Green housing and infrastructure investments key to energy revolution

The way we live and travel is at the heart of the future energy revolution. As such, this edition of State of the Nordic Region includes chapters on housing and air accessability as a compliment to the energy chapter. The Nordic Region is a global leader in combining ambitious climate and energy policy with steady economic growth. This position is largely the result of an abundance of hydro, nuclear and geothermal energy sources and ambitious, long-term and stable policy frameworks focused on decoupling GDP from CO2. Although this is of course positive, it is important to acknowledge that the majority of these gains have been absorbed by an increase in the absolute demand for energy, particularly in the buildings and transport sectors. As a result, continued action that takes a multipronged approach to energy challenges is required. While renewing our energy consumption we need to bear in mind that providing appropriate and accessible infrastructure is also vital to supporting strong economic growth.

Property has been steadily increasing in value over the past 10 years with increases in all of the Nordic countries surpassing the EU average by a substantial margin. These increases are perhaps a reflection of the failure of new construction rates to keep up with demand, particularly in the larger Nordic cities. Nordic countries have different supplement systems for housing provision, but, as yet, none have managed to address the increasing problem of housing shortage and high property prices in Nordic cities.

Air travel is also increasing in all of the Nordic countries. One explanation for this growth is the way that some airports in the Nordic Region have used their peripheral location in a European context as a strategic advantage and become a gateway to other continents. Rail links between airports and city centres have also improved the accessibility of air transport in Copenhagen, Stockholm, Oslo and Helsinki. Substantial opportunity to continue this growth is apparent in the vast majority of airports in the Nordic Region. This has important implications for economic development in both the major cities and more remote regions, but also for the environment.

Theme 4
INFRASTRUCTURE

Chapter 11.
THE FUTURE OF NORDIC CLIMATE AND ENERGY

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Maps and data: **Gustaf Norlén**, **Shinan Wang** and **Benjamin Donald Smith**

This chapter was written in collaboration between Nordregio and Nordic Energy Research. Indicators on the Nordic Energy Research website provide an overview of the key energy trends in the Nordic Region http://www.nordicenergy.org

The need for energy management is clear. It sets the basic conditions across the globe for societal well-being and defines the parameters for economic growth. This, combined with global attention on climate change in the wake of COP21 and the continuing challenge of maintaining energy security, has placed energy at the forefront of the global political agenda. The Nordic Region has emerged as a global leader in combining ambitious climate and energy policy with steady economic growth. Despite this, room for improvement remains, particularly with respect to the transport and building sectors and in terms of the potential benefits of further Nordic cooperation. This chapter begins by outlining both the current position and the path that is already laid out for us as regards our energy and climate goals. An overview is then provided of a select number of dimensions with respect to the energy sector viewed from a Nordic spatial perspective, including energy production and consumption, with a focus on low-carbon energy. We conclude by exploring the Nordic electricity trade, as well as a number of future developments set to deliver us towards a low carbon energy future.

The Nordic Region has emerged as a global leader in combining ambitious climate and energy policy with steady economic growth.

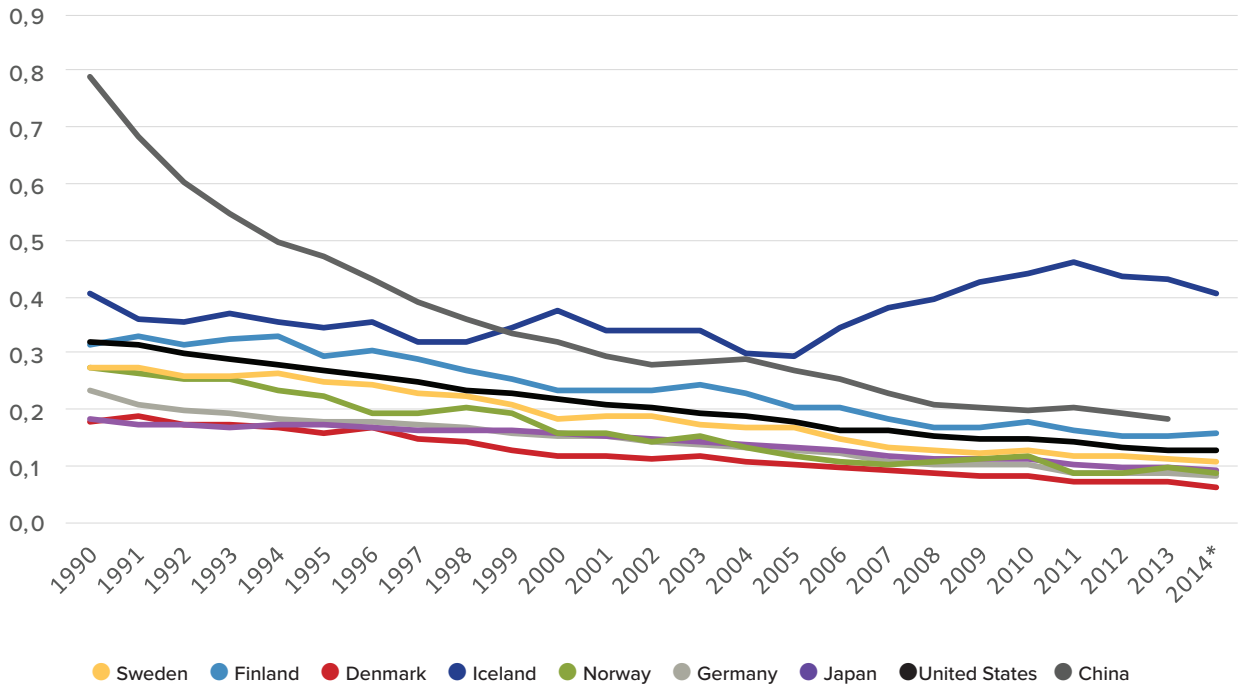
Is a fossil free future possible?

Figure 11.1 reflects a long-term trend across the Nordic countries - steady growth in GDP combined with flat growth in energy consumption, resulting in a reduction in the energy intensity of the economy. For instance, Denmark has a low ratio in both Figure 11.1 and 11.2 due to its proactive energy efficiency measures, lack of energy intensive industries and increased use of wind and biomass in electricity and heat production. Iceland is the exception here as it uses its abundant geothermal energy for heating and has little need for energy efficiency measures. As such, its growing energy intensity over the last decade reflects the increasingly dominant role of energy intensive industries such as aluminium smelting in its small economy. Given, however, that all of the country's electricity and 81% of its energy supply is renewable, an energy intensive industry is a smart approach for exporting its plentiful clean energy resources. At the same time, this model is currently under scrutiny as negotiations for a high capacity grid connection to the UK have recently gathered momentum.

In terms of the measure of carbon intensity with respect to electricity production, the Nordic Region is effectively 25 years ahead of the global trend – measured in CO2 emissions per unit of electricity generated. This is crucial assuming that if the 2-degree reduction target is achieved, the global carbon intensity rate in relation to electricity will reach the current Nordic level in 2039

Figure 11.1: **Energy Intensity of GDP**

Total primary energy supply (ktoe, IEA) / GDP (million 2015 USD, PPP, World Bank)

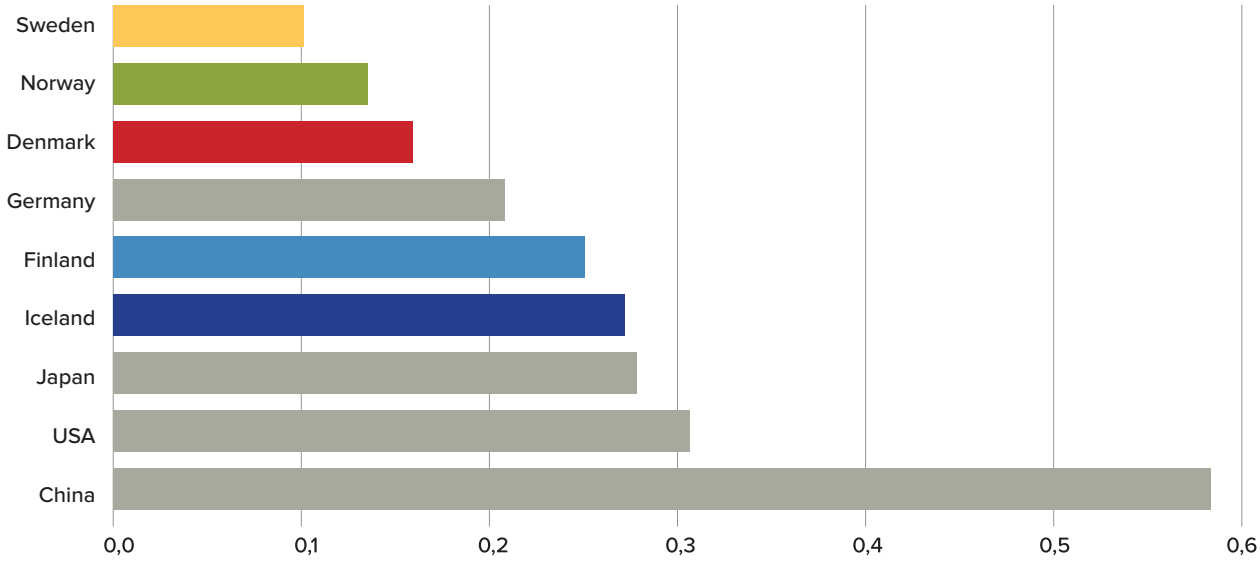


Data source: Nordic Energy Research, IEA (TPES) and World Bank (GDP). Note: Finland: Includes Åland. Greenland and Faroe Islands: No data. *Preliminary data for TPES in 2014

Energy Intensity of GDP: energy intensity is a measure of the energy efficiency of economic output, in this case shown by the total primary energy supply (in kilotons of oil equivalent) per million USD GDP (in 2015 USD, using Purchasing Power Parity). Most Nordic countries have achieved gradual improvements in energy intensity while retaining energy-intensive industries.

Figure 11.2: **CO2 intensity of GDP 2014**

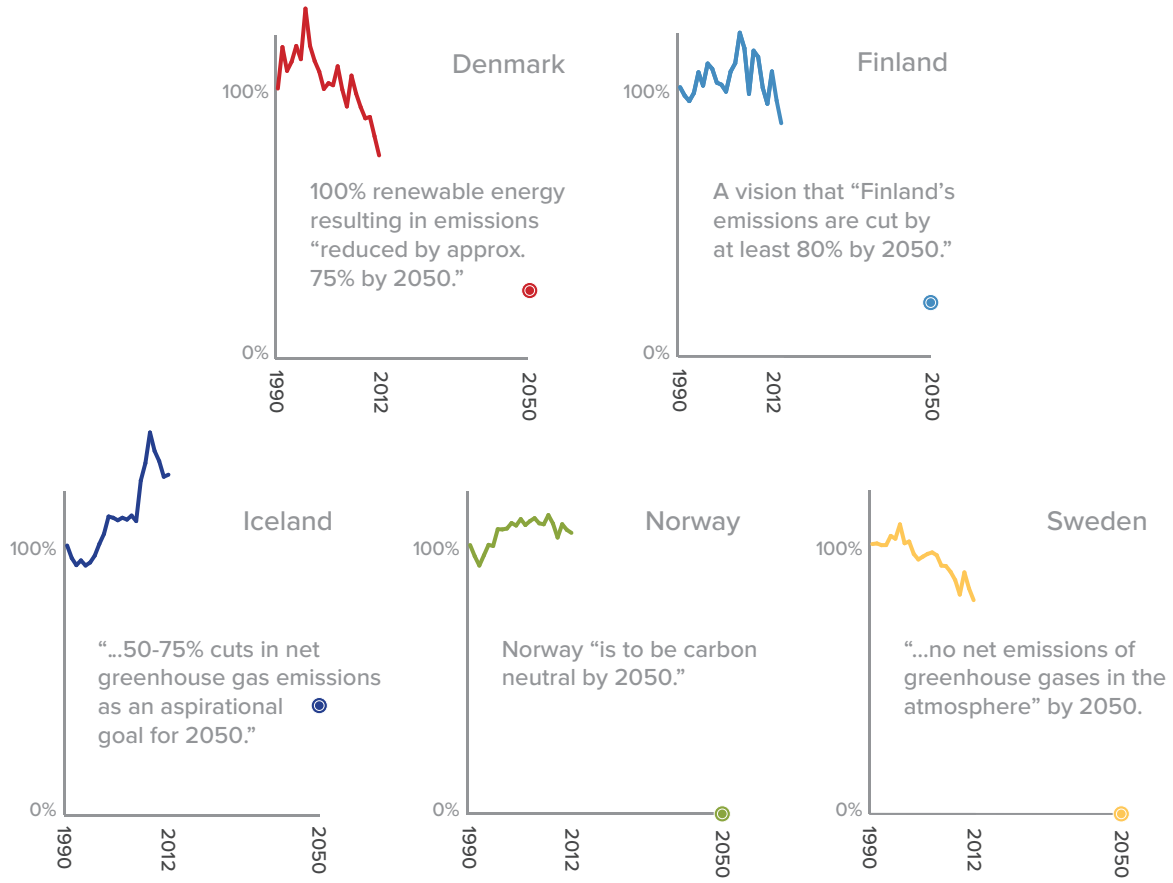
kg CO2 per $ 1 of GDP (PPP, 2015 USD)



Data source: Nordic Energy Research, European Commission / EDGAR (CO2) and World Bank (GDP). Note: Finland: Includes Åland. Greenland and Faroe Islands: No data

2014: the CO2 intensity of GDP is a measure of the CO2 emitted from fossil fuel use and industrial processes for every dollar of GDP. Despite a heavy reliance on energy-intensive industries, the CO2 intensity of the Nordic economies is generally lower than the major OECD economies. This is primarily due to low shares of fossil fuels in the energy mix. Iceland's intensity is highest in the region due to process emissions from aluminium production.

Figure 11.3: **Nordic climate targets**



Data source: Nordic Energy Research, EEA (GHG) and national governments. Note: Finland: Includes Åland. Faroe Islands and Greenland: No data

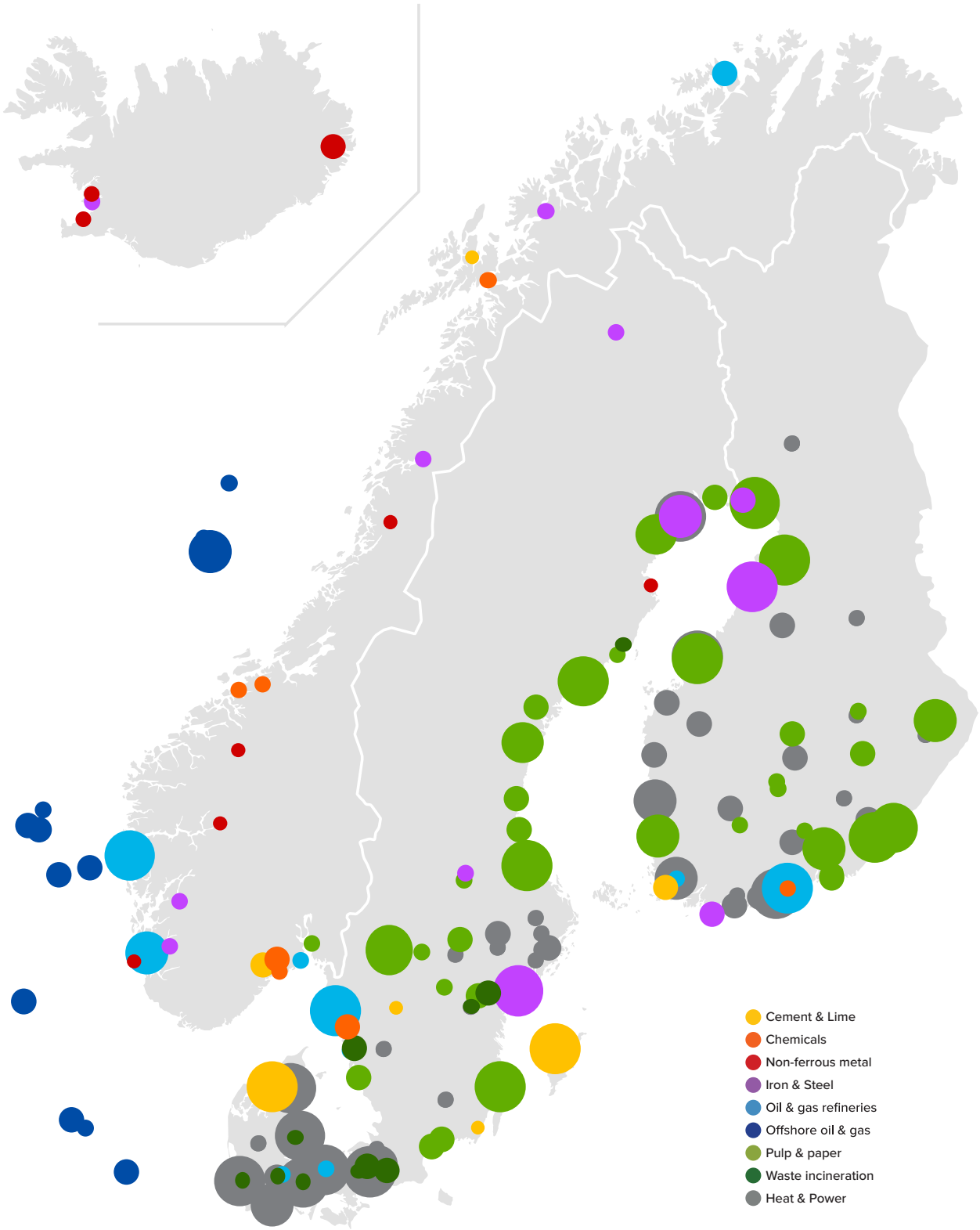
Nordic climate targets: domestic greenhouse gas emissions indexed to 1990. 2050 targets may be achieved using carbon offsets.

(IEA, 2014). Similarly, Figure 11.2 shows the CO2 intensity of selected national economies, providing a useful measure of their economic-environmental efficiency. The strong position of the Nordic countries compared to others such as China and the United States reflects, in part, their use of hydropower and nuclear power, recent additions to the energy mix, such as bioenergy and wind power.

The carbon intensity of electricity production or the fossil fuel intensity of the economy does not however tell the whole story. For example, measures of energy or CO2 intensity do not reflect our globalised economies with their significant levels of trade in goods and services, labour, energy and capital. This means that the connection between a country's economy and its energy system can be seen to be weakening when in fact energy consumption now takes place internationally rather than domestically. Countries that consume the metals refined using energy intensive processes in Iceland are a perfect example of this. In addition, as can be seen below, sectors such as transport, building and industry have high consumption levels, particularly of non-renewable energy. This means that considerable progress is required if we hope to reach our exemplary energy and climate goals set out in Figure 11.3. Only by making sustained progress towards these goals will we be able to consider ourselves as global leaders across the spectrum of aspects that truly define energy and climate progress

In short, fossil fuels still make up 45% of Nordic total primary energy supply. Meeting our collective goals by 2050 will require the reduction of this number to just 16% (IEA/NER, 2013). This is possible, but only through comprehensive demand management and by increasing the share of renewables. The high level of energy demand from the industrial sector in the Nordic Region also presents a substantial challenge. Currently, industry makes up 38% of the Nordic energy demand. This is well above the OECD average and constitutes the bulk of large Nordic point source emissions of CO2 (see Figure 11.4). For example, Figure 11.5 shows that, in sharp con-

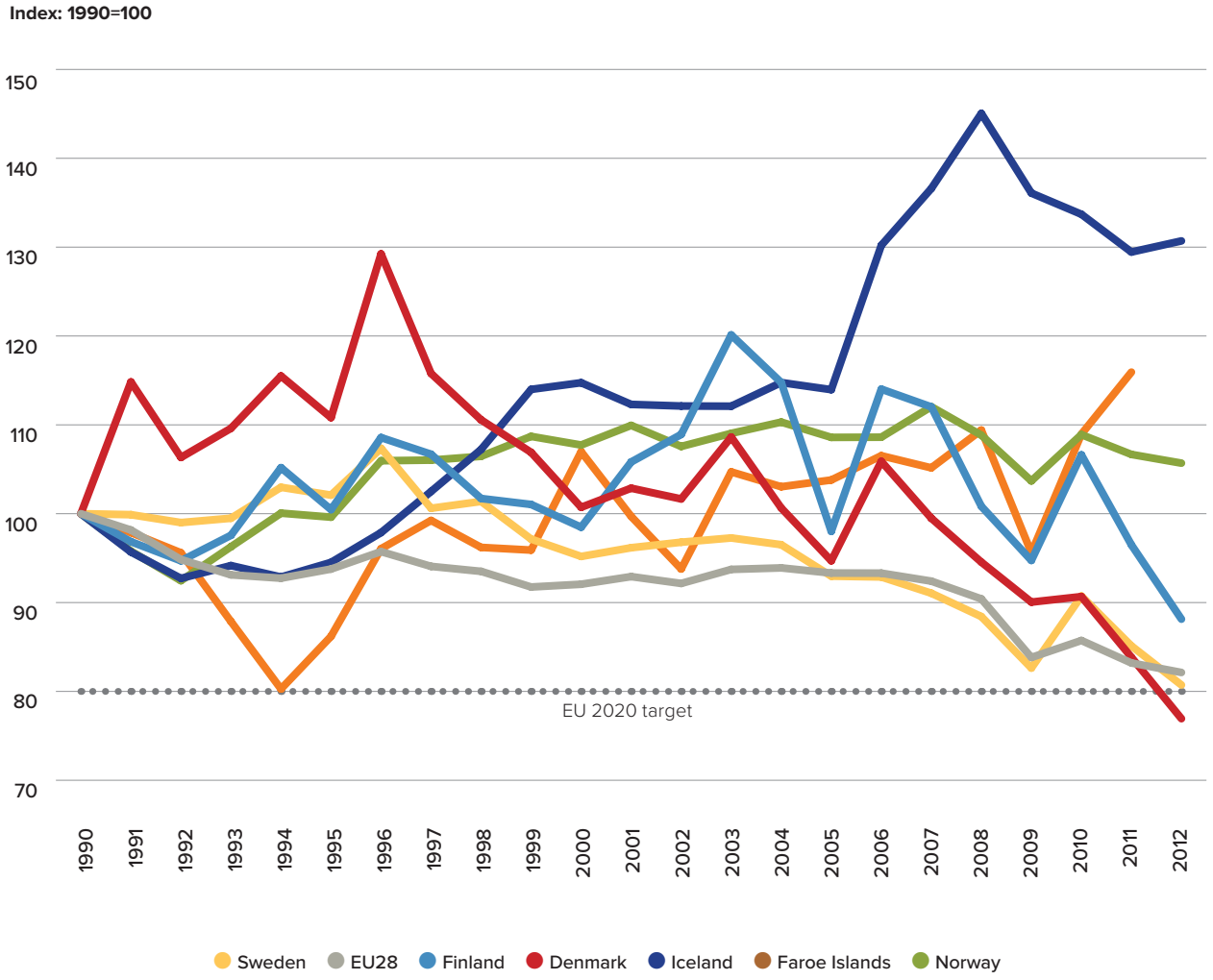
Figure 11.4: **Large CO2 point sources, 2011**



Data source: Nordic Energy Research, adapted from SINTEF/IVL, NORDICCS. Note: Faroe Islands and Greenland: No data

Figure 11.4: Large CO2 point sources, 2011: sources of CO2 emissions from selected large scale industries.

Figure 11.5: **Percent change in greenhouse gas emissions since 1990**



Percent change in greenhouse gas emissions since 1990: the EU 2020 target calls for a 20% reduction in European greenhouse gas emissions from 1990 levels.

Data source: Eurostat and Nordic Statbank. Note: Finland: Includes Åland. Faroe Islands: No data

trast to falling emission levels in Finland, Denmark and Sweden, Norway's emissions have actually increased since 1990. A large share of this growth can likely be accounted for by Norway's oil and gas industry (shown in Figure 11.4). As can be seen in Figure 11.4, other large industrial emitters include iron and steel in Sweden and Finland, non-ferrous metal such as aluminium in Iceland and Norway, chemicals in Norway, Sweden and Finland, and cement across the region. Maintaining these industries, while still meeting the ambitious 2050 climate goals laid out in Figure 11.3, will therefore require further research and development on, and eventually widespread deployment of carbon capture and storage.

The three faces of energy: consumption, production & trade

Energy has three fundamental dimensions: consumption, production and trade (i.e. transmission/distribution). Consumption describes the energy that is supplied and the purpose of its demand. Production describes the amount of energy created, regardless of where it is consumed. It can be thought of in economic terms value added, or quantity (in oil equivalence). And trade through transmission networks such as wires, pipelines, shipping or rail alleviates spatial imbalances between production and consumption.

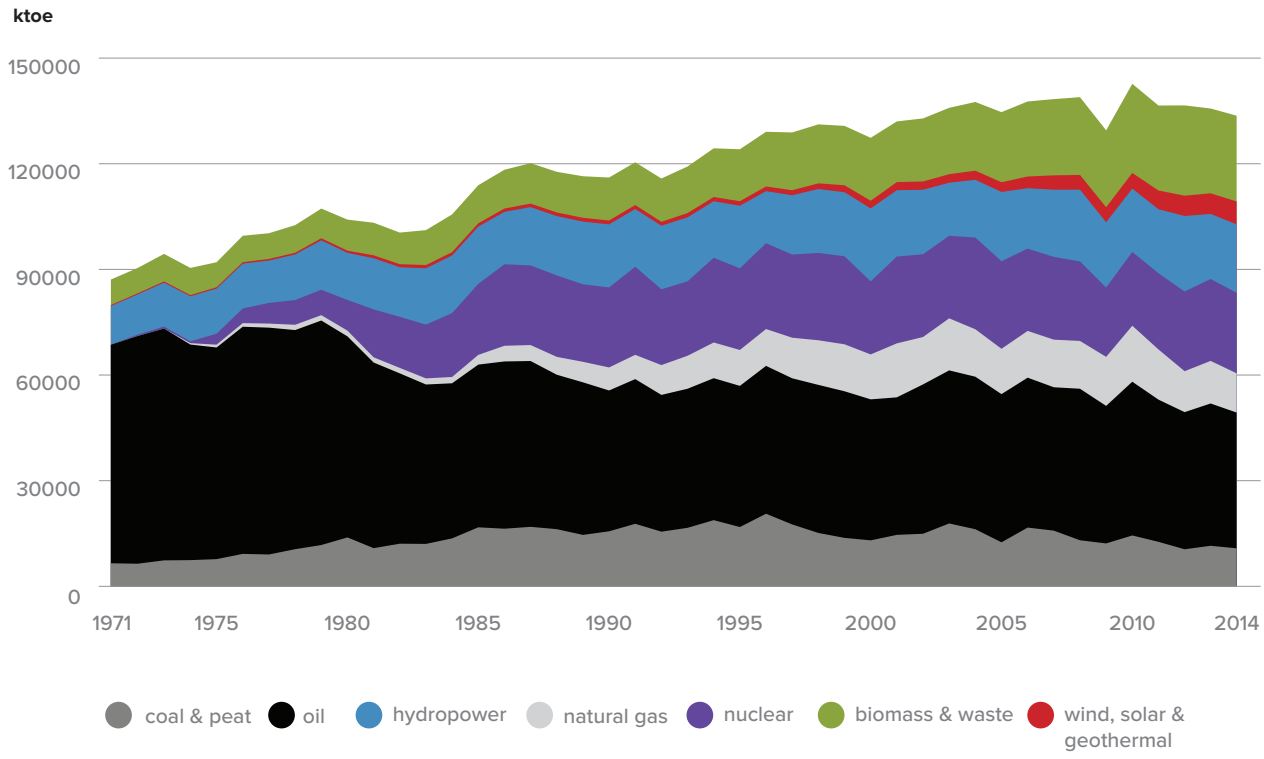
Consumption: growing demand in key sectors

Total Primary Energy Supply (TPES) is the sum of production and imports subtracting exports and storage changes. It therefore accounts for the total energy that is demanded by a given area. Figure 11.6 outlines the trends of Nordic TPES since the oil crises of the 1970s, showing a move away from oil towards alternative energy sources. Of particular note here is the rise of nuclear energy in Sweden and Finland, as well as a rise in the use of coal in Finland and Denmark. At the same time, the past forty years have seen a steady growth in renewable energy sources like biomass and wind, as well as geothermal energy in Iceland. These are used to generate electricity, heat and transport fuels especially in Sweden, Finland and Denmark. As Figure 11.7 demonstrates, electricity produced from renewable sources is also generated from hydropower in Norway, as well as a growing amount of wind power, particularly in Denmark and Sweden. Geothermal heat and power production is the most important energy source in Iceland. With nuclear power in Sweden and Finland, over half of the region's energy is CO2-free and, overall, 38% of the Nordic Region's total energy supply comes from renewable sources.

Despite these positive developments, oil is still the largest single energy source and the only one common to all five Nordic countries. This is due to its central role as a transport fuel. Also, despite the increases in both renewable and nuclear energy, the absolute demand for fossil fuels is roughly the same as it was 1971. This is due to an increase in the absolute demand for energy and an increase in fossil fuel use in transport and industry. In short, we see that the higher generation of low-carbon energy described above has come in addition to, not instead of, fossil fuels.

This growing demand for energy is largely explained by population growth, a higher share of single person households and by ongoing economic growth more generally. Figure 11.8 shows electricity consumption patterns across the Nordic Region, including a breakdown by main sector branches. Electricity demand for buildings generally represents a higher share of total

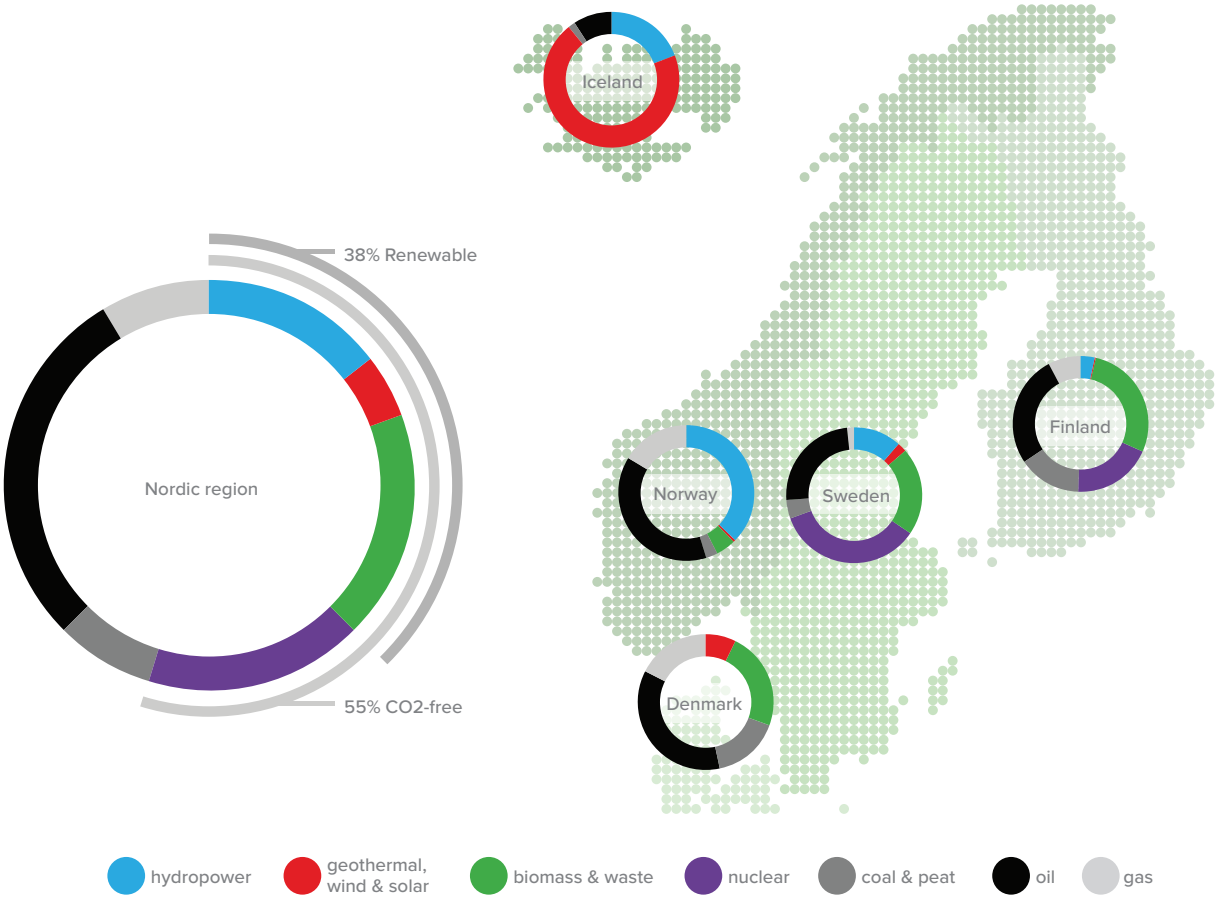
Figure 11.6: **Nordic total primary energy supply, 1971-2014**



Data source: Nordic Energy Research and IEA.

Nordic total primary energy supply, 1971-2014: trends in Nordic total primary energy supply by source. Reductions in the share of oil have been compensated by an increase in nuclear and biomass.

Figure 11.7: **Total primary energy supply mix for selected Nordic countries in 2014**



Data source: Nordic Energy Research and IEA. Note: Finland: Includes Åland. Faroe Islands and Greenland: No data

energy demand in urbanised regions, where overall energy demand is the highest but per capita energy use is lowest. Electricity and heating in buildings therefore represents a central intervention area for reducing absolute energy demand. This is illustrated in Figure 11.9, where buildings represent the largest single sector for energy consumption.

Looking ahead, overall improvements in CO2 emission levels must be met in large part by the demand sectors. Together with transport and industry, the building sector must play a central role here. Building codes and policies supporting energy efficiency measures in both new and existing buildings support a shift towards the creation of a greener building stock in the Nordic Region. Given that over 70% of today's existing building stock will be standing in 2050 however, a significant ramping up of deep renovation efforts is required in order to meet energy and climate targets (IEA/NER, 2013). Authorities at all levels need to take more action in this regard. Local governments are mainly responsible for governing the improvement of the building stock through investment and thus need to lead by example. At the same time, national government can provide significant support through policy investments that provide direct support for energy efficiency improvements in private buildings.

Production: towards renewable energy

Our energy and climate goals can only be met through a comprehensive approach that includes the widespread development of renewable energy. The European Commission's recent Renewable Energy Progress Report (EC, 2015) highlighted that Sweden, Finland and Denmark have not only already achieved their 2020 renewable energy targets, but have surpassed them by the three widest margins in Europe.

The steady progress of Nordic renewable energy deployment is evident in Figure 11.10. Denmark and Sweden's development is particularly notable, largely due to

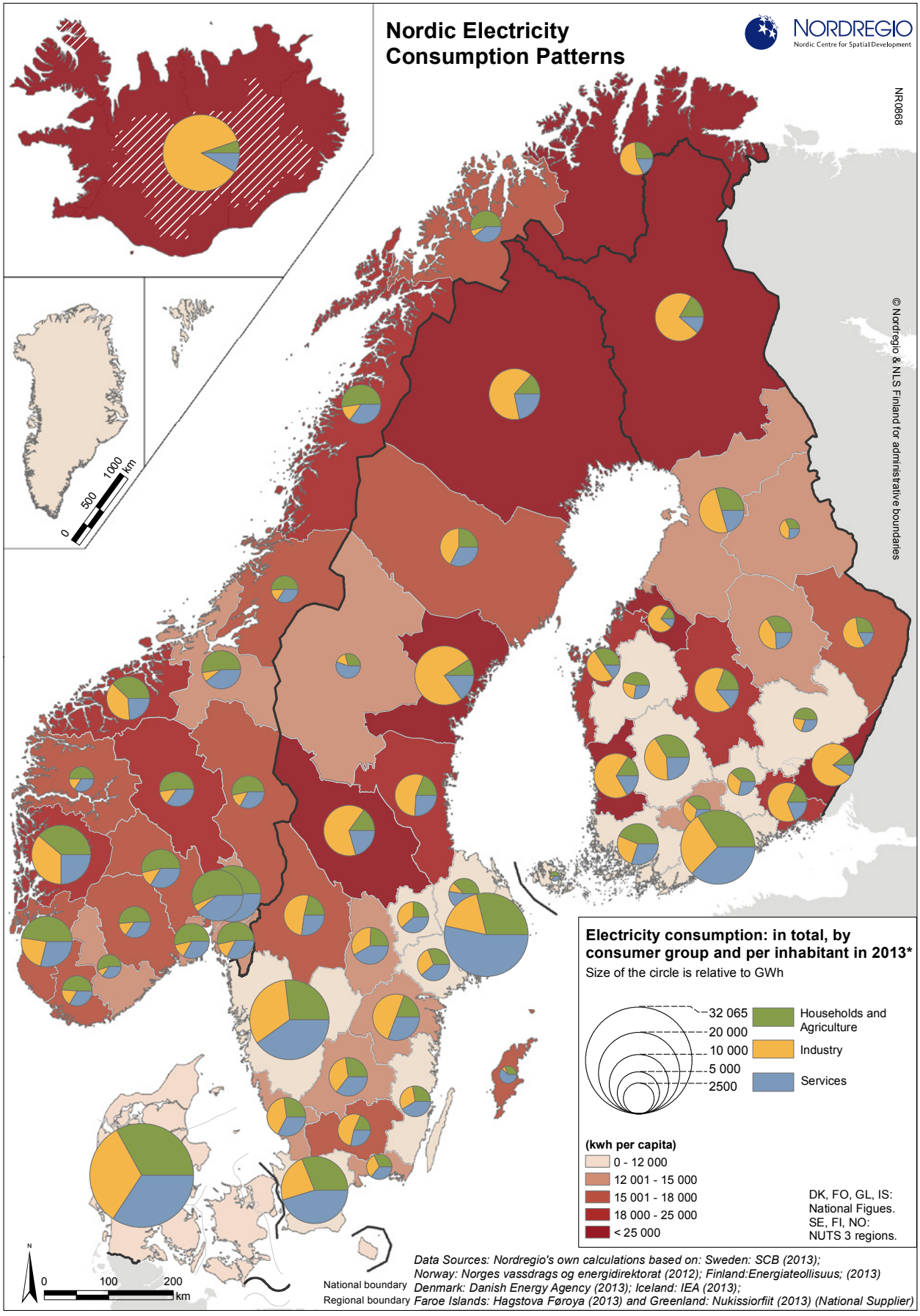


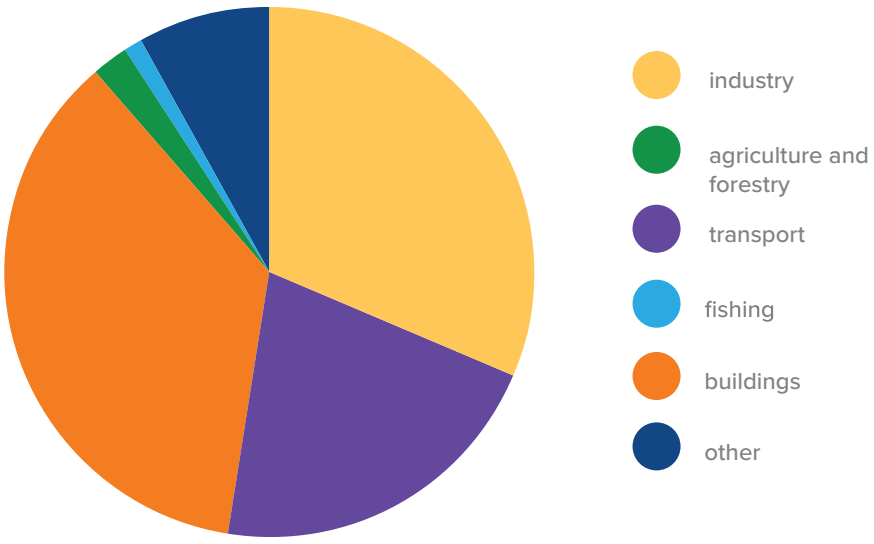
Figure 11.8: Nordic electricity consumption patterns: consumption by consumer group and per capita in 2013

their progress in the wind sector. At the same time, Figure 11.11 shows significant room for improvement with respect to renewable energy consumption in the transport sector. This is consistent with the increase in CO2 emissions from transport in recent decades. IEA projections show significant growth in demand for transport services in the Nordic Region between 2015 and 2050 – passenger by over 30% and freight by well over 20% (IEA/NER, 2013). As a result, urgent action is required to tackle Nordic transport emissions. Considering our expansive area in a European perspective, this must include improving the efficiency of long-haul transport technologies and shifting modes away from road freight and air traffic to rail and maritime shipping. Fuel-switching to biofuels is an ideal way to reduce emissions from long-haul road freight, aviation and shipping. Unfortunately however, other higher value uses for Nordic biomass such as paper and pulp, limits their availability for biofuels. Even if half of all road freight growth to 2050 is shifted to electric trains, biofuel demand may be so high that the Nordic Region is a net importer in 2050 (IEA/NER, 2013).

With respect to passenger transportation, policies and investments that promote the use of electric cars and public transportation powered by renewable energy sources will be crucial for meeting our energy and climate targets. Cities are the key drivers of this development through effective planning and policy instruments that promote the rapid roll-out of electric cars and support modal shifts toward public transit, cycling and walking. The Nordic Energy Technologies Perspectives 2013 report projected a reduction from today's 80Mt of Nordic transport CO2 emissions to just 10Mt in 2050 in order to meet Nordic climate targets (IEA/NER, 2013). Cities can lead this reduction as their larger populations, higher population densities, and shorter commuting distances make them well suited to key technologies such as EV charging infrastructure and public transport systems. In 2050, according to the report's Nordic Carbon-Neutral Scenario, 4% of passenger transport could be avoided through better urban planning, 20% shifted from cars to public transport, and 90% of all new car sales could be EVs.

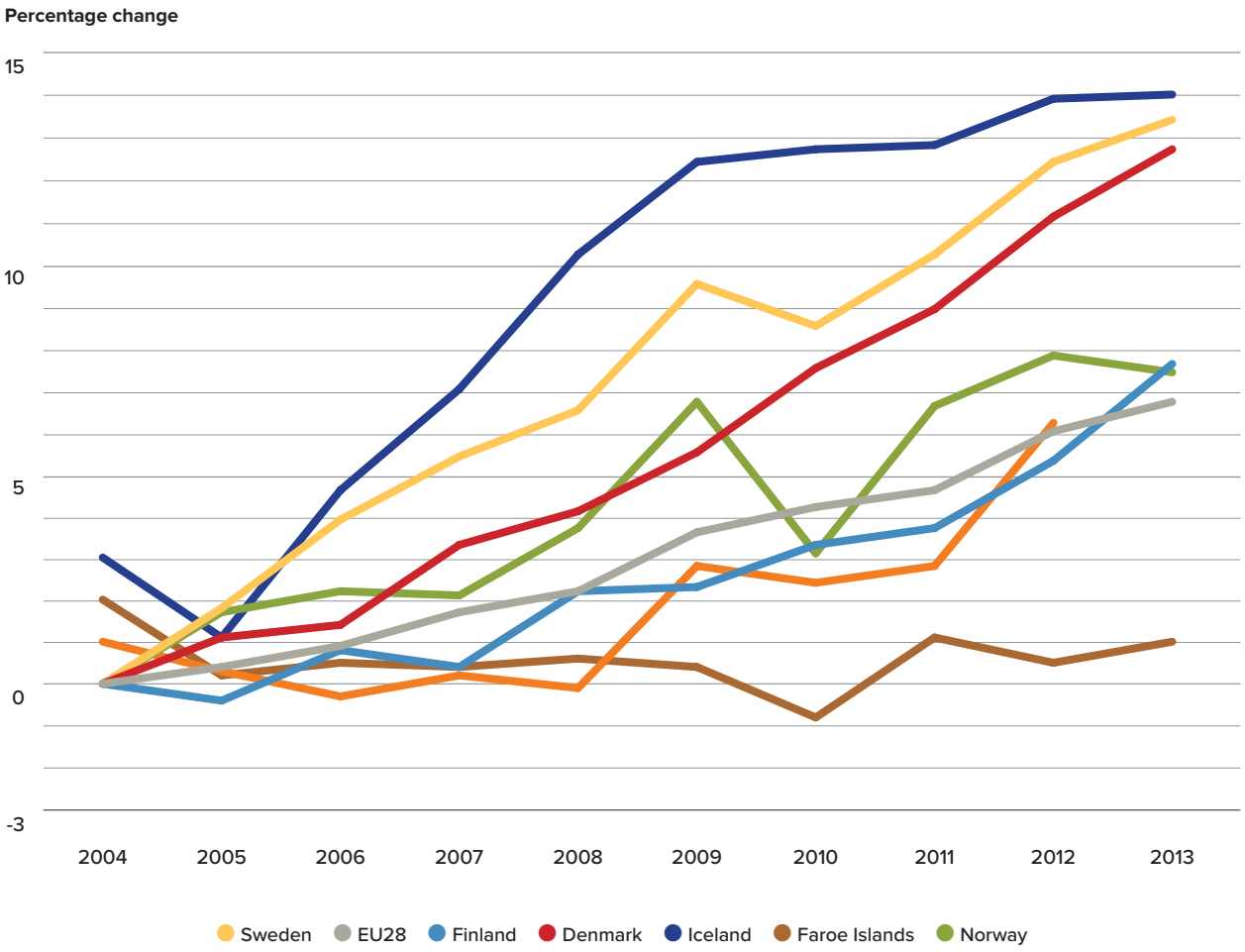
Figure 11.12 shows the spatial distribution of Nordic energy production per capita, by volume and by source type. A number of issues and patterns are evident. First and foremost, we see the high amount of electricity being produced for the five nuclear facilities in the Nordic Region. While Finland pushes ahead with new reactors, Sweden recently announced the early closure of certain reactors due to high costs and low power prices, painting an uncertain picture for the nuclear sector going forward. Second, a substantial volume of hydro-electricity is produced in southern Norway, throughout Iceland, Northern Sweden and Northern Finland. As a result, over half of Nordic electricity is produced from hydropower. With limited potential for the further development of hydropower however, wind represents a more likely area of future potential for the Nordic Region. Figure 11.12 shows some impressive results in terms of the production of wind power at the regional level. Regional wind power production has been strengthened in the past three years

Figure 11.9: **Nordic energy consumption by sector in 2012**



Data source: Nordic Energy Research, IEA

Figure 11.10: **Trends in the share of renewable energy in final energy consumption, 2004-2013**



Data source: Eurostat, NSI's and Jarðfeingi. Note: Finland: Includes Åland. Faroe Islands: energy use for international transport not included

throughout much of Denmark, Sweden, and to a lesser extent in Norway and Finland. Low power prices have however significantly impacted the wind sector too, leading to a slowing of deployment across the region in 2015.

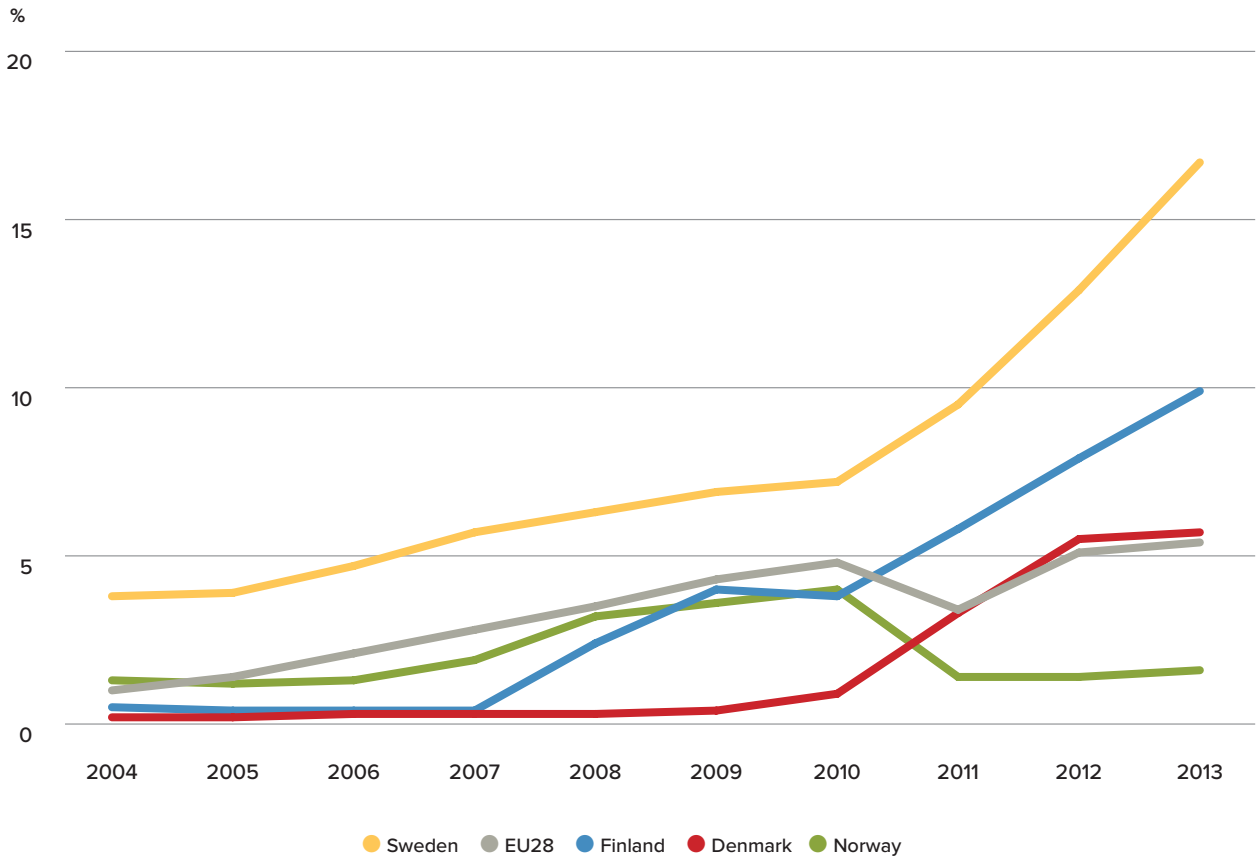
Despite the current lull in wind power investment, Nordic wind energy potential is undeniably significant. Nordic Energy Research has recently produced a new map that combines different data sources for each technology to indicate the areas of the Nordic Region that have the highest theoretical potential for various renewable energy sources. Figure 11.13 shows the potential for off-shore wind energy development throughout much of the coastal areas of the Nordic Region, and that the best solar resources are in Denmark and the capital regions of Sweden and Finland.

Trade: Nordic countries rely on each other

Significant electricity trade flows are evident between all Nordic countries with especially large flows between Norway, Sweden and Finland in 2014. Figure 11.14 shows the flow of electricity between trading regions in 2014, with hydropower transmitted from the west coast of Norway to Oslo in the east, and from central Sweden south to Stockholm. The Nordic Region is also a net exporter of electricity southwards to the European continent. The figure also shows the relatively small role that Russia plays in the Nordic electricity market compared to previous years, as Finland now imports less from Russia and depends more on trading with Sweden. From 2016 a new cable between Sweden and Lithuania will begin operation, and new cables from Norway to Germany and the UK are expected to come online in 2018 and 2020 respectively. If interconnection infrastructure is built out further, Nordic exports of clean electricity to the continent could increase significantly towards 2050.

In the Nordic Region we have wide differences, with some regions or countries being heavy net importers of energy to meet their demand (Denmark for instance), while others export a large share of their produced energy on international markets (e.g. Norway). Iceland,

Figure 11.11: **RES development in transport in selected Nordic Countries**



Data source: Eurostat. Note: Finland: Includes Åland. Faroe Islands, Greenland and Iceland: No data. Data missing and assumed for Finland in 2011 and 2012

with its energy-intensive refining of foreign raw materials into immediately exported goods can also be seen as a heavy exporter of energy, even though it may not appear this way in the statistics.

The Nordic Region has the world's most integrated international electricity market, enabling the optimisation of each country's diverse resources. Nordic electricity grid integration also provides security of supply against uncertainties. These uncertainties include annual variation in precipitation affecting hydropower reservoirs, unusually cold winters leading to increased heating demand, maintenance of nuclear power plants and changes in access to electricity markets outside the Nordic Region. This was exemplified in 2014 when Finland – already experiencing a delay in the construction of its newest nuclear power plant – was unable to continue the large net import of electricity from Russia that it had relied on in previous years. Finland therefore imported over 60% more electricity from Sweden in 2014 than in 2013, making that connection the largest cross-border flow of electricity in the region.

Market integration through a well-developed network also allows for the region to benefit from its significant variable renewable energy sources, where production is dictated by short-term changes in the weather. Figure 11.15 shows the share of gross electricity production coming from wind, solar and ocean power for selected countries. Denmark's high share of wind is evident, covering upwards of one third of its electricity production. Germany's deployment of wind and solar options gives it a total of around 15% for variable renewables, while Sweden and the UK have seen recent surges in wind power.

The higher the share of variable renewables, the greater the need for flexibility in the electricity system. Denmark is connected to Norway and Sweden by subsea interconnector. Under windy conditions, Denmark exports to Norway and Sweden. Under calm conditions, Denmark imports hydropower from these countries. Without this flexibility, the cost of wind power integration in Denmark would have been higher and the system less efficient.

The Nordic Region can further capitalise on its potential to supply clean electricity to Europe by making the common Nordic grid even stronger and more flexible. For example, the significant wind build-out expected in the Nordic Region will require additional infrastructure

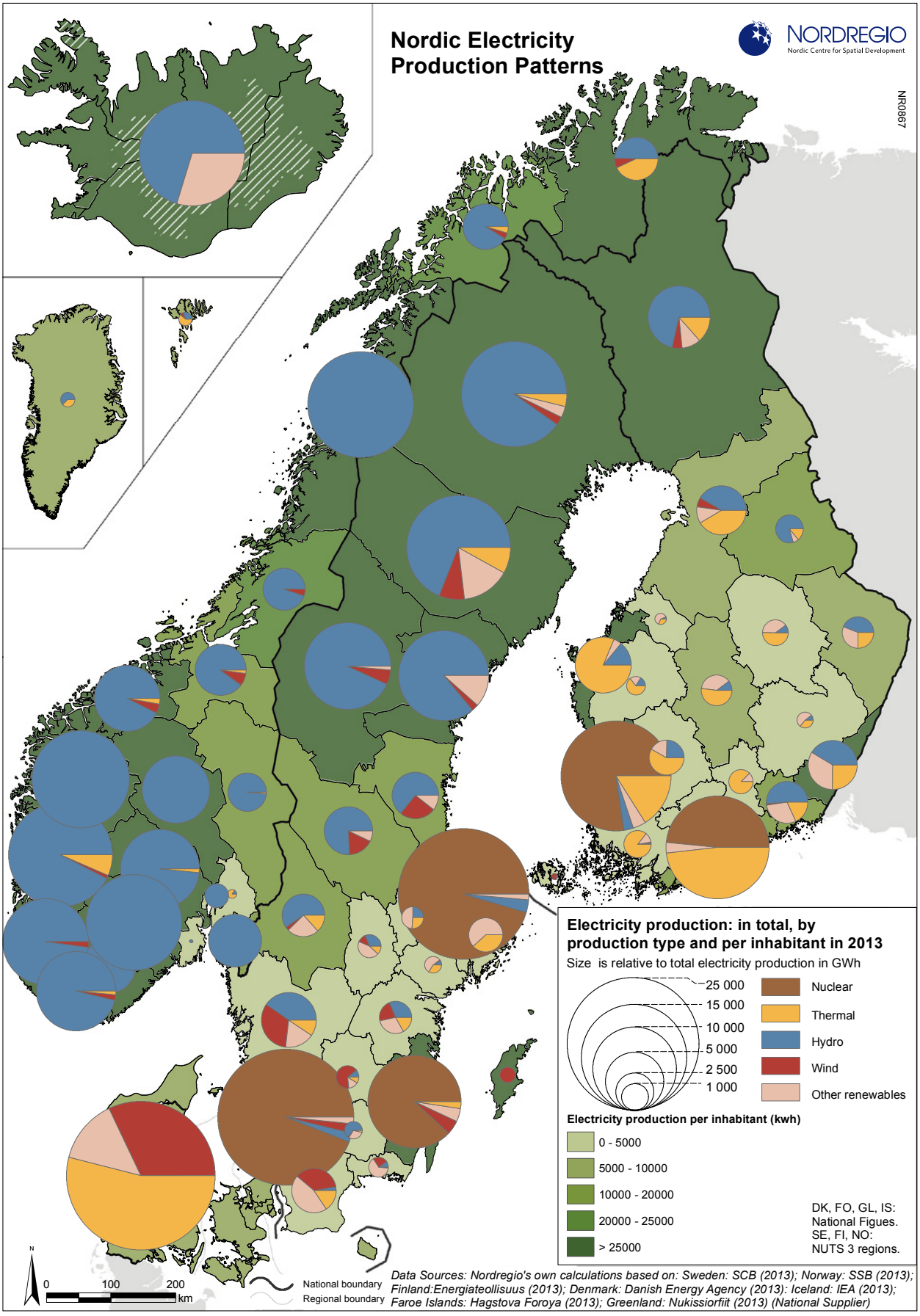


Figure 11.12: Nordic electricity production pattern: by volume (per capita) and by source groups in 2013

Figure 11.13: **Nordic Renewable energy potential**

SOLAR

The yellow coloured triangles on the renewable energy map indicate areas with a relatively high solar irradiation for the Nordic region – specifically a yearly sum of global irradation above 1150 kWh/m², measured at an optimal fixed inclination.

▸ EC. 2012. PVGIS. RE.JRC.EC.EUROPA.EU/PVGIS

GEOTHERMAL

The red coloured triangles on the renewable energy map indicate areas with high geothermal potential. This is defined as a heat flow density above 80 mW/m²

▸ EC. 2002. ATLAS OF GEOTHERMAL RESOURCES IN EUROPE. GOO.GL/BTKDC6 GOO.GL/96GVVO

BIOMASS

Green indicates areas with land cover suitable for production of biomass. This includes areas of forest, cultivated crops, and urban areas, which are defined as municipalities with a population density of over 100/km²

▸ NORDREGIO. 2008. GOO.GL/NBBFTK (ICELANDIC LAND COVER: GOO.GL/FV9VXT)
▸ NORDREGIO. 2011. GOO.GL/OBSCF0

WIND

The blue colour indicates areas with an average wind speed above 6 m/s at hub height. This is averaged over the period 2000-2005, at 80 m above ground level for onshore and 120 m for offshore, and corrected for orography and local roughness. Data for offshore areas is incomplete. A seperate dataset was used for Iceland, with measurements at 100 m above ground level.

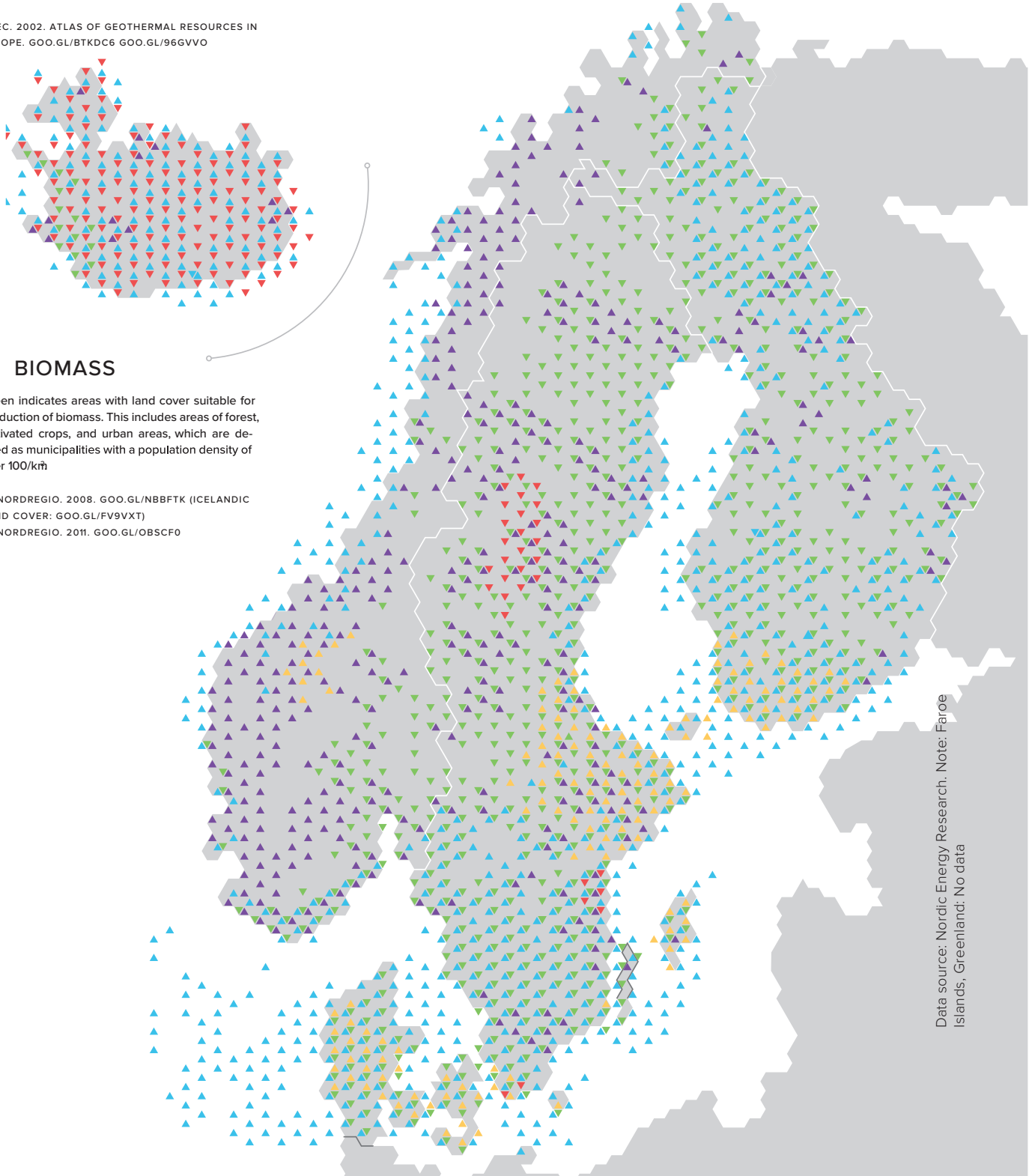
▸ EEA. 2009. EUROPE'S ONSHORE AND OFFSHORE WIND ENERGY POTENTIAL. P.14. GOO.GL/JC9HFR
▸ IMO. 2013. THE WIND ENERGY POTENTIAL OF ICELAND. P.27. GOO.GL/XTNYBK

HYDROPOWER

Politically, the greatest potential for increased hydropower generation in the Nordic region is through the upgrading of existing infrastrucutre.

The purple coloured triangles on the above map are indicating areas with existing hydropower installa tions in 2005 over 0,1 MW.

▸ LEHNER ET AL. 2005. THE IMPACT OF GLOBAL CHANGE ON THE HYDROPOWER POTENTIAL OF EUROPE. ENERGY POLICY. P.839-855. GOO.GL/UE2B5L



Data source: Nordic Energy Research. Note: Faroe Islands, Greenland: No data

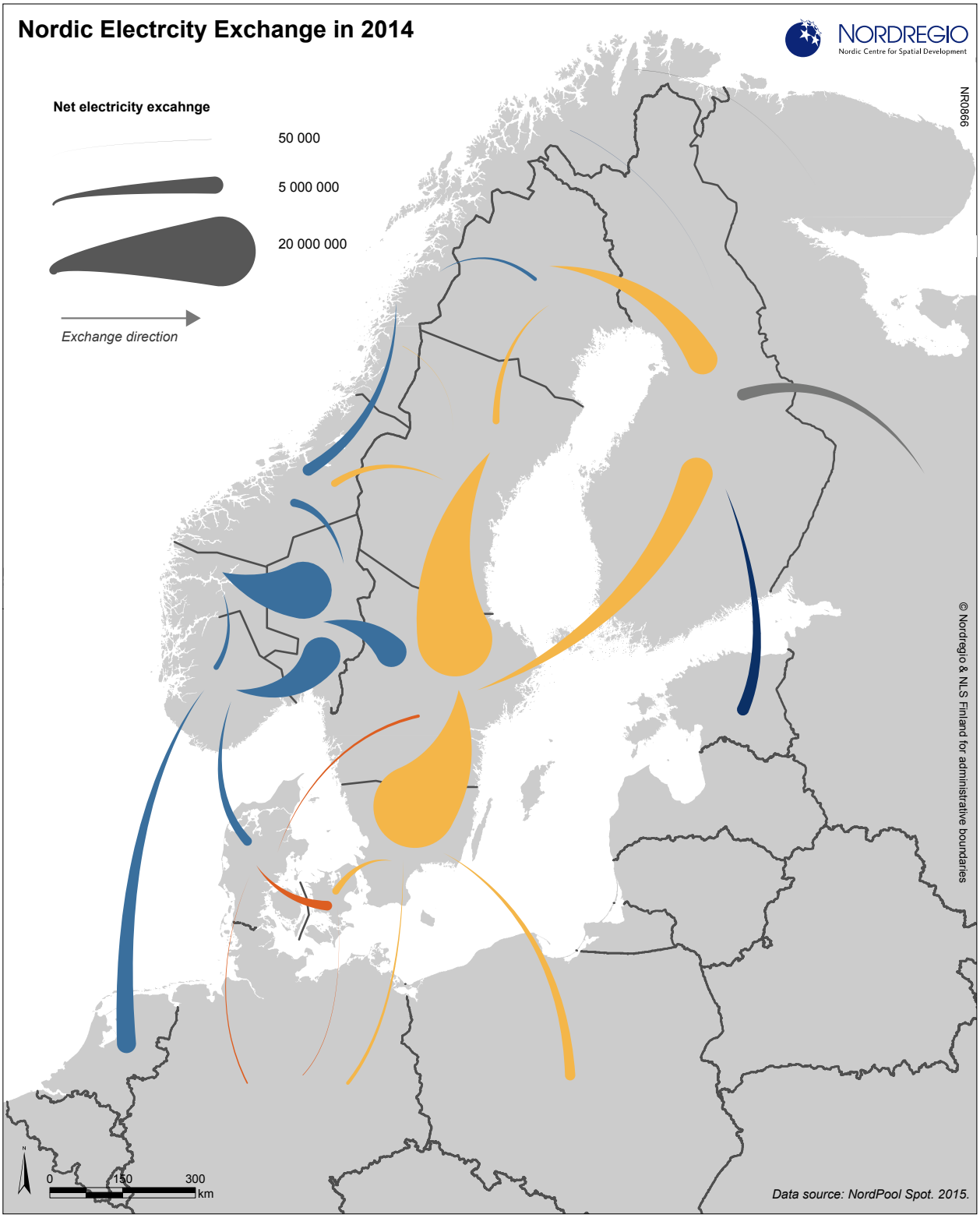
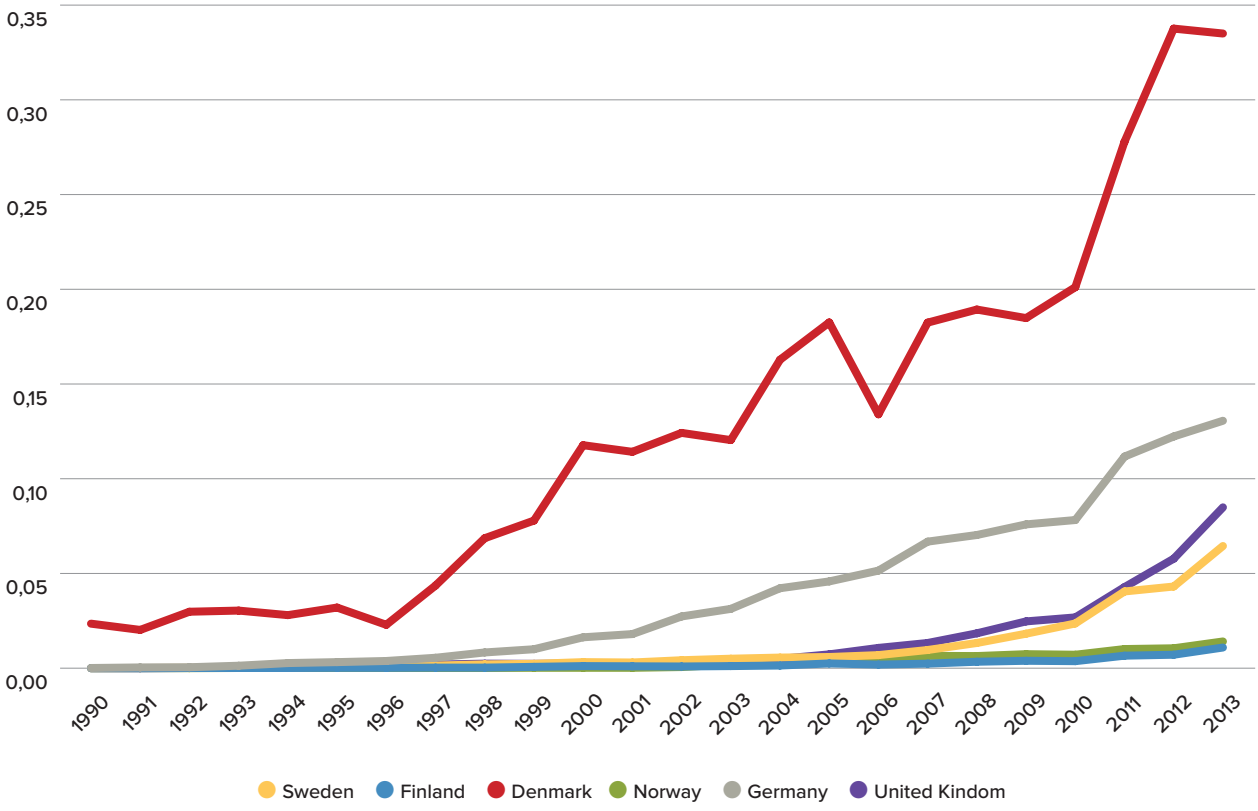


Figure 11.14: Nordic electricity exchange in 2014: net annual electricity trade flows between price zones in the Nordic Region and adjacent countries for 2014. The Nordic countries were net exporters in 2014, but much greater flows are evident within the Nordic countries, moving hydroelectric power from mountainous regions to major cities Note: Faroe Islands and Greenland: No data

Figure 11.15: **Share of variable renewables in gross electricity production**



Data source: Eurostat. Note: Finland: Includes Åland: Iceland, Greenland and Faroe Islands: No data

Share of variable renewables in gross electricity production: electricity production from variable renewables (wind, PV solar, ocean) as a share of gross production. Denmark's large share of wind power and Germany's wind and PV solar have necessitated measures in those countries to balance the weather-dependent production output from these technologies.

in order to be integrated efficiently. This can be facilitated through internal grid strengthening within and between the Nordic countries, through expansions in interconnector capacity to Europe, and through other interrelated flexibility measures. The forthcoming second edition of Nordic Energy Technology Perspectives will offer a special focus on the flexibility measures available to better integrate large amounts of new Nordic wind generation. In addition to grid integration with Europe, these include storage (such as pumped hydropower or battery electric vehicles), flexible supply (such as capacity mechanisms or dispatchable hydropower) and flexible demand (such as demand response, power-to-heat, or power-to-fuels).

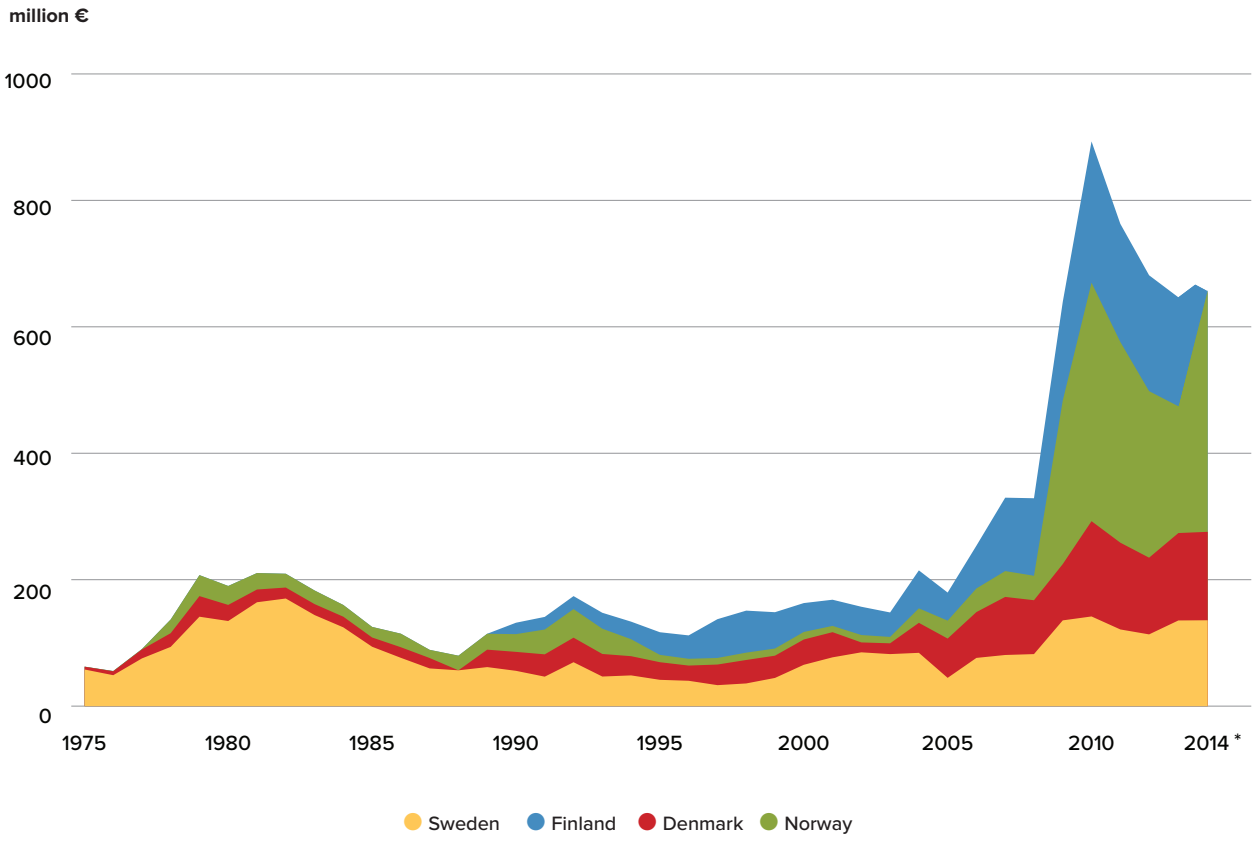
Funding strong for clean energy solutions

Public funding for non-nuclear low-carbon Research, Development and Demonstration (RD&D) in the Nordic countries has increased dramatically in the last decade. While these statistics are affected by allocation issues and do not account for private investment in RD&D, they paint a clear picture of the focus of Nordic governments on accelerating clean energy technology development. After decades of support at levels below its neighbours, Norway has emerged as the largest funder of low-carbon RD&D in recent years due in the main to two very large demonstration projects in CCS and aluminium smelting. The technology areas currently receiving the most support across the Nordic Region are energy efficiency and bioenergy.

Nordic cooperation is key to future energy development

The Nordic Region has emerged as a leader in many aspects of the global transition to cleaner energy systems. While 2014 may have seen the first global decoupling of GDP from energy-related CO2 emissions (IEA, 2015), the Nordic Region has exhibited a steady decoupling for almost 20 years.

Figure 11.16: **Public research and development investment budgets in low carbon energy sources**



Public research and development investment budgets in low carbon energy sources. Norway's significant increases in the last decade stem mainly from support of CCS technologies.

A strong Nordic electricity market and grid integration enhances efficiency and security of supply. This has allowed, for example, Denmark to integrate the world's highest share of variable renewables into its electricity system in an efficient manner.

Ambitious, long-term and stable policy frameworks have been the key to achieving this leading position. All five Nordic countries have used policy frameworks actively to decouple GDP from CO2, with carbon taxes and renewable energy incentives among the most effective examples.

However, there are a number of opportunities to further decarbonise the Nordic energy system. The Nordic Region can capitalise on its potential to supply clean electricity and balancing services to Europe by making the common Nordic grid stronger and more flexible. The significant wind build-out expected in the Nordic Region will require additional infrastructure in order to be integrated efficiently.

CO2 emissions from transport must be decoupled from rising demand for transport services if climate targets are to be met. Nordic cooperation in transport infrastructure and policy can accelerate this decoupling. Urban transportation can lead the uptake of electric vehicles and modal shifts to public transport, while a large-scale transition to sustainable biofuels can decarbonise long-distance road, sea and air transport.

Nordic cities are more energy efficient than rural areas and can deploy a wider range of technology options. District heating, electric vehicles and public transport systems are more efficient and economical in densely populated areas. Knowledge sharing between Nordic cities can identify best practices in urban energy systems.

Lastly, Nordic cooperation can reduce the cost of achieving national climate targets. According to the IEA (IEA/NER, 2013), the potential for cooperation is high in RD&D, infrastructure and policy development. Technologies with high cooperation potential include offshore wind, biofuels, CCS and the electricity grid.

Chapter 12
HOUSING:
Demand exceeds supply in Nordic markets

Author: **Moa Tunström**
Maps and data: **Gustaf Norlén**, **Anna von Zweygbergk**, **Julien Grunfelder** and **Linus Rispling**

How we choose to build our cities and regions forms the basis for our everyday lives. The built environment is also an important factor in future social, ecological, economic and spatial development. The character of this future development is however dependent upon the types of housing that are available, what is being built and at what price. Can migrants from other cities, regions or countries afford to move into the area assuming there are homes available to buy or rent? Is affordable student housing available? Answers to questions such as these, and the comparative Nordic approach can, for example, function as indications of social sustainability and integration, i.e. where can people with different resources actually settle and stay in the Nordic countries? Nordic cities are segregated and housing and construction are key factors in this development, influencing the spatial relations between different socio-economic groups.

The built environment is an important factor in future social, ecological, economic and spatial development.

Nordic property prices rising rapidly

Housing data is of relevance to several actors; developers, buyers and sellers on the housing market, tenants, the homeless, policymakers, and local as well as regional planners. The first indicator in respect of the current situation regarding housing in the Nordic countries presented here is the House Price Index, an index referring to the cost of housing on the property market, i.e. housing as a good up for sale. This illustrates the relationship between supply and demand. It is also an aspect that is highly dependent on financial market fluctuations, illustrating the financial risks residents in the Nordic countries are willing to take when it comes to housing.

Figure 12.1 shows the changes in the prices of residential property purchased by households (HPI) between the first quarter of 2005 and the first quarter of 2015, i.e. during a ten year period. The index, where 100=first quarter of 2005, is based on Eurostat's final market price data for all types of residential properties (apartments, detached houses, terraced houses etc.). In all of the Nordic countries HPIs have increased more than the EU average. As an example housing prices in Norway have increased by 400 percent in the period 1992-2014. During the same period prices overall have increased by only 55 percent (Statistics Norway 2015, p.19).

Prices fell as a result of the financial crisis in 2008 – this was true for all countries although the decrease was most visible in Denmark and Iceland. Sweden has however subsequently seen a rapid increase in house price levels. According to Eurostat, in European terms only Estonia has witnessed a more rapid increase.

Increasing property prices imply that property is a scarce and attractive resource. The effects of a steady price increase over a period of time can however vary. For example, high prices and competition in a national

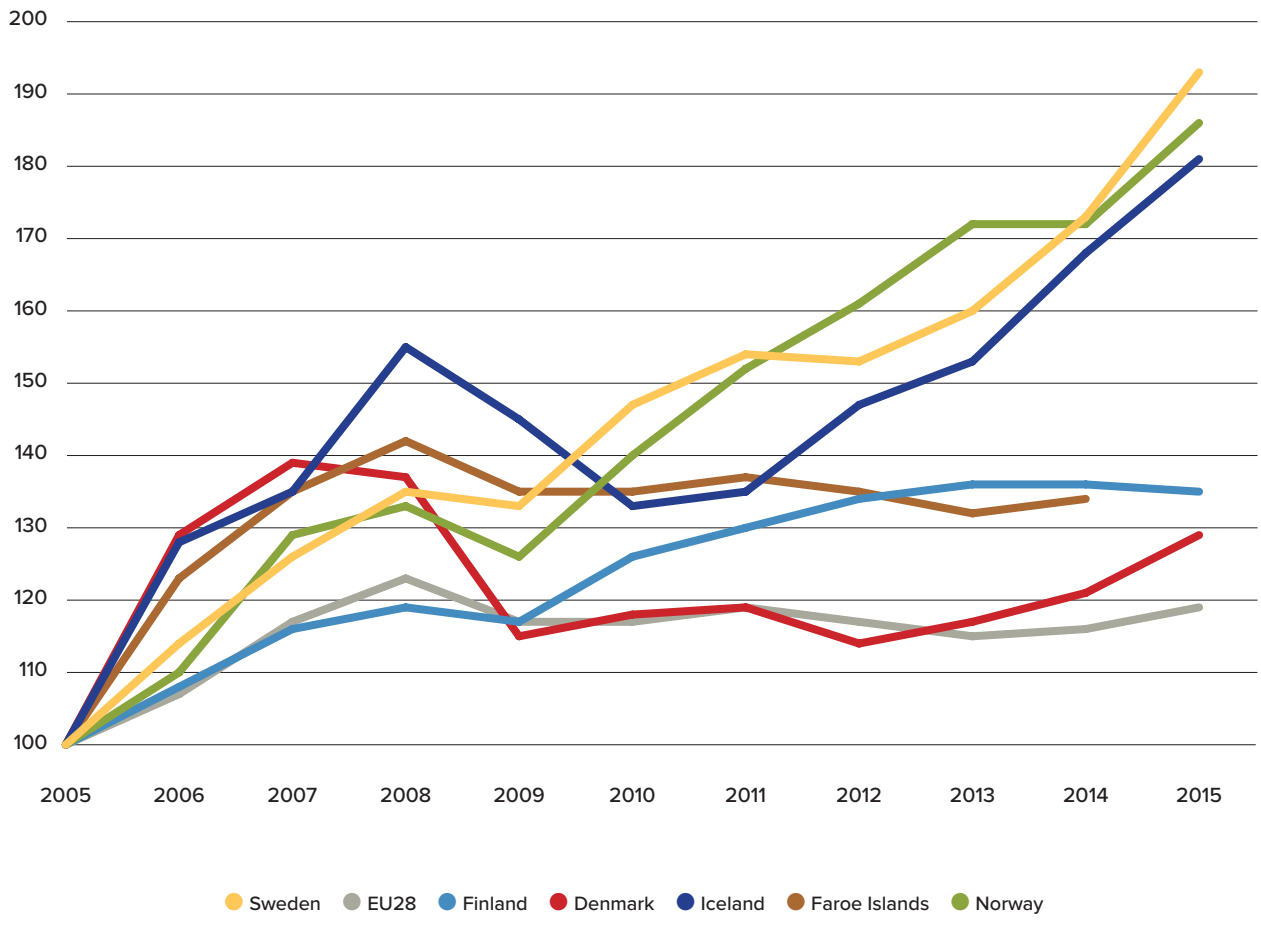
context where housing ownership is a positive norm and rental housing is negatively stigmatised can emphasise socio-economic differences. Whether there are measures in place to provide loans at attractive rates is also an important factor in terms of the socio-economic effects of rising housing prices.

Building sector recovery fails to meet housing need

House prices are of course related to what is available, what is being built and how this relates to existing demand. However, the housing construction sector is also strongly dependent on state support measures and international market trends. In the Nordic countries there are different views on what the role of the state should be in housing production. In Norway and Finland state institutions exist for the financing of housing construction and to support households to get onto the property ladder particularly in respect of different forms of owner-occupied housing, while in Denmark and Sweden stronger public housing companies exist instead (Boverket 2011).

The effects of international dependencies are visible in the two charts below (figures 12.2 and 13.3). Since the year 2000 the development of residential construction has followed a broadly similar pattern in Sweden, Norway, Denmark and Iceland. The socio-economic effects of the development of housing construction are however difficult to interpret from these charts since the data does not take tenure form into account. Whether the completed dwellings in the chart below (figure 12.2)

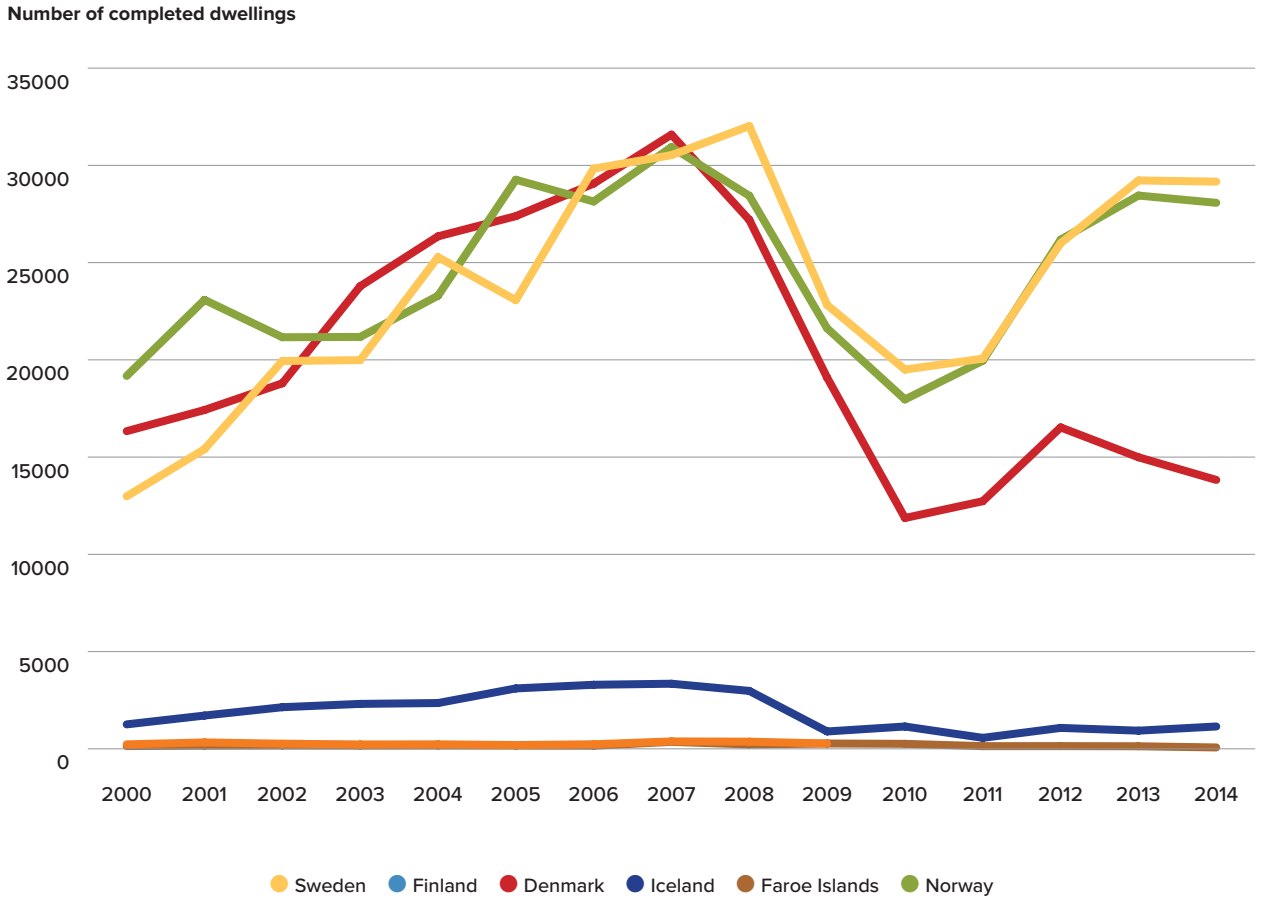
Figure 12.1: **National house price index (HPI), 2005-2015**



Data source: Eurostat. Finland: Includes Åland. Greenland: No data

Refers to the first quarter of each year. NB: HPI refers to final market price of residential property purchased by households

Figure 12.2: **Development of residential construction 2000-2014: number of completed dwellings**



Data source: NSI's. Finland, Åland: No time series data

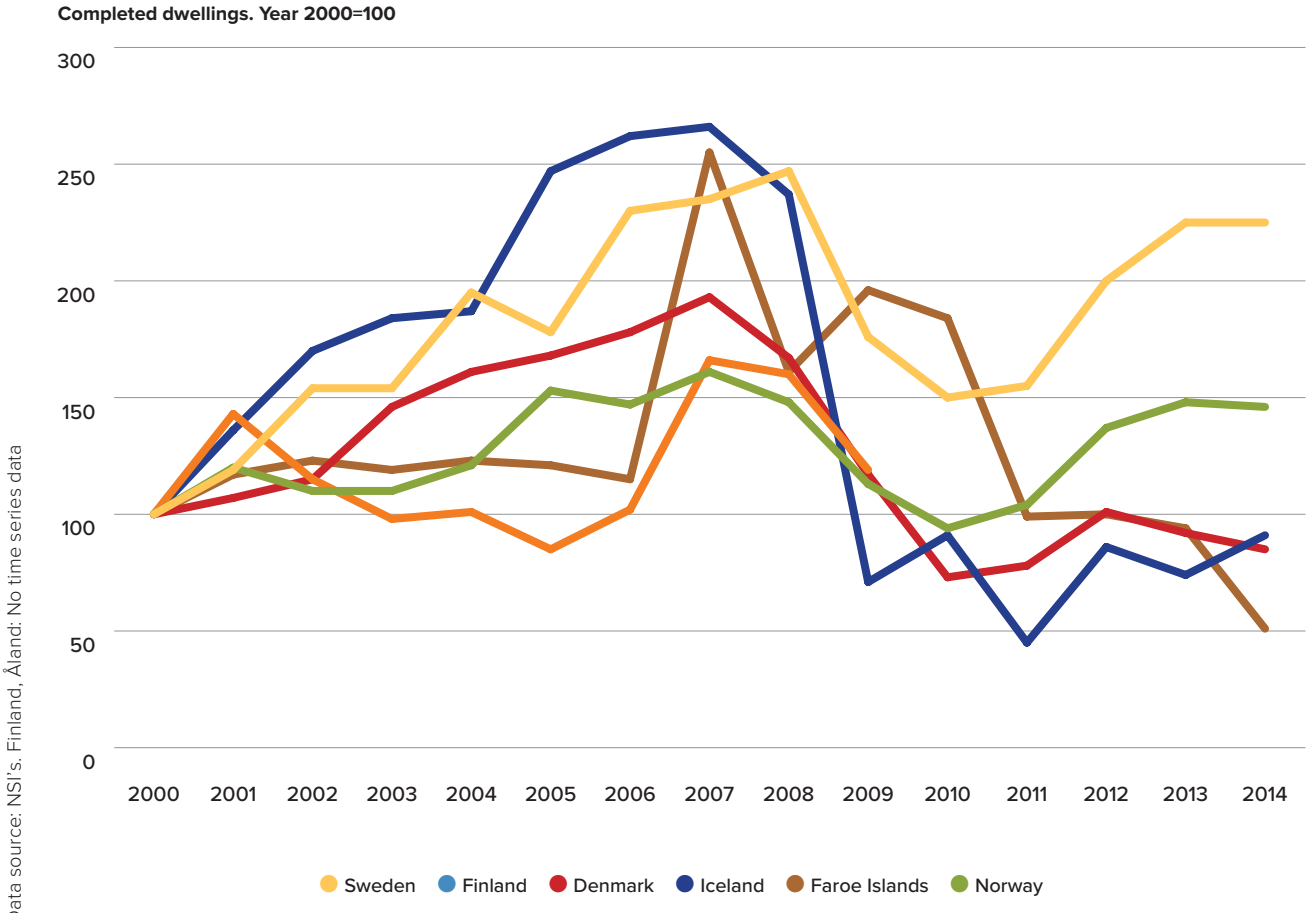
are rental or owner-occupied has a significant impact in terms of their socio-economic effects on the ground. Who can afford the homes, who can access them and how, where in the urban landscape are they located etc.?

House building declined significantly after the financial crisis. In Sweden and Norway the number of completed dwellings has however subsequently increased, but the big cities are still experiencing a housing shortage. This is particularly so in Sweden, where housing construction also fell in the early 1990s, and since then has remained on a comparatively low level. As a consequence of these historic downturns in house building, in 2012, almost half of Sweden's municipalities suffered from a lack of housing and thus young people in the larger urban regions in particular where finding it increasingly hard to find suitable accommodation (Statistics Sweden 2012, p.8-9). As can be seen in the charts below, Denmark has faced even greater problems in recovering than Sweden or Norway. It should moreover be emphasised that Sweden's increase is still relatively minor, both from a long term perspective and in relation to the general lack of housing.

The data for Finland was only available for the combined period 2010-2014 and has not therefore been included in the charts. In the map (figure 12.4) Finland is presented with the average from the period of 2010-2014. Looking, however, at the available data from a long term perspective (since 2001) on the national level for the volume of approved building permits, Finland's situation remains broadly similar to that of Sweden and Norway. Finland saw a rise in approved building permits up to 2008 and has thereafter witnessed a reduction in the rate of approved permits in relation to historic levels (Statistics Finland 2015).

Figure 12.2 shows absolute numbers for completed dwellings. These numbers must however be interpreted in relation to population size, while Figure 12.3 is indexed with 2000 as the index year. It is striking that ba-

Figure 12.3: **Development of residential construction, index 2000-2014: number of completed dwellings**



Data source: NSI's. Finland, Åland: No time series data

sically all of the Nordic countries are either stagnant or in real decline in 2013-2014, except Iceland which saw a minor increase. Iceland's property market was booming up to the financial crisis in 2008, but, the decline was severe after the onset of the crisis, and the small increase between 2013 and 2014 must be viewed in relation to the fact that new construction had reached rock-bottom in 2011 with the lowest index value for all of the Nordic countries during the 2000's.

Housing construction data on the national level is actually more of an indicator for the construction and business sector than for the actual spatial development of a country. Indeed, as noted previously, tenure forms are important in terms of the spatial development consequences new residential construction has, but also the location of new housing. In the map (figure 12.4) below housing construction is mapped on the municipal level providing some more information of the effects on the ground – in cities and regions. If it would be possi-

Comparing statistics on residential dwellings construction

There are no EU regulations in respect of the statistics on the construction of residential dwellings. The definitions do however seem to be fairly comparable between the Nordic countries and comparisons have been made in other studies, e.g. by Boverket (2011). The selected data in figures 12.2-12.5 show the number of new completed dwellings (on the municipal level). It should thus only include residential buildings (and not other kinds of new construction) and the unit is the "number of dwellings". All kinds of residential dwellings are included.

The challenge of housing data

Challenges exist both in terms of finding comparable data and in choosing the best explanatory level when it comes to using the data found in relation to housing and construction in a Nordic perspective. This is of course related to differences in policies between countries, as well as to specific historical contexts. For example, what are the available tenure forms in the different countries and cities? Is there an extensive endowment of 'social' housing? Who are the most prominent builders and landlords – public or private actors? All of these factors influence how housing develops in a country or city, and differences such as these can make statistical comparisons difficult. A good starting point in the search for information here is Eurostat, since their data is comparable between countries. They do not however have much data on housing, and the data that they do have is on the national level. National data can describe national policies, but when it comes to housing and construction in the Nordic perspective, municipal or even district level data is much more useful. If housing statistics are to be used as an indicator of spatial development, in an attempt to understand the spatial consequences of market trends, segregation or urban-rural relations, this would only be possible with access to comparable data on the municipal or district levels for all of the Nordic countries.

A second important remark to make in relation to the presented data is that the theme of this chapter, housing, is a general variable that can cover many aspects of housing. As such, this chapter is focused on property prices, residential construction, tenure forms and overcrowding.

ble to zoom in on this map and see the differences between urban and suburban areas in single municipalities illustrating the importance of land value, it would be even more instructive. Nevertheless, this map still has two striking characteristics. Firstly, the low level of construction in Swedish municipalities outside of the urban regions or larger cities is apparent. Overall, new construction especially in Norway and Finland is

It is striking that construction in basically all of the Nordic countries was either stagnant or in real decline in 2013-2014, except Iceland which saw a minor increase.

in general higher and more spread out geographically. Secondly, construction is relatively lower in Denmark, and the Copenhagen region stands out in comparison to the other Nordic capital regions. This is also in line with figure 12.2 and figure 12.3, which show a substantially lower new construction pace in Denmark in recent years when compared to Norway and Sweden. It is also notable that large parts of the rather rural island of Åland have recently seen a high share of newly completed dwellings. The municipality of Jomala near Mariehamn stands out in particular, indicating that the capital region on this small island is currently growing. The data on the map in figure 12.4 can be interpreted overall as an indication of urbanisation and the enlargement of cities, since many of the municipalities with the largest construction per capita are those on the edges of urban regions or just next to larger cities.

Home ownership dominant across the Nordics

This chapter has concentrated on the housing market for buyers, owners and developers. This section will however move the focus onto rental tenure. Across the Nordic countries several forms of tenure currently exist. As a resident you can rent or own your dwelling, individually or co-operatively, and in some cases there are also mixed tenure options. Housing policies regulate the role of public and/or social housing in relation to the dwellings bought and sold on the property market. The development each of these two main housing forms is then, in a sense, dependent on the other.

In addition, the role and organisation of the public housing companies differ within the Nordic context

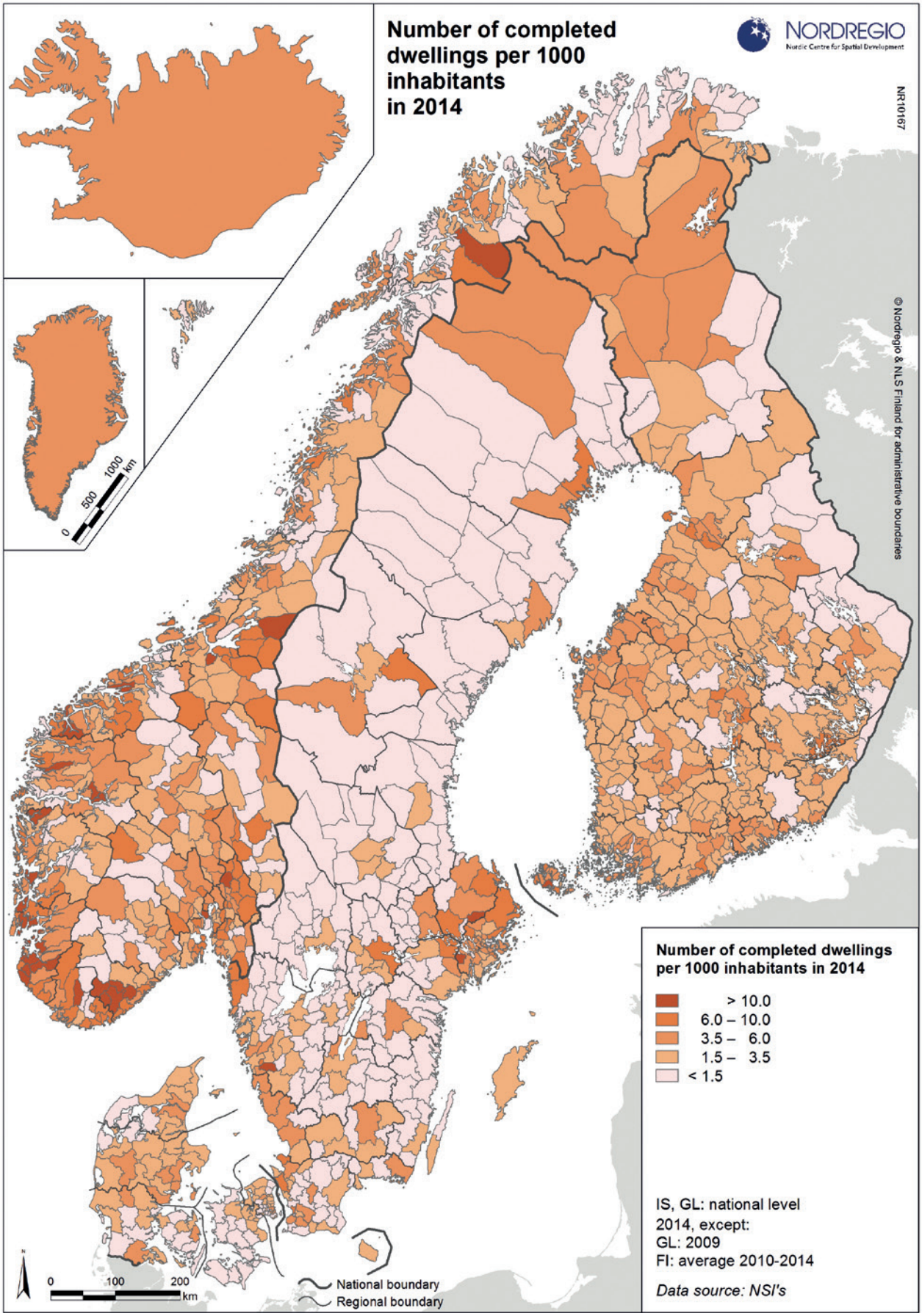


Figure 12.4: Number of completed dwellings per 1000 inhabitants in 2014

and the role and importance of social housing in the different countries significantly influences their housing markets (Bengtsson 2013, Boverket 2011). In Denmark and Sweden public housing companies providing rental housing ("almene boliger" and "allmännyttan", respectively), while in Norway the central actor building ownership dwellings for economically weaker groups is Husbanken. In Finland rental housing is made available with support from the state (ARA) (Boverket 2011).

Consequently, in order to be able to compare, generalisations have to be made. The table on forms of tenure in 2014 (table 12.1) shows the relationship between rented and owner-occupied housing, but in order to show this several sub-categories have been merged. Rental housing includes state subsidised rental housing as well as all other public and private housing under rental tenure while the ownership category also includes co-operative ownership forms. On the national level a rather similar picture occurs across most of the Nordic countries with owner-occupied housing of different kinds making up the largest share, around two-thirds of all households with housing for rent making up the other one-third. In Denmark a small share of the ownership category is termed "andelsboliger" which is the Danish form of co-operative ownership dwellings. In Sweden the largest share is ownership, followed by rental and co-operative ownership ("bostadsrätt"). This includes all forms of housing (apartments, detached houses, terraced houses, etc.).

As can clearly be seen Greenland provides a rather different model than the other countries as public, and thus rental, housing is the dominant form. Rental housing in Greenland is often owned by public organisations, for instance the national government or the municipalities, and in a few cases also by large companies (Rasmussen 2011, p.128). With its sparse population and harsh landscape, Greenland's towns and settlements have often been described as islands, creating relatively limited and distinctly separate labour and housing markets (OECD 2011, p.71). In the Faroe Islands almost all dwellings are privately owned (Rasmussen 2011, p.128), as they are also in Iceland (though this not represented in table 12.1). In Iceland, housing ownership is seen as a secure investment in an otherwise "boom and bust economy" (Karlsdóttir 2013, p.48).

Regarding the generally smaller share of rental properties in all countries except Greenland there are important aspects of this issue that are not immediately visible in the table. In Denmark and Finland state subsidies plays a much stronger role, making it possible for these two countries to provide housing at lower cost. In Finland the private rental market was around 20 percent in 2014 and the share of state subsidised dwellings around 13 percent. Tenants in state subsidised dwellings are selected on the basis of social appropriateness and financial need, i.e. social housing. In Sweden there is, instead of social housing, a system of needs-tested rent grants to households in place with a similar function of lowering rent levels for social groups lacking adequate resources. In Norway, on the other hand, there is basically no public housing at all. Rental apartments (around 23 percent in 2011) are mainly owned by private persons, making the position of rental tenure very different from countries where it is public and/or state subsidised, or where landlords are the municipalities themselves, unions or other associations (see Bengtsson 2013 for a comparative discussion on this).

Figure 12.5 shows the number of rental dwellings per 100 owned dwellings in 2014. It is again a simplified division of all the housing types where the category rental includes state-subsidised, public and private rental dwellings and the category ownership includes co-operatively owned dwellings as well as individual ownership. According to this map – with the exception of Greenland - rental housing predominates or is strong mainly in municipalities in or near the bigger cities in Sweden, Denmark and Finland, for example in municipalities around Copenhagen such as Brønd-

Table 12.1: **Forms of tenure in 2014.**

2014	Rental * %	Ownership** %	Other %
Denmark	38.7	57.8	3.4
Finland	32.8	67.1	0.0
Sweden	38.2	61.8	0.1
Norway	22.8	77.3	0,0
Faroe Islands	13.5	80.8	5.8
Greenland	59.1	31.0	9.9

* (including social housing, public as well as private rental)
** (including co-operative ownership)

Source: NSI's. Harmonisation by Nordregio. Note: Faroe Islands and Norway: 2011. Greenland: 2010

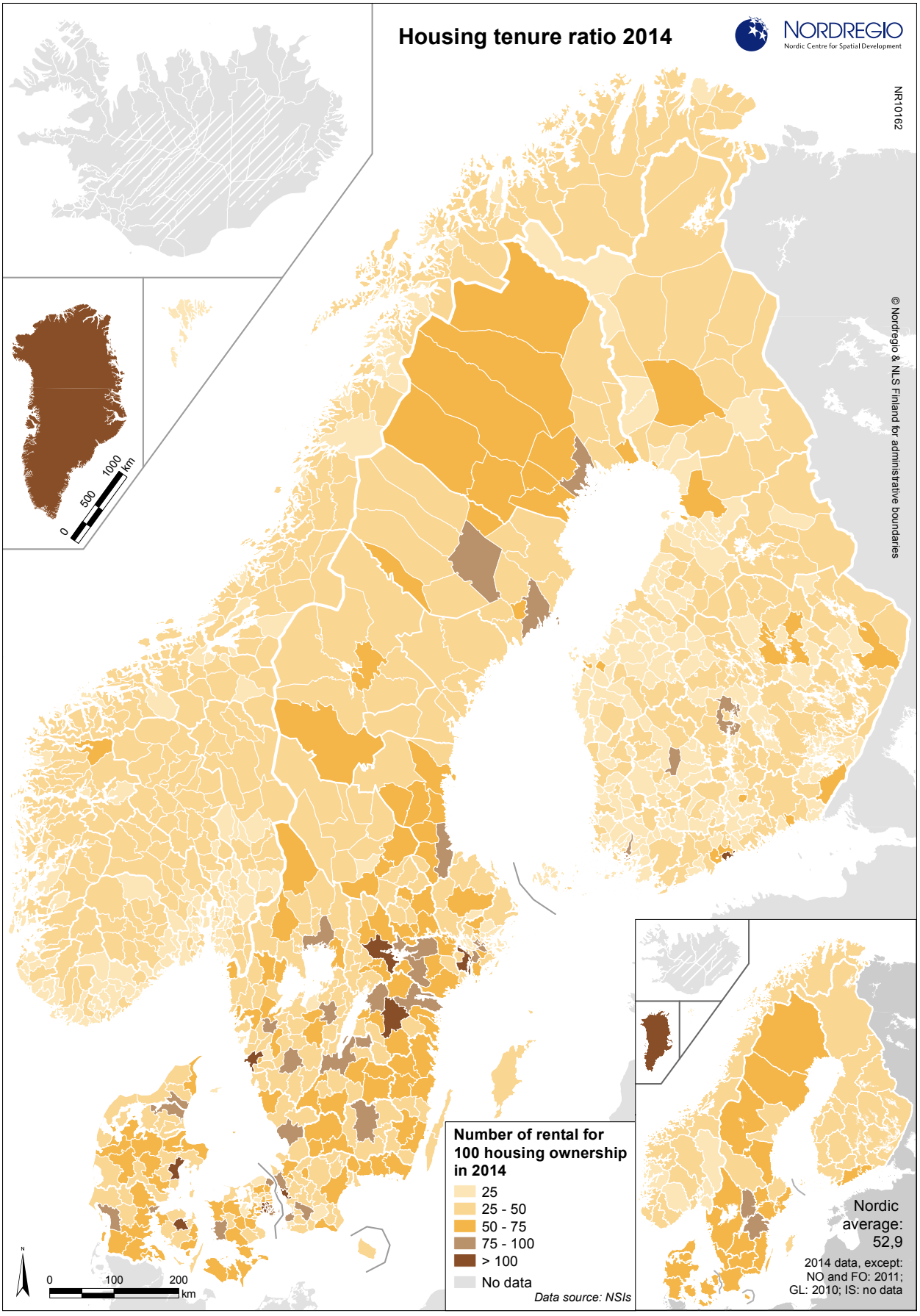


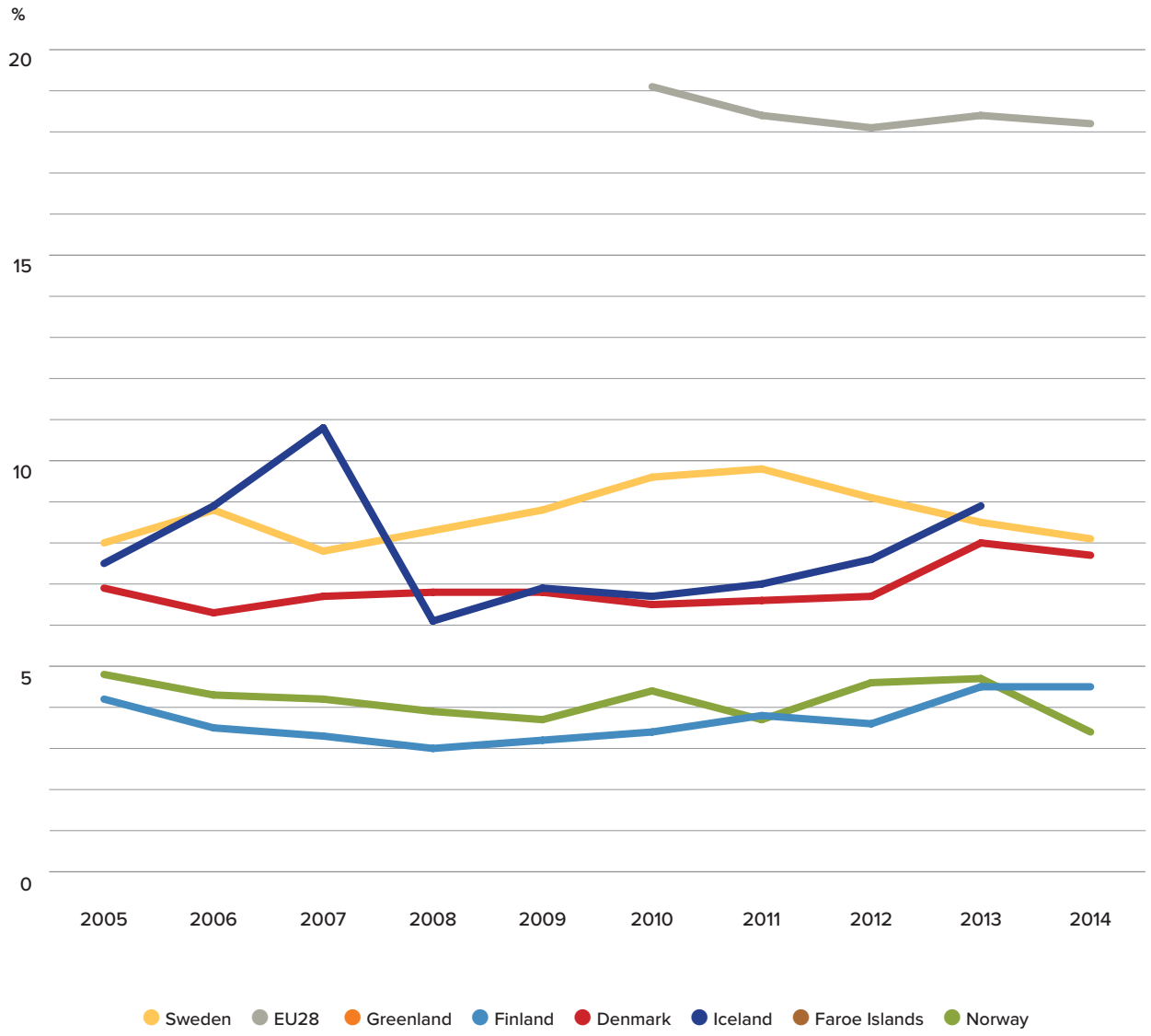
Figure 12.5: Housing tenure ratio 2014

by and Albertslund, in Södertälje and Sundbyberg in the Stockholm region and in Helsinki municipality. However, rental tenure is also dominant or strong in municipalities like Århus (Denmark), Fredericia (Denmark), Landskrona (Sweden), Turku (Finland) and Lycksele (Sweden). Overall however, housing ownership in different forms is strong in the Nordic countries. And although the map illustrates the entrenched position of housing ownership, it also illustrates the relatively stronger position of rental tenure in Sweden and Denmark in comparison to the other Nordic countries. In Norway, renting is primarily for the young and single, particularly in the cities (Statistics Norway 2015, p.18).

A strong relationship between overcrowding and poverty

A final variable presented here to illustrate the housing situation in the Nordic countries is that of overcrowding. As figures 12.6 and 12.7 illustrate there is a small gap between Norway and Finland with the smallest share of overcrowded population and Sweden, Denmark and Iceland with a somewhat larger share. The general picture of the Nordic countries is that crowding is much less of a problem here than in the European Union overall. It should however be emphasised that despite overcrowding being a relatively small problem nationally in the

Figure 12.6: **Share of overcrowded households (excluding singe-person households) 2005-2014**



Data source: Eurostat. Note: Finland: Includes Åland. Faroe Islands, Greenland: No data

Nordic context it is, according to Statistics Sweden for example, more common among the foreign-born population in Sweden, and particularly those foreign-born from outside Europe (Statistics Sweden 2014a). This could be seen as an indication of segregation, in the sense that overcrowding is a consequence of the difficulties faced by ethnic minorities in getting into the regular housing market (Ahmed & Hammarstedt 2008). Note also in Figure 12.7 how overcrowded households correspond with those at risk of poverty (defined as the persons with less than 60 percent of the median income), clearly illustrating a very vulnerable group (i.e. often immigrants from outside Europe, living in crowded conditions and at risk of poverty).

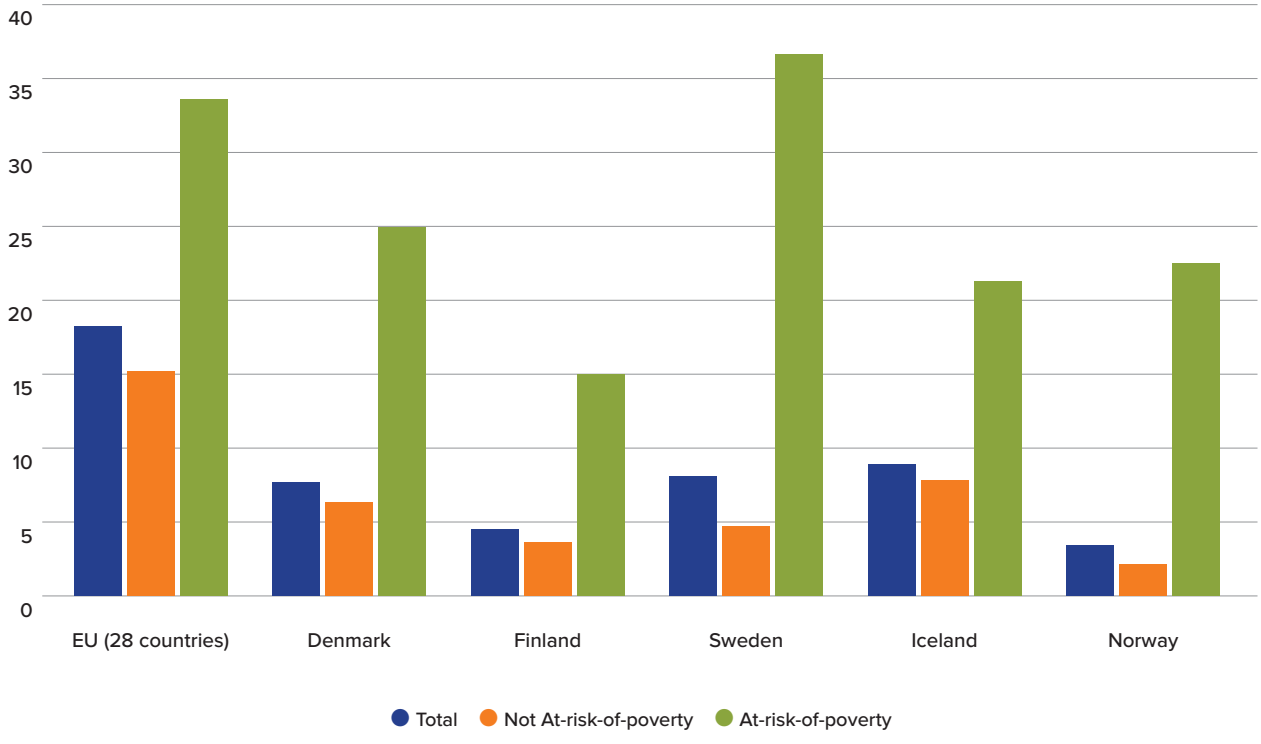
What counts as an overcrowded household?

Following Eurostat, an overcrowded household is defined as one which has fewer rooms than the sum of:

- one room for the household;
- one room per couple in the household;
- one room for each single person aged 18 or more;
- one room per pair of single people of the same gender between 12 and 17 years of age;
- one room for each single person between 12 and 17 years of age and not included in the previous category;
- one room per pair of children under 12 years of age.

Crowding can however be an indicator both of actual crowding due to the lack of affordable and/or adequate housing, and of a chosen "compact" lifestyle. In the data presented below single-person households have been excluded in order to gain a better picture of actual crowding due, perhaps, to the lack of affordable and/or adequate housing.

Figure 12.7: **Share of overcrowded households (excluding singe-person households) at-risk-of-poverty in 2014**



Data source: Eurostat. Note: Finland: Includes Åland. Faroe Islands, Greenland: No data

Chapter 13
AIR ACCESSIBILITY: Passenger numbers increasing, but the best is yet to come

Author: **Julien Grunfelder**
Maps and data: **Julien Grunfelder** and **Shinan Wang**

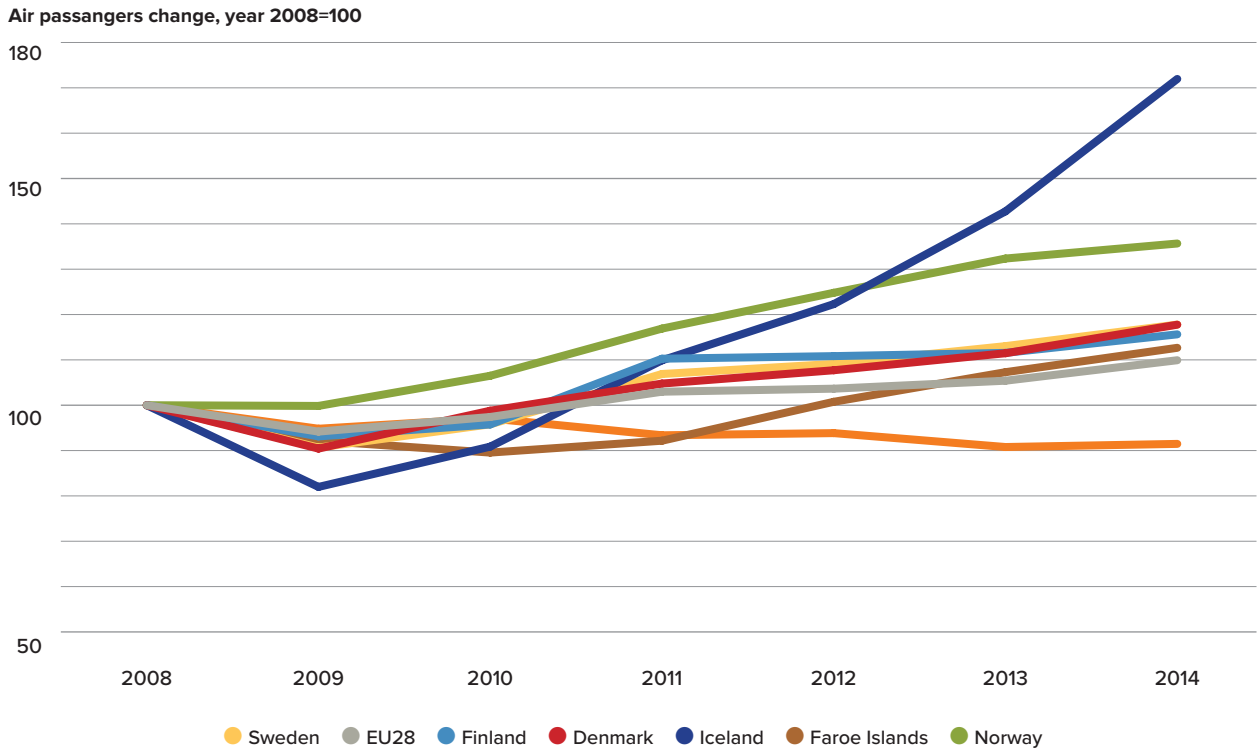
In 2014, nine airports located in Europe were included in the top 50 busiest airports in the world in terms of total number of passengers: none were located in the Nordic Region. Air traffic in Europe is largely dominated by five countries (France, Germany, Italy, Spain and the United Kingdom) which together absorb more than 60% of the total number of passengers. The Nordic Region's peripheral location and, in a broader European context, relatively low densities of both people and cities, result in a relatively low number of air passenger journeys being undertaken. In 2014, the share of air passengers in the Nordic Region was 13.7% of all passengers in European airports (12.2% in 2008). Looking at the European scale, Copenhagen-Kastrup is 15th, Oslo-Gardermoen is 17th, Stockholm-Arlanda is 21st and Helsinki-Vantaa is 30th.

Rising passenger numbers and substantial growth potential

Despite its relatively unimpressive performance in terms of absolute passenger numbers, air traffic volumes routing through Nordic airports suggest that the market remains underdeveloped, i.e. characterised by its immaturity. In other words, opportunities for growth remain in volume terms of across the vast majority of Nordic Region airports. This stands in stark contrast to those countries with mature airports where the capacity for growth is very limited (for instance: Paris-Charles de Gaulle and London-Heathrow). The figure 13.1 shows air passenger development for the Nordic countries and territories and for the EU28 for each year between 2008 and 2014, using the year 2008 as a reference. Since 2011, the increase in air passenger numbers has been higher in all the Nordic countries and the Faroe Islands than the European Union average, and has been largest in Iceland and Norway. This immaturity is clearly highlighted in the data on air passenger development, where all of the Nordic countries have a growth above the EU28 average of 9.9% for the period. Since 2012 Iceland has had the strongest increase reaching an index value of 172 in 2014. Norway has experienced a period of continuous increase since 2008 and attained an index value of 136 in 2014. Finally, Denmark, Finland and Sweden all developed rather similarly in terms of air passenger numbers during this period with each having index values around 117 in 2014. A recent study (European Commission, 2015) states that Denmark and Sweden are expected to see annual growth between 2-4% in the coming years. Iceland will have an even more impressive annual growth above 6% up to 2020, whereas Finland and Norway will only see an annual growth rate of 1-2%. The graph (figure 13.1) also shows that, with the exception of Iceland, the 2008 financial crisis has had only a limited impact on air traffic in the various domestic markets of the Nordic Region.

One of the reasons for the rapid growth in air passenger numbers in the Nordic countries since 2011 is the new strategies adopted by airports and airlines. Some of the airports and airlines based in the Nordic Region used their peripheral but strategic location in a European context as a natural competitive advantage to market themselves as gateways to other continents. This has been the primary strategy in both Finland and Iceland. The pairing of Finnair/Helsinki-Vantaa airport succeeded in marketing themselves as the gateway to Asia, offering the shortest route between Europe and East Asia and very efficient transit. Similarly, Icelandair/Keflavik airport produced a similar strategy as a new gateway to North America. It is also worth mentioning here the growth of the airline Norwegian Air Shuttle which has, since 2008, on a budget carrier basis significantly increased the number

Figure 13.1: **Air passengers by country for commercial flights in the Nordic countries**



Air passengers index development between 2008 and 2014

Data source: Eurostat, Statistics Greenland, Statistics Faroe Islands.
Note: Finland: Includes Åland

of operations and passengers in its two main Nordic hubs (Oslo Gardermoen and Stockholm Arlanda airports)

These new strategies developed by various Nordic airports and airlines have significantly increased air accessibility between the Nordic countries and other continents, via the main airports of the capital cities in each Nordic country. Figure 13.2 highlights intercontinental routes with an origin or destination in the main airport of each capital city in the Nordic countries. The map only includes direct scheduled commercial flights (situation as of January 2016) having at least one weekly flight. In other words, it does not include connecting flights, charters or cargo routes. Both North America and East Asia are relatively well connected to the Nordic countries, as are the Middle East and South East Asia, though to a lesser extent. A number of these intercontinental routes have been established quite recently, particularly those with the Middle East and Asia most of which were opened between 2011 and 2015. Routes to Africa and South America are more problematic to operate as the Nordic countries have no comparative advantage in developing them, hence the limited number of routes to the former and the complete lack of any routes at all to the latter.

Air transport in the Nordic countries is also characterised by strong moral and regulatory pressure towards the creation of more energy efficient operations, initiated by both the public and the private sectors (World Bank, 2012). The public sector contributes by means of various fiscal and policy measures, while the private sector contributes by using new, less pollutant emitting, planes (Norwegian Air Shuttle has one of the newest fleets in the world, while Finnair is the first European airline to buy and operate the new Airbus A350) and by employing such practices as for instance the continuous descent operations to reduce emissions during landing.

Supporting regional development through increased air traffic

It is generally acknowledged that airports have a significant effect on regional economic development. In our contemporary service-dominated societies, moving people has a bigger effect on the economic development of regions than moving goods (Florida, 2012), hence the importance of good air accessibility for the population. An increase in the air accessibility of a region results in the creation of jobs; not only direct jobs, but also indirect, induced and catalytic jobs (SEO, 2012). The number

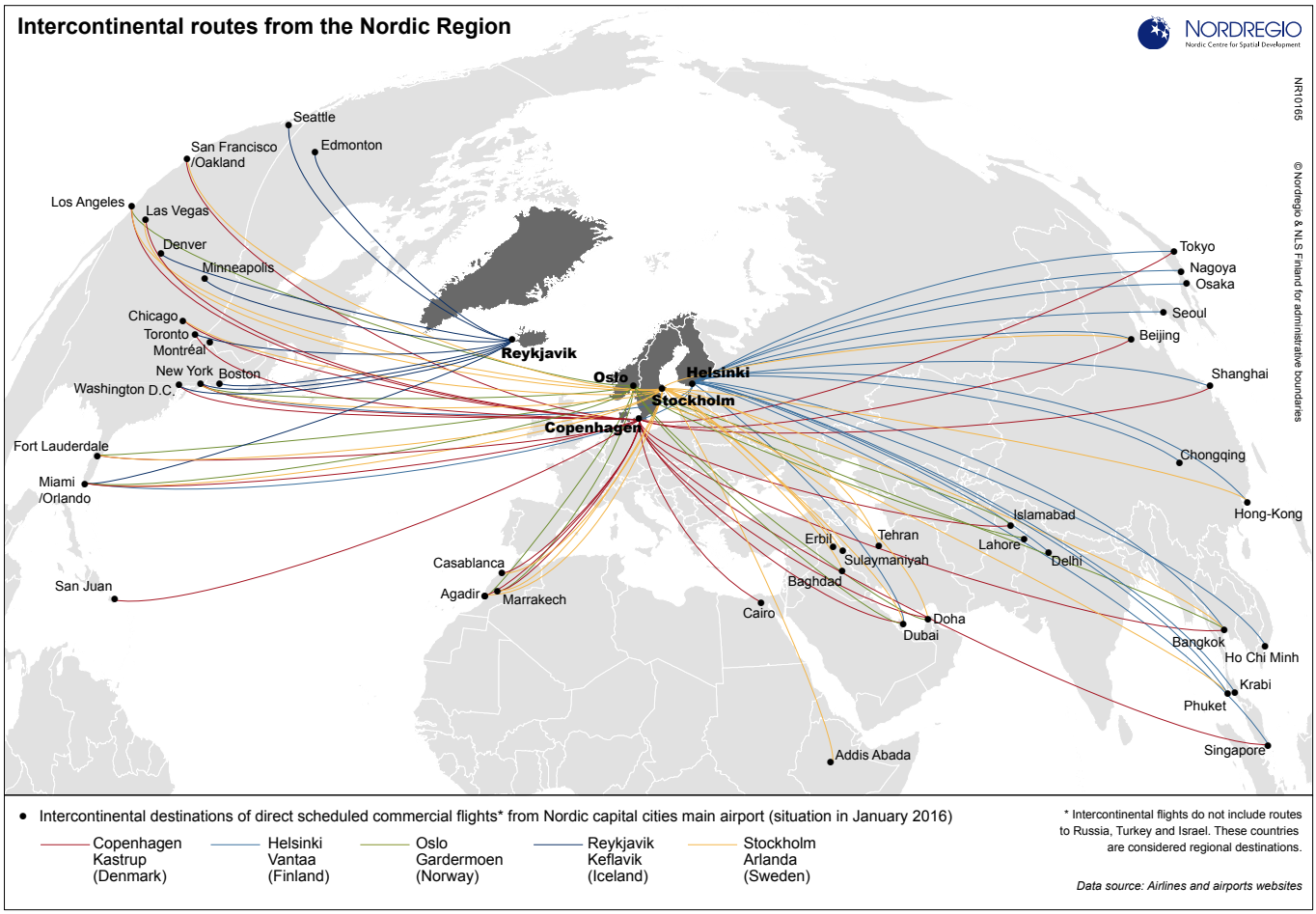


Figure 13.2: Intercontinental routes from the Nordic countries (direct scheduled intercontinental routes only)

of jobs in the Nordic Region generated by airport activities amounted to 612 800 in 2013 and their total contribution to national GDP varies from 4% in Norway to 9.5% in Iceland (InterVistas, 2015).

Almost 150 million passengers travelled through the airports of the Nordic Region in 2014, which means an increase of 22% since 2008. Approximately two thirds of the passengers were international (a 28% rise since 2008) while 60% of the total number of passengers travelled through one of the four largest airports (Copenhagen-Kastrup, Oslo-Gardermoen, Stockholm-Arlanda and Helsinki-Vantaa).

The organisation of air traffic flows is reflected in the number of domestic and international passengers in the airports of the Nordic Region. The map on domestic and international air passengers in 2014 (figure 13.3) shows that the majority of international passengers are found in a limited number of airports, mostly in the capital city airports plus a couple of metropolitan area airports. Denmark produces a slightly different pattern where the share of domestic passengers is rather low in its two largest airports, located in Copenhagen and Billund. This can, in part, be explained by the relatively small size of the country where domestic transport distances do not favour air traffic with the exception of that between Copenhagen and Aalborg where air traffic has a competitive advantage, resulting in a large share of domestic passengers at Aalborg airport.

It is also generally acknowledged that accessibility is more important than location (Rasker et al, 2009). This is particularly true for remote regions particularly for those in the Nordic Region, where airports participate significantly in the integration of these more physically distant regions. Air accessibility also has a significant social impact in these regions. For instance, it contributes to the maintenance of local services and it reduces the local population's feeling of peripherality, contributing to the creation of a strong general desire not to leave the region. The map on domestic and international air passengers per airport in the Nordic Region in 2014 (figure 13.3) also highlights the importance of small and medium sized airports for domestic passengers in the

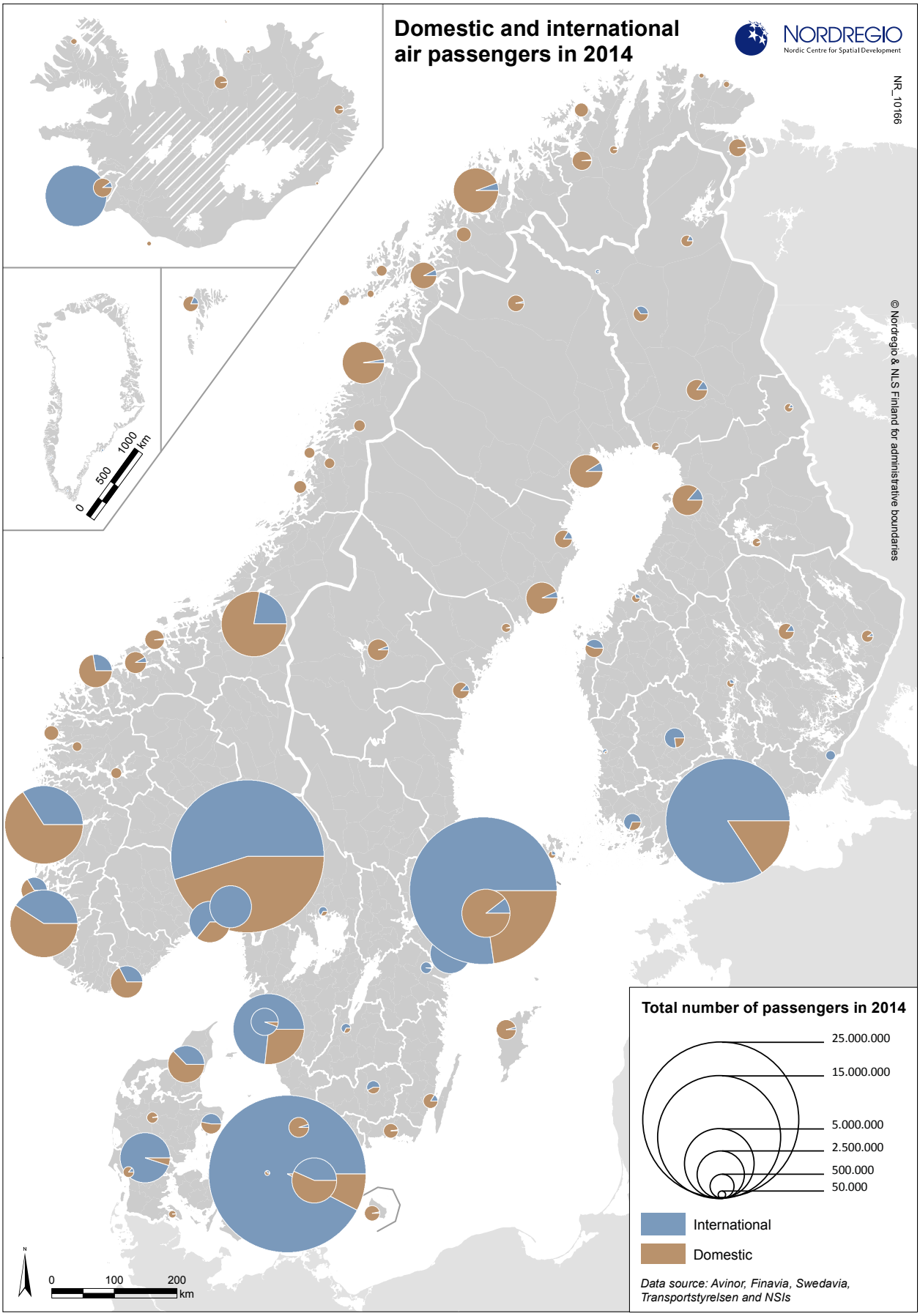


Figure 13.3: Domestic and international air passengers per airports in the Nordic Region in 2014

Figure 13.4: **Total number of passengers per commercial airport in 2014**

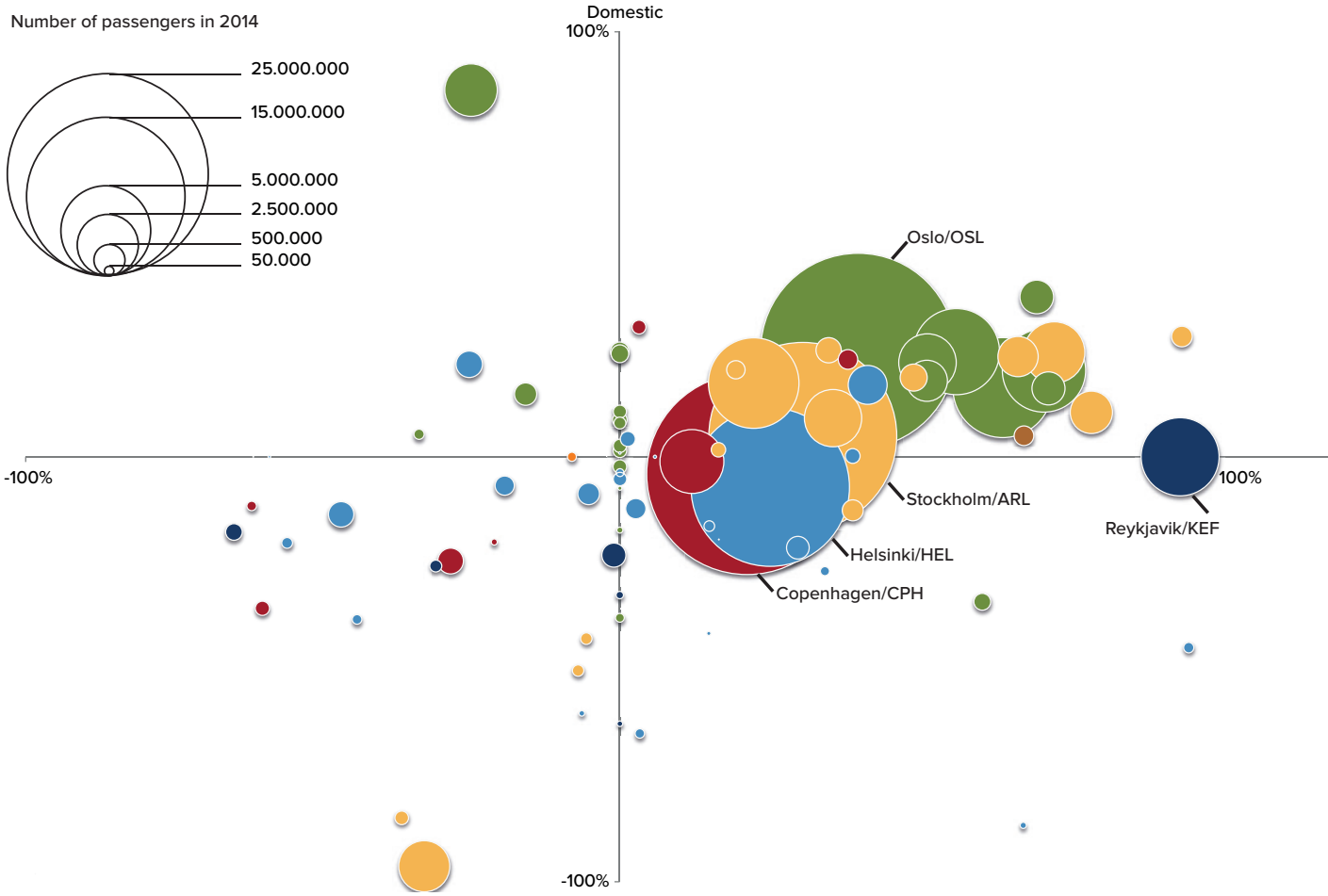


Figure 13.4: Total number of passengers per commercial airport in 2014, and domestic and international air passenger changes between 2008 and 2014 per commercial airports in the Nordic Region

northern parts of Norway, Sweden and Finland, as well as most of Iceland (with the exception of its capital region). The most remote areas of the Nordic Region undoubtedly suffer from a lack of transport infrastructure, mainly due to the low population densities, as well as the relatively long distances between urban settlements. These areas can also be challenged by both their topography and climate. As a consequence, these remote regions have no realistic alternative to air transport in terms of accessing the health and other public services lacking in their regions. Hence the population in these remote parts of the Nordic Region often displays a relatively higher number of domestic flights per inhabitant than national averages for the Nordic countries (Halpern & Bråthen, 2011). In terms of healthcare issues, population growth in these peripheral regions is more dependent on access to air transport than less remote regions. Air transport is thus the most viable option from a cost-benefit perspective for both patients and authorities (Halpern & Bråthen, 2011). Public subsidies for air routes are one solution to ensuring access to and from remote regions. In Norway, public subsidies through public service obligation (PSO) strongly contribute to the existence of domestic air routes. Indeed, Norway has the largest number of PSO routes in Europe (Bråthen, 2011) with a number of airports exclusively relying on PSO traffic, such as Hammerfest and Leknes (Bubalo, 2012).

Finally, the relatively large share of international passengers outside the capital regions can be explained by the existence of charter flights.

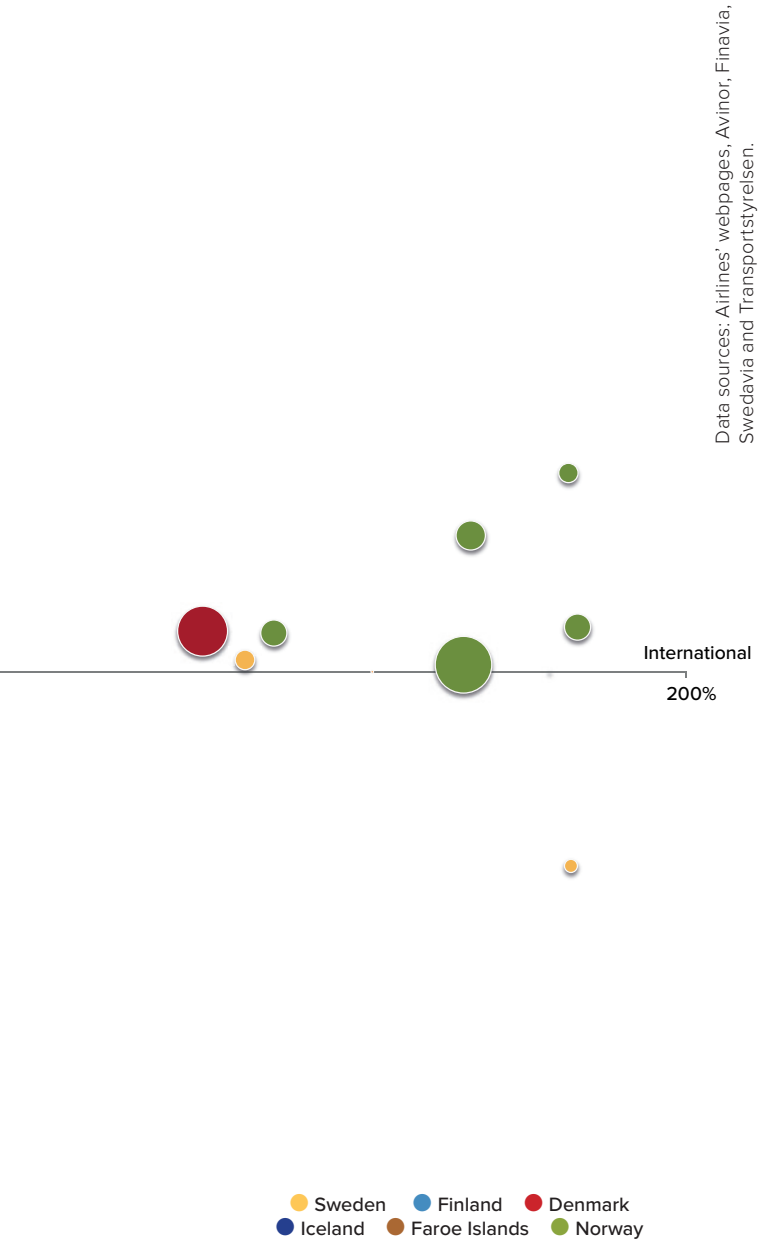


Figure 13.4 highlights changes for all types of flights (scheduled and charters) between 2008 and 2014 separated between domestic (vertical axis) and international passengers (horizontal axis) of all the commercial airports in the Nordic Region. Each colour corresponds to a country or territory of the Nordic Region and the size of the circles is proportional to the total number of passengers for each airport in 2014. The graph indicates growth in both domestic and international passengers for airports in Norway, as well as in Sweden, but to a lesser degree. The situations in Denmark, Finland and Iceland are rather similar with the main airport(s) seeing an increase in both domestic and international air passengers, while most of the other airports are either stagnating or suffering declines in both types of air passengers. The graph also shows that a number of very small airports have seen significant reductions in both domestic and international passengers. The graph also indicates that growth has mostly occurred in the main hub in each country. Finally, the growth of international passengers in small airports corresponds to the introduction of charter destinations to southern Europe.

Complementarity between airport and high speed train services

The high speed rail network (maximum speed of 200km/h and more) in the Nordic Region is rather limited compared to that of other European countries such as France, Spain and Italy. A number of projects to either update existing tracks or build entirely new sections for high speed train services are in their planning phases or under development, such as the line between Stockholm and Linköping in Sweden, that between Copenhagen and Fehmarn Belt in Denmark and between Helsinki and Turku in Finland. However, three of the Nordic countries have been particularly successful at integrating the two modes of transport (rail and air) by developing efficient rail services to their main airports. Oslo-Gardermoen airport has often been cited as the best example in the world of the integration of public transport (64% market share in 2008), which includes high speed train services with a market share of 39% (Transport Research Board, 2008). Stockholm provides another well-known example of such service integration with the 20 minute connection between Stockholm's main train station and Stockholm-Arlanda airport. Copenhagen Kastrup airport is also well integrated to the rail service network, even though most of the train traffic is not high speed train services (the only high speed trains are the X2000 coming from Sweden and crossing the Öresund). Helsinki Vantaa has recently been connected to the local commuter rail network, which allows connecting to the high speed train line to St. Petersburg with a change at Helsinki main train station and a joint ticketing.