



**Study on opportunities and barriers to electrification
in the Nordic region**

Make the Nordics carbon-neutral ASAP powered by affordable clean Nordic electricity

In 2019, Nordenergi decided to commission a study on the opportunities and barriers of electrification in the Nordics, to contribute to the discussion on how Europe can become carbon-neutral by 2050. The power sector and increased electrification have a crucial role in delivering a decarbonised society, and joint planning is therefore, necessary. The Nordic power market is a frontrunner for cross-border collaboration with the creation of Nordel in 1962, the establishing of the Nordic Electricity Market forum in 2017, and Nord Pool, the world's first true cross-border power exchange.

Nordenergi has always adhered to market principles with the idea to achieve decarbonisation in the most cost-efficient way. Hence, achieving decarbonisation through a robust European or global carbon emissions trading system has always been a key priority for Nordenergi.

The consultancy DNV GL has conducted this study based on criteria drawn up by Nordenergi. The four Nordic markets: Denmark, Finland, Norway, and Sweden, are included in this study. On all four markets, separate electrification and decarbonisation studies have been commissioned. This Nordic electrification study is based on input from these four national studies that, to some extent, are based on different assumptions about the future.

According to the four national studies the electricity demand will increase with more than 60 percent between 2020 - 2040. Wind power is estimated to increase from 14 percent of the electricity mix in 2020 to 40 percent in 2050.

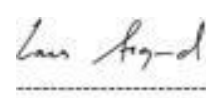
Moreover, Nordenergi has developed three strategic recommendations accompanying the study, which are necessary for achieving increased electrification and decarbonisation in the Nordics: joint transition planning, identifying Nordic strongpoints and facilitating the carbon-neutral customer.

These strategic recommendations include tackling barriers constraining the grid expansion in the Nordics, joint planning of capacity by the Nordic TSO's, building on early Nordic cooperation with a market-oriented approach, reward the customers that choose carbon-neutral electricity and demand flexibility should be created with market signals ensuring level-playing field within the power sector.

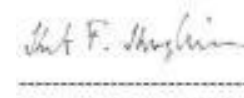
The strategic recommendations are necessary to follow to ensure that the Nordic countries reach carbon-neutrality well before 2050 with the help of the Nordic power sector



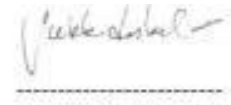
Gunilla Andrée, acting CEO
Swedenergy



Lars Aagaard, CEO
Danish Energy



Knut Kroepelien, CEO
Energy Norway



Jukka Leskelä, CEO
Finnish Energy



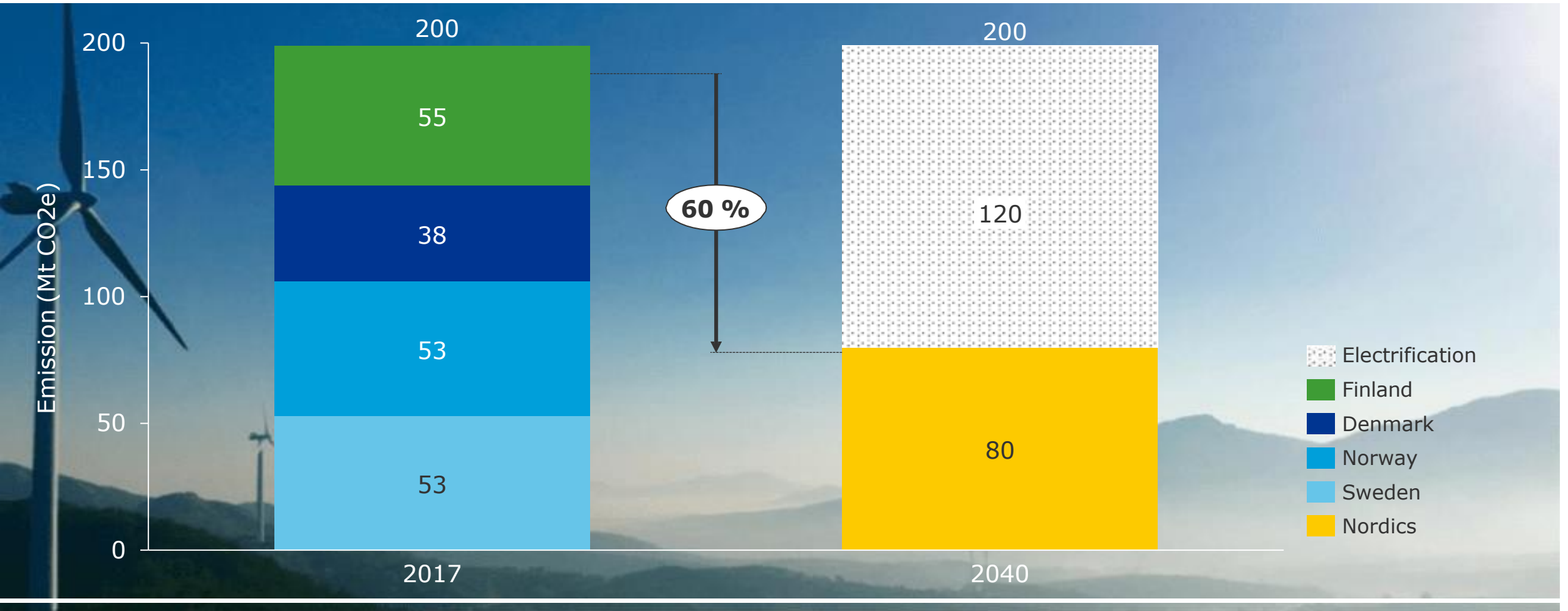


EXECUTIVE SUMMARY



DNV·GL

Rapid electrification can reduce Nordic emissions by 60 % by 2040



Electrification of industry and transport key drivers in a low carbon scenario



2020

Nordic electricity demand of **406 TWh**



2050

Nordic electricity demand of **664 TWh**



Industry: 173 TWh



Industry: 314 TWh (incl. 50 TWh P2X)



Transport: 9 TWh



Transport: 111 TWh (incl. 42 TWh P2X)



Households and service: 204 TWh



Households and service: 208 TWh



Losses: 19 TWh



Losses: 31 TWh

The scenario is based on national reports and not modelling results

Power demand for P2X and/or hydrogen is included in the industry and transport demand

Wind power forecasted to become the main source of electricity in the Nordics



2020

Wind power **14%** of Nordic generation mix



2050

Wind power **40%** of Nordic generation mix



Solar: 3 TWh



Solar: 31 TWh



Wind: 60 TWh



Wind: 295 TWh



Nuclear: 76 TWh



Nuclear: 96 TWh



Thermal: 63 TWh



Thermal: 45 TWh



Hydro: 224 TWh



Hydro: 235 TWh

The scenario is based on national reports and not modelling results

Key barriers to delivering on electrification potential in the Nordics

GENERATION

ELECTRICITY GENERATION

- **Difficult build-out of generation capacity:** Long and uncertain permitting processes for generation and grid infrastructure, and local opposition to new projects are obstacles to new-builds.
- **Demand-driven growth uncertainty:** Risk associated with demand growth materialising or not can lead to lower than expected market access.

SYSTEM ADEQUACY

ELECTRICITY SYSTEM ADEQUACY

- **Intermittency of wind and solar generation:** Supply and demand mismatch can lead to supply shortages as well as curtailment, weakening electrification and generation investment appetite.
- **Limited flexibility and storage capacity:** The nascent stage of development of new technology can be a hurdle to scaling up capacity. Regulation may not appropriately incentivise flexibility and demand-side participation.



ELECTRICITY DEMAND

- **Limited grid availability:** Long grid re-enforcement processes, high connection costs and permitting uncertainty weakens electrification growth and reduces its timeliness.
- **Uncertain evolution of future electricity demand:** The realisation of demand potential is dependant on market signals, technology development and EU climate policy development.

DEMAND

ELECTRICITY GRID

- **Long and uncertain planning processes:** Long planning and permitting processes makes grid upgrades and reinforcement time-consuming.
- **Long project development lead times:** The deployment of grid infrastructure often has long lead times, and can halt electrification progress.

GRID

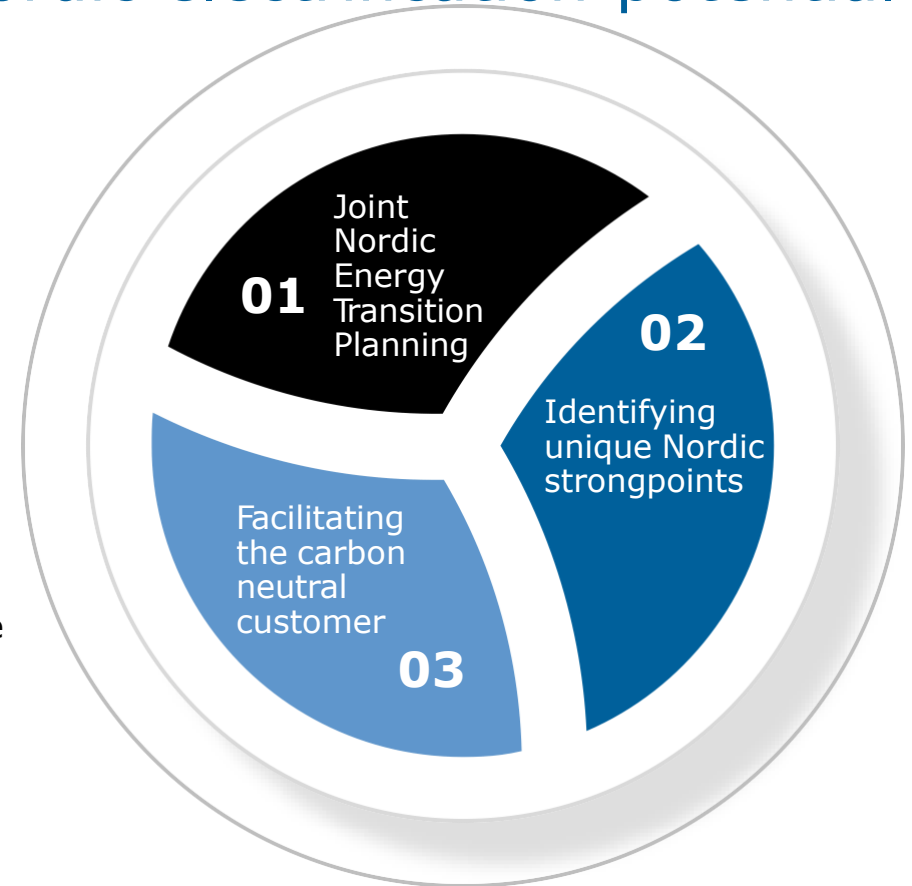


Strategic recommendations

Strategic recommendations for unlocking Nordic electrification potential

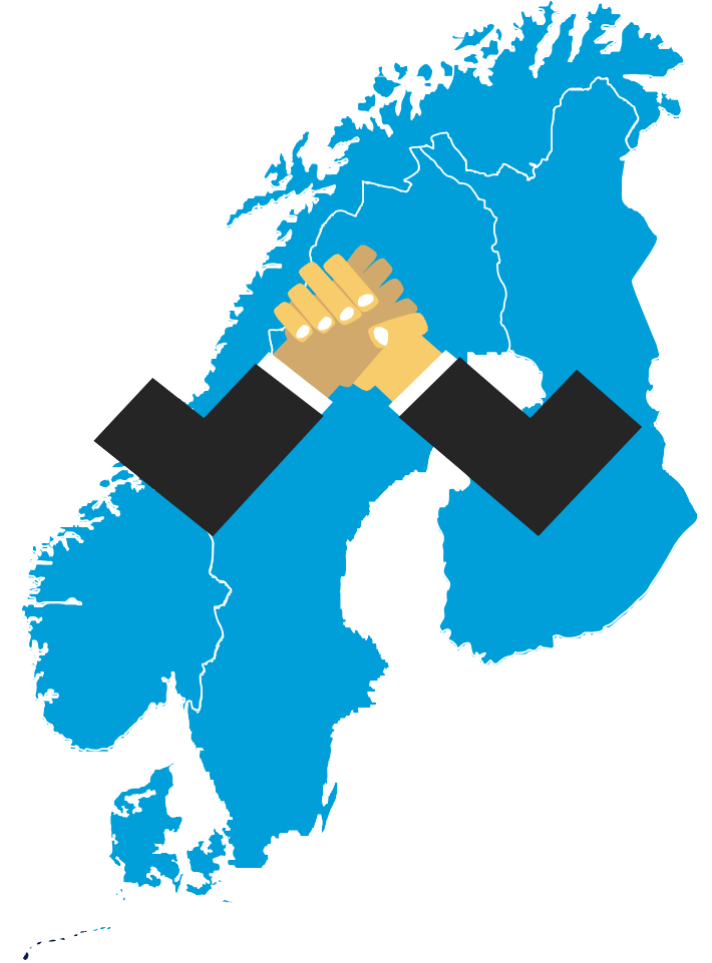
Continued deep decarbonisation is required for Nordic markets to deliver on ambitious climate targets. This report has highlighted that there is substantial scope for electrification to drive carbon reductions across sectors. The growing sense of urgency to mitigate climate change will further cement the importance of the electricity sector as a facilitator of economy-wide decarbonisation. In order to unlock this potential, three strategic recommendations have been formulated.

- **Joint Nordic energy transition planning:** Joint planning to ensure alignment between countries to coordinate power supply, grid and flexibility development to meet the rise in power demand from an electrification-driven energy transition with clean energy.
- **Identifying unique Nordic strongpoints:** Low carbon firm capacity from hydropower and nuclear, coupled with cost-competitive onshore wind and rising scope for offshore wind can facilitate the creation of power-to-x hubs and continued expansion of energy intensive industry.
- **Facilitating the carbon neutral customer:** Customers should be rewarded for choosing electric over fossil-fuelled solutions, and for adapting consumption to support the power system. Creating a cost-efficient transition to carbon neutral electricity with a holistic view of the energy system and the uptake of smart management that simplify the use of flexibility should be a key focus of policy.



Strategic recommendations (I) – Joint Nordic energy transition planning

- ④ **Identifying and tackling barriers for grid development:** Barriers prolonging grid expansion is a major obstacle associated with increasing the electrification of energy-use across the Nordic markets and the EU more broadly, including electrification in combination with hydrogen use in heavy, long haul road transport, aviation and maritime transport.
- ④ **Frontrunner in carbon-free transport:** Charging infrastructure expansion and increased joint Nordic strategy to promote electrification in combination with hydrogen use in heavy, long haul road transport, aviation and maritime transport.
- ④ **Alignment of flexibility markets and grid development:** Flexibility markets can give a better utilization of the grid, but substantial grid development is still necessary on all voltage levels.
- ④ **Increased Dialogue and co-operation:** The *Nordic Electricity Market Forum* constitutes a unique and important platform for the necessary involvement of stakeholders. As a vision and a road map is formulated, the next step is finding suitable arrangements to activate working groups suited to the purpose between the yearly Forums.
- ④ **Long-term planning for resource complementarity:** A shared Nordic holistic planning approach to electrification strategies must be built on the complementarity of energy resources across the Nordics. The enhanced cooperation of the Nordic TSO within long-term planning and system operations is fundamental.
- ④ **Common market needs common rules:** It is vital that the relevant regulation is synchronised and implemented in a harmonised way to create a level playing field and making it possible for market participants to benefit from a larger market.



Strategic recommendations (II) – Identifying Nordic market strongpoints

- ④ A key component of a holistic electrification strategy will be to identify competitive advantages for electricity-use and power generation in the Nordics. Notably, this will be to deepen the penetration of clean electricity in final energy use by leveraging the potential for clean and cost-competitive power generation.
- ④ **Electricity use:** A competitive low-carbon power generation segment, coupled with small populations and technology-friendly customers in a highly digitized economy, make the Nordics a prime market for ramping up:
 - ④ More **electricity-intensive industry**
 - ④ **P2X production** both for domestic use and exports
 - ④ Availability of **predictable flexibility-resources** in production and consumption
- ④ A long and beneficial history of Nordic co-operation in general and in electricity especially with the creation of Nordel in 1962 and the world's first true cross-border power exchange, Nord Pool.
- ④ **Competitive low carbon generation:** The Nordic market has an advantage by using competitive price-setting mechanisms for both the wholesale and the retail market. The Nordic market design provides a sound investment climate. Furthermore, low carbon firm capacity from hydropower and nuclear, coupled with favourable wind conditions onshore and offshore makes wind power a strongpoint across the Nordics.



Strategic recommendations (III) – Facilitating the carbon neutral customer

- ④ The power customer is the foundation of a strategy that seeks to increase the penetration of electricity in energy use. First, the customer needs to choose electricity over fossil fuels, and second market signals should stimulate flexible consumption. We call on correct market conditions and a level playing field for demand flexibility which is central to achieve efficient pricing and resource allocation in all competitive markets.
- ④ **Switching from fossil fuels to electricity:** The cost of carbon emissions needs to reward the customers that opt for low carbon solutions, aided by other incentives where necessary at the sector level to ensure that the switch away from fossil fuels is economically viable and attractive for businesses. The EU ETS ensures that decarbonization is done in the most cost-efficient way for society and Nordenergi therefore support expanding the system to other sectors, but it is also important to maintain the system's robustness. For sectors not included in the EU ETS, a carbon price signal is necessary to facilitate a cost-efficient transition to a carbon-neutral economy.
- ④ **A reliable power system that meets consumption needs:** The power demand stemming from increasing electrification levels will to a large extent be met by intermittent renewables. It is therefore key to foster markets that promote an efficient use of both production and consumption which benefits society. A holistic view of the energy system and the uptake of smart management that simplify the use of flexibility should be a key focus of policy.



Gudmund Bartnes

Gudmund.Bartnes@dnv.com

+47 997 44 267

www.dnvgl.com

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