

Renewable Energy in the Nordics 2021



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Renewable Energy in the Nordics 2021

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The work was guided by the [Working Group for Renewable Energy](#) – an intergovernmental group which supports the Nordic countries' efforts in renewable energy development, commissions analyses, and provides advice to the Energy Ministers of the Nordic countries.

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Nordic Energy Research

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Nordic Energy Research manages numerous projects, facilitates Ministerial working groups that provide input to energy technology policy making in the region, and funds research and analysis of shared Nordic interest that supports the region's ambition to reach carbon neutrality and create new growth industries based on green technology. It does so by expanding knowledge on sustainable energy and contributing to the development of new and competitive energy solutions. Nordic Energy Research has supported research at the intersection of transport, energy, and environment since its inception.

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The background of the page is a photograph of several rows of blue solar panels mounted on a structure, set against a clear blue sky. The panels are arranged in a grid pattern, and the perspective is from a low angle looking up at them.

Foreword

This report is the first in a series prepared by Nordic Energy Research, providing up-to-date and accessible statistical data on the development of renewable energy in the five Nordic countries: Denmark, Finland, Iceland, Norway, and Sweden. The report tracks progress towards Nordic carbon neutrality goals and EU renewable energy targets.

Two years ahead of schedule, the Nordic countries had all met their 2020 targets set in the EU Renewable Energy Directive, while less than half of member states were on track. The bloc aimed to meet 20 percent of its energy needs with renewables, while the Nordic targets ranged from 30 to 72 percent. These achievements, though remarkable, are perhaps not surprising.

It is no secret that the Nordic countries are endowed with abundant renewable energy resources. Yet, as each country transitions to carbon neutral electricity, heating, and transport, their combined lead in renewables stands to grow. The importance of all renewable energy sources in the region – biomass, wind, solar, hydropower and geothermal – is set to increase.

Strong progress has been made on renewable electricity and heating, while transport is high on the Nordic agenda. In the years ahead, decarbonising heavy vehicles, aviation, and shipping will be a priority. Together, the Nordic countries can lead the world in sustainable transport, and full carbon neutrality is on the horizon as national ambitions ramp up for 2030.

We hope that this publication will provide stakeholders, policymakers, and the public with robust and accessible information about renewable energy developments in the Nordic countries and EU-wide.

Oslo, June 2021

*Klaus Skytte,
CEO, Nordic Energy Research*

Summary

The European Union (EU) Renewable Energy Directive, enacted in 2009, established legally binding targets for the renewable energy share of final energy consumption in individual member states, including Norway and Iceland. While the EU overall had to meet at least 20 percent of its energy needs with renewables before 2020, the Nordic targets were more demanding: 30 percent for Denmark; 38 percent for Finland; 72 percent for Iceland; 67.5 percent for Norway; and 49 percent for Sweden.

Despite this, all the Nordic countries met or surpassed their targets two years in advance. They owe these achievements to the flexibility offered by the region's electricity markets, good starting positions relative to other countries in terms of renewables in the energy mix, and rising demand for carbon-free electricity, heating, and transport.

In recent years, the renewables share of Nordic energy consumption has risen at nearly three times the EU's pace. Yet, total energy consumption has remained stable since 2005, as renewables curb reliance on coal and gas, mainly for electricity and heat. While overall energy consumption per capita is above the EU average, more than half of the region's energy is renewably sourced, relative to about one fifth EU-wide.

Renewables are a consistent element of a changing energy landscape, as the region's electricity systems approach carbon-neutrality. More than three quarters of Nordic electricity consumption is renewable, versus the EU's one third share. The most significant change between 2018 and 2019 was in consumption of solar-generated electricity, which increased more than 24 percent (1.5 to 1.8 TWh). The wind share rose 14 percent (42.6 to 48.6 TWh), and that of biomass 6 percent (26.4 to 27.9 TWh), while the hydropower share remained about the same at around 235 TWh – a key component of the Nordic electricity system.

To some extent, renewable energy technologies reflect the natural resource endowments of each nation. Denmark, the southern-most Nordic country, consumes nearly half of the region's solar-generated electricity (1 TWh); Finland, with its large forest industry, accounts for 44 percent of biomass consumption (12 TWh); Iceland relies on geothermal sources, using more than half of "other renewables"¹ in the Nordics (6 TWh); Drawing on its water resources, Norway consumes 60 percent of all hydropower (140 TWh); Sweden consumes the most wind power (21 TWh) – 43 percent of the region's total.

1. "Other renewables" include concentrating solar power, geothermal, and ocean power (International Energy Agency).

All Nordic countries meet at least a third of their heating and cooling needs with renewable energy; Sweden, two thirds and Iceland more than three quarters. Per capita, the region consumes four times the EU average of renewable energy for heating and cooling. Norway draws on abundant hydropower, while in the other countries, district heat networks, often based on renewables, offer flexibility to switch fuels.

Across the region, transport gradually is shifting to renewable energy. Biofuels dominate by absolute consumption, while electricity is increasingly adopted on road and rail, driven by a surge of electric vehicles in Norway. If the Nordic countries were considered one, it would lead the EU with the highest share of renewable energy in transport. Despite this progress, decarbonising heavy-duty vehicles, aviation, and maritime transport, has proven to be challenging.

Chapter 1

Introduction

The European Commission adopted the [Renewable Energy Directive 2009/28/EC](#) (RED) in 2009, setting an EU-wide target to raise the overall share of renewable energy in gross final energy consumption from 8.5 percent in 2004 to at least 20 percent before 2020. Gross final energy consumption is the total energy used by end-consumers, as well as transmission and distribution losses for electricity and heat. The key indicator of progress on this target is the share of renewable energy in gross final energy consumption².

In accordance with the RED, legally binding targets were established for national shares of renewable energy consumption in member states, including Norway and Iceland in the European Economic Area (EEA). Member States reported progress on overall renewable energy shares and three sub-sectors: electricity (RES-E); heating and cooling (RES-H&C); and transport (RES-T). A sectoral target was also defined, requiring all members source at least 10 percent of transport fuels from renewables by 2020.

The RED introduced national trajectories for renewable energy shares in the intermediate years up to 2020, to ensure achievement of the targets, and avoid that Member States delay action. Each country's indicative trajectory was set out in a [National Renewable Energy Action Plan](#) (NREAP), with information on planned and existing policy measures to achieve the targets. The EU's 2020 Climate and Energy Package, of which the RED is part, also established a binding target of cutting greenhouse gas emissions by 20 percent relative to 1990 levels, and improving overall energy efficiency by 20 percent, before 2020.

The recast [Renewable Energy Directive 2018/2001/EU](#) (REDII) entered into force in December 2018, requiring the EU to meet at least 32 percent of its energy needs with renewables by 2030, with a possible upwards revision by 2023. This includes a 14 percent target for the share of renewable fuels in transport by 2030 and strengthened criteria for bioenergy sustainability. The revision aims to ensure that renewable energy contributes to achieve the EU climate ambition as part of the [European Green Deal](#), in line with the [2030 Climate Target Plan](#), and the [EU strategy on energy system integration](#) adopted on 8 July 2020.

This report assesses renewable energy consumption in the five Nordic countries: Denmark, Finland, Iceland, Norway, and Sweden. Chapter 2 provides a brief overview of energy consumption in the region. Chapter 3 reviews developments in renewable

2. See Annex 2 for a detailed description of the methodologies and definitions applied.

energy consumption. Chapter 4 describes how the Nordic countries met their national targets in advance of 2020 and tracks their progress relative to the EU-28³. Subsequent chapters report progress on renewable energy shares in the three sub-sectors: electricity (Chapter 5); heating and cooling (Chapter 6); and transport (Chapter 7).

Table 1-1 compares the renewables share of energy consumption in the Nordic countries and EU-28, as well as the three sub-sectors, summarising progress made between 2005 and 2019.

	NORDICS		EU-28	
	2005	2019	2005	2019
Renewable energy share (RES %)	37.7%	54%	9.1%	19.0 %
Renewable electricity share (RES-E %)	58.1%	77.6 %	14.8%	34.2%
Renewable heating share (RES-H&C %)	39.4%	57%	11.1%	21%
Renewable transport share (RES-T %)	3.3%	22.5%	1.8%	9.0%

Table 1-1

Renewables share of energy consumption in the Nordic countries and EU-28 (% gross final consumption, 2005 and 2019)

[Directive 2009/28/EC](#) on promotion of the use of energy from renewable sources established common accounting criteria for the 2020 targets on renewable energy sources. The data and statistics presented in this report apply the methodology established by the EU Renewables Directive and the Eurostat SHARES tool (**SH**ort **A**ssessment of **R**enewable **E**nergy **S**ources).

The SHARES tool focuses on the harmonised calculation of the share of energy from renewable sources. The advantage of the SHARES tool is that Member States use the exact same method to calculate the desired values. This prevents irregularities from varying parameters used in different calculation methods.

As a consequence, there may be differences between the renewable energy shares reported here and those reported in national energy statistical publications. Unless otherwise stated, the source of all data in this report is Eurostat. The report uses the latest SHARES tool data available in April 2021.

3. Data and statistics in this report cover the EU-28 through the end 2019, before the United Kingdom's withdrawal from the European Union had taken effect on 1 February 2020.

Chapter 2

Nordic energy consumption

In terms of final energy consumption, the Nordic countries differ particularly in their energy-intensive industries and natural resource endowments. Substantial hydroelectric potential and abundant raw materials, such as wood and minerals, have played an important role in the development of energy-intensive industry in the region. In most Nordic countries, widespread district heat networks offer the flexibility to switch fuels, as renewables curb reliance on coal and gas, mainly for electricity and heat.



Denmark has less energy-intensive industry relative to other Nordic countries, although this is changing as more large data centers are being established. Combined heat and power together with district heating networks, often fired with renewable biomass, provide much of the country's heat supply, while wind power met 45 percent of electricity demand in 2019. *



Finland's most important forms of renewable energy are forest-based bioenergy, side streams and other wood-based fuels stemming from its large forest and paper industries. Hydropower, wind power and ground heat play important roles, and combined heat and power and district heating are both central in the country's energy system.



Iceland meets most of its heat demand with geothermal resources, via district heating. Much of the country's tapped hydropower supplies energy-intensive industries, including aluminium smelting and data centres. While Iceland is not connected to the European grid, renewable energy used to produce goods and services for export displaces carbon intensive operations elsewhere.



Norway's hydropower has fostered electric heating and energy-intensive industries, such as manufacturing and mining. The country's reservoir capacity stores and regulates fluctuating energy supply from renewable sources like wind in neighbour countries, via the common Nordic grid.



Sweden's energy intensive industries cover paper and pulp, as well as steel manufacturing. A range of low-carbon sources are found in the country's energy mix, including hydropower – mostly for electricity – and bioenergy for heating, while wind power capacity is expanding rapidly.

** Eurostat figures differ from Energinet.dk – the Danish national transmission system operator reports that wind power met 47 percent of national electricity demand in 2019. Vind i systemet Wind Denmark*

Nordic energy consumption has remained stable as major sub-sectors transition to renewables.

Since 2005, Nordic energy consumption has totalled around 100 million tonnes of oil equivalent (Mtoe) annually, with a low of 96.6 Mtoe in 2009 after the global financial crisis, and a peak of 104.2 Mtoe the following year (Figure 2-1).

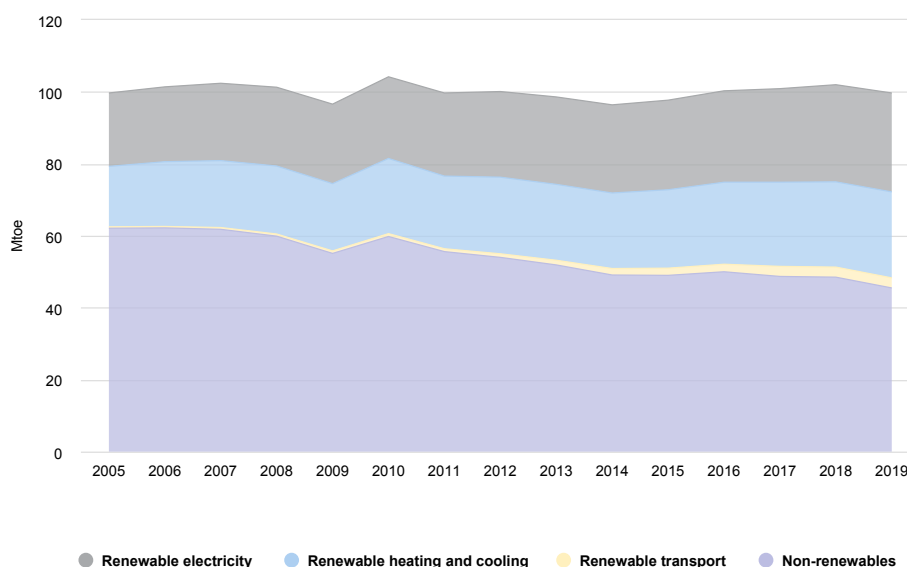


Figure 2-1

Energy consumption in the Nordic countries (Mtoe gross final consumption, 2005-2019)

In the wake of the crisis, overall energy consumption in the Nordic countries fell 4.6 percent – the same as the region's GDP decline.

Renewables continue to substitute non-renewables in Nordic energy consumption.

While overall Nordic energy consumption declined 2.1 percent from 101.9 Mtoe in 2018 to 99.7 in 2019, the region's renewable energy share rose 1.5 percent (0.8 Mtoe) and that of non-renewables fell 6.2 percent (3 Mtoe). Correspondingly, renewable energy consumption rose 2 percent in the electricity sub-sector, 0.9 percent in heating and cooling, and 2.5 percent in transport.

Nordic energy consumption in 2019 was virtually the same as in 2005. Over this period, non-renewable energy consumption declined more than one fifth (16.6 Mtoe), matched by an increase in renewable energy consumption of 16.6 Mtoe (44 percent), mainly in heating and cooling and electricity (Figure 2-2).

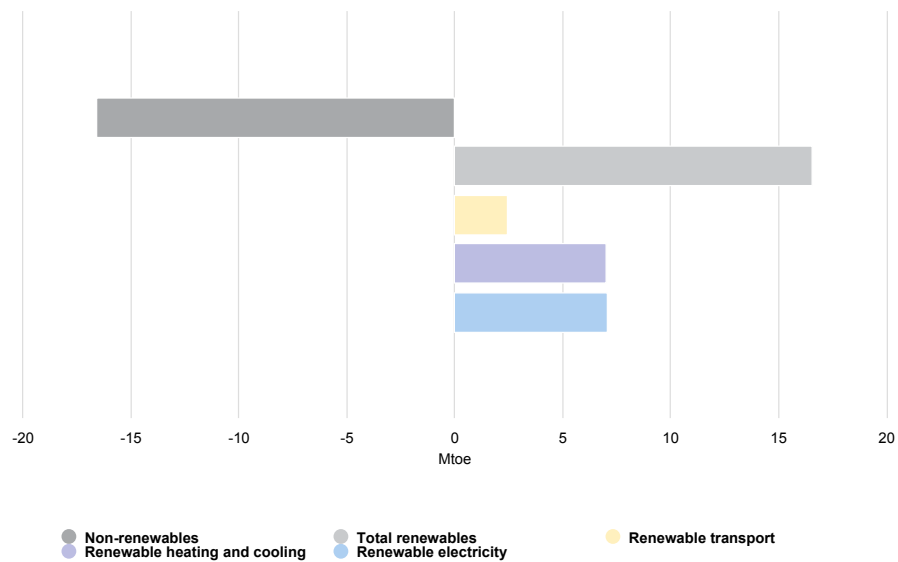


Figure 2-2

Change in energy consumption in the Nordic countries (Mtoe final consumption, 2005-2019)

Renewable energy use in Nordic transport grew sevenfold from a low base of 0.4 Mtoe in 2005 to 2.5 Mtoe in 2019 (Figure 2-3).

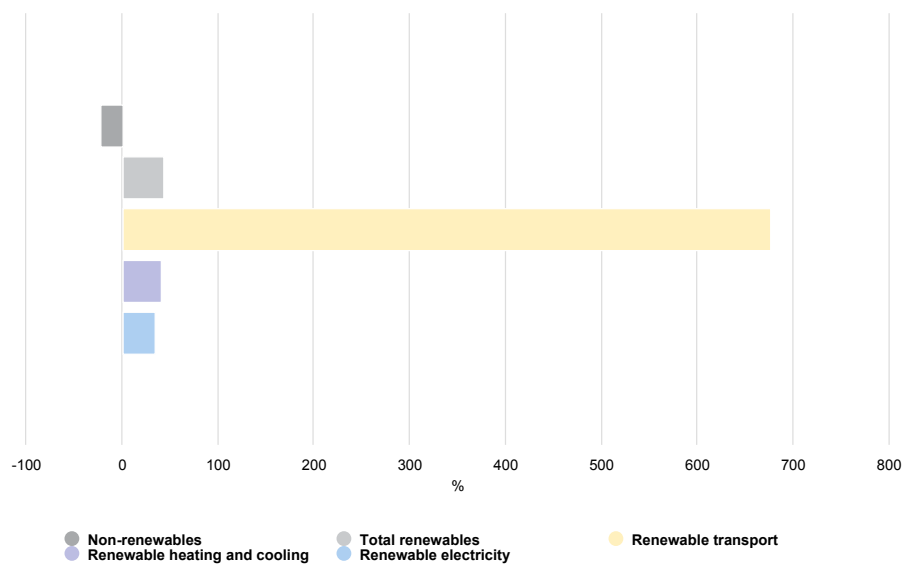


Figure 2-3

Energy consumption in the Nordic countries and EU-28 (% gross final consumption, 2019)

More than half of the region's energy is renewably sourced, compared to about one fifth EU-wide.

The European Union, together with Iceland and Norway (EU+IN), consumed 1,185 Mtoe of energy in 2019. Of this, the Nordic countries accounted for 23 percent (54 Mtoe) of all renewable energy consumed (236 Mtoe), but only 8.5 percent (100 Mtoe) of total energy produced.

The electricity sub-sector accounted for 28 percent of Nordic renewable energy consumption in 2019; 24 percent for heating and cooling, while the modest remainder went to transport (Figure 2-4).

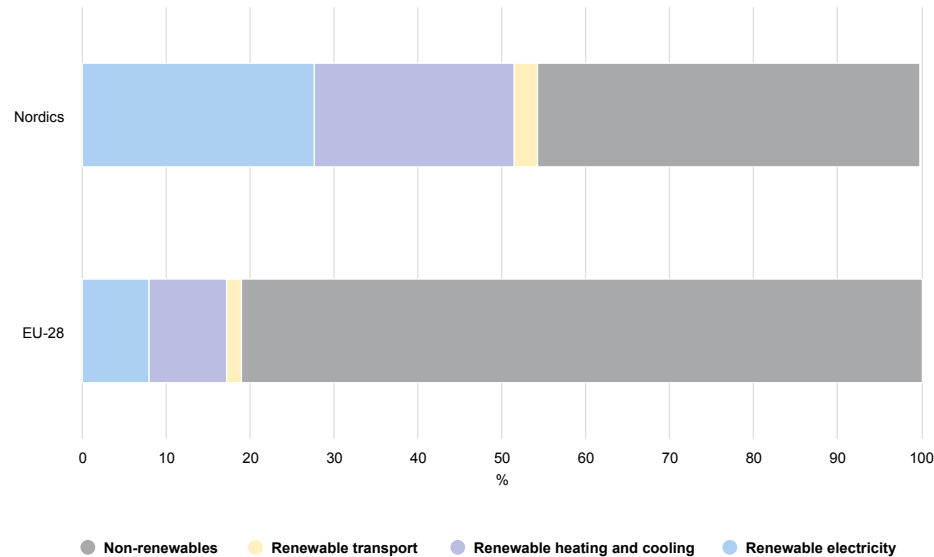


Figure 2-4
Energy consumption in the Nordic countries and EU-28 (% gross final consumption, 2019)

At 54 percent, more than half of all energy consumed in the region is sourced from renewables, while 46 percent comes from non-renewables, largely comprised of fossil fuels for transport and heating, and low-carbon nuclear energy in Sweden and Finland (Figure 2-5).

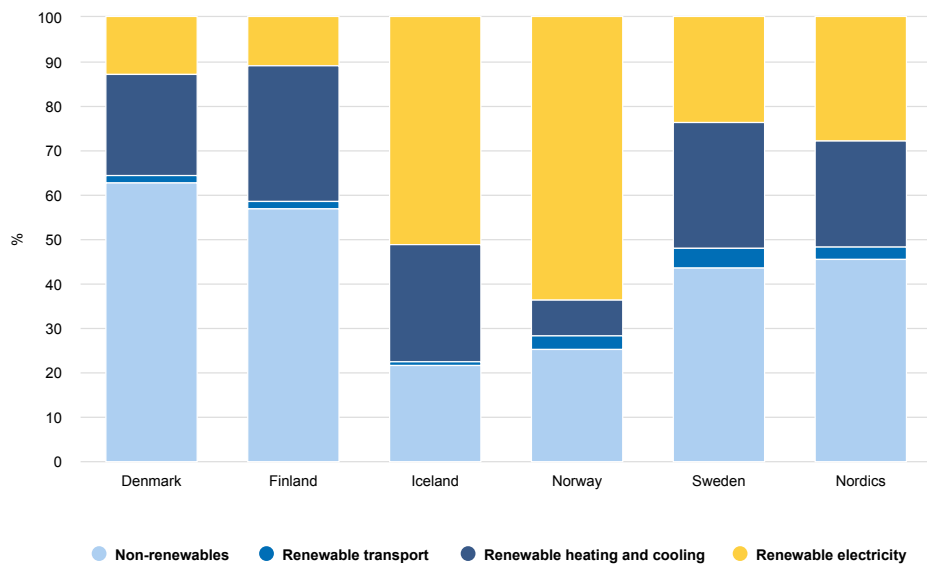


Figure 2-5

Energy consumption in the Nordic countries (% gross final consumption, 2019)

Renewable energy consumption has risen rapidly in Denmark and Iceland over recent years.

From 2005 to 2019, Denmark's renewable energy consumption rose more than any other Nordic country, an average 5.3 percent annually, followed by Iceland with 5.1 percent annually. Finland's renewable energy consumption had an average annual growth of 2.9 percent in this period, followed by Sweden at 2 percent, while Norway's consumption rose an average 1.7 percent annually, from a higher baseline.

In absolute terms, Sweden is the largest Nordic energy consumer at 34 Mtoe in 2019 – one third of the region's total. Finland accounted for more than a quarter of Nordic energy consumption, followed by Norway at one fifth, Denmark at one sixth, and Iceland at less than five percent. Sweden was also the largest consumer of renewable energy for heating and cooling and transport, while Norway consumed half of renewable energy used for electricity (Figure 3-3).

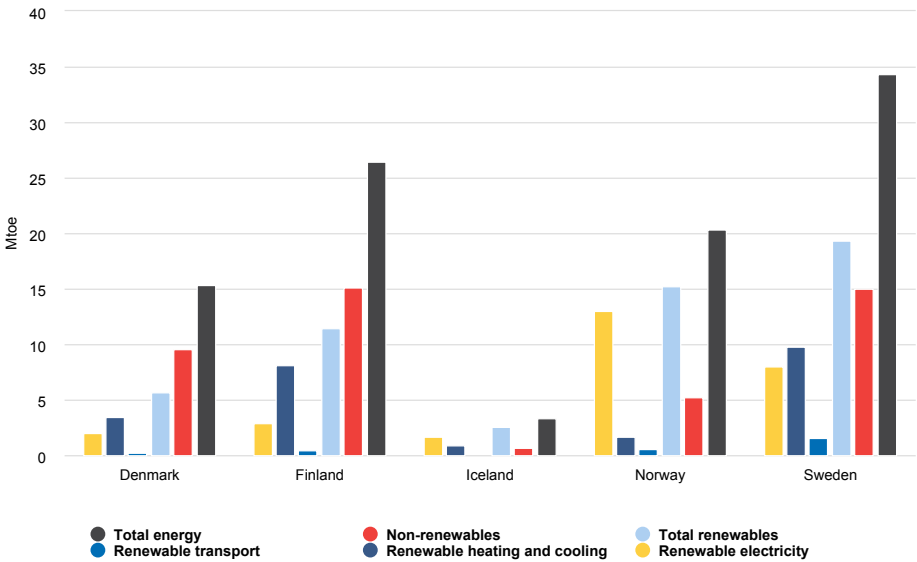


Figure 2-6
Energy consumption in the Nordic countries (Mtoe gross final consumption, 2019)

The Nordic countries consume more energy per capita than the EU average.

On average, Nordic consumers use more energy than their EU counterparts – 3.7 toe per capita in 2019, relative to 2.3. Iceland was the largest Nordic consumer at 9.2 toe per capita, followed by Finland at 4.8, Norway at 3.8, Sweden at 3.4, and Denmark at 2.6. (Figure 2-7).

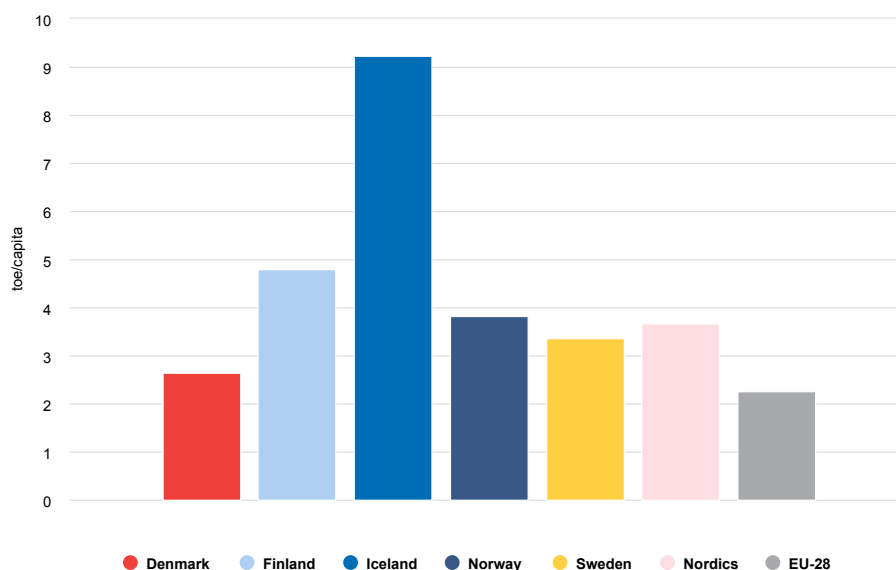


Figure 2-7

Energy consumption in the Nordic countries and EU-28 (toe per capita gross final consumption, 2019)

While relatively high energy consumption per capita in the Nordic region is mainly due to the cold climate, low population density and presence of energy-intensive industry, it also illustrates the energy intensity of the Nordic economies and the importance of energy efficiency measures.

Chapter 3

Renewable energy in the Nordics

Common to all five Nordic countries is a high share of renewable energy consumption, ranging from 36 to 73 percent in 2019, relative to the EU-28 share of 19 percent. Denmark is renowned for its pioneering use of wind energy, Finland and Sweden for bioenergy, Norway for hydropower and Iceland for geothermal energy. This highlights the diversity of the Nordic energy mixes and the benefits of regional integration.

Hydropower provides more than half of all Nordic electricity generated, and is increasingly supplemented with biomass, wind and solar. Heat is primarily produced from electricity, district heating and biomass, all largely generated from renewable energy sources. Deployment of variable renewables, such as wind and solar power, is also an important factor in the green transition of Nordic energy systems.

The electricity sub-sector is driving an increase in renewable energy consumption, followed by heating and cooling, and to a lesser extent, transport.

Total renewable energy consumption in the Nordic region amounted to 54.2 Mtoe in 2019, up 1.5 percent from the previous year. Half went to electricity, 45 percent to heating and cooling, and just 5 percent to transport (Figure 3-1).

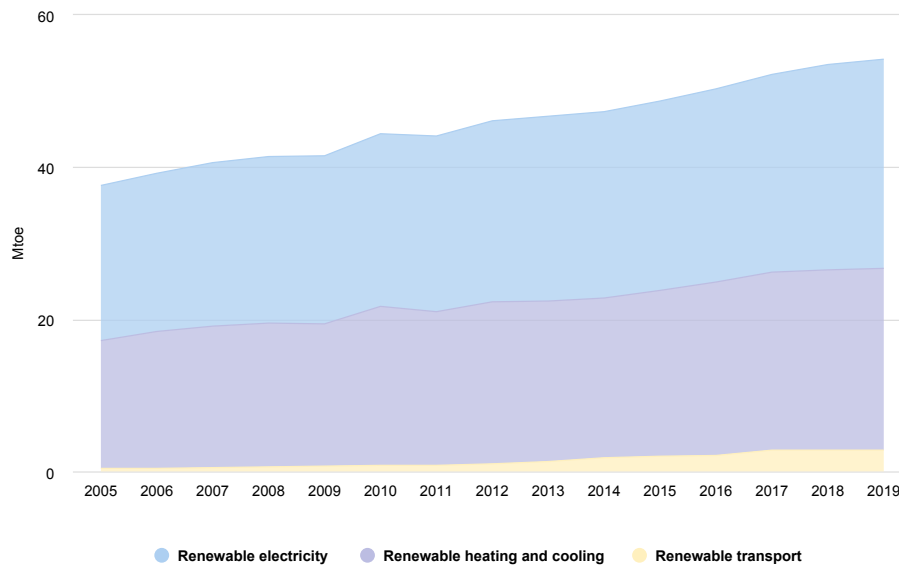


Figure 3-1

Renewable energy consumption in the Nordic countries (Mtoe gross final consumption, 2005-2019)

Nordic renewable energy consumption had an average annual growth of 2.5 percent between 2005-2019, while that of non-renewables fell 2 percent each year on average, in the same period (Figure 3-2).

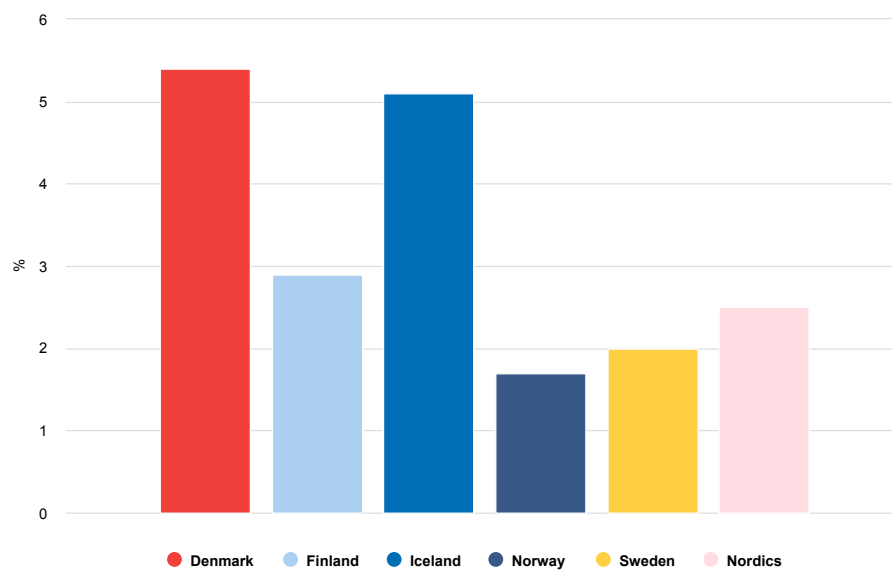


Figure 3-2

Average annual growth in renewable energy consumption in the Nordic countries (% change in gross final consumption, 2005-2019)

Renewable energy consumption has risen rapidly in Denmark and Iceland over recent years.

From 2005 to 2019, Denmark's renewable energy consumption rose more than any other Nordic country, an average 5.3 percent annually, followed by Iceland with 5.1 percent annually. Finland's renewable energy consumption had an average annual growth of 2.9 percent in this period, followed by Sweden at 2 percent, while Norway's consumption rose an average 1.7 percent annually, from a higher baseline.

In absolute terms, Sweden is the largest Nordic energy consumer at 34 Mtoe in 2019 – one third of the region's total. Finland accounted for more than a quarter of Nordic energy consumption, followed by Norway at one fifth, Denmark at one sixth, and Iceland at less than five percent. Sweden was also the largest consumer of renewable energy for heating and cooling and transport, while Norway consumed half of renewable energy used for electricity (Figure 3-3).

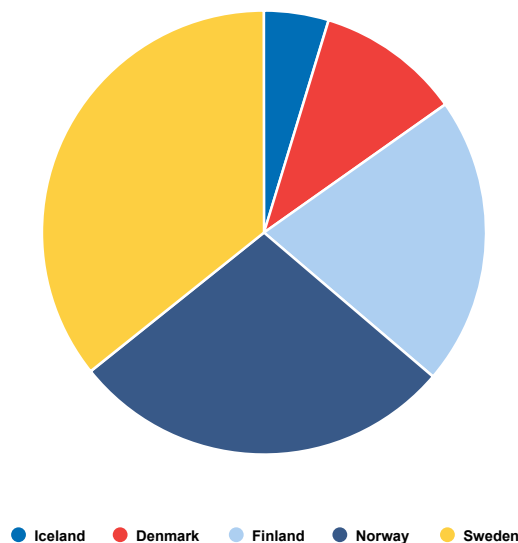


Figure 3-3

Renewable energy consumption in the Nordic countries (% of total Nordic gross final consumption, 2019)

With extensive geothermal resources, Iceland consumes far more renewable energy per capita than the Nordic average – 7.1 versus 2 toe. Norway and Finland consume 2.8 and 2 toe per capita, respectively, followed by Sweden at 1.9 and Denmark at 1. Per capita, the average Nordic consumer uses almost five times as much renewable energy as their EU counterparts (Figure 3-4).

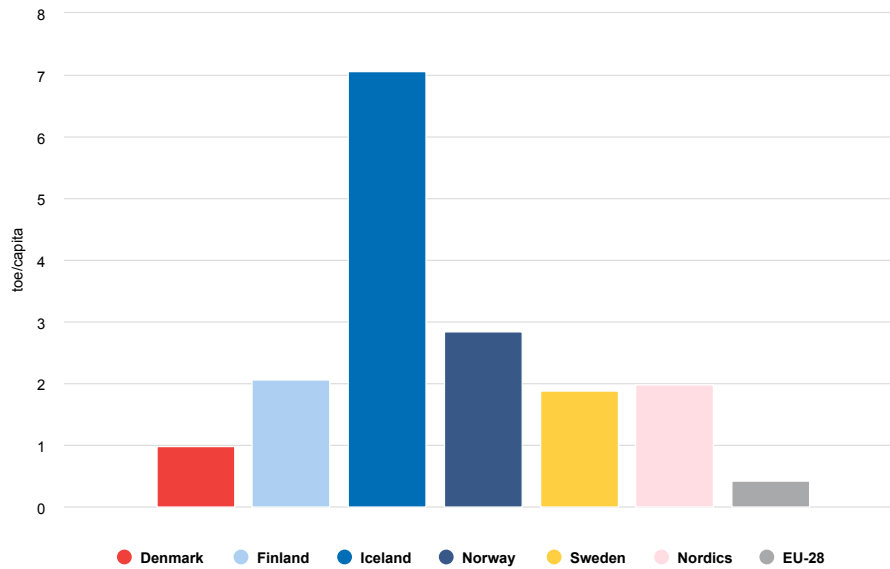


Figure 3-4

Renewable energy consumption in the Nordic countries and EU-28 (toe per capita gross final consumption, 2019)

The Nordic countries are front-runners in taking decisive action toward long-term energy and decarbonisation targets. In Denmark, Finland, Iceland, Norway, and Sweden, renewable energy consumption has grown steadily over the past decade. As the region moves toward a carbon-neutral energy system, renewables are set to remain consistent elements of a changing energy landscape.

Chapter 4

Nordic renewable energy and the EU targets

The RED established legally binding targets for the renewable energy share of final energy consumption in individual member states, including EEA members Norway and Iceland. While the EU had to meet at least 20 percent of its energy needs with renewables before 2020, the Nordic targets were more demanding: 30 percent for Denmark; 38 percent for Finland; 72 percent for Iceland; 67.5 percent for Norway; and 49 percent for Sweden.

Despite this, the Nordic countries met or surpassed their targets two years in advance, while less than half of EU member states were on track. They owe these achievements to the flexibility offered by the region's electricity markets, good starting positions relative to other countries in terms of renewables in the energy mix, and rising demand for carbon-free electricity, heating, and transport.

The renewables share of Nordic energy consumption has remained well above the EU average.

In 2010, the Nordic countries had renewables shares of energy consumption considerably higher than the EU average. From 2010 to 2019, the combined Nordic share rose an average 1.3 percentage points per year – nearly three times the EU's pace – demonstrating how the region would achieve its goals.

In 2019, the renewables share of Nordic energy consumption was three times the EU's – 54 versus 19 percent. However, the gap narrowed since 2005, when the region's share was four times the EU's – 38 versus 9 percent. While the Nordic countries lead, the EU has made gains over time (Figure 4-1).

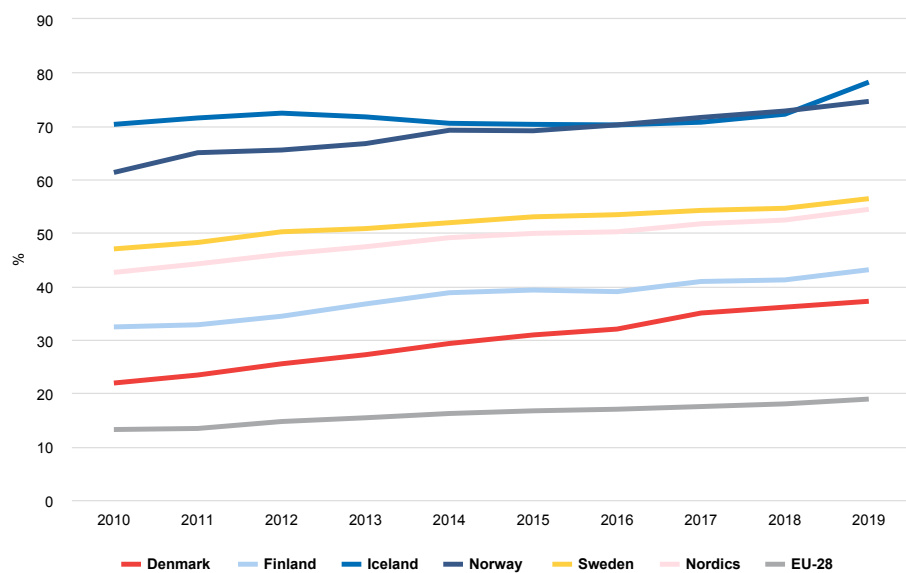


Figure 4-1

Renewables share of energy consumption in the Nordic countries and EU-28 (% gross final consumption, 2005-2019)

Denmark raised its renewables share of energy consumption more than any EU country.

Over the course of a decade, Denmark increased its renewable energy consumption 1.7 percentage-points each year on average, from 22 percent in 2010 to 37 percent in 2019, leading the EU. Among the Nordic countries, Norway follows, having raised its share 1.5 percentage-points each year on average, from a high 61 percent in 2010 to 75 percent in 2019 (Figure 4-2).

Sweden raised its renewables share of energy consumption 1 percentage-point each year on average from 2010 to 2019, while Finland managed 1.2 percentage-points each year on average – both were well above the EU average of 0.6. Iceland had the highest baseline in 2010 of 70 percent, raising its share 0.9 percentage points each year on average up to 2019.

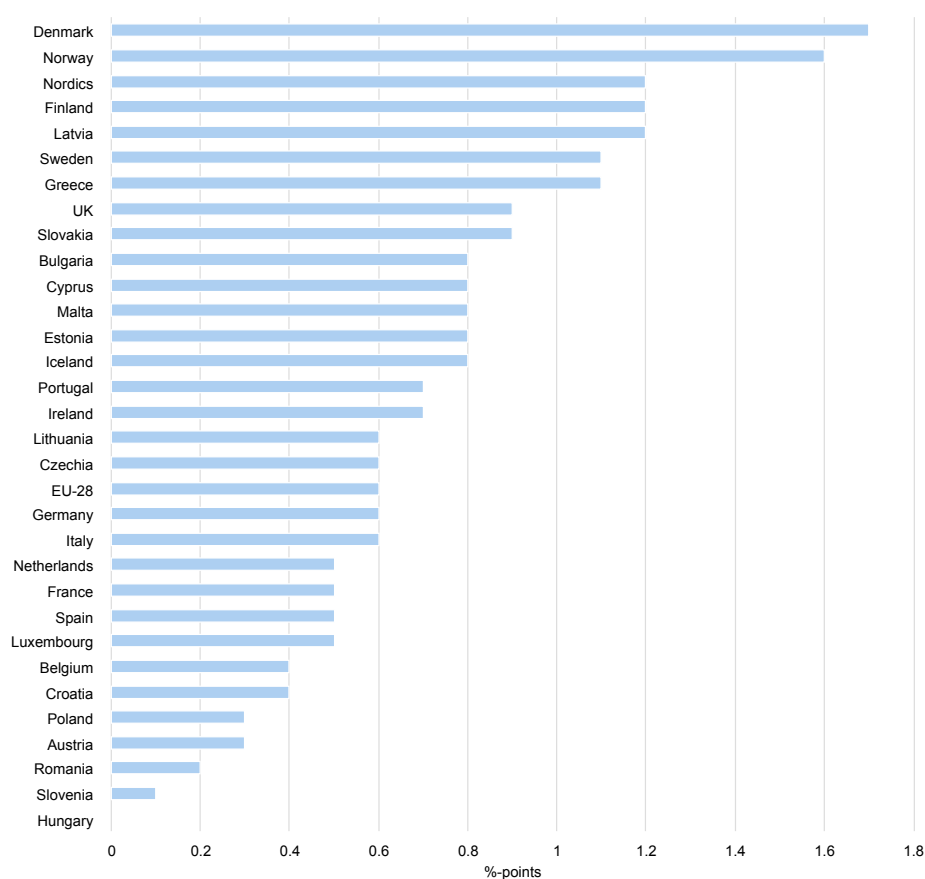


Figure 4-2

Average annual increase in renewables share of gross final energy consumption in the Nordic countries and EU-28 (%-points, 2010-2019)

If the Nordic countries were considered one, it would lead Europe in renewable energy consumption.

Four Nordic countries topped the EU+IN list in 2019 with their shares of renewable energy consumption: Norway at 72.8 percent, Iceland at 72.2 percent, Sweden at 54.6 percent and Finland at 41.2 percent, while Denmark, at 36.1 percent, occupied sixth place (Figure 4-3).

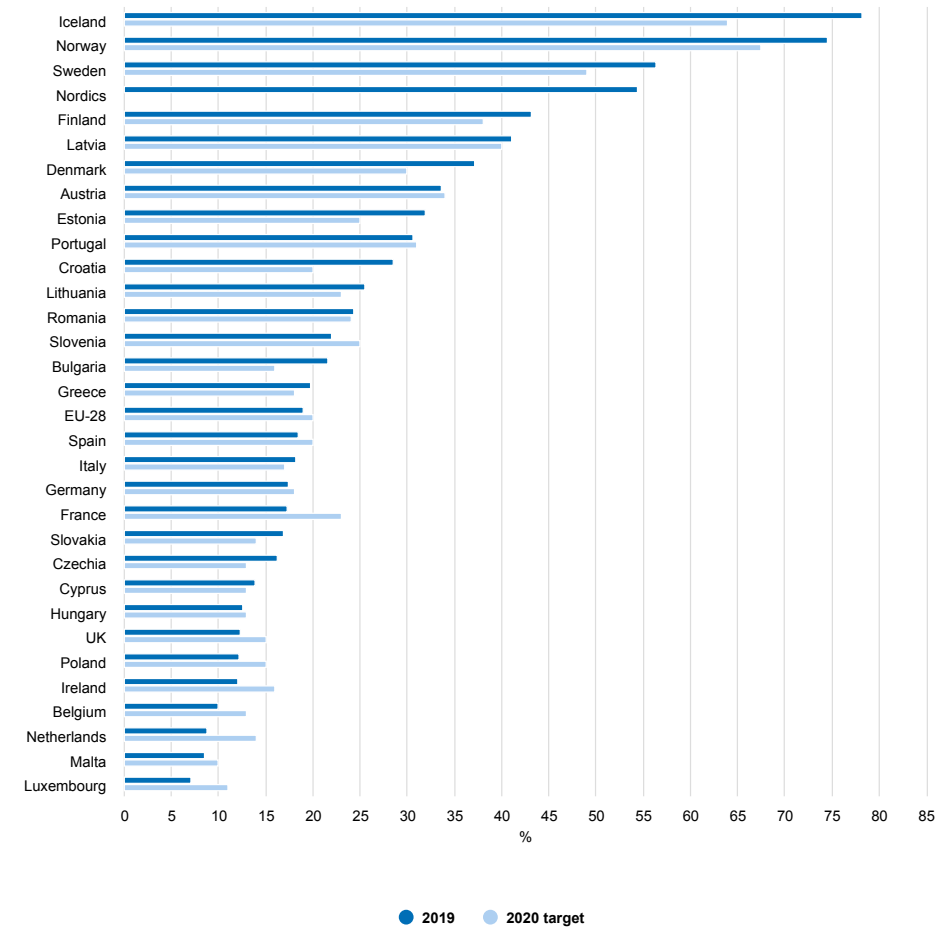


Figure 4-3
Renewables share of energy consumption and 2020 targets in the Nordic countries and EU-28 (% gross final consumption, 2019)

By 2018, two years in advance, all the Nordic countries had already met or surpassed their national 2020 targets established by the EU Renewable Energy Directive (Figure 4-4).

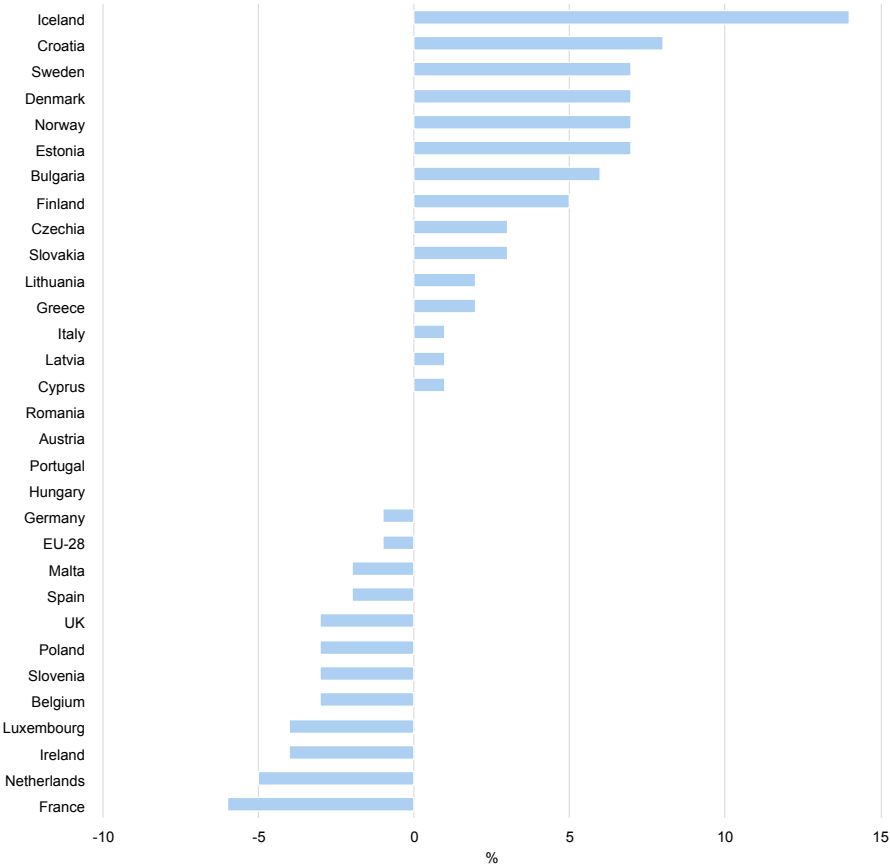


Figure 4-4
Distance to 2020 national target for renewables share of gross final energy consumption in the Nordic countries and EU-28 (%-points, 2019)

All Nordic countries were ahead of their indicative trajectories set out in the NREAPs – Denmark by more than 10 percentage points, Sweden by 8.6, Norway by 8, Finland by 6.4 and Iceland by 2.5 (Figure 4-5).

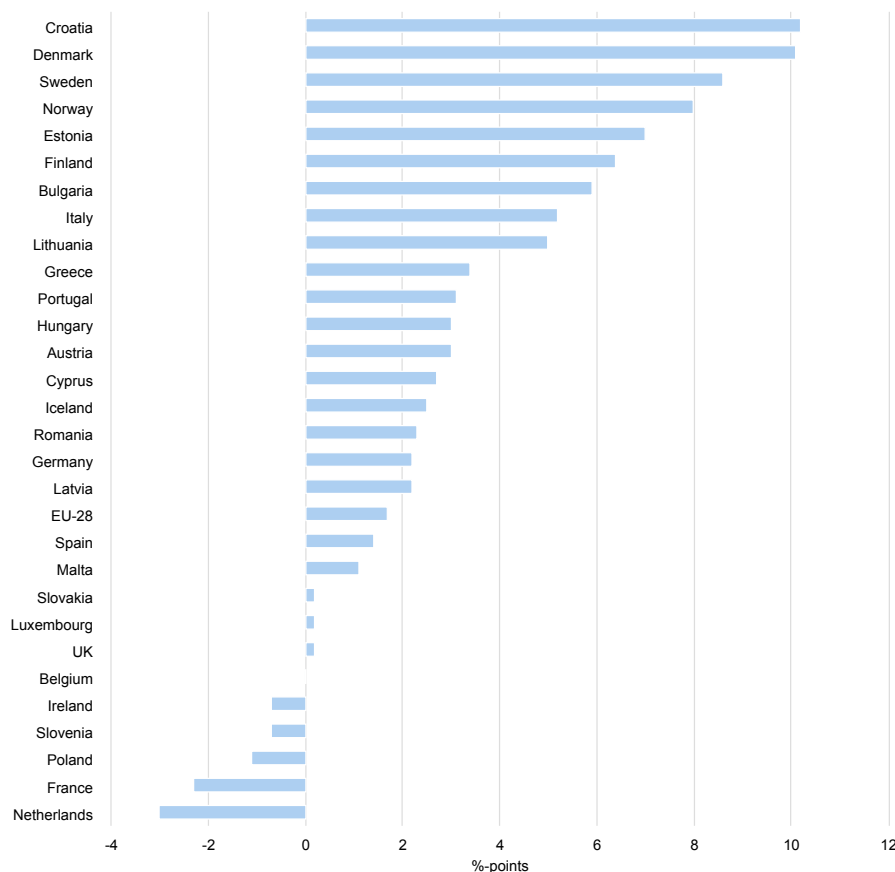


Figure 4-5

Distance to national trajectories for renewables share of gross final energy consumption in the Nordic countries and EU-28 (%-points, 2018)

In 2018, the EU was 1.7 percentage points ahead of its indicative trajectory to reach the 20 percent target by 2020. The bloc needed to increase its renewables share of energy consumption by 1 percentage point each year on average – double the annual average since 2010. Five EU countries were behind their 2020 trajectories at the time.

Chapter 5

Renewable electricity

The Nordic electricity system is a world leader in regional coupling of electricity grids. Interconnectors and transmission lines link countries across land and sea, while a common spot market ensures efficient trade across subnational price zones. This co-operation increases security of supply, lowers system costs and facilitates the integration of renewables. Clean electricity exports help displace emission-intensive power generation in neighbour countries, and dispatchable hydropower provides balancing services for variable renewables. In this regard, the Nordic electricity system plays a role in achieving EU climate targets.

The share of electricity from renewable energy sources is defined as the ratio between electricity produced from renewable energy sources and gross national electricity consumption. As stipulated in the Renewable Energy Directive 2009/28/EC, gross final consumption of electricity from renewable sources is the electricity produced from renewable energy sources. Hydropower plants⁴ are included, as well as electricity generated from biomass⁵ and waste, wind, solar and geothermal. Electricity production from wind and hydropower is accounted according to normalisation rules of Annex II of Directive 2009/28/EC.

Electricity consumption has remained stable in the region, as the mix is increasingly renewable and rapidly approaching carbon-neutrality.

Overall, Nordic electricity consumption has remained stable since 2005, at just above 400 TWh. With 418 TWh consumed in 2019, the region needed less electricity relative to 2010 (Figure 5-1).

4. Excluding hydropower electricity produced from pumped storage plants using water previously pumped uphill.
5. Including solid biofuels derived directly or indirectly from [biomass](#).

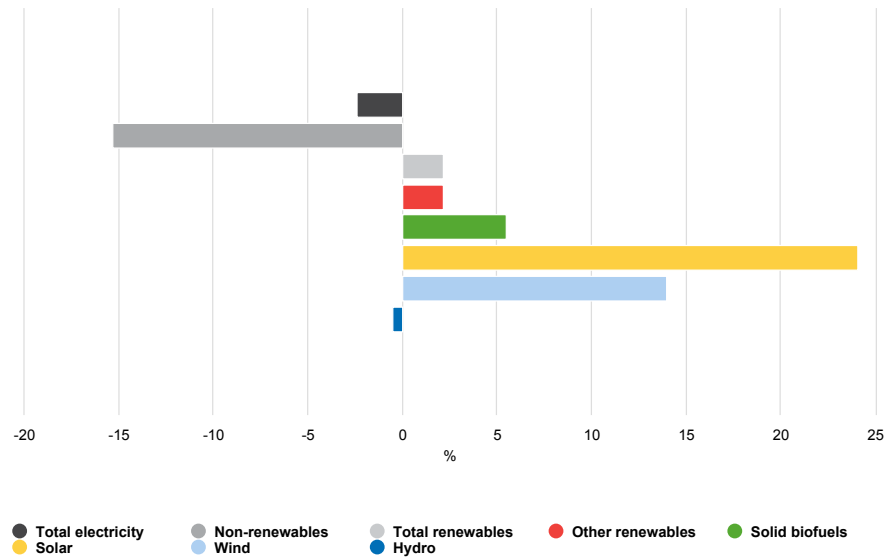


Figure 5-1

Nordic electricity consumption by energy technology (TWh gross final consumption, 2005-2019)

The Nordic countries continued adding renewables to the electricity mix in 2019. While overall consumption declined more than two percent relative to 2018, the renewables share rose while that of non-renewables fell. The most significant change was in consumption of solar-generated electricity which increased more than 24 percent from 1.5 to 1.8 TWh in 2019. Wind electricity consumption rose 14 percent (42.6 to 48.6 TWh), and biomass 6 percent (26.4 to 27.9 TWh), while the hydropower share remained about the same at around 235 TWh, dominating Nordic electricity consumption. (Figure 5-2).

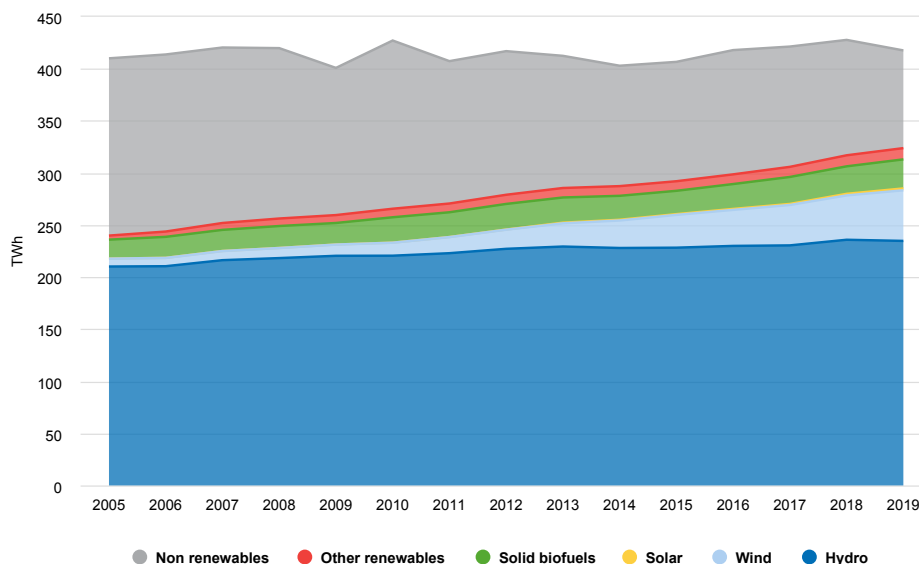


Figure 5-2

Change in Nordic electricity consumption (% change in gross final consumption, 2018-2019)

Factoring in nuclear energy in Finland and Sweden, which contributes around 30 percent and 40 percent to their respective power supply⁶, the overall share of fossil-free electricity in the Nordic region stands at about 98 percent of final consumption – a solid basis for a carbon-neutral energy system that encompasses transport and heating.

The Nordic region meets more than three quarters of its electricity needs with renewables, relative to the one third share of the EU-28.

The 2009 EU Renewable Energy Directive did not establish a sectoral target for the share of renewables in the electricity mix. However, the NREAPs submitted by EU Member States imply a renewable electricity share of 34.3 percent in 2020, up from 14.8 percent in 2005. By the end of 2019, the EU-28 share was 34.2 percent, virtually reaching the level indicated in the NREAPs. The renewables share of Nordic electricity consumption was 78 percent in 2019, up from 62 percent in 2010 (Figure 5-3).

6. According to the Swedish Energy Agency and Finnish Energy.

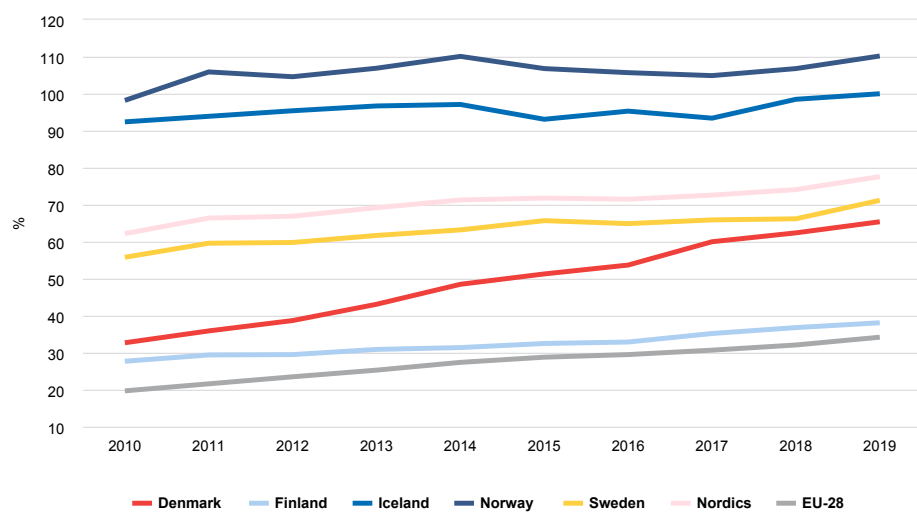


Figure 5-3

Renewables share of electricity consumption in the Nordic countries and EU-28 (% gross final consumption)

If the Nordic countries were considered one, it would have the highest renewable electricity share of any European country, nearly double the EU average. In 2019, Nordic countries occupied four of the top-5 positions for renewable electricity consumption in Europe. Norway produces more renewable electricity than it consumes, and Iceland's electricity mix is also in practice fully renewable⁷ (Figure 5-4).

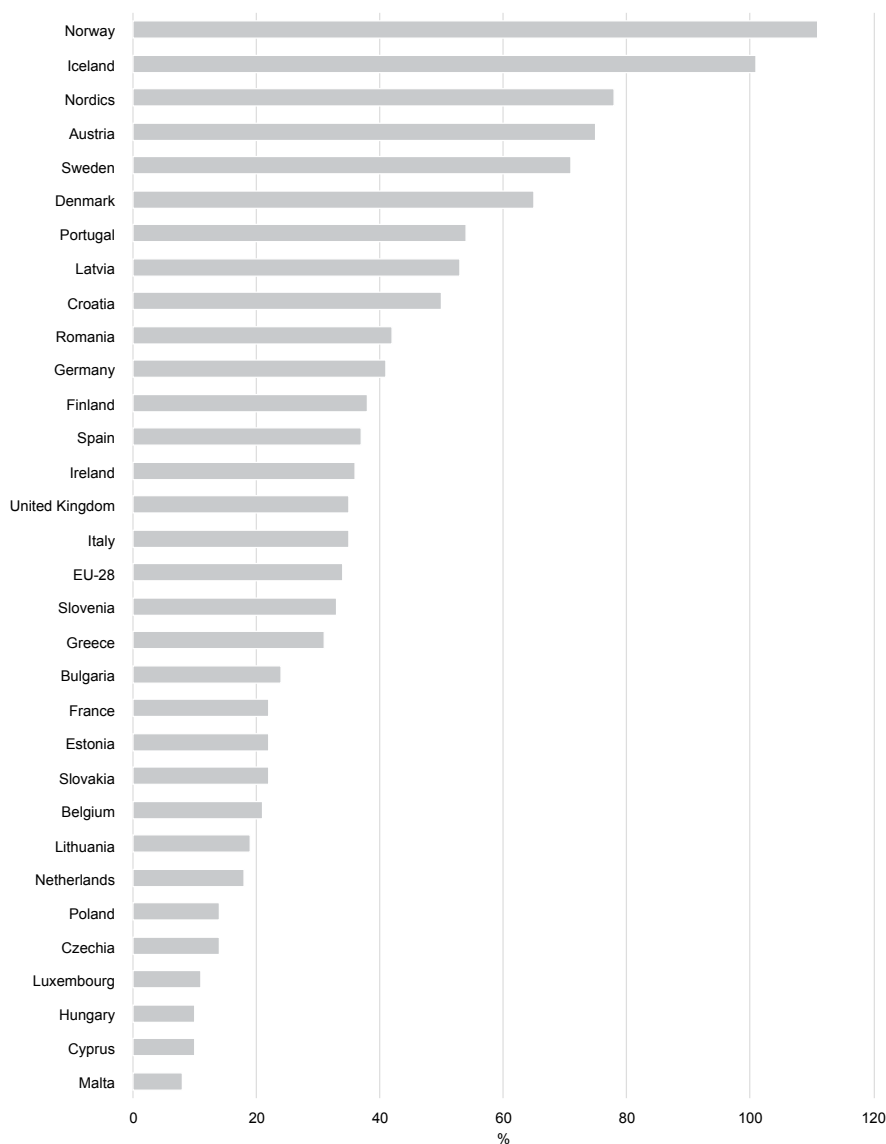


Figure 5-4

Renewables share of electricity consumption in the Nordic countries and EU-28 (% gross final consumption, 2019)

7. Government of Iceland 2021, Ministry of Industries and Innovation, Hydro Power Plants. <https://www.government.is/topics/business-and-industry/energy/hydro-power-plants/>

Wind, solar and hydropower are driving the rise in renewable electricity consumption.

Renewable electricity consumption has risen 58 TWh (22 percent) since 2010, to 324 TWh in 2019, while non-renewable electricity consumption fell 68 TWh, mainly due to Denmark and Finland having curbed reliance on coal and gas over the last decade. A rise in electricity consumption from wind (36 TWh or 288 percent) and hydropower (14 TWh or 6 percent) made up for the fall in non-renewables. Electricity consumption from biomass has remained relatively stable since 2010 at around 25 TWh, while solar power consumption doubled since 2016 to 1.8 TWh (Figure 5-5).

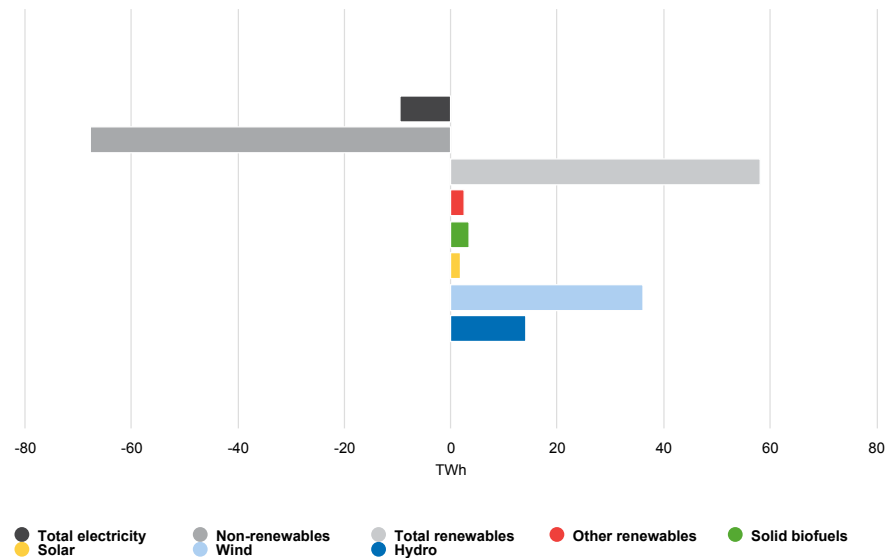


Figure 5-5

Change in Nordic electricity consumption (TWh gross final consumption, 2010-2019)

From 2010-2019, Nordic renewable electricity consumption had an average annual growth of 2 percent. Meanwhile, non-renewable electricity consumption fell 5 percent each year on average, while overall electricity consumption remained virtually unchanged (Figure 5-6).

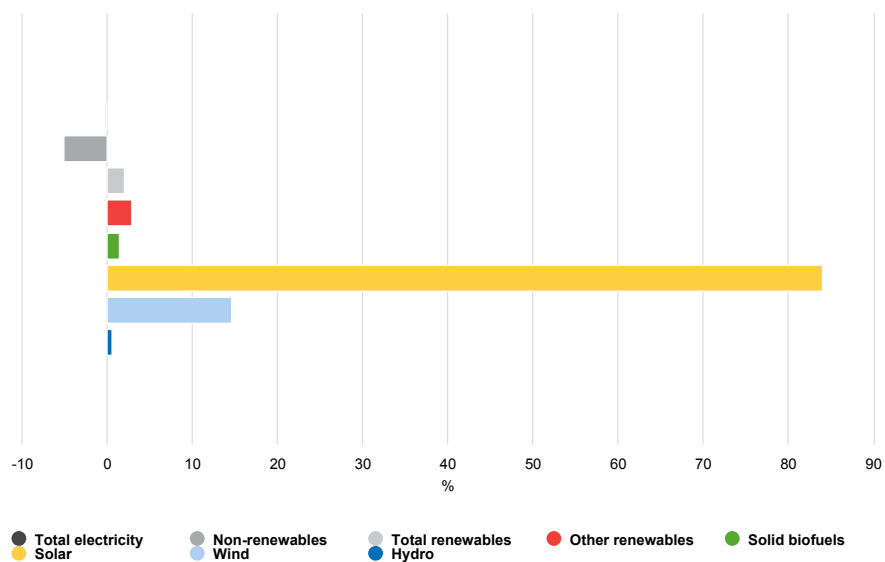


Figure 5-6

Average annual growth in Nordic electricity consumption by energy technology (% gross final consumption, 2010-2019)

Solar-generated electricity consumption grew more than any other energy source, 84 percent each year on average, albeit from a low base of just 1.7 TWh in 2010. Wind electricity consumption increased from 13 TWh in 2010 to 49 TWh in 2019 – with an average annual growth of 15 percent. Consumption of “other renewables” grew 3 percent each year on average, driven by Icelandic geothermal energy, while that of hydropower and biomass both grew about 1 percent each year on average in the same period.

In 2019, the Nordics accounted for the equivalent of 29 percent of all renewable electricity consumed in the EU. The Nordic share of renewable electricity consumption (78 percent) is almost three times the global share (28 percent)⁸ and more than twice the EU share of 34 percent. All Nordic countries have a share of renewable electricity consumption well above the EU average (Figure 5-7).

8. IEA (2020), Global Energy Review 2020, IEA, Paris.

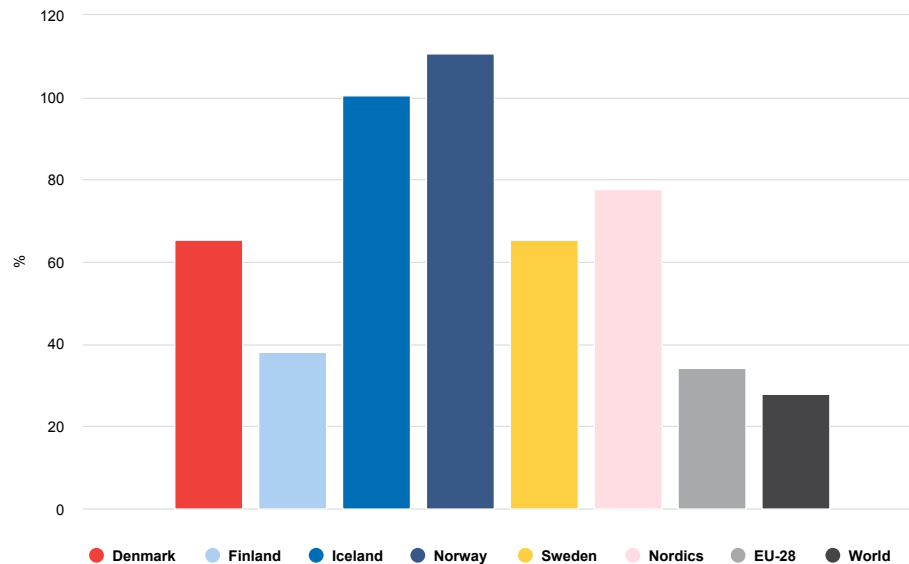


Figure 5-7

Renewables share of electricity consumption in the Nordic countries, EU-28, and World* (% gross final consumption, 2019)

Nordic electricity systems are highly based on renewables or nearly carbon-neutral by other means.

Norway, with its hydropower resources, and Iceland with its geothermal energy, have electricity systems that are in practice fully based on renewables. While Sweden consumes 41 TWh of non-renewables, this is almost exclusively nuclear power, making the country nearly carbon-neutral when it comes to electricity.

Norway and Sweden each accounted for over 140 TWh annually, making them the largest electricity consumers in the region. Norway has the highest share of renewables, drawing almost exclusively on hydropower (140 TWh), but with a growing role for wind. The electricity consumption of Finland (89 TWh), Denmark (35 TWh) and Iceland (20 TWh) combined almost equalled that of Norway (Figure 5-8).

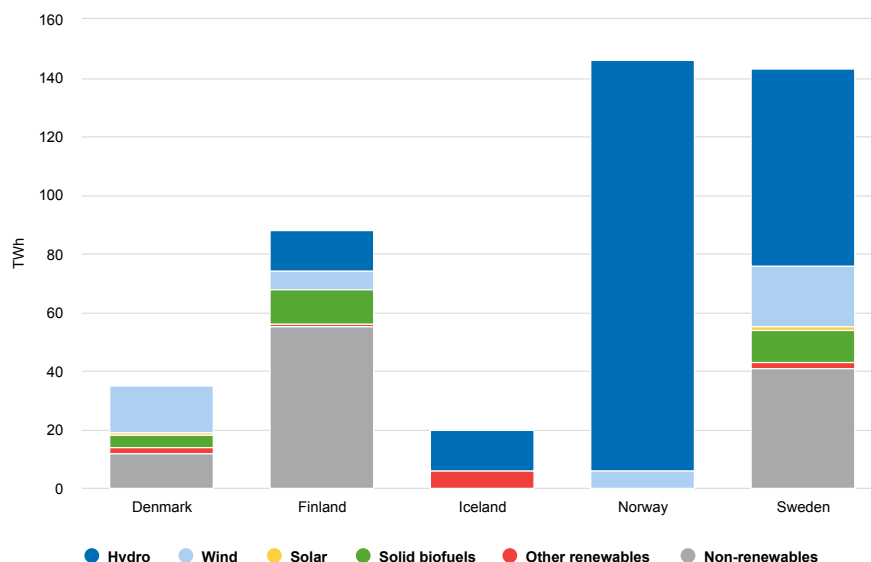


Figure 5-8

Nordic electricity consumption by energy technology (TWh gross final consumption, 2019)

The non-renewable share of Finland's electricity consumption is mostly made up of nuclear power and minor shares of coal and gas. The country imports electricity in the order of 20 TWh annually⁹ from Nordic electricity markets, the Russian Federation, and Estonia. Denmark imports some 5 TWh of electricity annually, including nuclear and hydropower from the Nordic markets¹⁰, with non-renewable electricity consumption primarily attributed to coal from Germany. Iceland's renewable electricity mix is made up of 14 TWh of hydropower and 6 TWh of "other renewables" – largely geothermal energy.

At 235 TWh, hydropower is by far the largest contributor to the region's electricity mix, making up three quarters of renewable electricity consumption, and more than half of overall electricity consumption. Wind power makes up 12 percent (42 TWh) of Nordic renewable electricity consumption, followed by biomass at 7 percent (24 TWh), solar at less than one percent (1.6 TWh) and "other renewables" at 3 percent (11 TWh) – mainly Icelandic geothermal power. Non-renewables provide for 22 percent of Nordic electricity consumption (94 TWh) (Figure 5-9).

9. Statistics Finland. Total consumption of energy increased by 2 per cent in 2018. Published: 28 March 2019.

10. Due to its electricity imports, Denmark consumes hydropower despite domestic production being near zero, and part of its electricity consumption comes from nuclear power despite the country having no nuclear power stations.

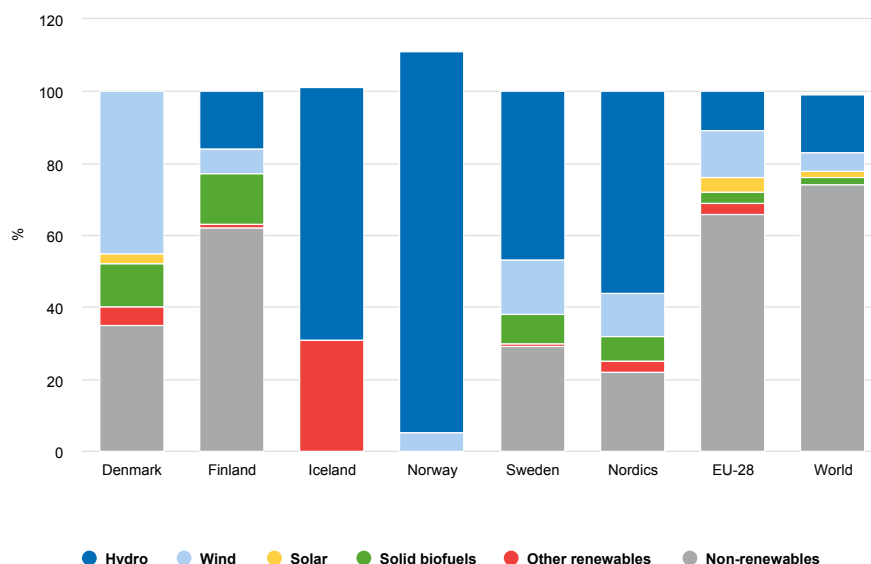


Figure 5-9

Nordic, EU, and Global electricity mix (% gross final consumption, 2019)

* Note that in the case of Norway the renewable electricity share exceeds 100 percent, implying that the country is a net-exporter of electricity generated from renewable sources.

The Nordic countries differ in the energy technologies used in their respective electricity mixes.

To some extent, renewable energy technologies reflect the natural resource endowments of each nation. Denmark, the southern-most Nordic country, consumes nearly half of the region's solar-generated electricity (1 TWh); Finland, with its large forest industry, accounts for 44 percent of biomass consumption (12 TWh); Iceland relies on geothermal sources, using more than half of "other renewables" in the Nordics (6 TWh); Drawing on its domestic water resources, Norway consumes 60 percent of all hydropower (140 TWh); Sweden consumes the most wind power (21 TWh) – 43 percent of the region's total.

In a European and global context, the Nordic countries have high shares of renewables in the electricity mix. The region's share of hydropower consumption is five times the EU's, while that of biomass is twice the EU's and three times the global share¹¹. The Nordic wind power share is 12 percent – more than double the global share, and close to the EU's 13 percent.

The region's high levels of renewable electricity consumption are largely attributable to hydropower, which – excluding Denmark – makes up a significant part of each country's electricity mix. On the other hand, Denmark has the highest share of wind power consumption in the world, having met at least 45 percent of national electricity demand in 2019 – about two thirds from onshore and one third from offshore wind.

11. IEA (2020), Electricity Information: Overview, IEA, Paris.

Chapter 6

Renewable heating and cooling

District heating systems, often based on renewables, cover most residential heating services in Denmark, Finland, and Sweden, and serve as a complementary technology to variable renewables, offering the flexibility to switch between fuels. In Norway, district heating is a useful supplement to electric heating generated from abundant hydropower. Over 90% of homes in Iceland are heated with direct geothermal. The number of Nordic suppliers of district cooling is on the rise, with most also supplying district heating.

Renewable energy in heating and cooling is defined as i) *final energy consumption* of compliant bioliquids or renewable energies other than electricity, heat and bioliquids in sectors other than transport; *derived heat* produced from geothermal, solar thermal, renewable municipal waste, solid biofuels, biogas and compliant bioliquids, or biogas blended in the natural gas network; and renewable energy from *heat pumps*. The RED does not set a sectoral target for the share of renewable energy in heating and cooling.

More than half of energy consumed in Nordic heating and cooling is renewably sourced.

The Nordic countries consumed almost 42 Mtoe of energy for heating and cooling in 2019 – approximately 42 percent of the region's overall energy consumption, with about a quarter of this total being sourced from renewables (Figure 6-1).

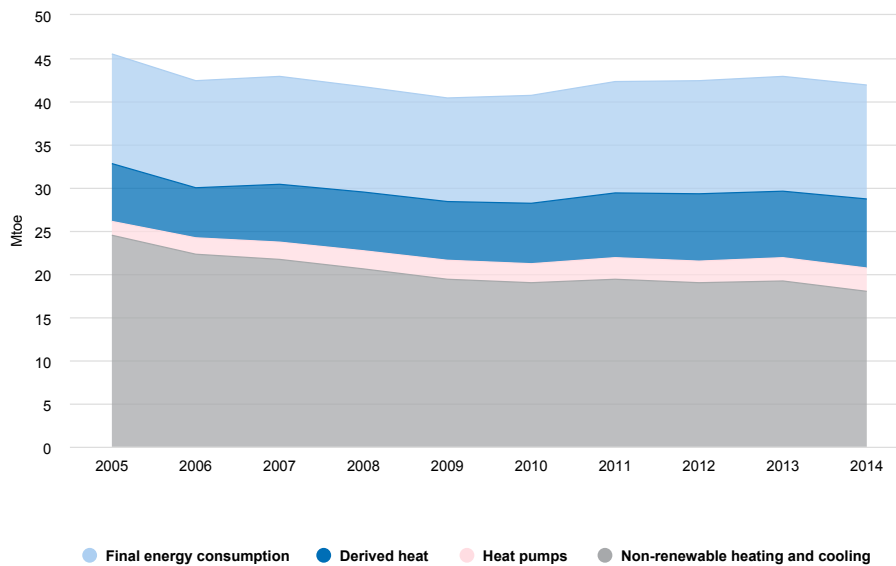


Figure 6-1

Energy used for heating and cooling in the Nordic countries (Mtoe gross final consumption, 2010-2019)

While Nordic energy consumption in heating and cooling fell two percent from 2018 to 2019, the larger renewables share rose 1 percent, and the smaller non-renewables share fell 6 percent. Energy consumption in Nordic heat pumps and derived heat both rose 3 percent (Figure 6-2).

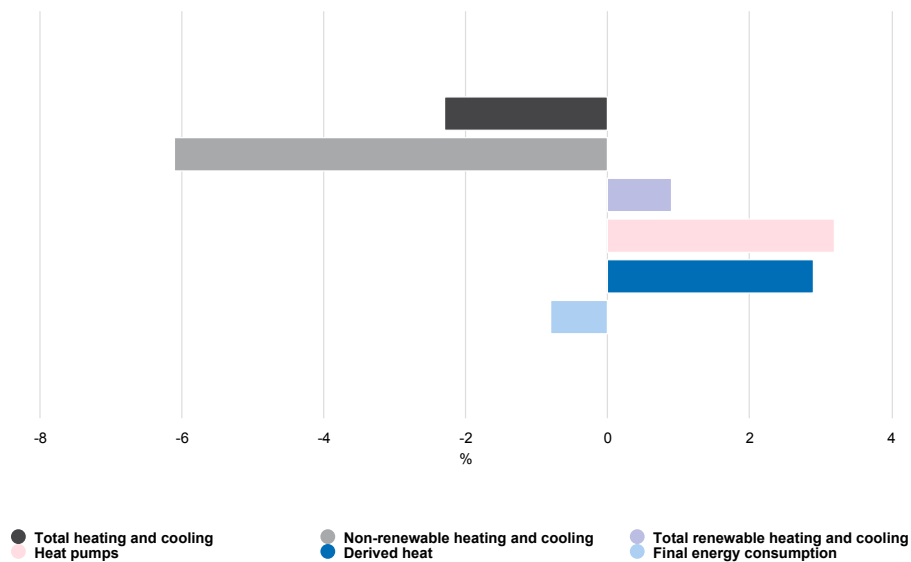


Figure 6-2

Change in energy use for heating and cooling in the Nordic countries (% change in gross final consumption, 2018-2019)

In 2019, 57 percent of Nordic energy consumption in heating and cooling was renewably sourced, up from 46 percent in 2010. The EU's share was about 21 percent, up from 16 percent in 2010 (Figure 6-3).

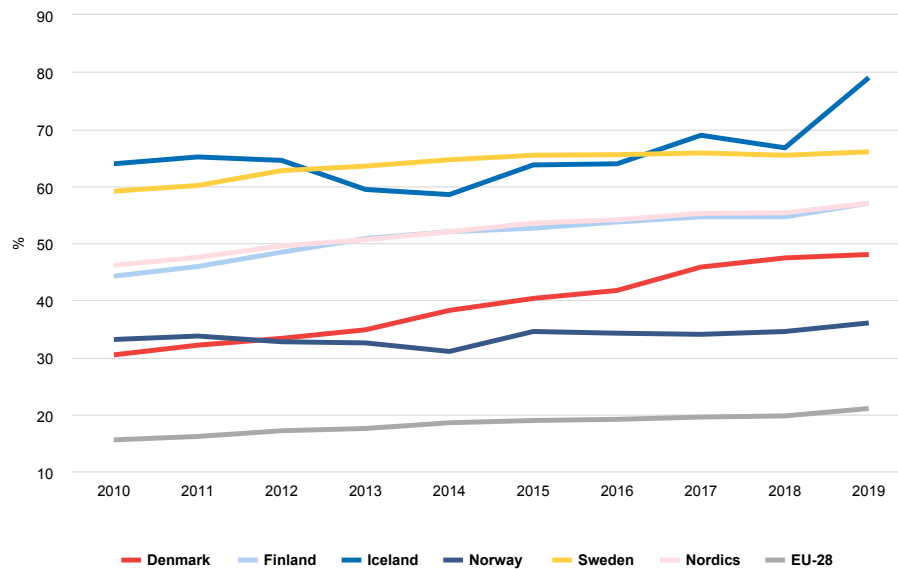


Figure 6-3

Renewables share of energy used for heating and cooling in the Nordic countries and EU-28 (% gross final consumption, 2010-2019)

All Nordic countries derive more than one third of their heating and cooling from renewables; Sweden, two thirds and Iceland nearly 80 percent.

All Nordic countries are above the EU average when it comes to renewable energy in heating and cooling, with Iceland and Sweden having the highest shares in Europe in 2019. If the Nordic countries were considered one, it would have the second highest share of renewable energy used for heating and cooling in Europe, after Latvia (58 percent), which consumes large amounts of sustainable biomass (Figure 6-4).

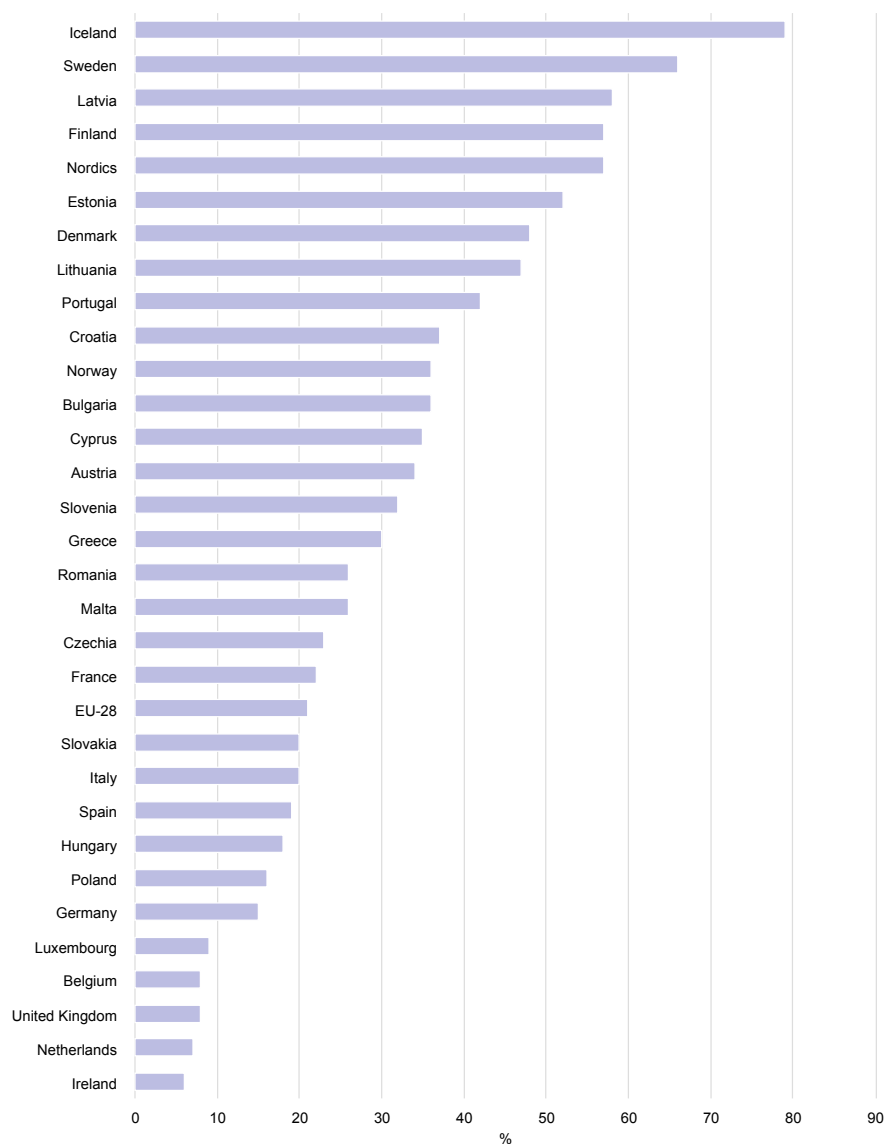


Figure 6-4

Renewables share of energy used for heating and cooling in the Nordic countries and EU-28 (% gross final consumption, 2019)

Overall, Nordic energy consumption in heating and cooling declined almost 8 percent (3,538 ktoe) between 2010 and 2019. However, the renewables share rose 14 percent, while the non-renewables share fell 27 percent in this period, with heat pumps (1,182 ktoe) and derived heat (1,246 ktoe) contributing most to the increase (Figure 6-5).

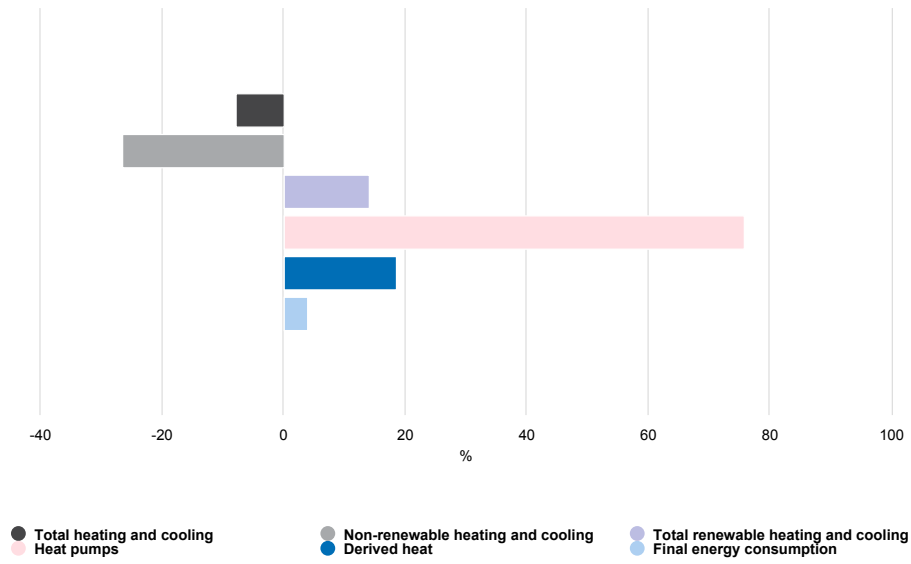


Figure 6-5

Change in energy use for heating and cooling in the Nordic countries (% change in gross final consumption, 2010-2019)

Due in part to the cold climate and widespread district heat networks, the Nordic countries consume far more renewable energy per capita for heating than the EU average.

In 2019, Nordic energy consumption in heating and cooling was 1.53 toe per capita, versus 1 toe EU-wide. Finland and Sweden each accounted for more than one third of Nordic energy consumed in heating and cooling, followed by Denmark at 17 percent, Norway at 11 percent and Iceland at 3 percent (Figure 6-6).

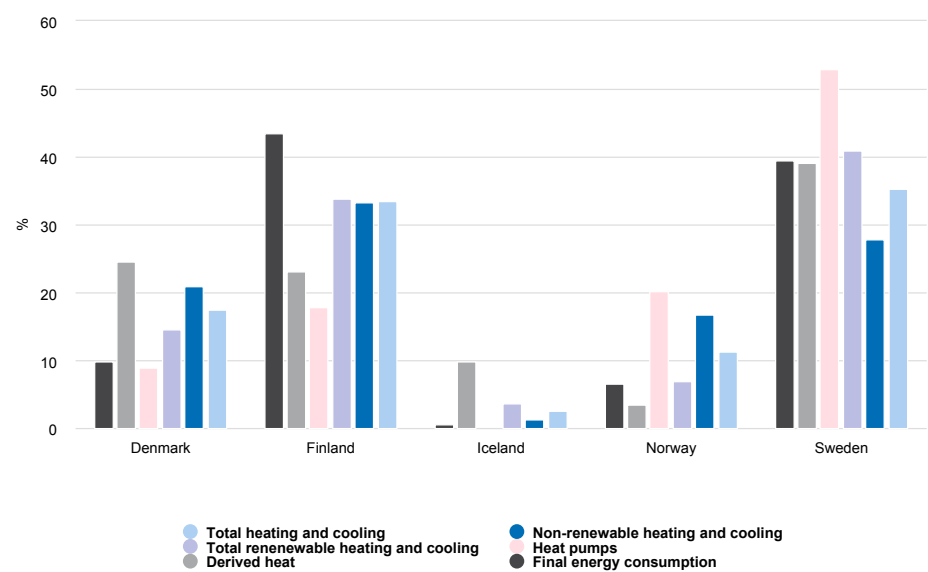


Figure 6-6
Energy used for heating and cooling in the Nordic countries (% total Nordic gross final consumption, 2019)

In absolute terms, Sweden is the largest Nordic consumer of renewable energy in heating and cooling, at 9.7 Mtoe, followed by Finland at 8 Mtoe and Denmark at 3.5 Mtoe. Per capita, Iceland and Finland consume the most renewable energy for heating and cooling in the region. According to the RED, renewable energy in heating and cooling does not include electricity, and since Norway’s hydropower has fostered electric heating, its energy consumption in this sub-sector appears relatively low (Figure 6-7).

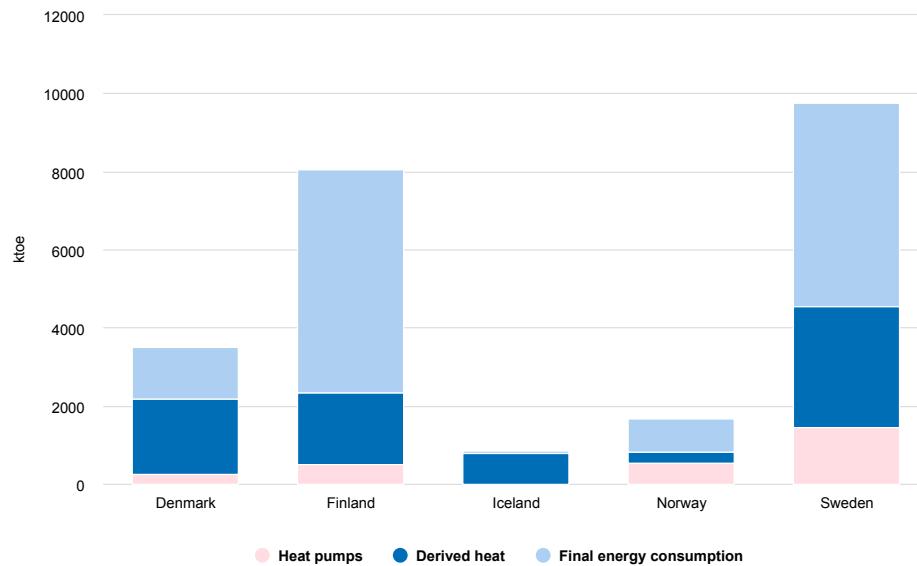


Figure 6-7

Renewable energy used for heating and cooling in the Nordic countries (ktoe gross final consumption, 2019)

Per capita, Nordic consumers use more than four times as much renewable energy in heating and cooling than their EU counterparts – 0.86 toe versus 0.2 toe in 2019 (Figure 6-8).

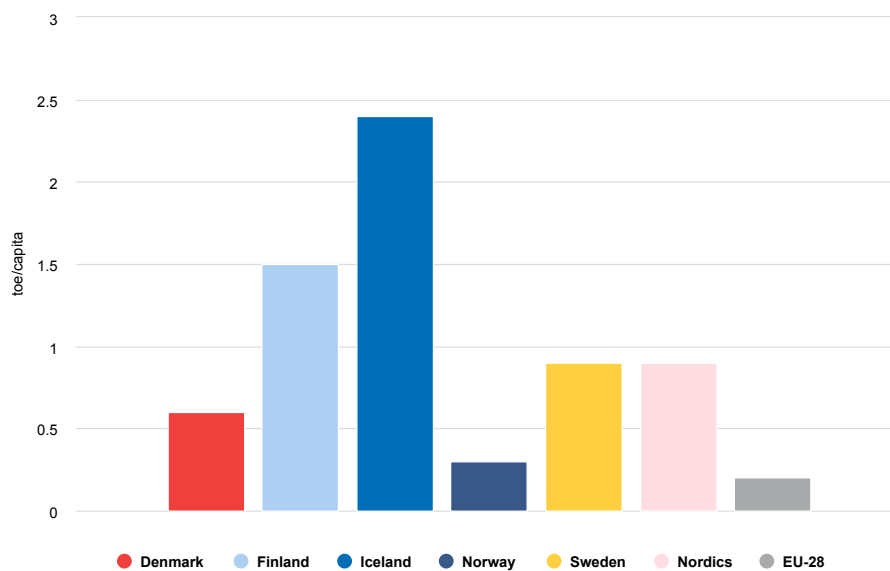


Figure 6-8

Renewable energy used for heating and cooling in the Nordic countries and EU-28 (toe per capita gross final consumption, 2019)

In 2019, heat pumps accounted for 7 percent and derived heat 19 percent of Nordic renewable energy consumption in heating and cooling, versus the EU's 3 percent shares in both categories (Figure 6-9).

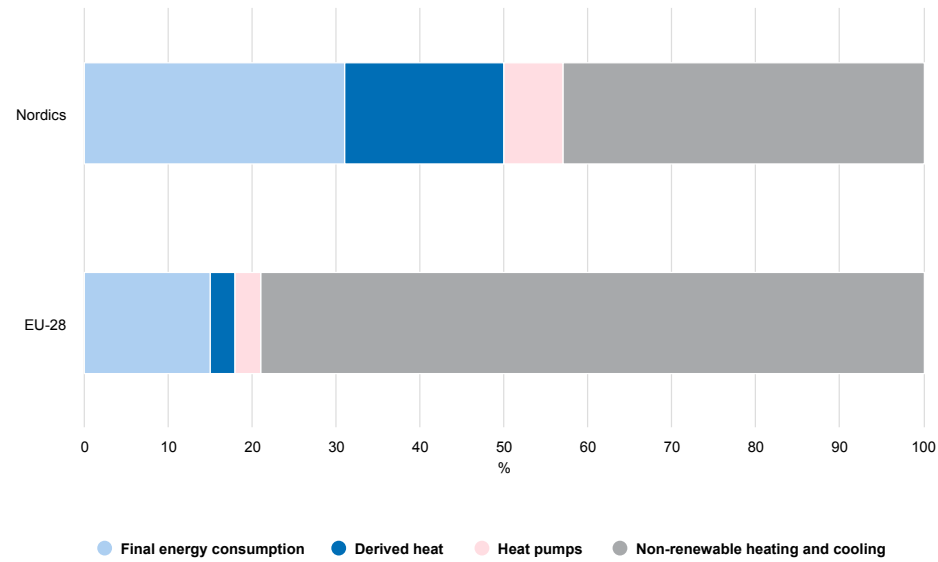


Figure 6-9
Renewable energy used for heating and cooling in the Nordic countries and EU-28 (% gross final consumption, 2019)

While about one fifth of energy consumed in heating and cooling EU-wide was renewably sourced in 2019, nearly 80 percent of the bloc's heating and cooling needs were met with natural gas, coal, oil products and non-renewable electricity (Figure 6-10).

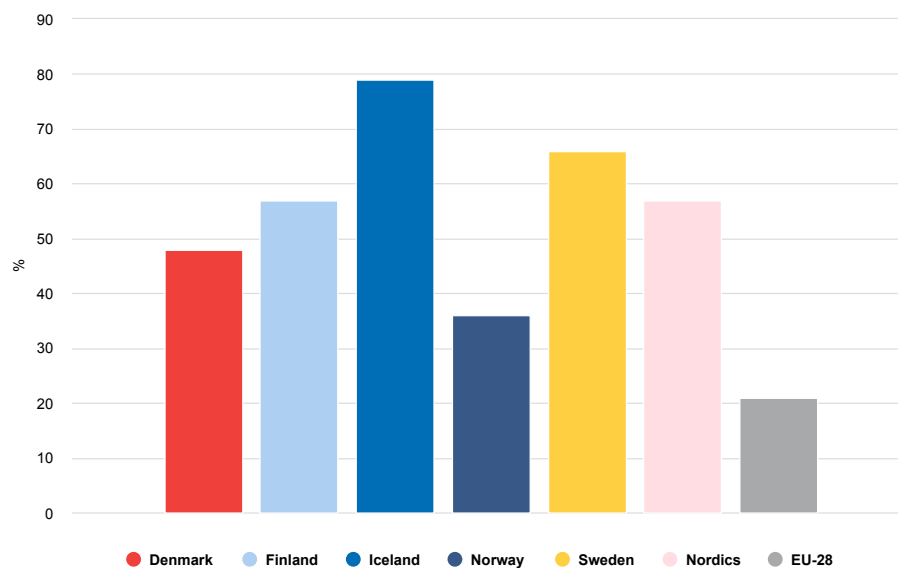


Figure 6-10

Renewables share of energy used for heating and cooling in the Nordic countries and EU-28 (% gross final consumption, 2019)

Heating and cooling are crucial to the EU's energy transition and its ambition to become a carbon-neutral economy by 2050. Buildings and industry still account for about half of the bloc's energy consumption in heating and cooling, making it the largest energy end-use sector, ahead of electricity and transport.

Chapter 7

Renewable transport

Transport remains a pressing challenge for the decarbonisation of Nordic energy systems, due to increased demand to move people and goods, and continued reliance on fossil fuels. However, progress has been made across the region, for example, on the deployment of electric vehicles in Norway, use of sustainable biofuels in Sweden and Finland, installation of shore power for vessels in Icelandic harbours, and electrification of the main rail lines in Denmark.

The RED established a national, binding sub-target for transport, mandating that all EU countries, as well as EEA-countries Norway and Iceland, reach a minimum 10 percent share of renewable energy use in transport by 2020. To stimulate certain types of renewable transport, the RED allows for multipliers when calculating national shares of renewable energy used in transport¹². Renewable electricity in electric road vehicles counts 2.5 times the energy content of the electricity input. Compliant biofuels that meet the Directive's sustainability criteria can be counted towards the target for renewable energy in transport.

Biofuels are the main renewable energy source in Nordic transport.

Globally, biofuels remain the dominant renewable energy option for transport, and the Nordic countries are no exception. Finland and Sweden have set specific renewable energy and CO₂ reduction targets for transport and are investing in biofuels to fulfil these ambitions. Sweden aims to reduce transport emission 70 percent by 2030 relative to 2010 levels, and the share of biofuels used in Finland's road traffic will be raised to 30 percent by 2030. Both countries benefit from large pulp and paper industries and forests as substantial natural resources.

The Nordic region accounts for almost 14 percent of sustainable biofuels consumed in transport EU-wide. In 2019, sustainable biofuels made up 56 percent (1.6 Mtoe) of renewable energy and 13 percent of total energy consumed in Nordic transport (Figure 7-1).

12. Renewable electricity in electric road vehicles counts 2.5 times the energy content of the renewable electricity input and the contribution of biofuels produced from wastes, residues, non-food cellulosic material, and ligno-cellulosic material is considered to count double that of other biofuels towards the target. Therefore, the sum of the individual technologies does not equal the total denominator in the calculation of the renewable energy share in transport.

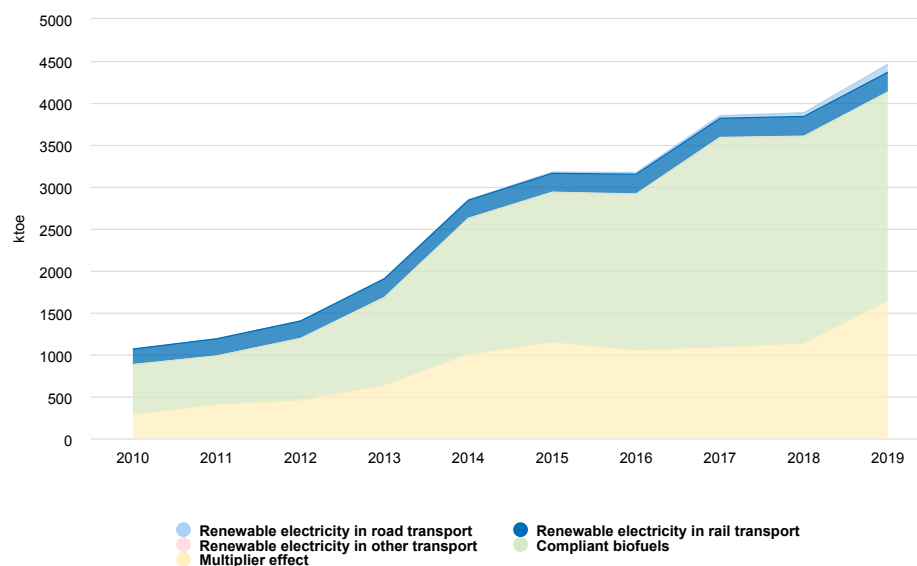


Figure 7-1

Renewable energy used for transport in the Nordic countries (ktoe gross final consumption, 2010-2019)

Renewable electricity in road transport made up less than 1 percent of the Nordic energy mix for transport in 2019, while the share of renewable electricity in rail transport was 1.2 percent. The share of renewable electricity in other transport modes¹³, such as aviation and domestic maritime navigation, was negligible at less than half a percent. The effect of the multipliers made up just over 8 percent of total energy consumed in Nordic transport.

Transport has proven difficult to decarbonise but has considerable potential for renewable energy.

While vehicle electrification is a viable option for road and rail transport, technical barriers limit direct electrification of other transport modes, such as aviation or shipping, due to the high energy densities required.

One potential solution is to convert renewable energy into processed hydrogen, using electrolyzers and electricity (Power-to-X) to provide an energy carrier to replace fossil fuel in transport, particularly for heavy-duty and long-distance applications. In July 2020, the European Commission adopted a dedicated hydrogen strategy¹⁴, in parallel with the strategy on energy system integration. As such, renewable energy can yet play a critical role in Europe's transition to carbon-neutral transport.

Total energy consumption in the Nordic transport sector fell 2 percent from 20.2

13. Transport modes, as defined in Regulation (EC) No 1099/2008, include: international aviation, domestic aviation, road, rail, domestic navigation, pipeline transport, and a category for transport not specified elsewhere. International marine bunkers (international shipping) are excluded and not considered in the transport sector.

14. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A hydrogen strategy for a climate-neutral Europe. com/2020/301 final.

Mtoe in 2018 to 19.8 Mtoe in 2019, consumption of renewable energy rose 15 percent (579 ktoe) to 4,5 Mtoe, increasing the share from 19.2 percent in 2018 to 22.5 percent in 2019 (Figure 7-2).

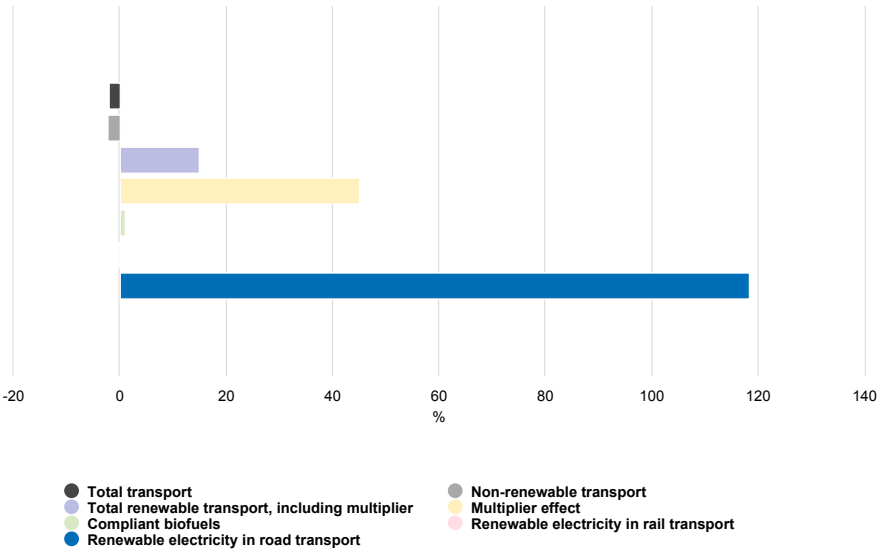


Figure 7-2
Change in energy use for transport in the Nordic countries (% change in gross final consumption, 2018-2019)

Renewable electricity consumption in Nordic transport rose 16 percent between 2018 and 2019, mainly due to the multiplier effect (508 ktoe) – renewable electricity consumption in electric road vehicles counts 2.5 times towards target fulfilment. Consumption of sustainable biofuels rose 1 percent, while that of renewable electricity in rail transport remained about the same.

In recent years, the Nordics have far outpaced the EU's share of renewable energy in transport.

In 2005, the renewables share of energy consumption in transport was 3.1 percent EU-wide and 3.3 percent in the Nordic region. In 2010, the Nordic share still roughly equalled the EU's, at about 5 percent. Subsequently, the Nordic share more than tripled, and since 2010, the region has outperformed Europe with a 17-percentage point rise to 22.5 percent in 2019, while the EU share rose 4 percentage points in the same period (Figure 7-3).

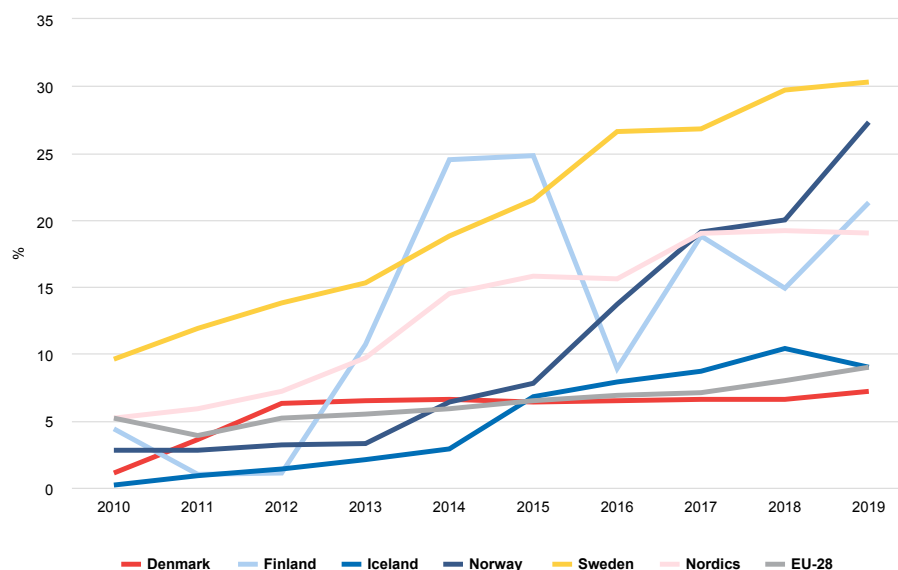


Figure 7-3

Renewables share of energy used for transport in the Nordic countries and EU-28 (% gross final consumption, 2010-2019)

The EU's consumption of renewable energy in transport had an average annual growth of 6.7 percent from 2010 to 2019, while Nordic consumption grew 16.3 percent each year on average in the same period.

Three Nordic countries topped the 2019 EU+IN list for the renewables share of energy consumed in transport – Sweden at 30 percent, Norway at 27 percent, and Finland at 21 percent – surpassing the 2020 target of 10 percent. Iceland and Denmark had shares of 9 and 7 percent respectively (Figure 7-4).

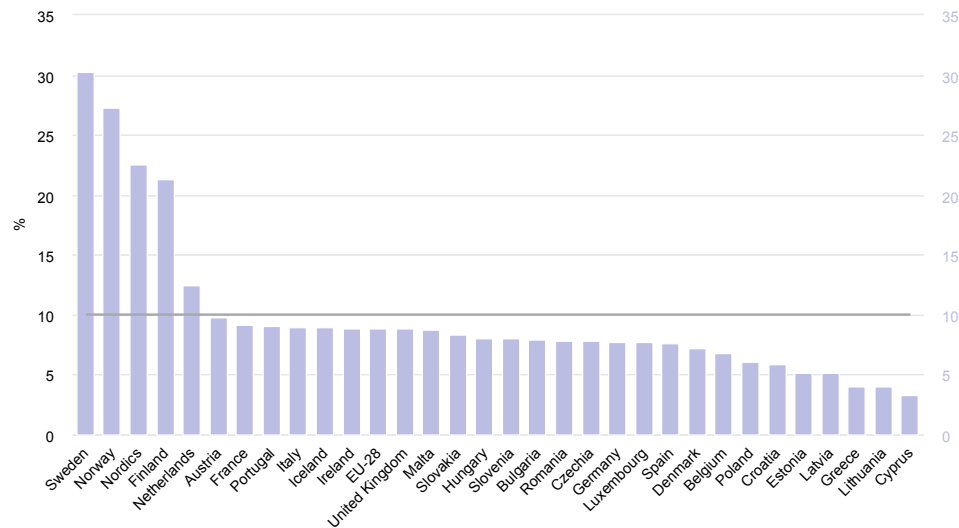


Figure 7-4

Renewables share of energy used for transport in the Nordic countries and EU-28 versus 2020 target (% gross final consumption, 2019)

If the Nordic countries were considered one, it would lead the EU with the highest share of renewable energy in transport.

In 2019, the region had a share of 22.5 percent renewable energy consumed in transport – more than twice the 2020 target and the EU’s 9 percent share (Figure 7-5).

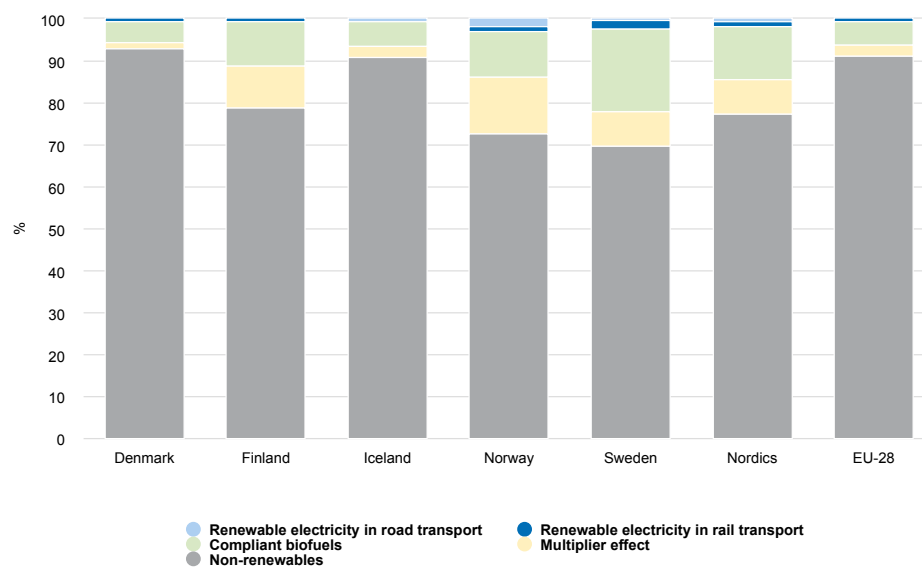


Figure 7-5

Energy used for transport in the Nordic countries and EU-28 (% gross final consumption, 2019)

The Nordic transport sector consumed 3 percent (648 ktoe) less energy in 2019 than in 2010, due to in part to efficiency gains from electrification of passenger vehicles and adoption of biofuels. As a result, renewable energy consumption has grown tremendously (3,395 ktoe) (Figure 7-6).

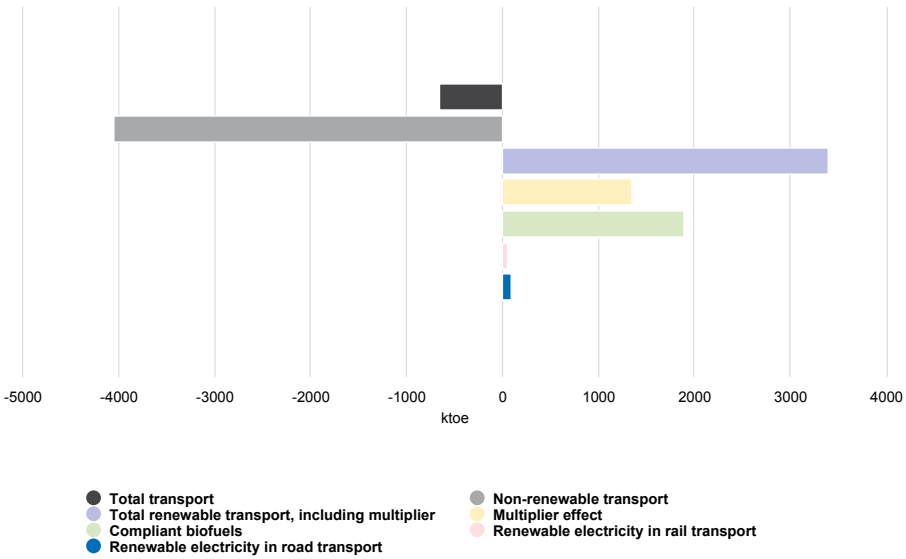


Figure 7-6
Change in energy use for transport in the Nordic countries (ktoe gross final consumption, 2010-2019)

Renewable electricity consumption rose almost 37000 percent in this period. Measured in absolute terms, biofuels were the main contributor to the increase in renewable energy consumption, rising 1,896 ktoe (316 percent).

Among the Nordic countries, Sweden accounted for more than one third of total energy and almost half of renewable energy consumed in Nordic transport in 2019. Meanwhile, more than three quarters of Nordic renewable energy used for electricity in road transport was consumed in Norway (Figure 7-7).

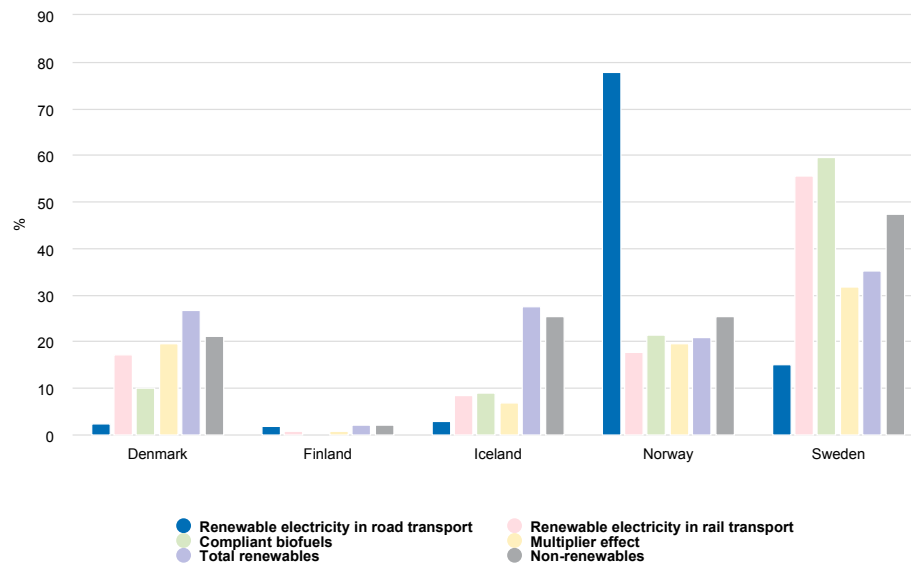


Figure 7-7

Energy used for transport in the Nordic countries (% of Nordic gross final consumption, 2019)

Sweden consumed more biofuels and renewable electricity for rail transport than all other Nordic countries combined. Norway's renewable energy consumption in transport totalled 1,136 ktoe, followed by Finland at 877, Denmark at 302 and Iceland at 31 (Figure 7-8).

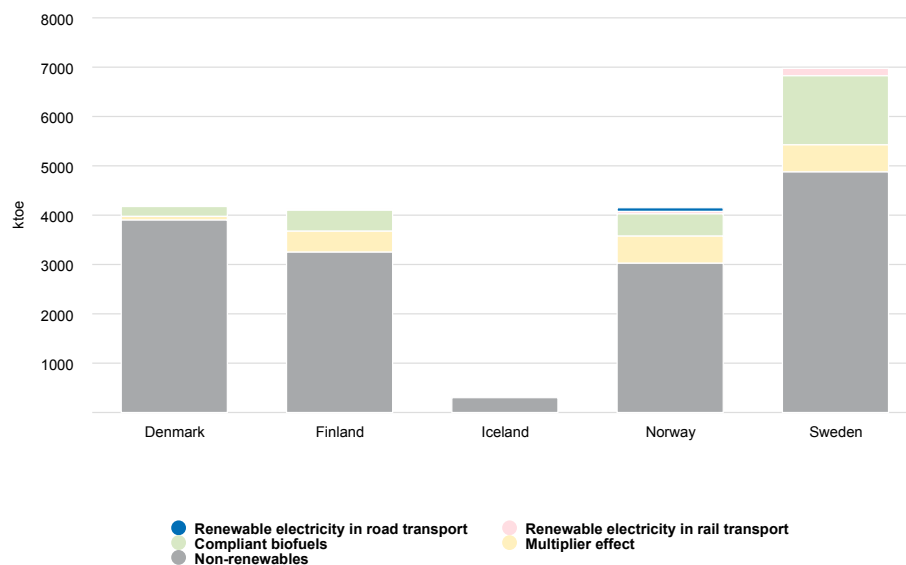


Figure 7-8

Energy used for transport in the Nordic countries (ktoe gross final consumption, 2019)

Per capita, the region consumed almost three times as much renewable energy in transport as the EU average – 0.163 toe versus 0.056 – with Sweden in the lead (Figure 7-9).

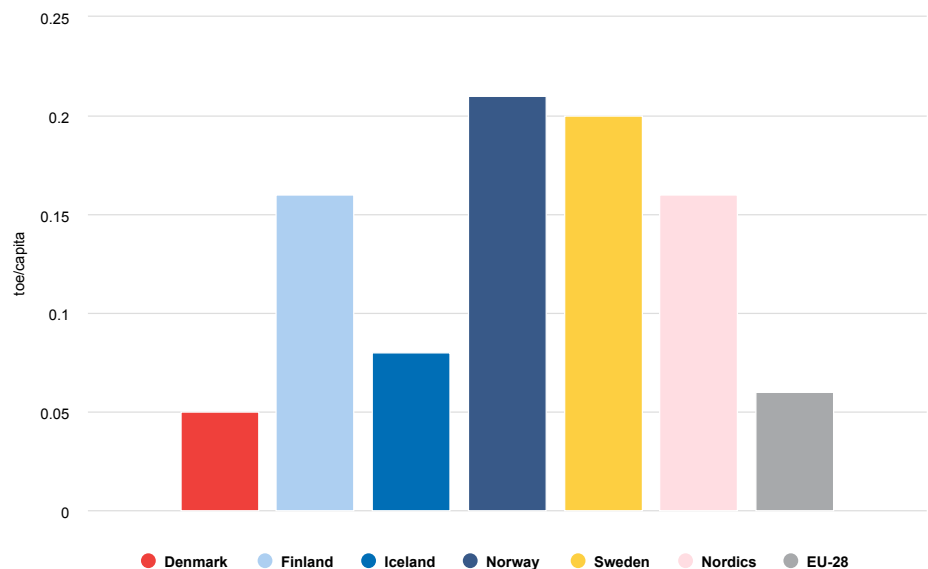


Figure 7-9
Renewable energy used for transport in the Nordic countries and EU-28 (toe per capita gross final consumption, 2019)

The rise of renewable electricity in Nordic road transport has been led by a surge of EVs in Norway.

Norway is widely recognized for its pioneering role in promoting electric vehicles (EVs). In 2019, the country accounted for 78 percent (74 ktoe) of the 95 ktoe of renewable electricity consumed in Nordic road transport. Norway’s high share of renewable electricity in road transport is the result of a fully renewable electricity supply and widespread adoption of EVs (Figure 7-10).

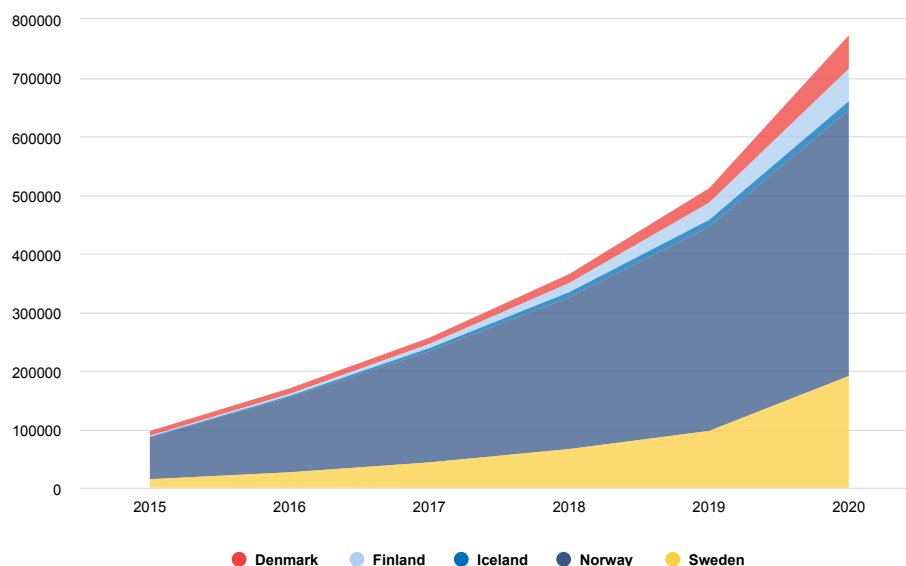


Figure 7-10

Battery Electric Vehicle (BEV) and Plug-in Hybrid-Electric Vehicle (PHEV) stock in the Nordic countries (thousands, 2015-2020)

The number of electric passenger vehicles in the Nordics has increased eight-fold, from 98,629 in 2015 to 772,249 in 2020. Of these, nearly 60 percent (453,960) were registered in Norway, where three quarters of new car sales in 2020 were battery electric vehicles (BEVs) or plug-in hybrid electric vehicles (PHEVs). In 2020, sales shares of electric cars exceeded 50% in Iceland and 30% in Sweden, while in the Nordic region, 16 percent of new car sales were EVs¹⁵.

Countries with high EV penetration tend to have low ratios of electric vehicle supply equipment per EV, such as Norway (0.03), Iceland (0.03) and Denmark (0.05). In these are relatively sparsely populated countries, with many detached houses and private parking spaces, most EV owners can largely use private home charging. To a lesser extent, this reflects that the Nordic countries have a higher proportion of fast chargers, with shares of 40% in Iceland, 31% in Norway and 17% in Denmark¹⁶.

Decarbonising heavy vehicles, aviation, and shipping has proven particularly challenging.

While achievements have been made in electrifying passenger vehicles, decarbonising other aspects of Nordic transport will be a priority in years ahead, with a growing role for Power-to-X in producing carbon-neutral fuels for heavy vehicles, aviation, and shipping, such as green hydrogen and ammonia.

Freight traffic volumes are on the rise, and with the current development, the Nordic governments recognise that there is a gap between actual CO₂-emissions and national objectives. It is anticipated that planned policies will not result in sufficient reductions, in light of 2030 climate objectives, and few measures within the

15. Nordic Energy Research (NER): Tracking Nordic Clean Energy Progress 2020, Nordic Energy Research 2020.

16. IEA (2021), Global EV Outlook 2021, IEA, Paris

transport sector focus on heavy-duty vehicles¹⁷.

None of the Nordic countries have set specific targets for aviation, yet some economic measures have been implemented¹⁸. As of 2019 Norway has a blending mandate for 0.5 percent advanced biofuels in aviation, with plans to increase it to 30 percent toward 2030. Norway also introduced a fuel tax on domestic flights, with a rate equivalent to about 55 EUR per tonne CO₂. Sweden mandated that the aviation sector reduce its carbon footprint, and along with Norway, introduced passenger taxes for domestic and EEA destinations, as well as longer routes.

The Nordic region is pioneering efforts to decarbonise the maritime sector and is at the forefront in electric maritime transport. Norway operates 40 percent of global battery electric and hybrid vessels, with 80 ferries expected to be in operation by 2022¹⁹. Norway and Denmark have proposed mandatory technical and design improvements for the existing fleet, as well as operational efficiency measures for ships. Initiatives in the Nordic countries, such as carbon taxes, the NO_x Agreement²⁰, environmentally differentiated port pricing, and electricity tax exemptions for shore power connections, could help to accelerate zero-carbon maritime transport²¹.

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17. Pinchasik, D. R., Hovi, I. B., Vierth, I., Mellin, A., Liimatainen, H., & Kristensen, N. B. (2018). Reducing CO₂ emissions from freight: Recent developments in freight transport in the Nordic countries and instruments for CO₂ reductions.
 18. Ydersbond, I. M., Buus Kristensen, N., & Thune-Larsen, H. (2020). Nordic Sustainable Aviation.
 19. DNV GL 2019.
 20. Environmental Agreement Concerning Reduction of NO_x Emissions for the Period 2018–2025 (The "NO_x Agreement 2018–2025")
 21. ITF (2020), "Navigating Towards Cleaner Maritime Shipping: Lessons from the Nordic Region", International Transport Forum Policy Papers, No. 80, OECD Publishing, Paris.

Annex 1.

Literature

European Commission (2020), Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A hydrogen strategy for a climate-neutral Europe. COM(2020) 301 final.

Directive 2009/28/EC on the promotion of the use of energy from renewable sources.

Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources.

European Alternative Fuel Observatory; www.eafo.eu

European Commission (2021), Energy, Heating and cooling. https://ec.europa.eu/energy/topics/energy-efficiency/heating-and-cooling_en

European Commission, Eurostat SHARES tool. <https://ec.europa.eu/eurostat/web/energy/data/shares>

European Commission, Eurostat: SHARES tool manual; Version 2018.031219;

Environmental Agreement Concerning Reduction of NO_x Emissions for the Period 2018–2025 (The "NO_x Agreement 2018–2025"). https://www.nho.no/siteassets/nox-fondet/the-nox-fund/the-agreement/en_nox-avtale-2018-final-draft.pdf

The European Parliament and The Council. Directive 2009/28/EC on the promotion of the use of energy from renewable sources; 23 April 2009.

The European Parliament and The Council. Recast EU Directive (EU) 2018/2001 the promotion of the use of energy from renewable sources.

The European Parliament and The Council. Regulation (EC) No 1099/2008 on energy statistics; 22 October 2018.

Government of Iceland 2021, Ministry of Industries and Innovation, Hydro Power Plants. <https://www.government.is/topics/business-and-industry/energy/hydro-power-plants/>

IEA (2020), Electricity Information: Overview, IEA, Paris <https://www.iea.org/reports/electricity-information-overview>

IEA (2020), Global Energy Review 2020, IEA, Paris. <https://www.iea.org/reports/global-energy-review-2020>

IEA (2020), Global Energy Review 2020: The impacts of the Covid-19 crisis on global energy demand and CO₂ emissions, International Energy Agency (IEA), Paris. <https://www.iea.org/reports/global-energy-review-2020>

IEA (2021), Global EV Outlook 2021, IEA, Paris <https://www.iea.org/reports/global-ev-outlook-2021>

IEA (2021), Other renewables, International Energy Agency (IEA), Paris.

<https://www.iea.org/fuels-and-technologies/other-renewables>

IEA (2019), World Energy Outlook 2019, IEA, Paris <https://www.iea.org/reports/world-energy-outlook-2019>

ITF (2020), "Navigating Towards Cleaner Maritime Shipping: Lessons from the Nordic Region", International Transport Forum Policy Papers, No. 80, OECD Publishing, Paris.

Jiang, P., Fan, Y. V., & Klemeš, J. J. (2021). Impacts of COVID-19 on energy demand and consumption: Challenges, lessons and emerging opportunities. *Applied energy*, 285, 116441.

Nordic Energy Research (NER): Tracking Nordic Clean Energy Progress 2020, Nordic Energy Research 2020.

Pinchasik, D. R., Hovi, I. B., Vierth, I., Mellin, A., Liimatainen, H., & Kristensen, N. B. (2018). Reducing CO₂ emissions from freight: Recent developments in freight transport in the Nordic countries and instruments for CO₂ reductions.

Regulation (EC) No 1099/2008 of the European Parliament and of the Council of 22 October 2008 on energy statistics (OJ 2008 L 304, p. 1).

Statistics Finland. Total consumption of energy increased by 2 per cent in 2018. Published: 28 March 2019. https://www.stat.fi/til/ehk/2018/04/ehk_2018_04_2019-03-28_tie_001_en.html

Wind Denmark (2021), Vind i systemet Wind Denmark.

Ydersbond, I. M., Buus Kristensen, N., & Thune-Larsen, H. (2020). Nordic Sustainable Aviation.

2013/114/EU: Commission Decision of 1 March 2013 establishing the guidelines for Member States on calculating renewable energy from heat pumps from different heat pump technologies pursuant to Article 5 of Directive 2009/28/EC of the European Parliament and of the Council (notified under document C(2013) 1082) Text with EEA relevance.

Annex 2.

Methodology and definitions

Unless otherwise stated in the text, all figures and calculations in this report are based on the European Commission's SHARES tool developed by Eurostat to ensure harmonised calculation of the share of energy from renewable sources among EU Member States. The legal basis for the implementation of all calculations and methodologies is Directive 2009/28/EC on renewables and on Regulation (EC) No 1099/2008, to which the Directive refers.

More details on the calculation methodology applied by Eurostat can be found in the [SHARES tool manual](#).

Renewable energy sources cover solar thermal and photovoltaic energy, hydro (including tide, wave and ocean energy), wind, geothermal energy and all forms of biomass (including biological waste and liquid biofuels). The contribution of renewable energy from heat pumps is also covered for the Member States for which this information was reported.

The numerator of this indicator is **gross final renewable energy consumption** – the renewable energy delivered to final consumers (industry, transport, households, services including public services, agriculture, forestry, and fisheries).

The denominator, **gross final energy consumption** of all energy sources, covers total energy delivered for energy purposes to final consumers as well as the transmission and distribution losses for electricity and heat. Exports/imports of electricity are not considered as renewable energy.

Statistical transfers and other flexibility measures reported to Eurostat and complying with the requirements of Articles 6-11 of Directive 2009/28/EC on the promotion of the use of energy from renewable sources are also considered in the presented data. Currently only Sweden with Norway, Luxembourg with Estonia and Luxembourg with Lithuania are using these flexibility measures.

The national shares of energy from renewable sources in gross final energy consumption are calculated according to specific calculation provisions of Directive 2009/28/EC on the promotion of the use of energy from renewable sources and Commission Decision 2013/114/EU establishing the guidelines for Member States on calculating renewable energy from heat pumps from different heat pump technologies.

The share of electricity from renewable energy sources is defined as the ratio between electricity produced from renewable energy sources and gross national electricity consumption. As stipulated in the Renewable Energy Directive 2009/28/EC, gross final consumption of electricity from renewable sources is the electricity produced from renewable energy sources. This includes hydropower plants (excluding hydropower electricity produced from pumped storage plants using water previously pumped uphill), as well as electricity generated from solid biofuels/wastes, wind, solar and geothermal installations.

Electricity production from hydropower and wind power is accounted according to normalisation rules of Annex II of Directive 2009/28/EC. This is done to avoid the annual fluctuations in hydropower and wind power production as a result of variances in wind or precipitation below or above average in a given year. Consequently, the figures here may differ from actual production and national figures that do not apply normalization to their data.

To calculate **the share of renewable energy in heating and cooling**, final consumption of energy from renewable sources is defined as final energy consumption of renewable energies other than electricity, heat and bioliquids in sectors other than transport. That means the final consumption of renewables in industry, households, services, agriculture, forestry and fisheries for heating and cooling purposes, plus district heating produced from renewables. The total final consumption in heating and cooling is the final consumption of all energy commodities, except electricity, for purposes other than transport, plus the consumption of heat for own use at electricity and heat plants and heat losses in networks.

The share of renewable energy in fuel consumed in transport is calculated based on energy statistics, according to the methodology as described in Directive 2009/28/EC. The contribution of all liquid biofuels is included within the calculation for this indicator until 2010.

In addition to the mandatory, national renewable energy targets, the 2009 EU Renewable Energy Directive established a national, binding transport sub-target, mandating all EU countries (as well as EEA-countries Norway and Iceland) to reach minimum 10 percent renewable energy in transport by 2020. Only biofuels that meet the Directive's sustainability criteria can be counted towards the target.

For data as of 2011, only biofuels and bioliquids declared by countries as compliant with criteria of sustainability as defined in Articles 17 and 18 of Directive 2009/28/EC are accounted towards the share of energy from renewable sources. Adjustments of energy consumption in aviation are applied for all countries according to Article 5(6).

To stimulate the development of certain types of renewable transport, the EU Renewable Energy Directive allows for multipliers when calculating national shares of renewable energy in transport. For example, renewable electricity in electric road vehicles counts 2.5 times the energy content of the renewable electricity input and the contribution of biofuels produced from wastes, residues, non-food cellulosic material, and lignocellulosic material is considered to count double that of other biofuels towards the target. Therefore, the sum of the individual technologies does not equal the total denominator in the calculation of the renewable energy share in transport.

The numerator 'energy from renewable sources consumed in transport' is, for the purpose of the calculations in the SHARES tool, defined as the sum of the following elements:

- Compliant biofuels (liquid and gaseous) in all modes of transport and, where applicable, the respective multiplier (2×) is used;
- Renewable electricity, by applying the national or community RES-E share to the total; electricity consumption in transport with the respective multiplier for road transport and for rail transport;

- Hydrogen of renewable origin in all modes of transport;
- Synthetic fuels of renewable origin in all modes of transport;
- Other forms of renewable energy with reported consumption in the transport sectors in the annual renewable questionnaire (geothermal, solar thermal, renewable municipal waste, solid biofuels).

Annex 3.

Abbreviations and acronyms

EU: European Union

EU+IN: European Union, Iceland, and Norway

Mtoe: One megatone (Mtoe) is one million toe (tonnes of oil equivalent)

Nordic countries / the Nordics: Denmark, Finland, Iceland, Norway and Sweden.

NREAPs: National renewable Energy Action Plans. Documents that explain how nations intend to meet their obligations under the Renewable Energy Directive, including their legally binding 2020 targets.

PV: Photovoltaic solar power.

RED: EU [Directive 2009/28/EC](#) on the use of energy from renewable sources.

RED II: Recast EU [Directive \(EU\) 2018/2001](#) the promotion of the use of energy from renewable sources

RES: Energy from renewable energy sources as defined in article 2 of [Directive 2009/28/EC](#). More details on the calculation methodology applied by Eurostat can be found in the [SHARES tool manual](#).

RES-E: Renewable energy in electricity. More details on the calculation methodology applied by Eurostat can be found in the [SHARES tool manual](#).

RES-H&C: Renewable energy in heating and cooling. More details on the calculation methodology applied by Eurostat can be found in the [SHARES tool manual](#).

RES-T: Renewable energy in transport. More details on the calculation methodology applied by Eurostat can be found in the [SHARES tool manual](#).

SHARES tool: The acronym SHARES stands for **SH**ort **A**ssessment of **R**enewable **E**nergy **S**ources. The SHARES tool developed by Eurostat ensures harmonised calculation of the share of energy from renewable sources among EU Member States. The legal basis for the implementation of all calculations and methodologies is Directive 2009/28/EC on renewables and on Regulation (EC) No 1099/2008, to which the Directive refers.

toe: One tonne of oil equivalent defined as the amount of energy released by burning one tonne of crude oil.

1 toe = 11.63 megawatt-hours (MWh) = 41.868 gigajoules (GJ) = 39,683,207.2 British thermal units (BTU) = 1.42857143 tonnes of coal equivalent (tce).

TWh: Terawatt-hour. 1 TWh equals one thousand GWh; one million MWh; and one billion kWh.

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