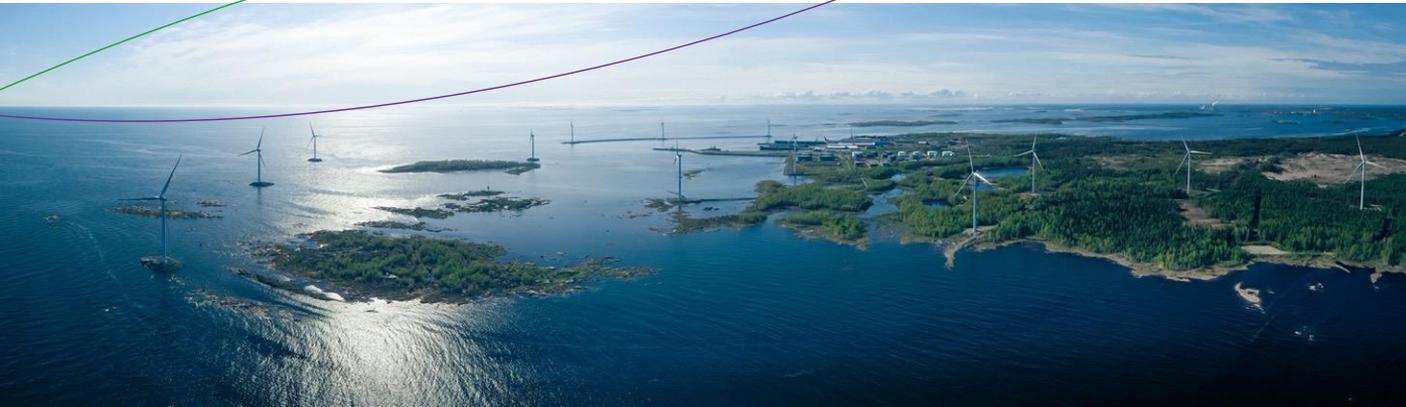
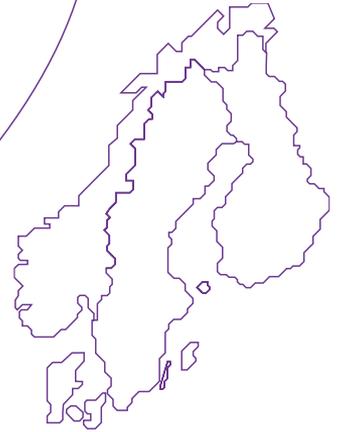


NORDIC GRID DEVELOPMENT PERSPECTIVE 2021

Sähkömarkkinatoimikunta 14.12.2021



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Nordic Grid Development Perspective 2021 – Background



- The Nordic Grid Development Perspective (NGDP) is requested by the Nordic Council of Ministers and the NGDP report is published every second year.
- NGDP2019 was delivered 2019, and it described the status of ongoing and planned investments of Nordic significance and investigated the need for and benefits of increased transmission capacities between the Nordic countries over five “corridors of interest”.

The aim of the NGDP2021 is to present a common Nordic view on selected key topics rather than presenting a technical grid development plan in purely traditional sense. Thus, NGDP2021 is named Nordic Grid Development Perspective (previously Plan).

Nordic Grid Development Perspective 2021 – Scope

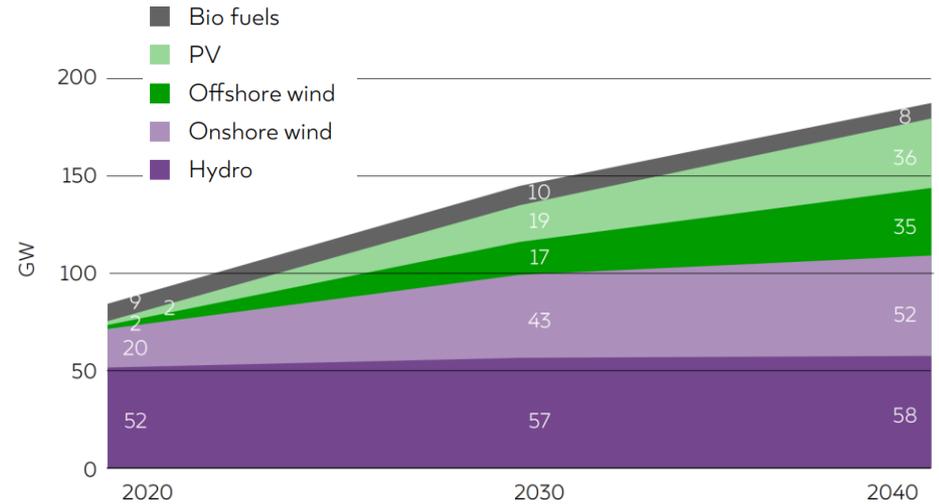
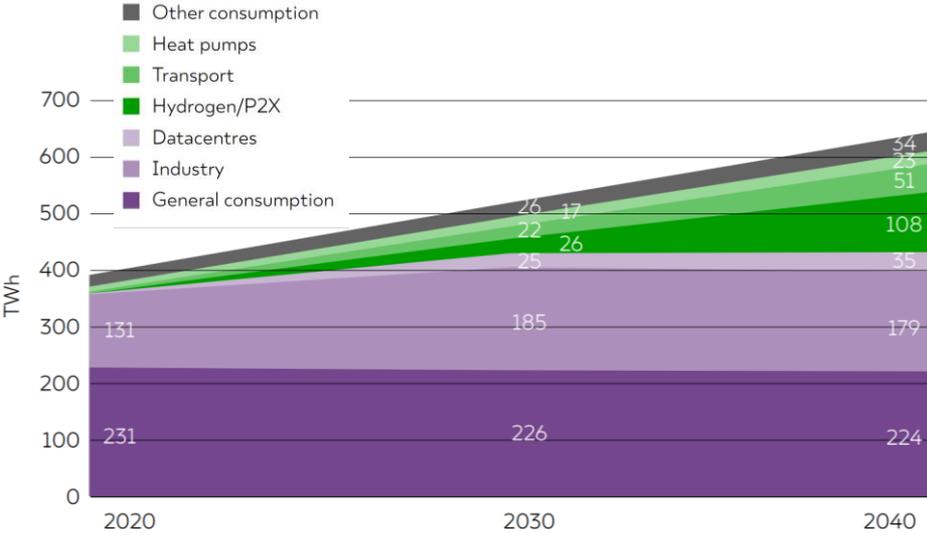
- NGDP2021 report consists of:
 - Common Nordic scenario “Climate Neutral Nordics” based on ENTSO-E TYNDP2020 scenario Distributed Energy and latest national scenarios
 - The created scenario was also presented earlier in a stakeholder webinar and publicly consulted.
 - Identification of system needs (IoSN) analysis for the Nordic grid in the created scenario
 - Investigation of the following focus areas, 1) North-South transfer, 2) Resource adequacy, 3) Offshore wind
 - Update of the status of the Nordic corridors from NGDP2019 and national planned / ongoing grid projects of "Nordic interest“.



Climate Neutral Nordics

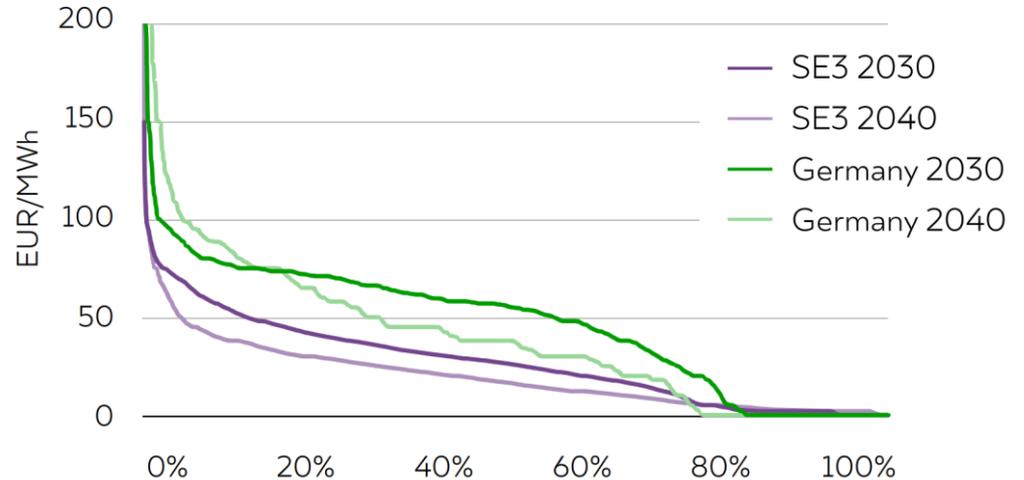
Nordic yearly electricity consumption grows from the current 400 TWh to 530 TWh (33%) by 2030 and 655 TWh (65%) by 2040.

Nordic renewable energy sources capacity increases from the current 85 GW to 145 GW (70 %) by 2030 and 189 GW (122 %) by 2040.



Climate Neutral Nordics Scenario – Electricity prices

- Volatility increases (high and low prices)
- Nordics is cheaper than the continent
 - Nordic average prices are approximately $\frac{1}{2}$ of the continental average prices



Nordics is an excellent place for power intensive investments!

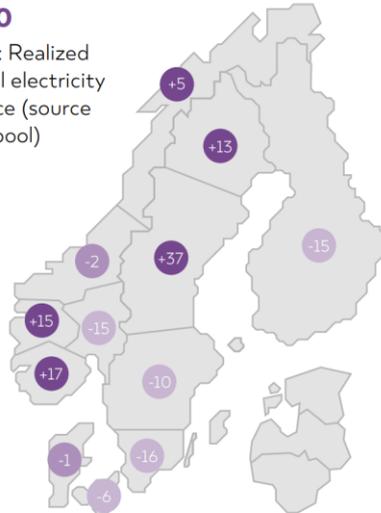
Identification of System Needs – Energy balance

Electricity Balance (TWh) in the Nordic bidding zones in 2030 and 2040 from the Climate Neutral Nordics scenario:

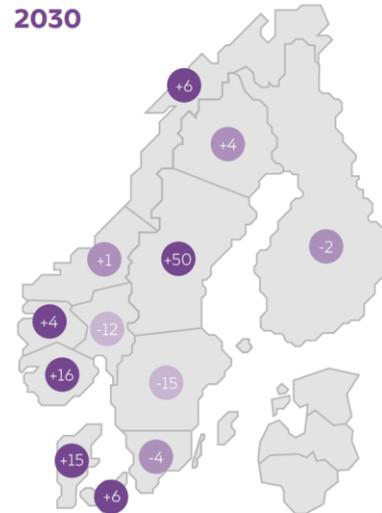
- The Nordics as a whole will have a positive energy balance in the future.
- However, there are large differences between different areas, leading to increasing flows in the system.

2020

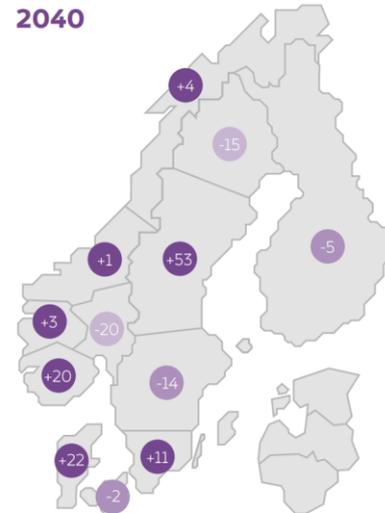
2020: Realized annual electricity balance (source Nordpool)



2030



2040



System Needs – Flows

Power flows (TWh) in 2020 and in the Climate Neutral Nordics 2040 scenario:

- Flows are expected to increase through most corridors.
- High flows remain through the same corridors as today.
- Consumption growth in the northern parts of Nordics affects flow patterns especially in Sweden.

↔ 2020: Realized market flow
↔ 2040: Climate Neutral Nordics

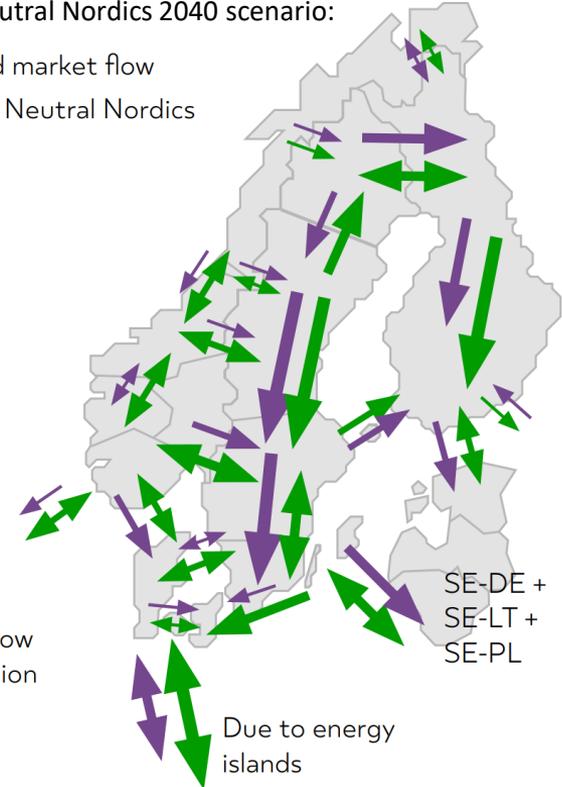
↔
0–5 TWh

↔
5–10 TWh

↔
10–25 TWh

↔
25+ TWh

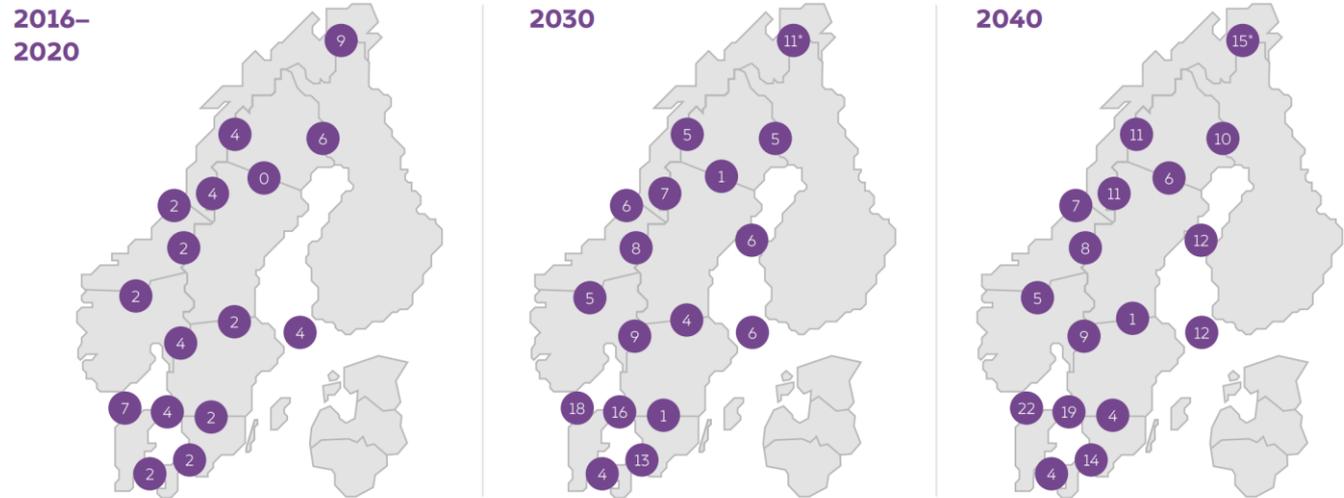
* Single direction arrow if >75% in one direction



System Needs – Price differences

Average absolute hour-by-hour price differences (in EUR/MWh) in the Climate Neutral Nordics scenario for 2030 and 2040, as well as an estimate of the average price differences today, based on prices from 2016 to 2020. For Norway, NO1, NO2 and NO5 have been considered as one bidding zone:

- Price differences are increasing from 2030 to 2040.
- This indicates a need to increase grid capacities in several corridors.

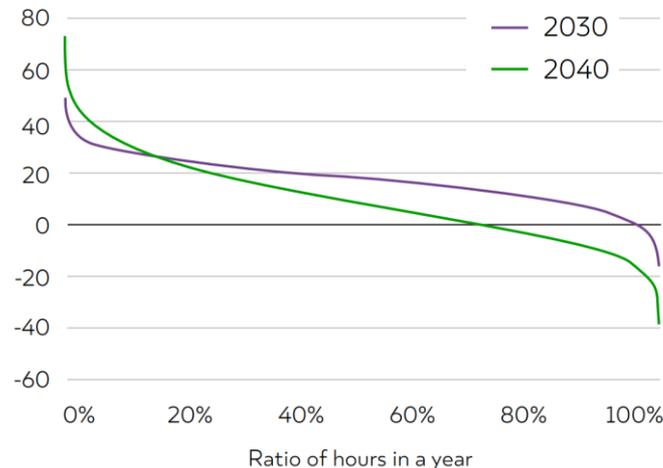


* Investment cost (which is not included in the analysis) between Finland and Norway is expected to be high compared to benefit (see Chapter 5 for more information).

Focus area: Resource adequacy

- Larger variation in power margin/balance in the future (volatility increases)
- Nordics will remain a surplus area considering annual energy production.
- Geographical spread of resources helps, but local challenges are still expected => collaboration needed at Nordic level.
- Flexibility is in an essential role in the future system.

The power margin for the Nordic region as a whole in the Climate Neutral Nordics scenario for the years 2030 and 2040 (DSR not included):



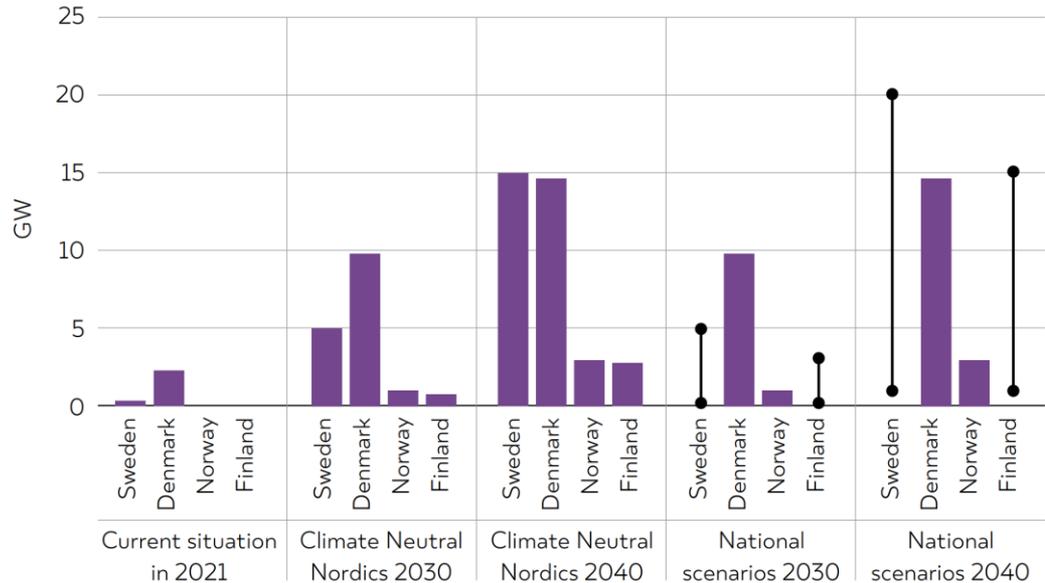
Ratio of time (%) with negative power margin for both 2030 and 2040 and maximum negative power margin (GW) without of consumption-side flexibility (i.e., the most negative value during the analysed years). Negative power margin indicates an import dependency or need of DSR

	Nordics	Denmark	Finland	Norway	Sweden
2030	3%	14%	26%	<1%	<1%
2030	-16 GW	-6 GW	-7 GW	-2 GW	-10 GW
2040	28%	24%	42%	<1%	8%
2040	-38 GW	-10 GW	-13 GW	-3 GW	-10 GW

Focus area: Offshore wind

- Currently, offshore wind capacity in the Nordics is around 2.5 GW.
- Climate Neutral Nordics: 17 GW by 2030 and 35 GW by 2040
- Large interest in all countries and large variation between different scenarios
- Somewhat different approaches in connecting offshore wind in different countries => may affect the future distribution of offshore wind among the countries.
- Collaboration of Nordic TSOs, together with the other TSOs in the North Sea and the Baltic Sea area, is needed.

Status of offshore wind in the different Nordic countries, expected development in various scenarios and received applications. The black dots show the minimum and maximum in case there are various national TSO scenarios:



Main messages of the NGDP report

1. Climate neutral society needs more electricity - significant investments to the grid and cross border connections are needed
2. The Nordics is an excellent place for future investments
3. Future system is more volatile - flexibility is needed and will be more profitable
4. Future system is more complex and has new characteristics - new solutions and collaboration throughout the whole energy system are needed
5. Regional grid plans and studies will be updated and developed

During the next ten years, the Nordic TSOs are building over 10,000 km of lines, over 100 new substations and making total investments worth around 25 billion euros.

Report available here: [Nordic Grid Development Perspective 2021](#) paves the way towards climate neutral Nordic power system – report published - Fingrid

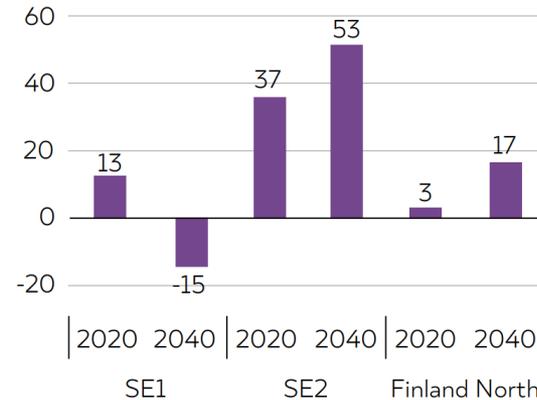
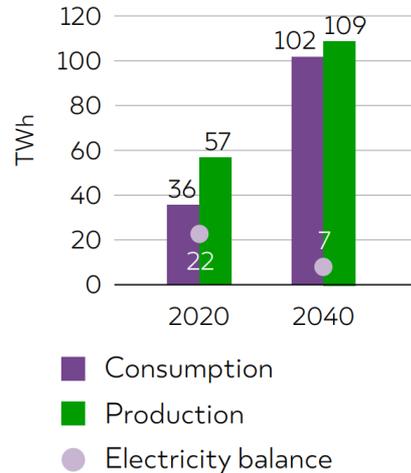


Additional slides

Focus area: North-South

- Both consumption and production grow in the northern parts of the Nordics
- The consumption growth brings the northern region towards lower electricity balance in 2020 compared with the current situation.
- Large energy deficit in price area SE1 increases the need for imports into northern parts of Sweden by 2040.

Left: yearly electricity balances for 2020 and 2040 for the area comprising the northern part of Norway (NO4), Sweden's bidding zone 1 (SE1) and the northern part of Finland (northern part of Finland includes the part of the country north of the Kemi-Oulujoki cut). Right: yearly electricity balances for 2020 and 2040 for the bidding zones SE1, SE2 and northern part of Finland, respectively.



Focus area: North-South – Different Countries

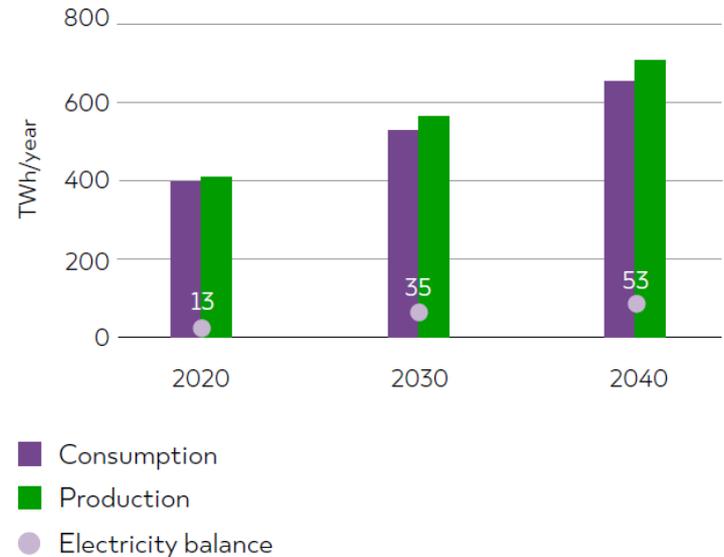
- Denmark: Increased flow from southern Sweden to eastern Denmark is expected. All other flows become more bidirectional.
- Finland: A significantly increased north-to-south energy transfer is expected.
- Norway: North-south energy flow will increase in magnitude and will be more often bidirectional.
- Sweden: will have a deficit of energy in its northernmost part that will make SE1 a net-importer. SE2-SE3 border will continue to experience large north-to-south flows. SE3-SE4 border will transfer less energy on average and become bidirectional.



Electricity Balance

- The Nordics will have a positive electricity balance in all analysed years
- Nordics remaining an exporter of electricity
- The power surplus is increasing through 2030 and towards 2040
- The large power surplus in 2040 of about 50 TWh in the Nordics, could serve to attract more consumption.
- As the generation becomes more variable and weather dependent, the challenges of maintaining the instantaneous power margin will increase

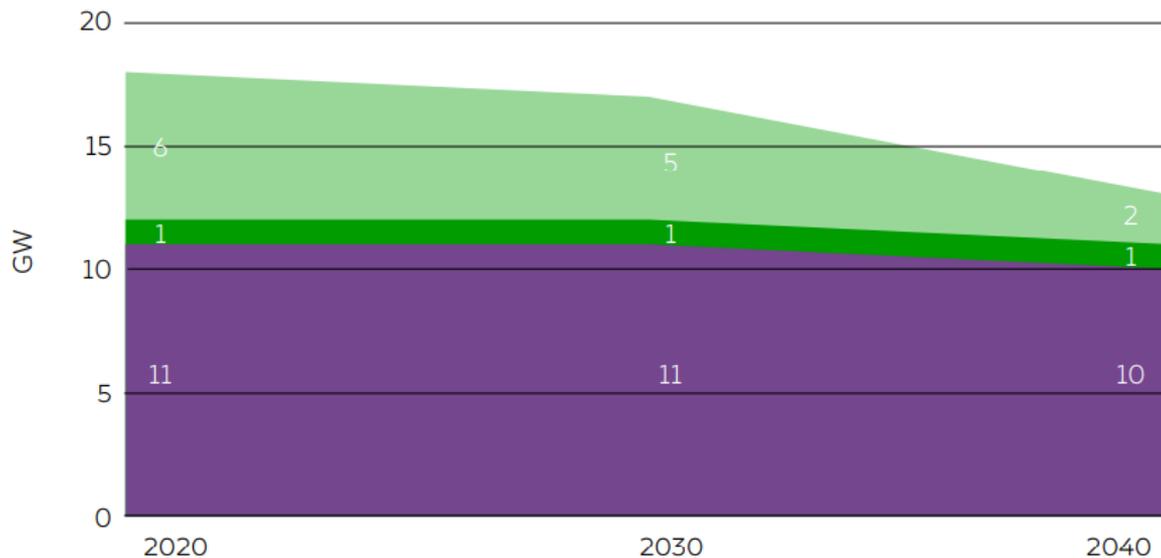
Figure 5 – Nordic electricity balance in the Climate Neutral Nordics scenario.



Climate Neutral Nordics: Thermal Capacity

Figure 3 – Development of Nordic thermal capacity from 2020 to 2040 in Climate Neutral Nordics scenario.

- Fossil
- Waste
- Nuclear



P2X Development

Figure 4 – Electrolyser capacity in the Climate Neutral Nordics scenario.

