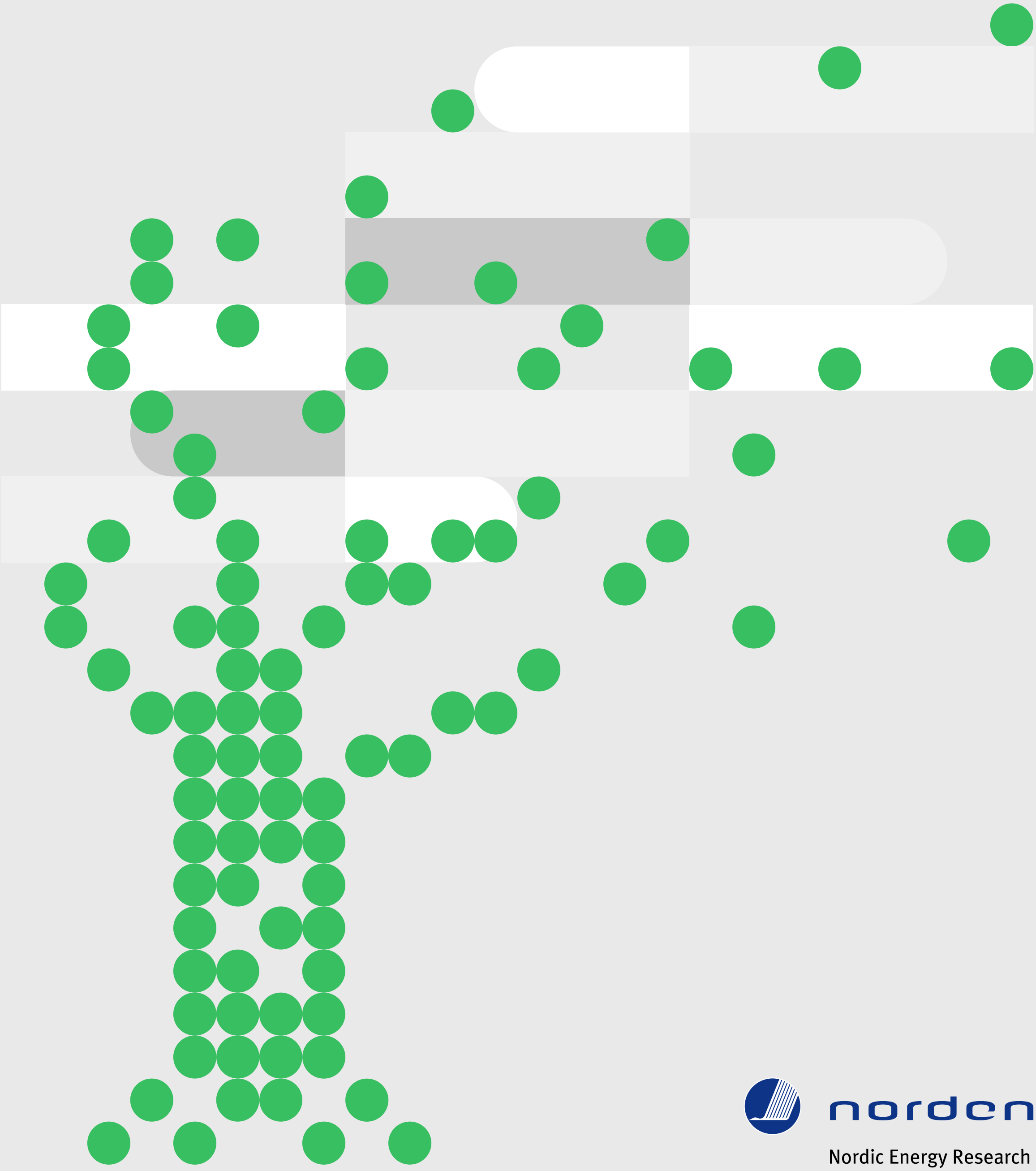
Renewable Energy Policies in the Nordic Region



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Preface

All five Nordic countries have set targets for the expansion of renewable energy production, and have ambitions of technology leadership within the sector. Policies will be pivotal in achieving these targets – the International Energy Agency (IEA) and others have frequently pointed to the critically important role of policies in the transition to a low-carbon energy system.[1]

However, choosing the type of policy instrument to use and the technology to target is no easy task for today's policy-makers. Looking to the experience of other countries can inform these decisions, but international comparisons of policies are few. This report aims to fill this niche, assisting Nordic energy technology policy-making by providing a historical context to existing renewable energy policies, and a quantitative comparison across the five Nordic countries.

Specifically, this report provides an overview of the development of renewable energy policies in the Nordic region over recent decades. This details how the five countries have prioritised different policy types and targeted different technologies over time. In addition, the report describes the intended outcome of these policies – measuring progress in developing and implementing new renewable energy technologies.

Renewable Energy Policies in the Nordic Region builds directly on the Nordic Energy Technology Scoreboard, published in 2010.[2] In addition to updating central indicators from the 2010 scoreboard, this report introduces a number of new indicators with a focus on policies. This report also provides important historical context to the scenarios for 2050 presented in the recent IEA publication: Nordic Energy Technology Perspectives.[3]

The information in this report has been compiled by authors Benjamin Donald Smith and Hans Joachim Motzfeldt of Nordic Energy Research, an institution under the auspices of the Nordic Council of Ministers. Financial support was provided by the Nordic Committee of Senior Officials for Energy, with review from the Nordic Working Group for Renewable Energy. The content of the publication is the sole responsibility of Nordic Energy Research.

1 IEA (2012a), 110

2 Klitkou, A. et al. (2010)

3 IEA (2013)

Contents

1. Introduction

Aim and structure

Aim of the report

This report aims to support energy technology policy-making in the Nordic countries by providing insight into how policies have shaped the Nordic energy system over the last three decades. The report uses quantitative indicators of renewable energy policies and their intended effects, combined with qualitative descriptions from the literature to tell this story. Based on this, the report describes the unique policy conditions of the Nordic countries, and highlights future policy needs of the region. The information gathered in this report can therefore offer valuable context to support the necessary energy technology policy decisions of the future.

Structure

The report is divided into three main sections:

- Visualising renewable energy policies

  This section provides a rough-grained mapping of the renewable energy policies implemented by the Nordic countries, visualising both their distribution by policy type and by the technology targeted.

- Measuring the intended effects of policies

  Here indicators visualise the intended output of the policies, by showing how much technology development has taken place, and how well the technologies have been implemented in the energy system.

- Future perspectives

  This section provides context to the future policies that will build on the current policy portfolio. It refers to a number of studies looking at the technologies and policies needed in order to achieve the long-term energy and climate targets for 2050.

Policy targets

The Nordic energy sector is undergoing changes to become more sustainable, secure and competitive. This transition is guided by a series of political targets for the reduction of greenhouse gas (GHG) emissions. These targets apply from the year 2012 through to 2050 and are present at the national, EU and UN level.

Targets for the increase in renewable energy generation are often discussed in context with emission reduction targets. Energy is the most central among the many sectors covered by emission reduction targets, and increasing renewable energy generation is one of many actions available to governments to reduce emissions in energy. The development and implementation of renewable energy technologies is high on the political agenda in the Nordic region, and is seen not only as a climate initiative, but as a driver for increased energy security and industrial development.

Climate targets

Table 1 outlines the emission reduction targets for the Nordic countries and the EU. Binding targets under the Kyoto protocol for 2012 are followed by European and national targets towards 2050. While there are no targets at the Nordic level, the national climate targets of the five Nordic countries for 2050 are similarly ambitious. All Nordic countries target significant GHG emission reductions, and despite already sourcing a relatively large share of their primary energy from renewable sources, all countries expect this to increase.

The national climate targets of the five Nordic countries for 2050 are similarly ambitious.

Renewable energy targets

All five Nordic countries are linked to the EU Renewable Energy Directive with binding commitments to increase the proportion of renewable energy by 2020.[4] Iceland and Norway, both non EU Member States, have also implemented the directive through EEA Agreements.[5] Their targets for 2020 are listed in Table 2 below.

4 European Commission (2009)

5 EFTA (2011)

Table 1. Emissions reduction targets for Nordic countries relative to 1990, 2012–2050

Greenhouse gas emission reduction targets (CO_2 equivalents) (reference: 1990)				
	2012 (Kyoto)	2020	2030	2050[6]
Denmark	-21%	-20% (EU target, non-ETS) -40% (National target, ETS and non-ETS)		Approx. -85%[7] (100% renewable energy supply)
Finland	0%	-16% (EU target, non ETS)		-80% (domestic)
Iceland	+10%	-15% (-30% if climate agreement)		-50–70% (net)
Norway	+1%	-30% (net, -40% if climate agreement)	-100% (net, if climate agreement)	-100% (net)
Sweden	+4%	-40% (EU target, non ETS)	Fossil fuel independent transport fleet	-100% (net)
EU total	-8%	-20% (EU target, -30% if climate agreement, -25% in EU Roadmap)	(-40% in EU Roadmap)	(-80% in EU Roadmap)

Source: IEA (2013)

Table 2. Renewable energy targets for gross final energy consumption

	Reference 2005	2020 (EU)
Denmark	17%	30% (35% national prognosis based on Energy Agreement 2012)
Finland	28.5%	38% (20% renewables in transport)
Iceland	55%	64%
Norway	58.2%	67.5%
Sweden	39.8%	49% (50% national decision)
EU	8.5%	20%

Sources: AGFE (2012), IEA (2013)

6 Note: Emission reduction targets for Norway (all), Sweden (2050) and Iceland (2050) may include offsets. Finland's 2050 target includes domestic reductions only.

7 Note: The Climate Change Policy Commissions calculations indicate Denmark's target of 100% renewable energy would lead to a reduction of approximately 85% of GHG.

European 20-20-20 targets

The climate and energy package is a binding legislation covering European climate and energy targets for 2020. These targets, known as the "20-20-20" targets, set three key objectives for 2020: A 20% reduction in EU greenhouse gas emissions from 1990 levels; raising the share of EU energy consumption produced from renewable resources to 20%; and an improvement in energy efficiency through a 20% reduction in consumption of primary energy by 2020.[8]

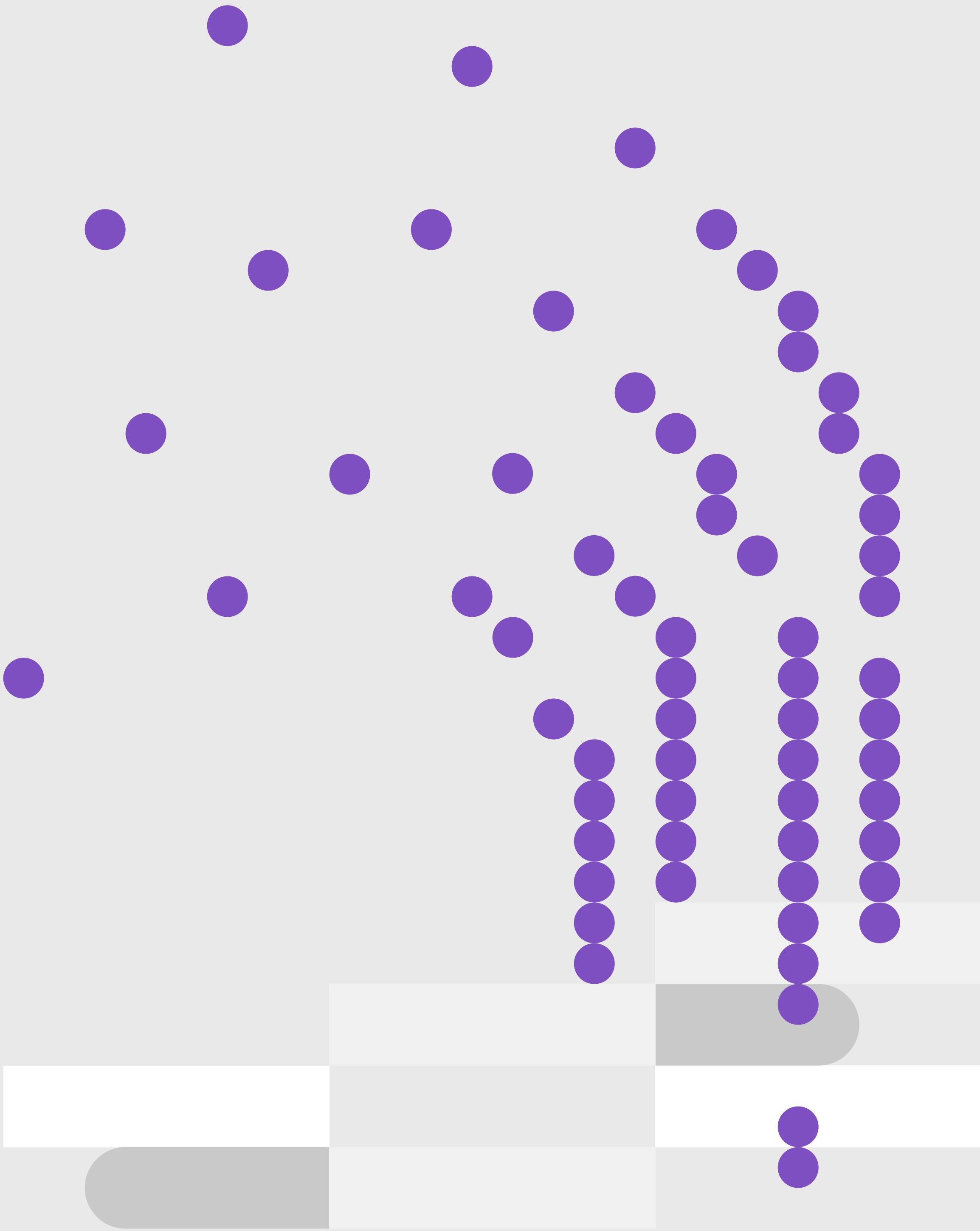
In order to meet these targets, modern renewable energy technologies must reach price parity with fossil fuels. In general, fossil fuels are more competitive in the prevalent economic system due to their maturity, economy of scale and the fact that their prices do not include the cost of the negative externalities from environmental impact. In addition, fossil fuels receive much larger government subsidies on a global scale than renewables. The International Energy Agency (IEA) estimates that in 2011 a total of USD 523 billion was spent worldwide on subsidising fossil fuels, up from USD 300 billion in 2009 and six times more than subsidies to renewables.[9]

On the other hand, recent years have seen a major shift in energy market developments and costs for renewable energy technology. In June 2012 the European Commission reported a strong growth in renewable energy markets and that a significant maturing of technologies has occurred.[10] The Commission states that in the five years to 2010, average photovoltaic system costs declined by 48% and module costs by 41%. Industry expects costs to drop further based on growth driven by current energy policies, reforms and the removal of market barriers. Onshore wind investment costs fell by 10% between 2008 and 2012.

Policies are considered the most important driver for bringing modern renewable energy technologies to the market.[11] Policies are critical in levelling the playing field for emerging renewable technologies and have contributed to the significant market developments seen in recent years. This report takes a closer look at these issues in the Nordic countries.

Fossil fuels receive much larger government subsidies on a global scale than renewables.

8 European Commission (2012a)
9 IEA (2012b)
10 European Commission (2012b)
11 Borup, M. et al. (2008), 6



2. Visualising renewable energy policies

This section visualises national-level renewable energy policies established by Nordic governments over the last decades. In doing so, the analysis provides an indication of the relative prioritisation of different technologies and policy measures within each Nordic country.

Renewable energy policy is often linked to three key objectives:

- Reducing environmental impact through the phase-out of fossil fuel-based energy sources.
- Creating economic growth through technology development and implementation.
- Increasing energy security though the displacement of energy imports and scarce energy sources.

Due to the wide applicability of these objectives, renewable energy policies are intertwined with environmental, economic and foreign policy, to name but a few. Therefore, initiatives from these policy areas have significant impact on renewable energy technology development and implementation, despite not being categorised as energy policies.

For the Nordic region, environmental impact and economic growth currently receive most attention in energy policy rhetoric. This is due to the fact that the region is a net exporter of energy, and also due to the internationally prominent role the Nordic countries wish to take in energy and climate issues. The Nordic countries have some of the world's most ambitious climate goals and some of the highest shares of renewable energy utilisation. Many of the largest companies in the region are energy-related, while the Nordic governments aspire to be leaders in renewable energy technology development, despite an increasingly competitive global market.

Many of the largest companies in the region are energy-related.

Energy security has been a more significant factor in previous decades, evident in Danish and Swedish transitions away from oil-fired power generation in 1970s and 1980s.

In a broad and long-term perspective, replacing fossil fuels with renewable energy will reduce emissions and other environmental impacts. However, it is important to consider that with the EU Emission Trading Scheme covering much of the energy system, the immediate and direct reduction in emissions attributable to supplementary national renewable energy policies can be debated. Under a European emissions cap, a reduction in one sector can be expected to result in a corresponding increase in another to meet the cap.

The policy initiatives featured in the visualisations below are drawn from the IEA renewable energy policy database[12], which is based on reporting from IEA member countries for the inclusion or exclusion of certain policies and their categorisation. Differences in reporting between countries can lead to variations in the data, which introduces important limitations. The database has been supplemented where applicable with additional information based on desk research by the authors.

Six *types of policies* have been selected from the database. For full definitions and a full description of the methodology used in selecting data from the database, see the Annex.

- Taxes: Renewable energy tax credits and carbon taxes;
- Tradable permits: Green certificates, quota policies or renewable energy obligations;
- Incentives and subsidies: Feed-in tariffs and premiums;
- Regulatory instruments: Acts, concessions and other regulations;
- Policy processes: White papers, action plans, strategies, agreements, public funds and programmes;
- Research, Development and Demonstration (RD&D): RD&D and technology programmes, RD&D strategies.

Policies are also shown categorised by *the renewable technology they target*.

- Multiple technologies (technology-neutral): These policies have elements providing support without specifically targeting certain renewable technologies.
- Wind
- Solar
- Bioenergy

In addition to showing the range of policies in place, this section presents the relative prioritisation in public support for energy technology development. Public RD&D budgets for low-carbon energy technologies are used, which are widely accepted as an indicator of the relative prioritisation by governments of specific renewable technologies.

12 IEA (2010a), IEA (2012c)

Analysis by country

Renewable energy policies saw a proliferation in all countries in the Nordic region from the middle of the 1990s. In the 5-year period between 1997 and 2002, most Nordic countries exhibited a significant increase in the number of active policy instruments. After about 2002 we see relative stabilisation of active policies in most countries. The following country-based analysis provides insight into the policy visualisations based on empirical analyses of the Nordic energy policy environments.

Denmark

Compared to other Nordic countries, the Danish introduction of regulatory instruments and incentives and subsidies began very early, with the introduction of the Electricity Supply Act and Heat Supply Act in the 1970s. This was followed by a period of little new policy introduction during the 1980s. In the 1990s we see a diffusion of policies, including the relatively early introduction of a CO_2 tax, and the liberalisation of the energy sector.

From the mid 1990s, the Danish government had a much greater focus on renewable energy[13], evidenced by the steep rise in the diversity of policy measures at the end of the decade. This trend applies particularly to policy processes in the form of concrete goals for shares of renewable energy, and incentives and subsidies.

With a change of government at the turn of the century, Denmark's focus shifted to the commercialisation of energy technology and we see a stabilisation in the number of active policies over the following years.[14] In 2007 the Ministry for Climate and Energy was created, which consolidated certain policies, evidenced by a slight decrease in the number of policies during those years. In recent years, there has been an increase in breadth in the Danish policy portfolio with new incentives, subsidies and RD&D measures.

In 2011, the government-appointed Danish Climate Commission presented scenarios to 2050, recommending that the parliament set a goal to become independent of fossil fuels in the long term. Based on this, the government set a target of 100% independence from fossil fuels by 2050. The Energy Agreement adopted in March 2012 steers Danish energy policy until 2020 and has the support of the majority of political parties.

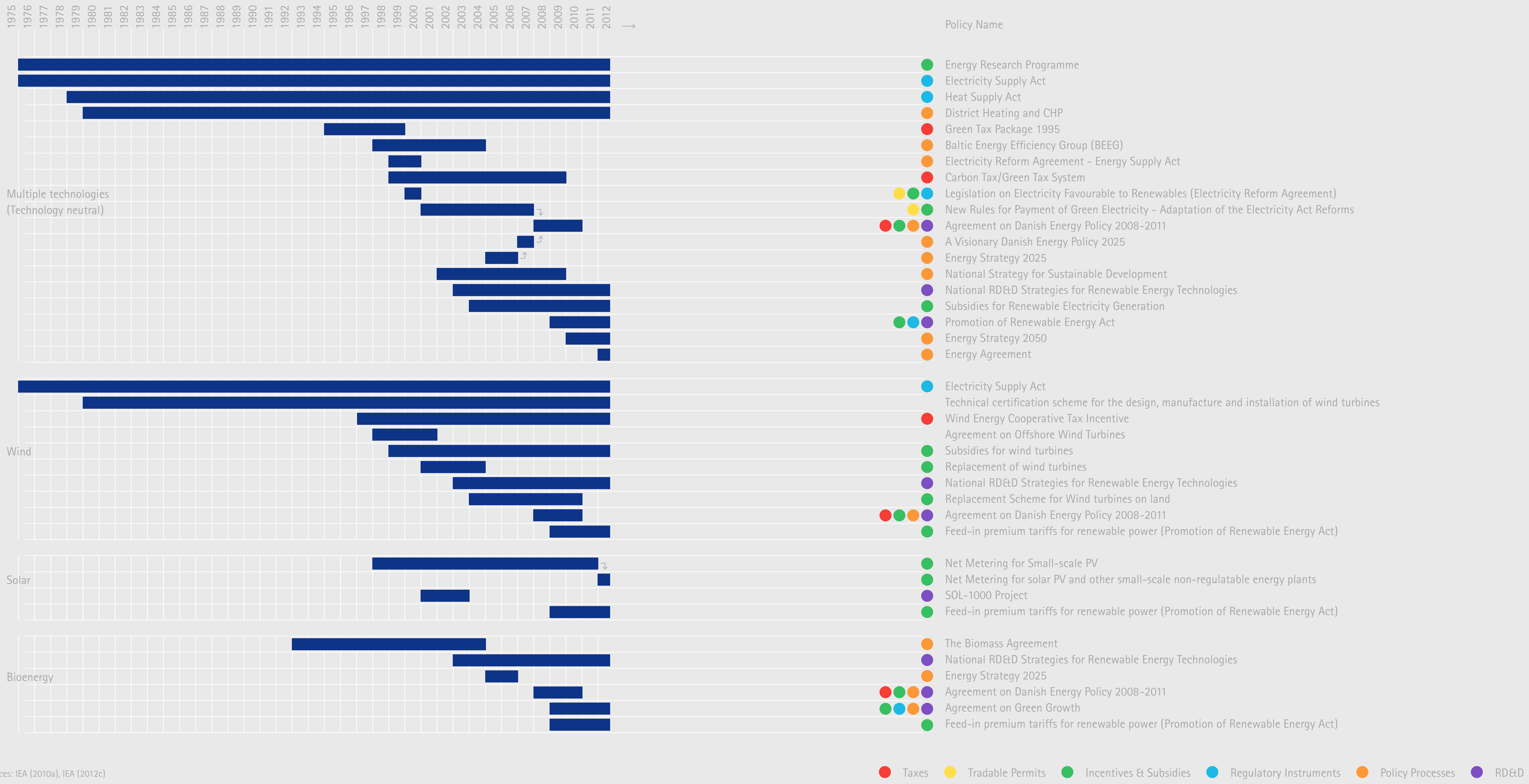
The Danish policy portfolio characteristically includes a number of technology-specific instruments targeting wind energy.

When looking at the distribution of policy elements by technology target, the Danish policy portfolio characteristically includes a number of technology-specific instruments targeting wind energy. Policies affecting wind range from planning and grid legislation to tariffs and taxes. In addition, certification and approval processes are well defined. The feed-in premium tariff is one of the most central policies for wind power in Denmark.

13 Klitkou, A. et al. (2008b), 20

14 Klitkou, A. et al. (2008b), 20

Figure 1. Danish policy elements by type and target



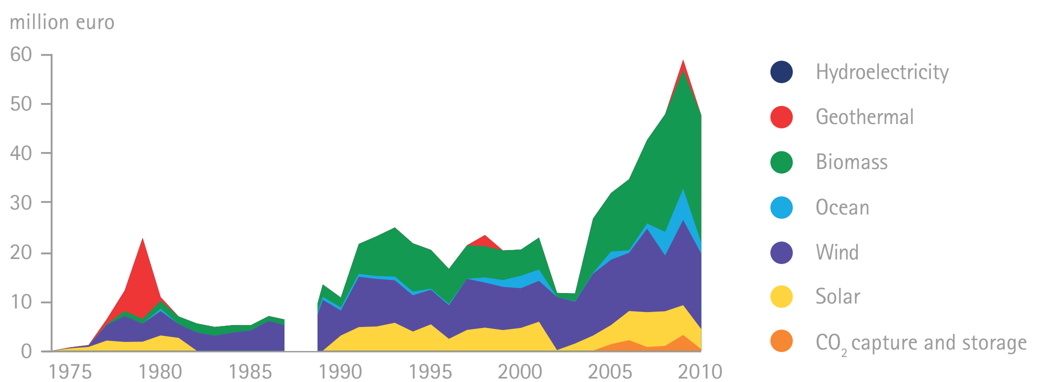
Sources: IEA (2010a), IEA (2012c)

Bioenergy is also covered by the feed-in premium tariff scheme, but with different conditions.[15] Solar power comprises only a minor share of total electricity production, and has been targeted by far fewer policy initiatives than wind or bioenergy. However, the net metering scheme for small-scale solar PV, combined with falling technology costs led to exponential growth in solar PV installations in 2012. This resulted in the policy being amended to reduce the incentives.

The net metering scheme for small-scale solar PV, combined with falling technology costs led to exponential growth in solar PV installations in 2012.

As evident in Figure 2, wind has accounted for the largest share of Denmark's public renewable energy RD&D budgets over time. However in recent years biomass has received more support. In 2002, a sharp drop in non-wind related budgets is evident in the figure. This was a result of a government change in 2001, which initially drastically reduced public funding for energy RD&D.[16] Despite this, over the last 30 years Danish public funding for wind RD&D has been relatively stable, and has been greater than funding for wind in other Nordic countries. RD&D on solar PV technologies has also received significant support in Denmark over the last two decades, but not to the extent of wind and bioenergy.

Figure 2. Danish public low-carbon RD&D budgets by technology



Source: Nordic Energy Research (2012) Note: Data missing for 1988

Finland

From 1993 onwards Finland has seen a rapid introduction of renewable energy policies, including incentives and subsidies, taxes and RD&D programmes.

Traditionally there has been significant integration between the energy supply and energy-consuming industries such as pulp and paper, forestry,

15 Borup, M. et al. (2008), 27, 29

16 Klitkou, A. et al. (2008b), 20

Finland is the only Nordic country where there have been more policies targeting a certain technology than technology-neutral policies with no specific target.

metals and chemicals industries – which together account for 50% of Finnish energy demand.[17] Paper and pulp, like forestry, has been a leading supplier of energy, giving Finland the industrial world's largest share of bioenergy in its energy mix.

Bioenergy has been the most common technology target for policies in Finland, and Finland is the only Nordic country where there have been more policies targeting a certain technology than technology-neutral policies with no specific target, which are the most common in the other Nordic countries.

Wind energy has potential in Finland for broadening the base of renewable energy sources, and features as a target technology in Finnish policies over the last decade. The main instrument of support has been investment subsidies, where wind received a higher share of costs covered compared to bioenergy. However, the total financial support actually mobilised for wind has been far less than for bioenergy, due in part to the complexity of the financing mechanism.[18] Finnish support for solar power has been a single policy over the last decade – the same investment subsidies offered to wind.

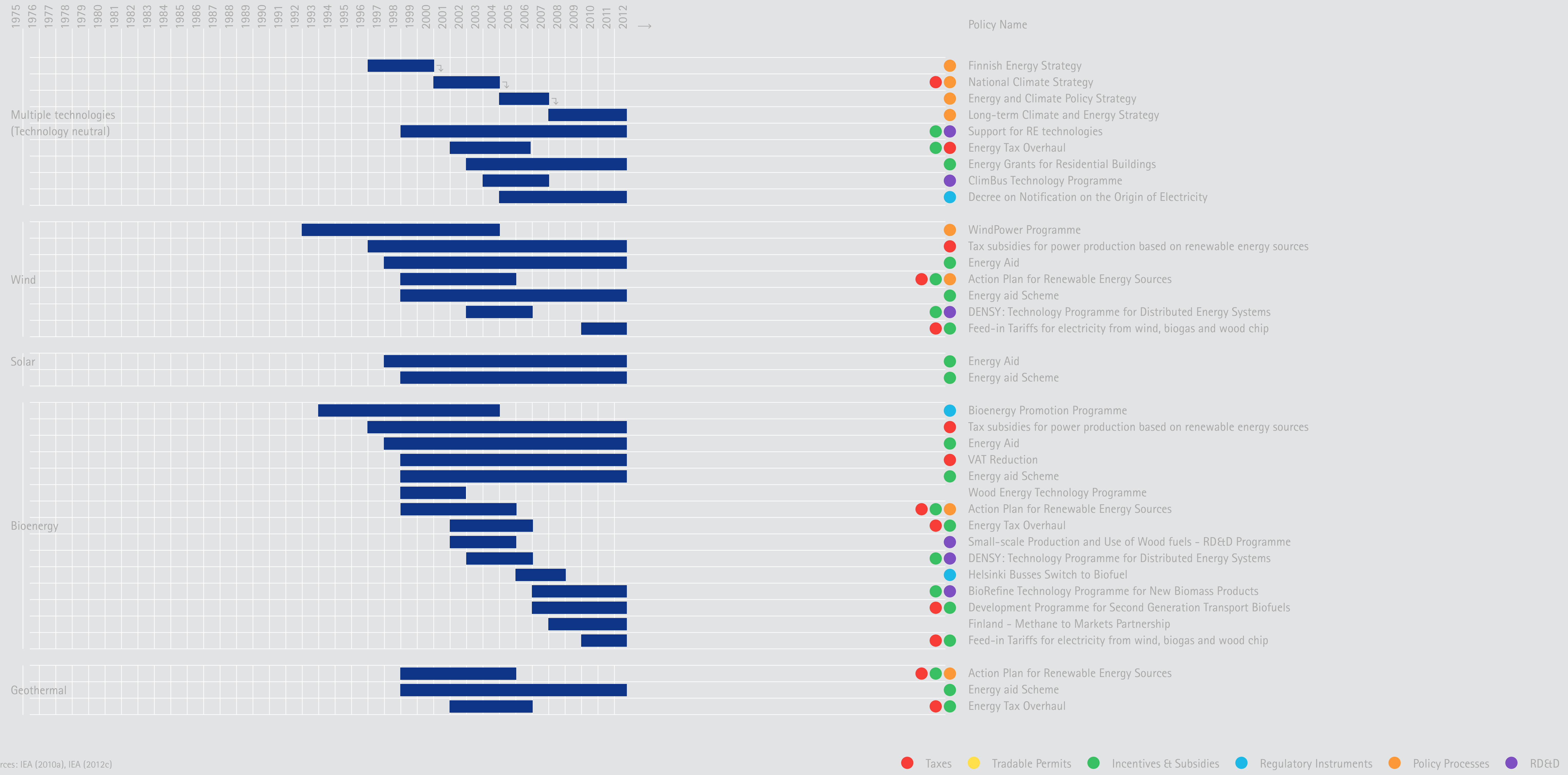
In 2010, Finland introduced a new technology-specific feed-in tariff system, which was implemented to spur the use of technologies like wind to a greater degree than former investment subsidies. In 2011 the feed-in tariff system for wind power also covered biogas electricity and small-scale combined heat and power from biomass. The total amount reserved for the feed-in tariff system in 2012 in the Finnish state budget was EUR 97 million, approximately one fifth of all support schemes in Finland targeting renewable energy.[19]

According to the Finnish Ministry of Employment and the Economy the construction of wind power in Finland progressed as expected during 2009 and 2010.[20] The feed-in tariff has had positive effect on implementation and has been a factor in the 45% increase in wind capacity seen in 2012, but new projects have not progressed as expected due to non-financial barriers.

Finnish public RD&D in renewable energy technologies focusses heavily on bioenergy, consistent with its other energy policies. Despite having multiple RD&D programmes targeting wind, in quantitative terms Finland has not generally prioritised wind energy technology in the past, with both total wind RD&D budgets and wind's share of renewable budgets being lower than other Nordic countries. Solar technologies have seen a similar trend, and only since 2005 has public RD&D support been recorded – giving a total investment in the technology far lower than the other Nordic countries. But despite this, Finland has established itself as a sub-supplier of wind energy technology, as detailed in Section 3.

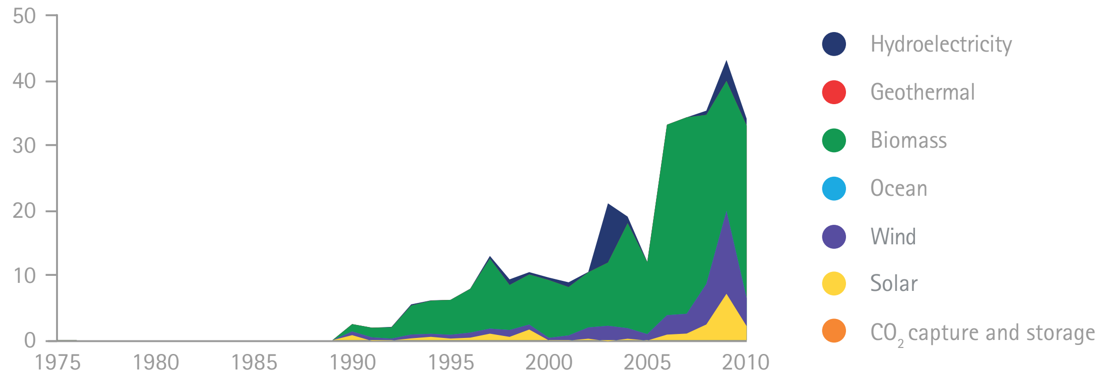
17 Borup, et al. (2008), 56
18 Borup, et al. (2008), 60
19 Ministry of Employment and the Economy of Finland (2012)
20 Ministry of Employment and the Economy of Finland (2012)

Figure 3. Finnish policy elements by type and target



Sources: IEA (2010a), IEA (2012c)

Figure 4. Finnish public low-carbon RD&D budgets by technology



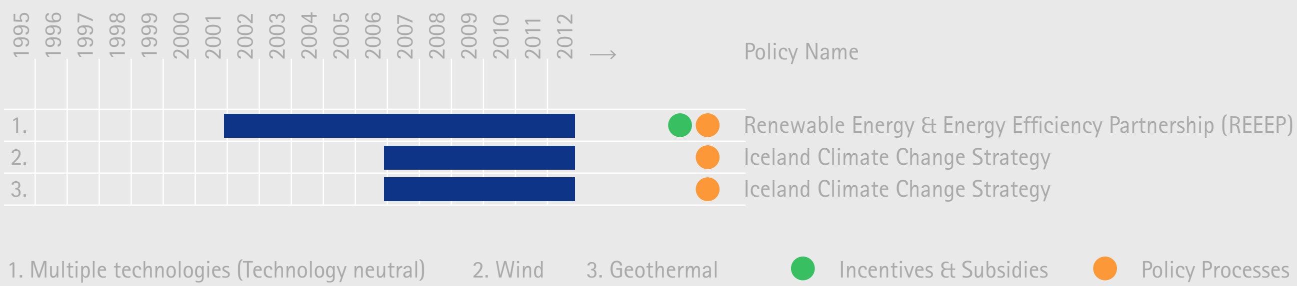
Source: Nordic Energy Research (2012) Note: Data not collected before 1990

Iceland

Iceland has few renewable energy policies. This is due to its small size, its energy system consisting essentially entirely of hydropower and geothermal energy, the fact it only utilises a fraction of the available resources, and its isolation from the Nordic grid. Support schemes for electricity are virtually absent because the need for them is so limited.[21] Iceland is not a member of the IEA and does not report public RD&D budgets, so no indicator is provided. However, the country has significant expertise in geothermal energy technologies.

21 Klitkou et al. (2008b), 87

Figure 5. Icelandic policy elements by type and target



Sources: IEA (2010a), IEA (2012c)

Norway

Norwegian energy policy is unique in that the energy system is highly electrified with virtually all electricity generated through hydropower. This has negated the need for energy policies for renewable electricity generation until recently. The country is endowed with vast resources in hydroelectric power and hydrocarbons, both of which are well utilised, and exported as electricity, oil and gas, or through goods created in energy intensive industries. Norway also has significant untapped wind and bioenergy resources, which could prove useful for future domestic and international demand.

Norway's policy portfolio is characterised by the early introduction of a carbon tax at the start of the 1990s, and like others in the region, a large number of policies being introduced between 1997 and 2004. Much of this expansion however, has been in policy processes, which have not resulted in a diverse base of policy instruments such as taxes, incentives and subsidies as seen in other Nordic countries.[22] The Norwegian policy portfolio has less focus on individual technologies than other Nordic countries, with most policies having technology-neutral elements.

The technology-neutral Norway-Sweden Green Certificate Scheme is the only functioning example in the EU of a cooperation mechanism under the RES-directive.

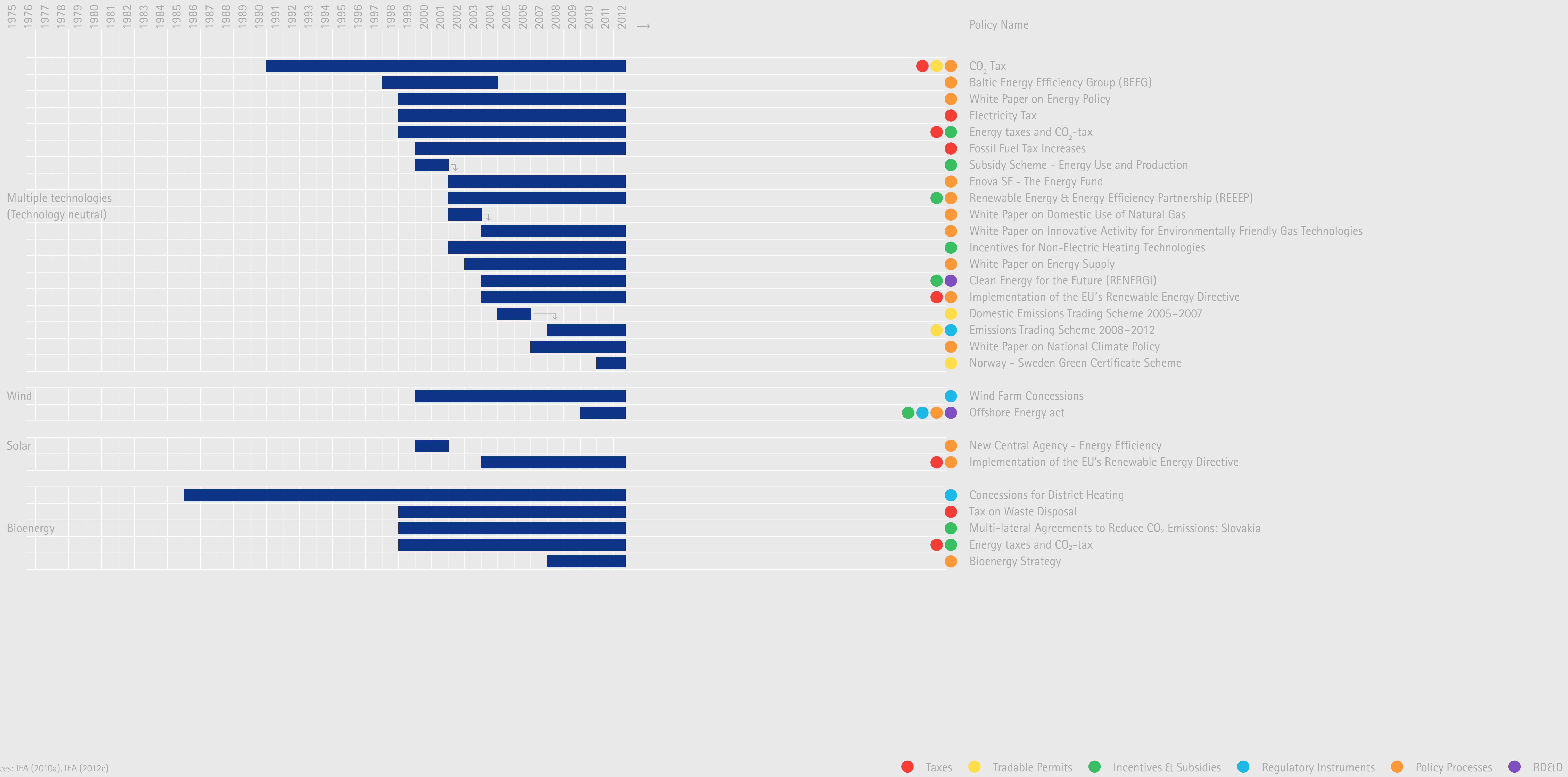
Support for wind power in Norway was low until the beginning of 2012. Like bioenergy, it has been supported through a very low feed-in tariff. Direct investment support to wind has since been offered through ENOVA. In 2012 Norway entered into an agreement with Sweden which established a common market for green certificates for electricity from 2012 until 2020. This technology-neutral policy is based on the Swedish scheme in place since 2003, and is the only functioning example in the EU of a cooperation mechanism under the RES-directive.[23] The scheme is expected to result in significant investment in wind due to the quality of the natural resources in Norway, targeting the production of 26.4TWh of new renewable electricity between both countries within 2020. Half of the new generation will be counted towards each country's renewable target regardless of where the generation takes place. Solar PV implementation has not been supported through specific programme to date.

Norwegian public low-carbon RD&D support has seen a marked increase in recent years. Carbon Capture and Storage (CCS) has received significant support, building on the country's expertise in oil and gas extraction, and the potential for storage sites off the Norwegian coast. This recent surge is in contrast to the levels of low-carbon RD&D support until the mid-2000s. Compared to other Nordic countries, Norway has had a greater focus on fossil fuel RD&D than renewables, considering that oil and gas extraction is the country's largest industry. Norway also has a focus on solar PV technologies, primarily as an export-driven industry. The solar PV industry is based on the country's electro-metallurgical competencies, and the fact that Norway has

22 Borup, et al. (2008), 55

23 European Commission (2013)

Figure 6. Norwegian policy elements by type and target

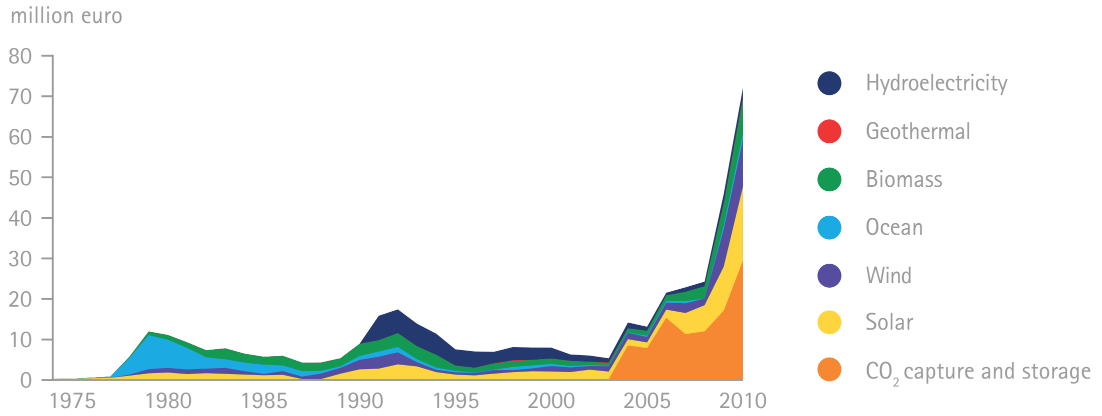


Sources: IEA (2010a), IEA (2012c)

one of the world's largest natural deposits of silicon.

Wind has accounted for 20–30% or total renewable budgets over the last decade (excluding CCS), but this is mainly due to the small size of renewable budgets in Norway. However, in the most recent years wind has seen increasing attention due to the large potential for offshore development.

Figure 7. Norwegian low-carbon RD&D budgets



Source: Nordic Energy Research (2012)

Sweden

Sweden started its energy research programme earlier than most, in 1975 as a response to the first oil crisis.[24] Significant nuclear capacity was installed during the 1980s but has faced strong public opposition. Following that, the country introduced a CO_2 tax and investment subsidy, mainly targeting bioenergy and wind. Sweden introduced its tradable green electricity certificate scheme in 2003, which has become an integral part of Swedish renewable energy policy. After implementation, the scheme was extended to 2035 and was later expanded to include Norway in 2012.

Sweden's policy portfolio is characterised by the broad range of instruments in place compared to other Nordic countries, especially in the last decade. Taxes, incentives and subsidies make up most of the policy instruments in play, with the tradable green electricity certificate scheme as the sole tradable permit policy element in force. A number of taxes have been phased out in the last five years, while CO_2 tax still plays an important role. Both the green certificate scheme and the CO_2 tax are credited with

Both the green certificate scheme and the CO_2 tax are credited with increasing renewable energy implementation in wind and bioenergy.

24 Klitkou et al. (2008b), 36

increasing renewable energy implementation in wind and bioenergy.[25]

Swedish policies target a broad set of technologies, providing a number of different support mechanisms to wind, solar and bioenergy. During the policy expansion in the mid-1990s most policies had technology-neutral elements, but in the last decade policies have targeted wind and bioenergy more specifically. However, the central green electricity certificate scheme is technology-neutral and does not have quotas for certain technologies.

Sweden's support for RD&D in wind is second only to Denmark over the last 35 years. This support is characterised by a 6-year period of very significant funding between 1977 and 1982. Support thereafter has dwindled – both in gross terms and as a share of total renewable RD&D support – and in recent years Sweden has prioritised public RD&D for wind even less than Finland and Norway. In the last decade, bioenergy has been the prime focus technology area, with a sharp increase in support in the last few years. Sweden aims to have a transport sector independent of fossil fuels by 2030 and biofuels are expected to play a significant role in achieving this.

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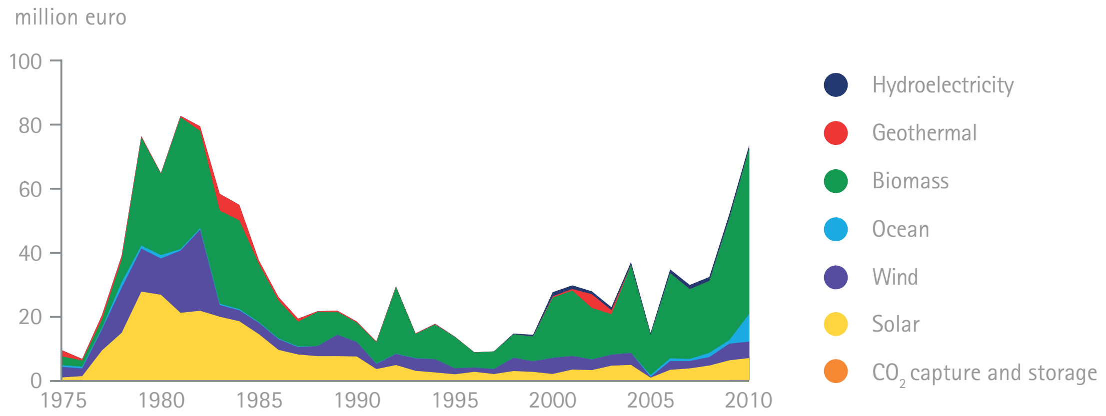
Swedish public support for solar PV RD&D has been relatively steady, with a gradual increase over the last decade. The only anomaly is the drop in funding for 2005 – the result of a political decision that cut energy RD&D funding across all technologies. Overall, Sweden has invested most of the Nordic countries in support for solar PV RD&D.

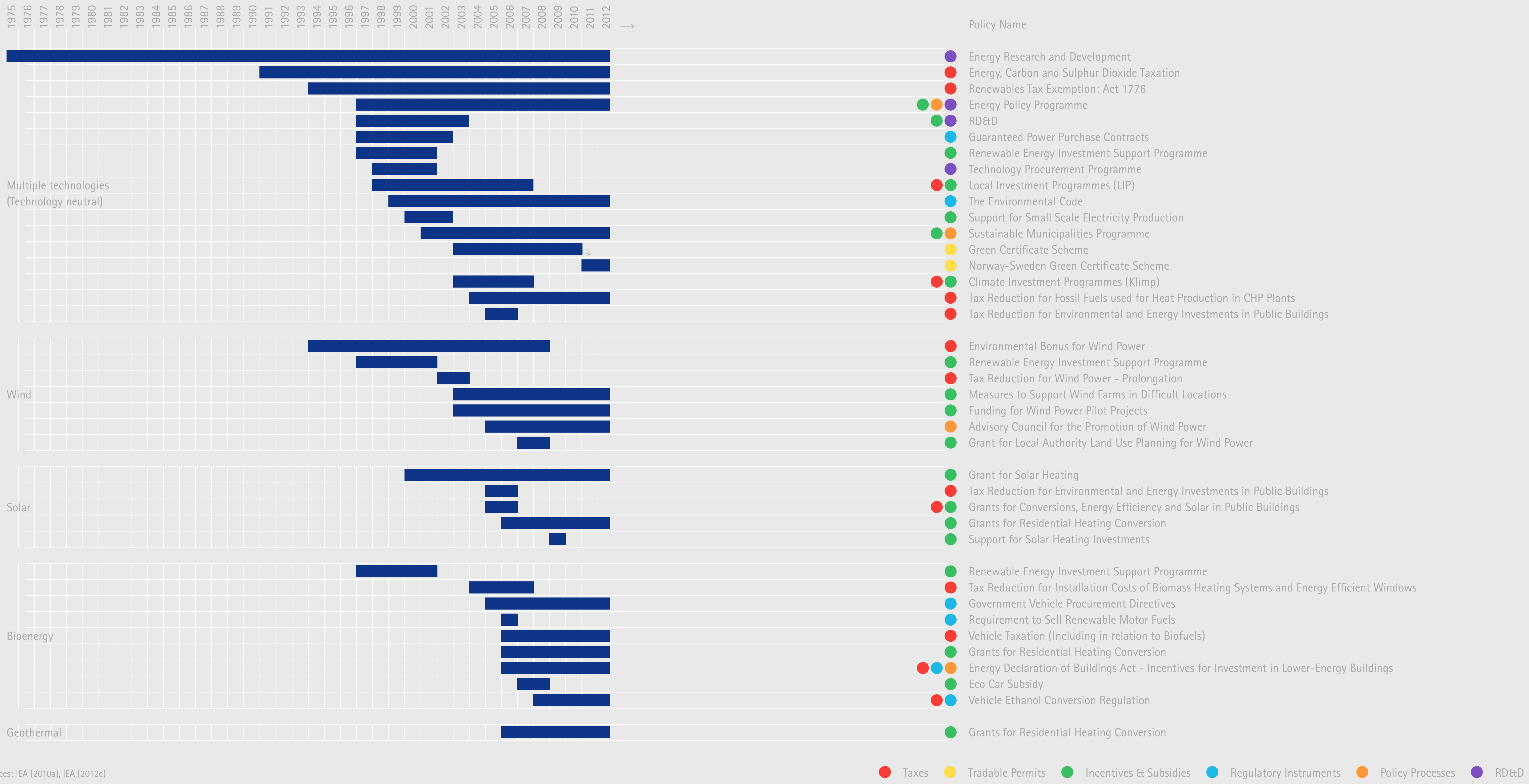
Figure 9. Swedish public low-carbon RD&D budgets



Source: Nordic Energy Research (2012)

25 Borup, et al. (2008), 38,39

Figure 8. Swedish policy elements by type and target



Sources: IEA (2010a), IEA (2012c)

Discussion

In general terms, the policy visualisations for the four largest Nordic countries are relatively similar. While Denmark and Sweden had beginnings in the 1970s, Norway in the 1980s and Finland in the 1990s, no country had a diverse policy portfolio by the early 1990s. It was not until the late 1990s that all four countries rapidly introduced a broad range of policy measures for renewable energy – broad in both policy type and technology target. Another similarity is evident in the plateau in the number of active policy elements in recent years. The effect of energy prices on policies is also evident, clear in the similarity between the policy visualisations above and oil prices as shown in the figure below.

A key difference between the Nordic countries is in the use of technology-specific and technology-neutral policies. All countries have a mixture of both, but the key support mechanisms for renewable electricity production differ markedly. The primary support mechanism for renewable electricity in Sweden and Norway is the technology-neutral green electricity certificate scheme, while the central policies in Denmark and Finland are technology-specific feed-in tariffs.

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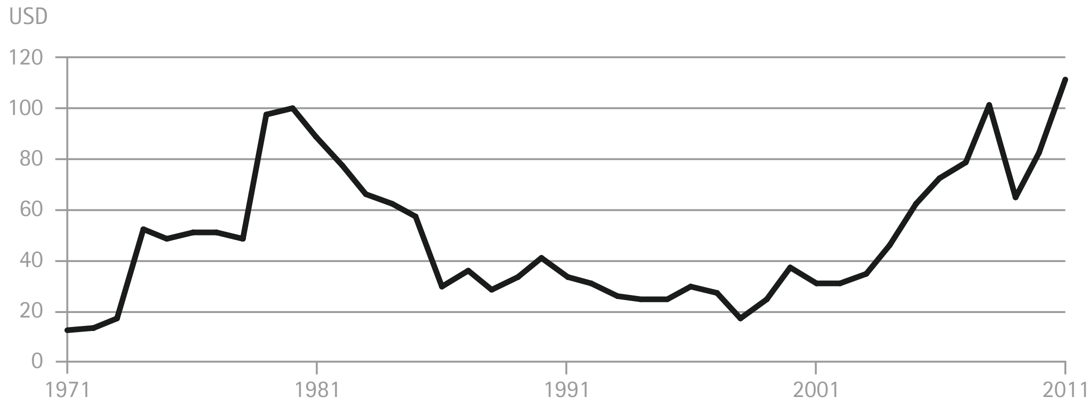
The different technology competencies are evident in the prioritisation of public support for RD&D in the different countries. Denmark supports wind RD&D while Finland supports bioenergy for example, corresponding to the high share of these energy sources in their respective energy mixes. The next section aims to take a closer look at these technology competencies and their implementation progress.

As an indicator, these policy maps provide an interesting overview of the timing and extent of the diffusion of renewable energy polices, and an indication of their type and target. What the maps do not show however, is the relative importance of individual policies. An obvious example is the Norway-Sweden Green Certificate Scheme, which has become one of the more important policies in the Swedish as well as Norwegian portfolio, but appears as just one of many active policy elements in the visualisation.

Figure 10. Crude oil prices (USD per barrel, 2011 prices)



Source: BP (2012)

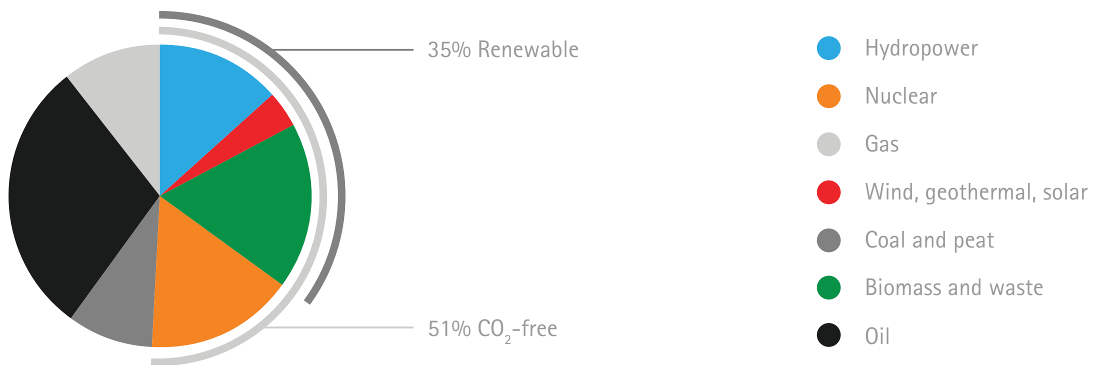
3. Measuring the intended effects of policies

This section provides a range of statistical indicators of the implementation – or deployment – of renewable energy technologies, as well as indicators of technological development and innovation activities. It builds on the policy visualisations of the previous section by providing a snapshot of the progress made towards renewable energy production targets and the outputs from governments' investments in RD&D. After a brief discussion of the implementation and development on a Nordic level, each country is discussed individually.

Technology implementation

In this report, the implementation of renewable energy technologies implies an increase in the installed capacity or production from these sources. In 2011 the Nordic countries had a 35% renewable total primary energy supply, compared to a global share of 13% in 2010.[26] When considering electricity production only, the renewable share was 65%. This is largely due to significant hydropower capacity in the Nordic region, most of which was already in place before the renewable energy policies discussed in Section 2 were implemented.

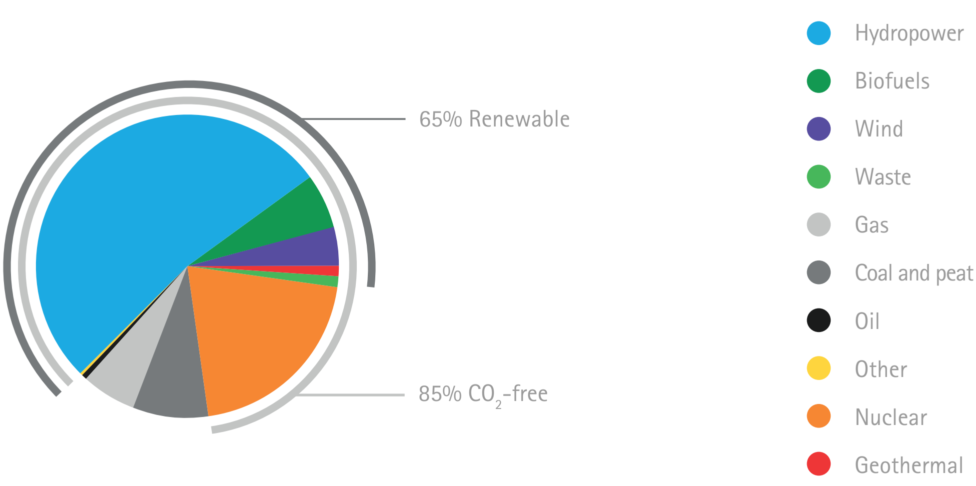
Figure 11. Nordic total primary energy supply in 2011



Source: Nordic Energy Research (2012)

26 IEA (2012b), 51

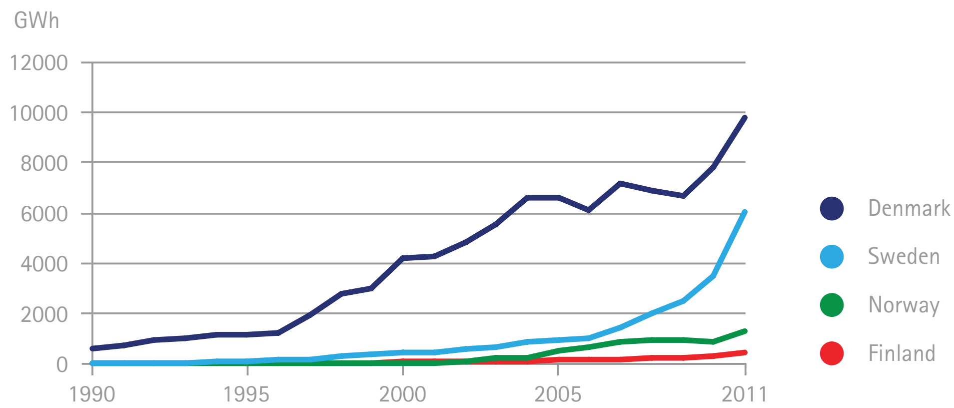
Figure 12. Nordic electricity production in 2011



Source: Nordic Energy Research (2012)

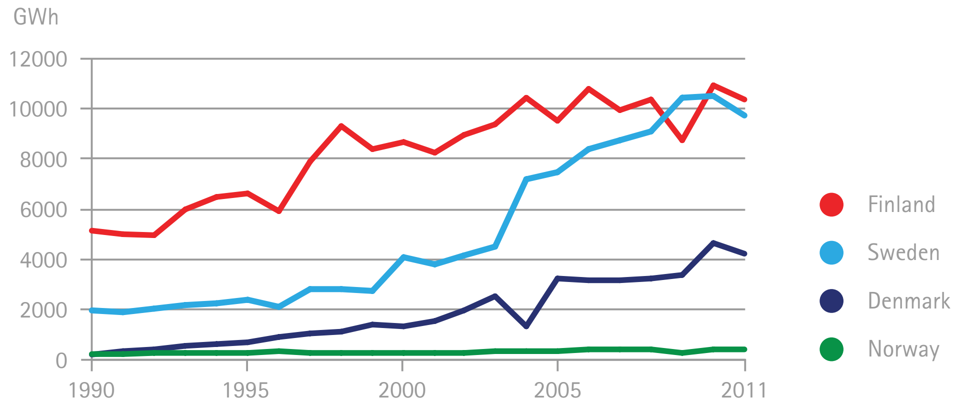
Electricity generation from wind power has seen a steady expansion in Denmark, with a stagnation in the late 2000's. The recent ramp up in Sweden has been attributed to the green electricity certificate scheme, while Norway and Finland's modest wind generation is expected to increase in the coming years under green certificate and feed-in tariff schemes. These issues are elaborated on by country below.

Figure 13. Electricity output from wind



Source: IEA (2012d)

Figure 14. Electricity output from biomass

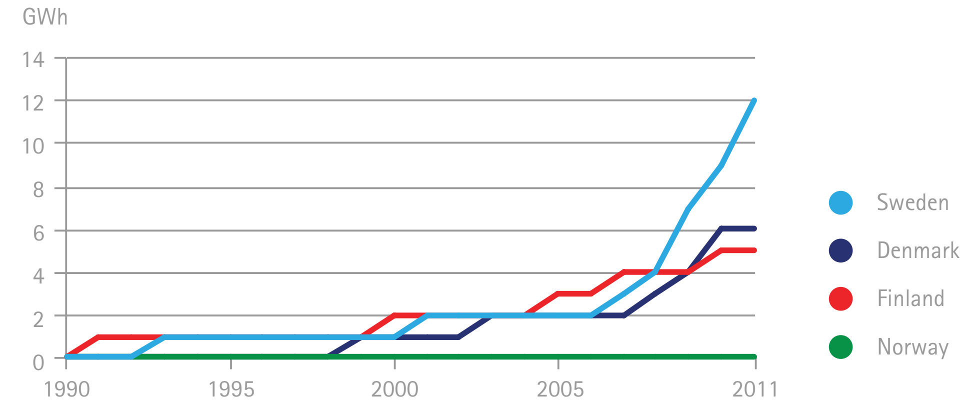


Source: IEA (2012d)

Electricity generation from bioenergy plays a large and important role in the Nordic energy mix, and is often cogenerated with heat, which is not captured in the figure. Finland's dip in electricity generation from bioenergy in 2009 is due to the paper and pulp industry's trouble during the financial crisis.

Solar PV has not yet made a significant impact on the electricity production of the Nordic countries and contributes a minute share in comparison to other renewables such as wind and bioenergy. However, as the technology becomes more competitive, implementation is expected to increase. While not captured in the figure, Denmark experienced rapid growth in solar PV installations in 2012 resulting in new policies to cool the market.

Figure 15. Electricity output from solar PV



Source: IEA (2012d)

Technology development

In this report, the development of technologies covers the innovation activities connected with their improvement. Unlike implementation, which can be measured in installed capacity or energy production, technology development is difficult to measure quantitatively. This report looks at export and import data, as well as scientific publishing and patenting activities.

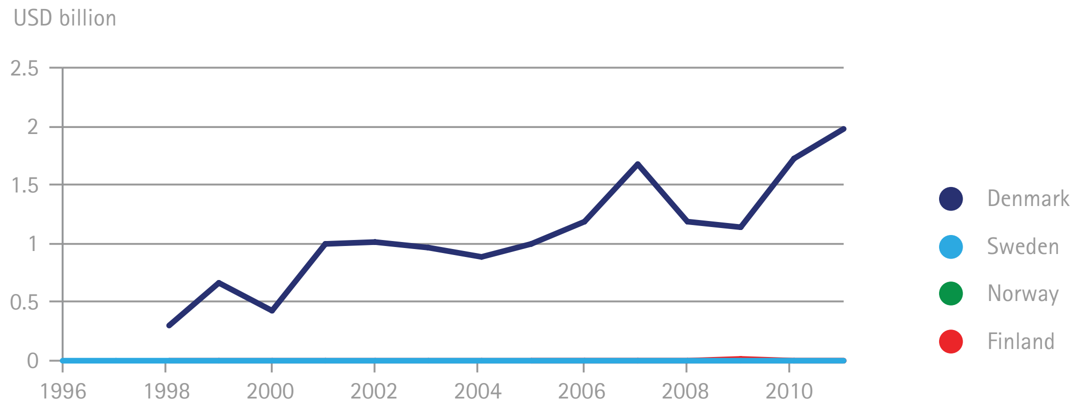
Import and export

Export statistics of energy technologies are a useful indicator of technology development performance. Policies to promote technology development are often interlinked with industrial policy and political aims to create jobs and boost exports. Exports are an especially relevant indicator for small countries like those in the Nordic region where domestic markets are often too small to sustain industries and firms soon target international markets. Import statistics are a useful indicator of the extent to which a country purchases a specific renewable technology instead of developing it domestically. Based on available data, exports and imports of wind related technology are shown below.

Denmark and Sweden are the leading Nordic countries in the implementation of wind power. Denmark has supplied its own technology for its implementation of wind power and has emerged as a leading technology exporter. Sweden on the other hand has imported its wind technology. These issues are discussed in more detail by country in the following section.

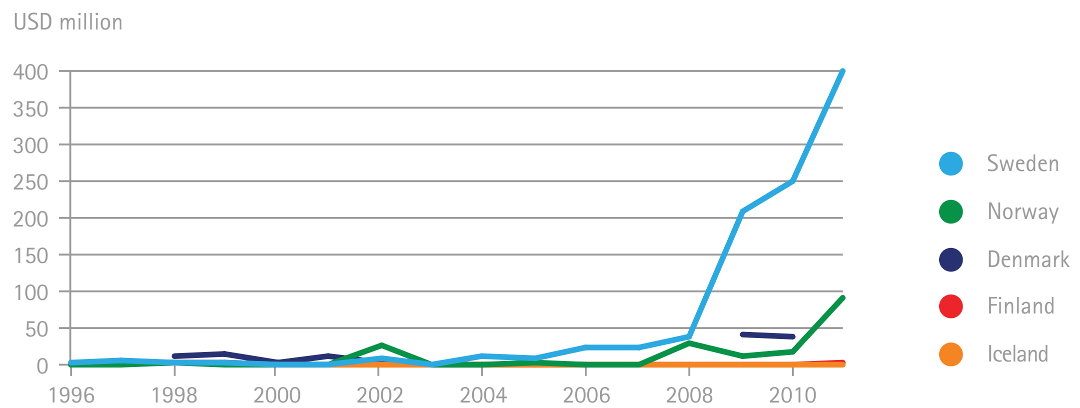
Denmark has supplied its own technology for its implementation of wind power and has emerged as a leading technology exporter. Sweden on the other hand has imported its wind technology.

Figure 16. Exports of wind turbines



Source: UN (2012)

Figure 17. Imports of wind turbines



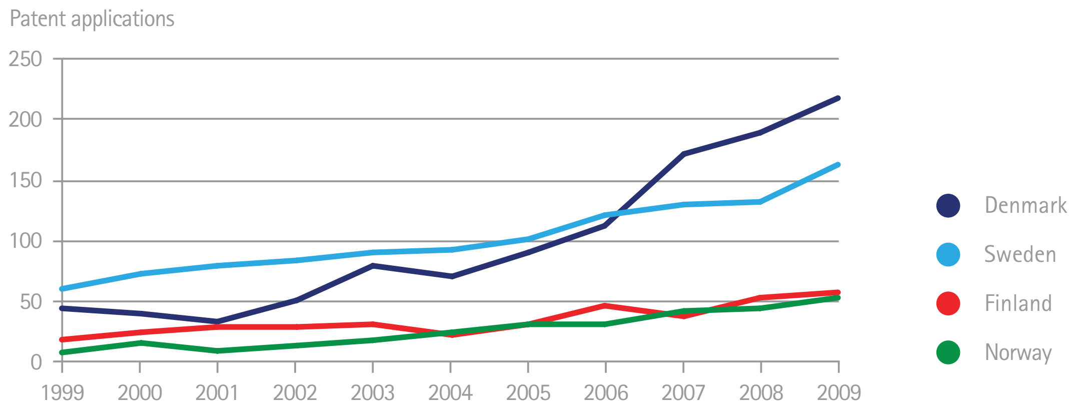
Source: UN (2012)

As with RD&D budgets, export statistics have issues with the categorisation of technologies. Finnish wind componentry is not captured in the figure due to these items not being classified as wind turbines, while it is not possible to show an export indicator for solar PV due to the UN Comtrade database's categorisation of solar panels amongst light emitting diodes and other unrelated technologies. Bioenergy has similar categorisation issues. Solar PV emerged as an export industry for the region based on predominantly Norwegian competencies, but these exports have decreased in recent years due to production being shifted to Asia.

Patenting

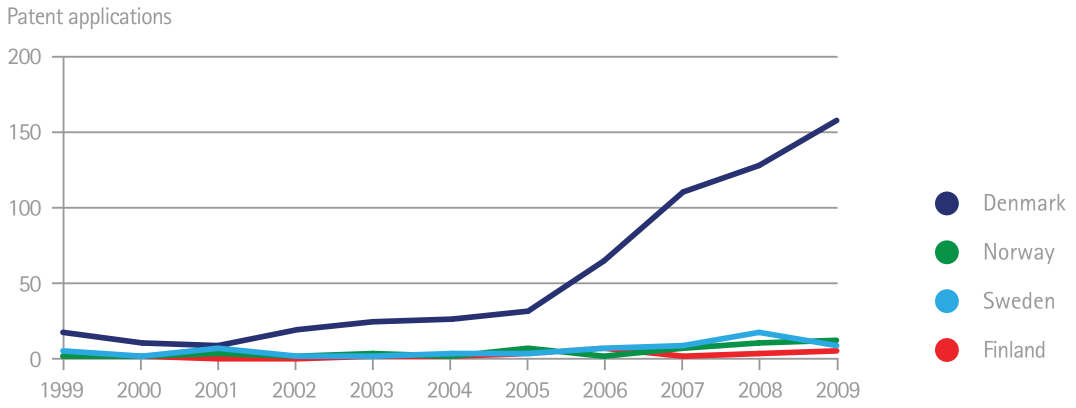
To provide insight into the processes between public RD&D funding and the eventual implementation or export of a technology, this report relies on data of patent applications to the European Patent Office (EPO). This indicator is a commonly accepted measurement of intermediate innovation output, coming before any direct economic value is gained or any impact is seen in the energy system. However, patents remain at best a proxy for the intended outcome of innovation activities – such as a technological improvement of economic value. One patent will not have the same impact on innovation as another and the results of these indicators rely strongly on the methodology used in data collection. Data for publications and patents is sourced from the OECD (2013) database on patents in environment-related technologies.

Figure 18. Patenting in low-carbon energy technologies



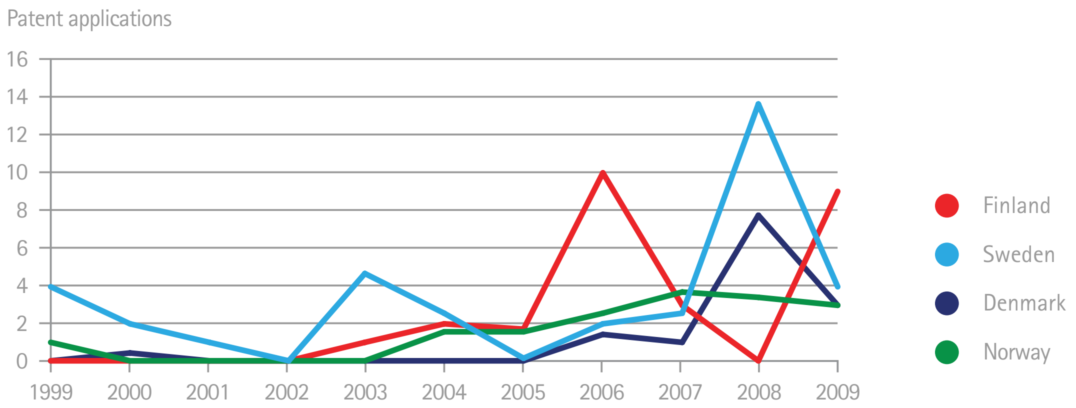
Source: OECD (2013) Note: EPO patent applications. Includes renewable energy, energy efficiency, and emission mitigation technologies

Figure 19. Patenting in wind energy technology



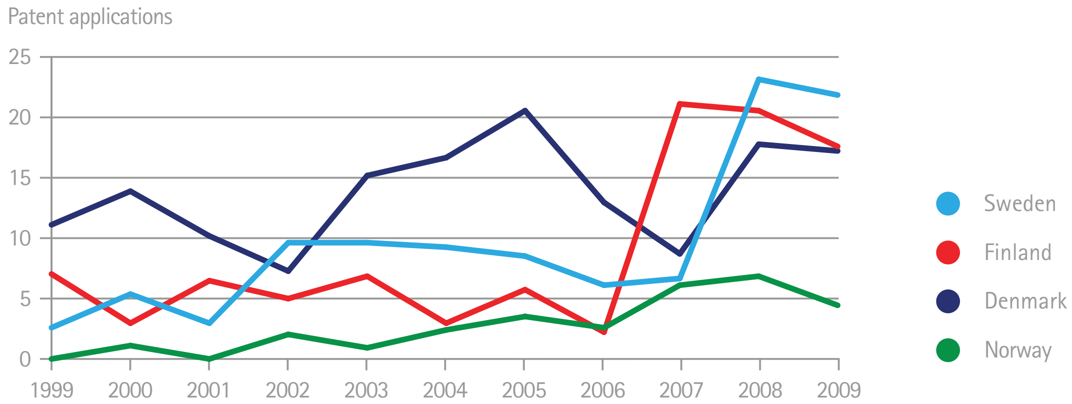
Source: OECD (2013) Note: EPO patent applications

Figure 20. Patenting in solar photovoltaic energy technology



Source: OECD (2013) Note: EPO patent applications

Figure 21. Patenting in bioenergy technology



Source: OECD (2013) Note: EPO patent applications. Includes biofuels, waste incineration and efficient thermal generation technologies

Danish patenting in low-carbon energy technologies is based on strong innovation in wind energy technology, while Sweden's performance builds heavily on patents filed for transportation fuel efficiency and emissions abatement.

Discussion by country

Denmark

Denmark's leadership in both the implementation and technology development of wind energy is evident in the indicators above. Vestas and other Danish companies are central technology providers in the global market for wind, and the country has a world-leading share of electricity generated by wind power.

Far more patents in wind technologies originate from Denmark than other Nordic countries. Patent applications rose significantly after 2005 due to a drive by Danish firms to protect their intellectual property in the face of increasing global competition.

Denmark has a significantly higher share of wind in its electricity mix than other Nordic countries. However, Sweden's generation from wind has picked up in recent years. From 2009 to 2011, Sweden's gross production more than doubled and reached 6 083 GWh in 2011. This is still less than Denmark's 9 744 GWh in 2011, and about equal to Danish generation eight years earlier in 2003.

Danish success in wind is due to an early start and the establishment of a domestic market in the late 1980s and 1990s.

Demand for wind technology at the national level became less of a driver for innovation in the sector, replaced by growing international demand.

Danish success in wind is due to an early start and the establishment of a domestic market in the late 1980s and 1990s.[27] Wind capacity received another boost in the mid to late-1990s in connection with the introduction of a number of well integrated polices specific to wind power.[28]

Existing industrial competencies have also played a significant role. Organisational aspects of the industry have come from the agricultural sector, while technical competencies and networks between SMEs have built on the machining and component sector.[29]

After the mid-2000s, the rapid growth in wind energy production slowed – with the exception of the offshore sector – while exports rose. Demand for wind technology at the national level became less of a driver for innovation in the sector, replaced by growing international demand.[30] This international demand was also a product of policy initiatives – albeit from foreign governments.

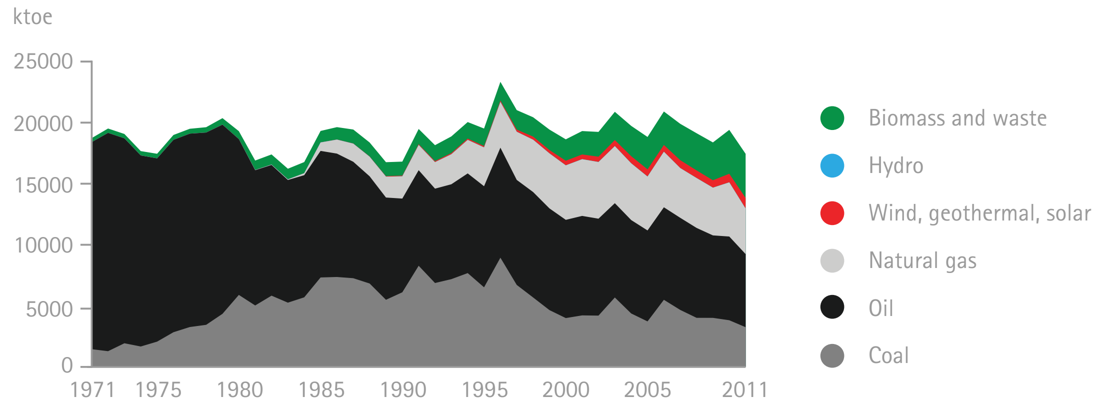
The wind power sector in Denmark has faced severe challenges recent years due to the financial crisis and faces strong competition from producers in Asia. Vestas for example, Denmark's largest turbine producer, has recently cut both RD&D spending and a number of jobs.[31]

Danish performance in patenting in solar PV is among the lowest of the Nordic countries, despite being the second largest funder of RD&D in the technology after Sweden. When it comes to implementation, Denmark's net-metering policy for small-scale solar PV has resulted in exponential growth in rooftop installations. Denmark is the most prolific Nordic country at filing patents in bioenergy over the last decade, due to a focus on biofuels.

The impact of increased electricity generation from wind is evident in Denmark's total primary energy supply. However, it is dwarfed by the much larger shares of fossil fuels that underpin transport, heat and power in the country. Denmark plans to have a completely renewable energy supply by 2050.[32]

27 Borup, et al. (2008), 25
28 Borup, et al. (2008), 73
29 Borup, et al. (2008), 80
30 Borup, et al. (2008), 37,73
31 Industryweek (2012)
32 Danish Energy Agency (2011)

Figure 22. Danish total primary energy supply, 1971-2011



Source: Nordic Energy Research (2012)

Finland

Finland has been most successful Nordic country in integrating solid biomass into its energy system, both for heat and power. The country is a global leader in this technology and has created important synergies between the forestry, paper and energy industries. Wind and solar power however, have not had the same success.

Indicators for patents in wind reflect Finland's low prioritisation of wind technology in policies and the relatively minor share of wind in the electricity mix. The 481GWh generated in 2011 was equivalent to 0.6% of Finnish electricity consumption.[33] Policies aiming to increase wind generation have largely failed to establish a foothold for the technology in the electricity mix, but hopes are high for the feed-in tariff introduced in 2010.[34] Although wind resources in Finland are not as large as in Norway, Denmark and Sweden, they are enough to support a significant expansion of wind capacity.[35]

Looking at exports, Finland is the only Nordic country to register wind energy exports apart from Denmark. At their highest point, Finnish exports were less than a hundredth of the Danish total for that year. However, Finnish wind technology development is stronger than the indicators let on. Building on its history in machine industry, Finland has established itself as a sub-supplier of wind energy technology, exporting generators, gearboxes, bearings and

Building on its history in machine industry, Finland has established itself as a sub-supplier of wind energy technology, exporting generators, gearboxes, bearings and drives.

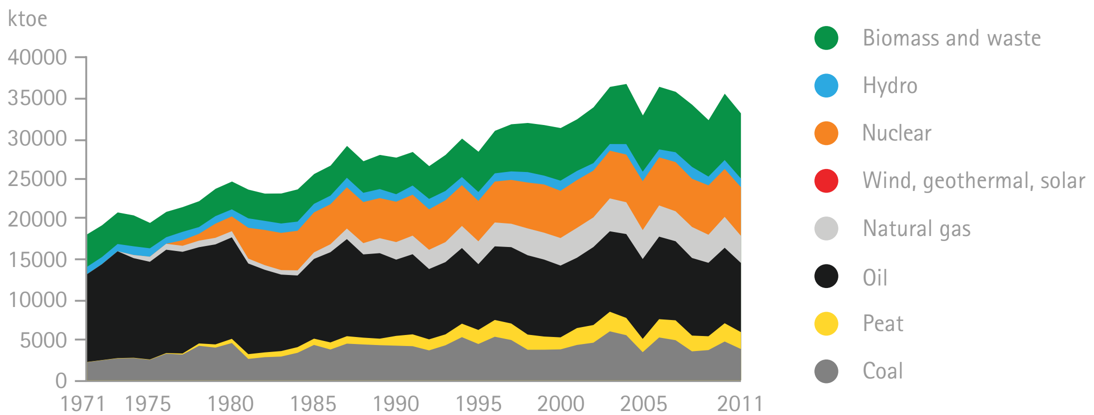
33 VTT (2012)
34 IEA (2008)
35 Borup, et al. (2008), 60

drives.[36] Component development and manufacturing is often missed by patent and export databases and analyses, due to their sometimes broadly defined applications.

Finland has not prioritised RD&D in solar PV technologies, and only since 2005 has public RD&D support been recorded – giving a total investment in the technology much lower than the other Nordic countries. As in all other Nordic countries, solar PV's contribution to the electricity mix is insignificant. Solar generation in Finland is largely for small-scale applications in remote areas, and is not well connected to the grid.[37]

Finland's total primary energy supply is the most diverse of the Nordic countries, and shows a high utilisation of biomass.

Figure 23. Finnish total primary energy supply, 1972-2011



Source: Nordic Energy Research (2012)

Iceland

Iceland has seen substantial growth in its production of geothermal heat and electricity, as well as hydropower. This is not due to specific policies targeting renewable energy, but rather increased demand from new industrial projects such as aluminium smelting.

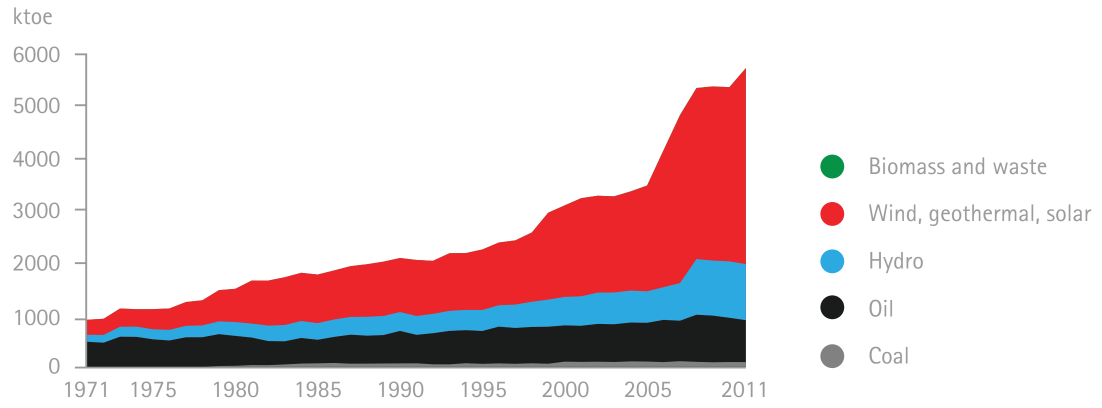
Iceland has vast untapped renewable energy resources, but due to its isolation from the European electricity grid, it cannot export excess power. Instead, it must export the energy embodied in energy-intensive products and services. Geothermal heat and power is the main area for technology development in Iceland, with minimal activities in wind and solar PV.

Iceland has vast untapped renewable energy resources, but due to its isolation from the European electricity grid, it cannot export excess power.

36 IEA (2008)

37 Borup, et al. (2008), 61

Figure 24. Icelandic total primary energy supply, 1972-2011



Source: Nordic Energy Research (2012)

Norway

Norway has vast existing hydropower capacity and a small but growing implementation of wind power. The country has had success in the development of solar PV technologies for export, with minimal domestic implementation.

Despite having better wind resources than Denmark[38], wind only constitutes 1% of Norwegian electricity production. In 2011, 1 293 GWh was generated from wind, close to three times Finnish production, and almost one sixth of Sweden's. The implementation of onshore wind stagnated for several years due to poor framework conditions, but hopes have risen again after the Norway-Sweden Green Certificate Scheme was implemented in 2012. At the end of 2011 Norway had 525 MW of installed capacity with an additional 195 MW built in 2012.[39]

Despite having better wind resources than Denmark, wind only constitutes 1% of Norwegian electricity production.

The potential for offshore wind competence in Norway is significant, not only due to the coastal wind resources, but also because of the existing offshore competencies from the oil and gas sectors. As these sectors decline, the application of their expertise to offshore foundation and service systems is a natural step. However, much of the offshore wind potential in Norway is in deeper water than in Denmark and other countries, meaning greater technological challenges and costs. Furthermore, these offshore areas are far from major load centres, requiring substantial investments in transmission capacity and comparatively high system losses. With technology development,

38 Borup, et al. (2008), 80

39 Vindportalen (2012)

these costs can be decreased, but due to the almost entirely renewable electricity production in Norway today, an expansion of wind in Norway will be to facilitate electricity exports and decarbonise the supply of neighbouring countries.[40]

When looking at patenting levels for solar PV, Norway has had less activity than other Nordic countries despite their leadership in the commercialisation of the technology. This highlights the shortcomings of patenting indicators as a measure of innovation. An earlier patent study at the European level gave Norway a strong lead over the other Nordic countries over roughly the same period.[41] A potential explanation could be Norway's focus on mature first generation crystalline silicon-based solar PV technologies, as opposed to Sweden's focus on second generation PV.[42]

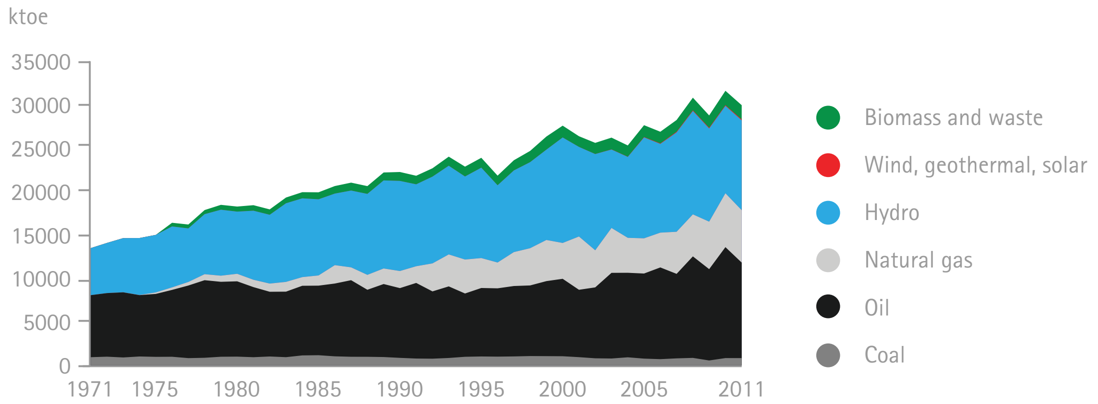
Norway has shown strength in terms of solar PV technology export. While comparable data for solar PV exports is not available for the region, Norway's largest solar company Renewable Energy Company (REC) accounted for 3% of the exports of the top 10 solar PV companies globally when the crystalline business was as its height.[43] The solar PV industry in Norway is based on Norway's existing electro-metallurgical competencies and one of the world's largest natural deposits of silicon. The industry had its beginnings in the 1970s, but it was not until the 1990s that the industry accelerated its development. This was due to the recognition of solar PV as an important technology in mitigating climate change, and the subsequent demand for wafers and modules abroad.[44] This demand – in particular from Germany and Japan – was driven by renewable energy policies in those countries. The market pull from foreign countries allowed the Norwegian solar PV industry to 'leap-frog' its domestic market and emerge as an export-driven industry.[45]

The market pull from foreign countries allowed the Norwegian solar PV industry to 'leap-frog' its domestic market and emerge as an export-driven industry.

In recent years, the Norwegian solar PV industry has been negatively affected by the financial crisis and competition from Asia. While there are still many active solar PV companies located in Norway, REC has seen financial difficulties and has been forced to shut down its domestic wafer production.[46]

40 Research Council of Norway (2010)
41 Klitkou et al. (2008)
42 Klitkou et al. (2008a), 22
43 Borup, et al. (2008), 11
44 Borup, et al. (2008), 49, Klitkou et al. (2008a), 17
45 Borup, et al. (2008), 33,80
46 Renewable Energy Corporation (2011)

Figure 25. Norwegian total primary energy supply, 1972-2011



Source: Nordic Energy Research (2012)

Sweden

Sweden has had considerable success in increasing its share of energy from biomass, and has recently initiated a dramatic increase in wind implementation. However, in technology development for wind for example, innovation output such as exports and patents is low compared to the high level of input through RD&D support.

The early spike in public support for wind RD&D evident in Figure 9 was initiated as a reaction to the oil crises and set in motion what could have become a significant export industry and electricity source. Sweden had the necessary technological competencies, but the translation of RD&D support to market success was derailed by the failure to establish a home market for wind technologies. This was due to a number of reasons. Sweden's focus on nuclear power in the 1980s created an oversupply of electricity and low prices, and at the time a strong opponent to wind expansion in the nuclear lobby. This, combined with low social desirability of the technology at the time, stifled the Swedish wind experiment before it had a chance to get going.[47]

Wind's impact on the electricity mix has only become apparent in the last few years. Wind began slowly following investment subsidies in 1991, and has since been driven by the green electricity certificate scheme, introduced in 2003. However, it was not until it was announced that the scheme would

It was not until it was announced that the scheme would last until 2035 that investments in wind began to increase significantly.

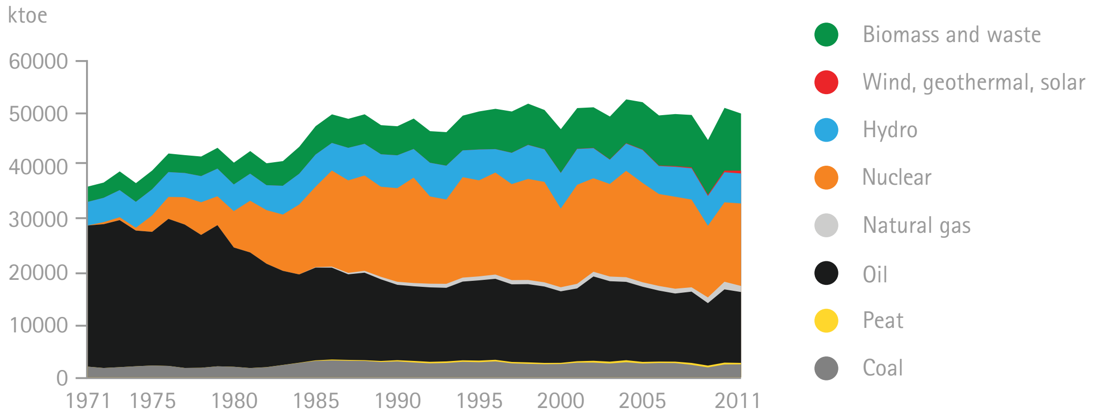
47 Borup, et al. (2008), 42

last until 2035 that investments in wind began to increase significantly.[48] The effect of these policies is evident in the recent rise in wind's share of the electricity mix, and by Sweden's recent increase in the import of wind turbines. Due to its prioritisation of short-term cost efficiency, the green electricity certificate scheme is not considered a significant force in encouraging technology development.[49]

Compared to the other Nordic countries, Sweden is slightly more prolific in terms of patenting in solar PV. This could be due to Sweden's strong science base and a focus on thin film, second-generation PV technologies.[50]

Like in Finland and Denmark, solar PV is largely implemented in remote locations, but is increasingly utilised in the building sector due to investment support policies.[51] Despite recent expansion, wind has not yet made a significant impact on the total primary energy supply.

Figure 26. Swedish total primary energy supply, 1972-2011



Source: Nordic Energy Research (2012)

48 Borup, et al. (2008), 42
49 Borup, et al. (2008), 44
50 Borup, et al. (2008a), 22
51 Borup, et al. (2008a), 23

Discussion

The indicators above shed light on the results that renewable energy policies look to achieve, such as increased technological implementation through renewable energy generation, and increased technological development through RD&D, innovation and technology exports. The scope was limited to certain technologies due to the availability of comparable data. In wind and solar PV technology development in the Nordic countries, the connection between successful technology development and the existence of an industrial base to build from is clear. This has been the case with Danish wind, Finnish wind components, and Norwegian solar PV.

The connection between successful technology development and the existence of an industrial base to build from is clear.

The Norwegian solar PV industry is a good example of this. It is built upon the industrial base provided by existing metallurgical competencies in the country. While natural resources for implementation – sunlight – are very poor and have naturally hampered any domestic market for solar panels, natural resources for innovation – silicon deposits – have been very influential in creating and export industry. The Danish solar PV sector on the other hand, has not had access to these resource and industrial bases. Despite receiving greater RD&D support than the sector in Norway, and attempts through policy to foster a domestic market for implementation, Danish technology development in solar PV has not been as successful. The current surge in implementation is based on imported technology.

Another example is that of wind power, Danish innovation has built upon existing machining competencies, while implementation has utilised excellent local wind resources, and organisational structures based on the agricultural sector. Greater implementation of offshore wind capacity is expected in coming decades, with the Norwegian coast offering significant potential. Common support schemes, such as the Norway-Sweden Green Certificate Scheme, are expected to facilitate greater utilisation of resource bases, such as wind potential in Norway.

Another important factor is the existence of a home or foreign market created through policy intervention. While a home market was instrumental in the success of Danish wind technology development and the failure of Swedish, it was not a factor in Norwegian solar PV, where it was the existence of a foreign market that spurred the innovation. In both home and foreign markets, renewable energy policies have been instrumental in their establishment.

Another important factor is the existence of a home or foreign market created through policy intervention.

The connection between technology development and implementation is another key factor amongst the small Nordic countries. While the implementation of technologies can promote development upstream in that technology area, and policies to support both activities often go hand in hand, they are not necessarily connected. The marketplace for renewable energy technologies is increasingly global, and for many countries the technology they implement will not be developed domestically. Import and export data therefore provides a more complete picture, despite being hampered by categorisation issues. Chinese competition in the solar PV

It is important to consider implementation and development as separate effects of policy initiatives, especially in small countries like the Nordics.

market is a very good example of this, with European solar installations increasingly based on equipment developed in Asia. Therefore, it is important to consider implementation and development as separate effects of policy initiatives, especially in small countries like the Nordics. Three examples are used to illustrate this.

In the case of wind power in Denmark, policies successfully facilitated both technology development and implementation – technology developed indigenously was subsequently implemented within the country. Technology development was supported through RD&D policies, as well as the economic incentives for innovation created by a home market. Implementation was supported through a number of integrated and relatively stable policies including subsidies, taxes and regulations. However, increases in the technology development activities in the last decade are not reflected in implementation indicators due to the technology being exported.

In Sweden too, both technology development and implementation in wind power have been facilitated through policies, but a significant time lag between these efforts has meant that foreign technology has been implemented. When innovation activities were high in the 1980s, neither Swedish nor foreign policies facilitated a market for wind turbines, meaning the innovation did not translate to technology export or implementation. Implementation came much later – in the last decade and especially in recent years after the extension of the green certificate scheme, leading to an increase in the import of wind energy technology. Sweden plans a significant increase in wind power implementation, driven by its green certificate scheme. However, this is unlikely to drive innovation in the sector, with most technology expected to be imported.[52]

Looking at solar PV in Norway, national policies have facilitated only innovation, with all solar PV technology being exported and none implemented domestically. Public RD&D has been the only significant policy in play in Norway, with market-based policies in Germany and Japan facilitating implementation there and a demand for Norwegian technology.

While valuable lessons can be gained from assessing the past, the Nordic governments have also provided indications of how they hope the future energy system will develop through targets and projections. The following section offers insight into the future of the Nordic energy system.

52 Borup, et al. (2008), 74

4. Future perspectives

While the previous sections have discussed renewable energy policies in the past and their desired effects on technology development and implementation, this section provides an overview of what is expected in the coming decades.

Towards 2020

2020 is significant year for renewable energy policy due to the EU's 20-20-20 targets. In June 2012 the European commission reported that Europe's renewable energy system has evolved much faster than foreseen when drafting the renewable energy directive before 2009.[53] In addition it is reported that technology development in renewable energy has experienced a major "push and pull effect" from renewable and R&D policies, and that European companies have become significant players in the global market, despite stiff competition.

Mature technologies operating in competitive energy markets within a well-functioning carbon cap and trade system should ultimately no longer need support.

The Commission states that mature technologies operating in competitive energy markets within a well-functioning carbon cap and trade system should ultimately no longer need support. Under the first period of the EU Emission Trading Scheme from 2005 to 2012, it has been clear that there is still a need for support through national policies in the Member States.

EU policies and directives have a significant impact on Nordic renewable energy policies, most evidently through the establishment of binding national targets. The transposition and adaptation to national circumstances of EU directives is up to the individual Member States, where cooperation between countries can have benefits. Nordic countries have made use of these cooperation mechanisms, notably through the Norway-Sweden Green Certificate Scheme.

Other forms of cooperation between the Nordic countries assist in working towards the binding targets of the EU. Examples include Nordic working groups for energy under the Nordic Council of Ministers, Nordic grid cooperation, cooperation between market regulators through NordREG, EU institutions such as ACER and ENTSO-E, and R&D support through Nordic Energy Research.

Nordic countries and their fulfilment of 2020 targets

Through the Renewable Energy Directive all five Nordic countries have a common framework with binding commitments to increase their proportion of renewable energy by 2020. These targets are outlined in Table 2. Information in this section is based on AGFE (2012).

53 European Commission (2012b)

Denmark

The Danish government expects the share of renewable energy in 2020 to be approximately 35%, 5% above their EU target. Existing support systems for renewable energy will continue, such as feed-in tariffs to promote the expansion of onshore wind power and biomass cogeneration, support for offshore wind development, and CO_2 and energy tax exemptions for renewable heat production. In transport, the mandatory blending of biofuels into petrol and diesel represents the main policy instrument. Denmark is in favour of sharing any excess production of renewable energy in the period to 2020 with other EU member states using renewable energy directive cooperation mechanisms. The government has also set milestones for the long-term expansion of renewable energy. All electricity and heat production must be 100% renewable within 2035, and the entire energy system, including transport, must be 100% renewable by 2050. Finally, electricity from wind power shall cover 50% of electricity consumption within 2020.

The Danish government expects the share of renewable energy in 2020 to be approximately 35%, 5% above their EU target.

Finland

The Finnish Government's ministerial working group on energy and climate policy finalised the updated National Energy and Climate Strategy in February 2013. The updated strategy will be submitted during 2013 as a public report for consideration by the Finnish Parliament. The strategy indicates that the previously determined measures will suffice to meet the renewable energy targets for 2020 of 38% of final energy consumption. In Finland, the use of renewable energy is increasing in a frontloaded manner, meaning that Finland will soon exceed the annual minimum targets for renewable energy set by the EU. When nearing the end of the review period, the estimated use of renewable energy and the obligations set by the EU will likely converge.

Norway

Norway will almost certainly fulfil its 2020 renewable generation target of 67.5% through national efforts and the common green electricity certificate scheme with Sweden. The scheme is a cooperation mechanism under the Renewable Energy Directive, where Norway registers half of all new generation towards its own target, regardless of whether the electricity is produced in Norway or Sweden. Norway has not yet taken a position on the use of other cooperation mechanisms. Another of Norway's key ongoing policies is the Enova Energy Fund.

Norway registers half of all new generation towards its own target, regardless of whether the electricity is produced in Norway or Sweden.

Sweden

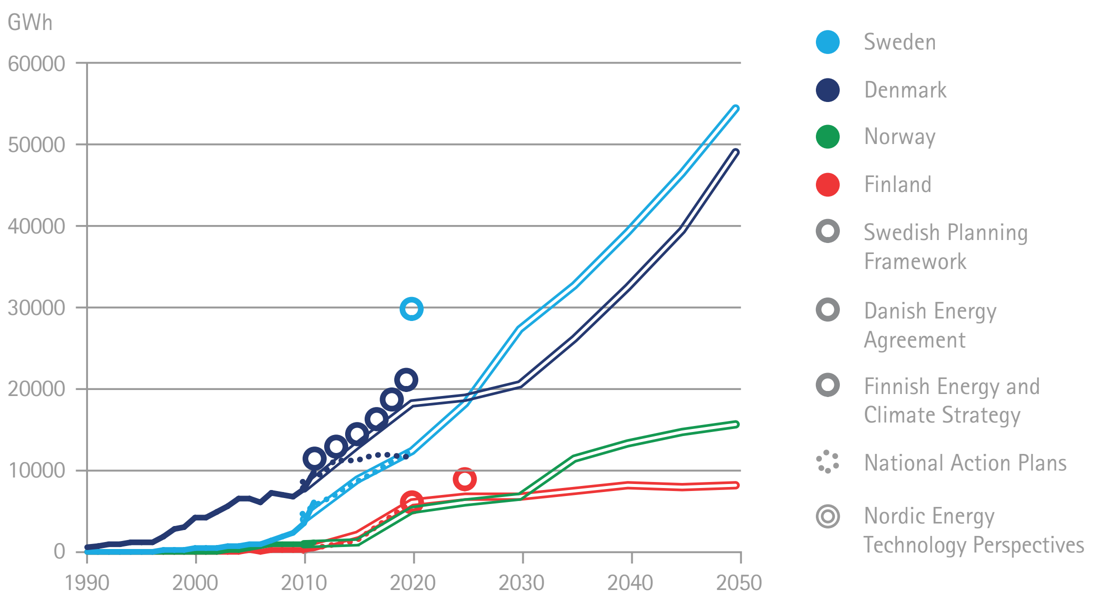
Sweden expects to have a renewable energy share of 50.2% by 2020, exceeding its EU target by 1.2 percentage points. The Swedish government is considering further cooperation mechanisms and the potential for the expansion of the green certificate scheme to countries other than Norway. The green certificate scheme is the most important policy for renewable electricity production in the coming years. It is supplemented with targeted efforts to eliminate market failures and non-financial barriers, reducing the cost of investments in new generation.

Projecting renewable electricity output

The figures below combine historical data on electricity generation from wind, bioenergy and solar, with projections of future development from various sources, including:

- National targets, development plans and planning frameworks.
- Indicative National Action Plans (NAP) for fulfilling the RES Directive, submitted by member states to the European Commission in 2010 (excluding Norway).
- Projections from the IEA's 2013 analysis of how the Nordic countries can achieve their climate targets for 2050, Nordic Energy Technology Perspectives Carbon-Neutral Scenario (NETP, covered in more detail below).

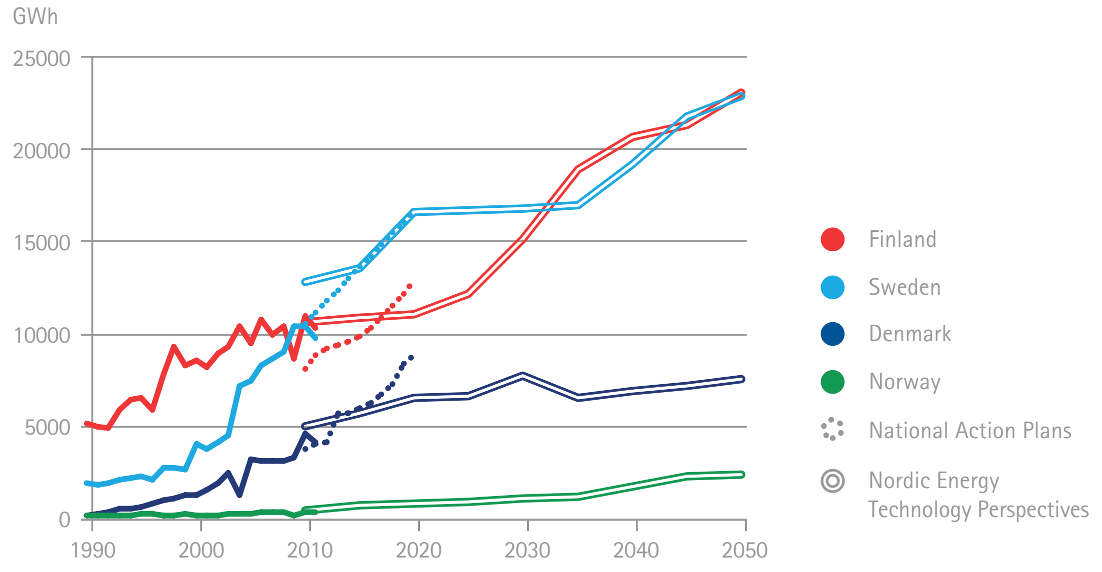
Figure 27. Historical and projected electricity output from wind



Sources: IEA (2012d) for historical data; Danish Energy Agency (2012), Ministry of Employment and the Economy of Finland (2013), Swedish Energy Agency (2007) for national targets; European Commission (2010) for National Allocation Plans to 2020; IEA (2013) for projections to 2050.

Wind generation is set to see a substantial increase in all countries. In Denmark, an ambitious target of 22TWh in 2020 from the 2012 national Energy Agreement has replaced the modest increase in wind projected in the indicative NAP submitted to the European Commission in 2010. This new target is more ambitious than the projections from the IEA's NETP analysis. Sweden has set a planning framework of a maximum of 30TWh by 2020, while their NAP and the NETP analysis project indicate 12.5TWh in 2020, ramping up to over 50TWh in 2050. Finland anticipates strong growth in its modest wind sector, with a target of 9TWh by 2025 – almost 20 times the generation from wind in 2011, and more ambitious than the NETP projections, even in 2050. The NETP analysis projects significant growth in Norway to over 15TWh of wind generation in 2050. One factor driving growth in electricity generation in the NETP analysis is an assumed demand in Continental Europe for net electricity import from the Nordic region.

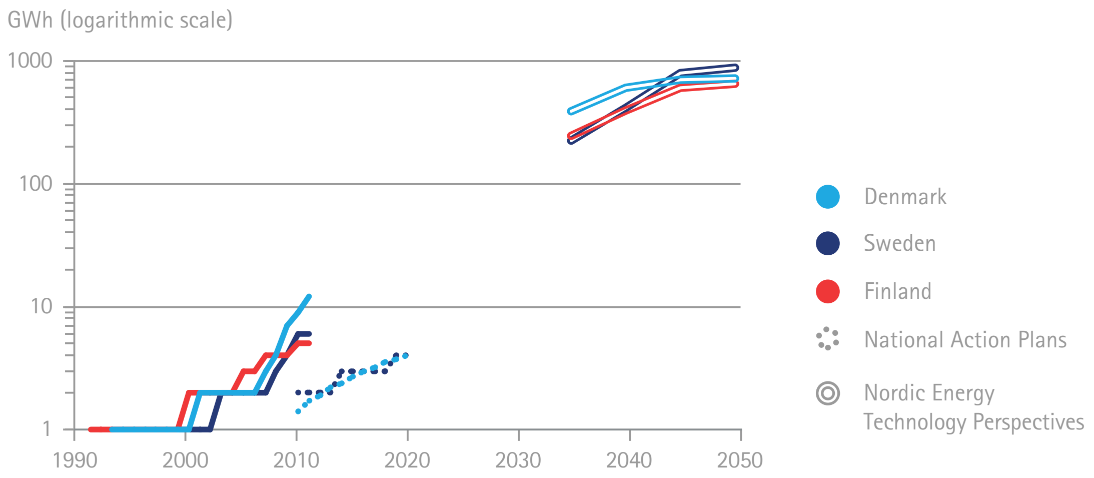
Figure 28. Historical and projected electricity output from biomass



Sources: IEA (2012d) for historical data, European Commission (2010) for National Allocation Plans to 2020; IEA (2013) for projections to 2050.

A drop in production due to the Finnish paper and pulp industry's trouble during the financial crisis resulted in a low starting point for their NAP submission in 2010. Both Denmark and Finland assumed higher growth rates in their NAPs than projections from the NETP analysis, which sees a doubling of electricity produced from biomass in 2050 by Finland, Sweden and Denmark.

Figure 29. Historical and projected electricity output from solar PV



Sources: IEA (2012d) for historical data, European Commission (2010) for National Allocation Plans to 2020; IEA (2013) for projections to 2050.

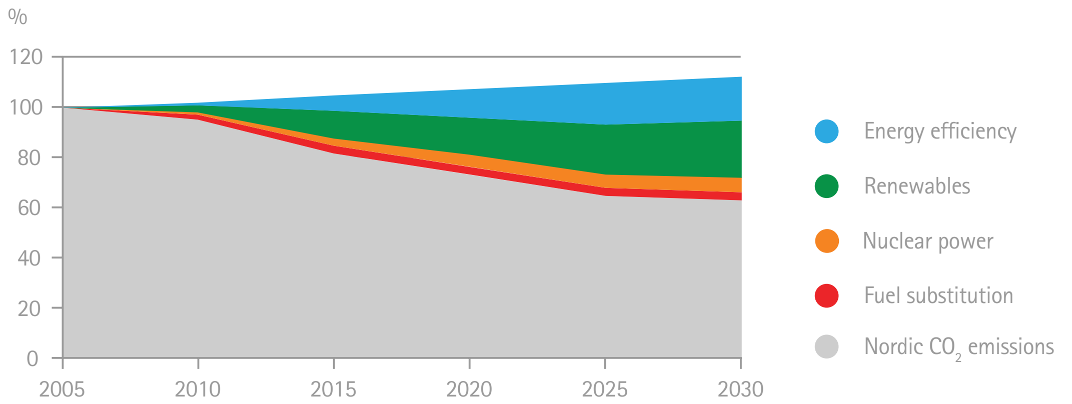
The figure above uses a logarithmic scale to allow very low historical data to be compared with much greater projections for the future. However, these projections from the NETP analysis constitute less than 0.5% of total electricity generation in 2050. Solar generation has developed faster than has been expected in the NAPs, which can be explained by the infancy of the industry in the Nordic countries and resulting uncertainty regarding its direction. Denmark now has a more ambitious national solar PV target of 200MW of installed capacity, which is much higher than the number reported in the National Action Plan of 6MW. However, due to the success of the net metering policy for small-scale solar PV, the anticipated capacity in 2020 is 1000MW, five times the target and equal to the NETP project for 2050.[54] Projections in the past for the implementation of solar power have often underestimated cost reductions and policy effects, and have therefore underestimated the growth of solar implementation.

The effect of meeting the EU 2020 targets

Analysis from Rydén (ed) 2010 shows the effect of implementing the renewable and efficiency EU 20-20-20 targets on Nordic CO_2 emissions. Implementation would entail a 95% carbon-free electricity system in the Nordic countries, compared to 85% in 2011. This points to the importance of sectors other than power in reducing emissions further, such as transport and industry.

54 Ministry of Foreign Affairs of Denmark (2012)

Figure 30. Nordic CO_2 emissions towards 2030



Source: Rydén (ed) (2010), 29

Post 2020

There is significant uncertainty with regard to what will happen after 2020. The Commission states that renewable energy shall become a vital part of the future European energy mix. This shall happen through reduced but effective policy support and trade. In addition, global leadership within renewable energy research and industrial development shall be maintained. According to the Commission, the combination of technology development and implementation is necessary so that the EU can continue to develop its renewable energy resources in a cost effective and affordable manner, as well as capture the associated competitiveness, economic and employment opportunities.[55]

In early 2013 the Commission adopted a Green Paper on "A 2030 framework for climate and energy policies", launching a public consultation process on the type, nature and level of potential climate and energy targets for 2030. More concrete proposals for the 2030 framework will be put forward by the Commission by the end of 2013, bridging the 2020 targets and the long-term climate goal of an 80–95% reduction in GHG emissions by 2050. Analyses from the Commission indicate that a 40% reduction of GHG emissions by 2030 compared to 1990 would be cost effective in meeting the 2050 target.[56]

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55 European Commission (2012b)
56 European Commission (2011)

The centre of gravity for the renewable energy sector is now moving from the mature markets in the West to emerging markets in Asia.

Recent signals from the Commission identify three different policy tracks under consideration.[57] The first track has a stronger focus on the current EU-ETS system than today, where CO_2 emission targets will become considerably more stringent post 2020. The second track continues with fixed national and EU renewable targets, but where support systems are much more coordinated than today. A third track could be a combination of both EU and national renewable targets combined with the EU-ETS and fully harmonised support policies for renewable energy.

Technology development in a global market

In addition to policy discussions within the EU, Nordic policy makers must take into account the fundamental market change within the renewable energy industry the last few years. Major Nordic producers of renewable energy technologies have experienced a dramatic shift in their global competitiveness. REC in solar PV and Vestas in wind have both been faced with increased global competition, especially from China.

A 2012 report from KPMG emphasised that recent economic turmoil makes it less attractive to invest in the production of equipment for renewable energy within the EU. The report claims that the centre of gravity for the renewable energy sector is now moving from the mature markets in the West to emerging markets in Asia. This trend is accelerated by recent cuts in government incentive schemes in EU countries such as Germany, Italy and Spain, while countries in Asia maintain or improve incentives for technology development.[58]

The solar PV sector offers a good example of the changing conditions. The price of solar PV panels has fallen drastically in recent years and China has become the leading producer. Over 700 Chinese companies now produce an annual capacity of 40GW, and nearly 95 percent of that is exported.[59]

Towards 2050

The global context

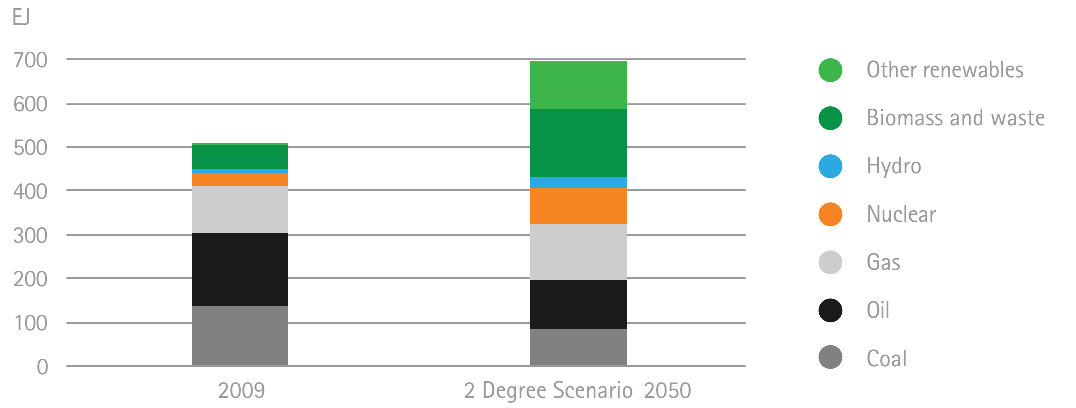
According the IPCC, by 2050 global GHG emissions need to be reduced by 50 to 85% to avoid the most harmful effects of climate change. Individually, the Nordic countries have announced ambitious energy and climate targets with similar time spans, as detailed in Table 1. Renewable energy is expected to play a significant role at the global, European and Nordic level.

The IEA's 2 Degree Scenario represents this reduction in GHG emissions for the energy sector. It argues that despite significant growth in energy

57 AGFE (2012)
58 KPMG (2012)
59 Offshore.no (2012)

demand, such a change will require that over 40% of the global energy supply in 2050 is renewable. This will mean the significant implementation of mature renewable energy sources as well as the development of new technologies. Technological breakthroughs are required, as well as reductions in the cost of immature technologies such as offshore wind and second generation biofuels. Public RD&D funding is a critical input in accelerating the rate of innovation.

Figure 31. Global total primary energy supply



Source: adapted from IEA (2012a)

European level

The EU has set a goal of reducing greenhouse gas emissions to 80% to 95% below 1990 levels by 2050. The Commission's Energy Roadmap 2050 explores how this goal can be achieved for the energy sector while at the same time improving the competitiveness and security of supply.[60]

The Roadmap describes five decarbonisation scenarios achieving the target. These scenarios range from a focus on energy efficiency, to a highly diversified energy mix, a high renewable share, late CCS implementation and low nuclear generation.

In all decarbonisation scenarios, renewable energy use will increase significantly. This is evident in the figure below, where the renewable share of energy consumption in 2050 rises 45 percentage points from today's level. The share of renewable energy in European electricity consumption in 2050 reaches 65% in the Commission's energy efficiency scenario and 97% in the high renewable scenario.

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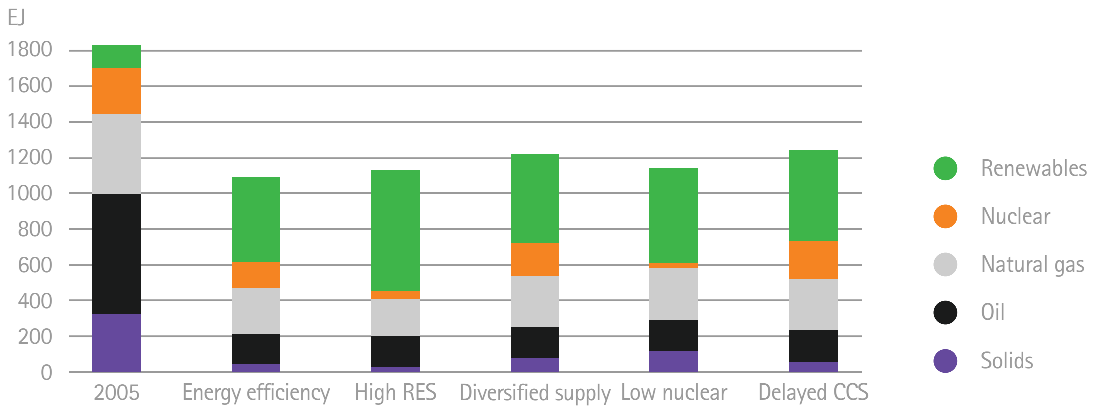
60 European Commission (2012d)

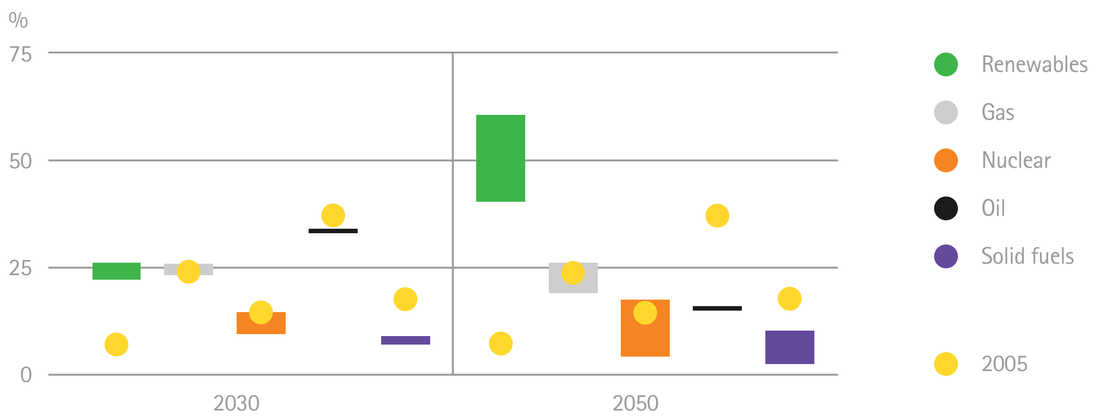
Figure 32. EU Energy Roadmap scenarios: Total primary energy supply by fuel in 2050



Source: European Commission (2012e)

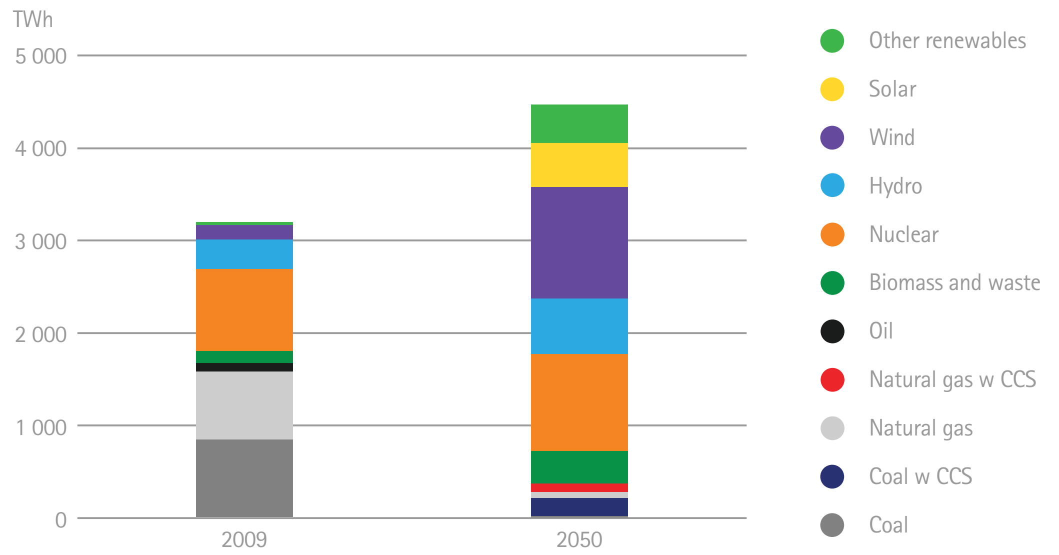
The IEA on the other hand, sees around 60% of Europe's electricity generation coming from renewables in 2050 in their 2 Degree Scenario. Coal and natural gas without CCS are essentially phased out, with natural gas providing a transition in 2030 before renewable sources grow further. Wind sees the largest increase, but other modern renewable technologies are also important in meeting the increasing demand for electricity.

Figure 33. EU Energy Roadmap scenarios: Primary energy consumption in 2030 and 2050



Source: European Commission (2012d), 6

Figure 34. European electricity generation in the 2DS scenario of IEA's ETP 2012



Source: IEA (2012a), 571

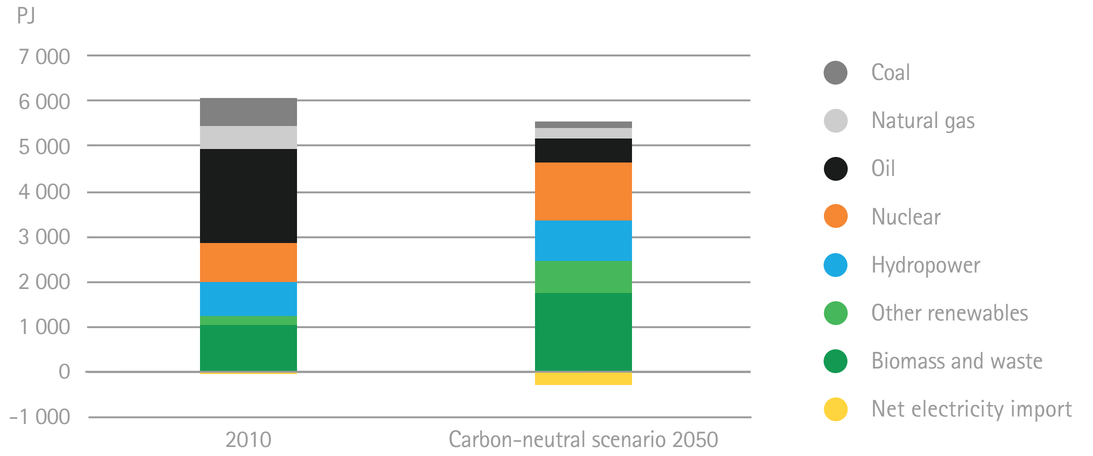
The Nordic region

The IEA has recently published a Nordic edition of their Energy Technology Perspectives publication.[61] It assesses how the Nordic energy sector could develop within the global 2 degree scenario, and introduces a new Carbon-Neutral Scenario where the region achieves a carbon-neutral energy sector by 2050. This scenario is in line with the political targets of the Nordic countries for 2050 outlined in Table 1.

To achieve the 85% reduction in energy-related emissions envisioned in the Carbon-Neutral Scenario, the IEA sees a significant increase in renewables and a mild increase in nuclear power. This, combined with an overall drop in demand and a near phase-out of fossil fuels, could lead to a Nordic region with significant net exports of clean electricity to Europe.

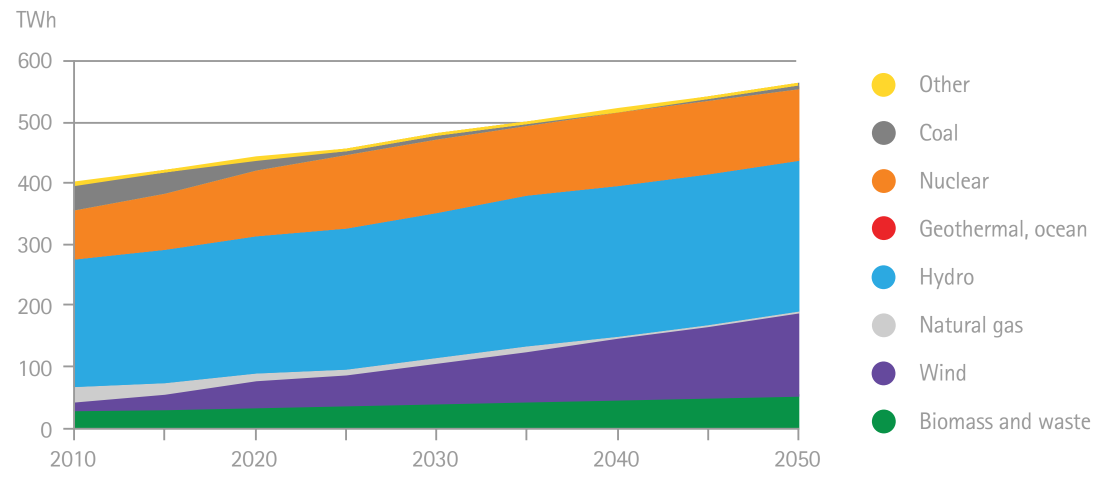
61 IEA (2013)

Figure 35. Nordic total primary energy supply in 2010 and 2050 in Carbon-Neutral Scenario



Source: IEA (2013)

Figure 36. Nordic electricity generation in the Carbon-Neutral Scenario



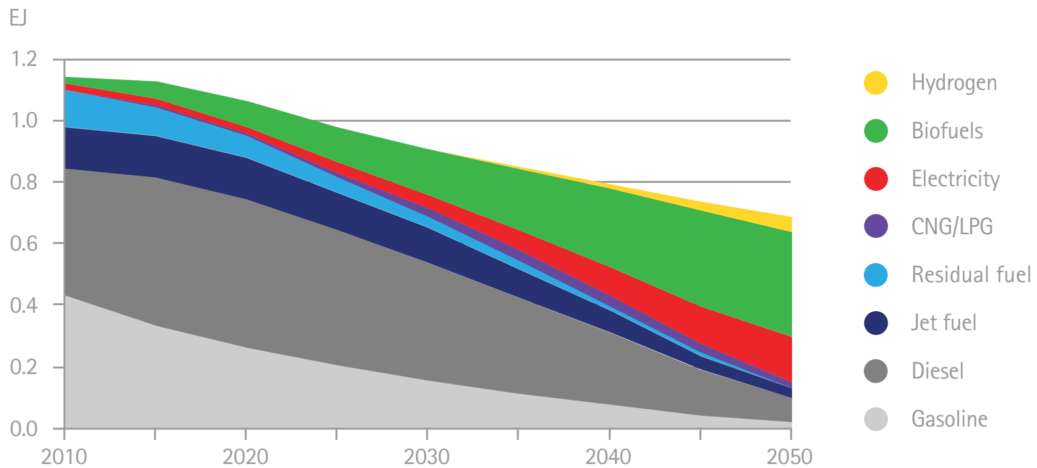
Source: IEA (2013)

Wind power accounts for a quarter of Nordic electricity generation in 2050 in the Carbon-Neutral Scenario. This is a significant increase in the Nordic region and will require investments in infrastructure as well as public acceptance – especially if it is seen to facilitate electricity export instead of domestic demand.

Wind power accounts for a quarter of Nordic electricity generation in 2050 in the Carbon-Neutral Scenario.

Biofuels are the other renewable energy source seeing a dramatic increase in the Carbon-Neutral Scenario. The IEA's analysis includes half of international transport emissions associated with the Nordic countries, and biofuels must play a large role in decarbonising these international emissions from the maritime and aviation sectors.

Figure 37. Nordic energy use in transport in the Carbon-Neutral Scenario



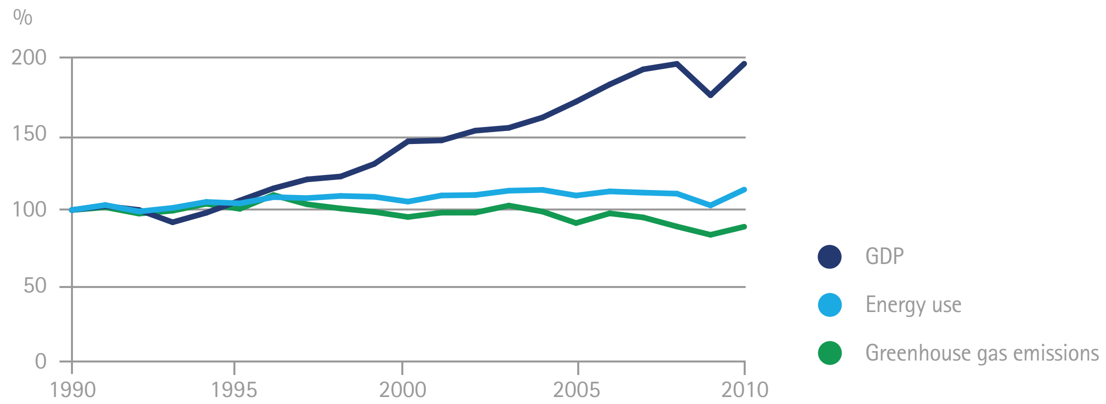
Source: IEA (2013)

The Carbon-Neutral Scenario requires that the energy intensity of the Nordic countries – the amount of energy required to produce a unit of GDP – is reduced by 60% from its 2010 level.[62] This is a significant change, but not unheard of in the Nordic region which has achieved a meaningful decoupling of GDP and energy use over the last decade.[63]

62 IEA (2013)

63 Nordic Council of Ministers (2011), 10

Figure 38. Decoupling of GDP, energy use and GHG emissions in the Nordic countries



Source: Nordic Energy Research (2012)

Alone, the Nordic countries represent about 1% each of the total amount of public RD&D funding for energy in the OECD.

Opportunities for Nordic cooperation toward 2050

There are significant opportunities for increased cooperation in facilitating both the implementation of renewable energy technologies as well as their development. The IEA points to the need for Nordic cooperation in infrastructure development and planning for CCS and transportation strategies.[64] Policy harmonisation is another important area, and the Norway-Sweden Green Certificate Scheme is a good example.

Nordic cooperation in energy RD&D is another area highlighted by the IEA.[65] The sharing of ideas, common access to networks, research facilities and markets has a significant impact on the effectiveness of clean energy RD&D, especially for small economies like those in the Nordic region. Alone, the Nordic countries represent about 1% each of the total amount of public RD&D funding for energy in the OECD. But together, Nordic researchers gain access to the combined and complementary RD&D resources of the entire region.

64 IEA (2013)

65 IEA (2013)

5. Conclusions

This report aims to support energy technology policy-making in the Nordic countries by visualising and comparing renewable energy policies and their intended effects. The report brings forth a unique Nordic overview of the development of renewable energy policies in the Nordic region over recent decades, and in this way offers new insights that can be used to meet the future policy needs of the region.

Clear effect of policies on implementation and development

While Denmark and Finland have opted for more technology-specific instruments to promote renewable electricity generation, the central instrument in Sweden and Norway is technology-neutral.

The policy visualisations presented in Section 2 of the report have highlighted the type and target of the various policy initiatives that implemented in the Nordic countries to increase renewable energy generation in recent decades. All countries show a diversification of the policy portfolio in the 1990s, with a clear prioritisation of different technologies and instruments by different countries. While Denmark and Finland have opted for more technology-specific instruments to promote renewable electricity generation, the central instrument in Sweden and Norway is technology-neutral. The indicators of the intended effects of these policies have described how both implementation and technology development activities have increased over the same period. The Nordic countries have been successful in implementing renewable energy production from wind and bioenergy. Combining these statistics with qualitative insight from the literature has shown that policy measures have been critical in facilitating the development and implementation of renewable energy technologies in the Nordic region.

Existing competencies and an international focus are vital

One unique policy factor that emerged in Section 3 of the report is the central role of existing resources and competencies. Each Nordic country has followed different pathways in their policy portfolios and has achieved different levels of technology development and implementation. These differences can be explained by the need for policies to build on existing competencies present in that country to be successful. As discussed in Section 3, every case of technology focus in the Nordic region – from Danish wind to Norwegian solar to Finnish bioenergy – derives from natural resources and existing competences.

It is not feasible for individual Nordic countries to meet their technology needs through indigenous technology development alone.

A second unique policy factor is that as small players in the expanding global market for renewable energy technologies, it is not feasible for individual Nordic countries to meet their technology needs through indigenous technology development alone. Only in some cases will activity be evident through the entire value chain – from research and development through to implementation of renewable energy in the energy system. The import and export of technologies are therefore important factors in connecting technological innovation and the implementation of those technologies.

Long-term, integrated and coordinated policies are needed towards 2050

The report has looked at projected developments towards 2050, and the factors influencing the future renewable energy policy needs of the Nordic countries in Section 4. The EU has already indicated its intentions towards 2050, which will heavily influence Nordic policy-making.

Long-term policies that are predictable beyond the coming years are important in fostering investor confidence and dynamic research networks. The case of Danish wind power from Section 2 illustrates this point. RD&D funding has been consistent over a long period, while Danish market-based policies have provided a stable climate for investment. Another example is the Swedish green electricity certificate scheme, which saw a much greater impact after the policy was extended to 2035.

Long-term policies that are predictable beyond the coming years are important in fostering investor confidence and dynamic research networks.

Integrated policies are important if both technology development and implementation are to be targeted. One example which illustrates a lack of integrated policies is the case of Swedish wind power technology development from Section 3, where innovation policies were not well timed with policies targeting implementation and market creation, assisting in the Swedish turbine industry's failure to become established. Danish wind provides a different example, where tight integration between implementation and development policies helped the country become a leader in both wind implementation in the energy system and wind technology development.

Lastly, renewable energy implementation and technology development benefit from the coordination of policies between countries. This is a conclusion from Section 4, which highlights the opportunities for increased cooperation between the small and compatible economies and energy systems of the Nordic region.

6. Annex – Methodology

IEA "Global Renewable Energy Policies and Measures Database" database

The IEA database for renewable energy policies was used as the primary source for the policy visualisations in section 2. This data was first accessed in August 2010 using the following search criteria:

Policy type

- Education and Outreach
- Financial
- Incentives/Subsidies
- Policy Processes
- Public Investment
- RD&D
- Regulatory Instruments
- Tradable Permits
- Voluntary Agreement

Policy target

- Bioenergy
- Fossil Fuels
- Geothermal
- Hydropower
- Multiple Renewable Energy Sources
- Ocean
- Solar
- Solar Photovoltaic
- Solar Thermal
- Wind

It was accessed again in December 2012 to update the information. The database itself has since been expanded with additional search criteria.

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