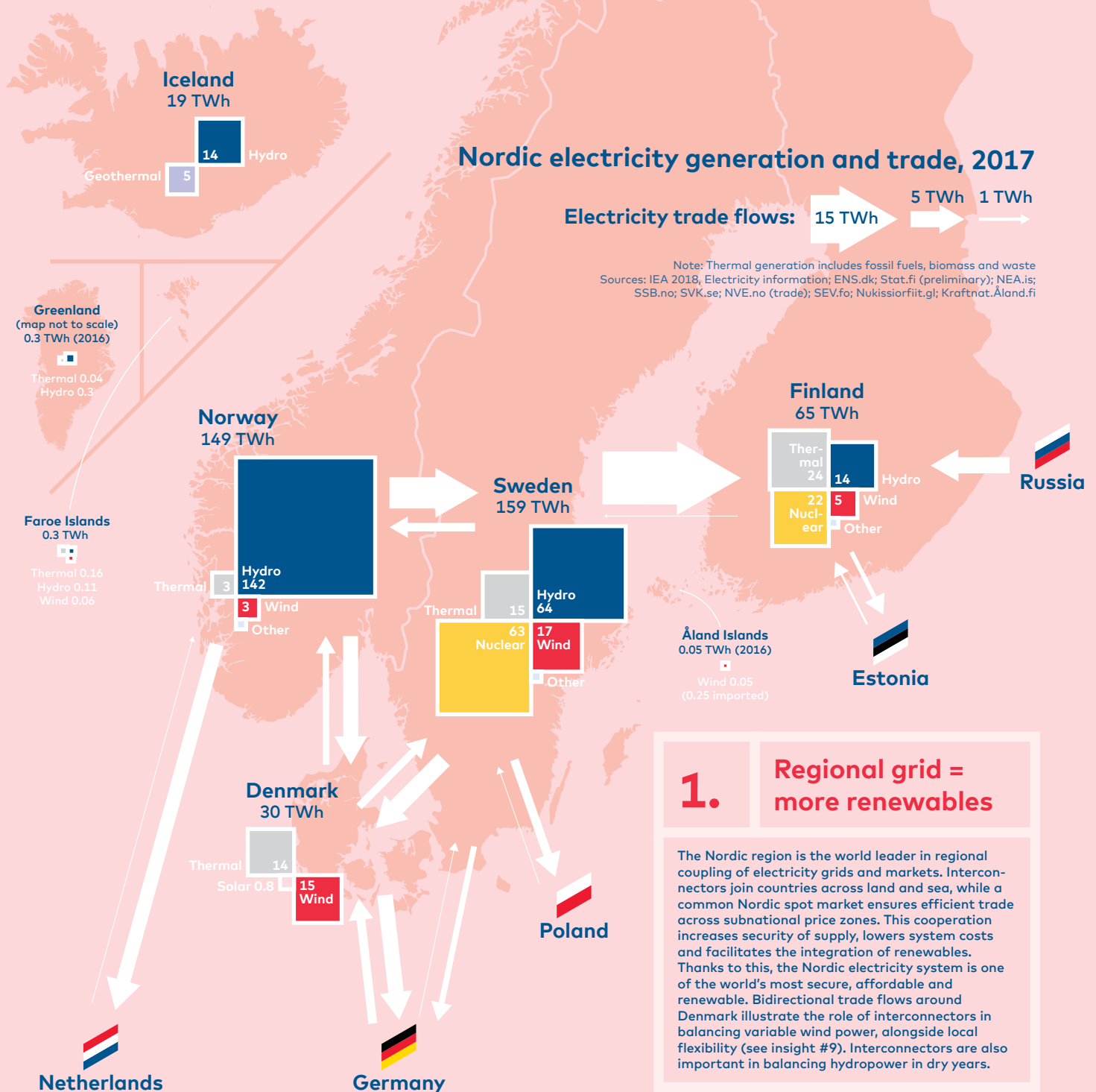




# 10 Insights

## into the Nordic energy system



### 1.

### Regional grid = more renewables

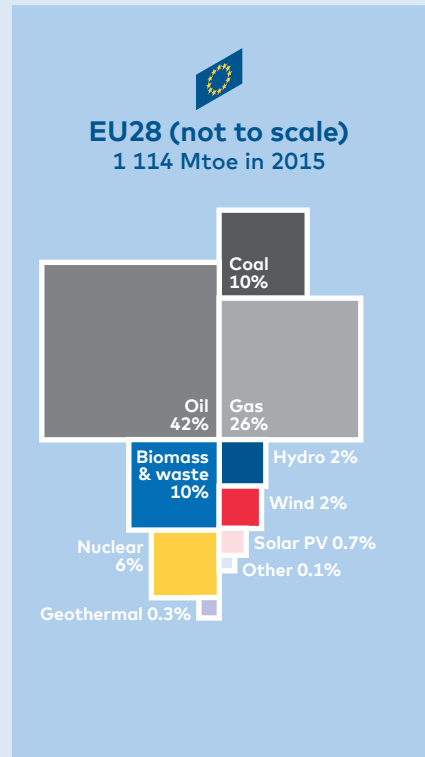
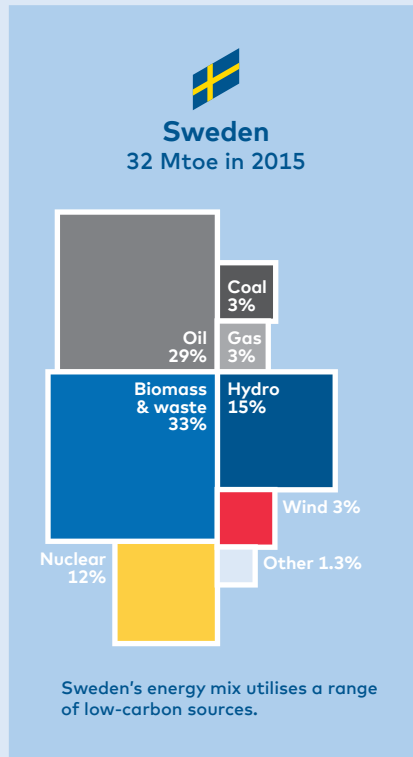
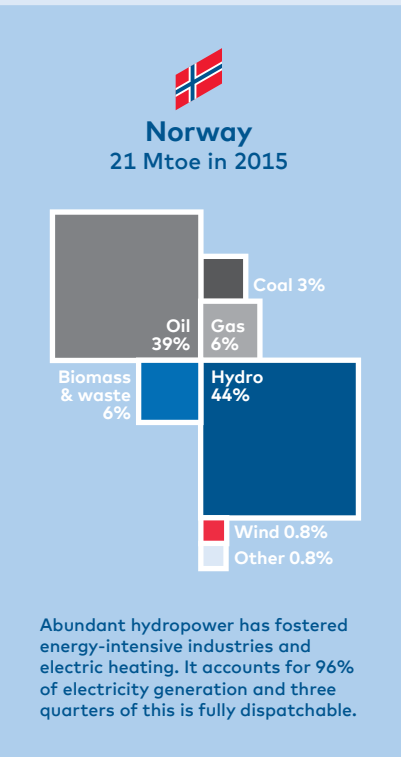
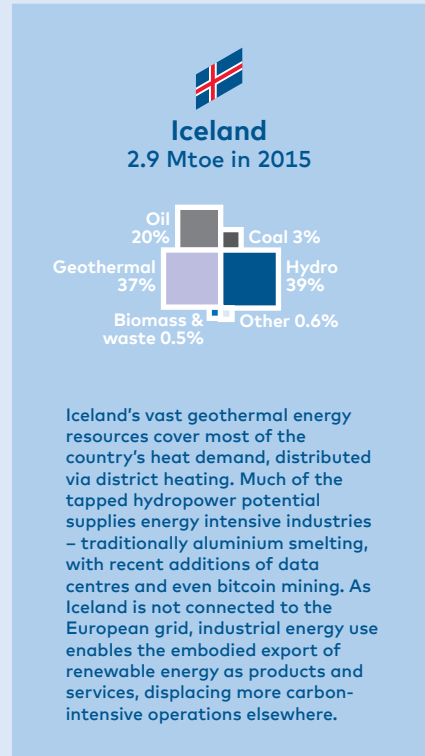
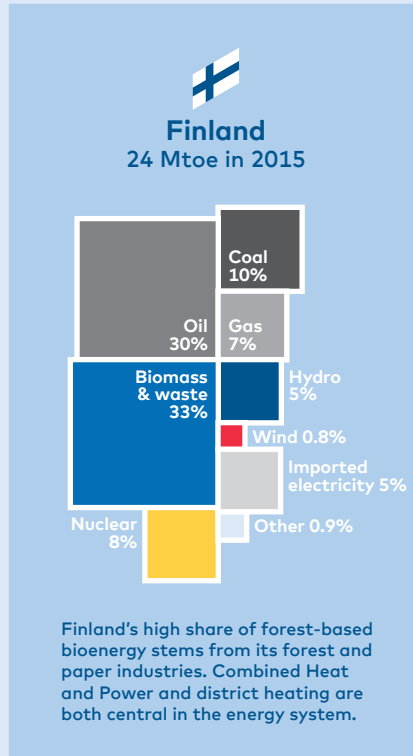
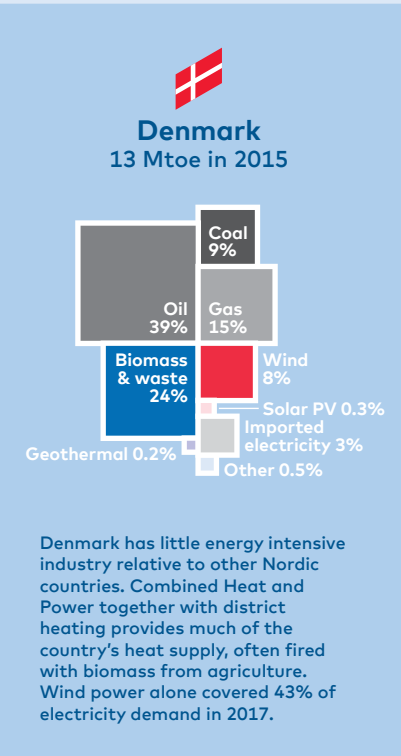
The Nordic region is the world leader in regional coupling of electricity grids and markets. Interconnectors join countries across land and sea, while a common Nordic spot market ensures efficient trade across subnational price zones. This cooperation increases security of supply, lowers system costs and facilitates the integration of renewables. Thanks to this, the Nordic electricity system is one of the world's most secure, affordable and renewable. Bidirectional trade flows around Denmark illustrate the role of interconnectors in balancing variable wind power, alongside local flexibility (see insight #9). Interconnectors are also important in balancing hydropower in dry years.

## 2.

### Similar but different

Common to all five countries is a high share of renewables, ranging from 32 to 73% in 2016, relative to the EU28 share of 17%. Another similarity is that transport is still dependent on oil – in fact, oil is the only energy source to play a significant role in all five countries. This highlights the diversity of the Nordic energy mixes and the benefits of regional integration.

### Total final consumption of energy



Year: 2015. Source: IEA 2018, Energy balances. Note: Total final consumption is energy consumed by end users such as industry, transport, buildings or agriculture. It excludes energy used in the energy sector for transformation, such as losses in thermal power generation, and fuel use for international shipping and aviation. The fuel composition of final consumption of electricity and heat is estimated, assuming the same composition as domestic production. EU28 figure is not to scale.

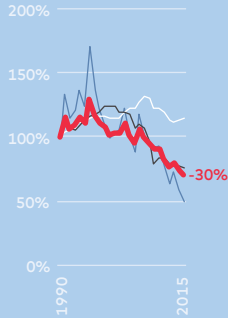
3.

Low-carbon ambitions

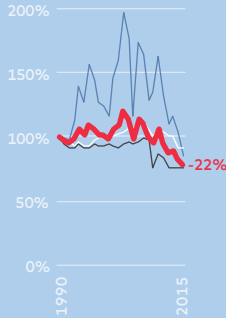
The carbon intensity of Nordic electricity is under 60 gCO<sub>2</sub>/kWh, compared to the global average of over 500. The world needs to match the current Nordic level by 2045 in order to realise the IEA's 2°C Scenario. An abundance of low-carbon electricity in the Nordic region provides a stepping stone to the mitigation of emissions from the more challenging sectors of transport and industry.

Climate targets and GHG emissions

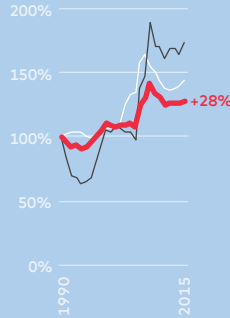
"Denmark is to be independent of fossil fuels by 2050"



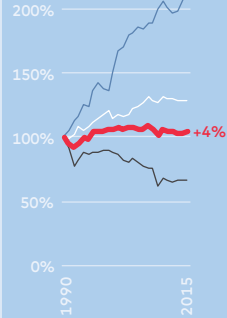
"GHG emissions reduced in Finland by at least 80% by 2050"



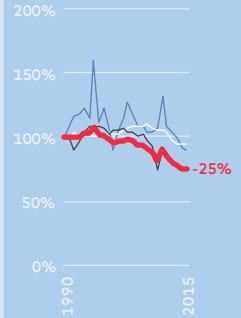
"Reduction of Iceland's net GHG emissions by 50-75% by 2050"



"Norway will be carbon neutral in 2050"



"Sweden to have no net emissions of GHG into the atmosphere by 2045"



- Total GHG emissions (excluding LULUCF)
- Energy supply (electricity, heat, fuel extraction & refining)
- Manufacturing industry (including process emissions)
- Transport

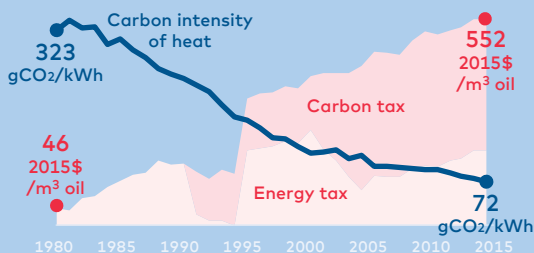
Source: UNFCCC, national governments (targets). Note: Norway's increase in energy supply emissions is due to oil and gas extraction. Iceland's target is currently under revision, its energy supply emissions are insignificant and not shown, and its increase in industrial emissions is due to aluminium production. Fluctuations in energy supply emissions in Denmark, Finland and Sweden are primarily due to thermal generation providing seasonal balancing to hydropower (wet/dry years) and heat demand (cold/warm winters).

4.

Steady policies

Energy and climate objectives have typically enjoyed broad parliamentary support in the Nordic countries. This has paved the way for steady and long-term energy policies such as carbon taxation, building codes and renewables support, giving clear signals to investors and consumers. Furthermore, the Nordic Council of Ministers facilitates regional cooperation on key policy areas. Sweden offers an example of steady and effective policy, where the district heating supply has been largely decarbonised. Gradually increasing carbon and energy taxes have helped to displace fossil fuels with bioenergy.

Decarbonisation of Swedish heat



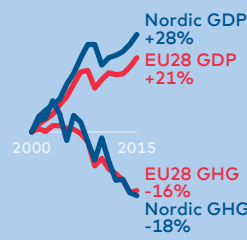
Source: IEA 2016, World Energy Outlook

5.

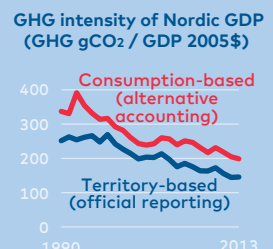
Good for the climate and the economy

The Nordic region has decoupled economic growth from GHG emissions faster than the EU28, despite having lower potential for decarbonisation due to its low-carbon heat and power supply. Alternative consumption-based emission accounting (emissions associated with products and services consumed in a country) can reveal if this was accompanied by greater carbon leakage. The figure to the right shows that while the Nordic countries, like most developed countries, have higher consumption-based emissions than territorial emissions, the difference has not changed significantly during the decoupling.

Decoupling GDP and GHG...



...without further carbon leakage



Sources: NMR 2017, Nordic Statistics (left); IEA/NER 2016, Nordic Energy Technology Perspectives (right)

## 6.

### Decarbonising island energy systems



The Faroe Islands are located between Norway and Iceland. Its 50 000 inhabitants have traditionally relied on expensive diesel generators, but plans are afoot to tap local resources in a smart and zero-emission energy system using wind, hydro, solar, tidal, pumped storage and batteries.



The Åland Islands rely on imported electricity from Sweden, but look to become a demonstration zone for a 100% renewable energy system. This will be based on distributed generation and flexibility, together with innovative market designs for energy and energy services.



Greenland aims to achieve a 100% renewable heat and power supply for its 55 000 residents by 2024, primarily by tapping its significant hydropower potential.

## 7.

### Leading the charge on electromobility

Car sales, Norway 2017



Steady policies offering a range of purchase incentives and user benefits have put Norway at the forefront of electric vehicle adoption. Average emissions for new cars in 2017 was 82 gCO<sub>2</sub>/km, well below the EU target of 95 gCO<sub>2</sub>/km in 2021.

Ferries are ideally suited to electrification due to their relatively short and predictable routes. The Nordic countries have a number of battery electric ferries on the water and under construction, both retrofits and new electric-specific designs.

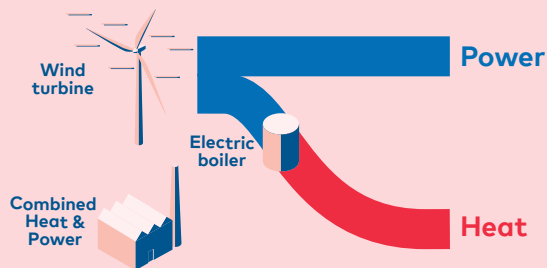


## 9.

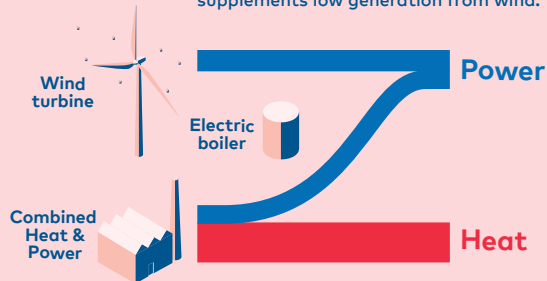
### Flexibility from heat

District heating systems cover the vast majority of residential heating services in Iceland and Denmark, and well over half in Finland and Sweden. District heating is a complementary technology to variable renewables as it is a source of flexibility. Denmark utilises heat alongside flexible thermal generation and electricity trade to integrate wind power equal to 43% of electricity demand in 2017. District heating systems are even capable of long-term storage by using large hot water pits.

**Too much wind** Power prices are low and a large electric boiler converts excess electricity to heat.



**Too little wind** Power prices are high and a CHP plant supplements low generation from wind.



Adapted from Flex4Res

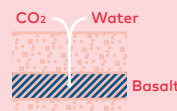
## 8.

### Mitigating industrial process emissions

New industrial processes can avoid process emissions that cannot be reduced by switching to renewable energy. The HYBRIT pilot plant in Sweden aims to produce fossil-free steel using hydrogen instead of coke, potentially cutting Swedish CO<sub>2</sub> by 10% and Finland's by 7%.



**Carbon Capture and Storage (CCS)** will be necessary for industrial emissions that cannot otherwise be avoided. CCS is also necessary to achieve negative emissions. Norway's full scale CCS project has studied CO<sub>2</sub> capture from a cement plant, a fertiliser factory and a waste-to-energy facility. The CO<sub>2</sub> will then be transported by ship to undersea storage.



**New carbon storage technologies:** Icelandic researchers found that CO<sub>2</sub> injected with water into basalt rock formations reacted quickly to form new minerals, becoming permanently stored underground.

## 10.

### The Nordic energy system's role in Europe

The Nordic region has substantial clean energy resources, especially hydropower and wind. The sustainable utilisation of these resources can contribute to achieving EU climate targets. Firstly, clean power can be exported to displace more emission-intensive generation. In 2017 net Nordic exports were 11 TWh, with Norway exporting 15 TWh and Sweden 20 TWh. This is set to increase with deployment of wind power in the Nordics and a number of transmission cables under construction and planning. Secondly, dispatchable hydropower in the Nordics can provide balancing services to help integrate variable renewables. This potential was explored in the IEA/NER report Nordic Energy Technology Perspectives 2016.