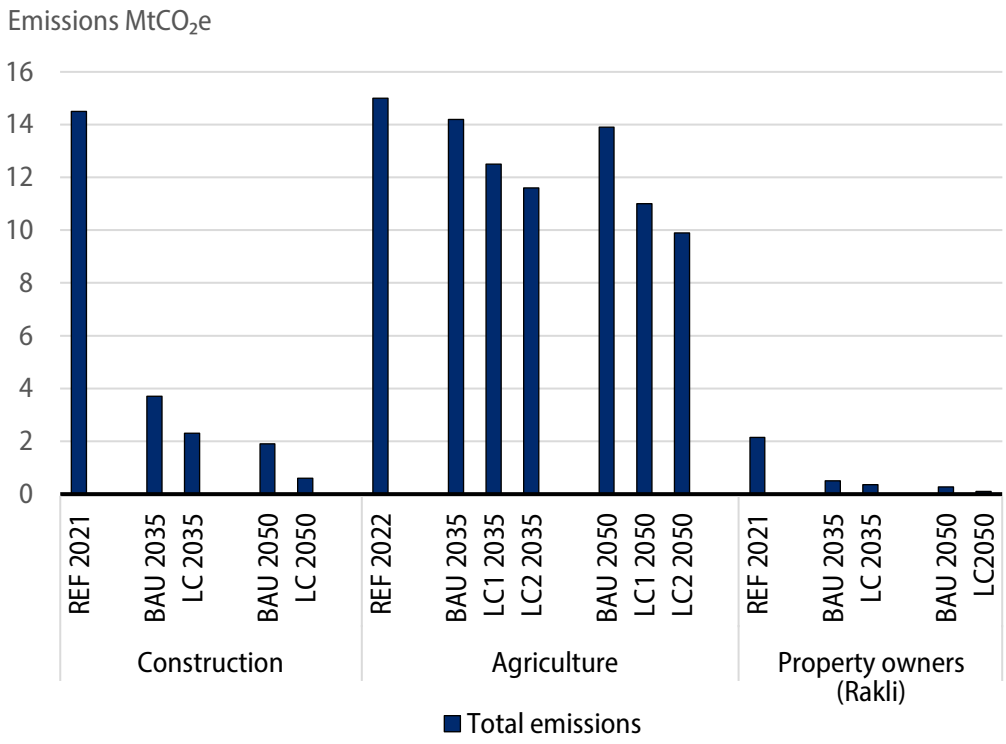
**Figure 3.** Development of greenhouse gas emissions from forestry, technology sector, chemical industry and services in different scenarios.[3]




While the 2024 roadmap update largely suggests that emissions from various sectors will decline more rapidly than previously anticipated, there are some differences in the pace of development. In the technology industry, for example, the projected reductions in both direct and indirect emissions are more moderate compared to the 2020 roadmap. These differences in the emission reduction paths of the 2020 and 2024 roadmaps can be attributed to the more optimistic assumptions made in 2020 roadmap regarding technological advancements and the operating environment. However, the technology industry has made progress in reducing emissions, as scope 1 and 2 emissions decreased by 18,8% in the industry between the publications of the two roadmaps (2017-2022).

3 For the forest industry, the graph covers only the capture and storage of biogenic carbon dioxide (BECCS), but the scenario work of the forest industry also includes a separate estimate of the utilization potential of recovered carbon dioxide (BECCU).

**Figure 4.** Development of emissions in different scenarios according to construction, agriculture and property owners roadmaps.[4]

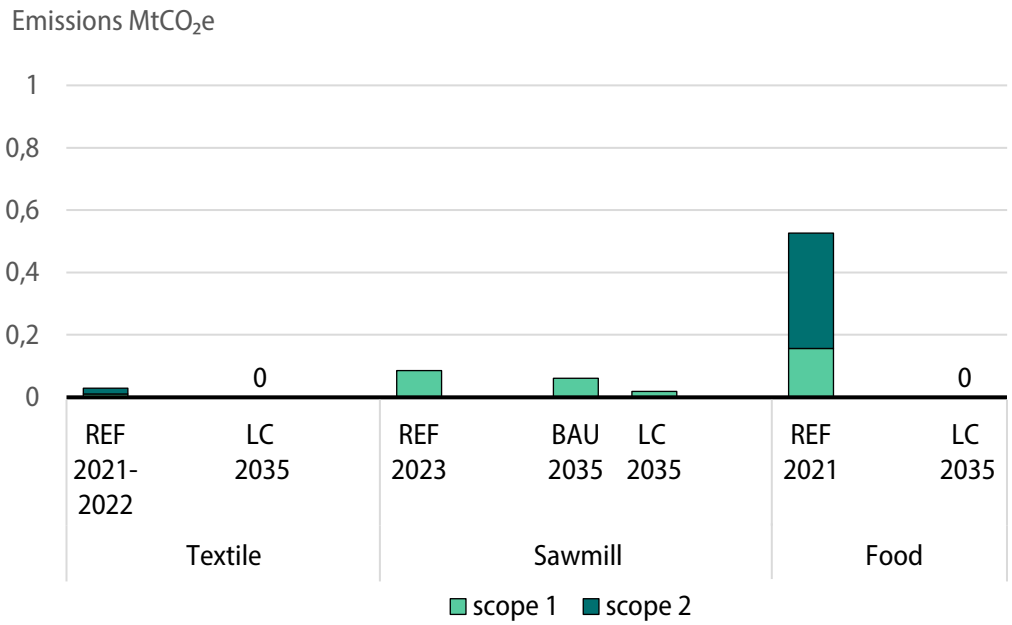



The innovative solutions scenario of the 2024 roadmap of the construction industry models a more significant decline in emissions for the sector than was predicted in the 2020 roadmap. On the other hand, according to the roadmap for agriculture, the estimated emissions reductions achievable by 2035 have become more moderate due to the slow implementation of measures related to carbon sequestration in mineral soils and emissions reduction in peatlands. In the Property owners roadmap, emissions remain relatively low and are of a similar magnitude to those projected in the 2020 roadmap.

4 Construction industry, agriculture and property owners have assessed their emissions extensively. The roadmap of the construction industry takes into account scope 1, scope 2 and scope 3 emissions, excluding in-service emissions from transport networks and emissions from the maintenance and repair of buildings. Emissions from agriculture include emissions from the land use sector, emissions from energy use and emissions from the agricultural sector. In Rakli's roadmap, emissions include emissions from new construction (including materials, construction site operations and transport), energy consumption during the operating phase and emissions from demolition. In this context, emissions are referred to as total emissions.

Figure 5 presents estimates of emission reduction trends in Finland's textile and fashion (STJM) sector, the sawmill industry, and the Finnish Food and Drink Industries' Federation (ETL) across different scenarios. It is worth noting that compared to the emissions levels of other sectors, the emissions from these industries were already significantly lower in the reference year. Both STJM and ETL aim to achieve zero emissions by 2035. For STJM, this target was already part of the 2020 roadmap, while ETL has increased its ambition regarding emission reduction targets compared to the 2020 roadmap.

**Figure 5.** Development of emissions from textile, sawmill and food industries in different scenarios.[5]




## 4.3 Clean energy production speeds up electrification

The sectoral roadmaps show that several industries are transitioning from production processes that traditionally relied on the combustion of fossil fuels to electrification. As Finland's energy production is increasingly based on clean energy sources, electrification will significantly reduce emissions across various industries.

5 In its roadmap, the sawmill industry assesses emissions generated within the sawmill gates, which may also include emissions from the production of purchased energy.

According to the Finnish energy industry roadmap, in an ambitious low-carbon scenario, which contributes to growth of the Finnish economy, emissions from electricity production and district heating will decrease to zero by 2035. In the scenario, emissions will become negative shortly after 2035, thanks to carbon capture, storage and utilization technologies. In comparison to the 2020 roadmap, the trend of declining emissions has strengthened.

Additionally, the role of digitalisation and artificial intelligence (AI) has increased in significance. These solutions can improve operational efficiency and reduce emissions, although they also increase energy demand. The Finnish technology industry's roadmap anticipates that artificial intelligence will a fast-growing sector in the technology industry. Data analytics and AI have the potential to reduce emissions both through energy system application and more efficient data analysis. The electrification trend highlights the importance of the energy industry and clean energy production in reducing industry emissions.

Green or clean hydrogen is also expected to play an important role in enabling future emission reductions, but the production of emission-free hydrogen requires a great deal of electricity. Hydrogen is separated from water by electricity in the production of hydrogen. By combining hydrogen with recovered carbon dioxide, synthetic fuels can be produced. Synthetic fuels produced from hydrogen can be used in sites using fossil fuels that are difficult to electrify, for example in logistics. Hydrogen can also be used in the production of emission-free steel.

While electrification helps decrease emissions, it also suggests that electricity demand will rise even further compared to the 2020 roadmaps. Although electrification was already a topic in the 2020 roadmaps, the 2024 roadmaps emphasize this even more (see Figure 6). According to the Finnish energy industry roadmap, electricity production in Finland is expected to increase. In the low-carbon scenario of the energy industry roadmap, electricity production is projected to grow 2,8 times by 2040 compared to 2023 levels. Even in the baseline scenario, electricity production is expected to increase by approximately 1,6 times.

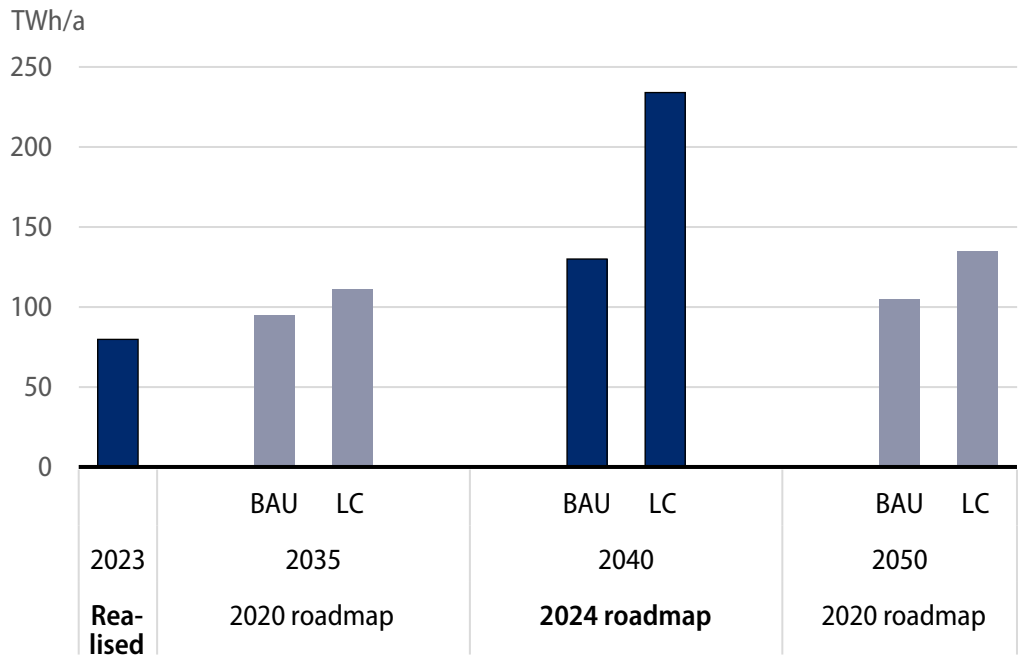
In the carbon neutral scenario of the Finnish chemical industry, the sector has almost completely transitioned away from fossil fuels by 2045 and its scope 1 and scope 2 are close to zero by 2045 requiring a strong trend of electrification. In this scenario, the chemical industry would need around 19,2 TWh of electricity in 2045. In addition, the sector has drafted a scenario which demonstrates an alternative pathway where the sector would in a large scale require recovered carbon dioxide and hydrogen as new basis for raw material. In this maximum recovery scenario, the production of polymers, chemicals, and fuels from recovered carbon dioxide

and hydrogen could require 100–160 TWh of clean electricity. In Finland, the total electricity consumption in 2023 was 79,8 TWh. The technology industry's roadmap also provides an outlook for demand for electricity growth. According to the roadmap, electricity consumption in the technology industry may increase to 16 TWh in 2030, 38 TWh in 2040 and 91 TWh in 2050.

It is important to note that the estimates presented by these above sectors involve uncertainties. This being said, the estimated increase for the need for electricity is so significant that if realized even partly, this would have a major impact on Finnish energy production and the adequacy of electricity networks. Although the estimates are far-reaching, their scale is one of the key observations of the roadmap process.

Onshore wind power and nuclear power will be the most important sources of clean electricity, but traditional hydropower and solar power will also play a key role in electricity production. Offshore wind power is also gaining ground. The importance of wind power has grown dramatically compared to the Finnish energy industry 2020 roadmap. While the low-carbon scenario in the 2020 roadmap envisioned 50TWh of wind power generation by 2050, the 2024 roadmap projects that 150TWh of wind power could be generated by 2040.

**Figure 6.** Electricity demand in the 2020 and 2024 roadmaps of the energy industry by scenario. Source: Finnish Energy.



The roadmaps indicate that meeting the growing demand for electricity will require clean, reliable, and competitively priced electricity. This will necessitate investments in electricity generation and energy networks to balance supply and demand. In its grid development plan, the Finnish national transmission grid operator Fingrid has estimated the total value of grid investments at around €4 billion between 2024 and 2033.

Compared to previous roadmaps, the discussion has expanded from electricity networks to energy networks in general. Hydrogen networks, in particular, and the flexibility they offer to the energy system have become increasingly important.

## 4.4 Technological solutions advance emissions abatement

The Finnish sectoral roadmaps place significant emphasis on the role of digitalization in emission reductions. Digitalization is not limited to the ICT sector as all industries can benefit from digital solutions. While many of these solutions are already in use, the potential exists to apply them even more widely. Compared to the 2020 roadmaps, artificial intelligence emerges as a new theme. The Finnish technology industry's roadmap highlights trends in the ICT sector, noting that AI-related business is growing. Similarly, the service sector roadmap recognizes the role of AI. While AI can enhance process efficiency, it also increases energy consumption. Digital solutions, including AI, can contribute to emissions reductions by improving energy and resource efficiency, servitization, and better data flow and processing. However, these technologies also demand significant energy resources. Despite this, the technology industry roadmap estimates that digital solutions could reduce emissions by around 20%.

Several roadmaps highlight the central role of carbon capture, storage, and utilization (CCUS) in achieving emissions reductions. For instance, in the energy industry's low-carbon scenario, approximately 1 Mt of carbon is projected to be recovered by 2050. The forest industry's scenario estimates that up to 6 Mt of biogenic carbon could be captured annually by 2040, with 5 $MtCO_2$/a utilized as industrial raw material. The chemical industry's low-carbon scenario anticipates recovering 0.5 $MtCO_2$ annually after 2030, with biogenic carbon accounting for 0.2 $MtCO_2$.

**Table 1.** Examples of technological solutions in emission reduction presented in the roadmaps include:

| Sector | Technology |
|---|---|
| Energy industry | Onshore and offshore wind, extending the operational lifetime of existing nuclear power plants, solar power, combined heat and power production from biofuels, electric boilers, small modular nuclear reactors (SMRs), pumped storage, carbon capture, storage and utilization, hydrogen production, transmission and storage |
| Technology industry | Low-carbon production technologies, e.g. in steel production, digital solutions, electrification of processes, electrification of machinery and means of transport, utilisation of energy efficiency, hydrogen, carbon capture technologies |
| Chemical industry | Green ammonia, electrolysis in green hydrogen production, carbon capture, utilization and storage technologies (CCUS), chemical recycling, more efficient process technologies |
| Forest industry | New technologies for pulp, paper and paperboard and mechanical wood products, such as more energy efficient drying technologies, 3d scanning methods; technologies for carbon capture, utilisation and storage (CCUS) as well as changes in the raw material base and material efficiency |
| Commerce sector | Low-emission vehicles, digital solutions |
| Service industries | Digital solutions and artificial intelligence (AI), green programming, more efficient equipment, machines and vehicles in service implementation or use, changes in vehicles driving forces |
| Building industry | Energy efficiency measures in building technology, building-specific heat production systems, smart solutions, technologies related to low-carbon building materials (e.g. CCS in cement industry, hydrogen in steel production), low-emission construction machines |
| Property owners | Low-carbon building-specific heating, such as heat pumps, hydrogen in the steel production, CCS in the cement industry, energy efficiency solutions supporting demand flexibility, digital solutions supporting the circular economy of facilities and materials in urban environments, digital solutions indicating the occupancy rate of facilities, smart solutions for properties supporting energy system renewal and demand flexibility |
| Agriculture | Unmanned machines, smart control, technological improvements in the hot air drying of cereals, solar panels |

| Sector | Technology |
|---|---|
| Sawmill industry | Frequency converters and more efficient motors in production processes, electric trucks, new indicators for improving resource efficiency |
| Food and drink industry | More energy-efficient production technologies, increasing own energy production with renewable energy technologies (e.g. solar power and biogas), low-emission vehicles, electrification |
| Textile industry | Production technologies for bio - and recycled textile fibres, sorting and recycling technologies, energy efficiency measures and energy-efficient production technologies, digital technologies for optimising manufacturing processes, renewable energy technologies, low emission modes of transport, software robotics, virtual technology |
| Hospitality sector | Energy-efficient machinery and equipment |
| Bioenergy sector | Solid, liquid and gaseous biofuels, technologies for the capture, utilization and storage of biogenic carbon (BECCS), biocarbon |

## 4.5 Shortages of critical raw materials can create bottlenecks

Some roadmaps point to the importance of securing access to critical raw materials in order to achieve emissions reductions. A stable operating environment and the availability of materials are essential, as shortages during periods of high demand could become bottlenecks for certain technologies. For example, the technology industry's roadmap suggests that companies can mitigate supply risks by diversifying suppliers, investing in material efficiency, recycling, and replacing critical raw materials with alternatives where possible.

## 4.6 Sectors can offer climate positive solutions in addition to emission reductions

Many roadmaps emphasize the handprint potential of various industries – their ability to offer positive climate solutions and help reduce emissions in other sectors. Through this handprint effect, industries can play a broader role in climate action beyond reducing their own emissions. Companies are striving to minimize their carbon footprint while maximizing their handprint on the global market.

However, the methods for calculating the handprint effect are still underdeveloped, and the reported potentials from different industries may not be directly comparable.

## 4.7 Collaboration is necessary in order to reduce scope 3 emissions

The roadmaps show that sectors are increasingly interconnected, and their emission reduction measures also partly overlap. The roadmaps can efficiently identify connections between the industries and the opportunities for cooperation. The industries themselves have also paid attention to this. For example, the construction industry roadmap has evaluated emission reduction measures the cross-sector business opportunities could offer. An industry can be in a decisive position as an enabler of emission reductions in another industry.

The interlinkages found between the energy industry and other sectors can create opportunities for emissions reductions and new business models. Cooperation between the energy system and the transport, industry and construction sectors creates synergies and promotes the efficient utilization of resources. The technology industry plays an essential role providing solutions for smart energy systems. In carbon capture, utilization and storage, interlinkages and cooperation are present across the value chain. The construction industry roadmap shows that cross-sectoral business is already common in the production of concrete. For example lignin, a byproduct of the pulp industry, is being developed to replace bitumen, which is currently used to make asphalt.

## 4.8 Circular economy is an important tool for emission reductions

Several roadmaps have identified the promotion of the circular economy as means to promote emission reductions in the sector. Business models and solutions that align with the circular economy may provide opportunities for creating new income flows and growth in many sectors. The circular economy business models are based on, for example, re-use or recycling, extending the life cycle of products through maintenance and repair measures, sharing economy or product as a service. The roadmaps have identified the potential of the circular economy to generate growth in the sector, both in the domestic and global markets.

For example, the chemical industry roadmap shows how renewable, recycled and synthetic raw materials could be used to change the raw material base, compensating for the reduction in production caused by fossil fuel phase-out. In the low-carbon scenario, renewable and recycled raw materials would account for 78% and synthetic for 2% of production raw materials. In the green growth scenario based on carbon capture, renewable and recycled raw material would account for a smaller share, 59%. In the green growth scenario, synthetic raw materials would replace more fossil raw material and would account for 26% of the chemical industry raw material base. Carbon dioxide recovered from the forest and energy industries in particular, but also from the chemical industry's own processes, would become an important raw material for the chemical industry. Changing the raw material base is both an opportunity and a challenge for the sector. According to the roadmap, the legislation on circular economy materials should be clarified, recycling methods developed and challenges related to the price, availability and quality of raw materials addressed.

The use of side streams provides more examples on how circular economy plays a central role in reducing emissions. Side streams from agriculture and forestry, the forest industry and the food industry can be used in electricity, heat and biogas production. For example, the food industry roadmap highlights the synergies between bioenergy production and the food industry in the utilization of side streams. In the construction industry, companies can reduce emissions from building materials by using wood and low-emission steel. The sawmill, forest and technology industries play an important role in the implementation of these solutions.  In trade and commerce, recycled packaging can reduce packaging emissions. The chemical industry can play a significant role in enhancing the recycling of plastics through chemical recycling.

## 4.9 Challenges in enabling investments that is needed for green growth

The sectors which have published low-carbon roadmaps have identified key investment needs, which vary by sector. Investment needs are mostly related to changes in production technology, clean energy technologies, expanding the product palette to low-carbon products, changes in raw materials, low-emission transportation, and research and development (R&D). Investments related to carbon capture, utilization, and storage are highlighted in the roadmaps linked to this value chain.

However, not all emission reduction measures require large investments. For example, the roadmap of the Real Estate Owners (Rakli ry) finds that resource and space efficiency, as well as circular economy models, can achieve emission reductions without significant additional investments. Some sectors have estimated their investment needs in their low-carbon roadmaps. The Finnish energy industry foresees that investment needs in a low-carbon scenario would amount to approximately €6,9 billion annually, while in the baseline scenario, investment needs are estimated at €2,7 billion annually. The construction sector estimates that over €8 billion will be needed to implement necessary energy efficiency actions. The chemical industry presents several outlooks for investment needs. In the baseline scenario, investment needs are estimated to stay at 1 billion per year while in the low carbon scenario, an addtional 400 million per year is foreseen. On top, in an ambitous low carbon growth scenario for chemical industry, additonal investments for CCU and green ammonia would be required.

The Confederation of Finnish Business (EK) has gathered Finland's planned green transition investments in a "green investment data window" (https://ek.fi/en/green-investments-in-finland/). The total value of the investment plans is around €270 billion, but not all of these investments will materialize. Only a small portion of the projects have reached the investment decision phase. However, the scale of these plans demonstrates the financial significance of green transition actions.

The biggest obstacles to realizing these investments are changes in the regulatory environment, economic uncertainty, and unfavourable conditions such as high interest rates. According to a survey conducted by the Finnish Food and Drink Industries' Federation, the long payback period is the biggest challenge for making investments. Additional challenges identified by the industry include the transfer of investment costs to consumer prices and the lack of investment subsidies. Attracting green transition investments to Finland is crucial for the country's economic growth outlook. Expensive investments in low-emission operations require favourable investment conditions, especially in an unstable economic environment.

## 4.10 Research, development and innovation are needed to unlock low-carbon solutions

The roadmaps identify industry-specific issues where R&D investments should be targeted. The circular economy, new low-carbon technologies and materials, and energy and material efficiency are often highlighted as R&D investment priorities.

For instance, the sawmill industry's roadmap suggests that R&D activities and incentives should focus on wood construction, while the food industry's roadmap emphasizes the need for low-carbon food production and growing technologies. The service industry's roadmap underscores the importance of R&D support for developing services that can enhance their handprint effect. Some roadmaps emphasize the need for funding innovation activities such as pilots. Since the roadmaps take a highly sector-specific approach to R&D&I activities, the detailed descriptions of R&D&I targets can be found in each sector's roadmap.

The technology industry's roadmap highlights the potential of virtual product development to improve R&D processes and enhance material and energy efficiency. More efficient product development can be achieved through technologies like virtual and augmented reality, digital twins, the Internet of Things, robotics, and automation.

The roadmaps also provide suggestions on how the public sector can create a more favourable operating environment for R&D&I activities, particularly through financial support. Several roadmaps call for R&D support, tax incentives, and a more favourable economic environment to promote R&D. For example, the food industry's roadmap warns that important low-carbon solutions may be missed if their development relies solely on market demand without government incentives.

## 4.11 New skills and training of workforce can accelerate green transition while lack of skilled labour can slow down the transition

Many sectoral roadmaps emphasize that new skills and workforce training are essential for accelerating the low-carbon transition, while a lack of skilled labour could hinder emissions reduction efforts. Continuous skills development is particularly important with regard to new regulations and stricter environmental requirements. Additionally, solving the climate crisis offers new opportunities in the labour market.

Some sectoral roadmaps, such as those of the construction industry (which highlights the need for skilled labour in wood construction and the use of recycled construction products) and the energy industry (which identifies a need for expertise in cybersecurity, data analytics, digitalization, and sustainability), identify specific labour needs. Carbon capture, storage, and utilization are also areas that will require new skills, creating jobs in this field. A study by VTT, commissioned by

by the Finnish energy, chemical, technology, and forestry industries, estimates that CCS&U could employ 1.100 workers directly by 2040, with additional indirect employment impacts. The technology industry has prepared a separete assesment on skills where the industry estimates that in the coming decade, 160.000 workers are needed in the technology sector, of which 60 % with tertiary education. The energy industry foresees that in the low carbon scenario, the sector could employ 100.000 workers in 2040.

The roadmaps also provide concrete proposals for improving the availability of skilled labour and developing education and training. More resources are needed for education, and training opportunities must be regionally available. The bioenergy sector's roadmap also emphasizes the importance of foreign labour for harvesting and transporting biomass. According to the energy industry's roadmap, science and maths proficiency are critical for the energy transition, which is why these skills should be improved starting from the primary and lower secondary school. Additionally, multidisciplinary and multi-skill training will become increasingly important in the future.

As part of the sectoral roadmap process, MEAE held discussions with SAK, the Central Organisation of Finnish Trade Unions. A survey conducted by SAK among its members revealed that 20 percent of respondents saw a need for workplace training due to climate-related changes. SAK stressed the employer's responsibility in addressing skills needs, noting that training can often take place on the job.

# 5 Sectoral roadmaps suggest an array of policy actions

The roadmaps demonstrate that sectors have identified measures and development paths that make it possible to strive for significant emission reductions. The availability of emission-free electricity is a prerequisite for implementing many emission reduction measures and investments in the green transition, as well as for ensuring international competitiveness. The availability of clean energy boosts the electrification of industrial production processes and the hydrogen economy, which plays a key role especially in roadmaps for the technology and chemical industries. At the same time, the roadmaps convey growing concerns about the uncertainty of the investment environment, which is caused by the effects of the covid-19 pandemic, inflation, rising interest rates, the energy crisis and Russia's aggressive war in Ukraine. In an uncertain investment environment, attention is paid to the fact that part of the emission reduction potential relies on technology, such as the use of green hydrogen, which is not yet widely used. Thus, how the investment environment will develop will have a significant impact on future emission trends in many sectors. Although many sectors have updated their emission reduction paths in a more ambitious direction, in some sectors the measures have not progressed as anticipated in the 2020 roadmaps.

The sectors suggest several policy actions for national and EU-level policymakers, aimed at creating a stable and predictable operating environment. According to the roadmaps, coherent and predictable policies and regulations can drive emissions reductions, while unpredictable and contradictory regulations can hinder investments in the green transition. The roadmaps emphasize that not all emissions reduction measures are profitable on a market basis and that public support is needed to facilitate these measures. Furthermore, other operating environment conditions must be favourable.

Attracting green transition investments to Finland is considered crucial. The prerequisites for a favourable investment environment include clear, long-term climate and energy policy guidelines, supportive regulation, and the availability of clean, competitively priced energy. The energy industry’s roadmap suggests that continuing and expanding the EU’s emissions trading system over the long term

can help attract investments by reducing the need for national measures that create investment uncertainty. Energy taxation should also be directed away from fossil energy sources, and licensing processes should be streamlined.

The roadmaps call for legislation that creates favourable conditions for emissions reductions. Regulation should be technology neutral, i.e. legislation should not favour or restrict the use of specific technologies. The roadmaps address regulatory developments at both national and EU levels, calling for simplification and clarification of regulations. Industries find it challenging to keep up with constantly changing and increasingly complex regulations. EU-level regulatory harmonization is seen as important to ensure a level playing field between companies operating in different Member States. However, national circumstances should also be recognized.

Political guidance should encourage industries to reduce emissions, and carbon capture may be necessary to eliminate remaining emissions in hard-to-abate sectors. The roadmaps suggest ways in which the public sector can support the implementation of CCS&U projects. For instance, the roadmaps emphasize that pricing captured carbon on the European market would incentivize the recovery and utilization of $CO_2$. A functioning carbon removal market could cover recovery costs. The bioenergy sector's roadmap highlights the importance of recognizing CCS&U in national policy positions and influencing EU-level decisions on carbon removal.

Some roadmaps propose legislative changes to support the market entry of new CCU products. For example, the energy industry's roadmap suggests that $CO_2$ from sustainable bioenergy and waste should be accepted as a raw material for the production of synthetic fuels. Investment subsidies, tax breaks, and incentives should also be used to promote CCS&U. The forest industry's roadmap calls for an incentive system for both demonstration and pilot plants, and later for commercial plants. The roadmaps highlight the need for smooth project approvals, and the bioenergy industry's roadmap points to the potential importance of bilateral agreements in facilitating the storage of captured $CO_2$, as Finland lacks suitable geological formations for $CO_2$ storage.

Security of supply and emergency preparedness are also highlighted in the roadmaps. Ensuring the availability of critical raw materials is particularly important for a society that is increasingly dependent on these materials. The technology industry's roadmap suggests that the supply of critical raw materials can be secured by utilizing domestic mining potential, modifying waste legislation, streamlining

permitting, and creating fair operating conditions for European companies. To address the chip shortage, the service sector's roadmap proposes an EU-wide joint procurement of chips.

Energy supply and food security are also key concerns for security of supply. Investing in diversified energy production and enabling flexibility through energy system integration can help mitigate risks to the energy supply. The food industry's roadmap emphasizes the importance of promoting biogas and green ammonia production through tax breaks and updates to the biogas programme, which would also support energy and fertilizer self-sufficiency and food security.

Mapping scope 3 emissions, a new theme in some roadmaps, increases understanding of emissions throughout the value chain and identifies the factors influencing them. The roadmaps stress the importance of collaboration between industries and actors in the value chain in order to implement emissions reduction measures. To ensure seamless cooperation, the roadmaps highlight the need for standardized emissions data, consistent calculation methods, and efficient information exchange. Collaboration is also essential for creating a smart energy system. According to the energy industry's roadmap, the integration of different sectors should be strengthened with a national strategy for clean gases.

The energy industry's roadmap emphasizes the importance of diverse energy production in ensuring energy availability. Future energy production can be supported by treating nuclear power as equal to renewable energy and enabling energy production by small modular reactors (SMRs) in municipalities. Additionally, onshore and offshore wind power development should be accelerated by simplifying zoning procedures and addressing radar system limitations in Eastern Finland. Recognizing the role of hydropower in the EU Water Framework Directive is also considered important. Research and development subsidies are needed for new energy technologies, and incentives are necessary for creating a smart energy system and making energy network investments.

Several industries emphasize the need to streamline and standardize reporting obligations to reduce the administrative burden on companies. Reporting should not be an end in itself; the focus should be on driving climate actions. However, reporting obligations can encourage more ambitious emissions reductions.

While regulation can guide industries toward a low-carbon future, financial support can provide the necessary conditions for implementing emissions reductions. Many companies have already implemented easier emissions reduction measures, but several roadmaps note that financial constraints are a significant barrier to further progress.

# 6 MEAE's takeaways from the process of sectoral low-carbon roadmaps 2024

The publication of new sectoral roadmaps in 2024 has provided fresh insights and an updated perspective on the low-carbon transition of Finnish industries. The process has highlighted the benefits of cross-sectoral cooperation and dialogue. For MEAE, this process has generated valuable information that will contribute to the ongoing update of Finland's National Energy and Climate Strategy, as well as the development of the National Industrial strategy.

The voluntary nature of the roadmap process has kept the threshold for participation low. The 14 participating sectors vary greatly in size and characteristics, and MEAE has refrained from imposing a uniform methodology, instead providing a list of questions and elements that each roadmap should address. MEAE greatly values the participation of both large sectors and smaller sectors. Involving smaller sectors has revealed interesting linkages between industries and sparked discussions on topics like the use of side streams and inter-sectoral cooperation to reduce emissions. The flexible process has led to roadmaps that are well-tailored to the specific needs and characteristics of each industrial sector.

The voluntary nature of the process has also fostered a strong sense of ownership among the sectors. Going forward, it is important that the sectors take steps to implement the findings from the low-carbon roadmaps. In particular, dialogue with companies and stakeholders at the grassroots level is crucial.

More information on the Finnish low-carbon roadmaps can be found at: https://tem.fi/en/low-carbon-roadmaps-2035.

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