SUMMARY 03.06.2024

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Carbon roadmap for Technology Industries of Finland

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The update of the carbon roadmap of Technology Industries of Finland is divided into four areas

Since 2020, there have been significant changes in the operating and investment environment.

The Ministry of Economic Affairs and Employment has launched an update of the roadmaps in order to obtain an up-to-date situational picture of the sectors' path to low emissions.

Current state of emissions
Updated technology industry scope 1-2 emissions and extension to scope 3 emissions.

Emission reduction measures
Possible measures for companies in the technology industry and four distinct special analyses; emission reduction potential in the field of hydrogen economy, potential to offer smart energy systems services, opportunities offered by digital solutions and artificial intelligence, and critical raw materials required for the double transition.

Emission scenarios
An overall picture of the development of emissions in the technology industry by 2050, updated for scope 1-2 emissions and expanded to scope 3 value chain emissions.

Carbon handprint
Updated description and market potential of example technologies in the technology industry.

To track the progression of the summary, find these icons to follow at the bottom of the pages:

Current state of emissions | Emission reduction measures | Emission scenarios | Carbon handprint

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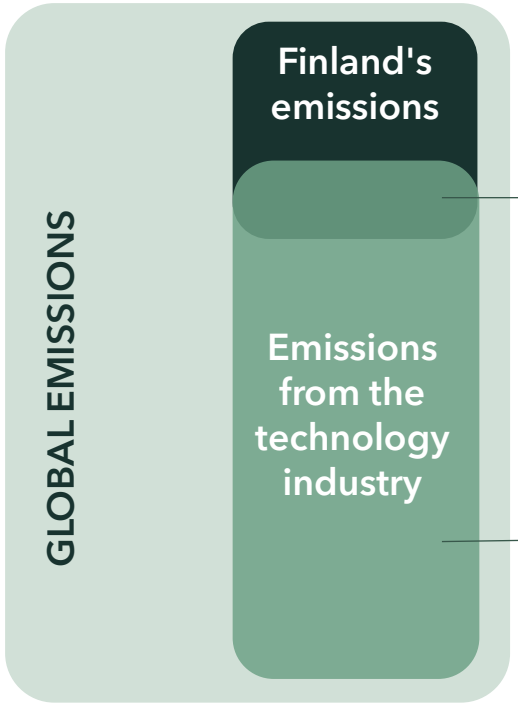
Current state of emissions

Decarbonization has in some cases slowed down, but also accelerated due to the crises that have occurred

	Consequences slowing down decarbonisation	Consequences accelerating decarbonisation
Interruptions in production and logistics	Price has been a more critical decision-making criterion than emission reductions	Potentially localized supply chains may have reduced transport emissions and costs
Geopolitical tensions	Russia's war against Ukraine, US subsidies for green transition	Production of critical materials is directed to Europe
Energy crisis	As energy prices have risen, price has been a more critical decision-making criterion instead of emission reductions.	Investments in energy efficiency and energy storage have accelerated the exit from natural gas in particular
Unstable economic outlook and fluctuations in policy-making	As inflation and financing costs have risen, willingness to invest has declined.	Increased willingness to increase self-sufficiency rate (e.g. raw materials, production chains, energy production)

The current state of the sector's emissions was mapped for 2022 – own emissions decreased compared to 2017



Illustrative image
-not in scale

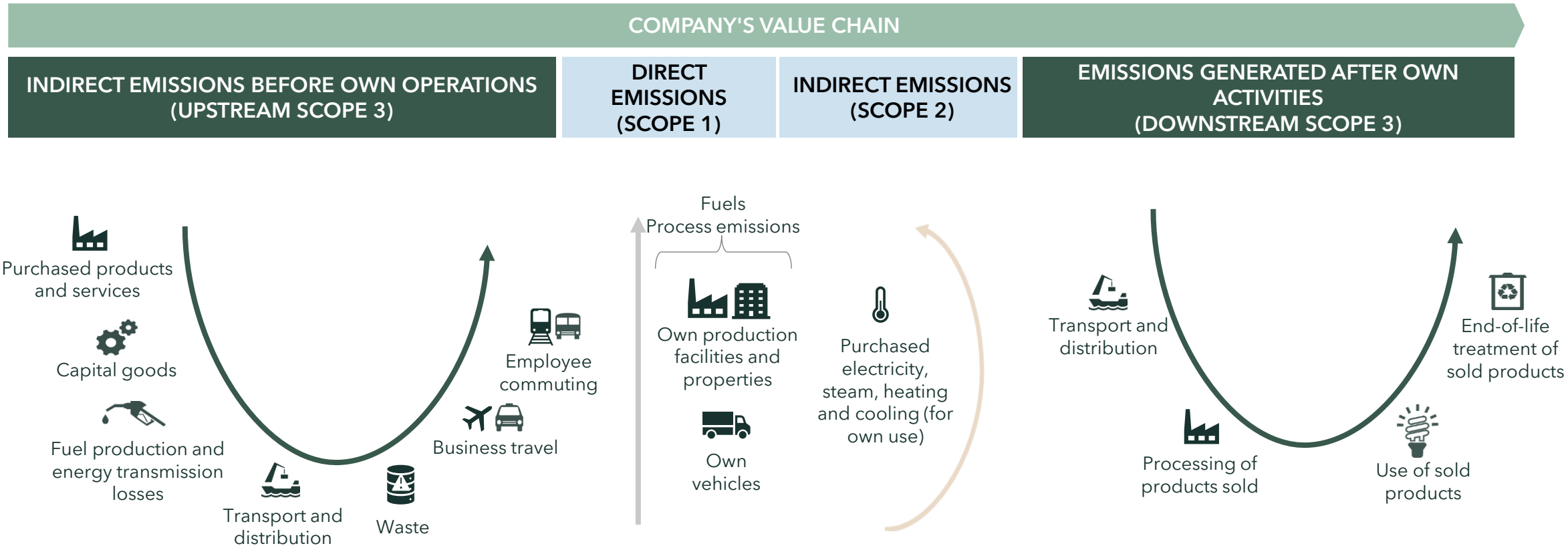
Direct emissions from the technology industry are: **5,0** $MtCO_2e/v$ **(–7%)**

The emissions caused by purchased energy are: **1,2** $MtCO_2e/v$ **(–45%)**

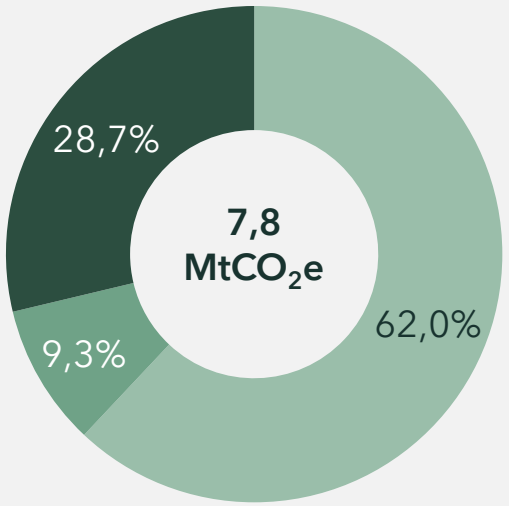
Indirect emissions generated in the sector's value chains as a % of the industry's total emissions **78%**

For the first time, the roadmap assessed indirect emissions from the technology industry value chain.

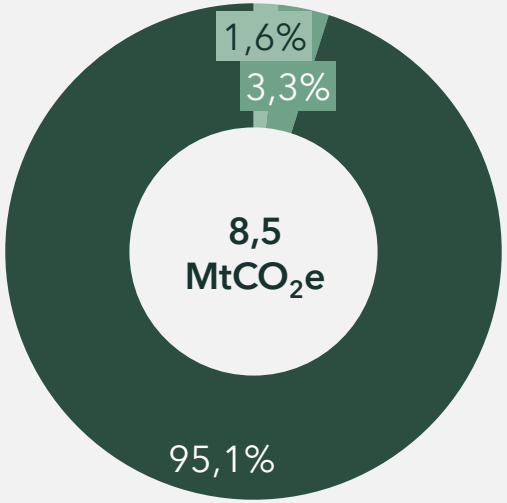
Relevant emissions sources for the technology industry exist at every stage of the value chain



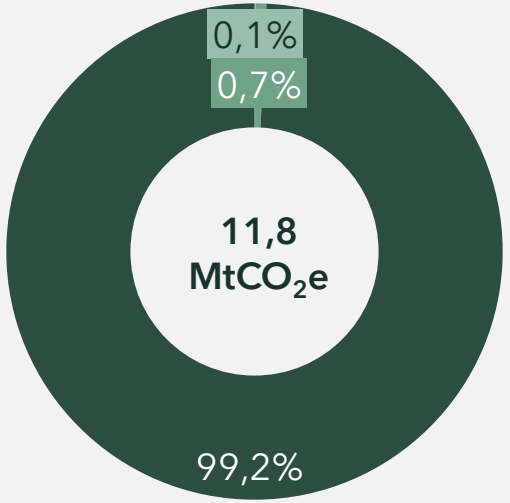
Technology Industries of Finland's emissions amount to 29 MtCO2e, most of which consists of indirect emissions from the value chain



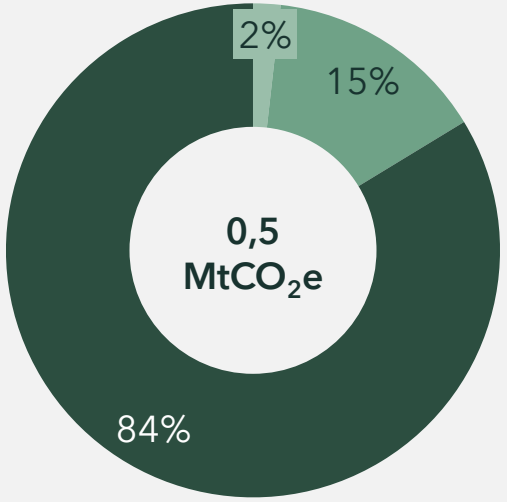
Metal refining (and mining)



Machinery and metal products industry



Electronics and electrical industry



Services*

Scope 1 Scope 2 Scope 3

Emissions in 2022

*Services combined due to small share: Design and consultancy (TOL(2008): 71) & Information technology (TOL(2008): 62-63).

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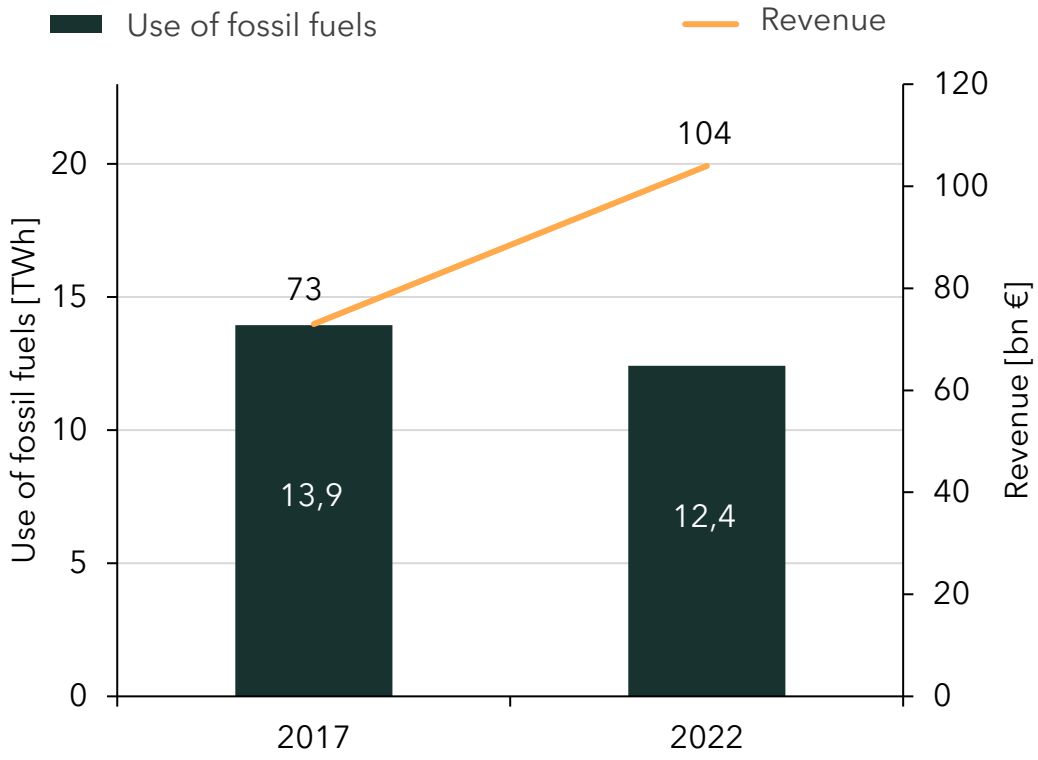
Emission reduction measures

By giving up fossil fuels, significant emission reductions can be achieved – decoupling has been successful!

Replacing fossil fuels

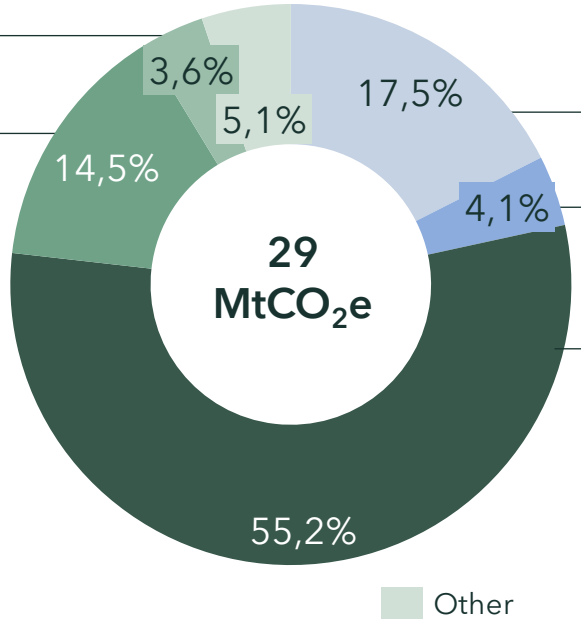
- In Finland, all industries together uses approximately 30 TWh of fossil fuels annually. **The technology industry uses about 41% of industrial fossil fuels, of which 95% is used in metals processing and mines alone.**
- In the longer term, the use of fossil fuels in industry will be replaced by **renewable energy sources, for example through biofuels or electrification.**
- **The use of fossil fuels has been successfully decoupled from net sales growth.**



Use and turnover of fossil fuels in Technology Industries of Finland (Source: Statistics Finland, Technology Industries of Finland)

Reducing emissions in the value chain requires cooperation

Distribution of emissions in the technology industry and related emission reduction measures



Scope 3 - Transport and distribution

- Favouring low-carbon modes of transport
- Cooperation with transport partners

Scope 3 - Procurement

- Low carbon materials and resource efficiency
- Cooperation with suppliers
- Extending the life cycle of fixed assets (e.g. machines, tools, IT equipment) and opportunities for circular economy

Scope 1

- Low carbon steel manufacturing
- Bio-based fuels
- Electrification
- Improving energy efficiency

Scope 2

- Improving energy efficiency
- Purchased energy certified with a guarantee of origin

Scope 3 – Use of sold products

- Product design, e.g. improving energy efficiency
- Enabling the use of low-carbon fuels
- Promoting sustainable operating practices

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Measures at the beginning of the value chain have an impact on the entire industry

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Significant emission reduction potential for the entire industry

Moderate emission reduction potential

Metal refining and mining

- Electrification
- Replacing fossil fuels
- Direct reduced iron (DRI) with hydrogen
- Green energy

Machinery and metal products industry

- Replacing fossil fuels
- Enabling emission-free use
- Use of low-carbon materials
- Low carbon transport

Electronics and electrical industry

- Enabling emission-free use
- Low carbon procurement
- Use of low-carbon critical materials

Services[1]

- Low carbon procurement
- Emission reductions in business travel
- Green purchasing energy

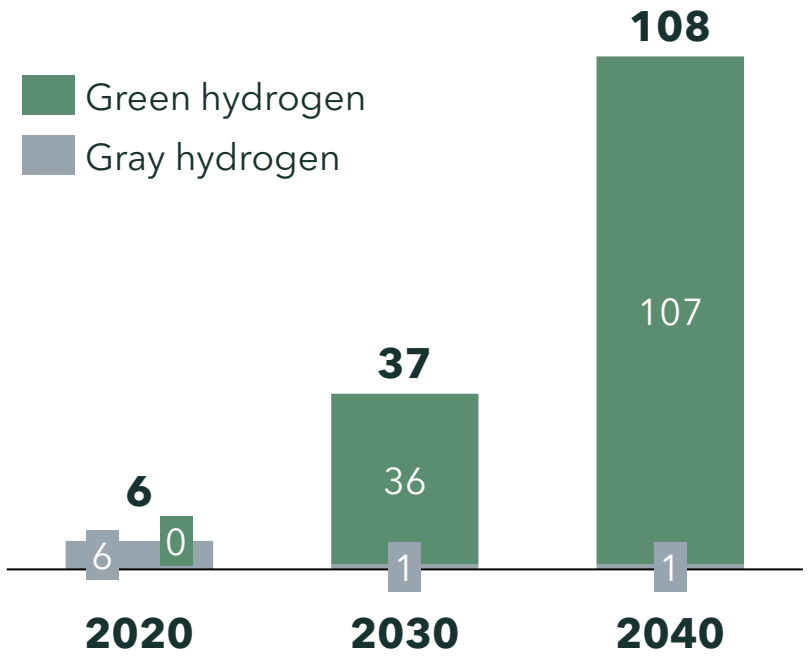
Industry-wide emission reduction measures

- Energy efficiency measures
- Increasing recycled materials
- Utilising digital solutions

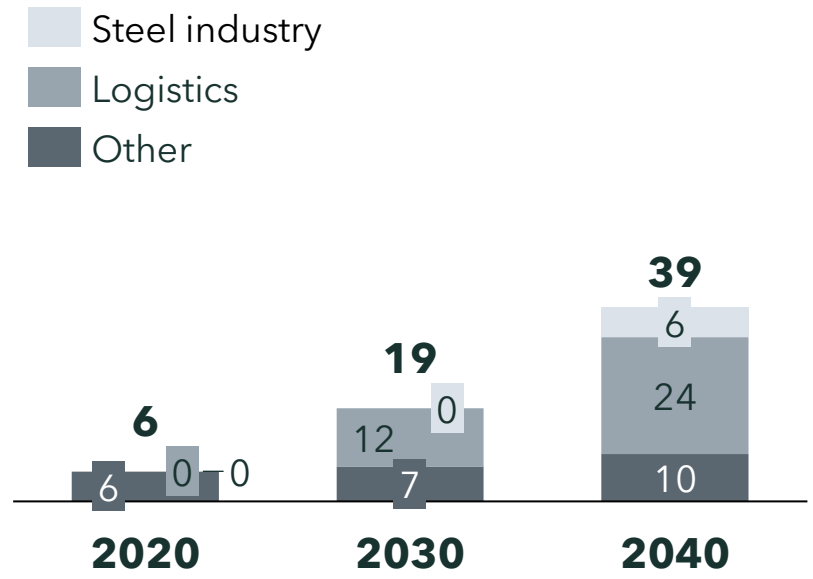
Current state of emissions | **Emission reduction measures** | Emission scenarios | Carbon handprint

Green hydrogen production capacity is still small, but investment plans are promising

Hydrogen production in Finland
TWh/a



Hydrogen consumption in Finland
TWh/a



The estimate is based on Government statistics on the current state and, for the future, on the average of the scenarios formed by Fingrid and Gasgrid, as well as Finland's target of supplying 10% of EU production in 2030. The Government's estimates are considerably more moderate than these.

2022. Vetytalous – mahdollisuudet ja rajoitteet. Government.
2023. Energian siirtoverkot vetytalouden ja puhtaan energiajärjestelmän mahdollistajina. Figrid & Gasgrid.

Hydrogen offers the technology industry emission reductions and a role as a technology supplier throughout the value chain

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Technology industry companies have significant **handprint potential** as solution providers in different parts of the hydrogen value chain. In other words, the role of companies is greater than just the technology industry's own emission reductions.

The biggest emission reductions from hydrogen use (>3 MtCO2e**) are seen in the steel industry (scope 1-2), even though only about 25% of hydrogen is directed to steel production.** This has cumulating effects globally across value chains.

The introduction of hydrogen and hydrogen-refined products will also **have emission reduction effects throughout the value chain (scope 3)**; procurement, emissions during the use of sold products and logistics.

However, achieving emission reductions requires that **technology industry companies are also prepared to pay for potentially more expensive** low-emission products and services, such as logistics.

Technology industry companies play a key role in demand response and other smart energy system capabilities

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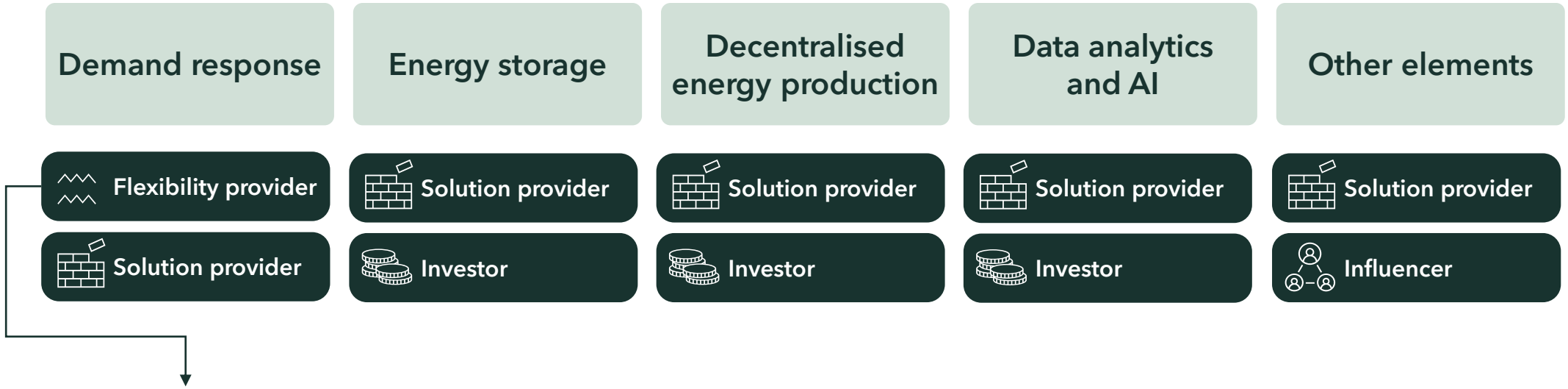
Key elements of a smart energy system and the roles of technology industry companies



The demand response capability of technology industry companies is approximately 20% of required capability in Finland

A prerequisite for emission reductions in digital solutions is their more extensive utilization

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Digital solutions examined are data analytics and smart solutions, digital twins and the Internet of Things, digital platforms and services, cloud services, virtual and augmented reality, robotics and automation, and blockchain technology.

1

Digital solutions are a **tool** for achieving emission reduction measures.

2

There is no single digital solution that solves several problems, but **solutions must be applied in connection with each other.**

3

The level of development of digital solutions **would enable more extensive utilization in companies** than is currently the case.

4

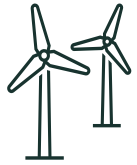
Utilizing the emission reduction potential of digital solutions **requires high-quality data and systematization.**

The emission reduction impact can be up to 20%,
if the energy used by digital solutions is green.

Securing access to critical materials is intrinsically linked to the digital green twin transition

The twin transitions, i.e. the green and digital transitions, respond to society's need for decarbonization.

Drivers of disruption



Replacing fossil fuels increases the need for renewable forms of energy.

Digital solutions, such as production optimisation, support the achievement of emission reductions.

The EU is currently highly dependent on certain countries for access to raw materials.

Securing the supply of critical materials is important for achieving decarbonization of companies.
Critical materials refer to materials that are scarce and involve procurement risk.

Necessary capabilities

Critical materials are needed to achieve emission reductions, so ensuring their availability becomes important from two perspectives:

1. Materials **required for products and services sold by companies**, e.g. Li-ion batteries, electrolysers, H2-DRI (direct reduced iron), communication networks.

2. Materials required for **companies' procurement related to emission reductions**, e.g. green electricity or emission-reducing production technologies.

Critical materials required for low-carbon technologies can be found in Finland

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*Finland's reserves

Renewable energy

- **Li-ion-batteries**
  - **Lithium***
  - **Graphite***
  - **Cobalt***
  - **Nickel***
- **Electro-lyzers**
  - **Graphite***
  - PGMs (palladium)
  - **Nickel***
- **Wind Turbines**: Special. rare earth elements used for magnets(**REE***)

E-mobility

- **Li-ion-batteries**
  - **Lithium***
  - **Graphite***
  - **Cobalt***
  - **Nickel***
- **Electric traction motors**: Special. rare earth elements used for magnets (**REE**)*

Energy-intensive industry (EIT)

- **H2-DRI**: No actual bottleneck materials, but noteworthy are:
  - **Green hydrogen**
  - DRI-grade iron ore
  - **Graphite***

ICT

- **Transmission networks**: A wide range of material needs, the most critical are **REEs***

Space-technology and defence (ATP)

- **3D-printing**: A lot of critical material needs, e.g. titanium
- **Robots**: Lots of different material needs

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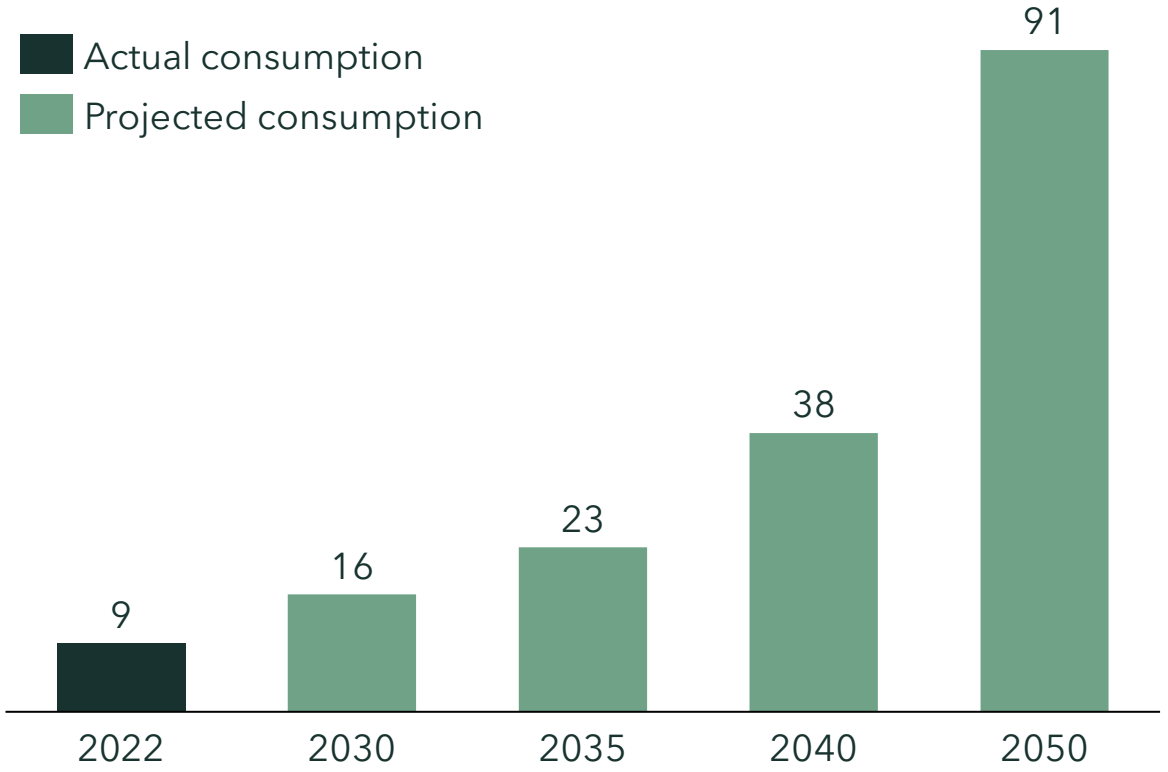
Emission scenarios

Electricity consumption will increase in the future

- In the scenario analysis of the roadmap, each scenario examined includes a forecast of electricity consumption growth.
- In 2022, Finland's electricity consumption was approximately 82 TWh. In the main industries of Technology Industries of Finland*, electricity consumption in 2022 was approximately 9.4 TWh[2]. We assume that the share of electricity consumption in Technology Industries of Finland's consumption will remain the same.
- **Finland's electricity consumption is growing strongly due to, e.g., electrification and the hydrogen economy**. According to Fingrid's electricity system vision, consumption will grow by approximately 7% per year until 2035, after which consumption will accelerate to 11% per year until mid-century.[1]

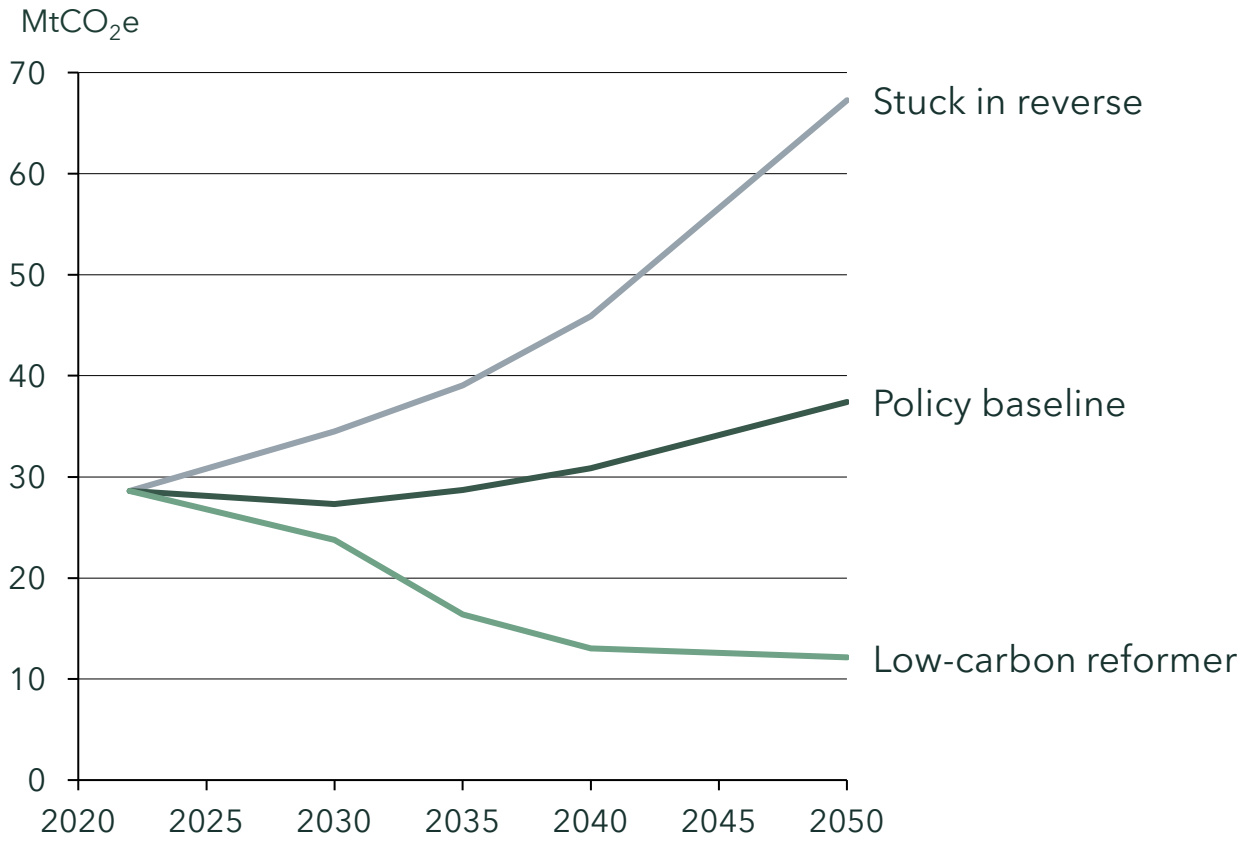
Projected growth in electricity consumption in Technology Industries of Finland[1], TWh



[1]Fingrid Power system vision 2023. Increase in electricity consumption in scenarios: Electricity into products, Wind hydrogen, Sea wind. It is assumed that the share of Technology Industries of Finland in electricity consumption will remain unchanged.
[2]Electricity consumption in 2022. Energy use in manufacturing by industry.
*Incl. main industries: Manufacture of basic metals and mines TOL(2008): 5-9 & 24, Electronics and electrical industry TOL(2008): 26-27, Machinery and metal products industry TOL(2008): 25, 28-30,33

Low-carbon reformer is successful – however, reducing emissions in the value chain means working together

Scope 1-3 emission reduction pathways for the Technology Industry



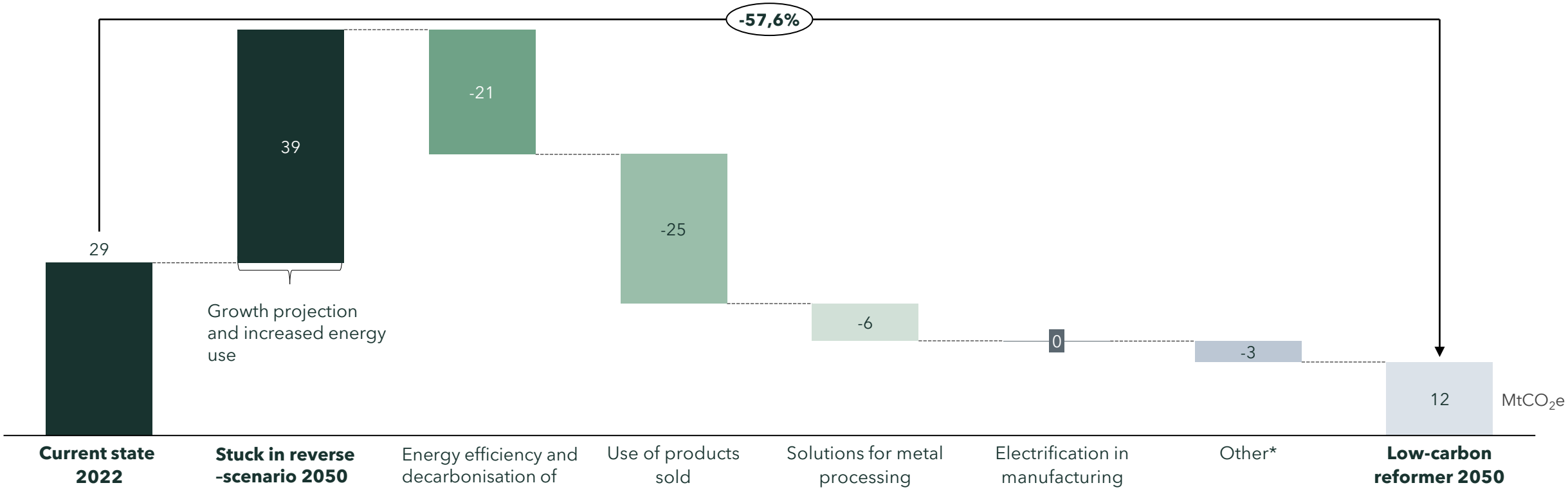
Stuck in reverse serves as a basis for other scenarios. It includes the assumption of an increase in the volume of production and an increase in energy consumption.

Policy baseline takes into account existing or decided policy measures in Finland and the EU in addition to growth assumptions.

Low-carbon reformer succeeds in significantly reducing direct and indirect emissions from purchased energy through investments (Scope 1&2). In addition to investments, the scenario takes into account society's accelerated decarbonisation in other sectors.

Low-carbon reformer actively invests in the introduction of low-emission solutions

Scope 1-3 emission reduction measures in the Low Carbon Reformer scenario



*Other: Emission reductions in procurement, logistics, business travel and commuting.

Investments will have a significant impact on emissions if realized – changes in the operating environment pose challenges

Historical development 2017-2022

Compared to the previous carbon roadmap **Scope 1-2 emissions have been reduced to 6.2 MtCO2e, which corresponds to an emission reduction of 19%.**

Scenario calculation result

A carbon roadmap review reveals that in scenario Low-carbon reformer Scope 1-2, emissions are at the level of **2.4 MtCO2e (2050). This corresponds to a 69% reduction in emissions compared to 2017.**

Comparison with the results of the previous roadmap

In the previous roadmap, the reduction in Scope 1-2 emissions was faster:

- In the accelerated technological development scenario **1 $MtCO_2e$** (2050)
- In the forced emission reduction scenario **0.7 $MtCO_2e$** (2050)

The previous roadmap assumed that technological development would take place faster and that the operating environment would be very favourable.

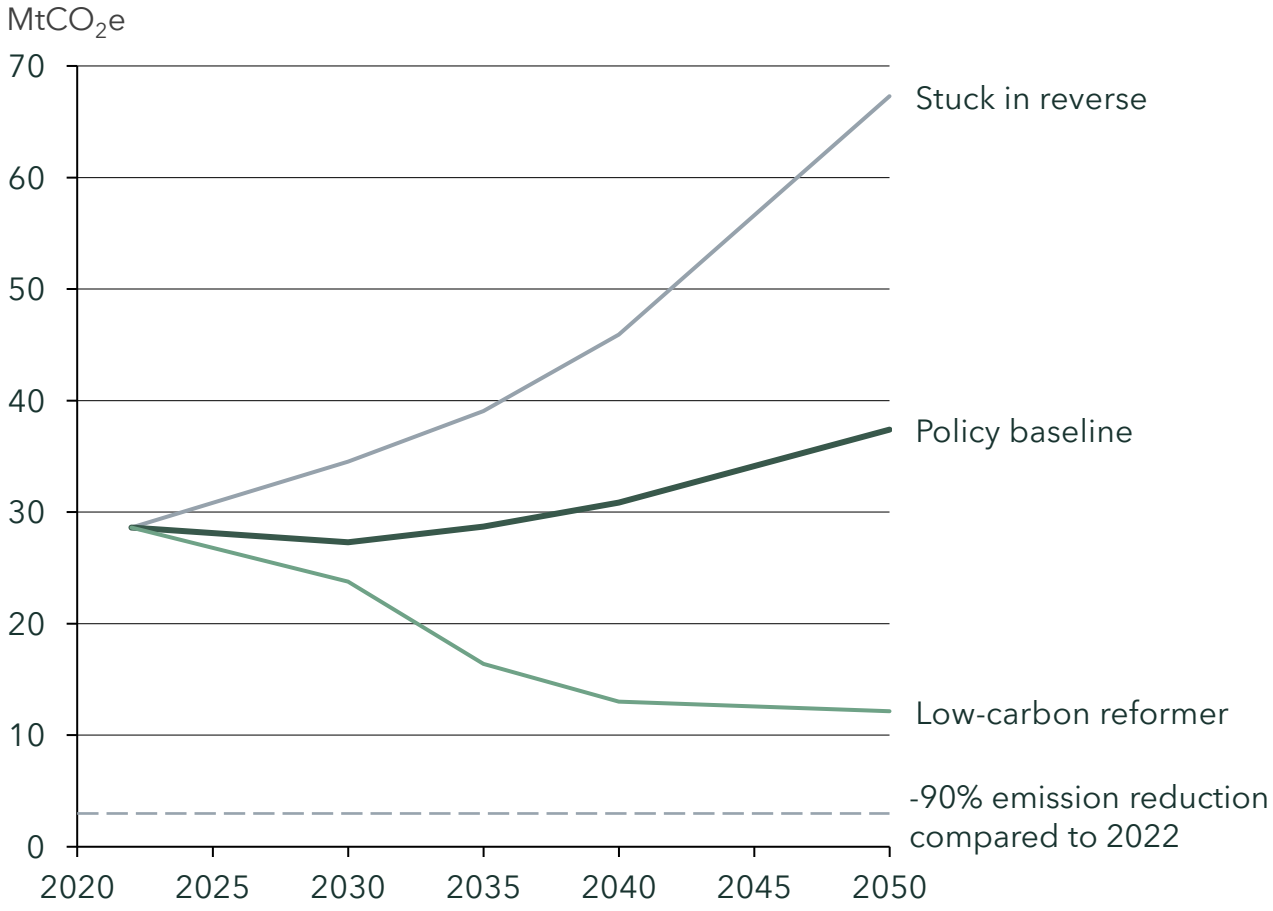
- **Companies should identify measures and invest an additional 1.8 MtCO2e in emission reductions** to achieve the 1.5-degree path according to climate science.
- Historical developments reveal that, if realized, **the investments will have a significant impact on emissions.**
- **Changes in the operating environment** have affected companies' willingness to invest, which is why the updated roadmap has created more cautious scenarios than the previous roadmap.

Emission reductions in the value chain require action from both the technology industry and other actors globally

Value chain emission reduction paths for the technology industry

- Scope 3 results, i.e. the calculation of indirect emissions in the value chain and emission reduction paths, are significantly more uncertain than Scope 1 and 2.
- The Low-carbon reformer scenario **achieves a 57% reduction in emissions by 2050** compared to the 2022 baseline.
- Compared to the 1.5-degree path according to climate science, there would still need to be **7.5 MtCO2e** emission reductions in 2050.
- Emission reductions in the value chain **need cooperation**. Without the **rapid decarbonization of other industries** and sectors globally, reductions in indirect emissions in the value chain will be difficult to achieve.

Scope 1-3 emission reduction pathways



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Carbon handprint

Carbon handprint means reducing the customers' footprint

Carbon handprint

Increasing benefits to customers and society

Describes organization's, product's, or service's **potential to reduce customers' emissions**

- No harmonized calculation standards, so it's important to be transparent
- Describes emissions avoided when a customer chooses a specific product or service instead of a specified benchmark.

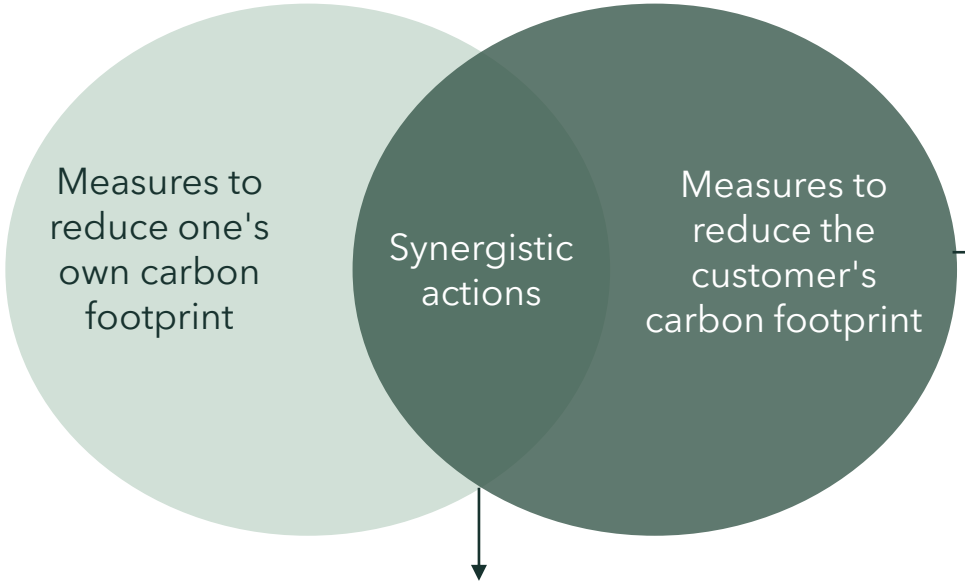
Carbon footprint

Minimizing harm to society, the environment and people

Describes the **negative climate impacts** of the product or organization

- Calculated based on actual data
- GHG protocol
- ISO standards
- Life cycle assessments and environmental product declarations (LCA & EPD)

The carbon handprint is always case-specific, and it is important to determine the benchmark



The handprint effect is based on a **smaller carbon footprint of the product or service than the benchmark**, i.e. the emissions avoided.

Example: Low-carbon steel

The handprint effect is based on **reducing customers' emissions** (more than the benchmark), while at the same time **reducing one's own carbon footprint.**

Example: Dual-fuel engines

The handprint effect is based on **reducing customers' emissions** (more than the benchmark), and this does not reduce the product/service's own carbon footprint.

Example: Software that reduces material loss

Finnish Technology Industry has a large carbon handprint in relation to the sector's carbon footprint

Direct (scope 1-2) emissions of Technology Industries of Finland in 2022

6 $MtCO_2e$

Technology Industries of Finland value chain (scope 3) emissions in 2022

23 $MtCO_2e$

-75 $MtCO_2e$

Annual handprint potential of Technology Industries of Finland export products[1]

The magnitude of the handprint potential arises from the assumption that technology industry's **export products would gain a certain share of their market globally.**

The calculation takes into account the annual emission reduction potential through both reducing one's own carbon footprint and reducing the carbon footprint of customers.

The industry's exports account for about 50% of Finland's total exports of goods and services

2023, Teknologiateollisuus on Suomen suurin vientiala - koostuu viidestä päätoimialasta, Technology Industries of Finland

[1] According to Previous roadmap .

Handprint potential is driven by both market growth and measures guiding emission reductions

Share of target markets' emissions in global emissions		Target market growth and actions guiding emission reductions
Marine industry	3%	Market size €173 billion €. Expected to triple by 2050. Demand is guided by the IMO's emission reduction targets and the transition of shipping to emissions trading.
Metal industry	7%	Steel production accounts for a significant part of the metal industry. Global demand is expected to grow by more than 30% by 2050.
Energy technology	32%	Energy consumption is expected to increase by 50% by 2050. The growth of energy technology is driven by the need to reduce fossil energy use.
Recycling technology	>3%	Global material use is expected to grow by 70% by 2050. The use of recycled materials plays an essential role in achieving emission reductions in other sectors.
Construction technology	21%	In 2022, the global construction market was worth approximately EUR 13.4 trillion. The market is expected to continue to grow at an annual growth rate of 5-6%.
Transport technology	15%	Growth in the volume of mobility, electrification of transport and phasing out fossil fuels will drive the growth in demand.
Manufacturing*	<5%	Growth is anticipated especially in the utilisation of digital solutions and new production technologies.

* Combines clusters of Design and Consulting, Information Technology, Automation and Measurement Technology and New and Existing Production Technologies

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Summary

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Progress has been made in reducing emissions in the sector – in the future, the greatest potential lies in Scope 3

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Current state of emissions 2022

Scope 1

Direct emissions from the technology industry are:

5,0 $MtCO_2e/v$

(-7%)

Compared to 2017

Scope 2

The emissions caused by purchased energy

1,2 $MtCO_2e/v$

(-45%)

Compared to 2017

Scope 3

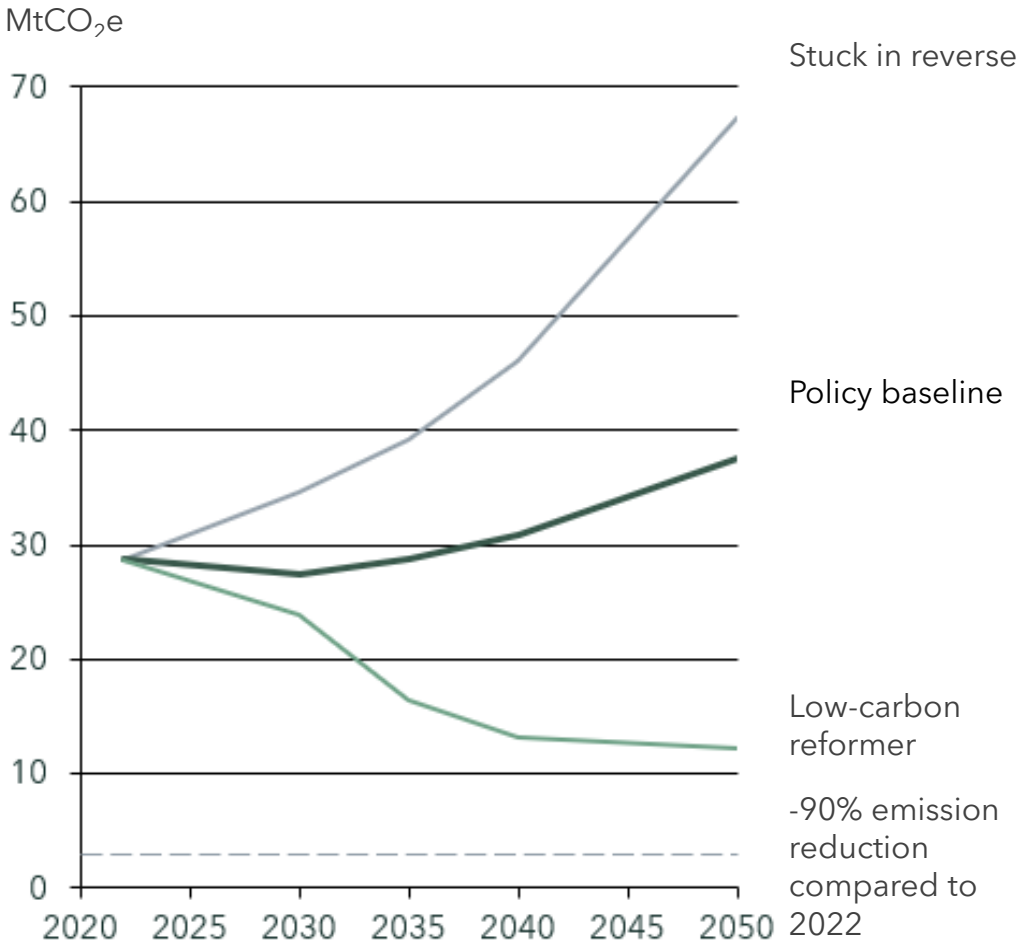
Indirect emissions generated in the sector's value chains cover the sector's total emissions

78%

-75 $MtCO_2e$

Annual handprint potential of technology industry export products

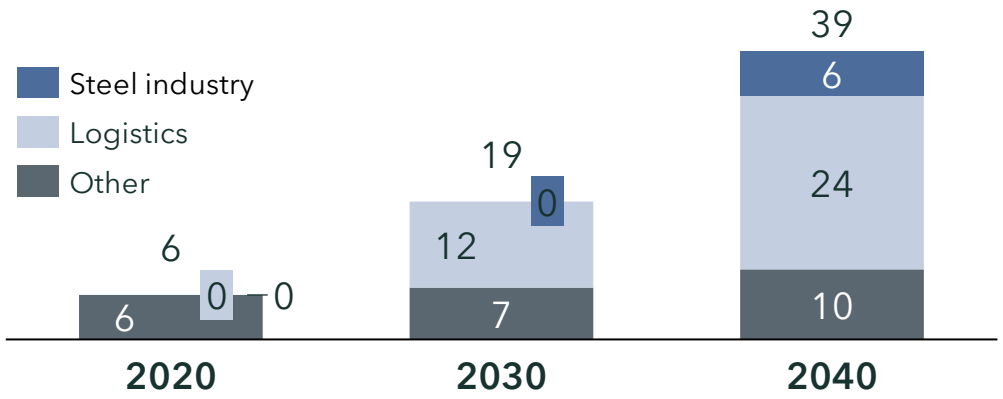
Emission reduction pathways (Scope 1-3)



The greatest impact of hydrogen on emissions can be seen in the renewal of the steel industry

Increase in hydrogen production and consumption in Finland...

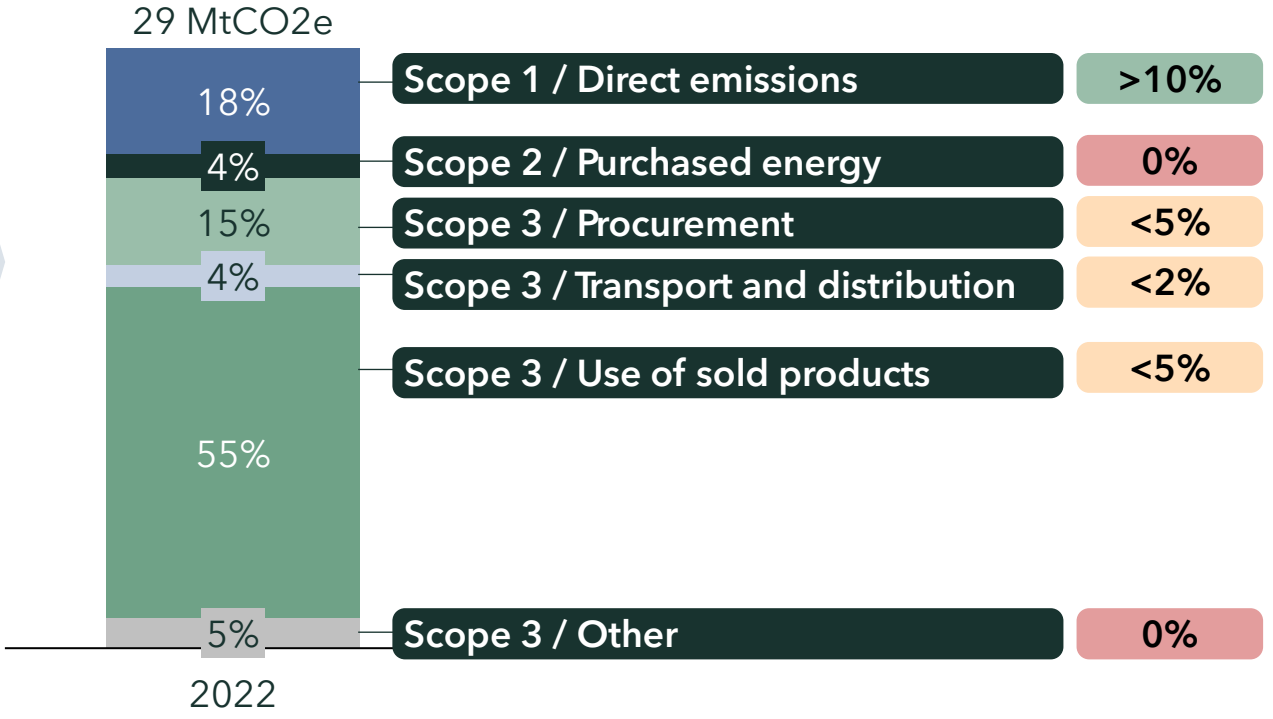
Projected consumption of hydrogen in Finland, TWh/a



	2020	2030	2040
Hydrogen production		37 TWh	108 TWh
Additional need for renewable electricity		53 TWh	154 TWh
Raw water consumption		10 milj. m^3/a	30 milj. m^3/a

... enables the technology industry to reduce emissions related to steel and logistics in particular

Distribution of emissions in the technology industry and hydrogen's emission reduction potential, % of total emissions



In the future, companies' climate work will be driven by regulation, markets and risk management

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Regulation and policy changes

- **Regulation related to combating climate change and responsible business in general has tightened** both nationally and internationally. New obligations have been imposed on companies that affect their activities.
- **The European Sustainability Reporting Directive (CSRD) introduces stricter reporting requirements for companies.** The directive obliges companies to report more comprehensively on their sustainable development measures, such as climate change mitigation, and their impact on the environment. This increases transparency and forces companies to invest more in their climate work to meet reporting requirements.

Competitive advantage and market opportunities

- **More and more companies are setting ambitious climate targets** and demanding similar commitments from their suppliers and other stakeholders.
- Technology industry customers, especially large international players, expect companies to adhere to high sustainability standards. In terms of competitiveness and customer relationships, **companies must invest in their climate work and show concrete results**.
- **57 per cent of Finland's goods exports go to the EU.** By utilizing the products, services and know-how of the Finnish technology industry, **Europe can be a driver of the green transition.**

Risk management and business continuity

- **Climate change brings with it significant risks to business,** such as extreme weather events, scarcity of natural resources and energy crises. Changes in the security environment also bring pressure to adapt.
- It is important for companies in the technology industry to manage these risks to **ensure business continuity and reduce operational disruptions.**
- **Proactive climate work can help companies anticipate and adapt to the challenges** posed by climate change. For example, improving energy efficiency and renewable energy **can protect a company from fluctuations in energy prices**. In addition, building sustainable supply chains can reduce dependence on vulnerable raw materials and production facilities.

Companies have succeeded in reducing their own emissions – value chain emissions are the next challenge

Companies have been able to reduce their own emissions	Even though the operating environment has been in turmoil, companies have succeeded in reducing direct emissions from their own operations
Emission reduction measures are still profitable.	Many measures will improve, for example, energy independence, security and the integration of different systems (e.g. smart energy system) while achieving emission benefits.
Many easy steps have been taken, but some can still be found	The difficulty factor increases in reducing emissions in the value chain. There are still simple measures, such as switching some fuels to bio-based ones in our own processes and transports, and green purchased energy, but a premium has to be paid for these.
Footprint and handprint measures often aligned	Companies can increase their own handprint and reduce their own carbon footprint with the same measures. The most significant handprint potential can be found in raw materials (low-carbon and recycled metals) and technologies that consume or produce energy.

Conditions and bottlenecks in companies for achieving emission reductions

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Conditions

Budgeting and investments

Investments in sustainable practices and technologies can accelerate demand generation and economies of scale for emission reduction solutions, leading to cost reductions in the long run.

Cooperation

Cooperation with the entire value chain enables cost-effective identification of the best emission reduction measures.

Management support and strategic planning

The strong commitment of the management ensures that emission reduction measures are prioritized and that sufficient resources are allocated to them. Long-term planning and understanding links are important e.g for the energy system.

Bottlenecks

Data availability and management

Sharing knowledge and consistent practices throughout the value chain leads to better solutions for monitoring, controlling and reducing emissions. Small businesses in particular should be taken into account.

Personnel capabilities

By raising employees' awareness of sustainable practices, employees are more likely to innovate and implement effective emission reduction strategies and align their daily work with the company's climate goals.

Securing critical materials

Stable availability of materials ensures that companies can produce and scale up sustainable solutions without disruptions in supply chains.

Conditions for achieving emission reductions and bottlenecks in the operating environment

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Conditions

Technology neutrality

Technology companies will be able to choose the most efficient and innovative solutions to reduce emissions, which will foster competition and accelerate the adoption of various green technologies.

Predictability of regulation

Stable and clear regulation helps companies confidently plan long-term investments in sustainable technologies, reducing the risks associated with sudden policy changes.

RDI investments

Financial support for R&D encourages technological development aimed at reducing emissions, enabling companies to develop and implement new low-emission technologies more efficiently.

Bottlenecks

Functioning electricity markets and energy networks

Technology industry companies are relying on electrification. A smart energy system ensures reliable and affordable access to renewable energy.

Efficient information sharing

The creation of industry alliances and networks can facilitate cooperation on emission reduction initiatives and share best practices. Improving access to open data promotes cooperation.

Securing critical materials

Stable availability of materials ensures that companies can produce and scale up sustainable solutions without disruptions in supply chains.