NORDIC CLEAN ENERGY SCENARIOS

Reaching Nordic Carbon Neutrality
The Role of Direct and In Direct Electrification

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Nordic Energy Research

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The platform for co-operative energy research and policy development under the auspices of the ***Nordic Council of Ministers***

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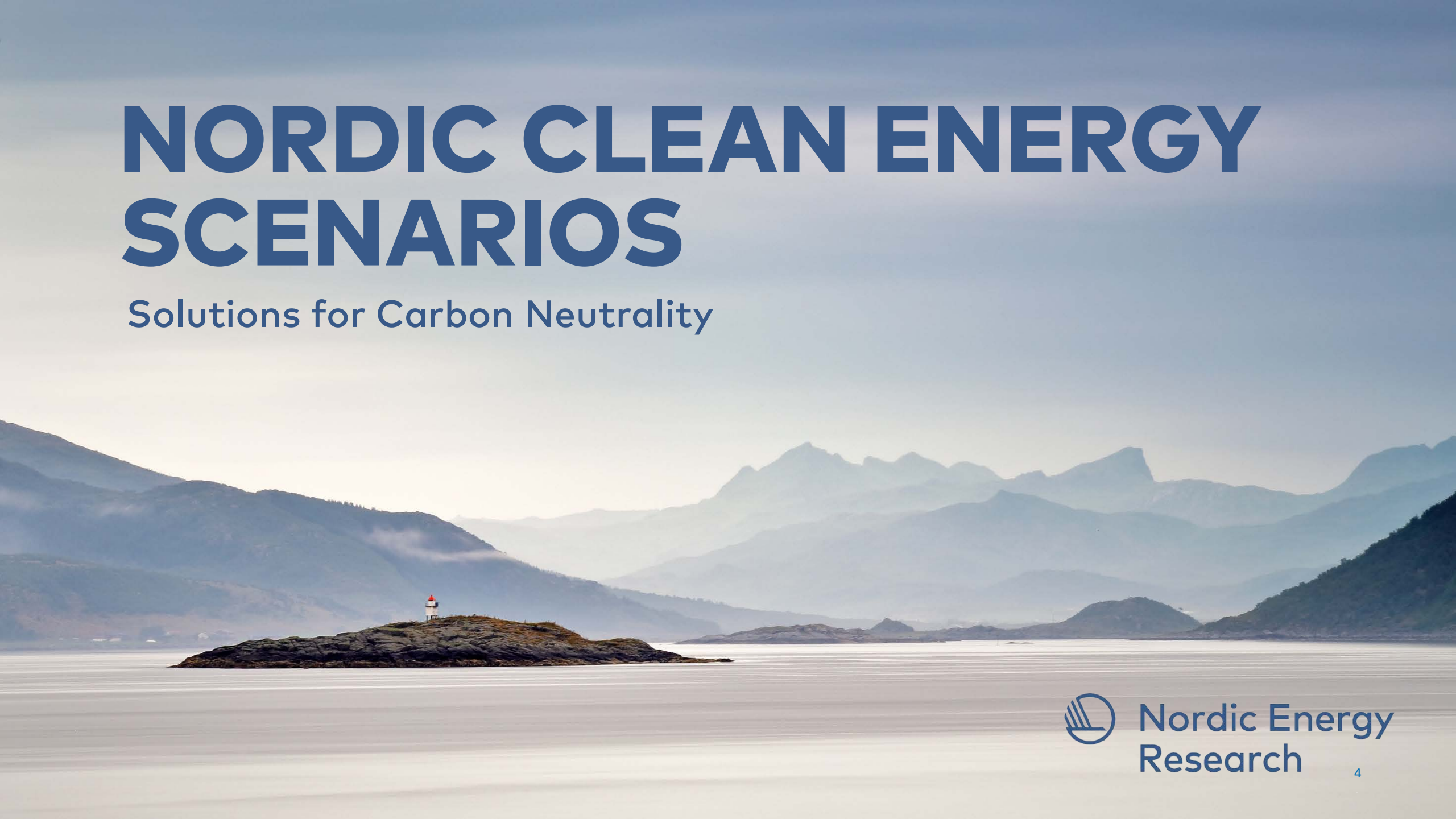
Solutions for Carbon Neutrality



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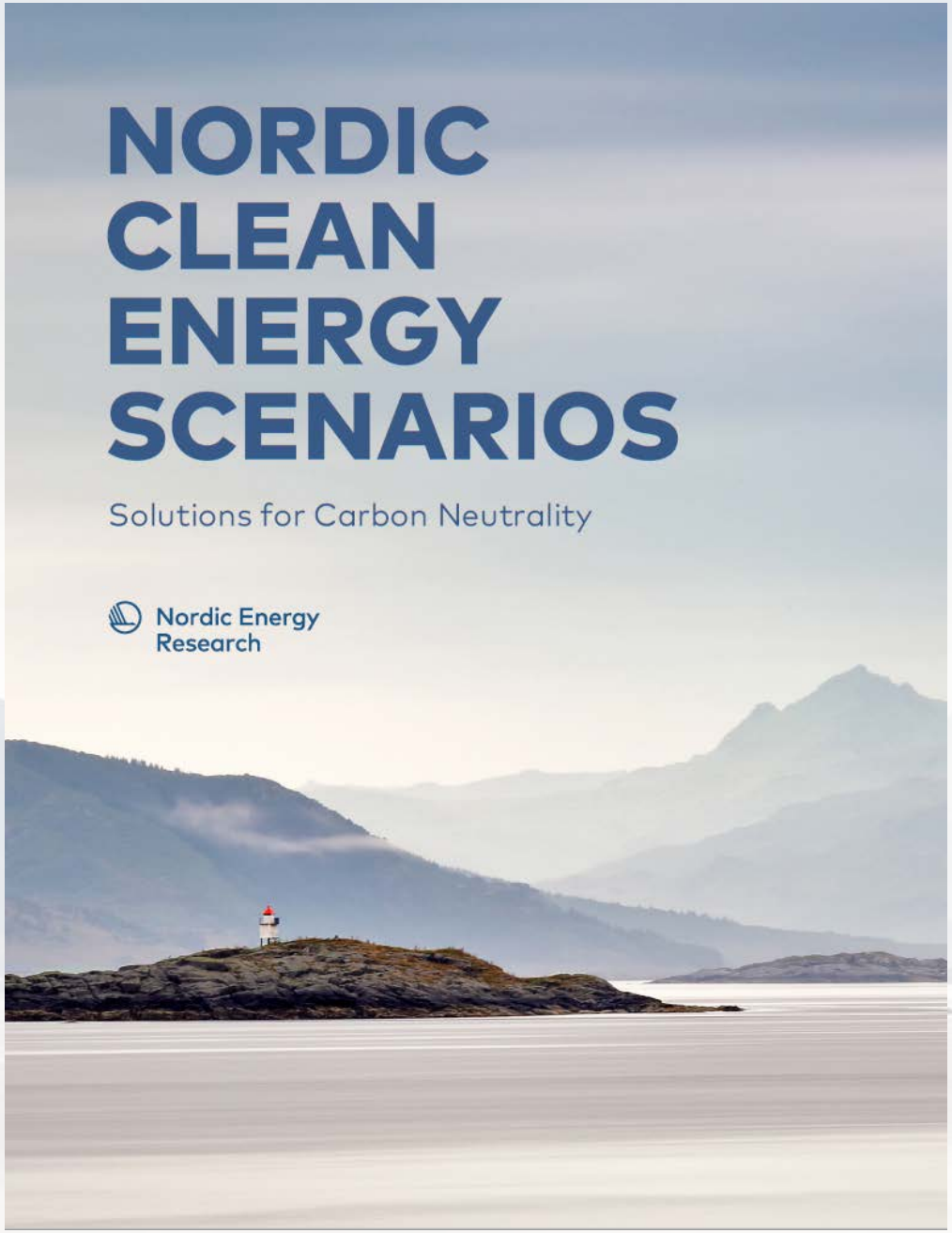
Stepping up Nordic Climate Co-operation

" The aim of the Nordic countries is to be carbon neutral and to demonstrate leadership in the fight against global warming"

- The Nordic prime ministers in their declaration at the summit in Helsinki 25.01.19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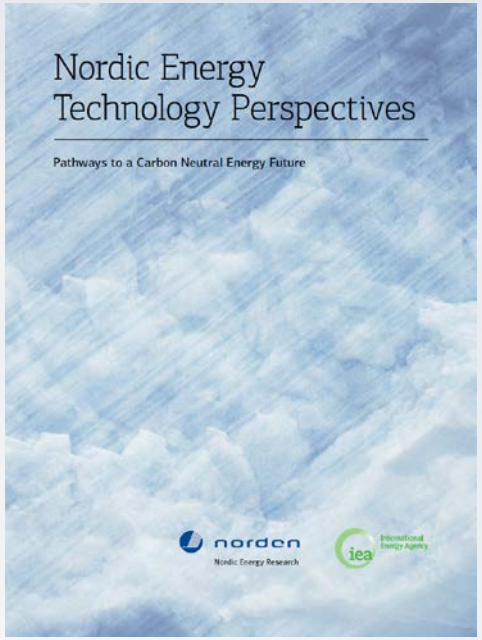
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Ea Energy Analyses

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Three scenarios

Carbon Neutral Nordic (CNN)

Nordic powerhouse (NPH)

Climate Neutral Behaviour (CNB)

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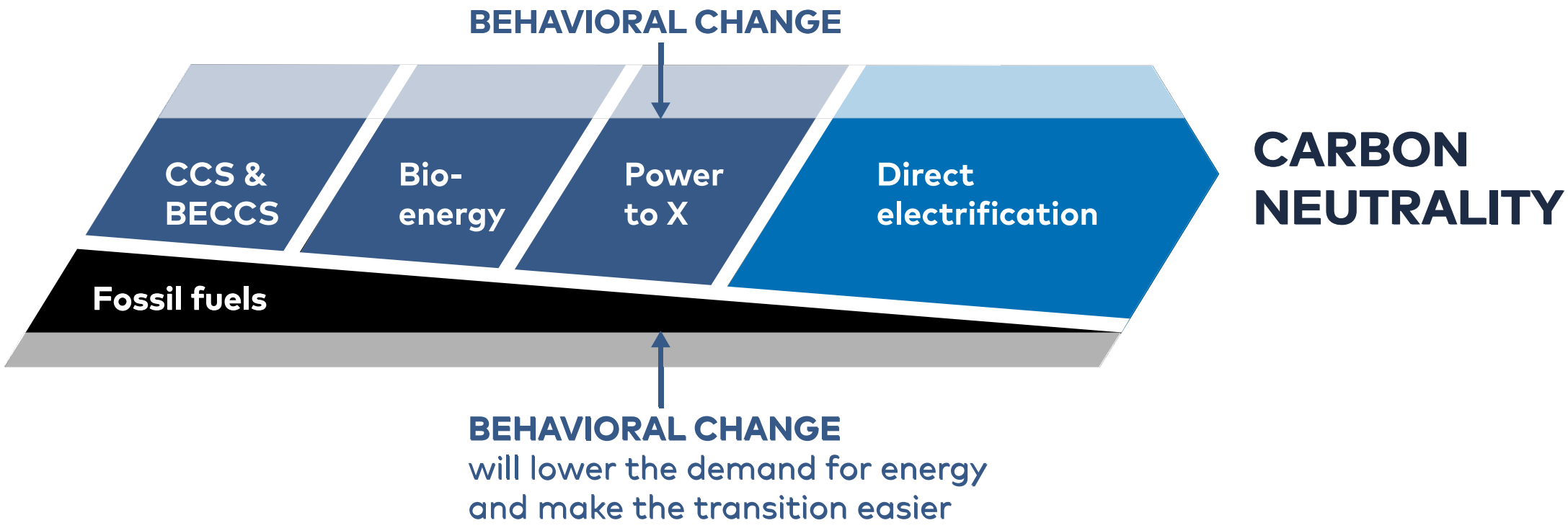
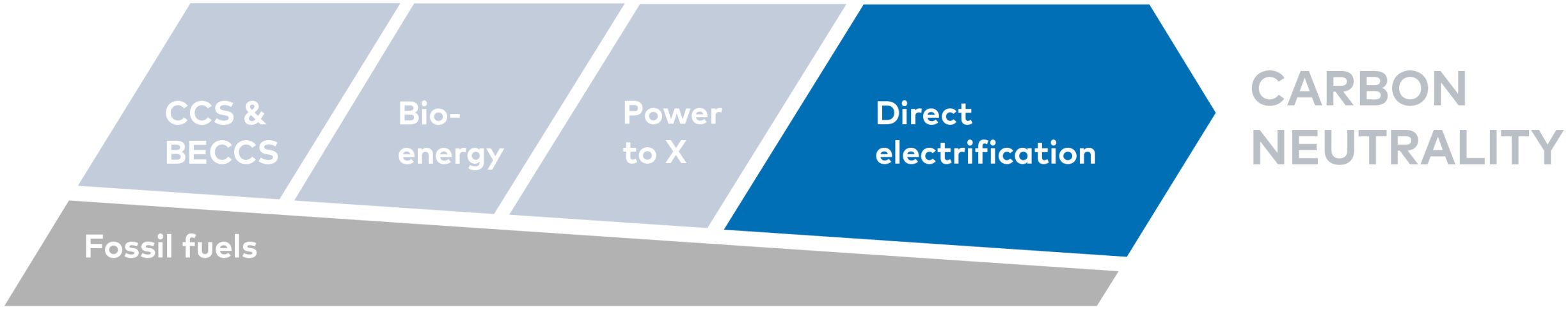
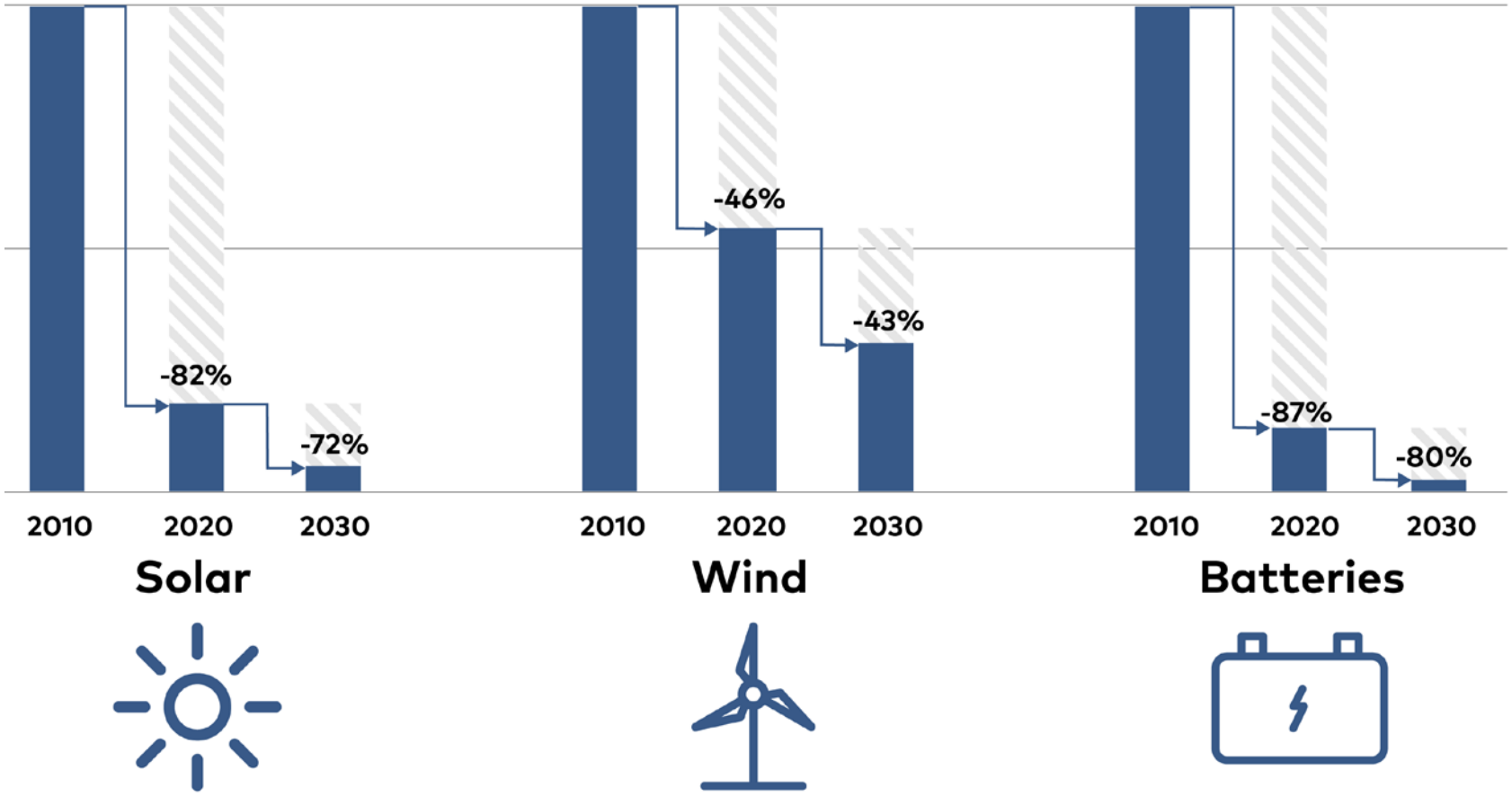
Five Solution Tracks to Carbon Neutrality



Direct Electrification is Central to all Decarbonisation Strategies

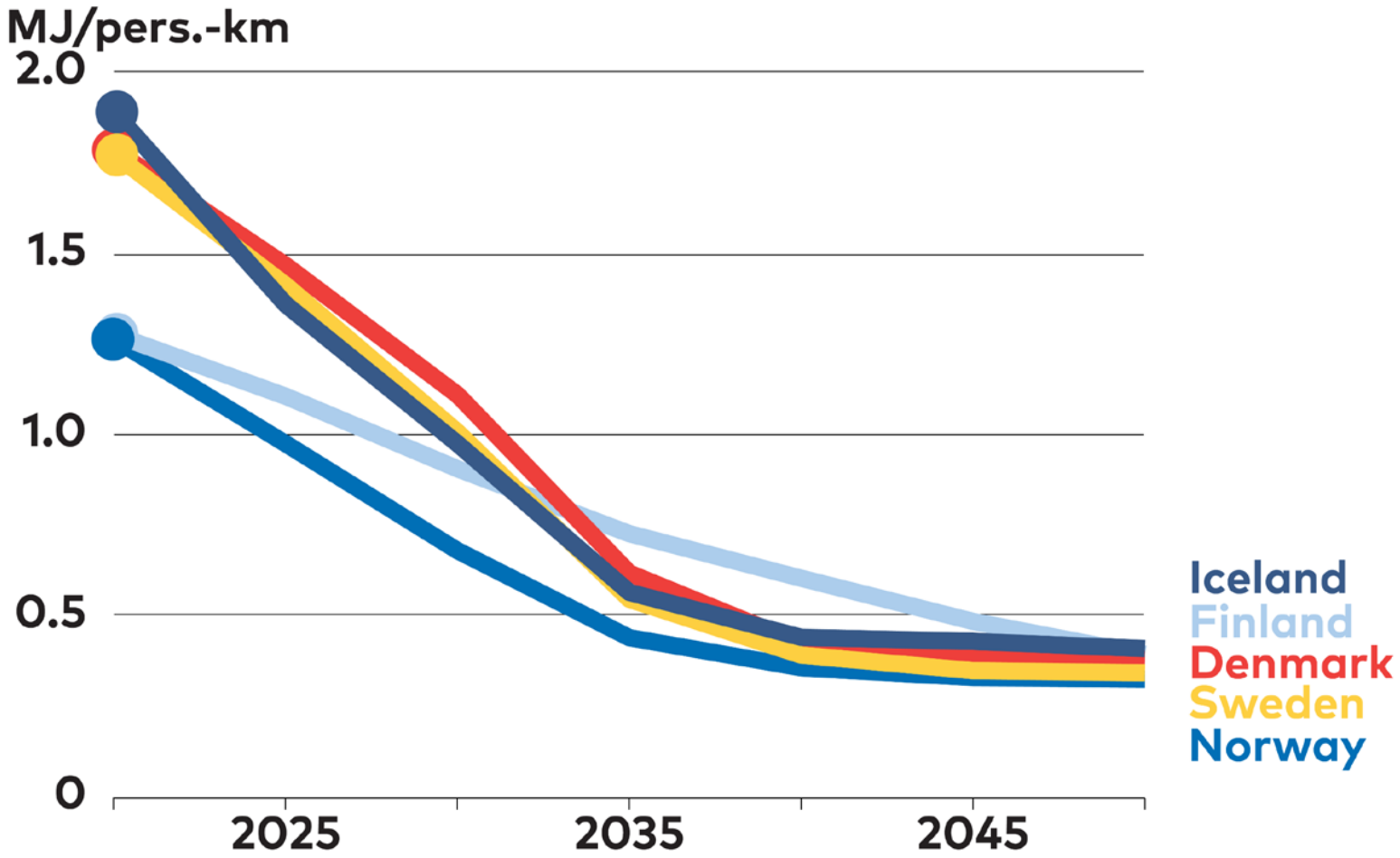


Cost reductions for key technologies increase the pace of the transition



Projected cost developments. Historical and expected development in cost/kWh for solar panels, wind turbines, and batteries. Adapted from Dorr & Seba, 2020.

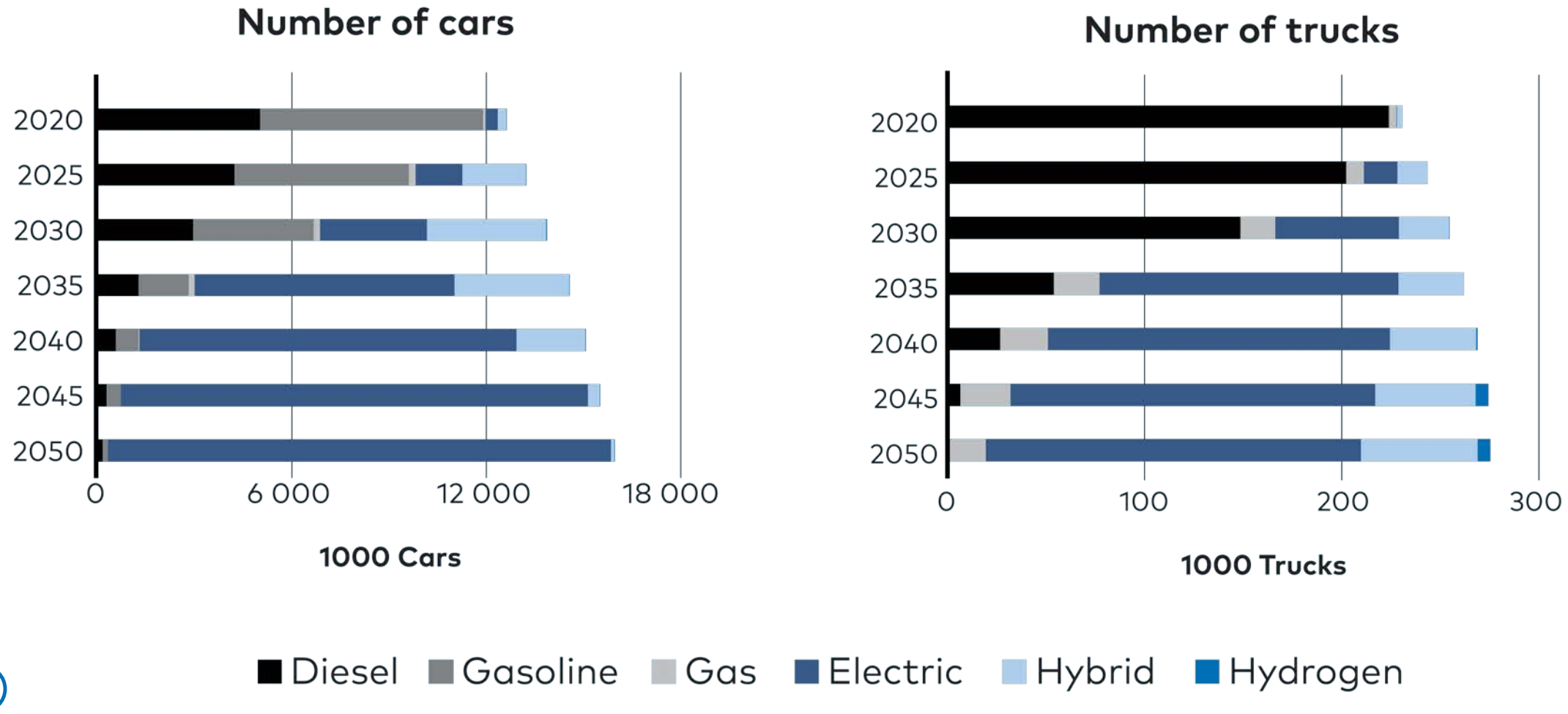
Direct electrification dramatically improves energy efficiency



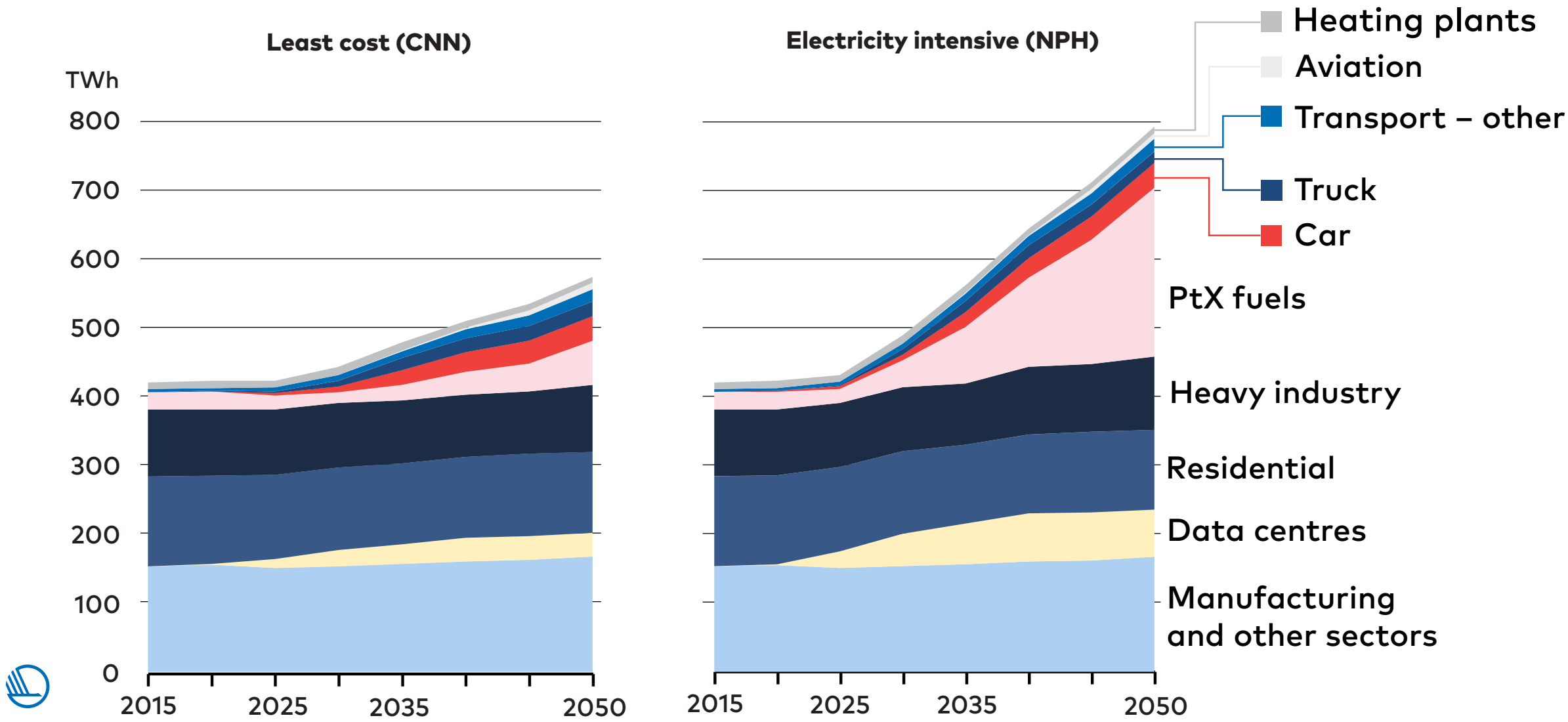
Energy consumption for cars per passenger km, CNN scenario

Cost reduction for electric vehicles drives the development of road transport electrification

Stock of cars and trucks (incl. vans) CNN and NPH scenario

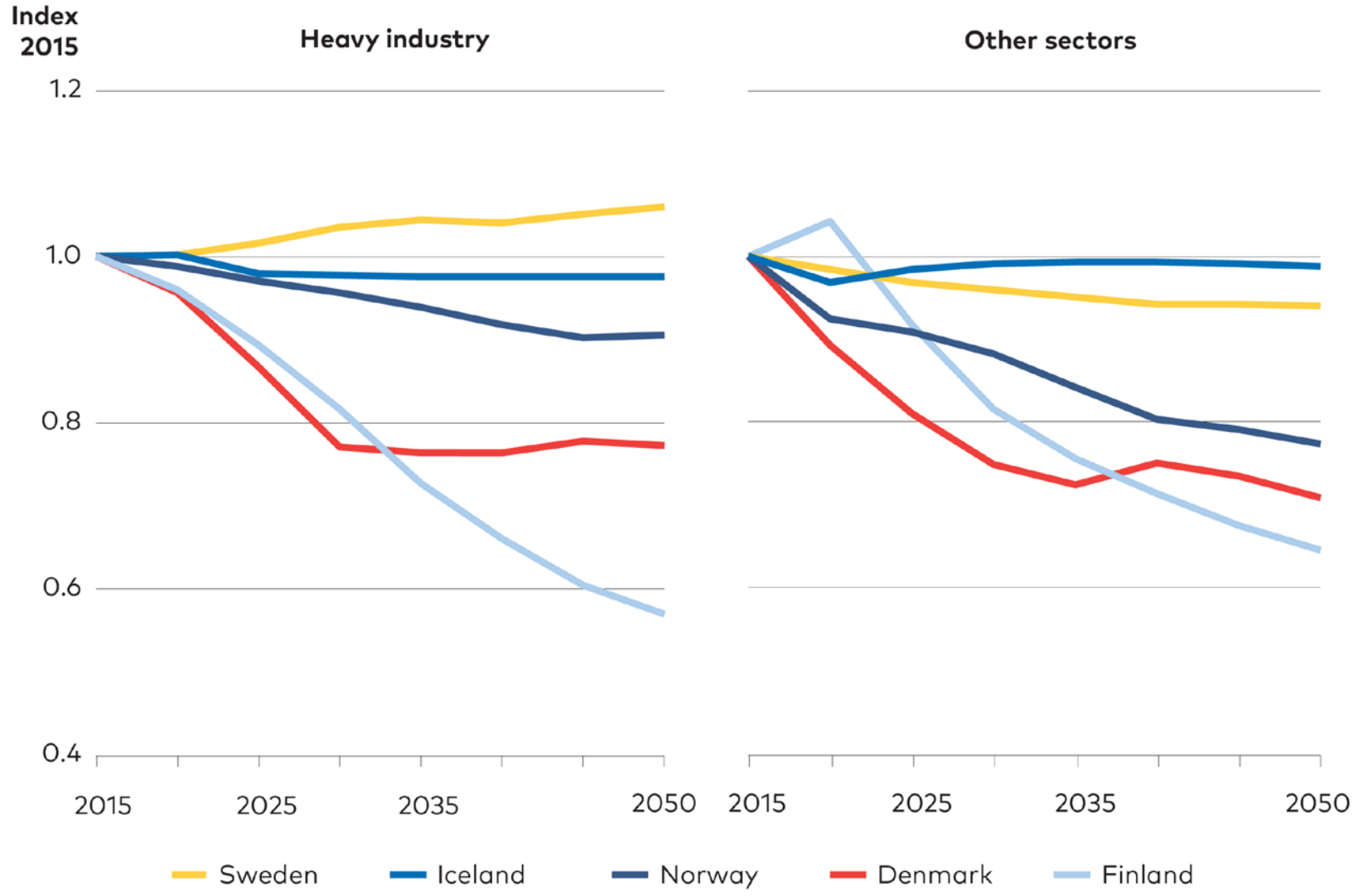


Modelled sector electricity demand



Electrification and process optimisation in industry

Important strategies for reduced energy intensity and even higher ambitions are possible



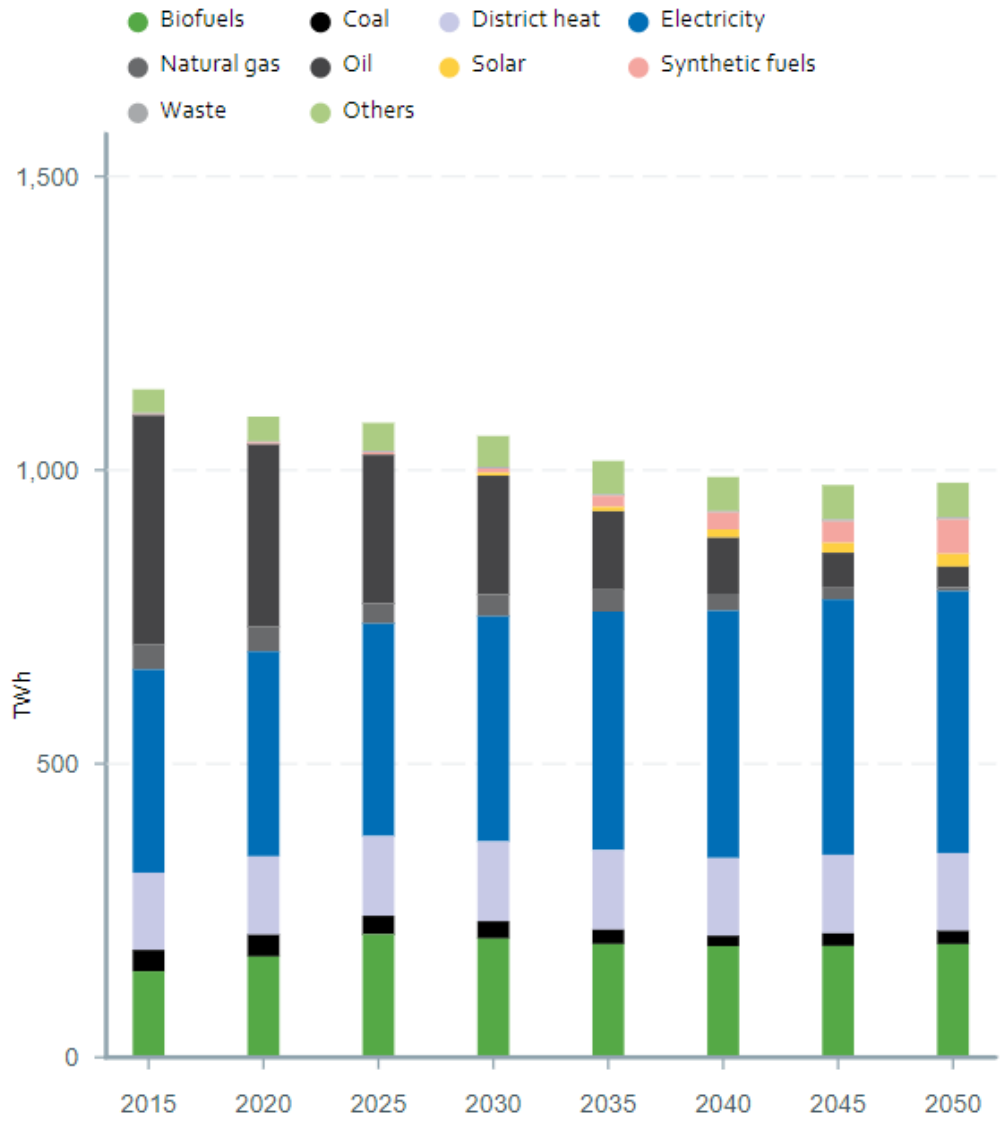
Energy intensity of industry and services - CNN scenario

Final energy consumption in the Nordic's

2020 CNN

Electricity share 31%

Green energy 50%

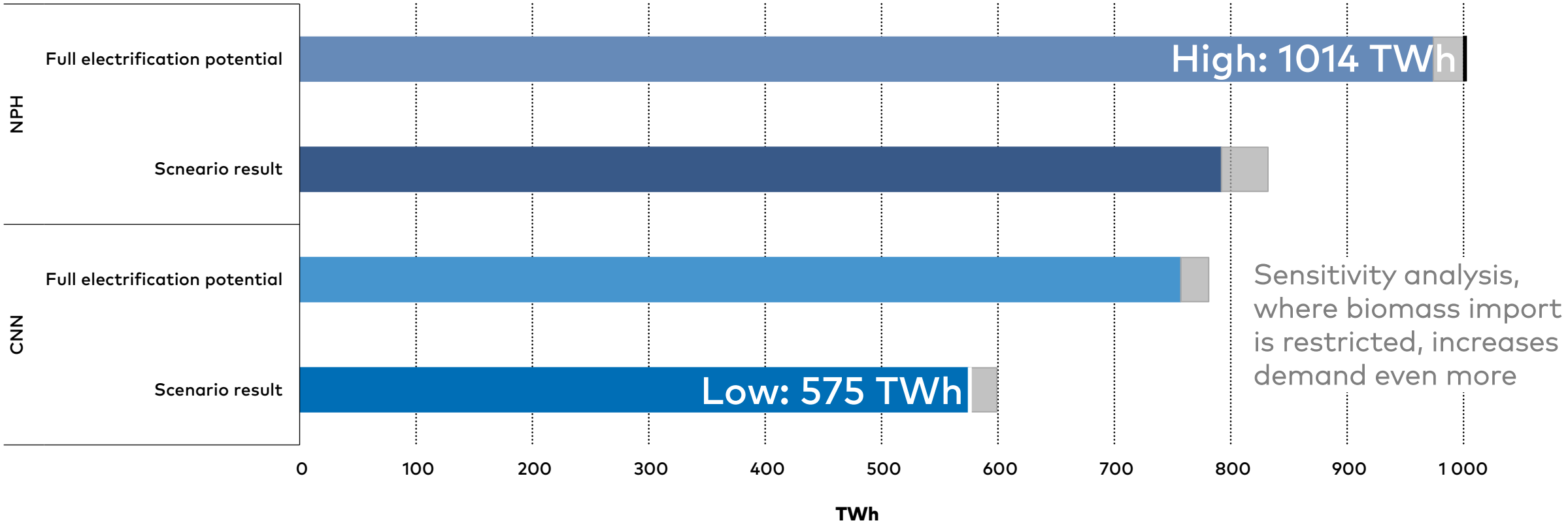


2050 CNN

Electricity share 46%

Green energy 93%

What electricity demand should we plan for by 2050?

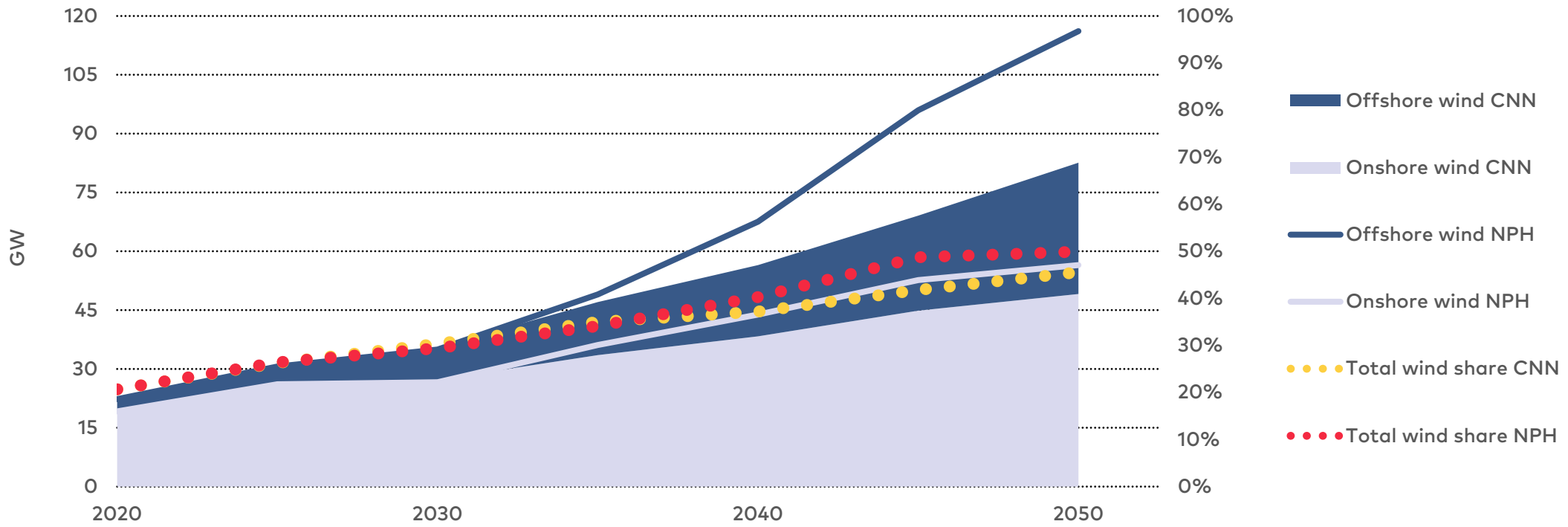


(Total Nordic demand in 2020: 423.6 TWh)

Key scenario developments in the Nordics

- In the Nordic's road transport is almost all electric by 2040
- Iceland and Norway leads with electricity shares of final energy at 60% and 70% in 2050
- In Sweden and Denmark more than 50% of district heating is produced with heat pumps in 2050

Nordic cooperation on integrated offshore wind and grid development will be important



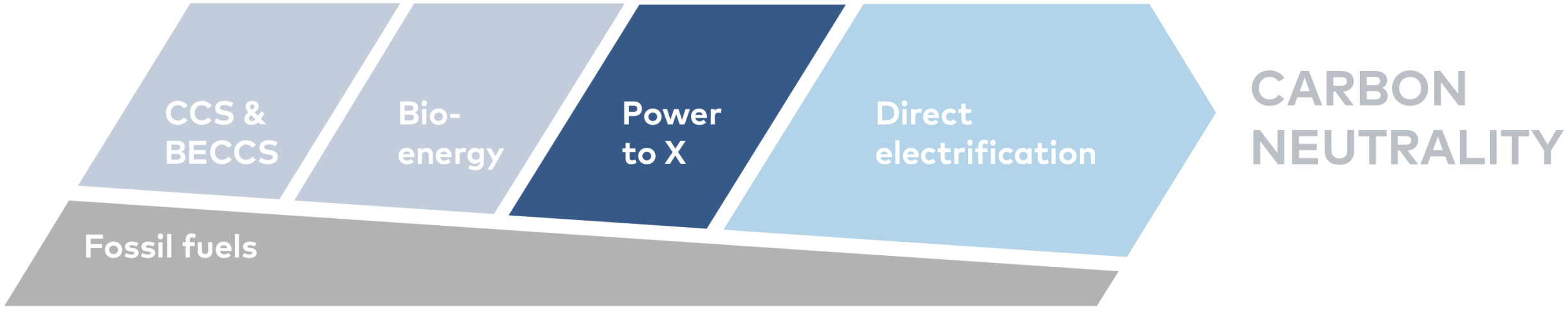
Capacity and total share of onshore and offshore wind

Key messages

Direct Electrification in the Nordic Clean Energy Scenarios

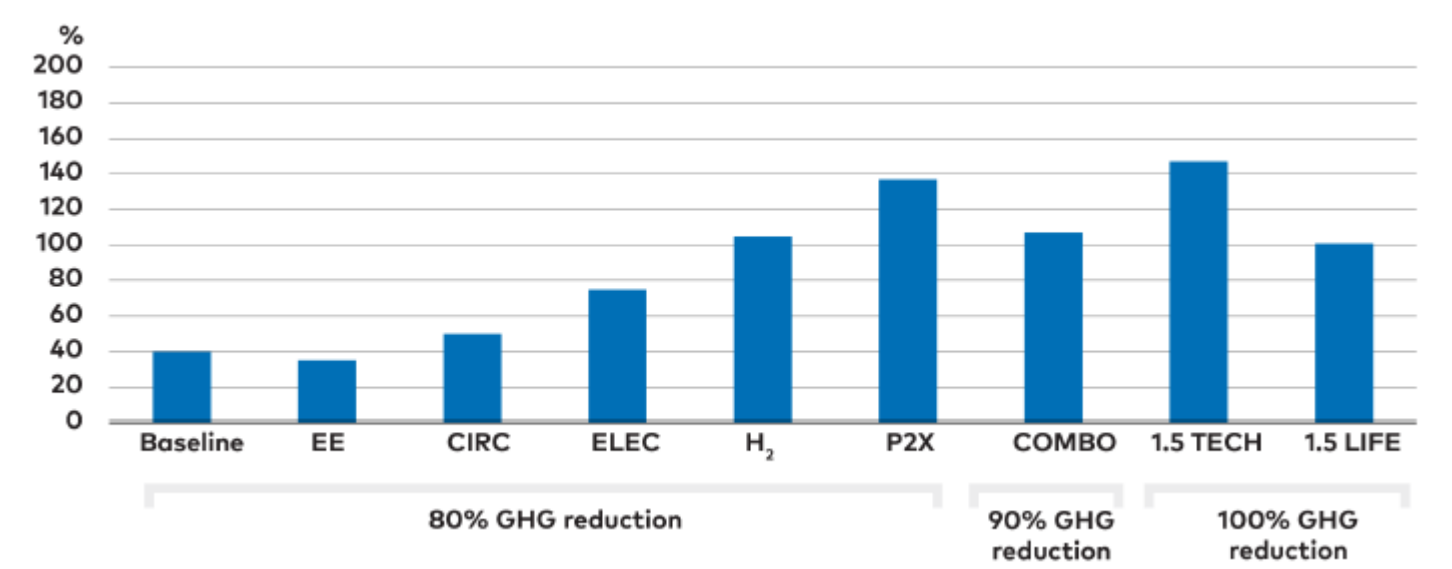
- To reach ambitious climate targets, direct electrification is the single most important measure in the Nordic Clean Energy Scenarios
- The potential for electrification is higher than what is shown in the scenarios
- High electrification rate requires high build of wind and solar power
- If wind and solar capacity are not built out fast enough, demand for biomass, biofuels, and electricity import will increase
- The big uncertainty is the development of PtX.....

Power-to-X and Hydrogen is not just Hype

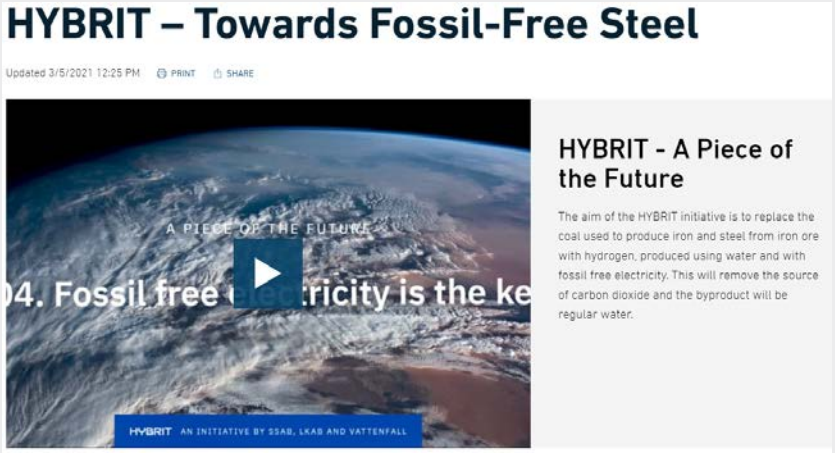


Hydrogen is essential in EU and industrial strategies for decarbonisation

- The EU targets 30 GW of electrolyzer capacity by 2030
- Following the 2018 EU climate strategy, power demand would double by 2050 – largely due to hydrogen



Increase in electricity demand by 2050 compared to 2015

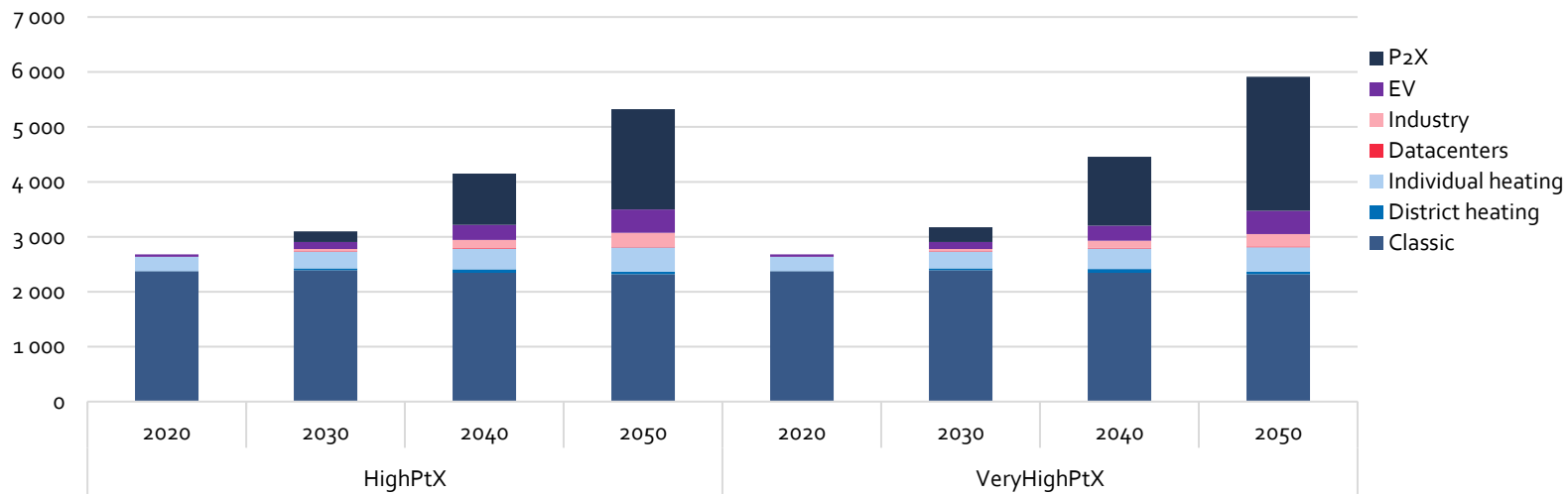


Power system analyses

Main assumptions

- WEO 2020's Sustainable Development Scenario fuel and CO2 prices
- Biomass constraint of 2700 PJ/year on the model area (fair share of global biomass resource)
- Strong cost reduction offshore wind
- Electricity demand
  - NoPtX – only direct electrification
  - HighPtX – EU COMBO scenario – 1826 TWh for PtX
  - Very-HighPtX - EU 1.5 Tech scenario – 2437 TWh for PtX

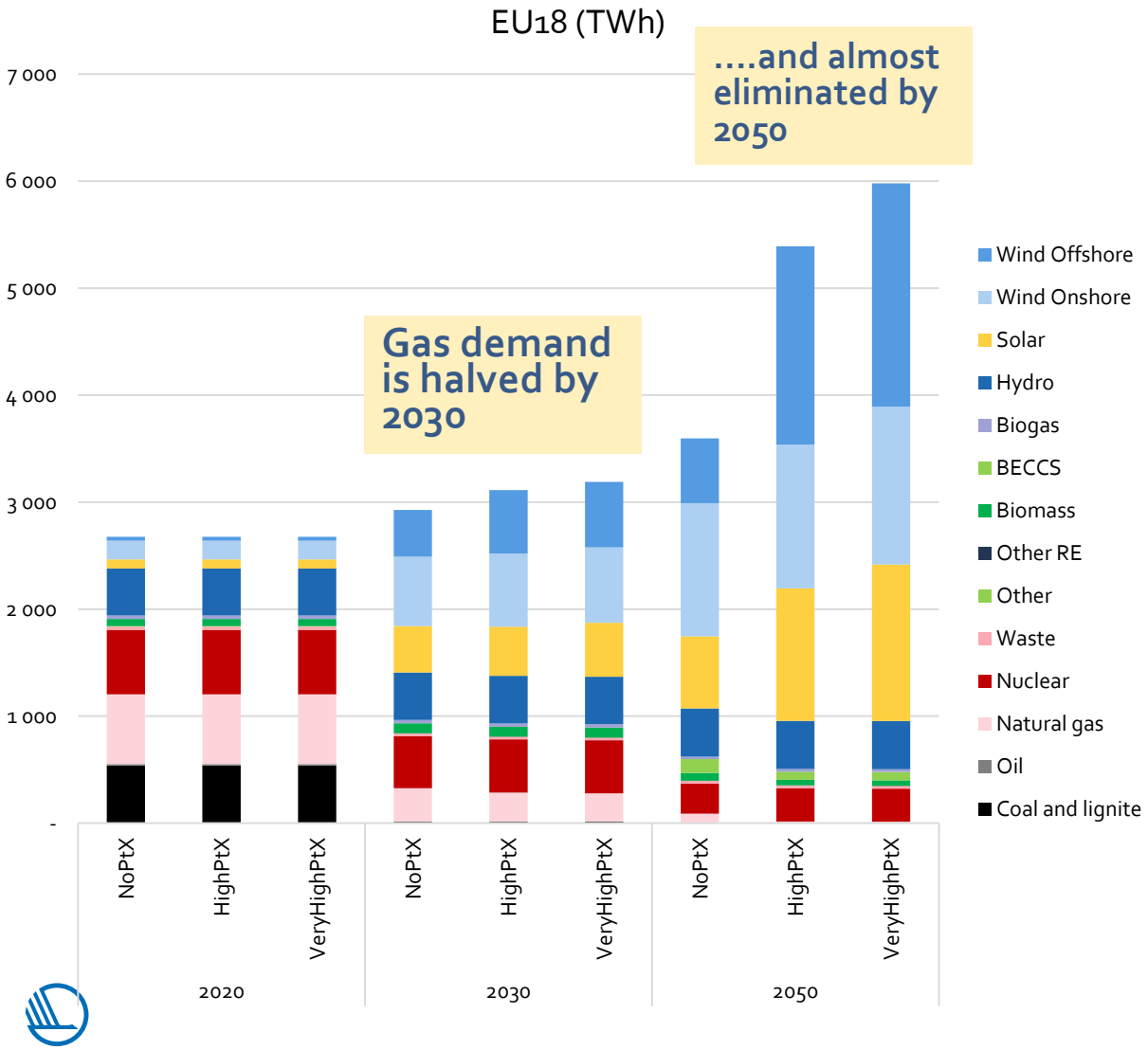
Europe 18 - Electricity demand (TWh)

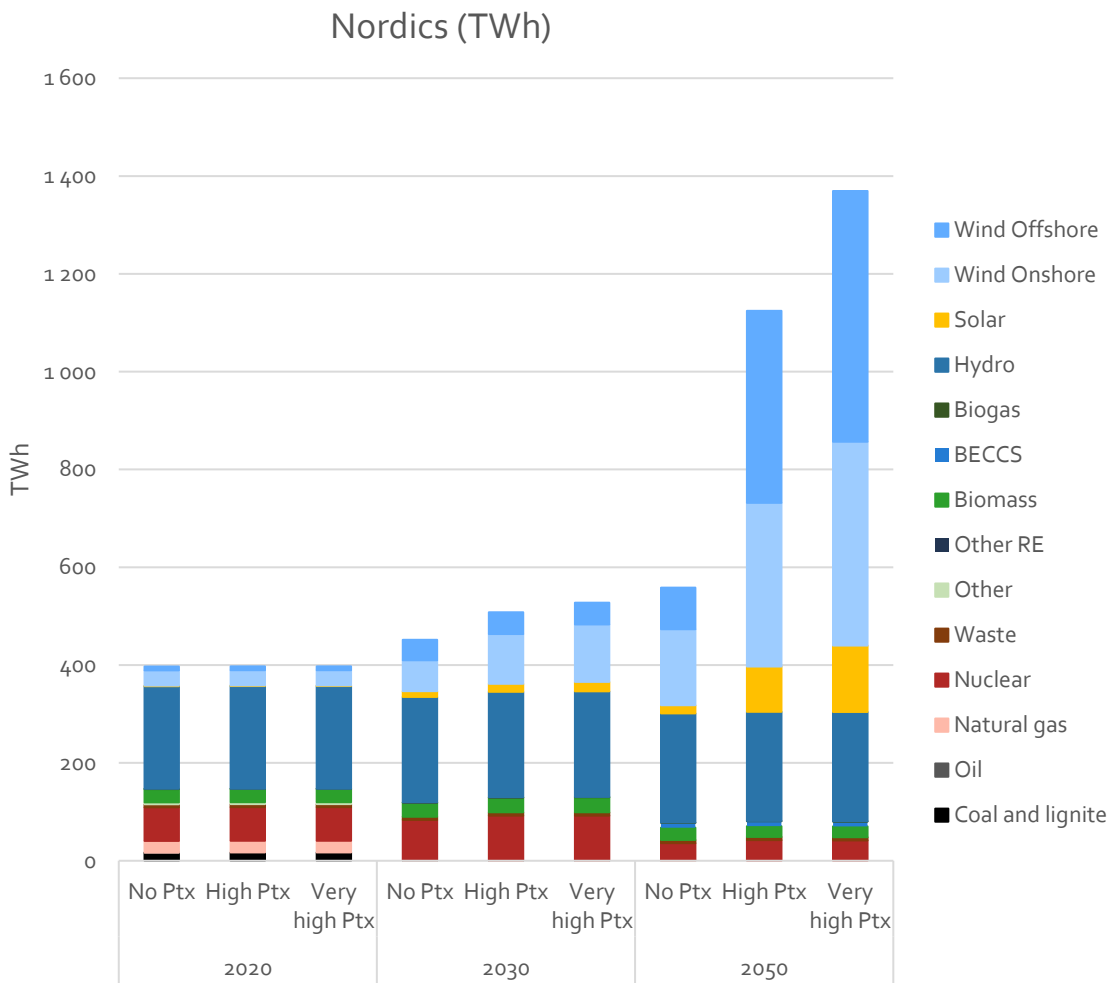


Balmorel power system model

- Detailed district heating modelling
- Electrification (EV, heating, industry)
- PtX – including option to redistribute demand for hydrogen
- Endogenous investment power plant and transmissions capacity

Power generation





Large portion of Nordic power is exported

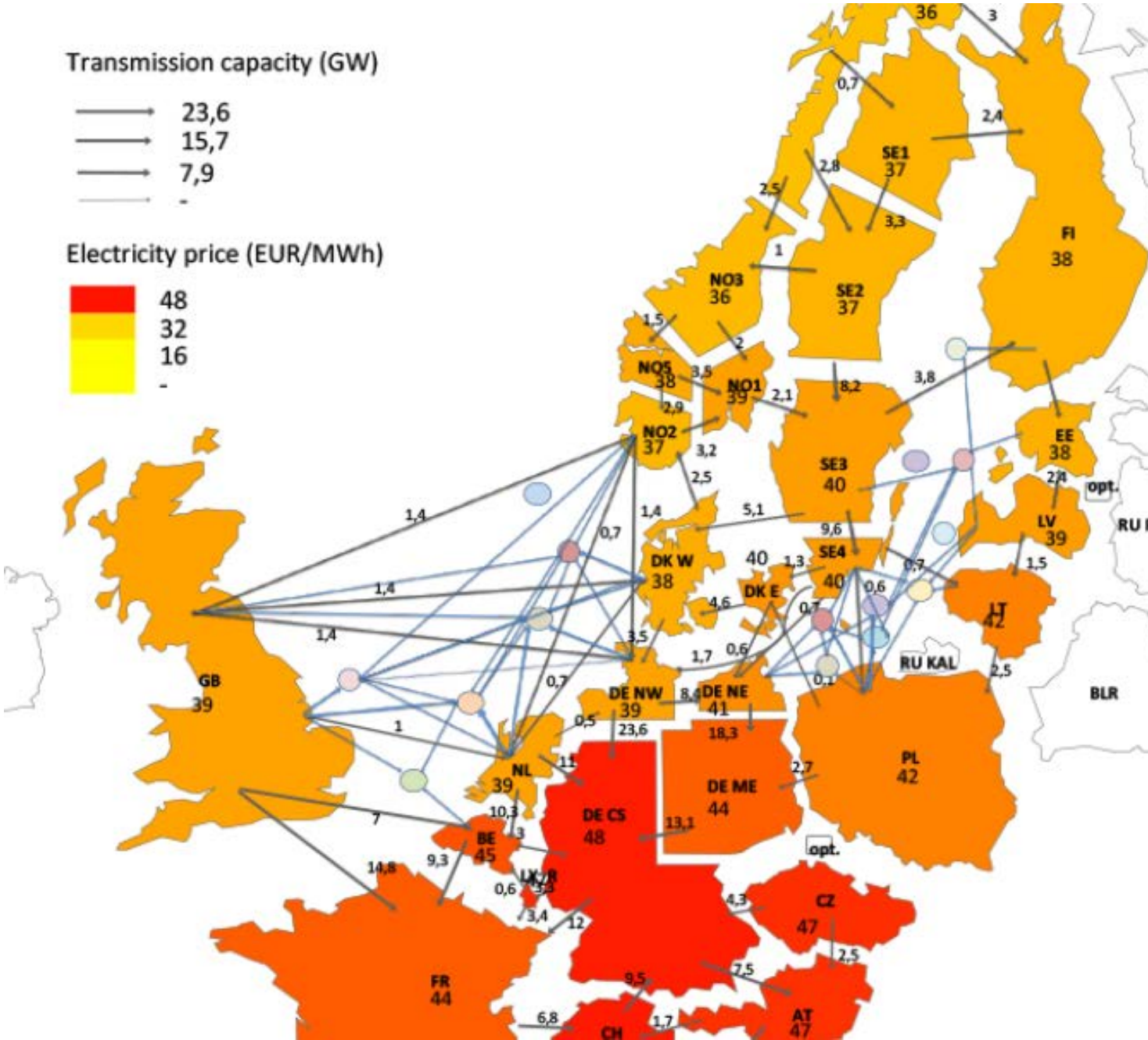
Nordic power supply 2050 divided by end-uses, TWh	NoPtX	HighPtX	Very-HighPtX
Electricity demand (excl. PtX)	471	476	475
PtX to serve Nordic demand	-	117	156
PtX for export	-	304	499
Net export of electricity	78	219	230
Grid losses	9	9	10
Total power generation	542	1124	1369

HighPtX 2050

- Meshed grid with off-shore hubs in the North Sea and the Baltic Sea
- Large exports from offshore wind in Danish and Swedish waters to continental Europe
- PtX evens out price differences between Nordics and continental Europe

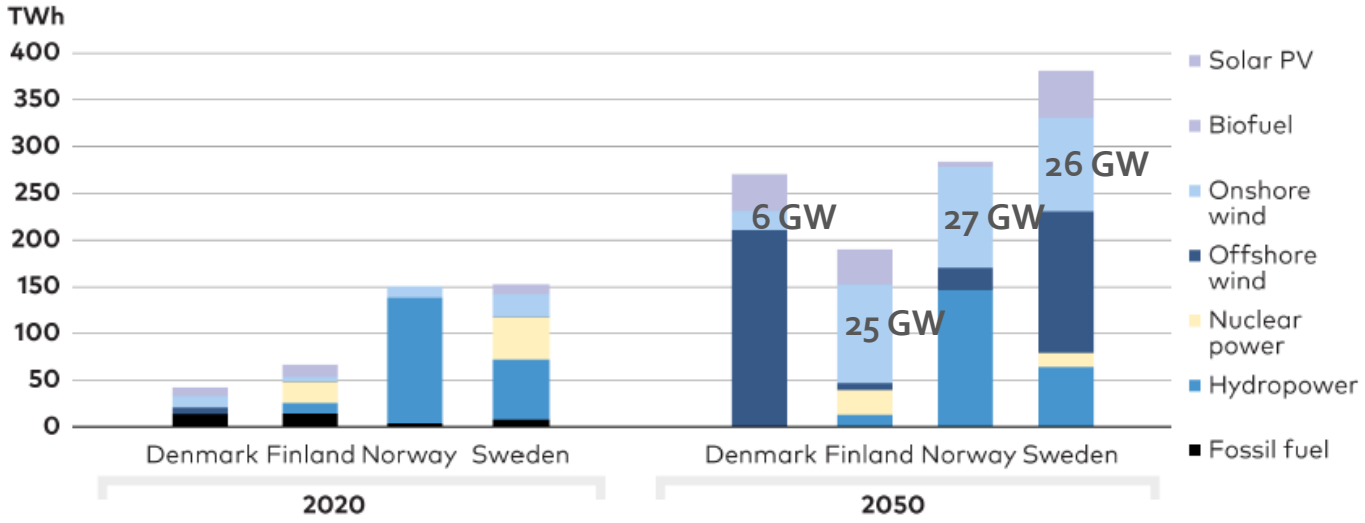
> 300 GW of offshore wind in the North Sea and Baltic Sea

+ app. 3 €/MWh with standard offshore prices

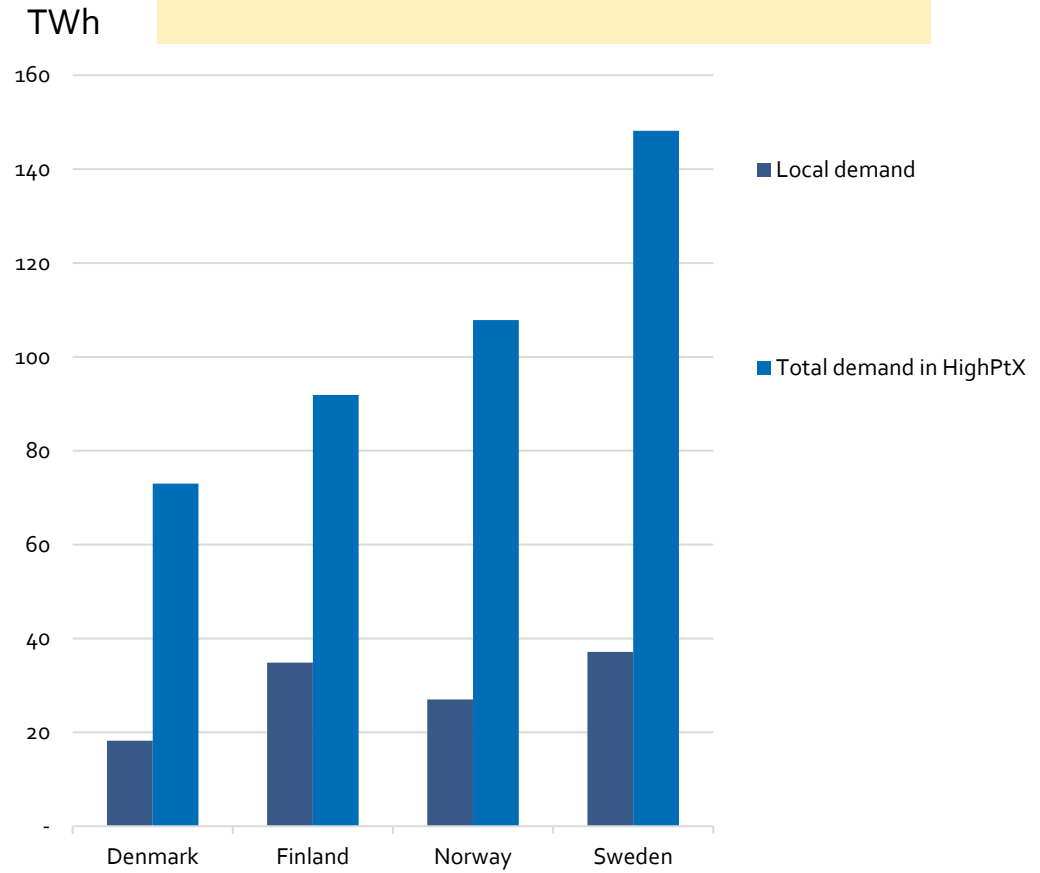


Nordic power generation

HighPtX case

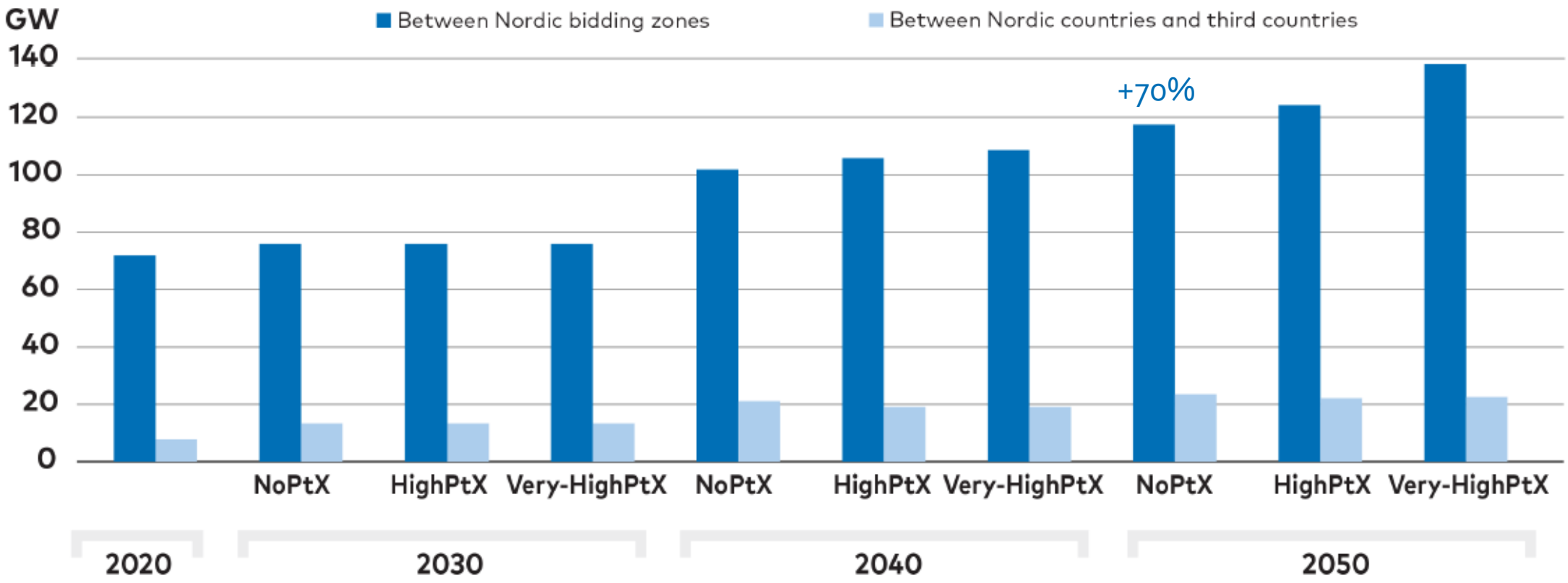


PtX demand by country



6 50 48 67 GW potential if same acceptance level as Germany today....

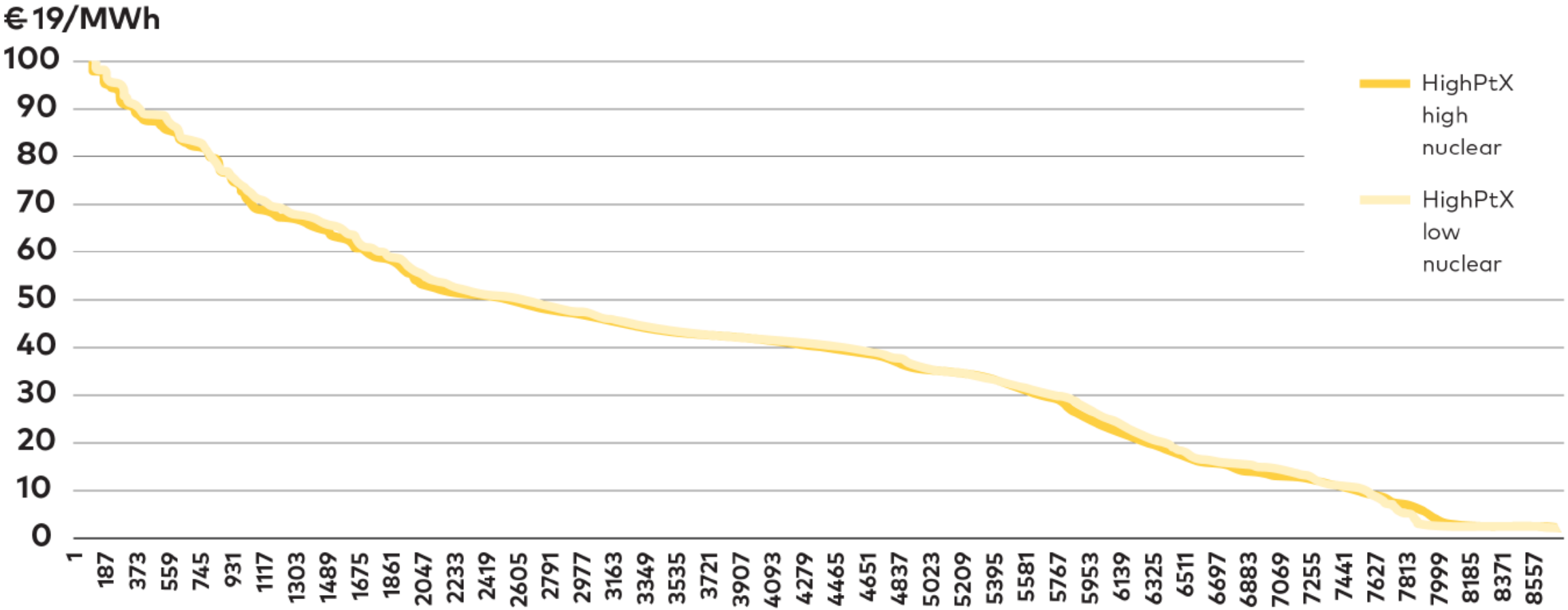
Need for significantly more transmission capacity in all cases



Offshore grid on top of this

Power prices will vary (more?)

HighPtX case



Green export opportunity

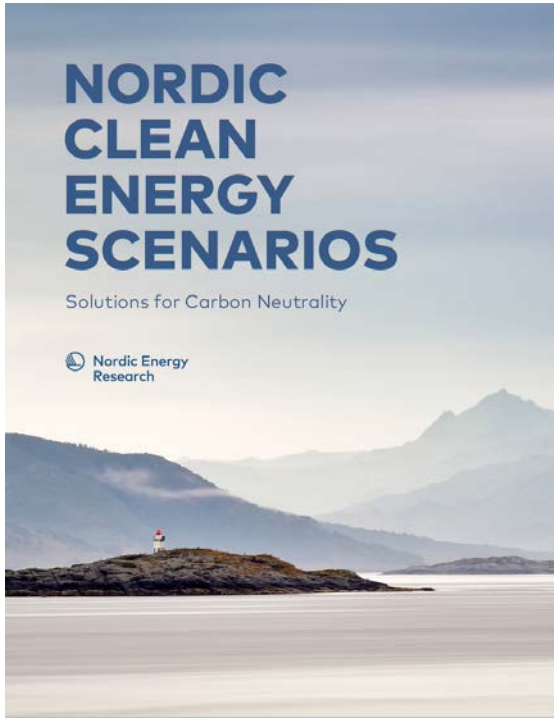
Potential exports of hydrogen and electricity by 2050	Exports in TWh	Estimated value in €
Green hydrogen	210	11.3 billion €
Blue hydrogen	100	5.4 billion €
Electricity	220	9.5 billion €
Total	**530**	**26.2 billion €**

+Estimated CO2-abatement: 46 Mt by 2050.

Key messages

Indirect Electrification in the Nordic Clean Energy Scenarios

- European hydrogen demand is an export opportunity for Nordic countries
- Are the Nordic countries ready for doubling or tripling power generation?
- In a balanced system, power prices will stay modest
  - PtX smoothens prices – and improve security of supply
- A decarbonised European power system is less sensitive to gas price variations – but new weather-related uncertainties emerge



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- Nordic energy statistics database
- Complete technology catalogue
- Web tool for scenario results and sensitivity analyses

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Solutions for Carbon Neutrality

Thank you!

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