Digital decarbonisation in Norway

How digital technologies enable decarbonisation across all sectors of our society … and how we can decarbonise the digital value chain

An Implement Economics study
commissioned by Google

February 2024

The digital decarbonisation report addresses two equally important priorities

1

Digital decarbonisation

How digital technologies enable the path toward Norway's ambitious climate goals.

2

Decarbonising digital

How we transform data centres and digital value chain to become carbon-free.

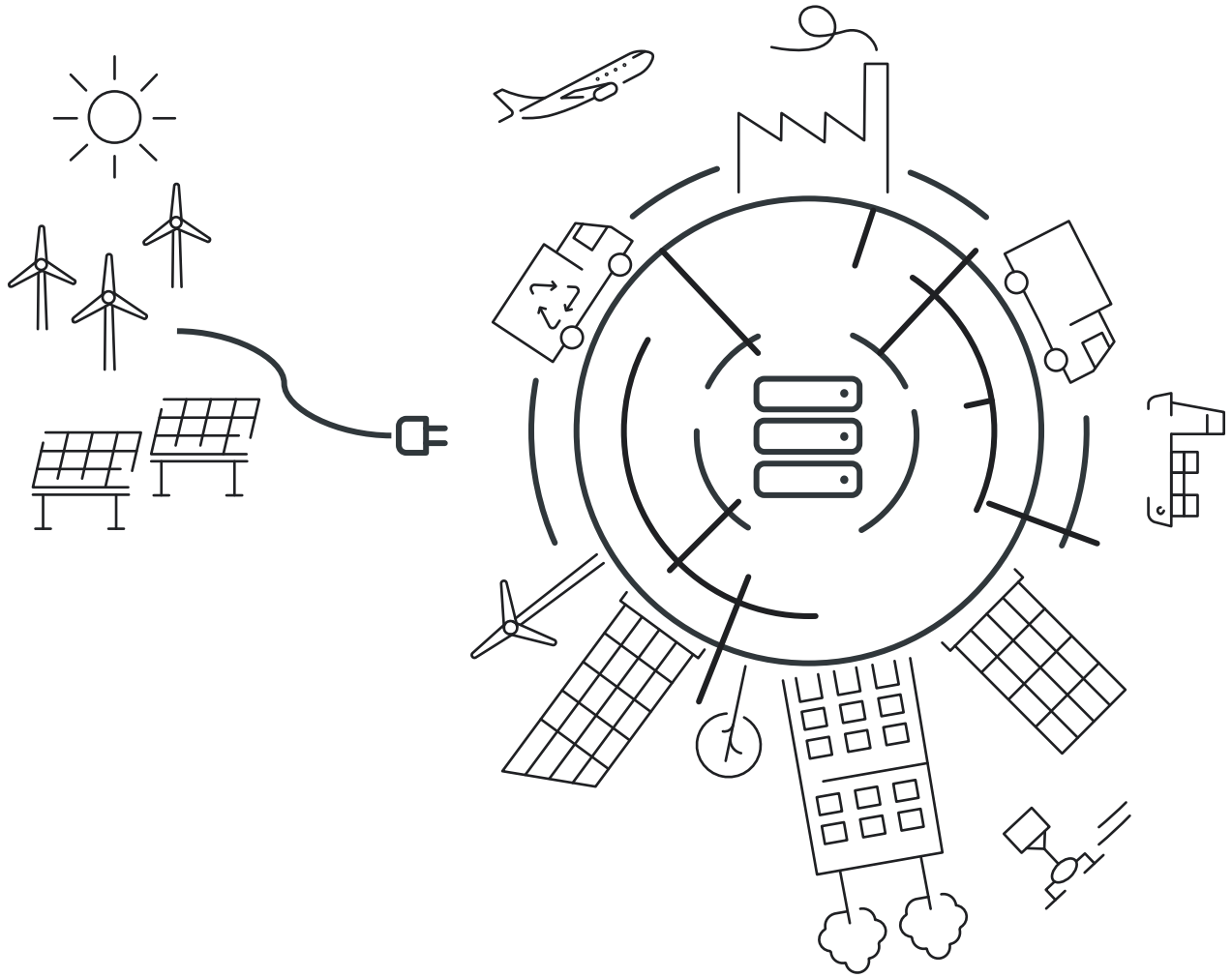


Table of contents

Summary

20-25% of onshore greenhouse gas reductions needed for Norway's 2050 target require digital enablement to work at scale and at a socially acceptable cost

- Norway has ambitious climate goals of a 55% reduction of gross greenhouse gas emissions by 2030 and 90-95% reduction by 2050.
- Digital technology is already making major contributions to achieving sustainability goals, including decarbonising the economy by e.g. supporting the transition to electrification and reducing fuel consumption.
- Digital processes and new technologies are helping us to **save scarce energy** and use it more efficiently. Digital solutions are also key in increasing the flexibility of the use of **renewable electricity** with **intelligent power grids.**
- The **digital sector** is also on its own decarbonisation journey. Decarbonisation enabled via digital solutions will outweigh emissions from data centres, and future gains are significant. Frontrunners in the sector are committing to 24/7 carbon-free energy as the most efficient way to progress towards a fully carbon-free digital sector.
- If all data centres in Europe achieved 100% hourly carbon-free energy (24/7 CFE), the EU would save **6-18 million tons of CO_2 in 2030** – this corresponds to Norway's agriculture and manufacturing emissions combined.

As a digital frontrunner, Norway's **win-win approach** to competitiveness and the green energy transition should have two parallel tracks:

- **Digital decarbonisation**: Maximising the enabling role of digital technologies by accelerating already available digital solutions at scale.
- **Decarbonising digital**: Minimising the carbon emissions across the entire European digital value chain by decarbonising all operational electricity emissions and addressing the emissions related to devices as well as servers and buildings etc.

The **digital decarbonisation** priority is about accelerating the uptake of digital solutions enabling climate change mitigation. This will require an enabling policy framework.

Norway's decarbonisation pathway requires digital technologies to work together with other technologies

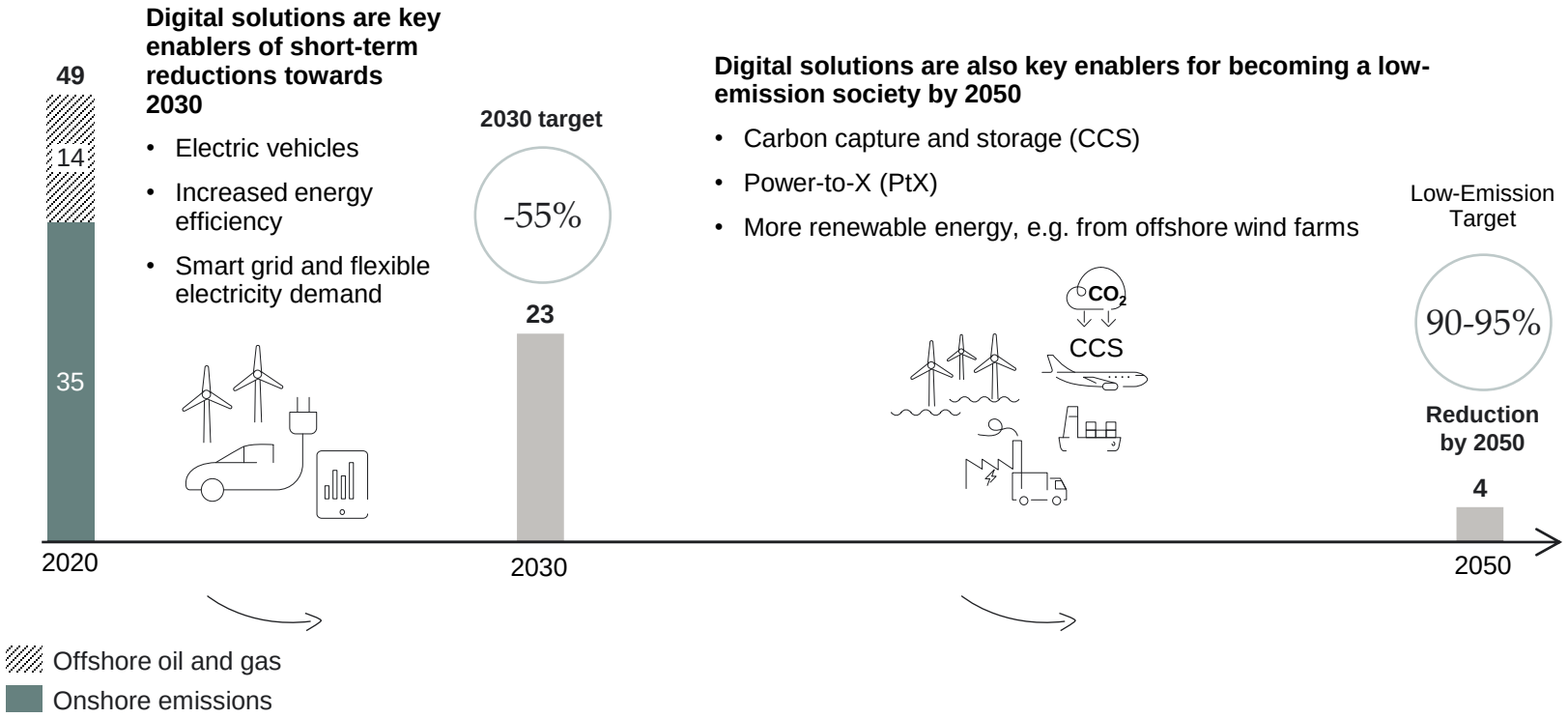
- The **manufacturing** sector accounts for approximately 33% of onshore Norwegian emissions. At least 10-15% of these emissions are to be reduced by improved energy efficiency and electrifying lighter industrial processes, which is being enabled by digital technologies such as predictive AI.
- Norway's **domestic transport** sector accounts for around 34% of onshore emissions. Around 50-60% of the reductions in transportation towards 2050 is expected to come from a switch to electric cars, trucks and buses. Smart charging apps, digitally integrated charging stations, smart grid solutions are already at work enabling this transformation.
- Norway's **agriculture** sector accounts for around 17% of onshore emissions. Estimates suggest that 20-25% of the emission reductions in agriculture will require some degree of digital enablement.
- The **heating of homes and buildings** is already being transformed by new building management systems using AI and machine learning. Using electricity more smartly is an important part of Norway's energy future, and much needed to avoiding energy crunches towards 2030.

The estimates and examples are not exhaustive, and there are numerous other ways in which digital solutions are already enabling the decarbonisation journey.

Digital technologies are important enablers of the green transition

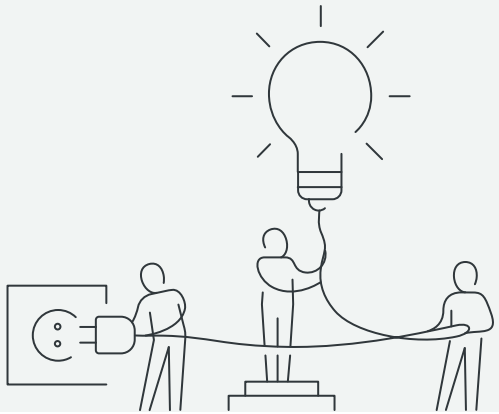
Norway aims to become a low-emission society by 2050. Digital innovation is seen as one of the driving forces to become a low-emission society and is part of the Norwegian government's climate action plan. Digital technologies will play a role in decarbonising almost every corner of the society – hence, the grand idea of the twin green and digital transition.

Norway's greenhouse gas emissions (gross)
$MtCO_2e$



What is the twin transition?

Twin transition refers to the interplay between digital and green transitions. Digital technologies will help economies reduce carbon emissions. Similarly, the green transition of our energy system will help the digital sector reduce its operational emissions.



Note: Emissions are defined as gross emissions from Norwegian territory, excluding LULUCF emissions, and thus do not include international transport. Onshore emissions are defined as total emission excl. emissions from offshore oil and gas. Decarbonisation of the offshore oil and gas sector arises in large part as a result of phasing out oil as an energy source. Consequently, this report does not address digital technologies that may reduce emissions from oil and gas extraction in the shorter term.
Source: Implement Economics based on Norwegian Ministry of Climate and Environment and the Norwegian Government.

The current onshore emissions from Norway are concentrated in two main sectors

Norway's onshore greenhouse gas emissions (gross), 2020

$MtCO_2e$

Decarbonisation initiatives in main sectors
(non-exhaustive)

- Efficiency improvements from precision farming
- Reduced food waste
- Changes in land-use

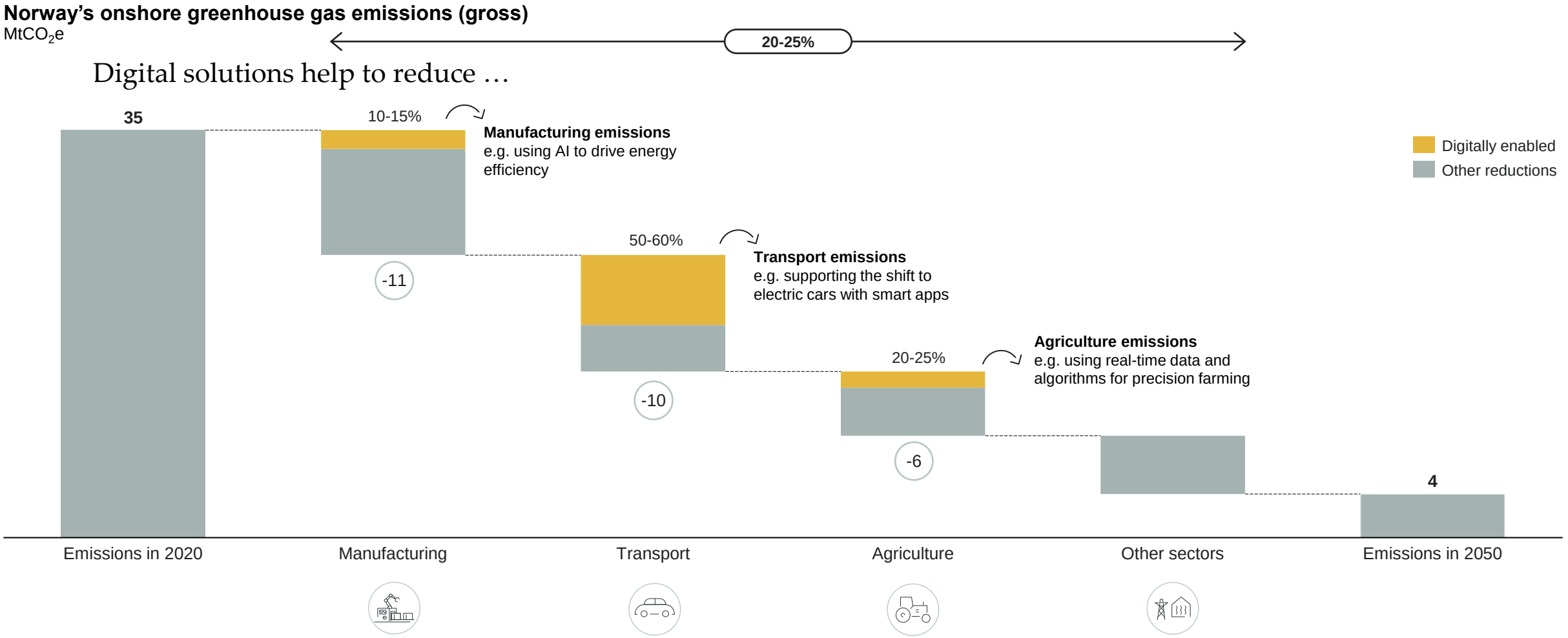
- Electric cars, vans, buses and small trucks
- Efficient and eco-friendly driving
- Reduced travel by use of digital tools (work from home and video conferences)
- Green fuels based on PtX for ships, aircraft and heavy vehicles

- Smart factory with AI systems
- Efficiency improvements
- Electrification of lighter processes
- Green fuels from PtX for heavy processes

- Smart buildings
- Transition to heat pumps
- Improved energy efficiency
- Sustainable building

Note: Data on greenhouse gas emissions and removals sent by countries to UNFCCC and the EU Greenhouse Gas Monitoring Mechanism (EU Member States). This data set reflects the GHG inventory data for 2020 as reported under the United Nations Framework Convention for Climate Change. CRF inventory categories: Industry and manufacturing: CRF 1A2 (manufacturing industries and construction) + CRF 2 (industrial processes and product use); Domestic transport: CRF 1.A.3; Agriculture: CRF 1A4c (agriculture, forestry and fishing) + CRF 3 (agriculture); Waste: CRF 5 (waste); Other combustion (CRF1A5a + CRF1A5b + CRF indirect CO2). Heating and onshore energy is defined as CRF 1A4a (commercial) + CRF 1A4b (residential) + leftover emissions from the energy sector (CRF 1A1 (energy industries) + 1B (fugitives)) not contained in offshore oil and gas.
Source: Implement Economics based on the European Environment Agency (EEA).

20-25% of onshore carbon reductions needed for Norway's 2050 target require some degree of digital enablement

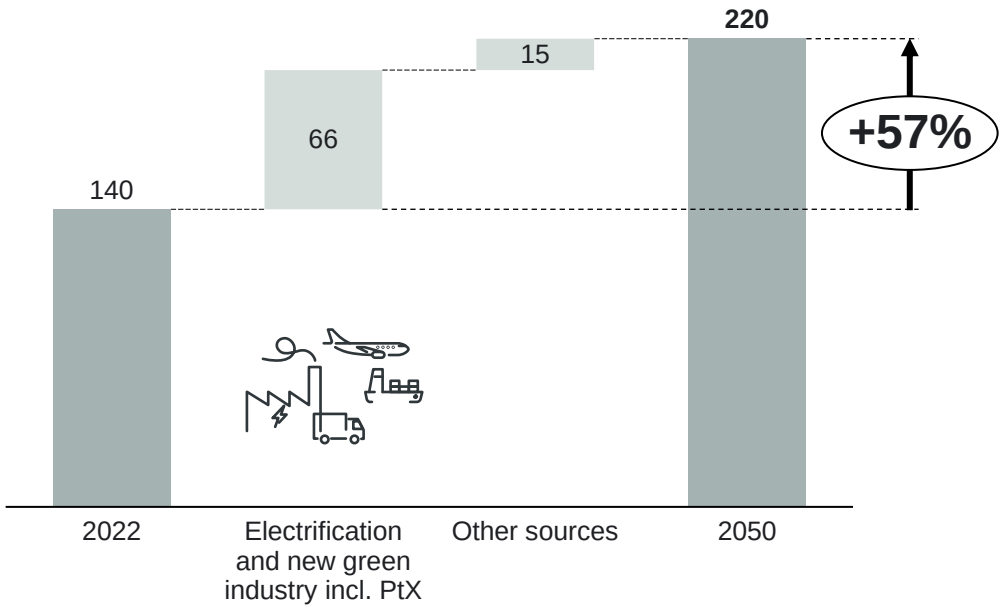


Note: The degree of digital enablement (20-25%) is expressed as a percentage of onshore gross greenhouse gas emissions. "Other sectors" Includes onshore energy and heating of buildings.
Source: Implement Economics based on Statnett, European Environment Agency (EEA), Transportøkonomisk institutt, Bellona, Malmodin, J and P. Bengmark, CapGemini and EnergiAktuelt.

Norway has cleaner power and is more electrified than the rest of Europe, yet Norway will need to introduce energy efficiency measures at scale and introduce more flexible power usage

Long-term electricity demand in Norway

TWh



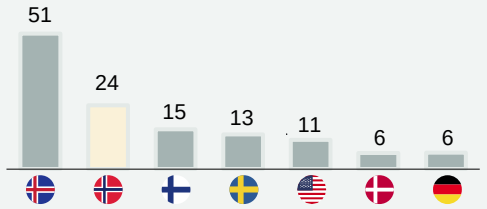
A new report by the IEA underscores the importance of digitalisation in securing the energy transition and modern electricity grids. Digital technologies like smart grids are crucial in managing bidirectional energy flows over longer distances, as uncertainty about the predictability of electricity flows grows.

Affordable and clean energy – a blessing or a curse?

Seen from a European perspective, Norway has enjoyed affordable energy for a long time. Norway also has some of cleanest electricity in the world, emitting only 29 gCO_2e per kWh of electricity. Neighbouring countries range from 45 gCO_2e/kWh (Sweden) to 181 gCO_2e/kWh (Denmark). Renewable sources account for 98% of electricity production, of which hydropower makes up 92%, and more than three-quarters of electricity production is flexible.

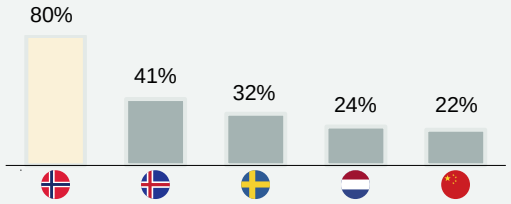
Norway has a very high electricity use per capita

Electricity demand
1,000 kWh per year per capita (2021)



Norway is leading on adoption of electric vehicles

Sales of electric vehicles
% of passenger vehicle sales (2022)



Energy crunch in Norway by 2027?

Statnett anticipates a significant increase in electricity consumption already by 2027 due to industrial growth and electrification. The power generation is forecasted to be less pronounced, potentially causing a negative energy balance in Norway. This may lead to energy deficiencies especially in southern Norway.

At the same time, Norway will gradually introduce more wind and solar power generation, which will introduce new fluctuations in the power system. To cope with these pressures in the electricity system, Norway will need to improve both the efficiency and flexibility of the electricity use.

Note: See *Electricity Grids and Secure Energy Transitions,* IEA (2023).
Source: Implement Economics based on Statnett, World Resources Institute (WRI), Ember, Energy Institute Statistical Review of World Energy, Energy Facts Norway and the IEA.

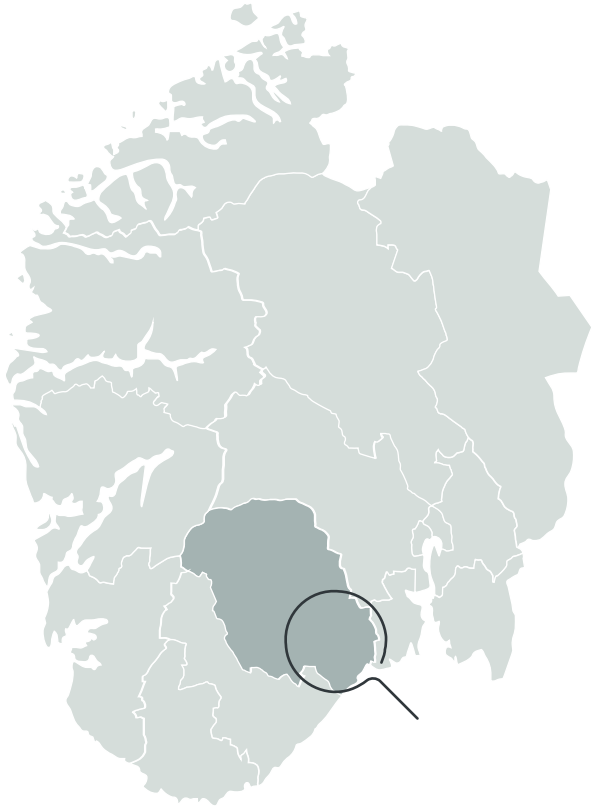
The world’s first climate positive industry region

> Decarbonisation and climate positivity are the common goals for all cluster members. Replacing fossil fuels and utilising carbon are some of the biggest challenges. None of these strategies are possible without being world class in digitalisation.

- Bård Stranheim, CEO (Powered by Telemark)

The Powered by Telemark cluster aims to become the world's first climate-positive industrial region

The cluster consists of 118 members in the Telemark/Vestfold region (also known as *Grenland* near Porsgrunn and Skien in southern Norway).
The cluster is committed to becoming climate neutral in 2040 and aims to be climate positive towards 2050 (i.e. capturing more carbon than emitting).



Large industry members (non-exhaustive)

Heidelberg Materials
YARA
eramet
INEOS Inovyn
ENRX

Medium industry members (non-exhaustive)

Vianode
DNV Imatis
KRANRINGEN
BREVIK engineering

Small industry members (non-exhaustive)

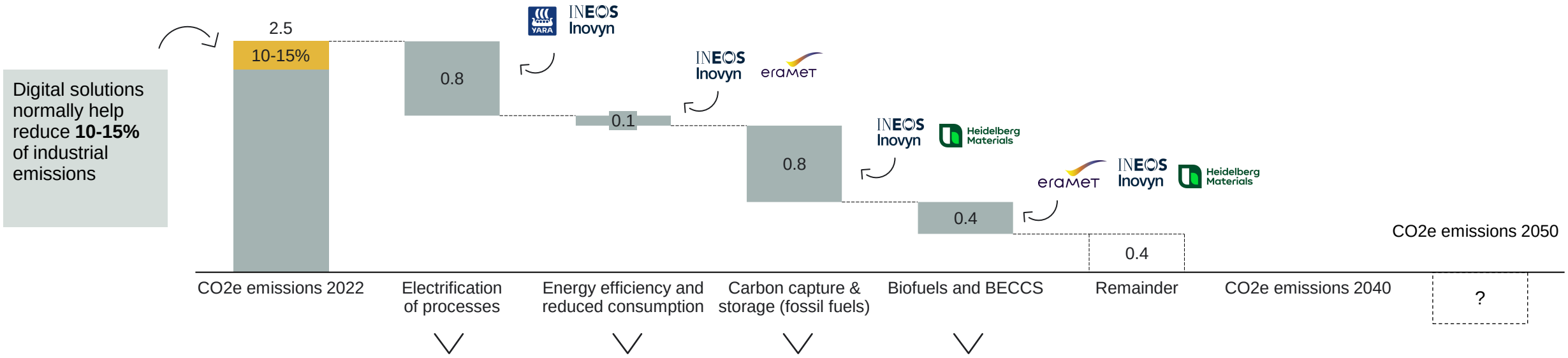
Nordic Electrofuel
HERØYA INDUSTRIPARK
Elektroskandia Norge
Hydrogen pro
KINERA
Opt-E

Note: The industrial and technology cluster Powered by Telemark is a merger of former Green Industry Cluster, Industrial Green Tech, IKT Telemark and the marketing-project Powered by Telemark.

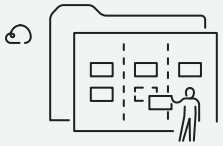
The cluster emits roughly 20% of Norway's manufacturing emissions, and digital solutions will play a key role in its pathway to becoming climate-positive

Net carbon emission reductions from identified and planned initiatives
$MtCO_2e$

Digital solutions normally help reduce **10-15%** of industrial emissions



Key digital solutions enabling emission reductions



- Energy management systems
- Simulation of electrified processes
- Real-time monitoring and control

- Energy management and efficiency systems
- Smart sensors and IoT devices

- Data analytics and predictive maintenance
- Blockchain for transparency and tracking
- Remote sensing and monitoring

- Precision agriculture and biomass management
- Data analytics for lifecycle assessments
- Process optimisation

The world's first climate positive industrial region

New technologies and initiatives are needed to achieve climate positivity. These include increased uses of biofuels, new digital solutions and increased carbon capture and storage.

Source: Implement Economics based on the Powered by Telemark.

Case examples

Digital solutions are already being implemented by large cluster members to drive the transition towards a climate-positive future

Using digital solutions to ease maintenance

Pipelife is Norway's largest producer of plastic pipe systems for water, sewage and electricity.

The company is expanding its use of digital twin (digital representation of real-world physical system) in manufacturing, which helps reduce environmental footprint by providing means for predictive maintenance and improving production efficiency.

Optimising farming practices with digital solutions

Yara is a Norwegian chemical company producing nitrogen-based mineral fertilisers, an emission-heavy process.

Yara provides a precision farming digital tool for the agricultural sector. The solution allows farmers to increase their nitrogen use efficiency and ultimately decreases emissions from agriculture.

See Yara case on page 21.

Digital solutions help monitor environmental data in porsgrunn

In Norway, Eramet is primarily involved in the production and processing of manganese alloys, which are emission-heavy activities.

With the help of Norwegian IT consultancy Evidi, Eramet is using digital service platforms to monitor and control its environmental data. The service platform facilitates the collection of data from various sensors and applications and compiles these in a more transparent form.

Using digital solutions to drive carbon capture & storage in brevik

Heidelberg Materials will launch the world's first high-volume carbon capture facility for cement production in Brevik, **capturing 400,000 tons of CO_2 annually** (half of the plant's emissions).

Innovative digital tools developed by MAN Energy Solutions, including digital twin engineering, have streamlined the CCS system, eliminating unnecessary components like heaters and valves. **This optimization reduces the plant's startup time from 12 hours to 20 minutes.**

Digital solutions will help the electrolysis process in rafnes

Inovyn is building a 20 MW electrolyser to produce clean hydrogen that will run on carbon-free electricity. It is estimated that the project will lead to a minimum reduction of **22,000 tonnes of CO_2e** every year across INEOS' operations in Norway.

Electrolysis is increasingly being controlled and optimized through digital means. Advanced control systems, incorporating AI and machine learning, can optimize the electrolysis process for efficiency, safety, and reliability.

Already implemented

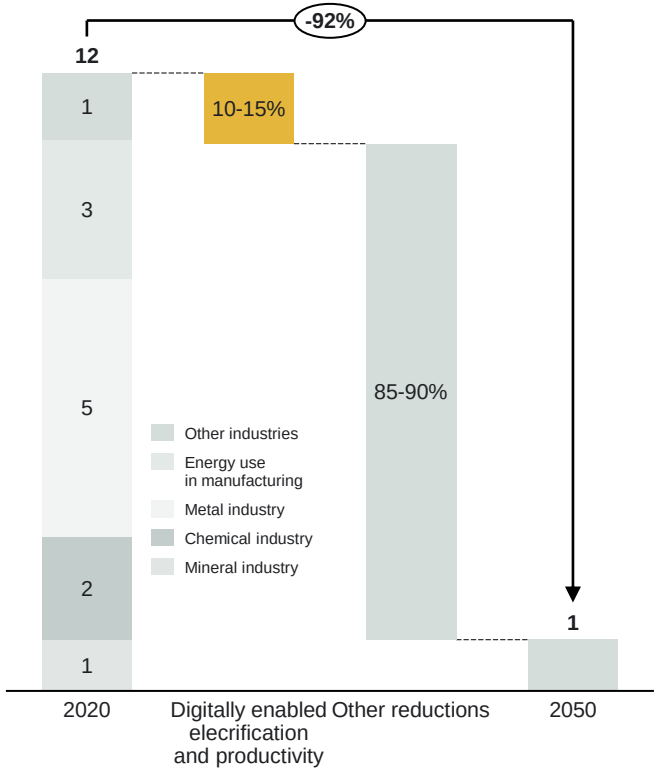
Planned implementation

Source: Implement Economics based on the Powered by Telemark, MAN group, Evidi, Inovyn, Norcem, Pipelife, og Yara International

Manufacturing

Digital solutions are helping to improve manufacturing energy efficiency, supporting electrification and reducing over-production

Manufacturing greenhouse gas emissions
$MtCO_2e$



Decarbonising manufacturing emissions requires …

Digital solutions can help this transition alongside other initiatives by …

01 Change production processes

- **Energy efficiencies with digital**. Digital solutions are used to optimise production processes at the factory floor and in the supply chain and is increasingly used for energy efficiency purposes.
  » *See SINTEF case.*

02 Change how we fuel our plants

- **Transition to heat pumps with digitally enabled smart grids**. Lighter industrial processes can switch from natural gas to heat pumps, which requires integration with smart grid solutions and flexible demand, which requires digital enablement.
- **Electrification of production processes** also requires a high degree of digital enablement and can help integrate renewable energy sources into production.

03 Change how we forecast demand

- **Reducing overproduction with digitally enabled demand forecasting**. AI and machine learning can help to better forecast demand in for example food production or clothing, leading to less overproduction and hence less energy use.

10-15%
of the emission reductions in manufacturing towards 2050 will require some degree of digital enablement.

Source: Implement Economics based on the EEA, SINTEF and Implement Consulting Group.

Case

Industry leaders are using AI to reduce emissions by optimising construction machinery

SINTEF and other industry players are pioneering AI for industrial use and construction machinery to reduce emissions.

Technology

As an example, SINTEF, with Skanska, Volvo and Ditio, pioneers AI for construction machinery to reduce emissions, expedite construction and cut costs.

The consortium uses AI, route optimisation and machine learning to boost machinery efficiency.

SINTEF Digital, in partnership with Skanska, is creating a real-time automated control system called “Datadrevet anleggsplass”, funded with 19 million Norwegian kroner – half from the Research Council of Norway’s Pilot-E scheme.

The AI technology is under commercialisation by Ditio and thus will become available to the whole industry.

Effect

In Norway, idle construction machinery leads to significant greenhouse gas emissions. The project aims to reduce emissions, time and costs in construction while making this solution widely accessible.

Reducing machine idling through smart solutions reduces emissions from machines left running. Furthermore, optimising routes with AI further cuts down emissions by reducing the distance that materials and machinery need to travel.

Decarbonisation potential

Construction machinery makes up significant emissions. For instance, in Oslo Municipality alone, construction machinery emitted 0.25 $MtCO_2e$ in 2019, equivalent to a quarter of the operational emissions from the Municipality of Oslo.

The project’s AI application has the potential to significantly impact emissions and efficiency, potentially saving 13 million liters of fuel annually. The project aims to cut at least 10% of construction machinery emissions, offering a real-time machine usage optimization tool.

SINTEF

Sector

- Manufacturing and construction

Type

- Use less

Objectives

- Energy saving

Technology

- AI, route optimisation, machine learning

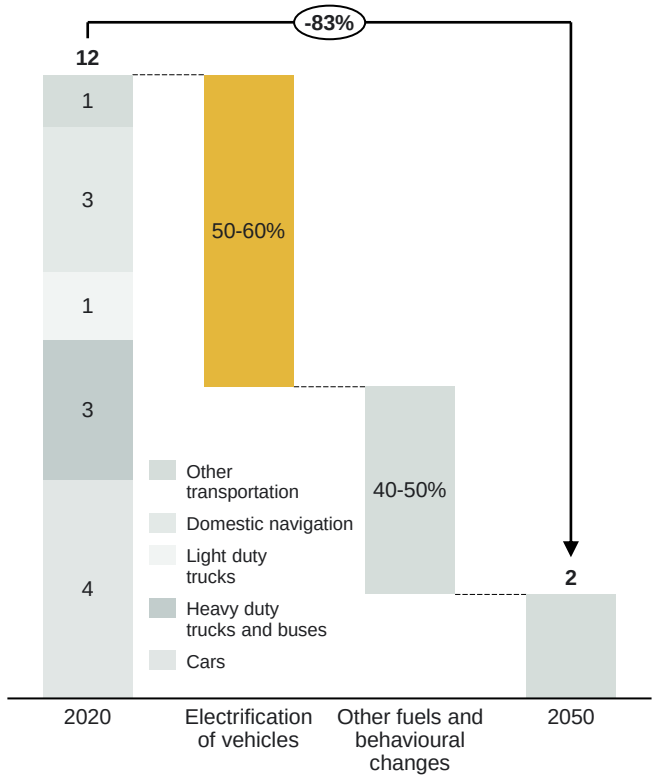
Source: Implement Economics based on industry research, KlimaOslo, SINTEF and EEA.

Transport

IMPLEMENT
CONSULTING GROUP

Digital technologies are key enablers of the transition to carbon-free transportation

Greenhouse gas emissions from Norway's domestic transport
$MtCO_2e$



Decarbonising transport emissions requires …

01 Change how we fuel our travel

02 Change the way we travel

03 Change how much we travel

Digital solutions can help this transition alongside other technologies by …

- Digital solutions optimise charging of electric vehicles (EVs) and ensure that green hydrogen and e-fuels from PtX give drivers carbon-free alternatives to fossil fuels.
  » See Ladeklubben case.

- Digital ride-sharing platforms contribute to lower emissions by enabling higher utilisation of vehicles.
- Digital solutions in public transport improve passenger experience and ease the transition to low-emissions options like trains and buses.
- Eco-routing software (e.g. Google Maps) helps drivers choose the most energy-efficient route together with digital solutions optimising traffic lighting and mobility.

- Video conferencing and working from home save transport emissions.

50-60%
of the emission reductions in domestic transport towards 2050 is expected to come from electrification, which in turn requires digital solutions to happen at scale and at acceptable social cost.

Source: Implement Economics based on the EEA and Transportøkonomisk Institutt.

Case

Digital app enabling flexible EV charging, supporting Norway as the country with the highest EV adoption rates in the world

The Norwegian EV association offers a charging app, providing a platform to help users with their EV charging sessions.

Technology

Ladeklubben assures a reliable and comprehensive charging infrastructure with over 40,000 fast chargers and 400,000 electric car chargers. This network coverage not only caters to the needs in Norway but also extends throughout the Nordic region and Europe, providing substantial support to EV drivers.

The app integrates features for starting and stopping the charging process as well as handling payments. Moreover, the app features an interactive map of EV chargers and is able to streamline payments across multiple EV charger operators.

Effect

Ladeklubben simplifies EV charging and makes it more reliable, solidifying Norway's transition to EVs. Furthermore, Ladeklubben has agreements with major EV charging operators (Recharge, e-on, Ionity, Kople, etc), easing consumers' adoption of EV charging solutions.

Decarbonisation potential

Road transport has an outsized impact on the environment, accounting for 20% of EU27's GHG emissions and 34% of Norway's onshore GHG emissions.

EVs are a key component in achieving net-zero transport, and solutions like Ladeklubben that ease the shift to greener cars are essential in the transition.

Ladeklubben

Norsk elbilforening

Sector

- Transportation

Type

- Do differently

Objectives

- Optimise EV charging

Technology

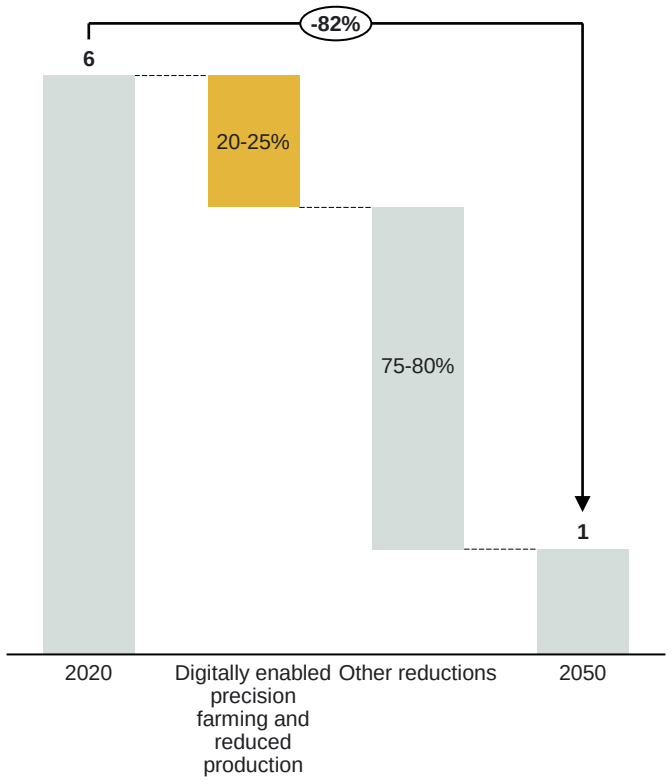
- Cloud technology, machine learning, AI, IoT

Source: Implement Economics based on market research, EEA and Norsk Elbilforening.

Agriculture

Digital technologies are helping the transition to a less greenhouse gas-intensive farming sector

Net greenhouse gas emissions from Norway's agriculture
$MtCO_2e$



Decarbonising agricultural emissions requires …

Digital solutions can help this transition alongside other technologies by …

01 Change how we farm

- New technologies such as PtX to produce green ammonia.
- New agriculture practices, such as data-driven precision farming, can reduce emissions.
  » *See Yara International case.*

02 Change what we eat and reduce food waste

- Digital solutions can help reduce food waste, which will reduce agriculture production without reducing consumption.

03 Change how we manage our land

- Drones and artificial intelligence can help identify land use possibilities and provide the greatest climate gain with lower greenhouse gas emissions.

20-25%
of the emission reductions in agriculture will require some degree of digital enablement.

Note: Agricultural emissions are calculated as CRF 3 (agriculture).
Source: Implement Economics based on Statnett, the EEA and Malmodin, J. and P. Bengmark.

Case
Smart and sustainable farming enabled by digital technology

Yara International champions sustainability in Norway's agriculture sector through its Atfarm initiative, which aims to optimize crop nutrition practices, like fertilisation.

Technology

Atfarm is a digital precision farming tool that harnesses technology, sensors, AI and machine learning to optimise crop nutrition practices.

Atfarm is powered by Yara's N-Sensor ® algorithm, with more than 30 years of field research. Atfarm allows monitoring crop growth using satellite images while the algorithm is able to detect growth in field differences in detail and consequently create very specific variable rate application maps for nitrogen fertilisation.

Effect

By delivering real-time biomass monitoring and weather data, farmers can make eco-conscious decisions about fertiliser, nitrogen and water use, leading to reduced environmental impact. Atfarm thereby allows farmers to increase their Nitrogen Use Efficiency (NUE) and increase yields.

Decarbonisation potential

In Norway, agriculture accounts for 17% of domestic greenhouse gas emissions. Reducing emissions from the agriculture sector is therefore an important step in reducing emissions and reaching Norway's climate goals.

Yara is actively pursuing decarbonisation across its operations and through the services it provides. Yara was able to reduce CO_2e emissions by 200,000 tons in 2022 and 143,000 tons in 2021. These are important milestones on the way to a target reduction of 30% by 2025.

Sector
- Agriculture

Type
- Precision farming

Objectives
- Reduce fertiliser emissions

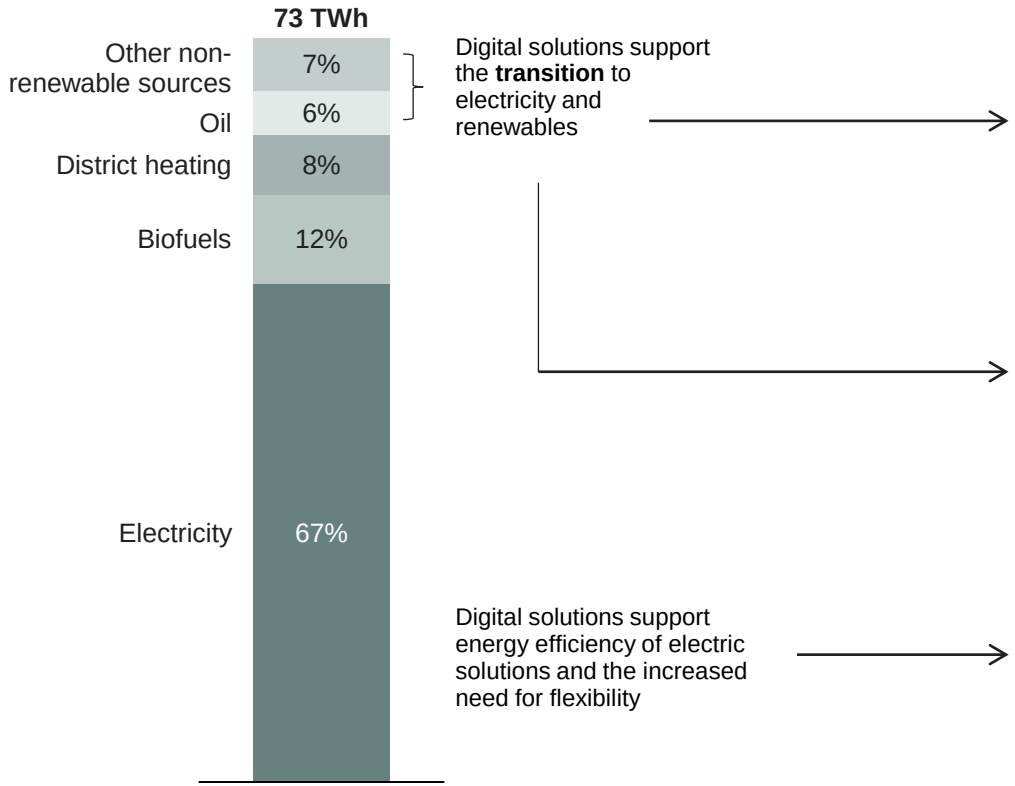
Technology
- AI, sensors, field data, machine learning

Source: Implement Economics based on Yara, EEA.

Homes and buildings

Digital technologies are helping the transition to even cleaner forms of heating Norwegian homes and buildings

Energy use for heating in Norway by source
% of heating energy demand



Green transition for heating of homes and buildings requires …

Digital solutions can help this transition alongside other technologies by …

01	Change how we heat and cool our buildings	• New building management systems using AI and machine learning improve energy efficiency of office buildings and shops. Digital solutions can also help enable the switch to heat pumps and/or intelligent district heating. *» See ClevAir case.*
02	Change how we construct and design our buildings	• Advanced technologies like IoT, artificial intelligence and machine learning make buildings smart, improving performance.
03	Change how we manage electricity flows	• Optimising energy production and distribution as well as energy consumption. *» See Tibber case.* • Smart grid systems enable real-time monitoring and control of electricity distribution, allowing for efficient load balancing and reducing wastage.

Source: Implement Economics based on Oslo Economics.

Case
Making buildings smarter, more energy efficient and sustainable

ClevAir specialises in smart building technology and solutions, providing smart systems for optimising energy efficiency.

Technology

ClevAir, owned by the technology company Opt-E, is a Norwegian company providing smart building technology that optimizes energy use in building's HVAC system (Heating, Ventilation and Air Conditioning).

ClevAir is a software solution and integrates with the building's existing infrastructure, with or without a building management system. It optimizes ventilation in real time using sensor data measuring indoor air quality (CO2 levels, temperature, radon etc.) and weather forecasts. The ClevAir algorithm cuts overconsumption in HVAC and stabilizes the indoor climate regardless of occupancy or weather.

Effect

ClevAir's technology helps reduce energy consumption and CO2 emissions, provides energy consumption insights and helps maintain a good indoor climate.

The ClevAir solution aim to buildings smarter and more energy-efficient using innovative technology and data-driven insights.

Decarbonisation potential

In Norway, heating of buildings emits roughly 2 $MtCO_2e$, corresponding to 5% of onshore emissions. Reducing these emissions with smart digital solutions is key to achieving Norway's decarbonisation goals.

ClevAir HVAC optimisation cuts overuse and reduces energy consumption and CO_2 emissions from the heating of buildings by 15-25%.

CLEVAIR™

Sector

- Buildings

Type

- Use less

Objectives

- Reduce energy consumption and CO_2 emissions

Technology

- AI, IoT, sensor technology

Source: Implement Economics based on market research, EEA and ClevAir.

Case
Smart app helping to optimise power usage in Norwegian homes

***Tibber* is a fully digital energy company. It helps customers to control their energy usage from a mobile app.**

Technology

Tibber provides a digital app that allows consumers to reduce their energy consumption.

Tibber's intelligent energy platform buys electricity from renewable energy providers on an hourly basis to find the best prices for customers. Customers install a smart app in their homes to monitor their electrical appliances and communicate with Tibber. They then use the app to manage their usage to take advantage of the lowest prices.

Tibber uses IoT technology to manage the large flow of information it needs to analyse in order to provide its consumers with favourable energy prices.

Effect

Tibber enables consumers to access the energy market with electric vehicles and smart home technology, making the physical energy system more flexible and effective.

Tibber helps consumers make smart and responsible choices. Their ambition is to use digital solutions to lower household energy consumption by 20%.

Decarbonisation potential

Onshore energy and heating make up roughly 11% of Norway's onshore greenhouse gas emissions.

Digital solutions that drive reductions in energy consumption, e.g. in Norwegian homes and buildings, have the potential to significantly contribute to the decarbonisation journey in this sector.

tibber

Sector

- Buildings

Type

- Use less

Objectives

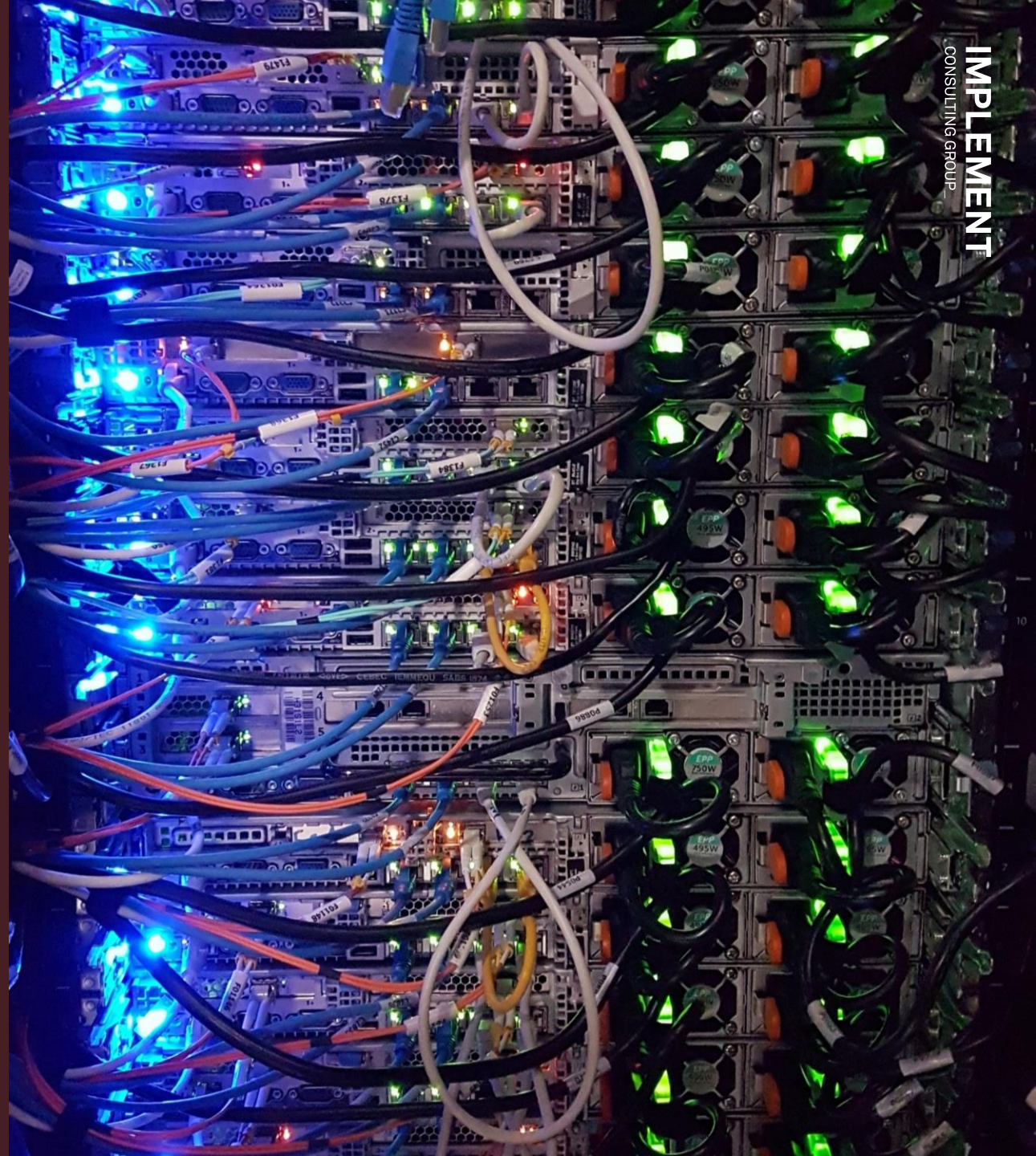
- Energy savings
- Demand flexibility
- Optimise use of renewable energy

Technology

- AI, IoT, sensor technology, cloud technology

Source: Implement Economics based on market research, EEA and Tibber.

Decarbonising digital



Decarbonisation enabled via digital solutions will outweigh emissions from data centres, and future gains are significant

Share of total EU emissions in 2020	Transport (21%)	Buildings (13%)	Manufacturing (21%)	Agri (13%)	Data centres (~0.5%)
Reductions will happen via …	A. Electric vehicles B. Alternative fuels C. Energy efficiency D. Reduced passenger transport E. Reduced freight transport	A. Insulation B. Energy efficiency C. District heating D. Heat pumps E. Alternative energy sources	A. Energy efficiency B. Processes efficiency C. Reduced waste	A. Grow sustainably B. Reduce consumption of livestock and other carbon-intensive products C. Increase efficiency of crops	A. Energy efficiency B. 24/7 CFE C. Net-zero supply chain
Digital tech crucial to this:	› **Smart charging apps** › **AI and ML** › **MaaS platforms** › **Video conferencing and online collaboration tools**	› **Grid control of heating** › **AI and ML** › **Smart thermostats**	› **AI, ML and IoT**	› **Sensors** › **Satellite data** › **Drones** › **AI, ML and IoT**	

Source: Implement Economics based on the EEA and the IEA.

24/7 carbon-free energy is the most efficient way to progress towards a fully carbon-free digital sector

This part of the report focuses on the energy use and carbon emissions related to the operation of data centres. Although they are only responsible for part of the total footprint of the digital sector, data centres are a segment of the digital sector under the direct control of tech companies and where tech companies can act – and have acted – to minimise their environmental impact.

24/7 carbon-free energy

24/7 carbon-free energy (CFE) means that every kilowatt hour of electricity consumption is met with carbon-free electricity sources every hour of every day everywhere.

The tech sector was among the first to acquire additional carbon-free energy through power purchase agreements (PPAs) and has been responsible for 45% of new carbon-free energy deployed through PPAs between 2010 and 2020, according to the International Energy Agency (IEA).

Many are going even further. After meeting its goal to match 100% of its global electricity consumption with renewable energy on an annual basis, Google set a new goal to run on 24/7 Carbon-free energy (CFE) on every grid where it operates across the world by 2030.

Other companies, such as Microsoft and Iron Mountain, are also on this journey. A new global effort has been created under Sustainable Energy for All and UN-Energy to coordinate among companies, governments and non-governmental organisations to develop new solutions to this challenge.

Google has set a goal to run on 24/7 carbon-free energy (CFE) on every grid where they operate by 2030

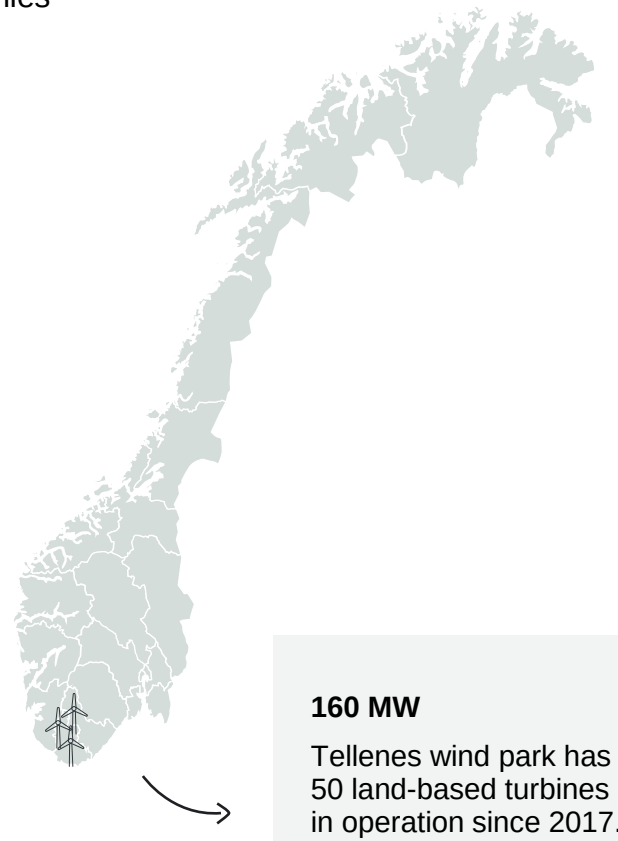
Google is approaching 100% carbon-free energy at Northern European locations

CFE Score at Google data centres 2022

The carbon-free energy score (CFE Score) measures the degree to which each hour of electricity consumption on a given regional grid is matched with carbon-free energy.

Google has been a contributor to the Norwegian grid since 2017

160 MW
Renewable energy capacity in Norway is supported by Google's agreements.



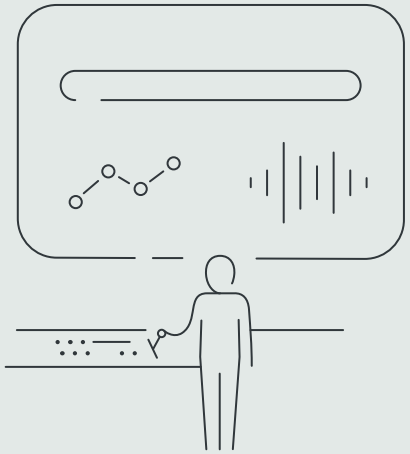
160 MW

Tellenes wind park has 50 land-based turbines in operation since 2017.

Note: Carbon-free energy is any type of electricity generation that does not directly emit carbon dioxide, including (but not limited to) solar, wind, geothermal, hydropower and nuclear. Sustainable biomass and carbon capture and storage (CCS) are special cases considered on a case-by-case basis but are often also considered carbon-free energy sources. An overview of Google's 24/7 energy is available at https://sustainability.google/progress/energy/. A further introduction to Google's approach to 24/7 carbon-free energy is available at https://www.gstatic.com/gumdrop/sustainability/24-7-explainer.pdf, and the methodologies and metrics are available at https://www.gstatic.com/gumdrop/sustainability/24x7-carbon-free-energy-methodologies-metrics.pdf.
Source: Implement Economics based on UN 24/7 Carbon-free Energy Compact, Google, and Norwegian Broadcasting Corporation.

A fully decarbonised data centre industry will enable the full potential of digital decarbonisation

Decarbonising digital means minimising the carbon emissions across the entire digital value chain by decarbonising all operational electricity emissions as well as addressing the embodied emissions.



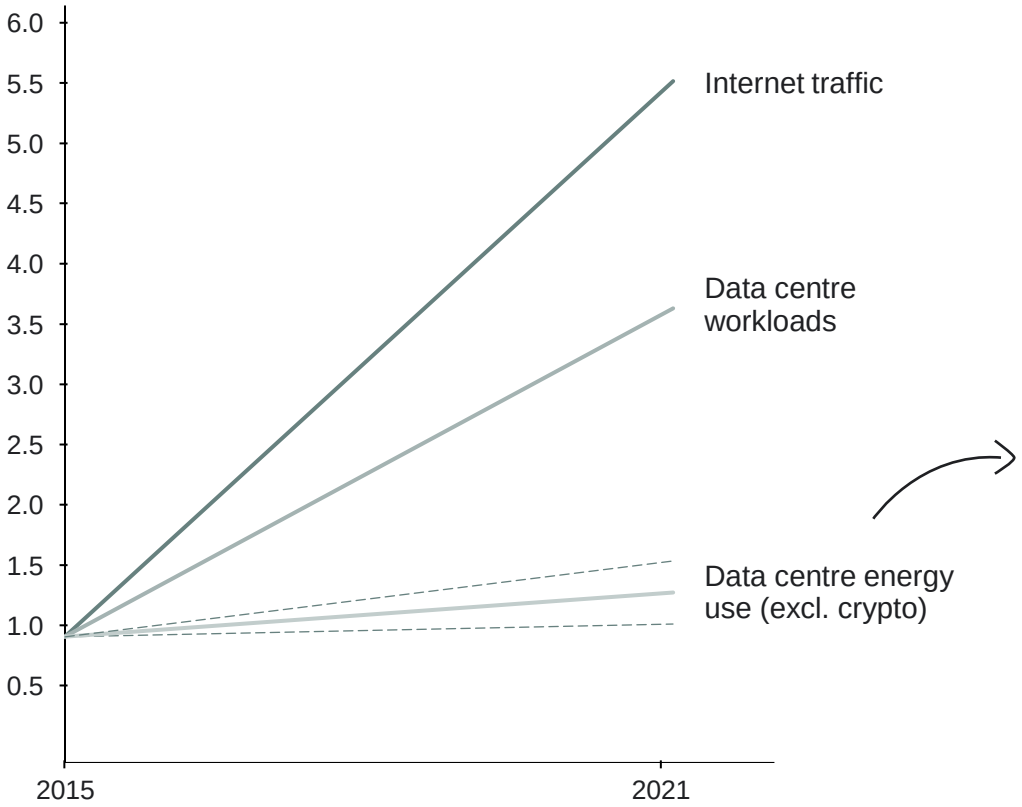
	Data centres	Networks	Devices
Operational emissions[1] *(scope 2)*	24/7 carbon-free electricity portfolios such as Google's *CFE Manager*[2] would be the most effective approach.	24/7 carbon-free energy deals, but networks do not have the same load-shifting possibilities as data centres.	Improved energy efficiency of devices plus decarbonisation of the general power supply.
Actions to make it happen:	• Accelerate carbon-free technology deployment. • Provide companies and consumers with a better measurement of real decarbonisation.		
Embodied emissions *(scope 3)*	Data centres should be working with their suppliers to bring down scope 3 emissions.	Network operators should be working with their suppliers to bring down scope 3 emissions.	Device manufactures should reduce operational footprint and improve circularity of products.
Actions to make it happen:	• Improved circularity in the digital sector through recycling, reusing, refurbishing, and maintaining. • Improving efficiency of EU climate policies through e.g. the carbon border adjustment mechanism		

Note: 1) The International Energy Agency (IEA) estimates global data centre energy use at 240-340 TWh in 2022 and global data transmission network energy use at 260-340 TWh in the same year, see https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks.

Note: 2) A CFE Manager is an energy service provider that an energy buyer tasks with assembling a portfolio of CFE projects. See more at: https://cloud.google.com/blog/topics/sustainability/a-new-clean-energy-purchasing-model-to-drive-decarbonization.

Decarbonising Europe's data centres with 24/7 carbon-free energy will save 6-18 million tons of CO_2 in 2030

Global internet traffic, data centre workloads and energy use



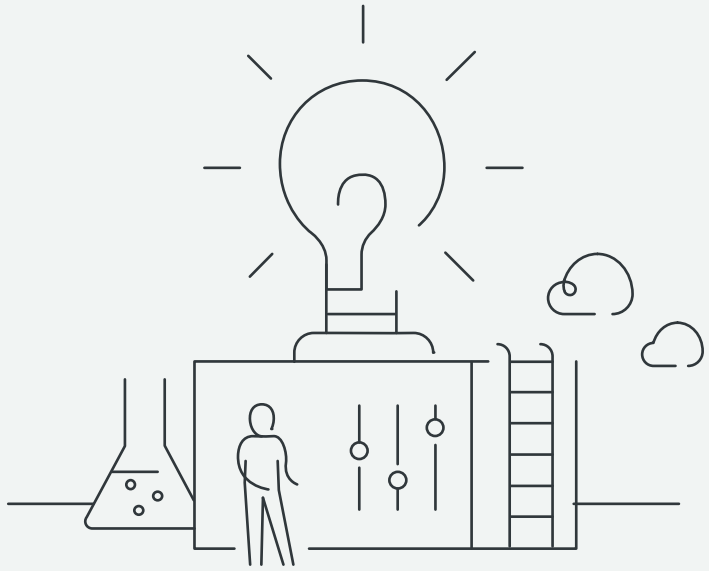
Operational emissions from data centres

Decarbonising digital towards 2030

Carbon-emissions will fall if all EU data centres meet 24/7 carbon-free energy goals such as those set by the frontrunner companies.

If all data centres in Europe achieved 100% hourly carbon-free energy (24/7 CFE), we will save **6-18 million tons of CO2 in 2030.**

This corresponds to Norway's agriculture and manufacturing emissions combined.



Source: Implement Economics based on the IEA and Montevecchi et al.