

Energy support measures and their impact on innovation in the renewable energy sector in Europe

ISSN 1725-2237



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Layout: EEA/Rosendahls – Schultz Grafisk A/S

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Luxembourg: Publications Office of the European Union, 2014

ISBN 978-92-9213-507-2
ISSN 1725-2237
doi:10.2800/25755

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Acknowledgements

This report was prepared by the European Environment Agency (EEA) and a consortium led by CE Delft.

The following experts from the consortium contributed to this report: Sander de Bruyn (CE Delft), Raphael Sauter (Institute for European Environmental Policy (IEEP)) and Geert Warringa (CE Delft), with support from Martine Smit (CE Delft), Martijn Blom (CE Delft), Axel Volkery (IEEP), Dorien Bennink (CE Delft), Maarten Afman (CE Delft), Milan Scasny (CUEC Prague), Agnieszka Markowska and Marisa Korteland (CE Delt).

The following experts from the EEA contributed to the report: Anca-Diana Barbu, Johannes Schilling and Mihai Tomescu.

Overall coordination of the report was carried out by Anca-Diana Barbu (EEA) and Sander de Bruyn (CE Delft).

The authors would like to thank the four countries participating in the case studies (the Czech Republic, the Netherlands, Spain and Switzerland) for their valuable contribution to this work.

The report benefited greatly from input received by members of the advisory group: Ronald Steenblik (OECD), Ivo Schmidt (DG Energy), Tom Howes (DG Energy), Manfred Rosenstock (DG Environment), Małgorzata Kicia (DG Environment), Jerzy Pienkowski (DG Economic and Financial Affairs), Francesco Ferioli (DG Competition), Peter Novak (Energotech Engineering), Renato Marra Campanale (Institute for Environmental Protection and Research (ISPRA)), Vladimir Vlk (Enterpriser, Czech Republic), Thomas Bettler (Bundesamt für Umwelt BAFU, Switzerland) and Ioannis Economides (Ministry of Commerce, Industry and Tourism, Cyprus)

EEA support for the preparation of this report was provided by Paul McAleavey, John Van Aardenne, Jock Martin, Stefan Ulrich Speck and Johannes Schilling.

The EEA also acknowledges comments received on the draft report from the national focal points and experts of EEA member countries, and from the European Commission and its Joint Research Centre (JRC). These comments were included in the report as far as was practically feasible.

Executive summary

Governments support energy production and consumption in order to meet social, economic and environmental objectives, and they have been doing so for decades. In times of economic crisis, public budgets and household incomes come under pressure. At the same time, countries need to kick-start their economies by creating new employment opportunities in emerging industries such as the renewable sector. This report examines the support allocated to energy production and consumption in Europe and its impact on innovation in renewable energy.

The study provides an overview, at European level, of the type of measures in place in 2012 to support energy consumption and production in 32 EEA countries. For four countries, a quantitative analysis is undertaken as well.

Progress towards innovation in the renewable sector is assessed using the number of patent applications to the European Patent Office (EPO) for various renewable energy technologies. The report explores the link between support measures for renewable energy and employment effects in two of the most developed renewable sectors in Europe, namely wind and solar photovoltaics (PV) as well.

The discussion is enhanced by an in-depth analysis at national level of the situation in four European countries: the Czech Republic, the Netherlands, Spain and Switzerland.

These countries were selected using seven criteria:

- in 2012, countries had to have in place feed-in tariffs/premiums to support renewable energy;
- geographical coverage;
- different progress towards the 2020 renewable targets;
- different innovation performance based on the Innovation Union Scorecard 2013;
- different economic structure;
- different energy mix;
- different drivers for renewable development (EU and non-EU countries).

The main purpose of this analysis is to highlight the part specific country circumstances play in the development of the renewable sector, by exploring related policy effectiveness and policy efficiency, as well as developments in the renewable sector in terms of innovation and employment. Coherence between policy objectives within relevant policy domains is also important, and is briefly addressed for these four countries.

The main findings of the report are summarised below.

Despite growing interest in promoting renewable energy, in 2012 many support measures in Europe targeting fossil fuels and nuclear sectors were still in place, and continued to affect public budgets.

Fossil fuel support in Europe is expressed mainly through fiscal exemptions to support the consumption of these fuels in certain economic sectors. They constitute a burden on public budgets, because they are revenue forgone by governments.

Renewable support is a mix of surcharges on the energy bill of the end users, and governmental support. In the case of electricity, the former type of support prevails. Consequently, such support does not represent a burden on public budgets, but it does affect energy prices for end users, particularly when the merit order effect is not passed on to them.

Support for the nuclear industry is poorly documented, but it has existed for decades in Europe in various forms, including explicit or implicit limited liability in case of major accidents, grants and government-mediated financing and regulated prices. Despite being difficult to quantify, this support can place a significant burden on the public budget.

Support for fossil fuels affects market conditions for renewable energy, but there is little evidence that the impact is significant, given the support allocated to the renewable sector.

Countries' strategies differ when it comes to supporting fossil fuels, so the renewable sector must compete with a unique price structure for these fuels in each country. A more harmonised framework for energy taxation would be a good start for facilitating further developments in the renewable sector.

Countries with a higher effective tax rate on carbon dioxide (CO₂) generally have a higher rate of patent applications in renewable technologies.

Several factors are crucial for the innovation process in the renewable sector: political will (or the lack thereof) to shift the focus onto the renewable sector, pre-existing innovation capabilities, the level of investment in research and development (R&D) for renewable technologies and renewable policy design. This has been observed in developments in Denmark as well as in the four target countries (the Czech Republic, the Netherlands, Spain and Switzerland).

The four target countries focus on a few key and mature renewable technologies such as onshore wind, solar PV, hydro and biomass. All three EU Member States need to step up efforts to boost policy effectiveness and policy efficiency, especially in those technologies considered to be key for meeting the 2020 targets in their respective National Renewable Energy Action Plans (NREAPs). Across all three EU Member States, biomass developments are consistently behind the respective technology-specific targets included in the NREAPs. All four countries need to increase efforts in the renewable heating and cooling sector.

Experiences of the three EU Member States studied in this report suggest that the NREAPs

should be revisited in light of recent technological price developments, economic developments and knowledge gained on the environmental consequences of various renewable technologies. This seems to be particularly relevant for biomass.

Renewable policy design has a significant impact on policy effectiveness and efficiency. Policy flexibility in managing rapid and significant cost reductions of these technologies and the way the policy's cost is contained over time determines not only how effective the policy is in achieving the set goal, but also at what cost this occurs. For example, Spain's long-term policy objectives and effective policy resulted in a sizeable domestic renewable sector. However, this development was achieved at relatively high policy costs with annual feed-in premium (FIP)/feed-in tariff (FIT) payments of around EUR 5 billion in 2011. By comparison, the Swiss annual FIT payments were around EUR 0.074 billion in 2011, albeit for a much less impressive deployment of these resources.

The strong focus on the market-pull policy type helped the innovation process in renewables, and generated some 2.2 million full-time equivalent jobs in Europe. However, a more balanced mix of market-pull and technological-push instruments (e.g. R&D investment), accompanied by greater attention to the quality of jobs created, will ensure the development of a more sustainable renewable energy industry in Europe.

If the renewable sector is to make a significant contribution to climate goals, energy security goals and more generally, green economic growth, policy objectives, particularly in the area of renewable energy, industry, economy and R&D, must be carefully designed, aligned and implemented.

1 Introduction

1.1 General background

Governments support energy production and consumption in order to meet social, economic and environmental objectives, and they have been doing so for decades. A recent study authorised by the European Commission (Ecofys, 2014) estimates that the direct historic support to energy technologies that still has an impact today amounts to somewhere between EUR₂₀₁₂ 3 billion and EUR₂₀₁₂ 15 billion.

Government intervention can be useful and effective in helping meet policy objectives, if it is well designed. However, a recent study (Ecofys and CE Delft, 2011) shows that because of governmental interventions in the energy markets, a level playing field does not exist between energy carriers and technologies for energy production. Moreover, although it should be possible to adapt such support over time to account for market changes, technological development or societal change, this has proven cumbersome in reality.

Revisiting the support allocated to energy sources is also necessary because of the economic crisis, which affected not only public budgets but also the income levels of many households in Europe. This has triggered debates on the need to optimise public expenditure, with some actors choosing to place more emphasis (with negative connotations) on the high capital cost of renewable energy.

The debate tends to overlook the fact that existing support to conventional energy sources goes well beyond direct support and tax exemptions. For example, past government support for R&D and infrastructures created large production capacity and distribution networks for the now-incumbent technologies (fossil fuel and nuclear), which can afford lower unit prices for energy production due to economies of scale. Systemic relations developed over time between technologies, infrastructures,

interdependent industries and users intensify the technological lock-in on conventional technologies. Consequently, renewable energy technologies must compete with the incumbent technologies in the current market place, not only as regards price, but also at institutional level.

In fact, all these interactions have hampered progress towards sustainable energy, worldwide. The International Energy Agency's recent publication, *World Energy Outlook 2013* (IEA, 2013), clearly sends this message.

On the other hand, innovation in and deployment of renewable energy may be viewed as an important driver in shaping the future of our economic systems, as emphasised in concepts like green growth (OECD, 2009) or the circular economy (Ellen McArthur Foundation, 2012) (¹). Nowadays, the renewable energy industry in Europe provides more than 2.2 million full-time equivalent jobs, according to one source (EurObserv'ER, 2013).

Recently, several reports have looked into the question of energy support. For example, *Support and costs of EU energy* (Ecofys, 2014) provides an overall picture of energy costs (including external costs) and quantifies the extent of public interventions in the energy market, using the levelised cost of energy (LCOE) approach. Another report, *Cost effectiveness of support to electricity – An assessment of economic efficiency* (EC, forthcoming) examines the economic efficiency of support to electricity generation. The report evaluates support to new PV, wind, combined-cycle gas turbine (CCGT), coal and nuclear plants in five countries (the Czech Republic, Germany, Italy, Poland and Spain), likewise using the levelised cost of electricity and the levelised revenues of electricity concepts. A third report, *Getting energy prices right* (IMF, 2014) published by the International Monetary Fund (IMF), proposes a methodology and

(¹) On 1 July 2014, the European Commission issued the communication *Towards a circular economy: A zero waste programme for Europe* (COM(2014)398 final). In this communication, the concept of circular economy is centred around waste and the recycling of materials, including in buildings (COM(2014) 445).

associated tools to adjust fiscal instruments so as to reflect environmental damage. All three reports hold a different perspective on energy support and provide different geographical coverage. This report offers yet another perspective, namely the impact of energy support on innovation. The report builds on four case studies (the Czech Republic, the Netherlands, Spain and Switzerland) for which existing expenditure data have been collected and analysed. Further details on the scope and the methodologies involved are presented in subsequent chapters.

1.2 EU policy context

In order to spur sustained investment in renewable energy, a clear, long-term policy perspective is necessary. This section gives a brief overview of the most relevant and recent EU policy frameworks that may impact innovation in and deployment of renewable energy technologies.

The *Roadmap for moving to a competitive low-carbon economy in 2050* (EC, 2011a) suggests that, by 2050, the EU should cut its greenhouse gas (GHG) emissions to 80 % below 1990 levels through domestic reductions alone. It sets out indicative milestones: a reduction of 40 % by 2030 and of 60 % by 2040. The communication also shows how the main sectors responsible for Europe's levels of GHG emissions (power generation, industry, transport, buildings and construction and agriculture) can make the transition to a low-carbon economy cost-effectively. For the electricity sector, the roadmap envisages that the sector will effectively be decarbonised by 2050, relying entirely on 'low-carbon technologies'.

The *Energy Roadmap 2050* (EC, 2011b) explores the challenge of meeting the EU's decarbonisation objective while at the same time ensuring security of energy supply and competitiveness. All scenarios analysed (illustrative in nature)⁽²⁾ imply major

changes in energy technologies, carbon prices and networks.

In January 2014, the European Commission agreed on *A policy framework for climate and energy in the period from 2020 to 2030* (EC, 2014a). The framework seeks to drive continued progress towards a low-carbon economy by setting new targets for GHG emissions reductions (40 %) and renewable energy (at least 27 %). In addition, the framework includes a proposal to reform the EU emission trading system (EU ETS), a set of key indicators to assess progress in achieving an internal energy market that delivers energy securely and at competitive prices, and a proposal to reform the energy governance system based on energy plans developed by the Member States. To complete the framework, the Communication on *Energy Efficiency and its contribution to energy security and the 2030 Framework for climate and energy policy* (EC, 2014b) proposed a 30 % improvement in energy efficiency by 2030. On 23 October, the Council adopted the 2030 framework. Compared to the EC proposal, the target for energy efficiency has been changed to 'at least 27 %' (EC, 2014c).

In addition to these climate and energy policy framework documents, specific communications related to the internal energy market and competition issues have been published and are relevant to the topic discussed in this report.

On 5 November 2013, the Commission published the communication *Delivering the internal electricity market and making the most of public intervention* (EC, 2013a), which includes guidelines for Member States on designing and reforming national support schemes for renewable energy, designing capacity mechanisms to ensure continuous supply of electricity and enhancing the role of consumers.

On April 2014, the European Commission adopted the new *Guidelines on State aid for environmental protection and energy 2014–2020* (EC, 2014d).

⁽²⁾ The communication includes five different scenarios.

- High energy efficiency (i.e. political commitment to very high energy savings) includes such measures as more stringent minimum requirements for appliances and new buildings, high renovation rates of existing buildings, and establishing energy savings obligations on energy utilities. This would lead to a decrease in energy demand of 41 % by 2050 as compared to the peaks in 2005 and 2006.
- Diversified supply technologies (i.e. no technology is preferred — all energy sources can compete on a market basis with no specific support measures) have decarbonisation driven by carbon pricing, assuming public acceptance of both nuclear and carbon capture and storage (CCS).
- High renewable energy sources (RES): strong support measures for RES, leading to a very high share of RES in gross final energy consumption (75 % in 2050) and a share of RES in electricity consumption, reaching 97 %.
- Delayed CCS: similar to the diversified supply technologies scenario, but it is assumed that CCS is delayed, leading to higher shares for nuclear energy, with decarbonisation driven by carbon prices rather than by a technology push.
- Low nuclear: similar to the diversified supply technologies scenario, but it is assumed that no new nuclear sources (besides reactors currently under construction) are being built, resulting in a higher penetration of CCS (around 32 % in power generation).

The guidelines apply as of 1 July 2014 for new installations only, and Member States are required to amend their national aid schemes for energy and environment by no later than 1 January 2016. Renewable energy schemes need to be brought in line with the guidelines only if they are prolonged or adapted. Among other things, the guidelines aim to support Member States in reaching their 2020 climate targets, while addressing market distortions that may result from support granted to renewable energy sources.

Issues to be considered include:

- shifting towards market-based approaches only (as of 2016, public support should only be provided in the form of market-oriented

mechanisms such as premiums, i.e. a top-up on the market price or tradable certificates);

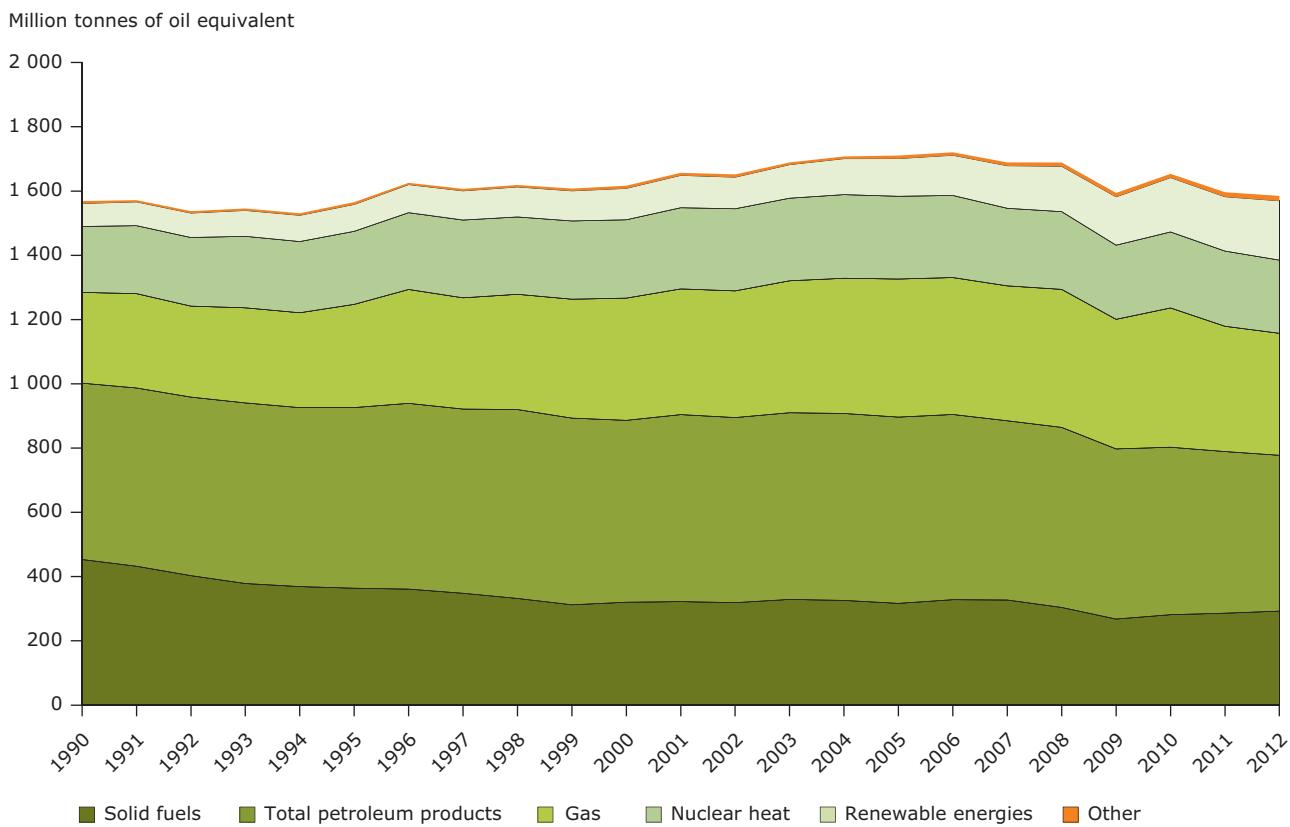
- a requirement that renewable energy generators be subject to balancing responsibilities;
- a gradual introduction of competitive bidding practices for public support.

The findings in this report illuminate further the recommendations in these latter communications ⁽³⁾.

1.3 Overview of selected energy indicators in EEA countries ⁽⁴⁾

In 2012 in the EU-28, the share of fossil fuels in primary energy consumption ⁽⁵⁾ was 73.9 % down, from 82.1 % in 1990. The share of renewable energy

Figure 1.1 Primary energy consumption by fuel, EU-28, 1990–2012



Source: EEA (2013-ENER26 database based on Eurostat).

⁽³⁾ This project started early in 2013, before the publication of the communications *Guidelines on State aid for environmental protection and energy 2014–2020* and *Delivering the internal electricity market and making the most of public intervention*. However, their recommendations are discussed where relevant throughout the report.

⁽⁴⁾ This project started early in 2013. At that time, 2012 data were not available, so the data and indicators calculated in subsequent chapters will have 2011 instead of 2012 data. For updated information, please http://www.eea.europa.eu/data-and-maps/indicators#c5=&c7=all&c0=10&b_start=0. Updating the data to reflect 2012 in subsequent chapters would not change the main messages of the report.

⁽⁵⁾ Here, primary energy consumption is calculated as gross inland energy consumption minus non-energy use.

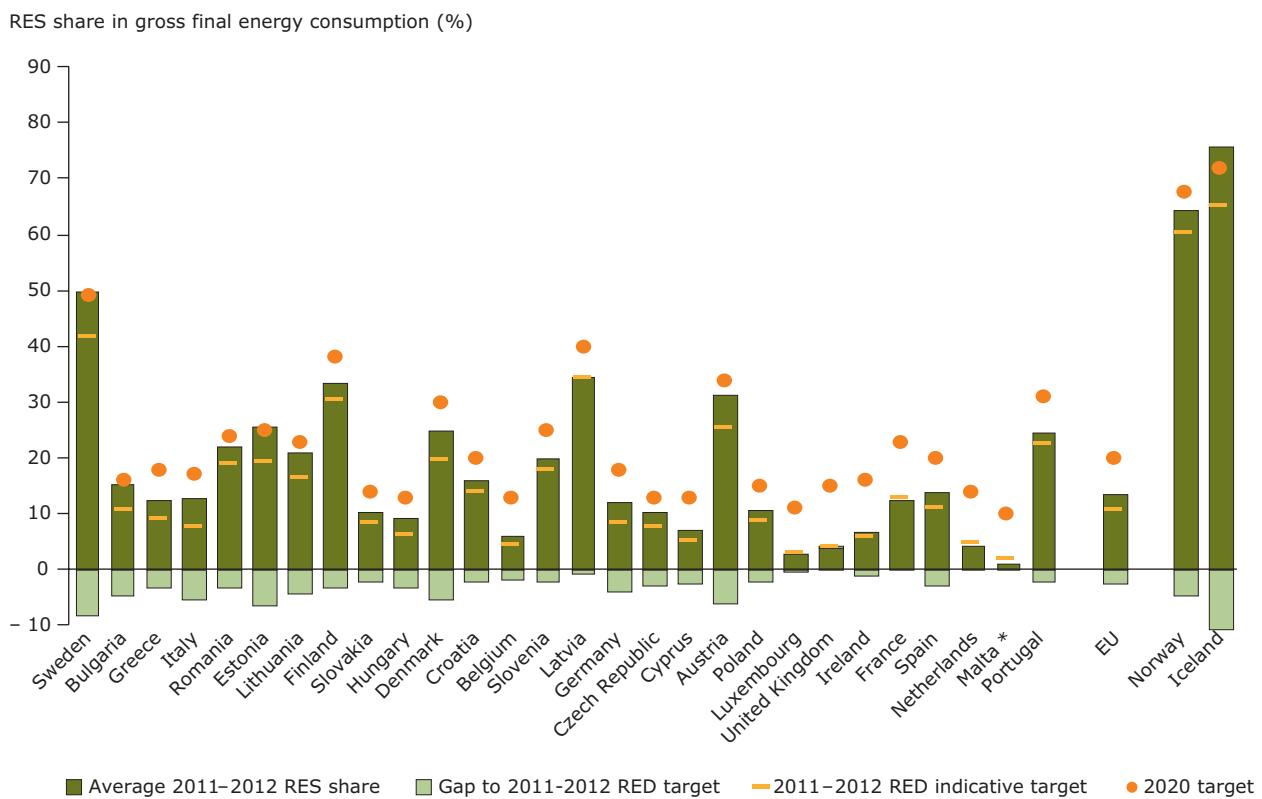
more than doubled, from around 4.5 % in 1990, to 11.6 % in 2012. The share of nuclear energy increased, from around 13.1 % in 1990, to 14.4 % in 2012 (see Figure 1.1).

In 2012, 22 Member States (Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Germany, Estonia, Greece, Croatia, Italy, Latvia, Lithuania, Luxembourg, Hungary, Austria, Poland, Romania, Slovenia, Slovakia, Finland, Sweden and the United Kingdom) were considered to be on track to meet their RES targets established under Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (known as the Renewable Energy Directive (RED)) (EC, 2009). These countries had

exceeded both their indicative 2011 to 2012 RED targets and their expected 2012 targets established under the NREAP. The United Kingdom had exceeded its 2012 NREAP target, and was just about in compliance with its 2011 to 2012 RED target. Iceland and Norway were considered to be on track to meet their RES targets established under the European Economic Area Agreement (see Figure 1.2). Three Member States (Ireland, Portugal and Spain) had reached or exceeded their indicative RED targets for 2011 to 2012, but were below their 2012 NREAP target.

Three Member States (France, Malta and the Netherlands) were not on track towards their RES targets. In 2012, these countries had reached neither their indicative RED target nor their NREAP targets (EEA, 2013a⁽⁶⁾).

Figure 1.2 Share of RES in final energy consumption in EEA countries, and RES targets



Note: The 2020 targets are set in the RED. In accordance with the accounting rules in the RED, electricity generated by hydro and wind were normalised for annual variations (hydro for 15 years, and wind for 5 years). The Short Assessment of Renewable Energy Sources (SHARES) manual provided by Eurostat contains details on the normalisation rule: please see http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/other_documents.

The targets for Iceland and Norway are part of Annex IV to the EEA Agreement.

* Data are estimated by Eurostat, based on the national data transmission under Regulation (EC) No 1099/2008 of 22 October 2008 on energy statistics.

Source: Eurostat SHARES Results, 2012; Eurostat, 2014; EEA, 2014.

⁽⁶⁾ For an update, please check EEA, 2014.

1.4 The scope

The main aim of the report is to provide a balanced discussion on various forms of support for all energy sources currently applied in Europe, and their role in fostering (or not fostering) innovation in the renewable energy sector.

The report provides the following:

- A discussion of the forms of support to all energy sources applicable in 32 EEA countries⁽⁷⁾ from 2005 to 2012, based on an inventory of support measures⁽⁸⁾. From this inventory, individual country fiches were generated, summarising the support measures in place in 2012 in each of the 32 EEA countries (published separately from the report).
- An analysis of factors that could influence the development of a robust innovation process in the energy sector developed around renewables in Europe, given the specific national context. This discussion is enriched with information from detailed case studies in four selected countries (the Czech Republic, the Netherlands, Spain and Switzerland).

1.5 Outline of the report

Chapter 1 contains background information and the scope of the report.

Chapter 2 includes an overview of support measures for energy production and consumption in 32 EEA countries for all energy sources (conventional fossil fuels, renewables and nuclear), split between different commodities (electricity and heat) and users. Furthermore, this chapter explores various aspects of the innovation process in the renewable sector, including the impact of support measures on this process.

Chapter 3 contains an analysis of factors that could influence the development of a robust innovation process in the energy sector, developed around the renewables sector in Europe, given the specific national context. This analysis is based on detailed case studies elaborated for the Czech Republic, the Netherlands, Spain and Switzerland (published separately from this report).

Chapter 4 contains details on methodologies employed in this report, including definitions of energy support measures and data sources.

⁽⁷⁾ Croatia was not an EEA Member when this project was initiated, and therefore was not included in the analysis.

⁽⁸⁾ A quantification of the support measures for all 32 countries covered was beyond the scope of this project, due to budget constraints. However, for the four target countries (the Czech Republic, the Netherlands, Spain and Switzerland), a quantification of existing support is provided. The inventory takes into account the point of impact of the support measure, in line with principles applied by the Organisation for Economic Cooperation and Development (OECD).

2 Energy support measures in EEA countries and innovation in the renewable sector

This chapter contains a qualitative overview (numeric analysis) of energy support measures in place in 32 EEA countries in 2012.

It also investigates various aspects of the innovation process in the renewable sector, and the impact the energy support measures may have had on it from 2005 to 2011/2012 for the majority of the 32 EEA countries. Additional analysis of relevant issues at national level is provided in Chapter 3, based on detailed case studies elaborated for the Czech Republic, the Netherlands, Spain and Switzerland.

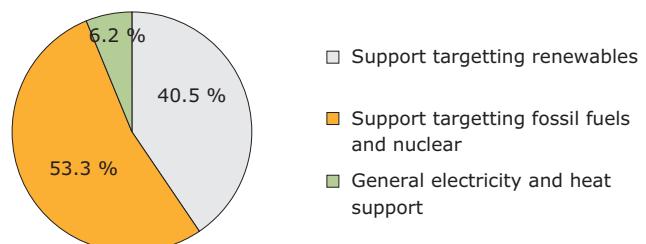
2.1 General overview of energy support measures in 32 EEA countries

In total, 582 support measures have been identified that were in place in 2012 in the 32 EEA countries. Figure 2.1 provides an overview of these support measures. Of the total 582 measures, 310 are associated with fossil fuels, and 236 with renewable energy (including biofuels), representing 40.5 % of the identified support measures. About 6 % of the identified support measures were targeted at electricity and/or heat production and consumption, and therefore did not alter the competitive situation between renewables and fossil fuels.

As seen in Figure 2.1, in 2012, EEA countries had in place more measures to support fossil fuels and nuclear than to support renewable energy. This is (partly) owing to the desire to keep certain economic sectors competitive. The communication *Roadmap to a Resource Efficient Europe* (EC, 2011c) calls for environmentally harmful support (EHS) to be phased out by 2020 'with due regard to the impact on people in need'. For a successful reform of EHS, simultaneous reforms are needed in the sectors involved.

Table 2.1 shows how the 582 identified support measures are distributed between renewables,

Figure 2.1 Distribution of energy support measures, 2012, EEA-32



Source: EEA.

Table 2.1 Energy support measures, by energy carrier and technology, 2012, EEA-32

	Fossil fuels	Nuclear	Renewables	Electricity and heat	Biofuels	Total
Direct subsidy	47	3	111	14	3	178
Fiscal exemptions	245	0	28	17	28	318
Non-financial measures	4.5	0	34	2	22.5	63
Other financial measures	1.5	1	8	2.5	0	13
Transfer of risk to government	3	5	2	0	0	10
Total	301	9	183	36	53	582

Note: Some measures were split among various energy carriers. In order to avoid double-counting, individual measures benefitting both petrol and biofuels, for example, have been split between both energy carriers equally ⁽⁹⁾. Because of this weighting factor applied for measures that span across various energy carriers or energy technologies, Table 2.1 includes figures with one decimal.

⁽⁹⁾ In other words, no attempt has been made to weight the importance of a particular measure for one energy carrier over another, and hence all energy carriers for which the measure applies have been treated equally.

conventional fossil fuels and nuclear. Fiscal exemptions appear to be the dominant form of energy support, especially for conventional fossil fuels, while renewable energy (excluding biofuels) appears to be mostly stimulated by direct monetary transfers. Relatively few measures concerning transfer of risk to governments are included. This is attributable more to the inadequate reporting of such measures than to these measures being a rare occurrence (see Annex 2, for a detailed discussion).

Even though EEA-32 countries appear to provide more support measures to conventional fossil fuels and nuclear than to renewable energy, there is a big difference between countries with respect to the overall distribution (see the discussion in Chapter 3).

Figure 2.2 shows the number and distribution of support measures for conventional fossil fuels, nuclear and renewables in EEA-32 countries.

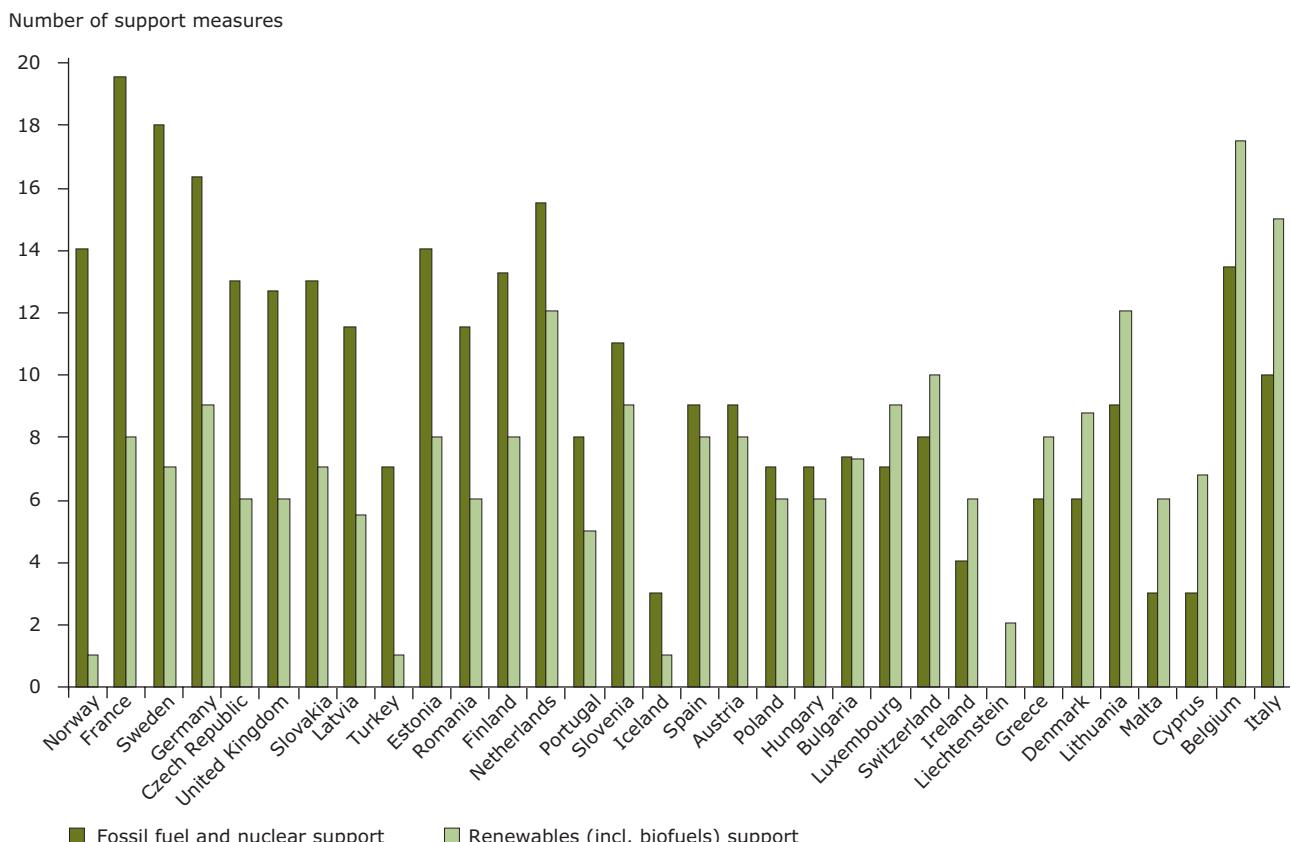
In Belgium, the high number of measures is attributable to the fact that different support measures for renewable energy are in place across different regions of Belgium.

Despite the larger number of measures being allocated to the conventional fossil fuels and nuclear, some countries chose to invest more in R&D for renewable technologies.

Figure 2.3 shows the amount of EUR₂₀₁₂/capita spent on R&D in energy technologies over the period from 2005 to 2011 in selected EEA countries. It is indicative of the direction countries may take concerning innovation in energy systems.

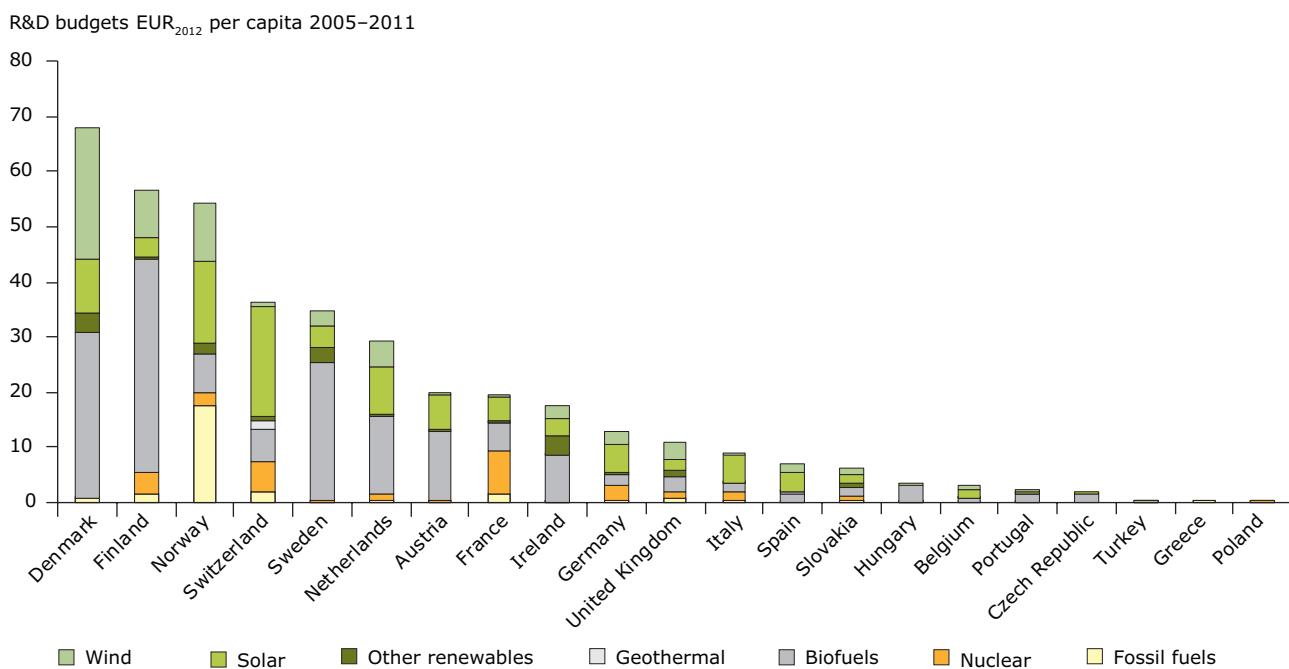
There are significant differences between countries concerning R&D support. Denmark has the highest amount of R&D support, amounting to almost EUR 70/capita from 2005 to 2011, while Greece,

Figure 2.2 Distribution of energy support measures between fossil fuels and renewables, EEA-32, 2012



Note: The figure is based on 546 out of 582 support measures, excluding generic electricity and heat support. This figure does not include all the additional measures from the IEA database on R&D expenditure as shown in Figure 2.3 because there was no information about the nature of these measures and consequently they could not be allocated to specific energy carriers, energy technologies or users. Here, only those R&D measures that were included in the OECD and RES-Legal databases are included.

Figure 2.3 Public R&D expenditure on energy technologies, selected EEA countries, 2005–2011 (EUR₂₀₁₂ per capita)



Note: This figure is based on the IEA database and may contain additional measures compared to those already in the OECD and RES-Legal databases considered in the inventory for this project. The reason why some of the data from the IEA database could not be captured in the inventory is that this project includes only those measures that are clearly specified in the national legislation have been included while the IEA database may include other forms of support such as public support to research institutes, etc. This figure shows that many more countries allocate public budgets for R&D, compared to those included in the two databases considered for this project.

Source: EEA, based on IEA (2013) for R&D budgets, Eurostat (2013) for population.

Poland and Turkey have almost no R&D support for energy technologies. This may also explain why Denmark seems to be the outlier in the analysis presented in Section 2.4 (see also Box 2.1 for further explanations).

2.2 Overview of renewable energy support

Renewable energy support in Europe is mainly allocated to the production of renewable energy (see Figure 2.4). It spans different types of instruments (see Figure 2.5). Overall, Belgium, Italy, Lithuania and the Netherlands have the highest number of instruments in place for renewable energy support. In Italy, the system changed in 2013, and a number of old support measures were replaced by a system of pre-auctioned FITs.

More than 60 % of renewable support measures are oriented towards production directly. Some countries, notably Belgium, Bulgaria, Estonia and Switzerland also have some policies in place related to the consumption of renewable energies. This

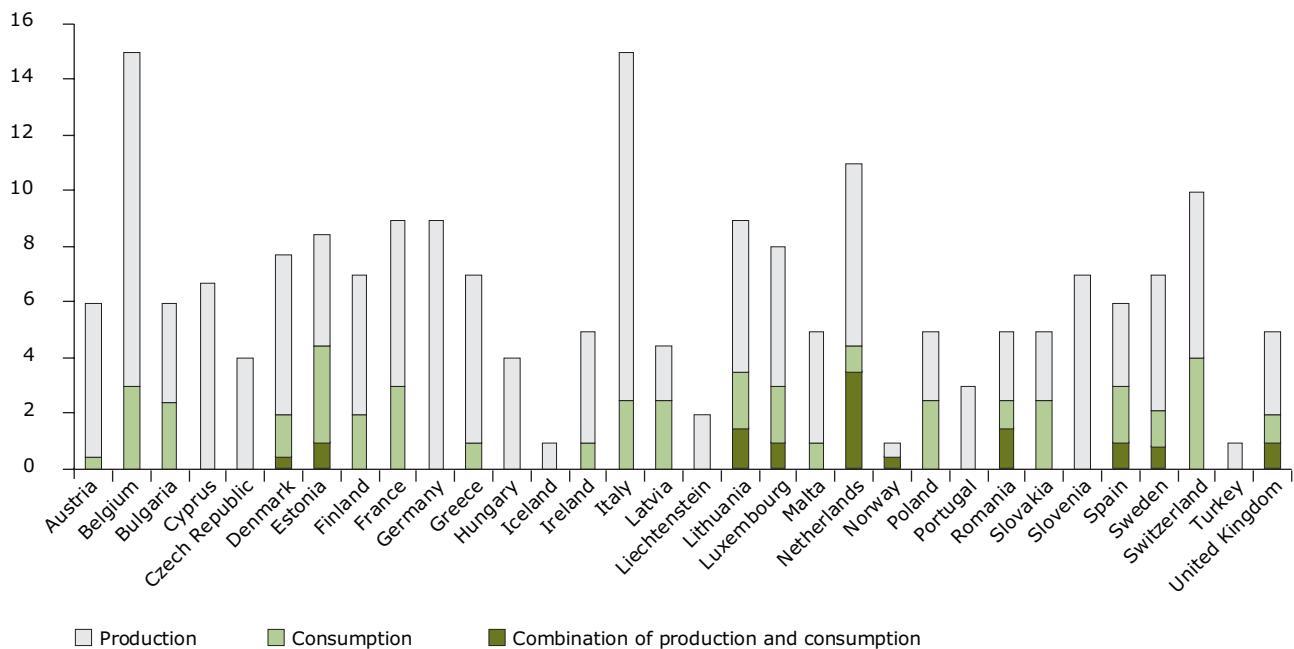
mainly takes the form of tax exemptions associated with the use of energy from renewable sources. However, there are relatively few of these types of measures.

In terms of the types of instruments, direct support is the dominant form of support in Austria, Cyprus, Estonia, Finland, Iceland and Romania. Tax instruments are relatively important in Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Spain, Sweden and Switzerland. Most countries have implemented a form of FITs and/or FIPs. FITs are relatively more important than FIPs in the 32 EEA countries. Belgium, Iceland, Norway, Poland, Romania and Sweden do not use FITs or FIPs to support renewable energy, but rather a quota system instead. The United Kingdom uses a combination of FITs, a quota obligation and tax regulation to support renewable energy (see Figure 2.5).

At the time of writing this report (2013–2014), most countries used a system of FITs/FIPs. The EC communication *Delivering the internal electricity market and making the most of public intervention* (EC, 2013a) calls for phasing out the FITs by 2016.

Figure 2.4 Point of incidence of renewable measures (excluding biofuels), EEA-32, 2012 ⁽¹⁰⁾

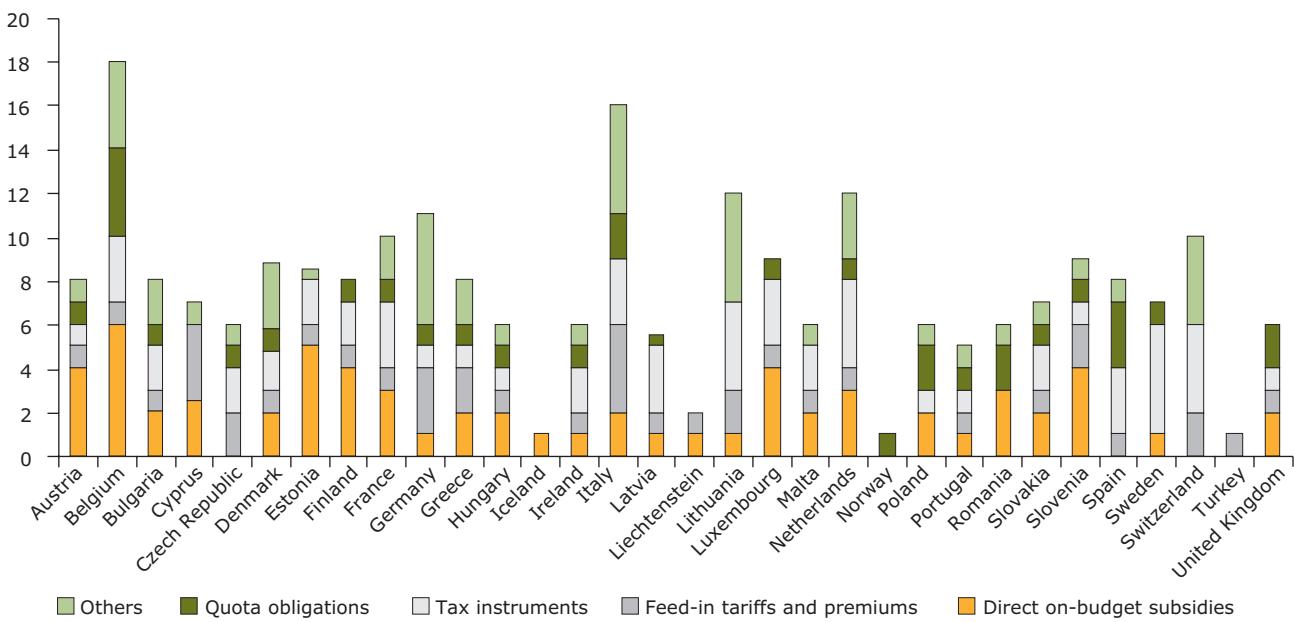
Number of measures



Source: EEA.

Figure 2.5 Types of instruments to support renewable energy, EEA-32, 2012

Number of measures



Source: EEA. For the Czech Republic, the Netherlands, Spain and Switzerland, additional information was used from the in-depth case studies elaborated for these countries.

⁽¹⁰⁾ Because transport was not the focus of this study, the data on support measures for biofuels are sketchy; this type of information was extracted in rough figures. This is why biofuels was not included in this graph, even though the database contains measures for biofuels support.

In most countries, end consumers pay for the main support scheme for electricity production (FITs or FIPs). Exceptions are the Czech Republic, Finland and the Netherlands, where the government covers the cost partly or completely. For heating, the situation is reversed. In most countries, support is covered by national or regional governments (e.g. Belgium) or by EU structural funds.

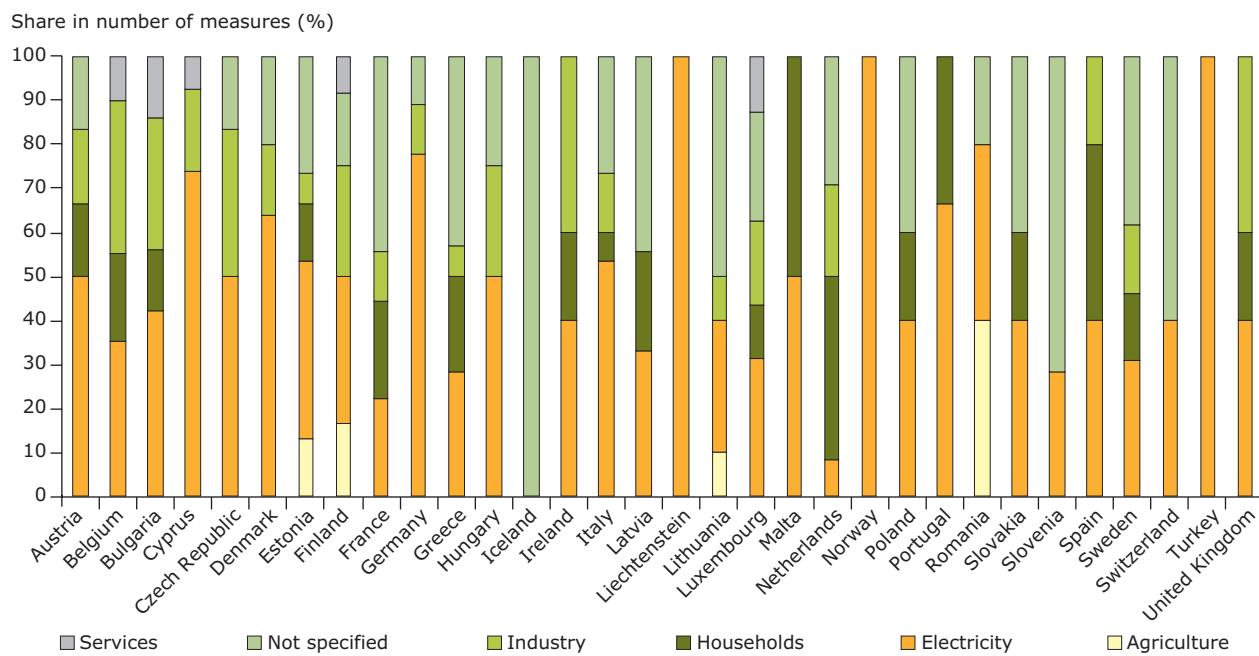
All countries have other support measures in place apart from the main policy tool, such as direct support, soft loans and tax incentives (for an overview, please see the country fiches published separately from this report). In most countries, these support measures are financed by governmental or EU structural funds. However, based on the in-depth studies conducted for the Czech Republic, the Netherlands and Spain (for details, see the case studies published separately from this report), the cost associated with the main policy tool (FIT or FIP) tends to represent more than 90 % of the overall cost for renewable support. Consequently, for electricity, the impact

of the support on public budgets is likely to be very limited already.

Not surprisingly, renewable energy support mostly targets electricity production (see Figure 2.6). For instance, in countries like Cyprus, Denmark, Germany, Italy, Liechtenstein, Norway and Turkey, more than 50 % of support measures are targeted at electricity production. Apart from the electricity sector, households are also an important target group: more than 20 % of identified support measures in support measures prevailing in France, Greece, Malta, the Netherlands, Portugal and Spain. Romania, Lithuania, Finland and Estonia have specific support measures related to renewable energy use in agriculture. Support measures targeted at renewable energy use in industry are especially important in Belgium, the Czech Republic, Ireland and the United Kingdom.

Estonia, Finland and Romania have specific support measures related to renewable energy use in agriculture.

Figure 2.6 Target groups for renewable energy support, EEA-32, 2012



Source: EEA.

2.3 Overview of fossil fuel and nuclear support

In Europe, most fossil fuel support is allocated to consumption of these fuels (see Figure 2.7). It mainly takes the form of fiscal exemptions for certain users of certain types of fossil fuels (see Figure 2.8). Fiscal exemptions are listed in every country in the 32 EEA countries, and are the only form of fossil fuel (and nuclear) support in Austria, Cyprus, Greece, Iceland, Italy, Lithuania, Luxembourg, Malta, Portugal, Sweden and Switzerland. Industry, agriculture and transport are the most important beneficiaries from the fiscal exemptions, although important differences exist between countries.

The *Roadmap to a Resource Efficient Europe* (EC, 2011c) calls for EHS to be phased out by 2020. This means that parallel measures to modernise sectors that benefit most from such support are also needed if the reform is to be successful.

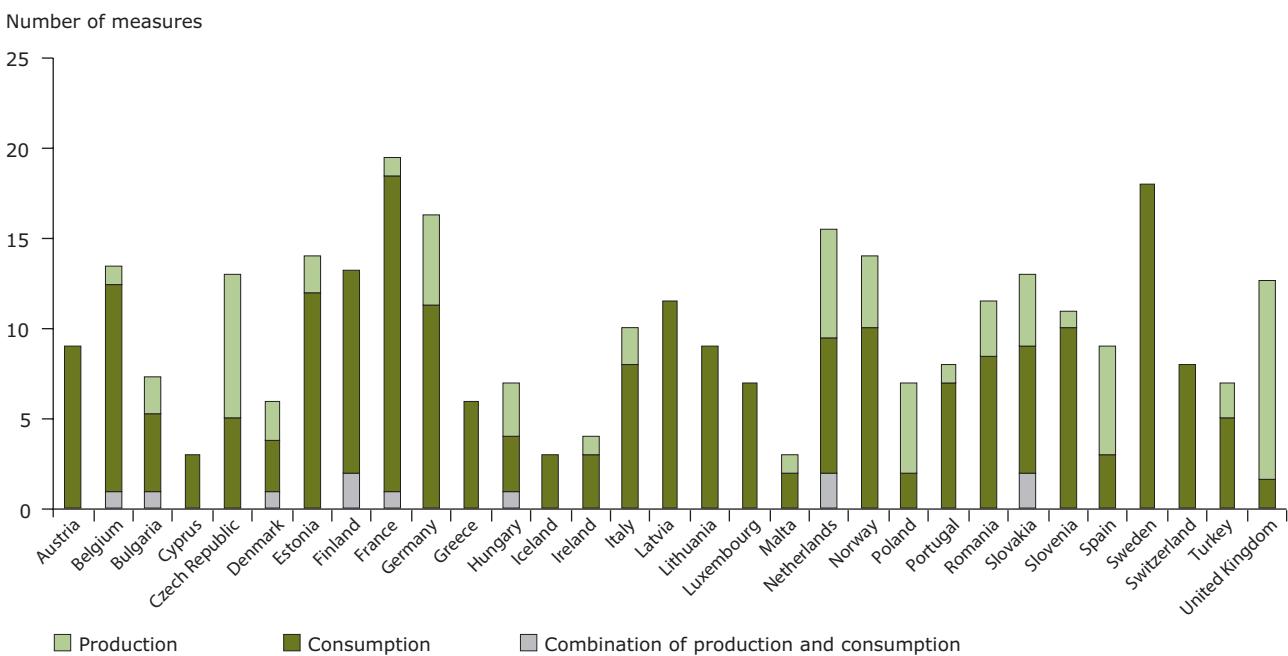
Direct support is important in relative terms in a few countries, especially in the Czech Republic, Hungary, Poland and Spain. In most cases, direct support is benefiting the mining sector — either directly as adjustment aid to restructuring

programmes, or as support to electricity companies consuming coal from national mines. Coal support in the EU must be phased out by 2018 though support to cover exceptional expenditures related to the closure of mines can still be given until 2027 (Council Decision 16229/1/10 + COR 1).

Transfer of risk to governments was not identified as an important instrument for fossil fuel support in the data sources used for this analysis. However, favourable capital loans and governmental guarantees (⁽¹¹⁾) given to investors may form an important and overlooked item in fossil fuel support in many countries. The fact that these have not been listed here does not imply that they do not exist — only that these measures are difficult to distinguish from the data sources used.

For each fossil fuel, there is a different mix of measures that is used in different countries (see Figure 2.9). It is worth noting that energy support measures are primarily granted for the resources extracted in each country. For example, support related to coal is dominant in the Czech Republic, Hungary, Ireland, Poland, Romania, Slovakia and Spain. Support related to natural gas is dominant in the Netherlands, Norway and the United Kingdom. Most countries have support

Figure 2.7 Point of incidence for support to fossil fuels, EEA-32, 2012



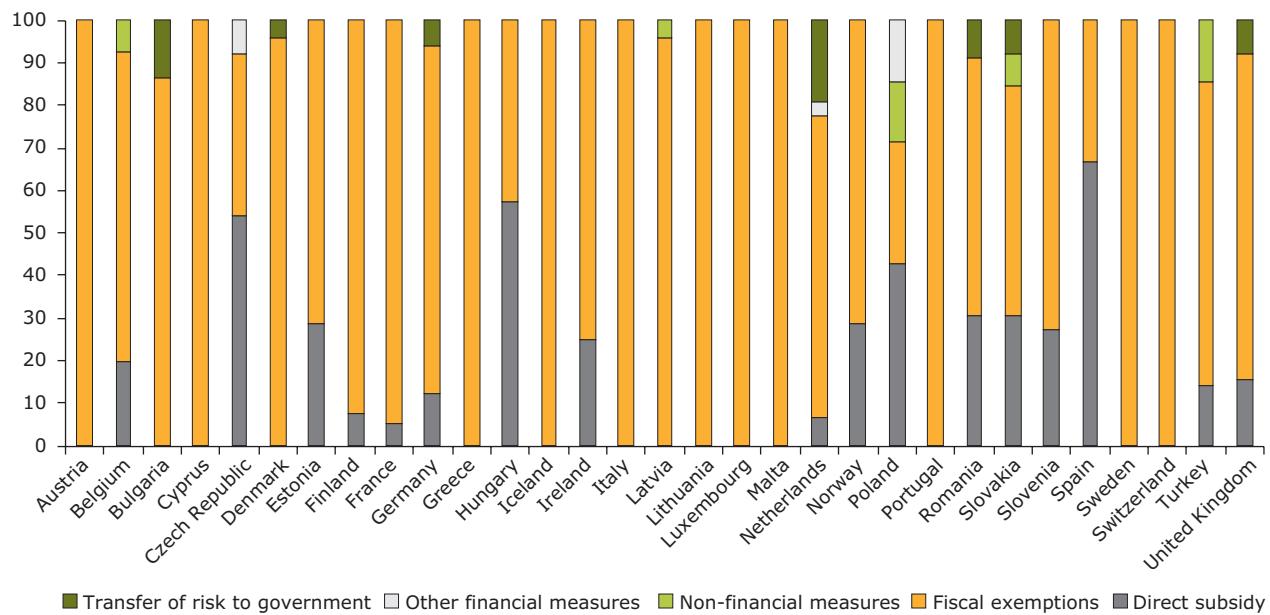
⁽¹¹⁾ State guarantees can be accepted as state aid under certain conditions. For more details see <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2008:155:0010:0022:EN:PDF>

related to heating oil or the use of gas oil. Virtually all countries grant support for the use of petrol and diesel to some groups of users (e.g. agriculture), and many countries have similar schemes for specific users of electricity, mostly for social reasons (e.g. hospitals and schools).

The small number of measures in Figure 2.9 associated with nuclear energy (and their absence in France in particular) is conspicuous. These measures do exist, but it was very difficult to find information on them in the literature reviewed. Governments have allocated support to the nuclear

Figure 2.8 Types of instruments to support fossil fuels and nuclear energy, EEA-32, 2012

Share in total measures (%)

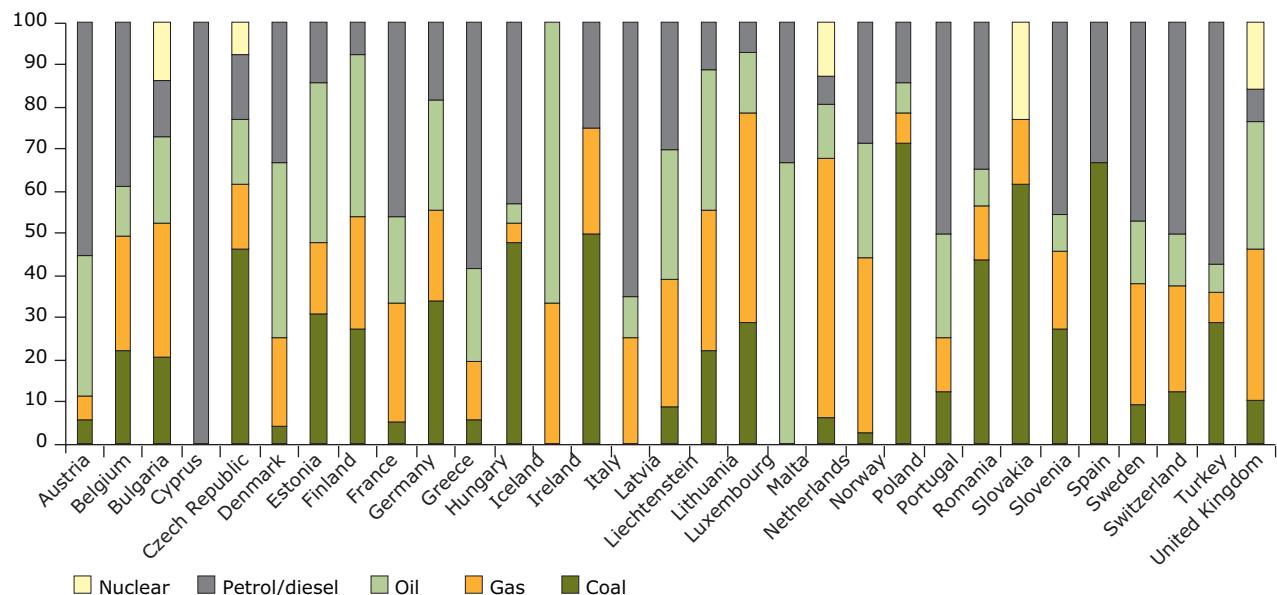


■ Transfer of risk to government □ Other financial measures ■ Non-financial measures ■ Fiscal exemptions ■ Direct subsidy

Source: EEA.

Figure 2.9 Distribution of support measures for fossil fuels and nuclear across different energy carriers, EEA-32, 2012

Share in total number of measures (%)



■ Nuclear ■ Petrol/diesel ■ Oil ■ Gas ■ Coal

Source: EEA.

industry for decades. Support for R&D is crucial in the early stages of development. Whilst this is a known fact, data are sketchy at best. For example, by some accounts, the United States alone had spent USD₂₀₁₁ 95.7 billion on nuclear R&D (fusion and fission) by 2012; data reported by the IEA on total governmental expenditure on nuclear fusion R&D from 21 countries in 2011 was just over USD 4.1 billion. The nuclear industry also receives support for building new power plants, usually in the form of governmental guarantees. Where nuclear power plants are owned and operated by state-owned monopolies, governments typically use a combination of grants and government-mediated finance. In a few countries (e.g. China, the United Kingdom and the United States), nuclear power plants benefit also from regulated prices or production bounties (Oosterhuis and ten Brink, 2014). Experts argue, however, that by far the most support to the nuclear industry comes from explicit or implicit limited liability in case of major accidents. For example, in France, the estimated support range (given the EUR 700 million ceiling) is somewhere between EUR 0.019 million and EUR 2 800 million per reactor year (Faure and Fiore, 2009). In most countries, nuclear power plants have to pay a fee into a waste management fund, to cover the costs of storing, treating and disposing of the radioactive material. Fees vary widely across countries, and most likely this is another area where support to the nuclear industry may exist. In the Czech Republic for instance, under the Atomic Energy Act 2002, the ČEZ group as a nuclear plant operator is required to put aside funds for waste disposal at the rate of EUR 0.002 per kilowatt-hour (kWh). This compares rather poorly with the rate required in France, for instance, of EUR 0.14/kWh (see the case study for the Czech Republic, published separately from this report).

2.4 Energy support measures and progress towards innovation in the renewable energy sector

The link between energy support and innovation is not straightforward. It depends, among others, on the original goal of the support: this could include supporting low-income households and improving equity, achieving energy security, increasing competitiveness of energy-intensive industries, correcting for externalities, and supporting domestic production and associated employment.

In this section, various correlations between different variables are explored, to assess the main drivers for innovation in the renewable energy sector and the impact support measures may have on this process. The choice of variables was limited to a large extent by data availability.

For example, Figure 2.10 shows that there is a weak relationship between per capita renewable energy production of wind, solar and geothermal and per capita patent applications granted in these categories (total over the 2005 to 2011 period)⁽¹²⁾. Denmark is clearly the outlier, with a much larger share of patents compared to the other countries. Luxembourg, Norway and Switzerland have a relatively high number of patents compared to their renewable energy production in these technologies. Italy, Portugal, and Spain tend to have much fewer patent applications as compared to their renewable energy production. This shows that a strong focus on deployment (demand-pull) does not necessarily lead to accelerated innovation in the renewable sector, a conclusion which is supported by the analysis conducted in the four target countries (see Chapter 3 and the country case studies for the Czech Republic, the Netherlands, Spain and Switzerland), and by a recent analysis by Zheng and Kammen (2014). This latter analysis, for example, suggests that despite a significant market-pull in Germany, the United States and Japan remain the top innovators in PV technology (see Figure 2.11). This means that the market-pull strategy applied in Germany had a significant leakage problem in a globalised PV market, and failed to generate innovation and manufacturing in this country.

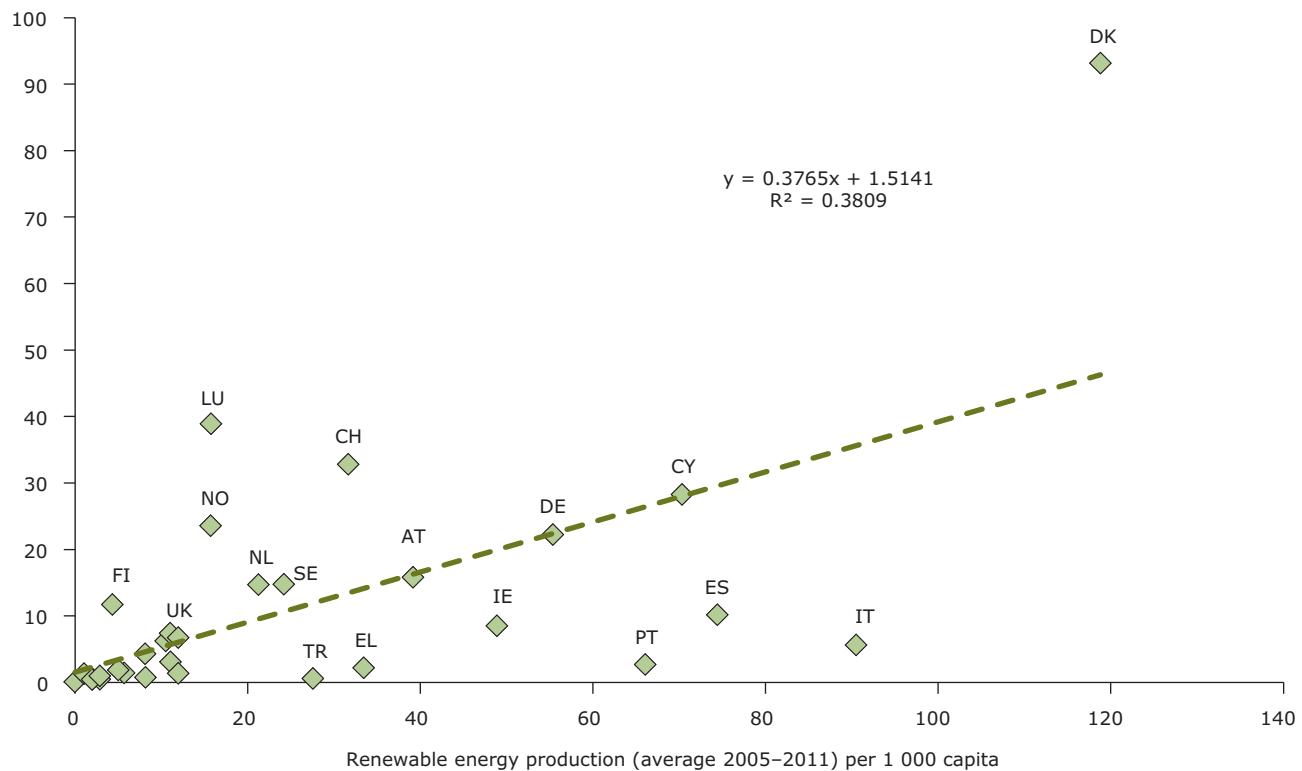
For renewable energy technologies, there is clear evidence that public support for R&D can be an important driving force for innovation. Figure 2.12 shows that a strong correlation exists between R&D expenditure and patent applications.

In general, the relationship between deployment of renewable energy technologies and employment is relatively weak. This may be because of the strong focus in Europe on deployment (market pull) to meet the 2020 targets and less emphasis on developing a strong domestic technological value chain to support this development (see also the discussion concerning Figure 2.11).

⁽¹²⁾ An analysis for the total renewable energy production would be heavily influenced by hydro electricity production, and would show less clear linkages with patent applications.

Figure 2.10 Relationship between patent application and production per capita in onshore wind, solar and geothermal energy, Europe, 2005–2011

Patent applications (total 2005–2011) per million capita

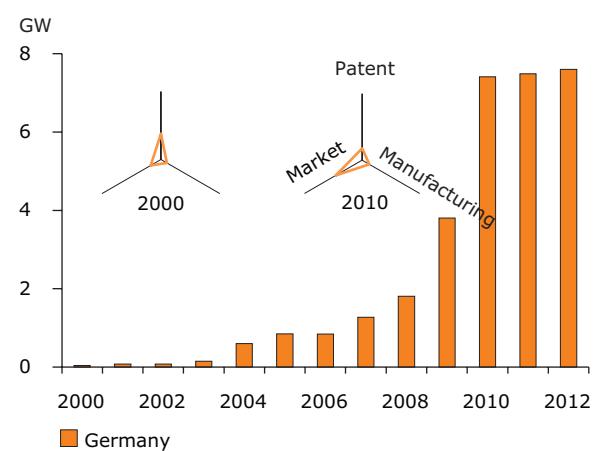
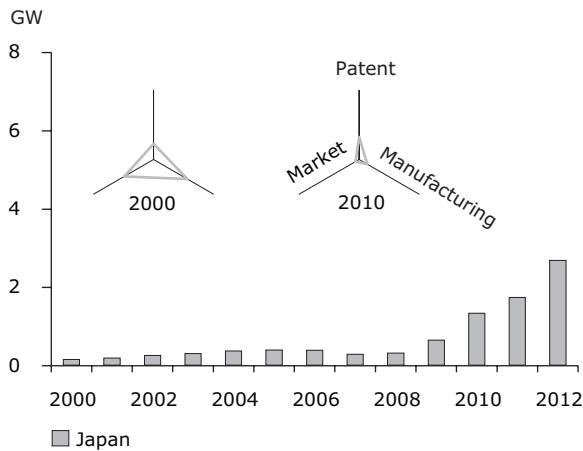
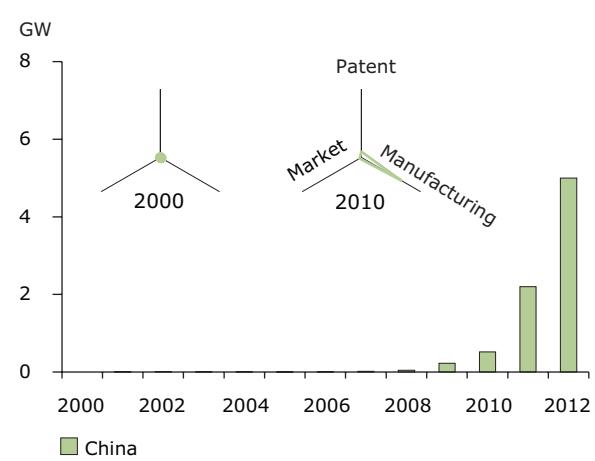
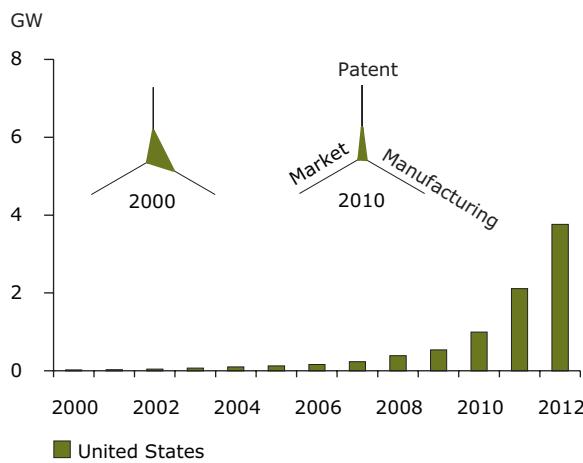


Note: These technologies were selected as relatively new renewables technologies, and production was calculated as an average over the period from 2005 to 2011. In addition, an analysis for the total renewable energy production would be heavily influenced by hydro electricity production, and would show less clear linkages with patent applications.

Country codes (based on Eurostat country codes at 1 June 2012: see http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Country_codes): AT (Austria), BE (Belgium), BG (Bulgaria), CH (Switzerland), CY (Cyprus), CZ (the Czech Republic), DE (Germany), DK (Denmark), EE (Estonia), ES (Spain), FI (Finland), FR (France), GR (Greece), HU (Hungary), IE (Ireland), IS (Iceland), IT (Italy), LI (Liechtenstein), LT (Lithuania), LU (Luxembourg), LV (Latvia), MT (Malta), NL (the Netherlands), NO (Norway), PL (Poland), PT (Portugal), RO (Romania), SE (Sweden), SI (Slovenia), SK (Slovakia), TR (Turkey), UK (the United Kingdom).

Source: OECD, 2013a (for patent applications); Eurostat, 2013 (for renewable energy production and population).

Figure 2.11 Evolution of innovation, manufacturing and market in the global PV industry, in four key countries

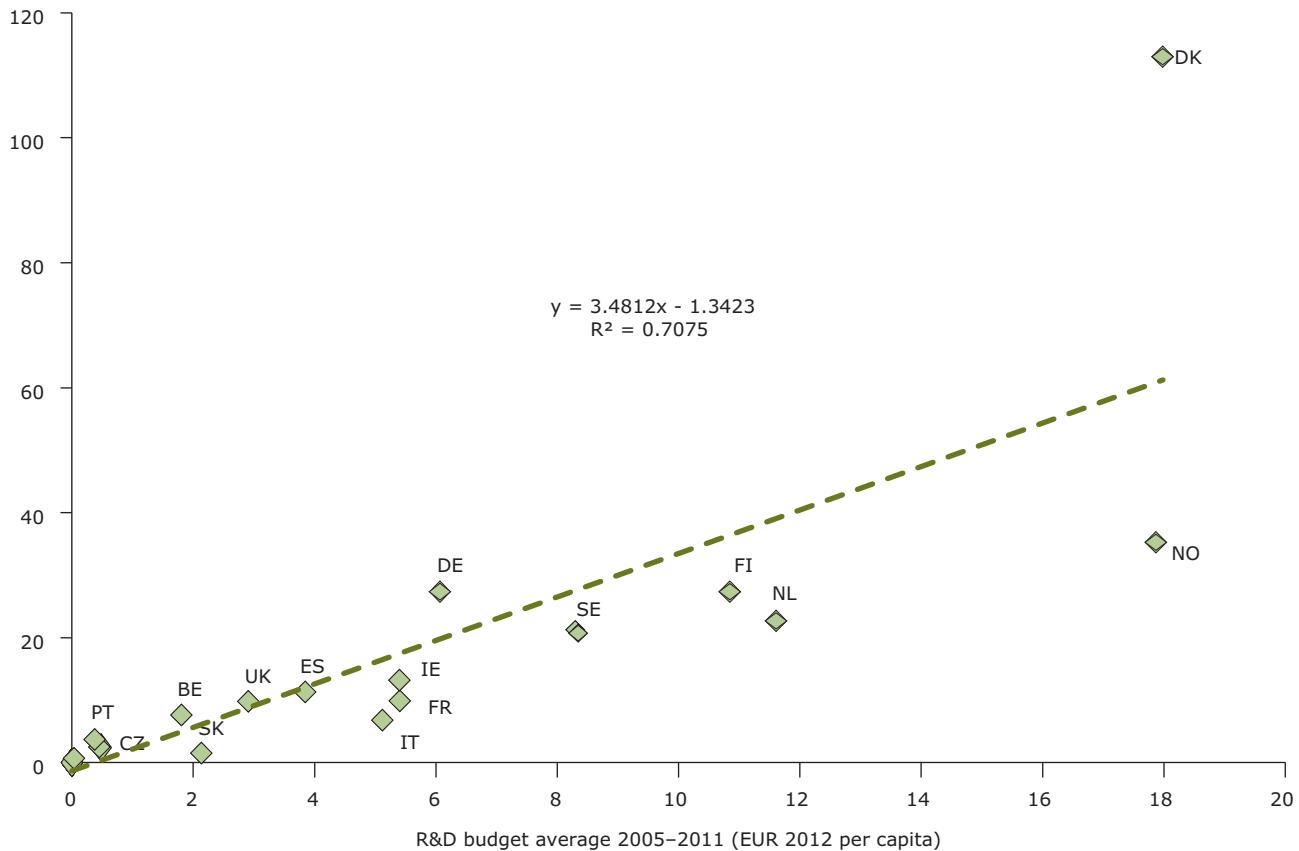


Note: The radar plot shows the relative shares of market size (measured in MW), manufacturing (measured in MW) and PCT patents among top four key nations in the solar PV industry with China being the top manufacturer, Germany the top market and the US the top innovator. Data is normalised to the sum of manufacturing.

Source: Zheng and Kammen, 2014.

Figure 2.12 Relationship between R&D expenditure and patents applications in renewable technologies, Europe, 2005–2011

Patent applications (total 2005–2011) per mio capita



Note: For country codes, please see note to Figure 2.10.

Sources: IEA, 2013 (for governmental R&D); OECD, 2013 (for patent applications); Eurostat, 2013 (for population).

Figures 2.13 and 2.14 provide the overview of the relationship between energy production per capita in 2011 and employment in the renewable energy sector in 2011 for solar PV energy and wind.

For solar PV, Figure 2.13 shows that countries like Belgium, France, Germany and Greece tend to employ more people in this sector than can be expected based on their production levels⁽¹³⁾. Countries like the Czech Republic, Cyprus and Spain on the other hand, employ fewer people than might be expected from their production levels. As discussed in Chapter 3, the type of employment

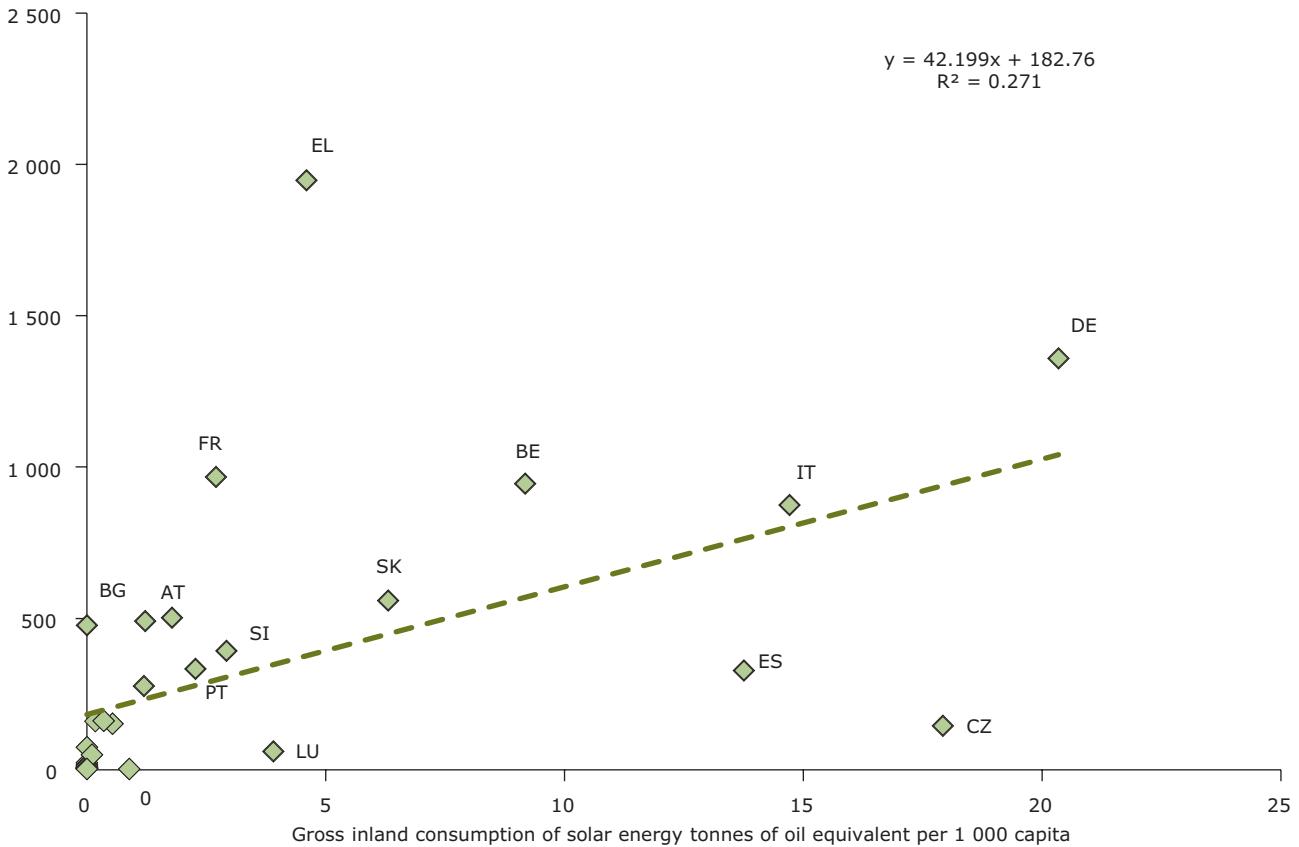
in this sector is also important when talking about innovation. In countries like the Czech Republic and Spain and, employment generated in the solar energy sector seemed to be mostly related to solar panel installation, because it fluctuated significantly and in sync with support for this technology (see also Chapter 3, as well as the country case studies).

For wind energy, the relationship between employment and production is more pronounced, as is shown in Figure 2.14. This might be because in the wind industry, jobs have been distributed more equally amongst different stages of the supply

⁽¹³⁾ In Figure 2.13 , solar PV and solar thermal have been considered together, and therefore the conclusion concerning Germany is not directly comparable with conclusions drawn from Figure 2.11.

Figure 2.13 Relationship between solar energy production and employment in the solar industry, Europe, 2011

Employees per million capita



Note: For country codes, please see note to Figure 2.10.

Source: EurObserv'ER, 2012 (for employment), Eurostat, 2013 (for energy production and population).

chain, from R&D to consultancy and installation. Countries like Bulgaria, Denmark, Finland, Luxembourg and Romania employ more people than might be expected, based on their production of wind energy. On the other hand, countries like Greece, Ireland, Lithuania, the Netherlands, Poland, Portugal and Spain, have less employment than might be expected, based on their production of wind energy.

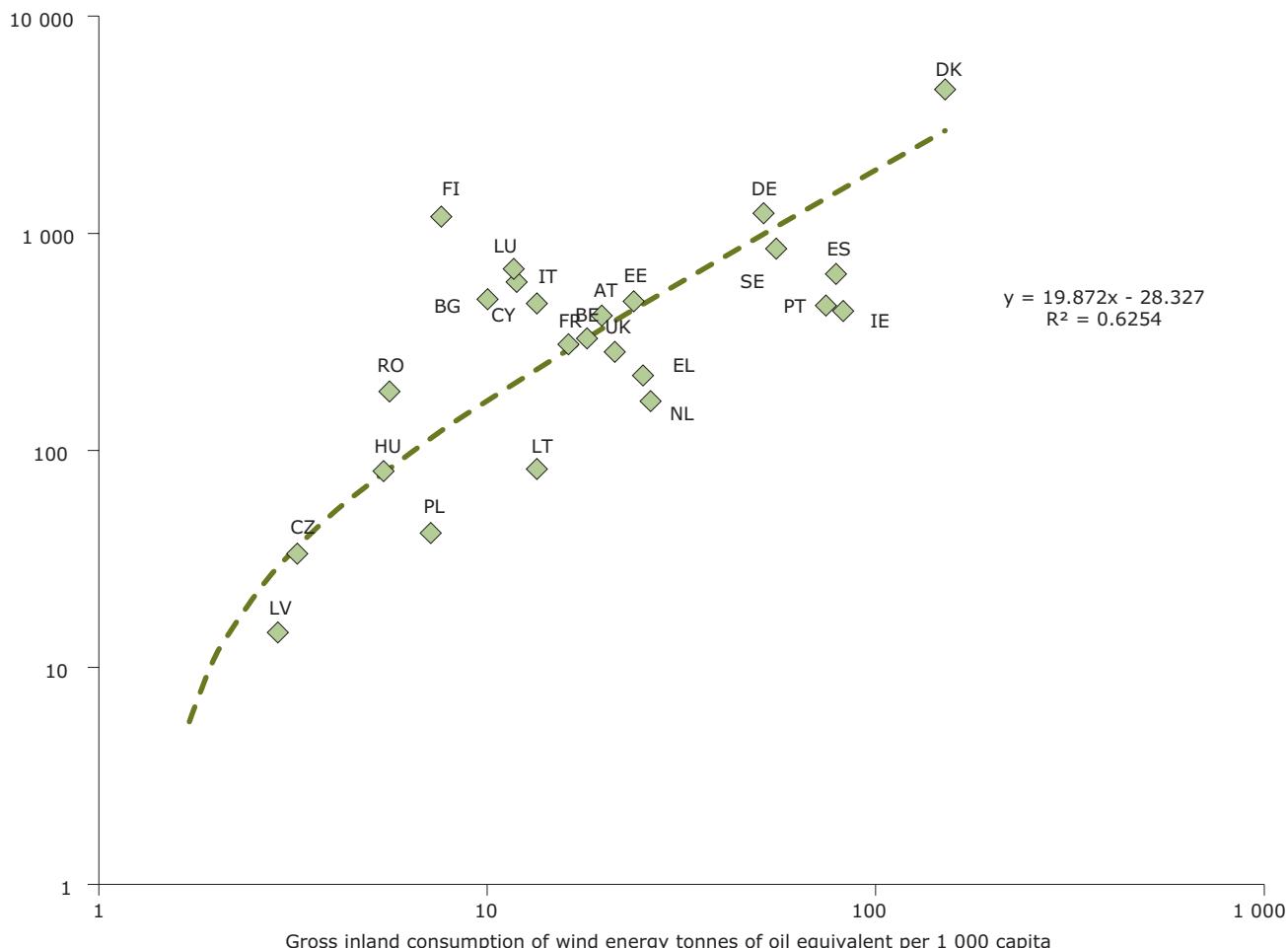
Fiscal exemptions seem to be the main type of instrument supporting conventional fossil fuel use:

this implies that important differences exist for various end users between the official tax rate and the effective tax rate (the real tax rate that is being paid). The price of fossil fuels varies considerably across countries because of differences in tax regimes, among others. According to the OECD (2013a), the average effective tax rate of fossil fuels in EEA countries ranges between EUR 2.1/GJ for Hungary to over EUR 6/GJ for Luxembourg, based on rates in April 2012. Luxembourg is clearly the outlier, due to the very large share of motor fuel consumption and the relatively low tax rates (⁽¹⁴⁾).

⁽¹⁴⁾ Luxembourg has a very high share of motor fuel consumption due to the fact that taxation on petrol and diesel is much lower than that of neighbouring countries (tank tourism). Since petrol and diesel are universally (including Luxembourg) taxed at much higher rates than fossil fuels for other end-uses, total taxation is higher in Luxembourg than in other countries, due to the high consumption of transport fuels.

Figure 2.14 Relationship between wind energy consumption and employment in the wind industry, Europe, 2011

Employees per million capita



Note: Both axes have had a logarithmic scale applied for clarity.
For country codes, please see note to Figure 2.10.

Source: own analysis based on EurObserv'ER, 2013 (for employment); Eurostat, 2013 (for energy production and population).

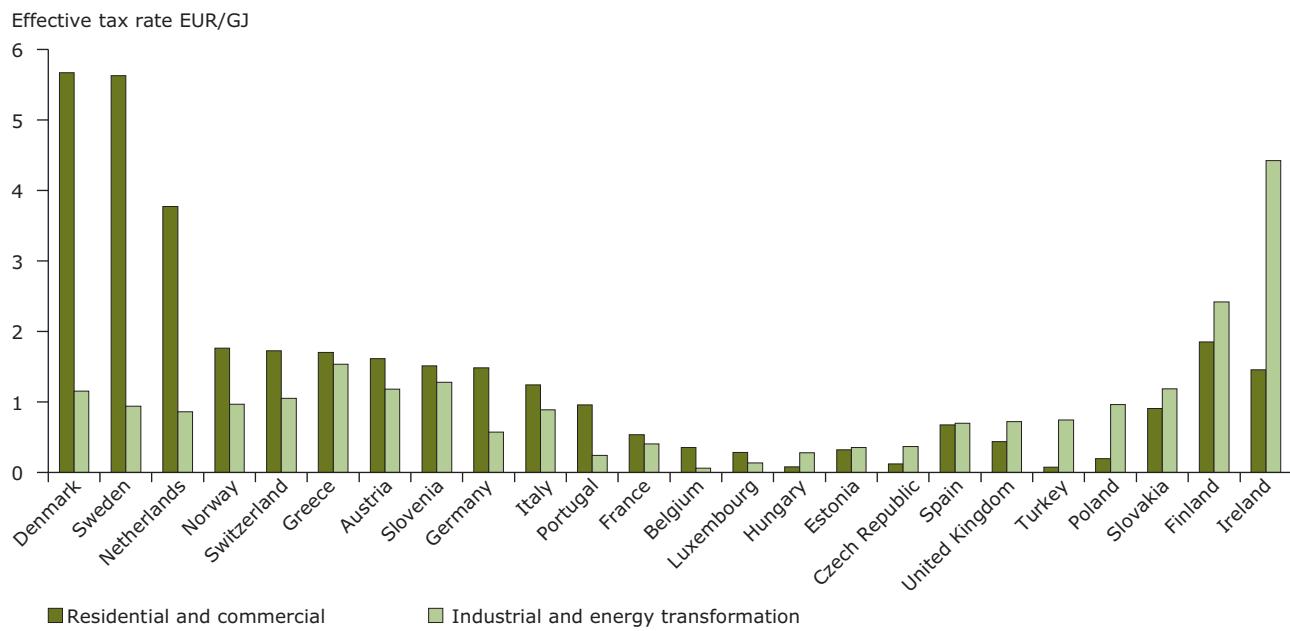
Apart from the difference in tax rates, variations in the energy mix of countries are also responsible for this difference in average effective tax rates. The OECD recalculated these energy taxes as implicit CO₂ taxes; when combined with explicit CO₂ taxes, a total effective tax rate was calculated for the overall energy mix. Based on these calculations, an indicator for fiscal exemptions was constructed that compares the average effective tax rate for the industrial sector with the average marginal tax rate for the residential sector (including the service sector).

Figure 2.15 shows that there are substantial differences in energy taxation between end users in most countries. Industrial energy use, for example, is taxed much lower than residential and commercial energy use in Denmark, Germany, the Netherlands and Sweden. Other countries (notably the Czech

Republic, Finland, Hungary, Ireland, Poland, Turkey, the United Kingdom) tend to apply a lower effective tax rate to residential and commercial energy use than to energy use in industry and electricity generation.

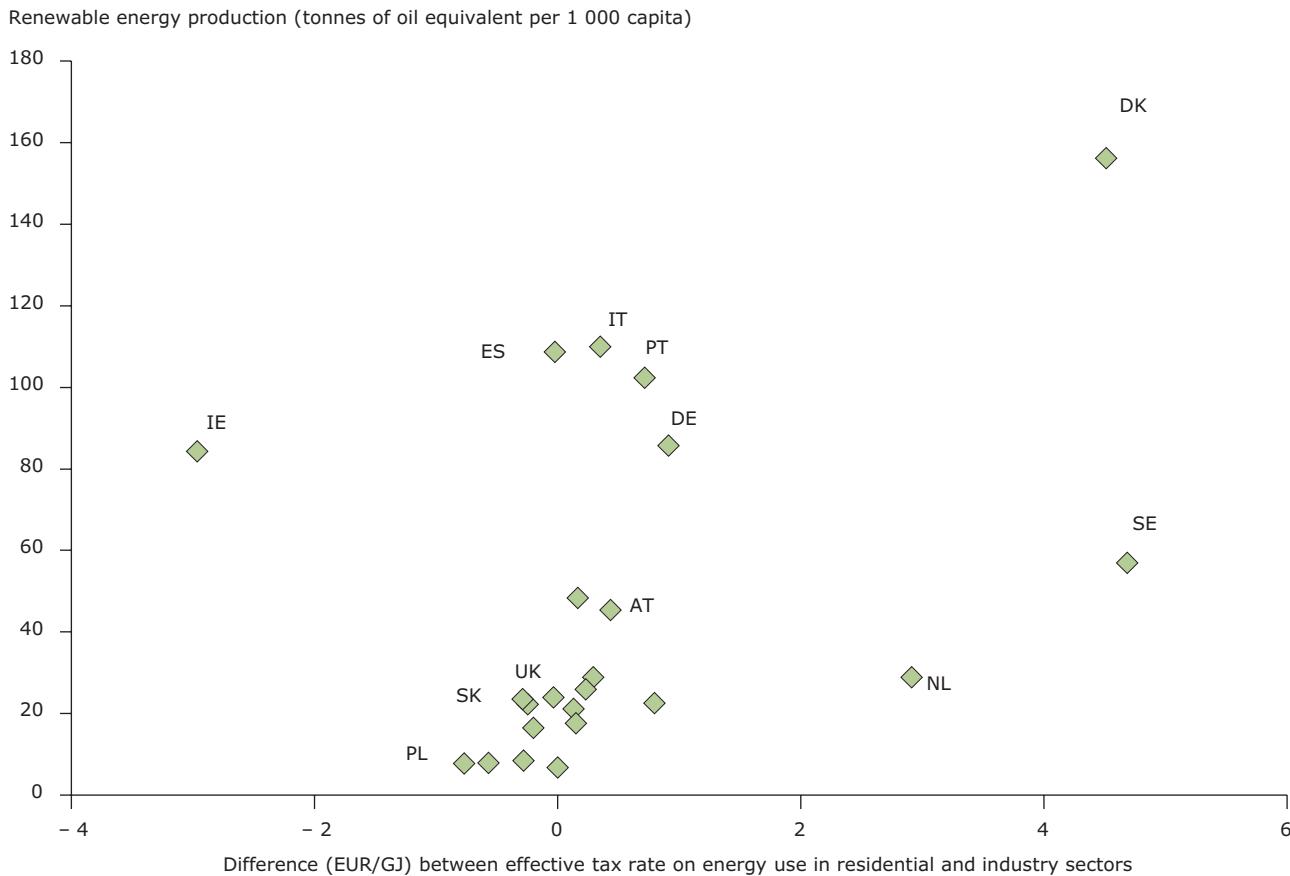
The differences in effective tax rates for various end users imply firstly that governments accept tax revenues foregone in trade for other policy goals (including industry competitiveness). Secondly, the deployment of renewables takes place in an existing incentive structure for fossil fuels that creates a unique context for every country. This notwithstanding, there does not seem to be a clear relationship between renewable energy production and the degree of tax exemptions. Figure 2.16 shows that there is hardly any correlation between the difference in effective tax rates (residential vs

Figure 2.15 Effective tax rates, Europe, 2012



Source: OECD, 2013b.

Figure 2.16 Relationship between the difference in effective tax rates for end users and renewable energy production per capita, Europe



Note: For country codes, please see note to Figure 2.10. Renewable energy production in this figure includes wind, solar and geothermal.

Source: EEA, based on OECD, 2013b; Eurostat, 2013.

industrial consumers) and per capita production of new renewable energy technologies (wind, solar PV and solar thermal and geothermal) (¹⁵).

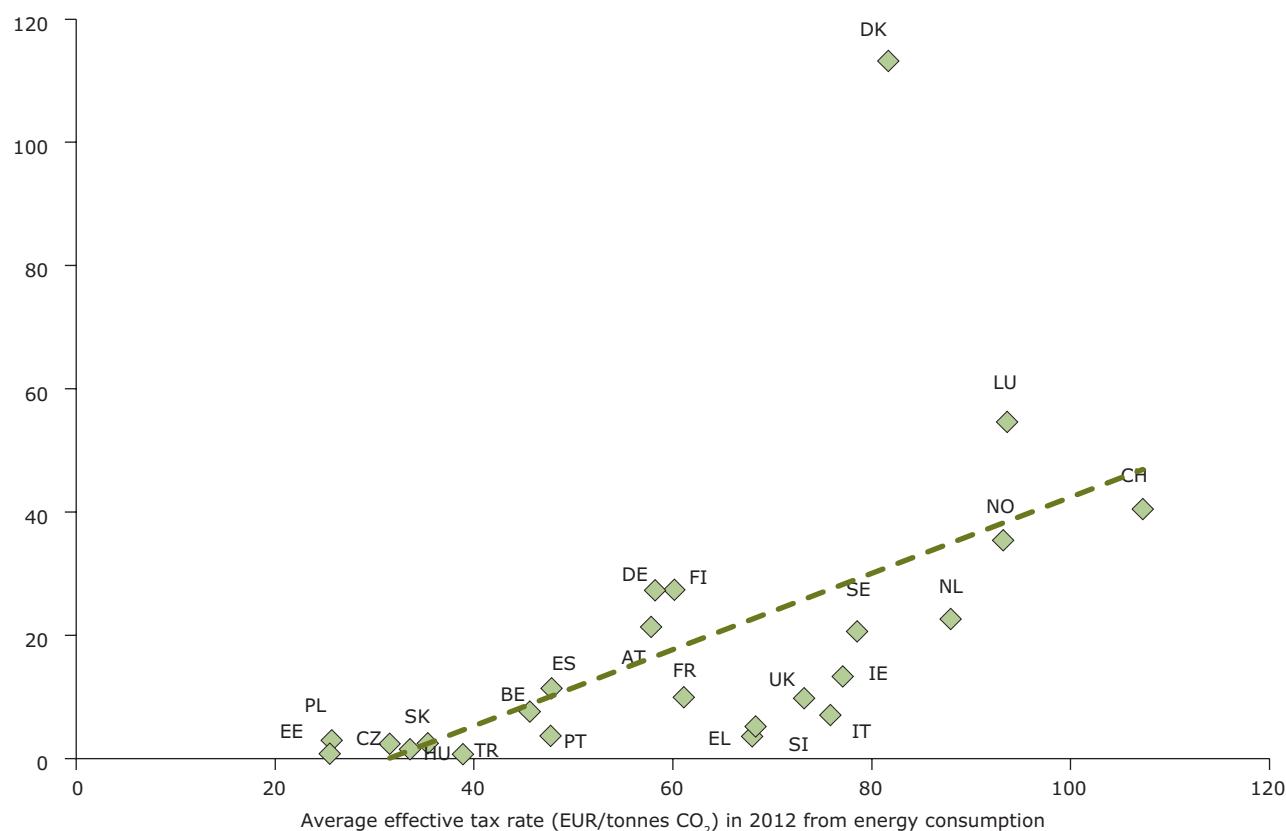
Figure 2.16 shows that Denmark, the Netherlands and Sweden have relatively high fiscal exemptions for their industries, but differ widely in the deployment of renewable energy technologies. Ireland, on the other hand, largely exempts residential heating from energy taxation, but also has above average deployment of renewable energy per capita. Countries like Germany, Italy, Portugal and Spain have relatively low levels of fiscal exemptions, and yet their per capita deployment of renewable energy technologies is above average. Therefore, existing tax exemptions (as a type of fossil fuel subsidy) may have an impact on renewable

energy deployment, but they are unlikely to be a major explanatory variable in the differences in per capita deployment of renewable energy technologies (¹⁶) in Europe. Other factors such as bold political decisions concerning the path for energy transition may also play a role in explaining the difference between countries with respect to renewable energy deployment.

The importance of the average level of CO₂ prices factored in the effective tax rate was also investigated. OECD data (2013b) show that countries with a substantial average effective tax rate on CO₂ from energy consumption generally have a higher rate of patent applications in the field of renewable energies (see Figure 2.17). Denmark is the clear exception here, with a very high share

Figure 2.17 Relationship between effective tax rate on CO₂ and patents per capita in renewable energy technologies, Europe

Patent applications (2006–2011) per million capita in renewable energy technologies



Note: For country codes, please see note to Figure 2.10.

Source: EEA, based on OECD, 2013a and 2013b.

(¹⁵) These technologies have been selected because they represent an earlier stage of the innovation process than large-scale hydro or biomass technologies.

(¹⁶) One of the reasons might be that in every country, support for renewable energy deployment is set up in such a way that it compensates for fossil fuel support. In this way, fossil fuel support will not influence deployment of renewable energy technologies, but will rather influence the costs of renewable energy deployment. This was not investigated in this study.

Box 2.1 The case of Denmark

In the analysis presented in Section 2.4, Denmark appears to be the outlier in many aspects; this may be explained as follows.

- On 22 March 2012, a political agreement between the major political parties in Denmark was reached which set the framework for a transition to a green and sustainable energy system in Denmark. It involves investing heavily in renewable energy and energy efficiency up to 2020 (in the range of DKK 90 million to DKK 150 billion). In addition, the energy agreement sets a framework requiring a continued high level for research, development and demonstration of new green energy technologies. However, this is not a new development. Denmark has been consistent in implementing sustainable energy concepts over the years, and it is now very advanced in achieving a sustainable energy system through increased energy efficiency and the share of renewable energy as well as the integration of energy networks (electricity and heat but gas as well is being considered) (a).
- Denmark has a very favourable environment for innovative clean-technology start-ups (b).
- Another reason may relate to a weakness in the patent applications indicator. Patent applications are statistical artefacts that suffer in some aspects: the country where the patent is submitted and granted is not necessarily the country where the research has been carried out. In some countries, like Denmark, the Netherlands, Sweden and Hungary, patent applications can be submitted in English, while in other countries, it must be translated into the national language: this can facilitate patent applications from international research collaborations in Denmark, for instance (c).
- A closer look at patent applications in Denmark reveals that most of the patents are in wind energy. Wind power provided just over 30 % of electricity production in Denmark in 2012, and this is expected to rise to 50 % by 2020. Also, Denmark was a pioneer in developing commercial wind power during the 1970s, and today a substantial share of the wind turbines around the world are produced by Danish manufacturers such as Vestas and Siemens Wind Power along with many component suppliers.

Overall, Denmark's outlier position in the correlations presented above can be explained by bold political decisions to transform the energy system, the early mover advantage in wind energy, and a favourable climate for innovative start-ups. The relatively low costs of patent applications and the opportunity to apply in English may have played a part, too.

(a) Danish Ministry of Energy, Climate and Buildings, 2013.

(b) See, for example, <http://www.cleantech.com/indexes/the-global-cleantech-innovation-index/2014-report>.

(c) See, for example, http://ec.europa.eu/internal_market/indprop/docs/patent/sec2011-482-final_en.pdf.

of patents per capita relative to its average effective tax rate on CO₂. While Denmark, Finland, Germany and Luxembourg have higher technology patent application than expected from their CO₂ tax rates, Greece, Ireland, Italy, Slovenia, and the United Kingdom typically have lower patent applications.

2.5 Conclusions

In 2012, many support measures were still oriented towards fossil fuels and nuclear in Europe, but the lack of an internationally agreed definition of energy support complicates the issue and greatly hinders any attempt to provide an accurate and comparable overview of such support measures across European countries.

Based on the data that could be collected, fossil fuel support seems to mostly take the form of fiscal exemptions and allowances to certain users of fossil

fuels. In countries that mine fossil fuels, specific grants for the use of these resources also apply (e.g. coal in the Czech Republic, Poland, Romania, Slovakia and Spain), lignite (Germany and Slovenia), oil (Norway) or natural gas (the Netherlands and Norway). Because support for fossil fuels mainly takes the form of tax exemptions, it represents revenue forgone by governments, and therefore has an impact on public budgets. Fossil fuel support in Europe is mostly oriented towards consumption.

Support for renewable energy is a mix of surcharges on end-users' energy bills and governmental support. For renewable electricity, the main policy tool is a FIT/FIP or a quota obligation which, in most cases, is financed through a surcharge on electricity bills. As such, support for renewable electricity is mainly oriented towards production, and does not place a burden on the public budget but rather on the final consumer. Were the merit order effect to be passed on to the end consumer, the net effect on

the electricity bill could be lowered. For renewable heat, however, support is more diversified, with investment support and grants being applied together with FITs/FIPs, so as to increase small-scale renewable heat uptake in buildings. This support is usually allocated from the government's (national or regional) budget or EU structural funds, and therefore could represent a burden on the public budget.

Fossil fuel support tends to generate quite different price signals in the 32 EEA countries. The wide variety in fossil fuel support schemes implies that renewable energy deployment must compete in every country with a unique price structure for fossil fuels. However, this does not seem to be the only factor affecting renewable energy deployment and innovation. Factors such as bold political decisions concerning the pathway for energy transition, and the expediency of establishing attractive legal and institutional frameworks to support it (see, for example, the case of Denmark) play an important role. In addition, other national circumstances as well as the renewable policy design play a part, as noted in Chapter 3.

CO₂ taxation has the potential to stimulate innovation in the renewable sector. However, the energy mix and the design of the instrument (e.g. exemptions or reduced taxation for various target groups) may influence its effectiveness.

A strong emphasis on market-pull type of measures to support renewable energy development does not necessarily lead to a solid and sustainable domestic renewable industry, due to leakages in the global market. Therefore, a more balanced approach, with enhanced focus towards innovation (technological-push) is required in Europe in the near future, if the development of renewable technologies is to take place in a cost-efficient and effective manner. This is discussed further in Chapter 3.

Existing data sources, while providing a good platform for discussion, reveal a less-than-ideal data coverage, particularly in areas like nuclear energy support, general R&D support, specific tax deductions and provisions related to capital investments in the hydrocarbon industries and regulation of capacity markets.

3 Energy support measures and their effect on innovation: national perspectives

3.1 Introduction

How do energy support measures affect the market conditions for renewable energy technologies and hence innovation in the renewable energy sector? This was the key question analysed in this report. In this chapter, the discussion is enriched with national perspectives from detailed case studies developed for four EEA member countries, namely the Czech Republic, the Netherlands, Spain, and Switzerland (¹⁷) (for the selection criteria, see Annex 3).

This chapter provides a quantitative overview of energy support measures (conventional fossil fuels, nuclear and renewables) in the target countries from 2005 to 2012 (¹⁸).

The effects of energy support on innovation are measured mainly in terms of how they affect the deployment of renewable energy technologies, but other stages of the innovation process (e.g. R&D) are also briefly investigated. One condition for a successful innovation process in the renewable sector is that policies specifically designed for this sector be effective, efficient and in tune with broader energy, economic and innovation policies. Consequently, this chapter presents a comparative analysis of renewable policy effectiveness and efficiency based on indicators, as well as other contextual issues such as R&D, employment and policy coherence, in the target countries. This analysis aims to determine key factors likely to contribute to a sound innovation process in the

renewable sector that can be sustained over a long period of time.

3.2 Key characteristics of the energy sector and support schemes in the target countries (¹⁹)

In 2011, Czech gross inland energy consumption was dominated by coal, while in the Netherlands the dominant sources were natural gas and oil; in Spain and Switzerland, oil played the dominant role. Switzerland had a relatively high share of nuclear energy (see Figure 3.1). The Netherlands had the lowest share of renewable energy sources in primary energy consumption in 2011 (4 %), followed by the Czech Republic (7 %), Spain (11 %) and Switzerland (19 %). Import dependency for all fossil fuels in 2011 (²⁰) was high in Spain (76.4 %) and Switzerland (all natural gas and oil is imported), and more moderate in the Netherlands (30.4 %) and the Czech Republic (27.9 %).

The Czech Republic, the Netherlands and Spain as EU Member States have binding national renewable energy targets for 2020 under the RED (EC, 2009) as well as their respective NREAPs. In 2013, Spain exceeded the average 2011 to 2012 trajectory under RED as well as the one under the NREAP, while the Czech Republic was on track for its average 2011 to 2012 trajectory under the RED but not for the NREAP. Reaching its interim targets under the RED and the NREAP was a challenge in the case of the Netherlands (see Figure 3.2) (²¹)

(¹⁷) The detailed case studies are available as separate studies accompanying this report.

(¹⁸) At the time of writing, there was very little information on support allocated in 2012 for the four countries subject to the quantitative analysis (the Czech Republic, the Netherlands, Spain and Switzerland). Where available, this support was included in the tables with the overview of quantitative support, but the analysis focuses on the period from 2005 to 2011, for which a more complete data set was available. For more details, see the country case studies.

(¹⁹) To see updated energy information for the countries with 2012 data, please view the EEA indicators at http://www.eea.europa.eu/data-and-maps/indicators#c5=&c7=all&c0=10&b_start=0. The update does not affect the conclusions of this analysis.

(²⁰) The import dependency for EU Member States is calculated as a ratio between net imports and gross inland consumption and bunkers. For details, see the EU energy figures, Statistical pocketbook 2013 (European Commission, 2013). For Switzerland, see Oil and Gas Security: Emergency response of IEA countries – Switzerland (IEA, 2012) (see <http://www.iea.org/publications/freepublications/publication/oil&gassecurityswitzerland2012.pdf>).

(²¹) For details, see the country case studies published separately from this report.

(EEA, 2013) (22). Switzerland did not have such a binding target, but had national targets in place for renewable electricity by 2030 and for renewable heating by 2020.

Apart from these structural differences in the energy supply and progress towards renewable objectives, a number of policy changes in some of the target countries over the period discussed in this report (2005–2012) had an important impact on the deployment of renewable energy technologies.

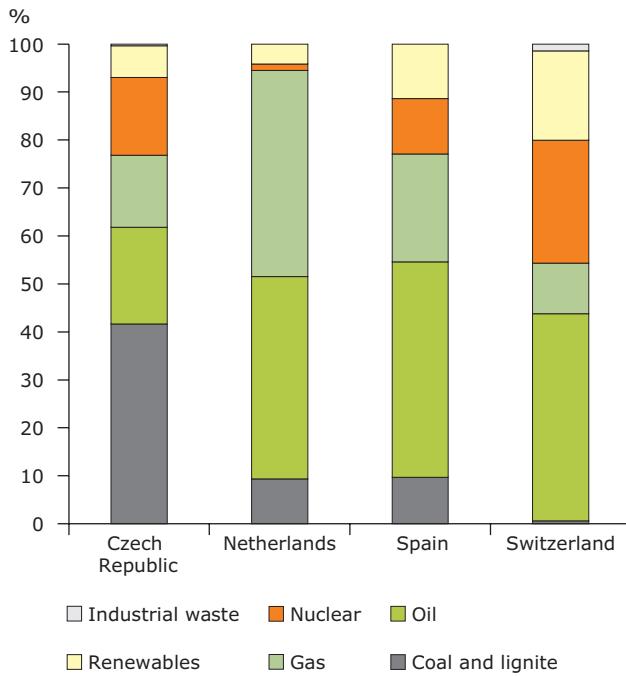
In Spain, a significant tariff deficit (23) kept accumulating over time. By the end of 2012, the tariff deficit was estimated to be EUR 25.5 billion (Couture and Bechberger, 2013), and became a key challenge in the Spanish electricity market. The imperative to address this problem has been the motivation for important reforms in the Spanish energy market as a whole and the Spanish renewable energy support framework in particular. Meanwhile, the Czech Republic considered expanding its nuclear power generation, although this was put on hold due to recent political uncertainties; Switzerland decided to

stop commissioning new nuclear power plants once the operational lifetime of existing nuclear power plants expires. All these decisions are relevant for renewable energy expansion. In the Netherlands, a new energy agreement (the National Energy Agreement for Sustainable Growth) was adopted in September 2013. This is an agreement between the Dutch government, enterprises, trade unions and non-governmental organisations (NGOs) to deliver, among other objectives, an increase in energy efficiency of 1.5 % per year up to 2020, an increase of the share of renewable energy in final energy consumption to 14 % in 2020 and 16 % in 2023, as well as 15 000 new jobs.

3.3 Quantitative overview of energy support in the target countries

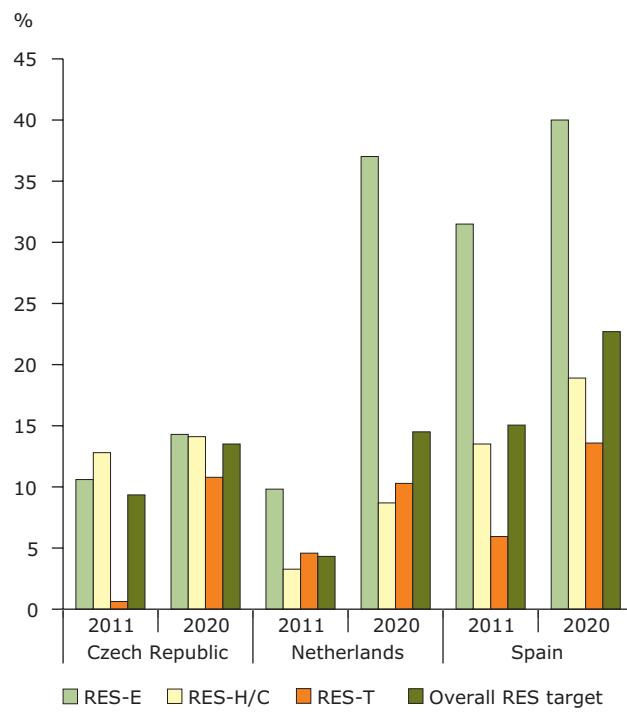
A quantification of the individual support measures provides a better understanding of the quality of the support and its impact on renewable energy generation technologies.

Figure 3.1 Gross inland energy consumption by fuel, the Czech Republic, the Netherlands, Spain and Switzerland, 2011



Source: EEA, 2013 (based on Eurostat data).

Figure 3.2 National renewable energy targets under the RED and the NREAPs (2011 vs 2020) for the Czech Republic, the Netherlands and Spain



Source: Eurostat, 2013; and EEA, 2013.

(22) For an update on the progress towards RES targets for these countries, see the EEA's Trends and Projections in Europe 2014 (EEA, 2014).
(23) The tariff deficits emerge because the regulated electricity prices do not completely cover the costs borne by electricity generators.

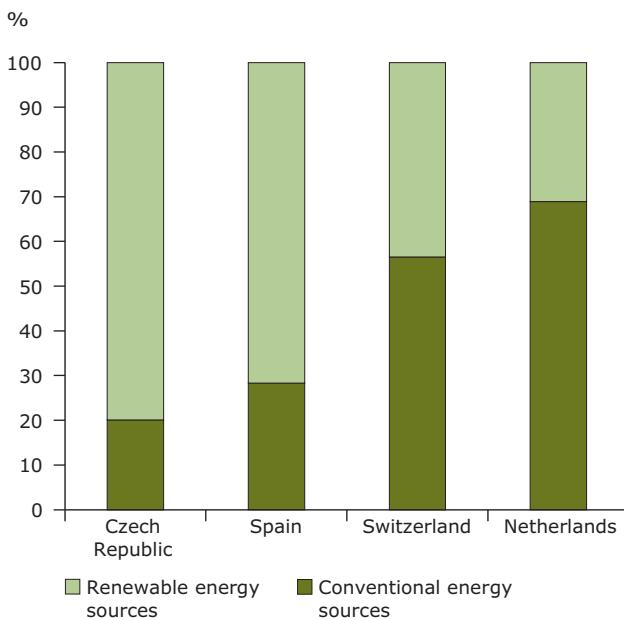
Sizeable tariff deficits exist also in Portugal and Greece. For details, see Energy Economic Development (EC, 2014e)

The comparison of the energy support expenditure for the year 2011, for which the most complete data set is available⁽²⁴⁾, shows that the Czech Republic spent 20 % and Spain spent 28 % of the total energy support on conventional energy sources, while most of the support was allocated to renewable energy sources (see Figure 3.3). By contrast, Switzerland and the Netherlands spent most of their support on conventional energy sources (57 % and 69 % respectively)⁽²⁵⁾.

Figure 3.3 should be viewed with reservations for the following reasons.

- It is only a snapshot of the support allocated to all forms of energy for the year 2011. The data presented in this figure are not inclusive of past support to conventional sources.

Figure 3.3 Share support: conventional fossil fuels vs renewable energy sources in the target countries, 2011



Source: EEA.

- The data for support to conventional sources are sketchy and are not easily accessible; the information on support to renewable energy is much better documented and is publicly available.
- Over recent years, support to renewable energy increased, precisely to ensure a level playing field with conventional sources. This may explain why, in some countries, support to renewable energy appears to be higher in 2011 than the support for conventional sources. This is illustrated in Figure 3.4 in the case of Spain.

Between 2005 and 2011, renewable energy support increased in all four countries, but by a very different margin: the Czech Republic from EUR 0.05 billion to EUR 1.3 billion, the Netherlands from EUR 0.5 billion to EUR 0.7 billion, Spain from EUR 0.8 billion to EUR 4.9 billion, and Switzerland from EUR 0.035 billion in 2005 to EUR 0.159 billion in 2011. For conventional fossil fuel and nuclear support, it is more difficult to estimate a trend, the lack of consistent data being a particular problem in this instance.

The FIT/FIP schemes were the single most important support measure for renewable energy in all four countries. During the observation period, FIT/FIP payments in the Czech Republic, Spain and Switzerland were financed via a levy on final electricity consumers; in the Netherlands, the FIP scheme was fully financed from the state budget until 2013.

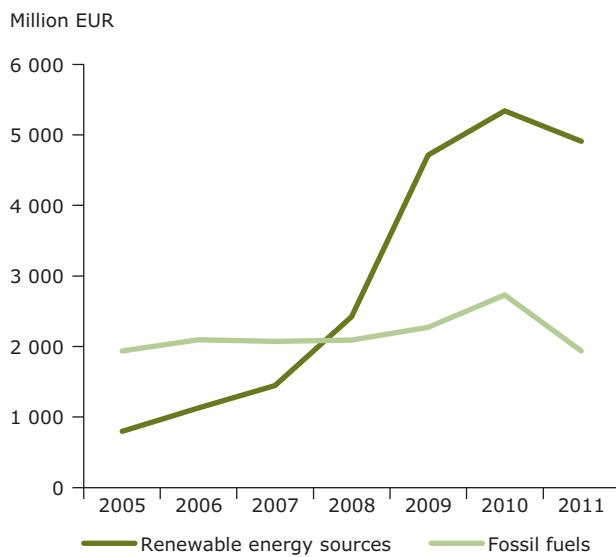
In the Czech Republic, all final consumers pay the same levy in support of the FIT/FIP scheme. More recently, the Czech Republic introduced a contribution from the state budget of EUR 500 million into the FIT/FIP scheme⁽²⁶⁾ to limit the burden on final consumers. In the Netherlands, it has been decided to gradually shift the funding for the FIP scheme (Subsidieregeling duurzame energieproductie (SDE+)) from the state budget to final consumers, so since 2013, the SDE+ has been partially financed by a special tax

⁽²⁴⁾ Missing data for 2011 for tax exemptions have been filled by using available data for the previous or the following year, assuming that expenditure would be at a similar level. It is important to emphasise that local or regional public expenditure is not included.

⁽²⁵⁾ It should be noted that in the Netherlands, tax exemptions granted to heavy industry on energy taxation were considered in the context of this report as an implicit support – in line with the practice of national case studies regarding environmental support measures (van Beers et al., 2002; ESM, 2005; Ecofys and CE Delft, 2011). Without this measure, the Netherlands would have supported the renewable energy sector more than fossil fuels and nuclear.

⁽²⁶⁾ The Czech government has decided to prevent a large electricity price increase by providing EUR 500 million yearly to the energy operator. This contribution is used to partially cover FIT/FIP support payments in order to prevent further increases of the levy to be paid by final electricity consumers to finance FIT/FIP payments. The 2013 amendment of the RES law sets a maximum limit of FIT/FIP support of CZK 495 per MWh (EUR 19/MWh).

Figure 3.4 Split of energy support measures in Spain between fossil fuels and renewable energy sources over time, million EUR, 2005–2011



Source: EEA.

imposed on the electricity price⁽²⁷⁾. The financing will be shared equally between companies and households. Spain introduced changes to ensure that FIT/FIP payments are fully covered by the final energy consumers, while exemptions for energy-intensive industry have been introduced in Switzerland.

This report focuses on support measures in place in the target countries from 2005 to 2012, a narrow margin chosen for practical and budgetary reasons. However, support measures have existed in Europe for decades (Ecofys, 2014) so it is important to put this discussion into perspective.

In the past, many conventional energy sources have benefited from various support measures helping to build an energy system based on large-scale conventional power plants. As a consequence, renewable energy sources compete at generation technology level with well-established conventional technologies, but also at institutional level and at the level of supporting infrastructures and the customer base. Support measures for renewable energy sources are one element to help renewable energy sources to increase their leverage over the conventional fossil fuel and nuclear technologies. It is therefore not surprising that the total

expenditure on support measures for renewable energy sources has increased in recent years in some countries in Europe. For example, over the observation period (2005–2011) the expenditure on renewable energy was higher than the expenditure on conventional energy sources in Spain and the Czech Republic (Figure 3.4 shows the case for Spain)⁽²⁸⁾.

3.4 Assessment of the effectiveness and efficiency of instruments of renewable energy support

3.4.1 Renewable energy policy effectiveness

The effectiveness of renewable policies was analysed using the Policy Impact Indicator (PII) (see also IEA (2011)). The PII shows to what extent the remaining gap to a future target for renewable energy sources is covered per year.

It is defined in this report as follows:

PII = additional generation in a given year divided by the difference between the generation in 2005 and the potential defined by the policy target.

For the EU Member States (the Czech Republic, the Netherlands and Spain), we measure the policy impact against the 2020 renewable energy targets for each technology as specified in the NREAPs. For Switzerland, the PII is calculated based on the 2030 target for renewable electricity as included in the Swiss Energy Act. Because of the different time-frames considered for the EU Member States and Switzerland, and because Swiss support is not technology specific, the PIIs can be compared only for the three EU Member States (for a discussion on the Swiss PII, see the case study for Switzerland published separately from this report).

As generation in 2005 is used as basis to calculate the remaining gap against the target set for 2020, a minimum average yearly PII of over 6.5 % would be required to meet the 2020 target. The value of 6.5 % is derived taking into consideration the 15-year period (2005–2020) over which the potential needs to be fulfilled ($6.5\% \times 15 = 97.5\%$), so a PII higher than 6.5 % would be needed for the full potential to be exploited. For Switzerland, because the target is set for 2030 instead of 2020 (so the time period is 25 years), a minimum average yearly PII of 4 % would be required to meet the target.

⁽²⁷⁾ See the case study for Netherlands for details.

⁽²⁸⁾ For more details, see the case study on Spain published separately from this report.

The effectiveness of the policies put in place to foster a deployment of renewable energy technologies in line with target objectives for 2020 varies widely per technology and country⁽²⁹⁾.

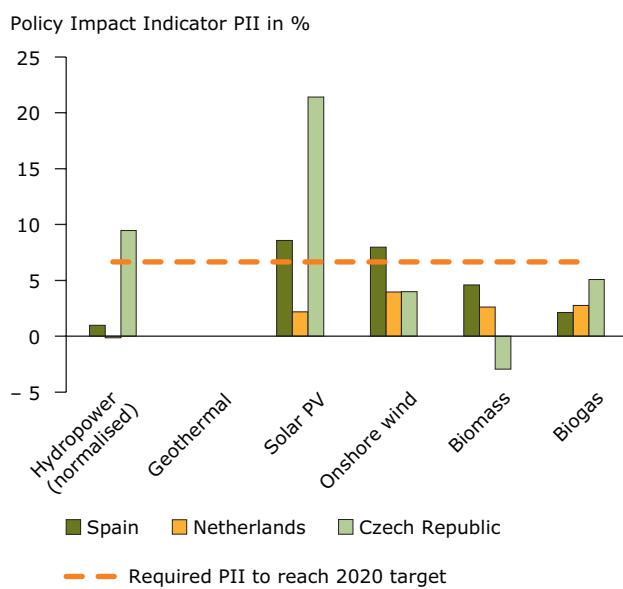
In the electricity sector, policies in place seemed to have been most effective for solar PV and wind energy technologies, but only Spain and the Czech Republic had a PII was above the threshold and therefore in line with the 2020 target (see Figure 3.5). The Czech policy framework for solar PV was clearly too ambitious, as in 2011 the PII was more than 92 % (therefore in 2011, the Czech Republic already produced 92 % of the solar PV potential estimated for 2020). In Spain, the deployment rate for onshore wind indicated that the policy framework in place was effective. In the Netherlands, the policy framework was not sufficiently effective to achieve any of the technology-specific 2020 targets. Improved policy effectiveness is required, in particular for those technologies that are supposed to grow strongly by 2020, according to the NREAPs. This is especially the case for concentrated solar power in Spain, and for wind energy and biomass in the Czech Republic and the Netherlands. However, it is important to bear in mind the fact that the NREAPs were prepared in 2011 based on data from 2008 or 2009

at best. It is therefore worth reflecting whether the specific technological targets established by these plans need further refinement if they are to adequately account for more recent technological costs, economic developments and knowledge about the environmental impacts.

In Switzerland, the policy framework was effective for reaching the 2010 interim target for renewable electricity, but deployment rates would not be sufficient to meet the Swiss 2030 target for renewable electricity (see details in the Swiss case study published separately from this report).

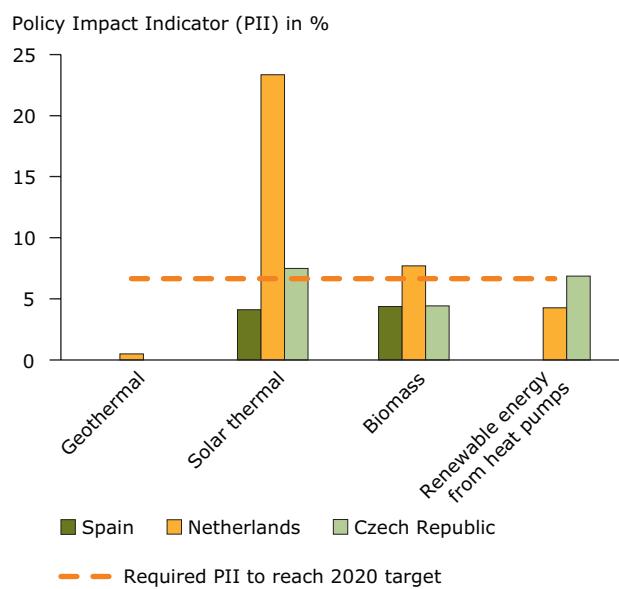
One key explanation for the difference in policy effectiveness seem to be the level of support and the design of the policy instrument. In the Czech Republic, there was particularly attractive financial support for solar PV, and in general there was no capacity cap. A similar situation existed in Spain for solar PV (until 2008 when a hard cap on cumulative installed PV capacity was introduced). In 2013, all support schemes for RES electricity were blocked in Spain. In the Netherlands, the PII did not reach the level required for the country to meet its 2020 target for any of the technologies, due to a variety of reasons (which differ per technology). Important barriers include relatively strong opposition

Figure 3.5 Average Policy Impact Indicator for renewable electricity technologies, 2006–2011



Source: EEA.

Figure 3.6 Average Policy Impact Indicator for renewable heating and cooling technologies, 2006–2011



Source: EEA.

⁽²⁹⁾ A technology-specific effectiveness assessment could be carried out for the three EU Member States only, based on the NREAPs under the RED, which require technology-specific pathways on how the national renewable energy targets will be met.

for wind energy (Not In My Backyard) and FIPs considered too low to be profitable for biomass and solar electricity projects. In addition, the design of the policy instrument may have played a role. In the Netherlands, the main support instrument is a sliding premium FITs with phased admission and escalating base tariffs. As such, there is some control over the capacity installed as the system rewards the lowest-cost renewables⁽³⁰⁾.

In the heating and cooling sector (see Figure 3.6)⁽³¹⁾, the existing policy frameworks were most effective for solar thermal, for which the average PII was 23 % in the Netherlands and 7.5 % in the Czech Republic. The reason for the high PII for solar thermal in the Netherlands is the low ambition in the Dutch NREAP for this type of renewable energy (underestimated potential). The Netherlands had also an effective policy framework in place for biomass, and the Czech Republic for heat pumps. The least progress was made in geothermal technologies in all countries, and further improvements are needed in this area.

Although the PII for solar thermal and biomass in the Netherlands has been above 6.5 % (23.3 % and 7.7 % respectively), policy effectiveness needs to increase in order to achieve the overall renewable heating target. The main reason is that the share of solar thermal in the overall renewable heating and cooling sector is small, while geothermal and heat pumps are much more important in quantitative terms; these are areas where not much progress took place in the Netherlands. In the Czech Republic, the relatively low PII (4.4 %) for biomass is of particular concern, as this category is by far the most important category in the overall target for heating and cooling according to the NREAP⁽³²⁾. In Spain, none of the PIIs are above the 6.5 % threshold, which means that much more effort needs to be made to boost the renewable contribution in the heating and cooling sector. Overall, we can conclude that policy effectiveness in the renewable heating sector needs to increase for the three countries, if they are to meet the 2020 targets. Again, as for the renewable electricity technologies, specific technological targets set in the NREAPs may need to be revisited to take into account new costs, economic developments and the environmental impacts.

While the above analysis of policy effectiveness focused on average policy effectiveness in the period between 2006 and 2011, it is important to note that there were important annual fluctuations, reflecting the market's sensitivity to contextual changes. The support schemes in the Netherlands and Switzerland remained stable during the observation period, but those in the Czech Republic and Spain underwent recent major changes (particularly for electricity). In these two countries, attractive FITs combined with costs reduction in global technology markets helped high deployment rates for solar PV in particular. However, important changes to the policy frameworks recently adopted or proposed in the Czech Republic and Spain will significantly worsen market conditions, and hence deployment rates in the near future. Important changes in Spain include a grid 'access toll' for renewable electricity generation, retroactive changes to FIT/FIP rates, a moratorium for the FIT/FIP scheme for new projects, and eventually, the abolishment of the FIP scheme. Similarly, in the Czech Republic, the government adopted a proposal to end the existing FIT/FIP scheme as of 1 January 2014, except for wind, geothermal, biomass and small hydropower projects before 31 December 2015⁽³³⁾.

3.4.2 Renewable policy efficiency

The efficiency of renewable policies was analysed using the Total Cost Indicator (TCI) (see also the IEA (2011)). The TCI shows the cost for a specific renewable energy support scheme. It is defined as follows:

TCI = how much a country spends in addition to the market price for energy to get an x amount of additional generation from a renewable technology.

For this purpose, the amount of annual FIT/FIP payments is compared to the wholesale value of the total annual electricity generation. As the concept focuses on renewable electricity generation (IEA, 2011), heating and cooling technologies are not included in this analysis⁽³⁴⁾.

⁽³⁰⁾ For details on the Dutch system, see the case study for the Netherlands published separately from this report.

⁽³¹⁾ For Switzerland, no PII for the heating and cooling sector could be calculated, since no long-term target for renewable heating has been set. In Switzerland, the policy framework was effective for meeting a 2010 interim target for renewable heating as included in the 'EnergieSchweiz' programme. For details, see the case study for Switzerland published separately from this report.

⁽³²⁾ In this report, we have considered the original NREAP from 2011, despite the fact that the Czech Republic resubmitted the plan in 2012. However, this is unlikely to dramatically change the conclusions of the analysis.

⁽³³⁾ For more details on the recent changes, please see the respective case studies.

⁽³⁴⁾ One reason why this indicator is calculated only for electricity is that heating markets are more local, and therefore it is very difficult to get an average wholesale price for heat, given that there is no authority that monitors this.

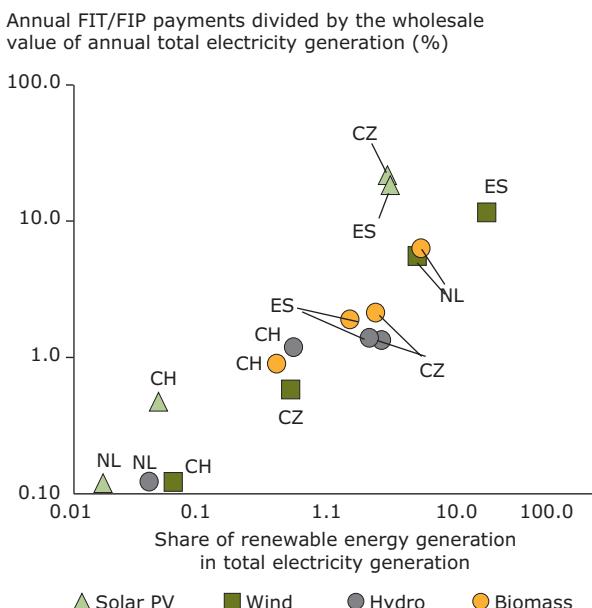
The comparison of the efficiency of the FIT/FIP schemes in the four countries shows important differences in the costs for increasing the share of renewable electricity in the energy mix. Not surprisingly, costs were highest for those schemes funding a relatively high share of more expensive technologies, in particular solar PV, as compared to lower-cost renewable electricity technologies such as biomass and hydropower⁽³⁵⁾. In the Netherlands and Switzerland, the share of additional PV output-supported FIT/FIP schemes remained negligible for the analysed period (2005–2011), and hence costs were very low for this specific technology (0.1 % and 0.47 % of the wholesale value of total electricity generation, respectively). By contrast, the Czech Republic and Spain both increased the share of solar PV output to 2.6 % and 2.5 % in total power output in 2011, with the total FIT/FIP payments for solar PV worth 18 % and 22 % respectively of the wholesale value of total electricity generation in that year (see Figure 3.7). As for wind energy, Spain doubled the total annual output, from 7 % of total electricity generation in 2005 to 14 % in 2011, but the value of FIT/FIP payments tripled in the same period, from less than 4 % in 2005 to nearly 12 % of the wholesale value of total electricity

generation in 2011. In the Netherlands, wind energy contributed to around 4 % to total annual electricity generation in 2011, for which FIP support was 5.5 % of the wholesale value of total annual electricity generation. In 2011, the biomass electricity contribution was 4.5 % in total Dutch annual electricity generation, while the FIP payments were worth around 6 % of the wholesale value of total electricity generation. In Switzerland, the biomass electricity output was 0.36 % in 2011 which costed 0.90 % of the wholesale value of total electricity generation in FIT payments.

The reasons for such significant differences in the technology-specific expenditure of each of the support schemes relate to the design of each scheme. Although support schemes in the Czech Republic and Spain initially did not include any features of technology-specific pre-allocation of support, the Swiss and Dutch systems did include such features from the outset (e.g. budget caps per technology in Switzerland, and competitive tendering in the Netherlands).

The Swiss FIT system was subject to an overall cap on the amount of money that can be levied on final consumers, and hence this limited the available overall budget to be spent on FIT payments. While this certainly helped keep costs under control, it has also limited deployment. In addition, the Swiss FIT system included technology-specific caps, ensuring that all technologies benefit to a certain extent from the available budget. In Switzerland, the technology-specific caps were essential for preventing the budget from being spent mostly on solar PV, given that most of the applications were on solar PV installations. Moreover, the FIT payments under the Swiss system are adopted annually, based on the generation costs of a reference plant using best available technology for each renewable energy technology eligible for support. The Dutch support scheme was capped, and was based on a competitive tendering process; it targeted the most cost-competitive technology. Special provisions for wind energy were included to account for technology-specific features. Moreover, the FIP system in the Netherlands was sliding with the electricity price in order to reduce costs and risks of 'over-subsidisation'. In Spain, the cost-efficiency of the FIT/FIP scheme was improved when caps were introduced in 2010. However, at the same time, major uncertainty was introduced following retroactive changes that negatively affected investors' confidence in the Spanish

Figure 3.7 Total cost indicator for renewable electricity, 2011



Note: For country codes, please see note to Figure 2.10.

Source: EEA.

⁽³⁵⁾ For a recent overview on renewable electricity generation costs, see IRENA (2013).

renewable energy market, as the effectiveness analysis for 2011 has already indicated.

When comparing costs for the support of renewable energy technologies, it is important to note that the TCI calculation does not specifically show the 'merit order effect'. This is a weak point of the TCI (IEA, 2011), since the 'merit order effect' can have a significant impact on wholesale electricity prices (see the discussion in Chapter 4). Under certain circumstances, the benefits in terms of reduced wholesale price can outweigh the costs for FIT payments, as was shown for wind electricity in Spain (Sáenz de Miera et al., 2008). However, further investigation of the 'merit order effect' lies outside the scope of this report.

Furthermore, when comparing costs for renewable support, it is important to bear in mind that the TCI is sensitive to changes in wholesale electricity prices. These prices fluctuated significantly over the observation period (for details, see the case studies).

3.5 Innovation and employment benefits from renewable energy support

3.5.1 Innovation

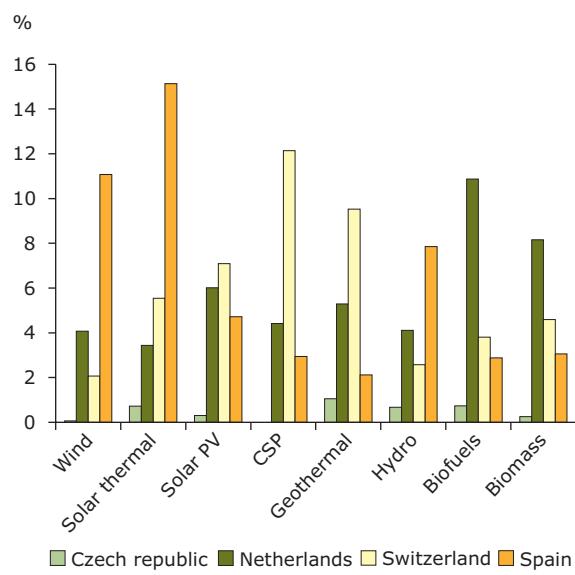
The key objective of the support measures for renewable energy sources was to meet the 2020 targets. In this way, renewable policies created market demand for these technologies and provided some impetus for innovation — albeit not sufficiently.

Figure 3.8 shows the share of renewable energy technology patent applications of the four countries in total patent applications in the EU-27 and Switzerland between 2006 and 2010⁽³⁶⁾. The data for Spain indicate that deployment can lead to R&D activity. Spain had a very high share in patent applications for wind, and a relatively high share for solar PV. The number of patents for both technologies grew very strongly between 2006 and 2010. At the same time, Spain had a relatively low share in patent applications for concentrated solar power (CSP), despite the fact that CSP was identified as a key technology for the Spanish renewable energy sector. By contrast, Switzerland had the highest share in CSP and solar PV patent applications, despite very low deployment rates

in Switzerland itself. This applies likewise to the Netherlands.

In all countries, the most important driver for innovation in the RES sector was the availability of targeted funding for R&D. In the Netherlands, for example, funding allocation is based on specific demands of (mostly larger) private industry through innovation contracts. In addition, each country builds on existing strengths. For instance, an important driver for the successful R&D sector for solar PV in the Netherlands is the existence of a strong PV cluster in the south-east of the Netherlands (Limburg and Noord-Brabant), comprising producers, suppliers and equipment factories. Switzerland's strength in solar technology is based on existing technological capabilities in this area, while its strength in geothermal may be related to the relatively high potential for geothermal energy in Switzerland. Spain's leading position in wind and solar thermal may be related to its early mover status in these technologies. In the Czech Republic, for instance, a number of sectors already exist (apart from the automotive industry) where skilled labour force and innovation activities could support further innovation in the RES sector, such

Figure 3.8 Share of renewable energy technology patent applications in %, EU-27 and Switzerland, 2006–2010



Source: OECD patents database, 2013. Data refer to patent applications filed under the Patent Co-operation Treaty (PCT). 2010 is the latest year for which data were available.

⁽³⁶⁾ This time period (2006–2010) differs from the period considered in other figures in the chapter (2005–2011), due to limited data availability.

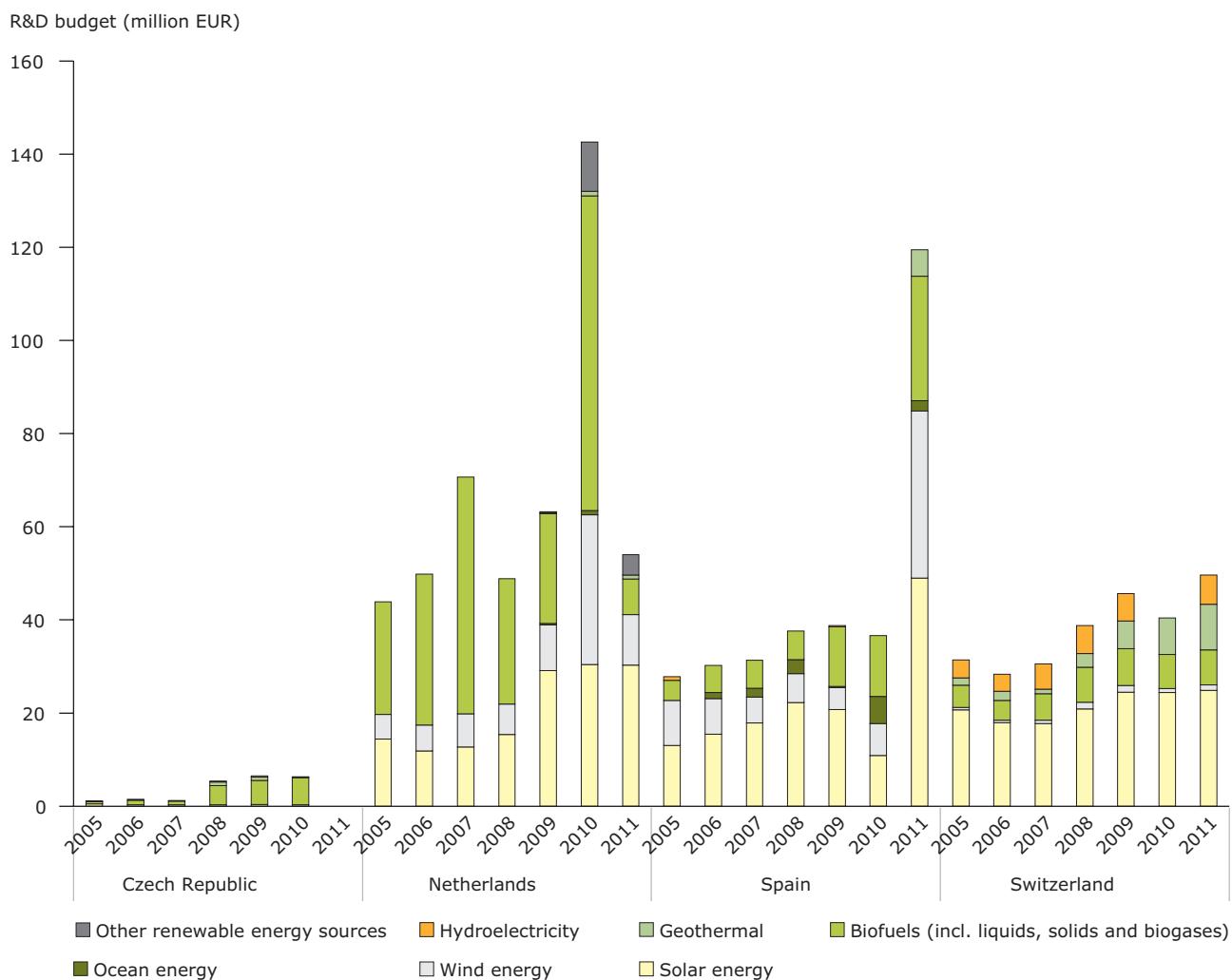
as electrical engineering and electronics, mechanical engineering, wood processing, and information and communication technologies. In addition, environmental awareness is high in the Czech Republic, leading to the establishment of several technological parks and business incubators for eco-technologies (see the country report from the Commission's eco-innovation database (³⁷)).

However, the Czech Republic has also the lowest gross domestic product (GDP) of all the countries reviewed. Isolating the technology-specific share of the R&D budget in the four countries reveals that

the Czech Republic focused on biofuels, while Spain and Switzerland had a strong focus on solar energy, and the Netherlands focused on solar energy and biofuels (³⁸). However new data from the new SETIS database (³⁹) help identify other areas for member countries to focus on. For example, in Spain, there seems to be some interest in biofuels as well as smart grids; some projects on smart grids exist in the Czech Republic as well.

The priorities in R&D budgets for renewables are reflected in Figure 3.9. The Netherlands is leading in biofuels and biomass technologies, while Switzerland

Figure 3.9 Total R&D for renewable energy technologies, 2005–2011 (million EUR, 2012 prices and exchange rates)



Source: IEA, 2013.

(³⁷) See <http://www.eco-innovation.eu>.

(³⁸) Including biorefinery concepts, electricity and heat from biomass, (including co-firing and co-feeding), gasification and gas cleaning.

(³⁹) See <http://setis.ec.europa.eu/energy-research>.

invests significantly in CSP and solar PV. In 2011, there was a huge increase in Spain's R&D budget for renewable energy technologies. Although it is not clear from the information available why this occurred, it may mean that despite the significant changes in the demand-pull type of policy framework for renewables introduced early in 2012, Spain continues to focus on renewables innovation (market-push) as part of its strategy to promote a green economy and green jobs (see also the country report under the Commission's eco-innovation database (⁴⁰)).

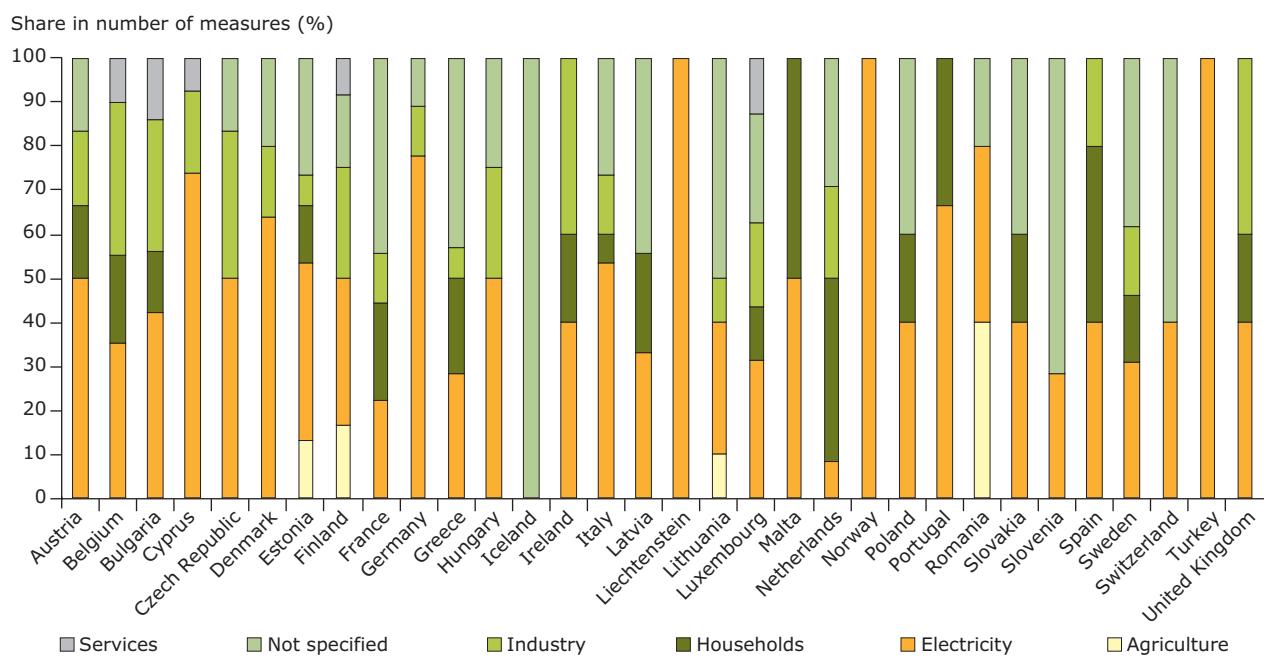
The share of renewable energy technologies in the total R&D budget shows that the overall strategic orientation towards energy technologies has been reviewed in the countries. In the Czech Republic, the highest share of the R&D budget between 2005 and 2010 (⁴¹) went to nuclear energy, possibly reflecting the objective to further expand nuclear power in the national electricity mix. In Switzerland, no one specific energy technology was greatly prioritised.

Nuclear received the highest share of the total R&D budget between 2005 and 2008; since 2009, renewable energy sources have the highest share, although they are closely followed by nuclear and energy efficiency. In Spain, and to a lesser extent in the Netherlands, there was a very strong focus on renewable energy technologies, particularly in certain years (see Figure 3.10).

3.5.2 Employment benefits of renewable energy support (⁴²)

After having analysed to what extent energy support measures influence the deployment of renewable energy technologies and which other drivers stimulate R&D in the renewable energy sector, the economic benefits in terms of employment and turnover in the renewable energy sector are compared across the four countries in 2010 and 2011, years for which data are available (⁴³).

Figure 3.10 Total Energy R&D budget per energy technology group, 2005–2011 (million EUR, 2012 prices and exchange rates)



Source: IEA, 2013.

(⁴⁰) See <http://setis.ec.europa.eu/energy-research>.

(⁴¹) There were no data for 2011.

(⁴²) When discussing the impact of renewable energy employment, one must distinguish between gross employment and net employment impact. 'Gross' means the total number of jobs created in the renewable sector along the supply chain, while 'net' involves taking into account job losses in conventional energy sectors, indirect job losses due to reduced incomes if renewables penetration leads to higher energy prices and other indirect effects. In this report, gross employment figures are used. For considerations on net employment, see, for example, the European project EmployRES (see http://ec.europa.eu/energy/renewables/studies/renewables_en.htm).

(⁴³) EurObserv'ER data are available for the Czech Republic, the Netherlands and Spain. For Switzerland, data from national sources are used.

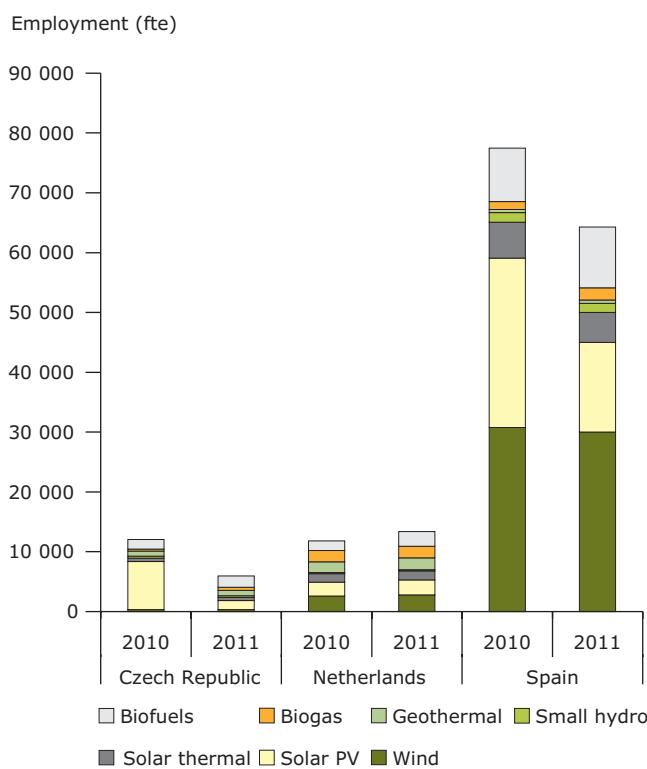
In 2011, total employment declined considerably in the Czech Republic and Spain, particularly in solar industries. In the Czech Republic, employment in the renewable sector decreased from roughly 12 000 jobs in 2010 to fewer than 6 000 in 2011, mainly due to the dip in the solar PV sector. In the Czech Republic, employment seemed to be related more to installation than to creating a sizeable manufacturing industry, despite the fact that the country does have significant manufacturing capability. In Spain, employment decreased, from 77 450 in 2010 to 64 300 in 2011, with the highest share of employment in the wind energy sector, followed by the solar PV sector (see Figure 3.11). In the Spanish solar PV sector, employment nearly halved between 2010 and 2011, declining from 28 350 to 15 000. By contrast, total employment in the Dutch renewable energy sector increased slightly in these two years, to below 14 000. In Switzerland in 2010, 46 200 direct and indirect jobs were reported (Rütter and Partner et al., 2013).

The significant decline in employment in the solar PV sector in the Czech Republic and in

Spain indicate a strong correlation between employment and the support measures in place. Recent changes to the policy frameworks are reflected in declining employment numbers in this sector. This development may be explained by the different approaches taken in the solar industry as compared with the wind industry. In the former, it seems that the focus was mainly on creating quick local employment in installations, at the expense of a more strategic move to create employment opportunities across the value chain, as had happened to a certain extent in the latter. This development may have come about as a result of the economic crisis, but it was also attributable to strong competition in manufacturing from China — something which is expected to increase in the future, despite current structures of European import tariffs for solar modules (44).

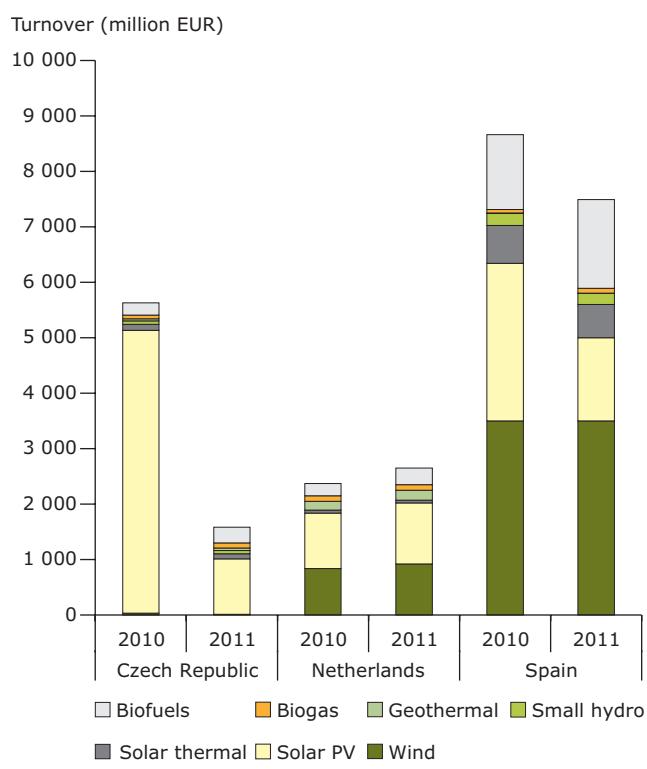
Trends for the turnover in the renewable energy sector seem to be similar with those for employment. The strong decrease of turnover, especially in Czech solar PV, is remarkable,

Figure 3.11 Employment in the renewable energy sector, per technology



Source: EurObserv'ER, 2012.

Figure 3.12 Turnover of the renewable energy sector (million EUR)



Source: EurObserv'ER, 2012.

(44) According to the recent report by GTM research, Global PV module manufacturers in 2013, Global PV Module Manufacturers 2013: Competitive Positioning, Consolidation and the China Factor. A podcast on the main findings of the report is available at <http://www.greentechmedia.com/research/report/global-pv-module-manufacturers-2013>.

indicating that the jobs created were indeed primarily those of installation companies (see Figure 3.12).

Based on national statistics in both Spain and Switzerland, the renewable energy sector contributes about 1 % to GDP, but the level of deployment of 'new' renewable energy technologies (excluding hydropower) between 2005 and 2011 is very different. Switzerland has significantly lower deployment levels than Spain, at considerably lower costs, but could benefit greatly from market demand and deployment in other European markets and in Asia.

3.6 Policy coherence

As stated at the beginning of the report, a sustained innovation process calls for specific renewable energy policies that are aligned with existing national energy, industrial and economic policies.

All four countries seem to have achieved good coherence among their policy objectives⁽⁴⁵⁾, but in some countries there is scope to investigate whether this is indeed the case. For example, in the Czech Republic, while energy, renewable energy, economic and innovation policy objectives are generally coherent, issues to examine further include:

- implementation of the objective to lower energy costs: cancellation from 2014 of operational support for new renewable electricity generators (with an exemption for wind and hydropower approved for building by 31 December 2014), and replacement with targeted investment support for cost-effective installations;
- the boundary conditions for limiting operational support to RES.

In Spain, the potential lack of coherence in energy and renewable energy policy objectives should be investigated, in relation to the aim of addressing the tariff deficit by suspending economic incentives for new renewable energy facilities.

Coherence in the implementation of the policy goals is also worth considering. An analysis of coherence in policy implementation was beyond the scope of the current report.

3.7 Conclusions

In this chapter, four European countries (the Czech Republic, the Netherlands, Spain and Switzerland) were compared: their energy mix, the effectiveness and efficiency of their renewable energy policy, their expenditure in R&D for energy technologies, and employment in the renewable sector.

The energy mix and the import dependency on fossil fuels are not the only factors affecting decisions with respect to the allocation of support to the energy industry in the target countries. For example, countries with the lowest and the highest degree of import dependency on fossil fuels, namely the Czech Republic and Spain, respectively, had equally high levels of support for renewable energy. Economic and climate mitigation considerations play a part as well.

In terms of policy frameworks, all countries have or had a FIT/FIP scheme in place to support the deployment of renewable electricity technologies over the observed period (2005–2012), but they show important differences in the features, effectiveness and efficiency.

Analysis shows that the Czech policy framework for solar PV (using a system of FIT/FIP payments) was far too ambitious: in 2011, 92 % of the potential estimated for the period from 2005 to 2020 for this technology had already been exhausted. Both the Czech Republic and Spain increased the share of solar PV to 2.5 % in total electricity generation in 2011, with total FIT/FIP payments amounting to 22 % and 18 % respectively of the wholesale value of total electricity generation in that year. Spain doubled the share of wind in total electricity generation from 2005 levels, reaching 14 % in 2011, while the value of FIT/FIP payments nearly tripled in the same period, from less than 4 % in 2005 to nearly 12 % of the wholesale value of total electricity generation in 2011. By comparison, developments in the Netherlands and Switzerland were a lot more modest. In the Netherlands, wind energy contributed to around 4 % of total annual electricity generation in 2011, of which FIP support represented only 5.5 % of the wholesale value of total annual electricity generation. In 2011, biomass electricity contributed to 4.5 % of Dutch annual electricity generation, and required FIP payments represented around 6 % of the wholesale value of total electricity generation. In Switzerland, additional biomass electricity output was 0.36 % in 2011, of which 0.90 % of the wholesale value of total

⁽⁴⁵⁾ For details, please see the specific country case-studies published separately from this report.

electricity generation was spent in the form of FIT payments. In all three EU Member States (the Czech Republic, the Netherlands and Spain), more targeted efforts are required to stimulate the deployment of those technologies expected to help meet 2020 targets as developed in the NREAPs. This is the case for concentrated solar power in Spain and for wind energy and biomass in the Czech Republic and the Netherlands. In Switzerland, the policy framework was effective enough to meet the 2010 interim target for renewable electricity, but observed deployment rates would not be sufficient to meet the Swiss 2030 target for renewable electricity. In all four countries, more policy efforts are needed in the renewable heating and cooling sector. Also, NREAPs should be adapted to capture recent developments in technological costs, economic context and knowledge about the environmental impacts.

One of the key factors affecting the renewable policy effectiveness and policy efficiency was the design of the policy instrument. This was particularly evident in the case of solar PV. Over the past 20 years, the price of PV modules has decreased by over 20 % every time the cumulative sold volume of PV modules has doubled (Prest, 2012). These cost reductions are attributable to ongoing technological product innovations (technological learning curve effects), continuous manufacturing efficiencies and increased economies of scale which are partly driven by rapid growth in market (especially developments in China).

The policy frameworks in the Czech Republic and Spain were not flexible enough to absorb this rapid cost development. One conclusion to be drawn from this is that any renewable policy instrument needs revisions at frequent intervals, to capture cost developments for emerging technologies, and to avoid overcompensation and stop-and-go policies that undermine long-term investor confidence in the sector.

Another important design aspect is the 'cost containment' seen particularly in policy frameworks in the Netherlands and Switzerland, but also in Spain in recent years. Usually there are two ways to deal with cost containment: tariff depression and capacity caps. The latter is being increasingly contemplated in Europe while the former has been in place for a while.

There are many ways to design a cap scheme. There may be a cap on total cumulative installed capacity, an annual capacity cap which is not cumulative, limits on project size, budgetary limitations available for the support, caps on cumulative total capacity of specific technologies, thereby altering the renewable

portfolio, a clause in the policy that triggers a review of the support automatically once a certain capacity has been reached, inclusion of auctioning mechanisms, etc.

A hard cap on total cumulative installed capacity is the least desirable and it is likely to have several negative impacts (Prest, 2012): it could limit further growth of renewables unless power purchase agreements can be concluded outside the support scheme, and it could inhibit any investment in domestic manufacturing and other activities characterised by low capital mobility.

This is what happened in Spain, for instance, with solar PV after 2008. The FIT payments under the Swiss system are adjusted annually based on the generation costs of a reference plant. The Dutch support scheme was capped and was based on a competitive tendering process, thereby aiming for use of the most cost-competitive technology. Moreover, the FIP system in the Netherlands was sliding with the electricity price, in order to reduce costs and risks of 'over-subsidisation'.

These findings shed some light on the need for the recommendations in the communication *Delivering the internal electricity market and making the most of public intervention* (EC, 2013), particularly with respect to the guidance for support schemes for renewable energy.

The evidence shows that a high level of deployment stimulated by public support does not necessarily result in a sound innovation process in the country itself. On the contrary, too effective (and too generous) policies tend not to stimulate cost reduction via technological innovation, but rather high levels of deployment at high costs, as witnessed in the Czech Republic, and to a lesser extent, in Spain. Factors other than support for deployment are at least equally important for innovation in the renewable sector, including R&D budgets as well as a strong national innovation system and an industrial base with the necessary capabilities to enter a new technology field such as renewable energy sources. In order to exploit these capabilities measured in terms of contribution to gross value added or employment, the market demand does not have to be domestic. This is reflected in the case of the Netherlands and Switzerland, for example. Therefore, a key lesson to draw from the comparison of the four countries is that a successful innovation processes requires a balanced mix of technological push and market pull policies. In the absence of R&D support, it is very difficult to stimulate technological innovation, as was seen especially in the Czech Republic.

4 Methodology

4.1 Introduction

Any attempt to accurately quantify the support to all energy sources is likely to be marred by the lack of internationally accepted definitions as to what constitutes support, as well as by less transparent reporting practices, particularly in the case of fossil fuels and nuclear energy. Therefore, the methodological approach, key to understanding the limitations of this analysis, is described in the following sections.

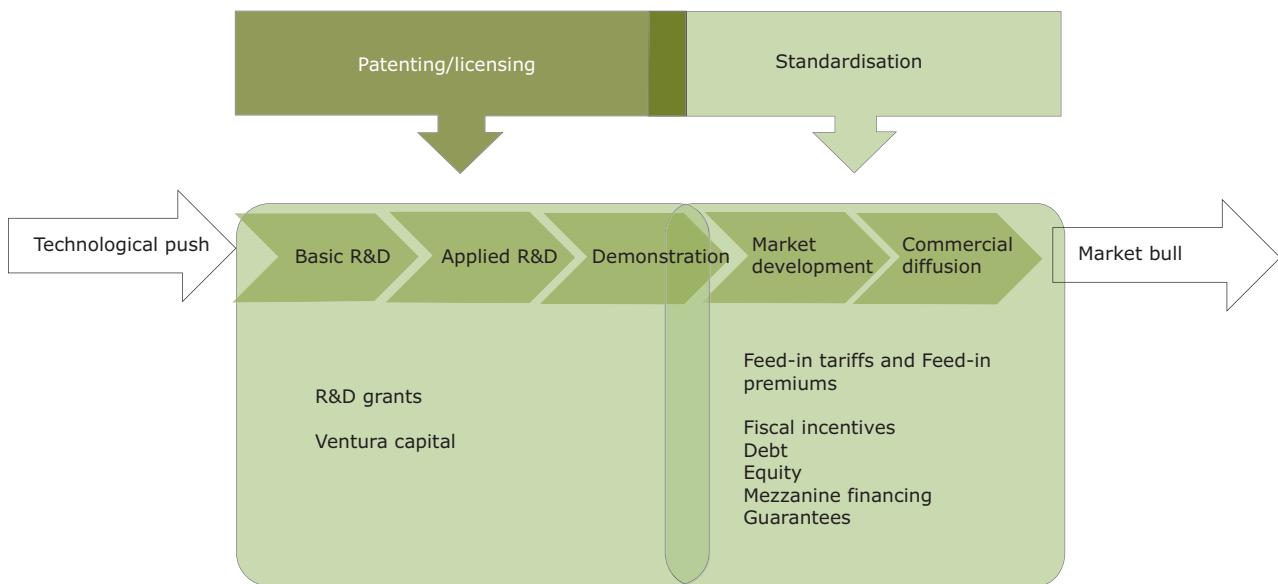
4.2 Concepts applied in this report

Innovation concerns the search for, and the discovery, experimentation, development, imitation and adoption of new products, new production processes and new organisational set-ups (Dosi and Orsenigo, 1988). In the energy sector, innovation may stem from practices that embed environmental regulations in

now-incumbent production processes (e.g. through energy efficiency), or lead to new technologies and practices (e.g. through renewable energies). This project is concerned with the latter form of innovation, namely innovation through new technologies and practices — and especially renewable energy technologies. While general economic and innovation policies may also steer innovation towards fossil fuel-related research, or energy savings, for example, these elements were not investigated in this report.

Innovation in the renewable energy sector involves a range of technologies that are at a different stage of market development. Capital needs for companies developing and employing renewable energy technologies can be quite different for each stage of the innovation process. Therefore, a mix of measures to support innovation in the renewable energy sector is needed (see Figure 4.1). An explanation of how different economic instruments work is provided in Figure 4.1.

Figure 4.1 Stages of the innovation process and associated economic instruments



Source: EEA, based on IRENA (2011) and Ecofys (2011).

Box 4.1 Definitions of selected financial instruments

Venture capital is financial capital provided to early stage, high potential growth startup companies. It is a type of private equity that generates return through an Initial Public Offering (IPO) or by selling the company.

Debt financing takes place when a company sells bonds, bills or notes to individual or institutional (e.g. banks) investors. In exchange of lending money, the creditors receive the principal plus an interest on the debt.

Equity financing takes place when a company issues shares of stock in a public offering.

Mezzanine financing is a hybrid between debt and equity financing and it is used usually to finance a company expansion. Mezzanine financing is basically debt capital which gives the lender the right to convert to ownership of the company or to equity interest in the company if the loan is not paid on time and in full.

This report addresses both market diffusion and deployment as the last stages in the innovation process, as well as the R&D phase, albeit briefly for the latter. The proxy used to measure innovation is the number of patent applications at EPO.

4.3 Energy support measures defined

The exact definition and measurement of a support is subject to ongoing debate. The OECD (2006) has noted that there is no universally accepted definition of a support — a comment that is still valid today. Especially in the case of tax credits or preferential loans, it is unclear what baseline (or benchmark) to use when assessing these supports (Steenblik, 2010). Various commonly used definitions usually fall in one of the following categories: definitions based on descriptions in legal documents (e.g. the World Trade Organization (WTO)); definitions based on the impact on the price per unit; and definitions based on the deviation from (social) marginal costs. For more details on definitions applied in literature, see Annex 1 to this report.

As noted by the OECD, a definition taken in a particular study is dependent on the purpose of the analysis. Ultimately, the definition chosen is both a practical and political choice, and reflects specific economic, social and political interests.

This study takes a pragmatic approach in dealing with these subjective elements.

Analysis in this report uses the following definition of an energy support measure.

An energy support measure is a government action that results in (marginal or average private) costs not born by economic agents (producers and consumers) and thus increasing the first-order demand or supply for specific energy carriers and/or energy technologies.

The following points need to be taken into consideration when interpreting this definition.

- By focusing on private costs, this definition excludes 'implicit support', by not pricing external costs from the production or consumption of fossil fuels, for instance. This choice was made because of budgetary constraints and the desire to account as accurately as possible for support that was actually given in Member States to various energy technologies or carriers in 2012 (over the period from 2005 to 2012 for the four target countries). A discussion on environmental externalities associated with energy production and consumption and a comparison with governmental interventions in the energy market, based on the LCOE, is available in Ecofys (2014). Also, the IMF (2014) has recently produced a methodology for calculating the level of fiscal instruments (e.g. environmental taxes), taking into account environmental externalities.
- Support measures under this definition are broader than support and fiscal exemptions, and include other forms of support such as grid access, mandatory quotas or risk transfer to the government.
- This definition uses 'government action' as a key criterion. Monopolistic behaviour is thus excluded if this monopoly is not the result of governmental interventions in the energy market.

This definition examines support measures that increase first-order demand or supply for specific energy carriers or energy technologies. The first-order element here implies that the support directly stimulates demand or supply for certain energy technologies (or carriers). FIT schemes, for example, initially increase the supply for renewable energy technologies. However, they also tend to increase costs of electricity for consumers if the merit order effect is not passed on to them, so electricity consumption may decline as a result.

This second-order impact is not included in this definition of support measures.

4.4 Types of energy support measures identified in this study

A description of types of measures covered in the literature is available in Annex 1. In this section, a brief description is included of support measures used in the report. Support measures covered in this study are split into five main categories and various subcategories, as shown in Table 4.1. The definitions for each type of measure as used in this report are provided in Annex 2 of the report.

Each of the support measures has been classified in the inventory, taking into consideration the following elements:

- type of instrument used in support (direct monetary transfers, preferential fiscal treatment, transfer of risk, mandates and obligations, other financial measures);
- detailed type of support measure (FITs or FIPs, energy tax allowances or energy tax exemptions);
- energy carrier subsidised (e.g. electricity, coal, oil or heat);
- renewable technology subsidised (e.g. solar, wind or geothermal);
- orientation of support (e.g. R&D, construction and investments, exploitation, consumption of energy or post-exploitation);
- targeted beneficiary sectors of support (e.g. agriculture, industry, households or transport).

4.5 Time horizon

The following time horizons have been used in the study:

- for the qualitative overview for all 32 EEA countries (including country fiches): only measures that were in place in 2012 have been considered.
- for the four target countries (the Czech Republic, the Netherlands, Spain and Switzerland): all measures that were in place from 2005 onwards and that were still in force in 2012 have been considered.

These limitations have been imposed for practical reasons. The year 2005 is the base year against which a number of recent energy and climate policies are being monitored. In addition, due to time and budgetary constraints, a longer time-frame could not be considered.

It is clear, however, that past support may still have an impact on existing energy market structures (Ecofys, 2014). For example, support measures related to infrastructure use inherited from the period before the liberalisation process and privatisation (Oosterhuis, 2001) have not been considered. The impact of past support regimes still remains an influential factor in the energy markets nowadays. While this type of past support also applies to some renewables (e.g. hydro energy), support for nuclear and fossil fuels has been much greater (Oosterhuis, 2001). However, not only financial support contributes to 'lock-in' and path dependency — the technical, institutional and social complex that has developed around incumbent technologies also plays a part (Hughes, 1987; Unruh, 2000).

4.6 Types of support measures not included in the inventory or the quantitative analysis

The aim of the project is to provide a clear picture of **national** support measures applied to **all forms**

Table 4.1 Measures identified in this report

Category	Subcategories
Direct monetary transfers	Direct on-budget support, FITs, FIPs, Adjustment Aids, Inherited liabilities, Induced Transfers, Others
Fiscal measures	Energy tax allowances (e.g. tax-free allowances), Energy tax exemptions, Other tax deductions (allowances and exemptions), Earmarked refunds of taxes
Transfer of risk to the government	Adjustment Aids, Inherited Liabilities, Others
Other financial measures	Adjustment Aids, Other tax deductions, Others
Non-financial measures	Quota obligations including green certificates trading schemes, Priority grid access, Others

of energy, and to investigate their impact on market conditions for renewable energy for the period from 2005 to 2012. Given the scope, several categories of support measures have not been included, because they are financed with contributions from EU funds (or generated by EU policy mechanisms) (46), because they cannot be allocated with certainty to a specific technology, or because they are a result of international treaties.

The following support measures are **not included** in this study:

- contributions from EU Structural and Cohesion Funds for energy efficiency and renewables;
- cross-support, i.e. support entirely financed by other users of the same kind of energy;
- support for energy efficiency (however, support for combined heat and power is included);
- public investments in infrastructure directly or indirectly related to transport and distribution of specific energy carriers, including already depreciated energy infrastructure (e.g. gas infrastructure);
- public support for programmes related to the termination of energy production activities, in as far as these expenditures are not part of the normal costs that should have been borne by the operator of the activity;
- energy tax and VAT exemptions for aviation and maritime shipping, since they are provided by all countries due to international treaties;
- support for transport fuels will be accounted for where information is readily available, but they are not the focus of this report; support for modes of transport has not been included;
- free allowances granted under the EU ETS to energy-intensive industries for emissions below the product-specified benchmarks;
- funding provided under the NER300 programme in the EU ETS for investment in carbon capture and storage (CCS) and innovative renewable energy technologies;
- compensation payments to electricity users in the EU ETS under the State Aid Guidelines in the EC (COM 2012/3230 Final);
- support to unconventional energy sources or to end-of-pipe technologies such as CCS (outside the NER300 envelope).

While these measures have not been included in this overview, they do matter for the deployment of renewables and hence for innovation in this

sector. First, they alter the relative marginal costs of renewables compared to fossil fuels, and therefore change the degree of competition between various energy carriers/technologies. Second, they may lower the costs of energy use and thereby stimulate the use of energy. Third, they may have impacts on the innovation processes (e.g. in the case of projects financed under the NER300 programme).

The carbon emission trading scheme EU ETS is probably the most important omission. The EU ETS influences the deployment of renewables in the following ways.

1. By putting a price on CO₂ emissions from electricity production, renewable energy is relatively in a more favourable competitive situation compared to fossil fuels. However, current prices in the EU ETS are lower compared to the prices of EUR 30 per tonne CO₂ foreseen in the EU ETS Impact Assessment of 2008 (EC, 2008). Therefore, the current price of between EUR 3 per tonne CO₂ and EUR 5 per tonne CO₂ can be regarded 'under-priced' for renewable energy deployment — at least, compared to the expected 20–20–20 policy package that was agreed in 2008.
2. Industrial installations that are deemed to face a risk of carbon leakage receive free allowances up to the product-specified benchmarks. Currently, about 95 % of emissions to industrial installations are granted with no costs (CE Delft, 2013). However, the free allocation should not, in theory at least, influence the marginal costs (but only the average cost), and therefore the impact of free allocation may have only minor implications for the deployment of renewables. Moreover, most electricity producers (with temporary exceptions for new Member States) would still have to buy their emission allowances in auctions.
3. In 2012, it was decided that compensation of industrial users for the increase in electricity prices would be eligible under the State Aid Conditions (EC, 2012). Member States can, within predefined boundaries, decide themselves whether or not to compensate their industries. Although this is a clear (environmentally harmful) support, this was not taken into account because the measure was still under development in many Member States at the time of writing this report.
4. Under the NER300 programme, 300 million allowances are set aside in the New Entrants'

(46) Such policies have not been investigated because the focus is primarily on national policies. Moreover, EU policies are designed to impact overall market conditions in the energy market as little as possible.

Reserve of the European Emissions Trading Scheme for subsidising installations of innovative renewable energy technology and CCS. In 2012, support was granted under the scheme to 24 renewable energy projects. These have not been included in the overview for every country in this study, because it is not part of the national policies⁽⁴⁷⁾.

4.7 Data sources

The most important sources of information used for this analysis include:

- the OECD second Inventory of Estimated Budgetary Support and Tax Expenditures for Fossil Fuels from 2013 (referred to as OECD-TADFFSS in the country fiches);
- the report prepared by the Institute of Environmental Studies (IVM) for DG Environment: *Budgetary support and tax expenditures for fossil fuels: An inventory for six non-OECD EU countries* (referred to as DG-ENV 2013 in the country fiches);
- the RES-Legal database from the EU (referred to as RES-LEGAL in the country fiches);
- additional literature and information from national experts.

During the data collection and the elaboration of this report, a number of methodological and data interpretation decisions had to be taken, which further affect the limitations of this report. For a more detailed description of the issues, including criteria for the selection of the four target countries, please refer to Annex 3 to the report.

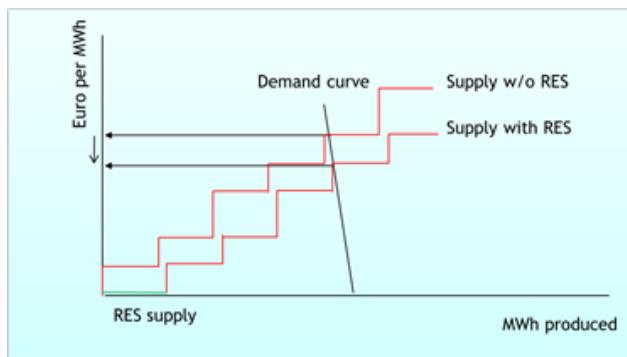
4.8 The merit order effect of renewable energy

In the analysis presented in Chapter 3, renewable policy efficiency is analysed via the TCI indicator. To calculate the TCI, the premiums paid for various renewable electricity technologies are calculated as a percentage of the total wholesale electricity price. Calculated in this way, the indicator cannot show the specific contribution of the merit order effect. However, in countries with a large share of

renewable in electricity production, such an effect can be quite significant, and in some cases, could well compensate for the premiums paid for these technologies. Therefore, it is important that a brief discussion on this effect be provided in this section.

It is often thought that renewable electricity support simply raises the electricity price for consumers if support is financed via a levy on final energy consumers (such as the FITs and FIPs). However, the total impact on costs is not so straightforward. Renewable electricity (with the exception of biomass) has substantive upfront investment costs, but very low operational costs. In other words, renewable energy technologies tend to enter the merit order as a first technology. Transmission operators may even be obliged to use renewable energy technologies as first technology if priority dispatch applies. Therefore, the supply curve shifts to the right (see Figure 4.2), which implies that renewable energies may actually lower the wholesale electricity price, at least in the short term (Würzburg et al., 2013). Figure 4.2 shows the current capacity of the different energy techniques (x-axis) and the price in EUR/MWh (y-axis). So, while a system of FIPs/FITs financed by a levy on electricity consumers raises the energy bill, there is at the same time a tendency for wholesale electricity prices to drop due to the merit order impact. Therefore, the total additional costs for supporting renewable energy should not be simply equivalent to the FIPs/FITs, but should rather reflect the merit order effect, in which case it should be lower than (if not offsetting all) the support allocated through specific renewable policies.

Figure 4.2 Short-run impact of renewable energy penetration on merit order



Source: de Bruyn, 2013.

⁽⁴⁷⁾ See http://ec.europa.eu/clima/news/docs/c_2012_9432_en.pdf.

For example, Tveten et al. (2013) estimate that (subsidised) solar electricity generation has depressed average electricity prices by 7 % in Germany between 2010 and 2011. The average daily maximum price and daily price variation are also found to decrease, by 13 % and 23 % on average respectively. McConnell et al. (2013), observing price decreases between 8.6 % and 12 % in the Australian power market due to solar PV, conclude that such price savings could eventually even outweigh the FIT policy costs, implying net savings for consumers of electricity.

Therefore, the general public perception that renewable electricity support is expensive and leads to income disparities (as poor households spend

larger shares of their budgets on electricity) may not be justified, given the empirical evidence. When energy support measures are introduced in the market, they may influence the merit order, and this can benefit consumers, depending on how much of the achieved reductions are passed on to them. From a societal perspective, however, these positive welfare effects of lower prices for consumers (consumer surplus), may come at the expense of reduced profitability for electricity producers. The net overall welfare effect may therefore be more dependent on average price differences between fossil fuels and renewables, on the one hand (negative welfare effect), and positive effects of renewables, on the other hand (CO₂ reduction, air quality, innovation, reduced dependency, etc.).

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Acronyms

CCGT	Combined-cycle gas turbine
CCS	Carbon capture and storage
CIT	Corporate income tax
CO ₂	Carbon dioxide
CSP	Concentrated solar power
DG	Directorate-General
EEA	European Environment Agency
EHS	Environmentally harmful support
EPO	European Patent Office
ESM	Erasmus centre for Sustainability and Management
GDP	Gross domestic product
GHG	Greenhouse gas
IEA	International Energy Agency
IEEP	Institute for European Environmental Policy
IMF	International Monetary Fund
ISPRA	Institute for Environmental Protection and Research
IVM	Instituut voor Milieuvraagstukken
JRC	Joint Research Centre
LCOE	Levelised cost of energy
NGO	Non-governmental organisations
NREAP	National Renewable Energy Action Plans
PCT	Patent Co-operation Treaty
PII	Policy Impact Indicator
PV	photovoltaics
R&D	Research and development
RED	Renewable Energy Directive
SDE	Subsidieregeling duurzame energieproductie
SHARES	Short Assessment of Renewable Energy Sources
TCI	Total Cost Indicator
WTO	World Trade Organization

Annex 1 Definitions for energy support in literature

Energy support measures are allocated either to energy production or to energy consumption. Although specific policy mixes differ per country, support measures on fossil fuels are often deployed on consumption, while support measures on nuclear energy and renewables have frequently been directed at production.

Other dimensions of the distinctions in support measures exist. Some measures, like on-budget support, energy tax exemptions and allowances and other tax allowances and credits, have direct consequences for the public budget, as revenue forgone by the government. Other measures, such as a system of FITs and premiums financed through a surcharge on the electricity bills, will have no impact on public budgets. However, a system of FITs and premiums is sometimes financed through the state budget; in this case, it has a direct consequence for the public budget.

A1.1 Energy support for production

Some support measures targeting energy production lower the marginal costs of production. It is possible, for example, through regulation, to keep energy or fuel prices below a cost coverage level of producing and distributing them, including a 'normal or counterfactual energy tax level'. These support measures lower the unit cost of each kilojoule of energy produced and delivered to the consumer. One example is support for renewable energy such as FITs or FIPs. In a competitive energy market, production-related support measures will alter (relative) prices, and will thus increase the quantity of production units⁽⁴⁸⁾.

Other support measures affecting the average costs of production include investment support or insurance, or a tax including a tax-free base. These support measures are lump-sum benefits and are not related to the amount of energy produced or consumed. However, they tend to lower the total cost of

production and hence the average cost per unit, and may result in more attractive investment climate for specific production technologies. In this way, support mechanisms shape **investment** decisions in energy production technologies in favour of the targeted technology, either intentionally or unintentionally. For example, tax allowances targeting the extraction sectors lower average costs and raise the profitability of the sector. They typically take the form of a corporate income tax (CIT) system, accelerated depreciation allowances for capital, investment tax credits, additional deductions for exploration and production, and preferential capital gains treatment.

Production support can promote the consumption of one type of fuel over another, by reducing the cost of the input for operators of power plants. This type of policy has often been applied in the past to the coal used to produce electricity in countries with coalmines, and is currently applied for renewable energy support in the field of biofuels.

A1.2 Energy support for consumption

Support measures for energy consumption relate to specific transfers of income to certain groups of energy consumers that may be exempt from taxes or permitted special deductions. Policy measures that provide transfers to consumers of energy include direct payments to final consumers for the purchase of fuels or electricity, and the value of transfers to consumers created through government interventions that artificially depress the domestic price, compared with a reference price.

The effect of consumption support measures on the market is to distort prices and lower end-use prices for consumers, which may increase energy use and reduce incentives for energy saving. As noted above, lowering the energy cost can be achieved either via the **marginal** cost (the last unit of energy used) by tariff deductions, or via the **average cost**. Lowering

⁽⁴⁸⁾ In monopolistic markets, however, these support measures may not alter prices or supply.

Table A1.1 Examples of support measures and their effect on costs

	Marginal costs	Average costs
Consumer	Energy tax exemptions	Energy tax-free allowances
	Earmarked refunds of energy taxes	Free provision of energy services
Producer	FITs	Depreciation allowances
	FIPs	Investment tax credits
	Quota obligations	Preferential capital gains

the average energy cost can be the result of support measures that do not have a relationship with the amount of energy consumed. For example, in the Netherlands, households were compensated for the increase in the energy tax. This was done by introducing a tax-free allowance of EUR 320 (per

year) for every household with a grid connection, independent of the amount of energy consumed. Providing a limited amount of coal free for heating to miners, as occurs in some countries, is another example of a measure that influences the average costs of using energy.

Annex 2 Types of support measures included in the inventory underpinning the analysis in this report

A2.1 Direct monetary transfers

Direct monetary transfers are support schemes in which transfers from one party to another are enforced by government decisions. Hence both the transfers from governmental budgets to producers or consumers of energy (so-called on-budget support) and the induced transfers from consumers of electricity towards producers are forms of direct support.

For the purpose of this report, we have distinguished between various direct monetary transfers:

- FITs
- FIPs
- other induced transfers
- direct support related to adjustment aids
- direct support related to inherited liabilities
- other direct on-budget support

a. Feed-in tariffs (FITs)

A FIT scheme is a support instrument creating financial incentives for feeding electricity or heat from renewable sources into the grid or thermal systems.

It includes two key provisions: a) guaranteed grid access, and b) long-term guaranteed prices at which power producers can sell energy generated from renewable sources into the grid or thermal system.

Since the prices against which electricity or heat will be purchased are fixed, eventual price risks come at the expense of the energy consumers. If, for instance, spot prices of electricity fall, a FIT system can overstimulate the production of renewables, since the price differential between spot prices and guaranteed prices tends to become large. Therefore, the FIT primarily insures investors of renewable energy against market insecurities. In order to minimise allocative inefficiencies, FITs require an up-front and continuous administrative commitment to set the payments accurately. If the FIT payments are set too high, they could result in a

higher overall policy cost; if set too low, they could result in little or no new RE generation.

FIT payment rates normally differ between various technologies. FITs can be paid from the state budget or, more often, through an excise tax put on the consumption of energy (heat or electricity) by its regulator. Industrial energy users are often exempt from paying such taxes.

b. Feed-in premiums (FIPs)

This is a support instrument for selling electricity or heat from renewable energies directly on the (spot) market, receiving a premium on top of the particular market price. In contrast to the FIT, there may not be a purchase obligation, and it creates an incentive to feed electricity into the grid during peak demand.

FIPs can be constant or sliding. Constant premium policies typically provide a 'constant' (i.e. non-variable) premium on top of the (spot) market price. In the electricity market, this design guarantees that a fixed bonus rides on top of the spot market price of electricity. In this case, the risk of electricity price changes lies entirely with the renewable generator. When a sliding variant is chosen, the premium varies with the spot market price of electricity. The risk of price changes in the electricity market is then born by the government or by consumers, depending on how the FIP is financed (from governmental budget or via the energy bill). FIPs are sometimes used in combination with FITs for renewable energy support. FIPs can be paid from the state budgets or from an induced levy by the regulator, and are usually differentiated according to the various renewable energy technologies.

c. Other induced transfers

Induced transfers are government-enforced obligations on market participants to pay a premium on electricity prices used for specific purposes. FITs and premiums for renewable energy are such examples. However, similar schemes exist for other forms of energy as well. For example, in the United Kingdom, a similar system exists for nuclear

energy, called 'contract for difference', where the government guarantees the strike price for electricity for nuclear power producers. If the wholesale price falls below the strike price, a levy on consumer bills will cover the difference. If the wholesale price is over the strike price, the generator pays back the difference to the government. Payment of this mechanism goes through a fund outside the state budget. Hungary, Ireland and Poland are other countries with levies on top of the electricity prices that are put in funds for specific purposes.

Direct support related to adjustments aids

A special case of direct on-budget support is the support related to the transformation of a sector (or a company). This is normally a temporary support. Under some conditions, adjustment aids are made possible under the EU State Aid Guidelines. Only the coal industry profits from adjustment aids in Europe. Support related to adjustment aids is available in the Czech Republic, Germany, Hungary, Poland, Slovenia, Spain and Romania. They relate to restructuring, decommissioning and social schemes such as early retirement payments. In most cases, they refer to coal support. Coal support in EU Member States need to be phased out by 2018, from the EU State Aid Guidelines, though support related to cover exceptional expenditures related to the closure of mines can still be given until 2027 (Council Decision 16229/1/10 + COR 1).

Direct support related to inherited liabilities

A special case of direct-on-budget support concerns the privatisation of energy companies. In some cases, governments have taken over certain liabilities of energy companies, for various reasons. For example, when the company is sold to shareholders, the government assumes part or all of the existing liabilities (e.g. long-term contracts to sell energy below the market price), hoping to maximise revenues from the sale. Another situation is when a company needs to become economically viable. In this case, the company is not sold to external shareholders (as it represents a negative value), but instead the government takes over some of the liabilities (e.g. the environmental claims for cleaning up old facilities of the company) in order to make the company economically viable in the marketplace.

Only in the second case, does support matter from the point of view of its impact on the price of energy carriers. In the absence of governmental support, the company would go bankrupt. In the first case, it is expected that the prices of energy carriers will hardly be affected, since shareholders expect a decent profit on their investments. In the absence

of support, shareholder investments would be lower and prices would be lower, so this is more a distributional issue than one affecting market prices of energy carriers.

Support related to inherited liabilities is generally allocated to mining companies and nuclear facilities.

Other direct on-budget support

Direct on-budget support is paid from the state budget. Generally speaking, this support has been declining, as WTO rules and the EU State Aid Guidelines leave less room for it. Examples of direct support are investment support or support to R&D activities.

Direct on-budget support can also take the form of favourable conditions for lending and borrowing. Conditional loans, forgivable loans and interest-rate support are all classified as direct on-budget support in the database. Other forms of direct support are lump-sum payments for heating bills. Most support in this category relates to support for renewable energy, though substantive support for fossil fuel and electricity and heat has been defined as well.

d. Other (off-budget) support

A few measures might be considered direct support, but these are not paid off from the state budget. They are financed through separate funds instead. The funds may have originated from the state budget or have been created by the energy companies. With respect to the latter, support may take the form of soft loans granted to the pre-exploitation phase for various energy carriers (e.g. geothermal drilling in Germany).

A2.2 Fiscal measures

Fiscal measures are measures that use existing tax systems to give preferential treatment to a certain energy carrier, energy technology or energy user. Special tax credits, deductions, exemptions and allowances related to the overall scheme of energy taxes offer implicit support to energy users. In this study, a distinction is made between tax exemptions, tax allowances and earmarked refunds. In addition, we differentiate between tax allowances and exemptions of energy taxes and special provisions made for other taxes (e.g. profit tax) related to the use of energy.

Energy tax exemptions

Energy tax exemptions are special exclusions and deductions on energy taxes for a predefined group

of users or energy carriers. For governments, they represent a loss in tax revenues. Energy tax exemptions are normally applied for specific purposes such as preserving the competitiveness of energy intensive industries. Some countries (e.g. Ireland) have specific energy tax exemptions for households. Preferential tax treatments for specific users are also part of the group of tax exemptions.

Energy tax exemptions may define either a reduced rate or a zero rate for certain groups, so that these groups do not have to pay energy taxes. Such exemptions exist (e.g. LPG in Belgium), but they are quite specific exemptions allowed under the 2003 Energy Taxation Directive (2003/96/EC). Exemptions of VAT on the use of energy have been included here as a form of energy tax exemption, as long as this is not treated uniformly across all users of energy. Exemptions to CO₂ taxes have been included in the database as energy tax exemptions. Also, other pollution taxes applicable to one energy carrier but not another have been qualified as energy tax exemptions. Exemptions from royalty taxes for mining have also been included as energy tax exemptions. All countries provide tax exemptions to international aviation and shipping — these are not included in the database.

Energy tax exemptions do influence the marginal costs of energy use. Energy tax exemptions on electricity are in principle neutral to the competition between renewables and fossil fuel-based electricity generation.

Energy tax allowances

Tax allowances imply that on a certain proportion of a taxable good or factor of production, no taxes need to be paid. Tax allowances are sometimes used in energy taxation, and they provide a proportion of energy use that is not being taxed. As such, they consist of a transfer of income from the government to the users of energy.

Allowances to royalty taxes for mining facilities and allowances for reduced VAT rates up to a certain consumption level of energy have been included here as a form of energy tax allowance.

In general, tax allowances alter the average costs of energy use without influencing the marginal costs. As such, they may be established to mitigate adverse income distribution impacts from energy taxation. Because they do not alter the marginal

costs of energy use, they are neutral with respect to competition between energy carriers. Generally speaking, it was difficult to distinguish energy tax exemptions from energy tax allowances in the database, given the available information, and given the time and budget allocated for this project. In many cases, it could not be discerned if the tax was implied as a reduced rate for specific users, or if it was implemented as a tax-free allowance up to a certain limit.

Earmarked refunds

Some countries (e.g. Austria, Spain, and Switzerland) have not installed tax exemptions for specific users, but rather use a refund scheme. Such refunds are available under specific conditions.

When applied to a refund of energy taxes, earmarked refunds do influence the costs of energy use. Energy tax refunds on electricity are in principle neutral as relates to the competition between renewables and fossil fuel-based electricity generation.

Other tax deductions

A special form of fiscal measure are the deductions (exemptions or allowances) given on other taxes because of the production of certain energy carriers. This mostly relates to investment support, where for example, part of the investment can be depreciated faster as a means to reduce profit taxes. Also, special treatment of energy producers as regards profit taxes may be considered to be fiscal measures.

Special tax deductions generally tend to influence the average costs of production and not the marginal costs, although this should be investigated in more detail, on a case-by-case basis.

Moreover, deductions from social security (or pension) payments have been classified as 'other tax deductions', despite not being literally equivalent to a tax.

A2.3 Transfer of risk to the government

Transfer of risk can occur if the state is taking over (part of) the risk of energy production. It may take the form of state guarantees for private investors so that they can borrow at more favourable conditions from banks. It may also mean taking over insurances in case of accidents, as with nuclear facilities ⁽⁴⁹⁾.

⁽⁴⁹⁾ The EU is currently assessing its role in insurance and compensation of damages caused by accidents of nuclear power plants (nuclear liability). For example, the need for common rules is explored. See http://ec.europa.eu/energy/nuclear/consultations/20130718_powerplants_en.htm.

For example, in the Czech Republic, the risk of cleaning up mining facilities has been transferred to the state. However, if these transfers of risk involve annual payments from the state budgets, they are considered to be direct support in the project database. It is only when the transfer of risk leads to irregular claims on (future) state budgets that it is included in the inventory as transfer of risk. One should bear in mind that the distinction between what is considered direct support and what is considered a transfer or risk is somewhat arbitrary.

In the database, the transfer of risk measures has been categorised into adjustment aids or inherited liabilities.

a. Adjustment aid

Adjustment aid is temporary support allocated with the purpose of transforming certain problematic sectors into viable and sustainable economic sectors. Adjustment aid might be targeted at eliminating overcapacity or reducing environmentally harmful practices in extraction industries, for example. Adjustment aid will always be under scrutiny of the State Aid Guidelines in EU Member States. Such an adjustment aid was allowed for the coal mining facilities. Coal support in EU Member States needs to be phased out by 2018 according to the EU State Aid Guidelines, though support covering exceptional expenditures related to the closure of mines can still be given until 2027 (Council Decision 16229/1/10 + COR 1).

b. Inherited liabilities

Inherited liabilities refer to companies that used to be owned by the state, and were subsequently privatised. During the privatisation process, certain liabilities (e.g. clean-up of environmental damages) may be transferred to the state.

A2.4 Other financial measures

A number of measures have been classified in the database as other financial measures.

These measures relate mostly to the following.

- Net metering, which is an electricity policy for consumers who own small-scale renewable energy facilities (mostly solar), where the owner receives retail credit for at least a portion of the

electricity they generate. Rules differ widely between countries.

- Tax benefits that exist for consumers who put their savings in a green fund. This enables the banks to offer loans at lower interest rates to 'green' projects. If renewable projects are eligible under these funds, such support is included in the inventory as an 'other financial measure'.
- Policies that regulate prices of energy by putting certain maximum levels on prices that energy suppliers or net operators can charge.

A2.5 Non-financial measures

Non-financial support measures relate to mandates, obligations and (voluntary) agreements that have been settled between the government and producers and consumers of energy.

Three categories are distinguished here.

a. Quota obligations

Some countries have established quota obligations for producers or consumers of renewables. In the energy production sector, the quota is linked to a specific target. For biofuels, the quota represents the obligatory minimum share of these fuels in petrol and diesel.

b. Priority grid access

Many countries have rules that oblige grid operators to give priority access to renewable energy plants. Grid operators have also an obligation to connect to and to expand the grid, should the connection of a plant require this expansion.

Rules regarding the connection of cooling/heating networks have been considered in the inventory as priority grid access measures, and are already in place in Lithuania, for example.

c. Other measures

This category refers to (voluntary) agreements that have been made in relation to the production and consumption of energy. These might be agreements with market participants about accelerating R&D in the energy sector, but also they might take the form of provision of free coal to coalminers in Slovakia and Turkey, for example.

Annex 3 Data and methodological challenges

A3.1 Data development

Data collection has been cumbersome, particularly for fossil fuel and nuclear support. One of the most important and very useful sources of information for these areas is the OECD databases on fossil fuel support (OECD-TADFFSS). They are based on data which OECD member countries report to the OECD Secretariat.

There are, however, certain limitations to this database: for example, there is a lack of common definitions for energy tax exemptions and allowances. This means that countries may be referring to dissimilar types of support when reporting such measures to the OECD. In addition, many countries do not view the differentiation between taxes on diesel and petrol as a support; Sweden is an exception, and has reported this to the OECD Secretariat as a form of support. In the United Kingdom, the excise exemption of fossil fuels for heating purposes is not part of the OECD database, even though this is quite a substantial support.

In this study, such measures have only been included if they have been reported as a support to the OECD Secretariat or were included in one of the other sources of information used. No attempt was made to estimate this type of support, except in the case of the four target countries (the Czech Republic, the Netherlands, Spain and Switzerland).

Another issue is that many categories of support measures seem to be absent in the OECD database. One example is the United Kingdom's excise tax exemption for heating fuels.

The same applies to renewables. While the overview of renewable energy support measures overall seems to be more complete than for fossil fuel support, some support measures, like transfer of risk for geothermal drilling, are poorly covered by the RES-Legal database. Additional sources of

renewable energy support have been investigated only for the four countries in the case studies.

The link between energy support, innovation and wider economic benefits is also difficult to investigate because of poor data quality. Two indicators that are usually used to measure success in innovation are patent applications that have been granted and R&D expenditures. While useful for understanding some aspects of the innovation process, these two indicators have their drawbacks when used in the context of economic benefits. The number of patent counts, as a measure of technology output, has been widely used in the scientific literature on innovative activities.

Apart from the obvious statistical problems (e.g. the country where the patent application was submitted may differ from the country where the invention took place⁽⁵⁰⁾), there is no information regarding the (expected) economic value of these patents (Dernis and Kahn, 2004). In other words, by counting the number of patents, each patent has the same value when constructing the indicator. Therefore, such an indicator is ill suited to assess a patent's contribution to economic activities.

International trade and comparative advantages pose another challenge in linking renewable deployment with innovation and with wider economic benefits. In a single European market, it might be expected that due to economies of scale, some countries will specialise in production of renewable energy technologies, while others will specialise in other products (e.g. food products). Trade assures that the most efficient allocation for production specialisation will be realised. If each country that supports renewable energies does this with the goal of stimulating its own national industries, total welfare and economic growth in the EU will drop, because economies of scale and learning effects will be insufficiently realised. This applies on a global scale. Hence, the creation of a national renewable industry and employment

⁽⁵⁰⁾ The indicators on patent applications under the PCT are based on inventors' addresses; this is a problem as the inventor may reside in one country, while the patent is owned by the headquarters of an enterprise in another country.

cannot be the prime policy objective for all countries.

In principle, such impacts could be investigated by taking into account trade statistics, which may also provide information on the development of cost structures over time. However, current trade statistics on renewable energy technologies are poor and incomplete (⁵¹).

A3.2 Data collection

In general the collection of data on energy support measures has been cumbersome. For the four target countries investigated in more detail, additional sources of information have been explored.

Comparing the information collected for the target countries with the information available in literature for all 32 EEA countries, leads to the following observations:

Coverage of support for renewable energy is much better than the one for fossil fuels and nuclear. Past support however it is difficult to discern from the RES-Legal database used.

- Coverage of nuclear support has been poor. In general, there is not much detailed and public information available that allows a summary of the various support schemes that exist for nuclear energy.
- Coverage of R&D support is also poor. Although virtually every country provides public support for R&D activities on energy technologies, and quantitative information is available for most countries in the IEA database, the OECD and RES-Legal databases identify only 11 measures in 6 countries that are related to R&D support.
- Coverage of energy tax exemptions, allowances and rebates is fair, but suffers from the lack of a common definition — most likely, countries will differ in the tax provisions they submit to the OECD Secretariat as support. Many countries do not regard the differentiation between taxes on diesel and petrol as a form of support.
- Coverage of provisions specific to the hydrocarbon industry and electricity producers has been poor. Both the hydrocarbon industry and the power production sector may also profit

from numerous specific provisions related to profit taxes, social security funds, etc. and these have not been very well documented. A comparison of information available in the Ernst and Young tax report (Ernst and Young, 2013) with that of the OECD-TADFFSS database showed that many omissions exist. The full inclusion of information from the Ernst and Young tax report in the database proved to be outside the scope of the present study, but should be the subject for future work.

- Coverage of policy measures related to the regulation of capacity mechanisms has been poor.

A3.3 Methodological choices related to the scope of the report

This report called for a number of methodological choices to be taken: these are discussed further in this section.

For example, not all relevant support measures have been included in the database, due to time and budget limitations of this project (in addition to those mentioned in Section 4.6 in the main text of the report). In particular, support measures related to soft loans (e.g. under the European Investment Bank regimes) and the numerous examples of specific fiscal treatment of, for instance, profit taxes for the fossil fuel-based sector (that could be labelled as specific support) have not been fully captured in this study. Further work will be needed to complete the picture, by including, for example, measures from the EU State Aid database. On the other hand, there are also measures included in the database elaborated for this project that are not included in the OECD database. These include an overview of support to nuclear energy, overviews of support to renewable energy, additional sources of information from the literature, regarding, for instance, specific provisions to hydrocarbon industries in Denmark, and support measures that have been identified in the (national) literature for the four countries of the case studies.

The number of measures in place in certain countries are being counted and differentiated among the various energy carriers. In order to avoid double-counting, an individual measure (e.g. a tax exemption) that benefits both coal and

⁽⁵¹⁾ In the COMTRADE database, renewable energy technologies are not individually identified in the SITC classification. For example, solar PV is grouped together with light emitting diodes (SITC 77637), and for wind energy, only the generating sets are (together with battery operated emergency sets, for instance) part of SITC (71652). Rotor blades are in yet another category.

natural gas was split between the two energy carriers using a weighting factor. Both energy carriers were treated equally. This approach was necessary in order to make the information in the graphs consistent with the total number of support measures identified in this report.

There are some differences in the way the four target countries have been treated in this report, particularly with respect to fossil fuel support and biofuels. The reasons for this are explained below.

First, countries diverge in the support that they report to the OECD Secretariat. For example, in its reporting to the OECD Secretariat, Spain includes tax exemptions related to domestic aviation, waterways and railways. Such figures are not mentioned by the other countries, and no estimates for such support could be made. Biofuels support takes the form of mandatory obligations in the Czech Republic, the Netherlands and Spain and the form of tax exemptions in Switzerland. While tax exemptions were quantified as a support measure in this report, mandatory obligations have not been quantified, even though they tend to raise prices for consumers. Secondly, in the case of the Netherlands, the existing literature on energy support measures (Ecofys and CE Delft, 2011; ESM, 2005; van Beers et al., 2002) reported highly decreasing taxation rates for electricity and natural gas as a support. Therefore, in the present report, this measure was considered as support despite not being officially reported to the OECD as such. Moreover, none of the other countries reported such measures as support to the OECD, and in the absence of relevant literature, such measures were not considered as support in the present report for the other countries. Therefore, caution is advised when comparing the amount of energy support across the four countries.

A3.4 Country selection criteria

The four target countries studied in detail in this report were selected using seven criteria:

- using FITs and/or FIPs after 2005;
- representing geographical spread, i.e. northern/central Europe, southern Europe, and central/eastern Europe;

- being at different stages of progress in reaching their renewable 2020 target (evaluated in 2013 at the start of the project);
- having different innovation performances, in particular in the renewable energy sector;
- having different economic structures, in particular with respect to industrial performance;
- having a different energy mix;
- having different drivers for renewable development (EU vs non-EU);
- voluntary expressions of interest from the countries, to be included in the report.
- Selection criterion: availability of feed-in tariffs/premiums

Selection criterion: geographical diversity

Geographical diversity would have to be ensured by choosing at least one country in each of the following groups.

- **Group I** representing northern/central Europe: Belgium, Denmark, Germany, Ireland, Luxembourg, **the Netherlands**, Austria, Finland, the United Kingdom or **Switzerland**.
- **Group II** representing southern Europe: Greece, **Spain**, France, Cyprus, Malta or Portugal.
- **Group III** representing central/eastern Europe: Bulgaria, **the Czech Republic**, Estonia, Latvia, Lithuania, Poland, Romania, Slovenia or Slovakia.

Selection criterion: progress on renewable energy targets in 2013⁽⁵³⁾

The Commission's *Renewable energy progress report* (EC, 2013a) published in March 2013 assesses Member States' progress in reaching their 2020 RES targets.

Selection criterion: Innovation performance

The selection of EEA member countries with differences in their innovation performance will help to identify key factors for a sustained innovation process for renewable energy sector. For this purpose, two data sources were used: the European Commission's Innovation Union Scoreboard 2013⁽⁵⁴⁾ and the OECD patents database.

⁽⁵³⁾ A more updated picture on progress made towards renewable targets is included in Chapter 1 of this report. Here it was important to present the situation as it was in 2013 when the project started.

⁽⁵⁴⁾ Innovation Union Scoreboard 2013.

Table A3.1 Countries with a feed-in tariff/premium, 2013, EEA-32

EEA member country	FIT/FIP
Belgium	X
Bulgaria	X
Czech Republic	X
Denmark	X
Germany	X
Estonia	X
Ireland	X
Greece	X
Spain	X
France	X
Italy	X
Cyprus	X
Latvia	X
Lithuania	X
Luxembourg	X
Hungary	X
Malta	X
Netherlands	X
Austria	X
Poland	
Portugal	X
Romania	
Slovenia	X
Slovakia	X
Finland	X
Sweden	
United Kingdom	X
Norway	
Lichtenstein	n/a
Switzerland	X
Iceland	n/a
Turkey	X

Note: n/a indicates that no data were available. Selected countries have been printed in bold

The OECD patent database (⁵⁵) can be used to focus on one of the key indicators among the top-performing countries in the renewable energy sector.

Selection criterion: industrial performance
With respect to the industrial performance of EU EEA member countries, an industrial performance scoreboard was published by the

European Commission in 2012 (EC, 2012). The scoreboard assessed EU Member States according to their performance in five areas: manufacturing productivity, export performance, innovation and sustainability, business environment and infrastructure, and finance and investment. Member States are clustered in three groups: 'consistent performers', 'uneven performers' and 'catching-up'.

(⁵⁵) See <http://www.oecd.org/sti/inno/oecdpatentdatabases.htm>.

Annex 3

Table A3.2 Progress made towards RES targets, EU-27

	2005 RES share	2010 RES share	1st interim target	2020 RES target
Austria	23.3 %	30.1 %	25.4 %	34 %
Belgium	2.2 %	5.4 %	4.4 %	13 %
Bulgaria	9.4 %	13.8 %	10.7 %	16 %
Cyprus	2.9 %	5.7 %	4.9 %	13 %
Czech Republic	6.1 %	9.4 %	7.5 %	13 %
Germany	5.8 %	11.0 %	8.2 %	18 %
Denmark	17 %	22.2 %	19.6 %	30 %
Estonia	18 %	24.3 %	19.4 %	25 %
Greece	6.9 %	9.7 %	9.1 %	18 %
Spain	8.7 %	13.8 %	10.9 %	20 %
Finland	28.5 %	33 %	30.4 %	38 %
France	10.3 %	13.5 %	12.8 %	23 %
Hungary	4.3 %	8.8 %	6.0 %	13 %
Ireland	3.1 %	5.8 %	5.7 %	16 %
Italy	5.2 %	10.4 %	7.6 %	17 %
Lithuania	15 %	19.7 %	16.6 %	23 %
Luxembourg	0.9 %	3 %	2.9 %	11 %
Latvia	32.6 %	32.6 %	34.0 %	40 %
Malta	0 %	0.4 %	2.0 %	10 %
Netherlands	2.4 %	3.8 %	4.7 %	14 %
Poland	7.2 %	9.5 %	8.8 %	15 %
Portugal	20.5 %	24.6 %	22.6 %	31 %
Romania	17.8 %	23.6 %	19.0 %	24 %
Sweden	39.8 %	49.1 %	41.6 %	49 %
Slovenia	16.0 %	19.9 %	17.8 %	25 %
Slovakia	6.7 %	9.8 %	8.2 %	14 %
United Kingdom	1.3 %	3.3 %	4.0 %	15 %
EU	8.5 %	12.7 %	10.7 %	20 %

Notes: Green indicates that countries overachieved their first interim target by more than 2 percentage points.

Yellow indicates that countries came close to their target, and either missed their interim target by less than 1 percentage point, or overreached the target by less than 2 percentage points.

Orange indicates that countries did not meet the interim target.

Source: EC, 2013a, p. 15.

Table A3.3 EU Innovation Scorecard 2013

EEA member countries	
Innovation leaders	Denmark, Finland, Germany, Sweden, Switzerland
Innovation followers	Austria, Belgium, Cyprus, Estonia, France, Ireland, Luxembourg, Netherlands , Slovenia, United Kingdom, Iceland
Moderate innovators	Czech Republic , Greece, Hungary, Italy, Lithuania, Malta, Portugal, Slovakia, Spain , Norway
Modest innovators	Bulgaria, Latvia, Poland, Romania, Turkey

Source: EC, 2013a and 2013b.

Table A3.4 Overview of the industrial performance indicator

	Northern/central Europe	Southern Europe	Central/eastern Europe
'Consistent performers'	Germany, Denmark, Finland, Austria, Ireland, Netherlands , United Kingdom, Belgium	France	
'Uneven performers'	Luxembourg	Spain , Portugal, Greece, Cyprus	Estonia, Slovenia
'Catching-up'			Bulgaria, Czech Republic , Hungary, Slovakia, Latvia, Lithuania, Romania, Poland

Note: Based on the criteria described above, the following countries were selected as target countries for this report: the Czech Republic, the Netherlands, Spain and Switzerland.

European Environment Agency

**Energy support measures and their impact on innovation
in the renewable energy sector in Europe**

2014 — 69 pp. — 21 x 29.7 cm

ISBN 978-92-9213-507-2
doi:10.2800/25755

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