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Renewable energy in Europe 2016

Recent growth and knock-on effects

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Acronyms, abbreviations, units and terms

CCS	Carbon capture and storage
CHP	Combined heat and power
CRF	Common reporting format
CSP	Concentrated solar power
EEA	European Environment Agency
EED	Energy Efficiency Directive (Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC)
ENTSO-E	European Network of Transmission System Operators for Electricity
EPBD	Energy Performance of Buildings Directive (Directive 2010/31/EU on the energy performance of buildings)
ETC/ACM	European Topic Centre on Air Pollution and Climate Change Mitigation. The ETC/ACM is a consortium of European institutes contracted by the EEA to carry out specific tasks in the field of air pollution and climate change.
ETS	Emissions Trading Scheme
EU	European Union
EU-28	Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovenia, Slovakia, Spain, Sweden, United Kingdom
GFEC	Gross final energy consumption means the energy commodities delivered for energy purposes to industry, transport, households, services including public services, agriculture, forestry and fisheries, as well as the consumption of electricity and heat by the energy branch for electricity and heat production and including losses of electricity and heat in distribution and transmission (see Article 2(f) of Directive 2009/28/EC). With this, it excludes transformation losses, which are included in GIEC. In calculating a Member State's GFEC for the purpose of measuring its compliance with the targets and interim Renewable Energy Directive (RED) and National Renewable Energy Action Plan (NREAP) trajectories, the amount of energy consumed in aviation shall, as a proportion of that Member State's gross final consumption of energy, be considered to be no more than 6.18 % (4.12 % for Cyprus and Malta).
GHG	Greenhouse gas
GIEC	Gross inland energy consumption, sometimes abbreviated as gross inland consumption, is the total energy demand of a country or region. It represents the quantity of energy necessary to satisfy inland consumption of the geographical entity under consideration.

GW	Gigawatt
IEA	International Energy Agency
ILUC	Indirect land-use change, in the context of Directive (EU) 2015/1513 of the European Parliament and of the Council, of 9 September 2015, amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources.
ktoe	Kilotonne of oil equivalent
LULUCF	Land use, land use change and forestry — a term used in relation to the forestry and agricultural sector in the international climate negotiations under the United Framework Convention on Climate Change
Mtoe	Million tonne of oil equivalent
MW	Megawatt
MWh	Megawatt-hour (1 million watt-hours)
NREAP	National Renewable Energy Action Plan
PE	Primary energy: in the context of the EED, this represents GIEC minus n on-energy use
OECD	Organisation for Economic Co-operation and Development
PR	Progress report
PV	Solar photovoltaic energy
R&D	Research and development
RED	Renewable Energy Directive (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)
RES	Renewable energy sources
RES-E	Renewable electricity
RES-H&C	Renewable heating and cooling
RES-T	Renewable energy consumed in transport
SHARES	Short Assessment of Renewable Energy Sources. Tool developed by Eurostat and aimed at facilitating the calculation of the share of energy from renewable sources according to the RED.
SPF	Seasonal performance factor
TPES	Total primary energy supply

Geographical coverage in Chapter 3

The presentation of the global picture in Chapter 3 follows as far as possible the geographic coverage and regional aggregation used by the International Energy Agency. For investments, the aggregation used by Bloomberg New Energy Finance (Bloomberg, 2015) was used, given that a finer corresponding aggregation was not available.

Africa	Includes Algeria; Angola; Benin; Botswana (from 1981); Cameroon; Congo; Côte d'Ivoire; Democratic Republic of the Congo; Egypt; Eritrea; Ethiopia; Gabon; Ghana; Kenya; Libya; Mauritius; Morocco; Mozambique; Namibia (from 1991); Niger (from 2000); Nigeria; Senegal; South Africa; South Sudan; Sudan *; United Republic of Tanzania; Togo; Tunisia; Zambia; Zimbabwe and Other Africa. Other Africa includes Botswana (until 1980); Burkina Faso; Burundi; Cape Verde; Central African Republic; Chad; Comoros; Djibouti; Equatorial Guinea; The Gambia; Guinea; Guinea-Bissau; Lesotho; Liberia; Madagascar; Malawi; Mali; Mauritania; Namibia (until 1990); Niger (until 1999); Réunion; Rwanda; São Tomé and Príncipe; Seychelles; Sierra Leone; Somalia; Swaziland; and Uganda * South Sudan became an independent country on 9 July 2011. From 2012 onwards, data for South Sudan have been reported separately.
Americas	Consisting of OECD Americas (Canada, Chile, Mexico and the United States) and non-OECD Americas (Argentina; Bolivia; Brazil; Colombia; Costa Rica; Cuba; Curaçao *; Dominican Republic; Ecuador; El Salvador; Guatemala; Haiti; Honduras; Jamaica; Nicaragua; Panama; Paraguay; Peru; Trinidad and Tobago; Uruguay; Venezuela; and Other non-OECD Americas. Other non-OECD Americas includes Antigua and Barbuda; Aruba; Bahamas; Barbados; Belize; Bermuda; British Virgin Islands; Cayman Islands; Dominica; Falkland Islands (Islas Malvinas); French Guiana; Grenada; Guadeloupe; Guyana; Martinique; Montserrat; Puerto Rico (for natural gas and electricity); Saint Kitts and Nevis; Saint Lucia; Saint Pierre and Miquelon; Saint Vincent and the Grenadines; Suriname; Turks and Caicos Islands; Bonaire (from 2012); Saba (from 2012); Saint Eustratius (from 2012); and Sint Maarten (from 2012). * Netherlands Antilles was dissolved on 10 October 2010, resulting in two new constituent countries, Curaçao and Sint Maarten, with the remaining islands joining the Netherlands as special municipalities. In this edition, the methodology for accounting for the energy statistics of Netherlands Antilles has been revised in order to follow the above-mentioned geographical changes. From 2012 onwards, data account for the energy statistics of Curaçao only. Prior to 2012, data remain unchanged and still cover the entire territory of the former Netherlands Antilles.
ASOC	Asia and Oceania, including OECD Asia and Oceania (Australia, Israel, Japan, South Korea and New Zealand) and Asia (Bangladesh; Brunei; Cambodia (from 1995); India; Indonesia; North Korea; Malaysia; Mongolia (from 1985); Myanmar/Burma; Nepal; Pakistan; Philippines; Singapore; Sri Lanka; Chinese Taipei; Thailand; Vietnam; and Other Asia. Other Asia includes Afghanistan; Bhutan; Cambodia (until 1994); Cook Islands; Fiji; French Polynesia; Kiribati; Laos; Macau, China; Maldives; Mongolia (until 1984); New Caledonia; Palau (from 1994); Papua New Guinea; Samoa; Solomon Islands; Timor-Leste; Tonga; and Vanuatu).
CIS	Commonwealth of Independent States: Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.
Other Europe and CIS	Albania; Andorra; Armenia; Azerbaijan; Belarus; Bosnia and Herzegovina; Channel Islands; Georgia; Iceland; Isle of Man; Kazakhstan; Kosovo *; Kyrgyzstan; Liechtenstein; the Former Yugoslav Republic of Macedonia; Moldova; Monaco; Montenegro; Norway; Russia; San Marino; Serbia; Switzerland; Tajikistan; Turkey; Turkmenistan; Ukraine; and Uzbekistan. * Under United Nations Security Council Resolution 1244/99.
Middle East	Bahrain; Islamic Republic of Iran; Iraq; Jordan; Israel; West Bank Gaza; Kuwait; Lebanon; Oman; Qatar; Saudi Arabia; Syrian Arab Republic; United Arab Emirates and Yemen.

Executive summary

Background and policy

The development of a resilient Energy Union with a forward-looking climate policy is one of the strategic objectives of the European Union (EU). To encourage the transition to a more secure, affordable and decarbonised energy system the EU adopted climate and energy targets for 2020 and 2030 together with a long-term goal to reduce EU-wide greenhouse gas (GHG) emissions by 80–95 % below 1990 levels by 2050 (European Council, 2009). Meeting these objectives will require switching to low-carbon energy sources and mastering our energy demand through energy and resource efficiency improvements and through lifestyle changes.

Renewable energy sources (RES) are already a main contributor to this energy transition. Compared with fossil fuel alternatives they have a high GHG mitigation potential as well as lower health and environment impacts. Increasing the use of renewables during the coming years will bring considerable benefits in terms of green jobs and growth. This could well prove decisive as Europe strives to become a sustainable, low-carbon economy by 2050.

This report complements the findings shown in the *Trends and Projections in Europe 2015 — Tracking progress towards Europe's climate and energy targets* report (EEA, 2015b) with details about the 2013 RES progress at EU and at country level, and for key RES technologies. Furthermore, it provides approximated estimates for RES development in 2014 and seeks to answer the following key questions:

- Which fossil energy sources were substituted by the growth of RES consumption since 2005 and what would have been their GHG emissions?
- How do European RES developments compare against renewable energy transformations occurring in other parts of the world?

Key findings

RES progress

EEA calculations show that the EU-wide share of renewable energy in final EU energy use has increased from 14.3 % in 2012 to 15.0 % in 2013. The EEA approximated RES estimate for 2014 – as calculated in August 2015 – indicates that the EU RES share continued to grow, reaching 15.2 % in 2014. Recent information from Eurostat confirms this growth and illustrates that the actual EU-wide RES share grew even stronger than anticipated by the EEA, reaching 16.0 % in 2014. This progress enabled the EU to be on track with the indicative trajectory in the Renewable Energy Directive, as well as with the expected trajectory from the National Renewable Energy Action Plans (NREAPs) adopted by countries.

At Member State level the RES shares vary widely, ranging from over 30 % of gross final energy consumption in countries such as Finland, Latvia and Sweden, to less than 5 % in Luxembourg (3.6 %), Malta (3.8 %) and the Netherlands (4.5 %). In 11 countries, renewable energy consumption in 2013 was below what was expected in their NREAPs. Almost half of all countries will need to increase their growth rate post-2013 to reach the expectations for 2020 as set out in their NREAPs.

In 2013, renewable heating and cooling continued to be the dominant RES market sector in Europe, representing over half of all gross final consumption of renewables in 18 Member States. Solid biomass-based technologies are still predominant in this sector, but the fastest compound annual growth rates since 2005 were recorded by biogas, heat pumps and solar thermal technologies. The renewable electricity market sector grew fastest in 2013, driven by sustained growth especially in the onshore wind and solar photovoltaic (PV) power technologies. In contrast to the heating and cooling sector, renewable electricity represented more than half of all RES consumption in only five Member States (Croatia, Ireland, Portugal, Spain and the United Kingdom). The contribution of renewable energy in transport varied from a maximum of 48 % of all RES consumption (Luxembourg) to 1 % or less (Estonia, Portugal and Spain). The consumption of biofuels in transport has slowed and more or less stalled since 2010, with 2013 being the first year in which the total consumption of biofuels decreased compared to previous years since 2005.

Effects on energy consumption and GHG emissions
The increased consumption of renewable energy sources has also been beneficial in other areas: EU and national progress towards the RES target since 2005 means that RES have effectively displaced fossil fuels. In this way it has complemented the adopted climate mitigation policies and has improved overall energy security.

The additional consumption of renewable energy, compared to the level of consumption in 2005, allowed the EU to cut its demand for fossil fuels by 110 Mtoe in 2013 (equivalent to almost one tenth of all fossil fuels used across the EU in 2013, and comparable to the fossil fuel consumption of France in that year), and by an estimated 114 Mtoe in 2014 respectively. Coal was the fuel most substituted by renewables across Europe in 2013 and 2014 (roughly 45 % of all avoided fossil fuels), followed by natural gas (roughly 29 % of all avoided fossil fuels). The latter is particularly relevant in the context of declining EU gas resources and increasing geopolitical risks. The reduction of petroleum products and related fuels was less pronounced due to the lesser share of renewable energy use in the transport sector.

The growth in the consumption of renewable energy after 2005 helped the EU achieve an estimated gross reduction of CO_2 emissions of 362 Mt in 2013 and 380 Mt in 2014 – an amount that is equivalent to the yearly GHG emissions of Poland. Three quarters of these effects have taken place in energy-intensive industrial sectors under the EU Emissions Trading Scheme (ETS), where the increase in renewable electricity decreased the need for the most carbon-intensive fossil fuels. Overall, the gross avoided CO_2 emissions corresponded to a 7 % reduction in total EU GHG emissions in 2013, increasing to an estimated 9 % in 2014.

In absolute terms, Germany, Italy and Spain achieved the largest reduction in domestic fossil fuel use *and* avoided GHG emissions, as a result of national RES deployment since 2005. In relative terms, Sweden, Denmark and Austria substituted the most fossil fuels and were able to avoid the most GHGs in proportion to their total domestic fossil fuels use and their national GHG emissions.

Statistically, the increase of the RES share since 2005 resulted in a 2 % EU-wide reduction in primary energy consumption in 2014. This is due to the existing definitions and accounting rules in use for energy statistics. It is worth highlighting that statistically some technologies led to a relatively large decrease of primary energy use (e.g. wind power and solar PV), while others led to an increase (e.g. solid biomass use, geothermal energy). The interplay between RES technologies and primary energy is also relevant for the Member States in the context of national efforts to meet their energy efficiency targets by 2020.

Measured as a share of total research and development (R&D) expenditures, growth in RES funding across 15 Member States (the only data available at the time of writing) increased slowly, from 20.2 % in 2005 to 26.8 % in 2013, while energy efficiency and transmission and storage technologies have benefitted more from a net increase in funding. Clearly improvements in efficiency, transmission, and storage will be important elements of the energy transition. However, the fact that RES R&D funding is stagnating hints at a potential to lose out on the breakthrough technologies of tomorrow. In this context the International Energy Agency has recommended the tripling of current R&D spending on clean-energy innovation.

RES developments: a global perspective
The EU has contributed signficantly to the worldwide demonstration and commercialisation of progressive renewable energy technologies such as solar PV and wind power. In 2014, the EU-28 had the largest installed and connected solar PV capacity in the world (three times more than China) and the largest wind power capacity globally. The pace of development of these technologies has picked up since 2010 also in other parts of the world.

Since 2005 the EU has led the way in funding the development of RES. During the period 2005–2012 Europe (EU-28 and CIS, the only aggregation for which data was available at the time of writing) recorded the highest share in total new global investments in RES, surpassed only by China since 2013. Europe's share of investments in renewable energy fluctuated between 40–50 % until 2011, highlighting its pioneering role in encouraging the growth of renewable energy technologies globally.

The EU is one of the key global players with regard to employment in the renewable energy sector. In 2014, it had the second highest per-capita employment in the area of renewable energy behind Brazil.

The largest employers in the EU renewables sector are the wind, solar PV and solid biomass industries. Over the past five years, job losses were experienced in the solar PV industry and in the wind power sector, as competition from China continued to grow. Despite this, renewable energy related jobs per person in the workforce in the EU-28 remain, to date, larger than in China.

1 Introduction

One of the priorities of the European Union (EU) is the creation of a resilient Energy Union with a forward-looking climate policy that is capable of delivering the adopted 2020 and 2030 climate and energy targets and the EU's longer-term climate objectives. To achieve this, Europe has to decarbonise its energy supply, integrate the fragmented national energy markets into a smooth functioning and coherent European system, and set up a framework that allows the effective coordination of national efforts (EC, 2015a). With fossil fuels accounting for roughly three-quarters of the EU's gross inland energy consumption (GIEC) in 2013, much remains to be done to achieve the envisaged transformation of the energy sector.

Renewable energy sources (RES) are important contributors to this transition, because they mitigate GHG emissions, lower environmental pressures associated with conventional energy production and reduce the reliance of fossil fuels. Other benefits associated with the growth of RES include the reduction of fossil fuel imports, the diversification of energy supply and the creation of jobs, skills and innovation in local markets and in progressive sectors with significant growth potential. In a life-cycle perspective, the environmental pressures arising from renewable energy technologies are 3–10 times lower than from fossil fuel based systems (UNEP, 2015). However, as with all industrial activities renewable energy projects too may increase health and environmental pressures, especially is project designs and technologies do not take into account local considerations (EEA, 2015c).

Developing a strong renewable energy base in Europe has implications for Europe's competitiveness and export potential.

1.1 Renewable energy targets for 2020 and 2030

As part of the climate and energy policy package for 2020 (see Box 1.1), Directive 2009/28/EC on the promotion of the use of energy from renewable sources (known as the Renewable Energy Directive, RED) commits the EU to achieving a 20 % share of renewable energy in gross final energy consumption (GFEC) by 2020 and a 10 % share of renewable energy in transport energy consumption by the same year ([1]).

The 20 % EU RES target for 2020 is split into binding national targets as shown in Figure 2.1. These national targets are set at different levels, to reflect national circumstances.

In the run-up to 2020, two interim trajectories are of particular interest in assessing EU and Member States' progress towards their binding targets.

- The minimum **indicative RED trajectories** for each country. These trajectories concern only the total RES share. They run until 2018, ending in 2020 in the binding national RES share targets. They are provided in the RED to ensure that the national RES targets will be met ([2]).
- **Expected trajectories** adopted by Member States in their National Renewable Energy Action Plans (NREAPs) under the RED. These NREAP trajectories concern not only the overall RES share but also the shares of renewables in the electricity, heating and cooling, and transport sectors up to 2020.

The EU's renewable energy target for transport, of 10 % by 2020, is divided equally into 10 % national transport targets for all countries. The RED also provides a set of options for cooperation in order to help countries achieve their targets cost-effectively.

For 2030, the European Council agreed to increase the EU's renewable energy share to at least 27 % of gross final EU energy consumption. The European Commission is in the process of preparing a renewable energy package and a policy to address the sustainability of bioenergy in the post-2020 period. These new proposals, expected in 2016, will complement the post-2030

([1]) 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 (OJ L 140, 5.6.2009, p. 16–62).
([2]) Annex I, Part B of Directive 2009/28/EC.

Box 1.1 EU renewable energy policies for 2020 and 2030

A combination of national targets and objectives has been set for each Member State regarding reductions in GHG emissions, gross final consumption of renewable energy and improvements in energy efficiency.

- Meeting the 20 % binding EU-wide renewable energy target is mandated by the RED and depends on each Member State's achievement of its national 2020 RES target.
- Under the RED country NREAP reports of 2010, Member States were required to outline the **expected trajectories** of their national RES shares from 2010 up to 2020. Countries also have to report biennially on national progress towards **indicative** RED and **expected** NREAP targets. National progress reports were submitted to the European Commission in 2011, 2013 and in December 2015.
- The RED includes a set of sustainability criteria for liquid biofuels consumed in transport. To address the negative environmental consequences of indirect land-use change caused by some types of biofuels, the RED was amended in 2015. In 2012, the European Commission proposed to limit the contribution of food-based biofuels to a maximum of 5 %. A political agreement was reached in 2015, to cap the amount of biofuels produced from energy crops grown on agricultural land to at most 7 % of all final transport energy consumption in 2020. In accordance with this agreement, Member States are to set national targets for advanced biofuels in their legislation (EU, 2015a; EU, 2015b).

Targets and trajectories for reductions in GHG emissions and for RES shares were set jointly under the 2009 climate and energy package, so the expected reductions in emissions from RES in the run-up to 2020 were taken into account when setting the GHG targets.

In addition to the legally binding targets for 2020, the EU has recently adopted an energy and climate framework for 2030. This framework sets out a target for the renewable energy share in 2030 and was adopted in late 2014 in a decision by the European Council (EU, 2014). The binding EU-wide RES target for 2030 is not accompanied by specific national targets. National plans will have to flesh out concrete measures to reach that binding EU-wide target. The Council's decision calls on Member States to agree on the governance process for their design and implementation.

Specifically, three new EU-wide commitments for climate and energy for the year 2030 include (EU, 2014):

- a binding minimum 40 % domestic reduction in GHG emissions compared with 1990 levels;
- a binding minimum 27 % share of GFEC;
- an indicative minimum 27 % improvement in energy efficiency.

national RES contributions that countries will outline within their integrated national climate and energy plans under the Energy Union, with a view of at least reaching the 27 % EU target (EC, 2015a).

1.2 About this report

1.2.1 Purpose

This report shows in detail the RES developments that have taken place in Europe since 2005. Since early access to the most recent information on the growth of RES shares is relevant for policymakers and practitioners, the report complements national data reported to Eurostat with European Environment Agency (EEA) estimates for RES developments in 2014. The report also summarises some of the benefits of growing RES consumption in Europe, and it outlines global RES developments to put the European developments in perspective. As such, the report complements the broader cross-sectoral analysis presented in the annual EEA report *Trends and projections in Europe 2015 — Tracking progress towards Europe's climate and energy targets for 2020* (EEA, 2015b).

1.2.2 RES progress reporting by the European Commission Commission's assessment of renewable energy sources

In line with legal requirements under the RED ([3]), the European Commission formally assesses the EU and Member States' progress in the promotion and use of renewable energy towards the 2020 RES targets. The European Commission publishes its assessments every two years in the form of a Commission renewable energy progress report. The most recent Communication on this topic was adopted in June 2015 (EC, 2015b). It presents historical RES developments up to 2012 (using data from Eurostat and from Member States' renewable energy progress reports of 2013), complemented by a forward-looking assessment of RES progress. Since 2015, the monitoring of progress towards the objectives of the Energy Union, including progress towards the decarbonisation of the EU energy system and economy, is being assessed under the European Commission's State of the Energy Union initiative (EC, 2015a).

1.2.3 Report structure and data

Structure

This report documents the findings of the detailed RES share assessment performed by the EEA in the context of the Trends and Projections in Europe 2015 report (EEA, 2015b). It is divided into three parts: Chapter 1 explains the context of the assessment; Chapter 2 gives an account of key RES developments at the EU level and in individual Member States and highlights certain benefits arising from the increase in RES consumption since 2005; and Chapter 3 presents global RES developments to help put the EU developments into context.

Data

This report presents primary and secondary data, aggregated in figures and tables intended to facilitate an overall assessment of RES developments. Primary data include numbers taken directly from Eurostat, the NREAPs, the country biennial progress reports (PRs), the International Energy Agency (IEA) and data obtained from other organisations and sources. Secondary data refers to data derived from the primary data. All data may have undergone changes of unit. Data sources and parameters are indicated throughout each chapter. Primary data on RES shares in GFEC are currently available for the period 2005–2013 only.

1.2.4 Scope and limitations

Approximated estimates for the share of gross final consumption of renewable energy resources (RES share proxies)

The cut-off date for most data sources incorporated in the calculation of approximated RES shares was 31 July 2015, as the RES proxies were developed for use in the Trends and Projections in Europe 2015 report that was published in October 2015 (EEA, 2015b); a limited update using Organisation for Economic Co-operation and Development (OECD) data was included at the end of November 2015. By the time of the publication of this report, **actual 2014 RES share data are also available from Eurostat (2016) and from the European Commission (2016).** These actual data have been shown in Table 2.2.

The EEA 2014 RES shares are, ultimately, estimated values. These values cannot substitute for data reported by countries. The methodology applied for approximating values of renewable energy shares in the year t-1 has been described in a previous EEA report (EEA, 2015a); the latest changes to that method are outlined in Annex 1 of the current report. Confidence in the estimated RES share proxy values is highest in the electricity sector. Dynamics in the renewable heating and cooling market sector might be underestimated because the available data are more limited in this sector. Finally, the specific accounting rules in the RED concerning renewables consumed in transport are difficult to replicate. Despite these challenges, the estimation of RES share proxies yields plausible results in most cases and should be further improved, especially if more timely information and data that are relevant for the estimations become available.

Gross avoided greenhouse gas emissions

Section 2.3 estimates the gross effects of renewable energy consumption on GHG emissions based on primary data available via Eurostat. The term **gross**

([3]) According to the RED, countries shall submit progress reports to the European Commission by the end of 2013.

avoided GHG emissions illustrates the theoretical character of the GHG effects estimated in this way, as these contributions do not necessarily represent **net GHG savings per se** nor are they based on life-cycle assessment or full carbon accounting ([4]). Section 2.3 also estimates effects on fossil fuel consumption and primary energy consumption. A detailed description of the methodology applied for approximating these effects has been described in a previous EEA report (EEA, 2015a).

Geographical scope

Owing to the limited availability of primary data, this assessment focuses on the 28 EU Member States (EU-28). In Chapter 3, renewable energy shares in primary energy supply are taken from the IEA's renewable energy and waste statistics (IEA, 2015) and aggregated into world regions for comparison. The IEA (2014) provides data for total primary energy supply (TPES) ([5]) for all energies and all renewable energies and detailed data for 13 types of renewable energies ([6]). The IEA's definition of TPES is equivalent to Eurostat's definition of GIEC. From these IEA data, renewable energy shares of GIEC were calculated for selected world regions. In specific cases, a different aggregation is shown when the corresponding IEA aggregation is not possible. For details, see the notes on geographical coverage in the list of abbreviations.

Renewable energy investments

The authors of this report have been unable to identify a central, public information source on global RES technology investments. The most comprehensive source of information regarding RES investments is Bloomberg New Energy Finance (Bloomberg, 2015). Several studies have made use of this source to give insight into the global development of investments in renewable energy technology, and these were used as sources of information for this report. The covered period is 2005–2013, and the focus is on new renewable energy investments per region for those regions included in the above-mentioned reports. Investment figures were originally supplied in nominal billion US dollars. For the purpose of this report, figures in US dollars have been converted to euros using the Eurostat dataset on exchange rates (Eurostat, 2015a). Nominal values include inflation. Comparability across regions and time therefore remains limited ([7]).

Renewable energy employment

Renewably energy deployment requires specific skills and value chains, which leads to the creation of new jobs. Jobs can be estimated using various methods with different levels of detail (see IRENA, 2015b). As data availability varies across regions and data differ in how they are generated and in their quality, a consistent time-series is not available to date. For these reasons, only a snapshot of the recent past (2014), by available region and technology, can be shown. Direct and indirect jobs related to renewable energies per region for the year 2014 are presented below and stem from (IRENA, 2015b).

Other limitations

The methods applied in this report to estimate RES impacts on energy consumption and GHGs cannot be used to assign these effects to particular drivers, circumstances or policies, other than the increased consumption of RES itself. These methodologies provide valuable insights, but, as the assumptions are static (i.e. the same set of assumptions is applied to all years in the period), assumptions need to be re-adjusted at times to reflect real-life conditions. A detailed description of the methods was given in the 2015 report (EEA, 2015a).

([4]) In the absence of specific information on current bioenergy systems, CO_2 emissions from the combustion of biomass (including biofuels/bioliquids) were not included in national GHG emission totals in this report and **a zero emission factor** had to be applied to all energy uses of biomass. This should not be interpreted, however, as an endorsement of default biomass sustainability or carbon neutrality. It should be noted that, according to United Framework Convention on Climate Change (UNFCCC) Reporting Guidelines, these emissions have to be reported separately in GHG inventories as a memorandum item (mainly to avoid double counting emissions from a reporting perspective), with the assumption being that unsustainable biomass production would show as a loss of biomass stock in the LULUCF sector and thus not in the energy sector.

([5]) In databases with a global coverage, usually only energy data on TPES — equivalent to GIEC — rather than final energy consumption are available, as the latter are more difficult to collect.

([6]) Hydroelectricity; tidal, wave and ocean energy; wind energy; solar photovoltaics; solar thermal energy; geothermal energy; biogas; biodiesel; biogasoline; other liquid biofuels; solid biofuels excluding charcoal; charcoal; and renewable municipal waste. Please note that a more detailed split of technologies is used in Chapter 2.

([7]) To adjust for inflation one would need to consider individual inflation rates — or deflators — for each of the regions. As the regions are composed of heterogeneous countries, probably experiencing different levels of inflation, it is not possible to make this conversion. This needs to be taken into account when interpreting the data.

2 RES developments in Europe

This chapter complements and deepens the assessment of the EU's and Member States' progress in the deployment of RES in the EEA's *Trends and projections* report (EEA, 2015b). We have analysed actual and approximated recent progress at the EU level and in the 28 EU Member States.

The analysis shows that:

- the EU-28 share of renewable energy increased from 14.3 % in 2012 to 15.0 % in 2013;
- EEA approximated estimates — as calculated in August 2015 and as shown further in this report — indicate that the EU RES share continued to grow in 2014 and reached 15.2 % ([8]);
- in both 2013 and 2014, the EU was on track, compared with the trajectories in the RED and the NREAPs.

The EEA approximated estimates for the RES shares shown in this report were superseded recently by the publication by Eurostat of 2014 RES shares (Eurostat, 2016). According to those data, the RES share of the EU-28 increased to 16.0 % in 2014.

The current report also estimates the gross effects of renewable energy deployment on GHG emissions, fossil fuel consumption and primary energy consumption. In 2014, the additional consumption of renewable energy, compared with the level of gross final RES consumption in 2005, allowed the EU to:

- reduce total GHG emissions by 380 Mton CO_2 equivalent to about 9 % of total EU GHG emissions;
- cut its demand for fossil fuels by 114 Mtoe (million tonnes of oil equivalent), or roughly 10 % of total EU fossil fuel consumption;
- reduce its primary energy consumption by 32 Mtoe, equivalent to a 2 % reduction of primary energy consumption across the EU.

2.1 Actual and approximated recent progress

2.1.1 Renewable energy consumption at the EU-28 level

Progress towards the 2020 target was assessed by comparing it with the interim trajectories in the RED and the NREAPs (see Figure 2.1). The RED sets minimum indicative trajectories for each country, which end in the binding national RES share targets for 2020. The NREAPs that Member States submitted in mid-2010 describe the indicative national paths to meet the 2020 RES targets and include separate estimated trajectories for electricity, heating and cooling, and transport. They are, on the whole, more ambitious than the indicative RED trajectories. The indicative and estimated trajectories enable progress to be monitored, but they become increasingly outdated as conditions and policies change ([9]). Steeper learning curves and consequent cost reductions achieved by some renewable energy technologies imply that the shares of these technologies will be higher in 2020 than those anticipated in the NREAPs. Therefore, the NREAP trajectories should be seen as 'expected pathways', rather than national targets for particular RES technologies.

Recent EEA assessments show that in both 2013 and 2014 the EU was on track compared with both trajectories for its share of gross final renewable energy consumption (EEA, 2015b).

- The indicative RED target for the EU for the years 2013 and 2014 is 12.1 %. With a share of 15.0 % in 2013, and with an estimated RES share of 15.2 % in 2014, the RES share has already surpassed the target level ([10]).

([8]) The approximations are made using a harmonised method that can be applied to all Member States using centrally available and harmonised datasets. It is not intended to be a tailor-made approach and the results need to be considered with that in mind. For details, see Section 1.2.4 and Annexes 1 and 2.

([9]) Some Member States have since updated their NREAPs. The most recent versions were used for this report.

([10]) The EEA approximated RES estimates for 2014 (the RES proxies) shown above are slightly different from the estimates included in the 2015 *Trends and projections* report (EEA, 2015b). This is because the RES proxies shown in that report were updated and now take stock of previously unavailable data.

- Based on the Member States' NREAPs, the combined EU-28 RES shares were projected to be 13.8 % in 2013 and 14.5 % in 2014.

As can be seen in Figure 2.1 and in Table 2.1, a small part of biofuel consumption could not be demonstrated to be compliant with the sustainability criteria for inclusion in the calculation for the RED. The figure shows that the RES share increases only slightly when uncertified biofuels are included in the calculation.

Figure 2.2 shows the actual and approximated RES consumption in the EU-28, as well as the consumption levels expected up to 2020 on the basis of the NREAPs. The gross final renewable energy consumption increased from 163.0 Mtoe in 2012 to 171.0 Mtoe in 2013. The RES share is calculated by dividing this RES consumption by the so-called RES denominator ([11]). Figure 2.2 shows that the final energy consumption turned out to be lower than that expected in the 'energy efficiency' scenarios in the NREAPs. This is due to a number of factors, including the lower than expected economic growth (Ecofys, 2014). Countries had to submit their NREAPs by mid-2010 and so they had to make assumptions about the speed of economic recovery after the financial crisis of 2008 ([12]).

Figure 2.1 EU-28 actual and approximated progress to interim and 2020 targets

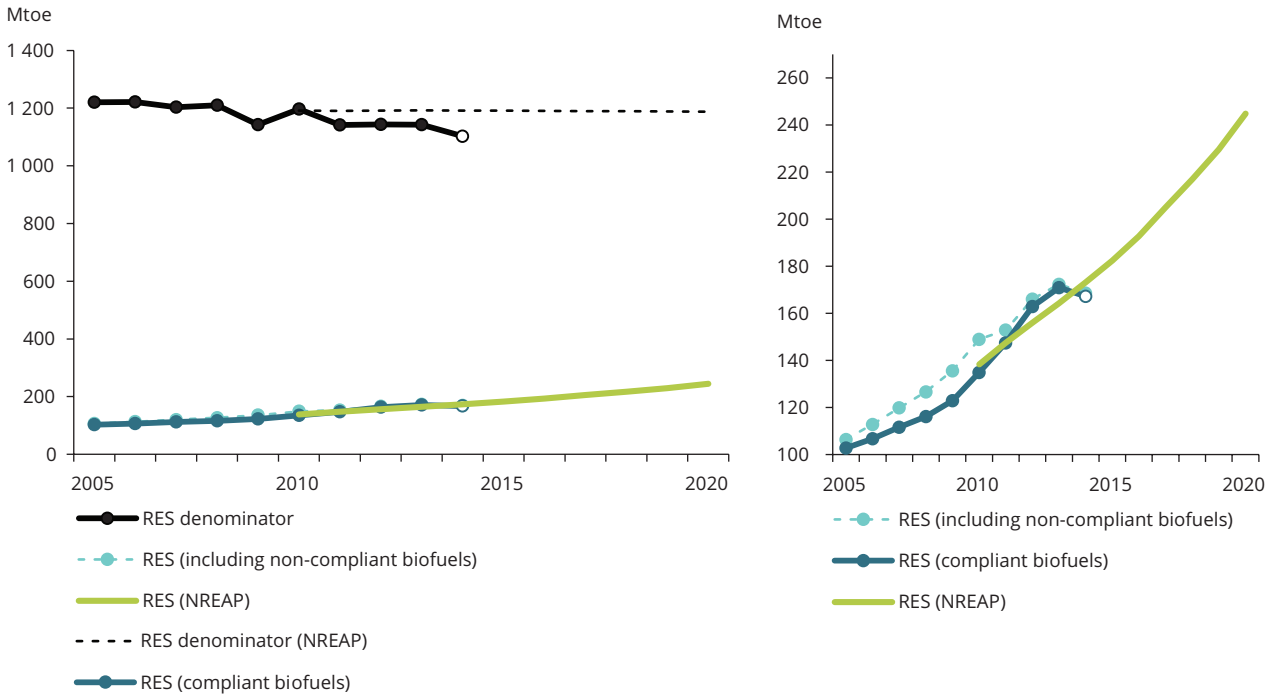
Note: The NREAP trajectory represents cumulative expected realisations according to Member States' NREAPs. For a consistent comparison across years, this figure provides separately the RES shares accounting only for biofuels complying with RED sustainability criteria and the additional RES shares due to the other biofuels. In contrast, the RES share series reported by Eurostat (2015b; SHARES Results 2013) takes into account all biofuels for the period from 2005 to 2010 and only biofuels complying with RED sustainability criteria from 2011 onwards. The RES shares for 2014 are approximated estimates.

Source: EEA (based on data from Eurostat, NREAP reports using GFEC after adjusting for aviation in the energy efficiency scenario and the Renewable Energy Directive (2009/28/EC)).

([11]) The RES denominator is equal to the total GFEC, except that a reduction is applied in case the final energy consumption for aviation is expected to be higher than 6.18 % (4.12 % for Malta and Cyprus). In the RES numerator, hydropower and wind power are normalised. Under the accounting rules in the RED, electricity generated by hydro- and wind power were normalised for annual variations (hydro for 15 years and wind for 5 years). For details on the normalisation rule, see the SHARES manual provided by Eurostat (2015b).

([12]) The real gross domestic product (GDP) growth rates in the EU-28 were 2.1 % in 2010, 1.8 % in 2011, – 0.5 % in 2012, 0.2 % in 2013 and 1.4 % in 2014. Source: Eurostat, Real GDP growth rate — volume, Percentage change on previous year, Code: tec00115.

Figure 2.2 EU-28 actual, approximated and expected RES deployment



Note: The figure on the left depicts the growth in RES consumption since 2005 against the actual total EU GFEC (i.e. RES denominator) as well as the expected total EU GFEC (i.e. RES denominator (NREAP)). The latter trajectory (dotted black line) represents the cumulative expected GFEC according to the Member States' NREAPs and is apparently higher than the actually realised consumption. The figure on the right illustrates in detail the RES trajectory since 2005. Hydropower and wind power are normalised.

Source: EEA (based on data from Eurostat and NREAP reports using GFEC after adjusting for aviation in the energy efficiency scenario).

Table 2.1 EU-28 actual and approximated progress to interim and 2020 targets

EU-28	Actual contribution			Expected NREAP trajectory			RED
	RES	RES denominator	RES share	RES	RES denominator	RES share	Indicative trajectory
	Mtoe	Mtoe	-	Mtoe	Mtoe	-	-
2005	102.9 (106.5)	1 221	8.7 %				8.7 %
2006	106.8 (112.9)	1 221	9.2 %				
2007	111.7 (119.9)	1 203	10.0 %				
2008	116.2 (126.7)	1 209	10.5 %				
2009	122.9 (135.6)	1 143	11.9 %				
2010	134.9 (149.0)	1 196	12.5 %	138.4	1 191	11.6 %	
2011	147.5 (152.9)	1 141	12.9 %	147.6	1 190	12.4 %	11.0 %
2012	163.0 (166.1)	1 144	14.3 %	156.0	1 191	13.1 %	
2013	171.0 (172.4)	1 143	15.0 %	164.3	1 192	13.8 %	12.1 %
2014	167.2 (168.6)	1 102	15.2 %	173.2	1 192	14.5 %	
2015				182.4	1 191	15.3 %	13.8 %
2016				192.8	1 190	16.2 %	
2017				205.1	1 190	17.2 %	16.0 %
2018				217.0	1 189	18.2 %	
2019				229.6	1 188	19.3 %	
2020				244.9	1 187	20.6 %	20.0 %

Source: EEA (based on data from Eurostat, NREAP reports using GFEC after adjusting for aviation in the energy efficiency scenario and the Renewable Energy Directive (2009/28/EC)). The second column shows the consumption of RES accounting only for biofuels complying with RED sustainability criteria. RES consumption accounting for all biofuels is shown in parentheses. Hydropower and wind power are normalised.

2.1.2 Renewable energy consumption in the EU-28 Member States

Figure 2.3 shows the actual RES shares in the EU Member States for 2005 and 2013 and the approximated RES shares for 2014. The RES share varies widely between Member States. In 2013, the highest shares of renewable energy were attained by Sweden (52.1 %), Latvia (37.1 %) and Finland (36.8 %). Luxembourg (3.6 %), Malta (3.8 %) and the Netherlands (4.5 %) realised the lowest shares. The figure also shows the RED target share for 2020. This overall target was differentiated for the Member States to reflect national circumstances, RES potentials and starting points.

Evaluation of trajectories and progress towards targets

To evaluate intermediate progress, the RED provides 'minimum indicative RES trajectories' for each country, formulated as average target shares for periods of two consecutive years starting with 2011–2012. The trajectories become steeper towards 2020. The indicative targets are shown in Table 2.2 and can be compared with the RES share in 2013 and the 2014 proxy estimates.

- All but three Member States have already met or exceeded their indicative RED targets for 2013–2014. Only the United Kingdom, the Netherlands and Luxembourg were still below their 2013–2014 indicative RED target.
- Twenty-one Member States have already exceeded the indicative RED target for 2015–2016, and 12 Member States have even exceeded the RED target for 2017–2018.
- Bulgaria, Sweden and Estonia are the only Member States that have managed to reach their binding 2020 RED target.

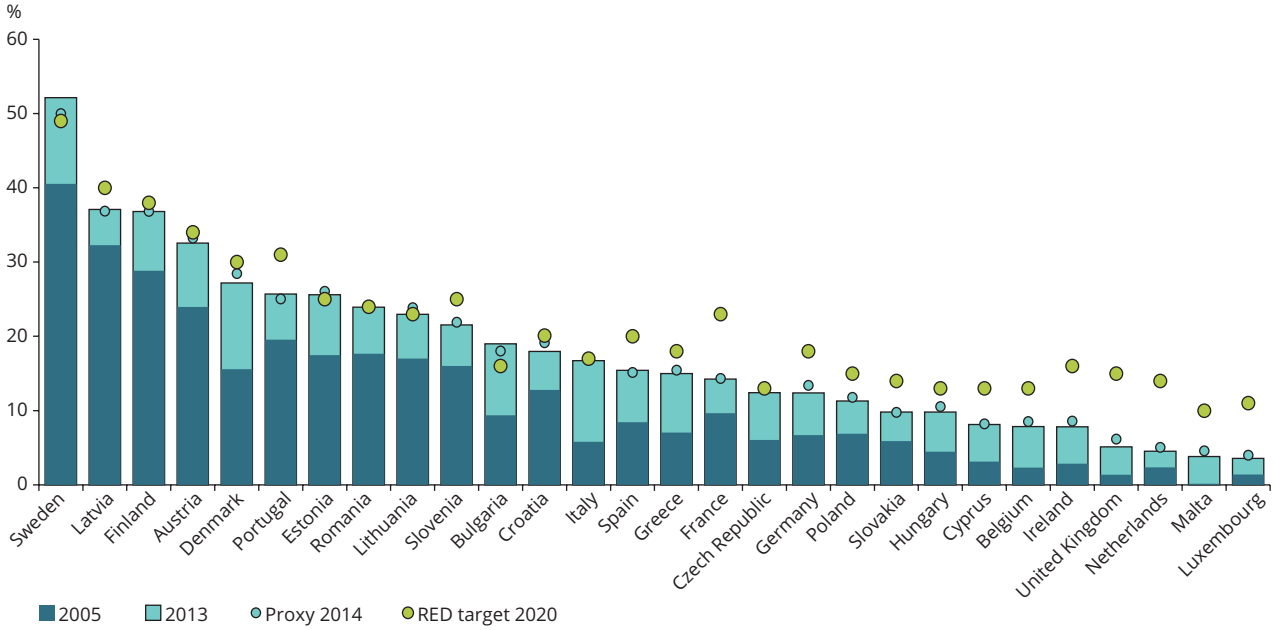
Renewable energy shares in 2013

Table 2.3 shows the change in the RES share in each of the EU-28 Member States from 2012 to 2013. Bulgaria realised the largest increase in its RES share (+ 3.0 percentage points). This is due to an increase in Bulgaria's RES consumption, but also due to a decrease in its GFEC. Had the GFEC remained unchanged, the RES share would have increased by 2.0 percentage points.

Greece increased its RES share by 1.6 percentage points. Without the reduction in its GFEC, related to the recession, Greece would have increased its RES share by only 0.1 percentage point.

In 2013, there were four Member States in which actual RES consumption decreased, namely Sweden, Slovakia, Latvia and Estonia. However, among all EU Member States, only Slovakia and Estonia registered a decreasing RES share in 2013 compared with 2012.

Figure 2.3 Actual and approximated RES shares in the EU-28 Member States



Note: The dark blue bars show the RES shares in 2005. The tops of the light blue bars show the levels that the RES shares reached in 2013.

Source: EEA (based on data from Eurostat and the Renewable Energy Directive (2009/28/EC)).

Table 2.2 Member States' trajectories and progress towards targets (%)

Member State	RES share			RES proxy share (EEA)	RES data (ESTAT)	Average share	Indicative RED trajectory (2-year averages)			Binding RED target
(Rank in 2005 → rank in 2013)	2005	2012	2013	2014	2014	2013-2014	2013–2014	2015–2016	2017–2018	2020
Sweden (1)	40.5	51.1	52.1	50.0	52.6	51.1	42.6	43.9	45.8	49.0
Latvia (2)	32.3	35.8	37.1	36.9	38.7	37.0	34.8	35.9	37.4	40.0
Finland (3)	28.8	34.5	36.8	36.8	38.7	36.8	31.4	32.8	34.7	38.0
Austria (4)	23.9	32.1	32.6	33.2	33.1	32.9	26.5	28.1	30.3	34.0
Denmark (10 → 5)	15.6	25.6	27.2	28.5	29.2	27.8	20.9	22.9	25.5	30.0
Portugal (5 → 6)	19.5	25.0	25.7	25.0	27.0	25.4	23.7	25.2	27.3	31.0
Estonia (7)	17.5	25.8	25.6	26.1	26.5	25.8	20.1	21.2	22.6	25.0
Romania (6 → 8)	17.6	22.8	23.9	24.0	24.9	24.0	19.7	20.6	21.8	24.0
Lithuania (8 → 9)	17.0	21.7	23.0	23.9	23.9	23.4	17.4	18.6	20.2	23.0
Slovenia (9 → 10)	16.0	20.2	21.5	21.9	21.9	21.7	18.7	20.1	21.9	25.0
Bulgaria (13 → 11)	9.4	16.0	19.0	18.0	18.0	18.5	11.4	12.4	13.7	16.0
Croatia (11 → 12) (*)	12.8	16.8	18.0	19.1	27.9	18.6	15.0	16.1	17.6	20.1
Italy (20 → 13)	5.8	15.4	16.7	17.1	17.1	16.9	8.7	10.5	12.9	17.0
Spain (14)	8.4	14.3	15.4	15.1	16.2	15.3	12.1	13.8	16.0	20.0
Greece (15)	7.0	13.4	15.0	15.4	15.3	15.2	10.2	11.9	14.1	18.0
France (12 → 16)	9.6	13.6	14.2	14.3	14.3	14.3	14.1	16.0	18.6	23.0
Czech Republic (18 → 17)	6.0	11.4	12.4	13.2	13.4	12.8	8.2	9.2	10.6	13.0
Germany (17 → 18)	6.7	12.1	12.4	13.4	13.8	12.9	9.5	11.3	13.7	18.0
Poland (16 → 19)	6.9	10.9	11.3	11.8	11.4	11.5	9.5	10.7	12.3	15.0
Slovakia (19 →20)	5.9	10.4	9.8	9.8	11.6	9.8	8.9	10.0	11.4	14.0
Hungary (21)	4.5	9.5	9.8	10.5	9.5	10.2	6.9	8.2	10.0	13.0
Cyprus (22)	3.1	6.8	8.1	8.2	9.0	8.2	5.9	7.4	9.5	13.0
Belgium (25 → 23)	2.3	7.4	7.9	8.5	8.0	8.2	5.4	7.1	9.2	13.0
Ireland (23 → 24)	2.9	7.3	7.8	8.6	8.6	8.2	7.0	8.9	11.5	16.0
United Kingdom (27 → 25)	1.4	4.2	5.1	6.2	7.0	5.7	5.4	7.5	10.2	15.0
Netherlands (24 → 26)	2.3	4.5	4.5	5.0	5.5	4.8	5.9	7.6	9.9	14.0
Malta (28 → 27)	0.2	2.7	3.8	4.6	4.7	4.2	3.0	4.5	6.5	10.0
Luxembourg (26 → 28)	1.4	3.1	3.6	4.0	4.5	3.8	3.9	5.4	7.5	11.0

Note: In the first column, the parentheses indicate country ranking by largest RES share, in 2005 and 2013, respectively. Early estimates for the RES share in 2014, as approximated by EEA and its ETC/ACM, are shown in the fifth column. The EEA–ETC/ACM RES proxies were estimated based on the information sources available at 31 July 2015; a limited update of RES proxies was done with OECD data at the end of November 2015. Reported RES shares have been provided since by Eurostat (2016) and these are shown in the sixth column. For Croatia (*), the RES data for 2014 shown in the sixth column entail a considerable upward revision compared to the RES SHARES 2013 values (Eurostat, 2016, 2015b). This explains the significant difference compared with the estimated RES proxy.

Source: EEA (based on data from Eurostat and the Renewable Energy Directive (2009/28/EC)).

Table 2.3 Change in RES share from 2012 to 2013 in the EU-28 Member States

Member State	Assuming unchanged GFEC	Assuming unchanged final RES consumption	Actual
Bulgaria	2.0	0.9	3.0
Finland	1.7	0.7	2.4
Denmark	1.3	0.3	1.6
Greece	0.1	1.5	1.6
Cyprus	0.7	0.6	1.3
Italy	0.9	0.4	1.3
Slovenia	0.9	0.3	1.3
Latvia	– 0.2	1.5	1.3
Lithuania	0.7	0.5	1.2
Malta	1.2	0.0	1.2
Romania	0.0	1.1	1.1
Spain	0.7	0.4	1.1
Croatia	0.9	0.2	1.1
Sweden	0.0	1.4	1.1
Czech Republic	1.1	– 0.1	1.0
United Kingdom	1.0	0.0	1.0
Portugal	0.1	0.6	0.7
France	1.0	– 0.3	0.7
Ireland	0.6	– 0.1	0.5
Luxembourg	0.4	0.0	0.4
Austria	1.0	– 0.5	0.4
Belgium	0.6	– 0.2	0.4
Poland	0.2	0.2	0.4
Germany	0.6	– 0.3	0.3
Hungary	0.4	– 0.1	0.3
Netherlands	0.0	0.0	0.0
Estonia	– 0.2	0.0	– 0.2
Slovakia	– 0.2	– 0.4	– 0.5

Note: The second column shows the change in the RES share from 2012 to 2013 when the Member States' GFEC (after adjusting for aviation correction) is kept equal to its value in 2012. The third column shows the change in the RES share when RES consumption is kept equal to its value in 2012. In other words, it visualises the impacts of changes in energy consumption between 2012 and 2013 on the RES share. The fourth column shows the actual change in the RES share from 2012 to 2013, as defined in the RED.

Source: EEA (based on data from Eurostat).

Table 2.4 ranks the EU-28 Member States based on their consumption of renewable energy in 2013. In 2013, Germany was the largest consumer of renewable energy, followed by France and Italy. In 2005, France was still the largest consumer of renewables, but France's 4 % growth rate in the period 2005–2013 was lower than Germany's 8 % growth rate.

In 11 Member States, the renewable energy consumption in 2013 was below the expected realisation in their NREAPs. Thirteen Member States will need to increase their growth rate post-2013 to reach the expectations for 2020 in their NREAPs.

Table 2.4 Member States' trajectories and progress towards targets

	Gross final consumption of RES (ktoe)			RES proxy (ktoe)	Expected NREAP trajectory (ktoe)				Realised growth rate	Required growth rate
(Rank in 2005 → rank in 2013)	2005	2012	2013	2014	2012	2013	2014	2020	2005–2013	2013–2020
Germany (2 → 1)	15 124	26 455	27 754	28 955	25 231	26 154	27 526	38 556	8 %	5 %
France (1 → 2)	15 923	21 093	22 632	21 679	23 389	24 857	26 359	36 744	4 %	7 %
Italy (5 → 3)	8 042	19 618	20 737	20 381	12 182	13 030	13 921	21 489	13 %	1 %
Sweden (3 → 4)	14 442	17 903	17 879	16 840	16 596	16 985	17 375	19 716	3 %	1 %
Spain (4 → 5)	8 525	12 305	12 911	12 432	14 531	15 079	15 612	20 523	5 %	7 %
Finland (6)	7 506	9 054	9 491	9 572	8 253	8 494	8 733	10 695	3 %	2 %
Austria (7)	6 830	8 977	9 251	9 269	8 107	8 192	8 286	9 267	4 %	0 %
Poland (9 → 8)	4 237	7 334	7 479	7 840	6 594	6 923	7 230	10 628	7 %	5 %
United Kingdom (12 → 9)	2 073	5 624	7 009	8 099	5 982	6 802	7 932	20 465	16 %	17 %
Romania (8 → 10)	4 600	5 570	5 578	5 845	5 121	5 304	5 490	7 232	2 %	4 %
Portugal (10 → 11)	3 792	4 178	4 198	4 035	5 054	5 122	5 200	6 044	1 %	5 %
Denmark (11 → 12)	2 559	3 955	4 150	4 261	4 005	4 525	4 515	5 061	6 %	3 %
Czech Republic (13)	1 661	2 864	3 131	3 206	3 100	3 248	3 396	4 150	8 %	4 %
Belgium (18 → 14)	871	2 561	2 785	2 888	2 094	2 356	2 759	5 302	16 %	10 %
Greece (14 → 15)	1 522	2 397	2 413	2 469	2 656	2 922	3 185	5 015	6 %	11 %
Netherlands (16)	1 230	2 336	2 360	2 452	2 873	3 341	3 917	7 339	8 %	18 %
Bulgaria (17)	1 032	1 643	1 846	1 789	1 292	1 401	1 555	2 044	8 %	1 %
Hungary (21 → 18)	842	1 465	1 532	1 582	1 430	1 479	1 574	2 855	8 %	9 %
Latvia (15 → 19)	1 378	1 510	1 501	1 494	1 452	1 473	1 512	1 921	1 %	4 %
Lithuania (19 → 20)	852	1 102	1 137	1 147	932	1 024	1 114	1 472	4 %	4 %
Slovakia (23 → 21)	702	1 115	1 094	1 080	1 112	1 179	1 269	1 698	6 %	6 %
Croatia (20 → 22)	844	1 034	1 086	1 115	973	1 040	1 105	1 470	3 %	4 %
Slovenia (22 → 23)	813	1 028	1 075	1 072	939	994	1 030	1 343	4 %	3 %
Ireland (25 → 24)	363	795	859	925	1 146	1 356	1 456	2 268	11 %	15 %
Estonia (24 → 25)	548	823	818	837	709	742	758	861	5 %	1 %
Luxembourg (26)	61	129	145	159	99	127	156	391	11 %	15 %
Cyprus (27)	51	107	118	122	126	142	164	263	11 %	12 %
Malta (28)	1	12	17	21	12	18	26	55	55 %	18 %

Notes: This table shows the realised growth rate in the period 2005–2013 and the growth rate over the period 2013–2020 required to reach the expected realisations in the NREAPs. In the first column the parentheses indicate country ranking by largest RES consumption, in 2005 and 2013, respectively. The required growth rates, in the last column, are calculated as compound annual growth rates expressed against the expected national realisations by 2020 according to the NREAPs. Hydropower and wind power have been normalised. The EEA–ETC/ACM RES proxies were estimated based on the information sources available at 31 July 2015; a limited update of RES proxies was done with OECD data at the end of November 2015. More recent estimates for the 2014 RES shares were produced by EurObserv'ER (EurObserv'ER, 2015a-g). Reported RES shares have been provided since by the European Commission (2016) and by Eurostat (2016).

Source: EEA (based on data from Eurostat and NREAP reports).

Estimated renewable energy shares in 2014

Table 2.5 shows the approximated results for the shares of renewable electricity (RES-E), renewable heating and cooling (RES-H&C), renewable energy for transport (RES-T) and the overall RES consumption in 2014. Annex 1 discusses the methodology and data sources that the EEA used for the calculation of the approximated estimates.

For 2014, the results of the RES share proxy calculations indicate that the share of gross final RES consumption increased in all but one Member State (Bulgaria). According to the approximated estimates for 2014, for

Table 2.5 Approximated RES shares in 2014 in the EU-28 Member States (%)

	EEA proxy for 2014				National 2014 RES data			
Member State	**RES-E**	**RES-H&C**	**RES-T**	**RES**	**RES-E**	**RES-H&C**	**RES-T**	**RES**
Austria (*)	69.8	34.4	7.7	33.2	69.2	45.3	8.6	33.0
Belgium	13.6	8.8	4.8	8.5	n.a.	n.a.	n.a.	n.a.
Bulgaria (*)	19.4	27.6	3.0	18.0	18.9	28.3	5.3	18.0
Cyprus	8.0	20.4	1.0	8.2	n.a.	n.a.	n.a.	n.a.
Czech Republic	13.2	16.3	6.7	13.2	n.a.	n.a.	n.a.	n.a.
Germany	29.0	11.3	7.0	13.4	28.2	12.2	6.65	13.8
Denmark (*)	44.9	36.3	6.7	28.5	48.5	38.4	5.7	28.5
Estonia	13.4	43.6	0.2	26.1	14.6	45.2	0.2	26.5
Greece	22.2	27.5	1.1	15.4	n.a.	n.a.	n.a.	n.a.
Spain	37.1	13.9	0.5	15.1	37.8	15.8	0.5	16.2
Finland	31.8	50.6	9.9	36.8	n.a.	n.a.	n.a.	n.a.
France	18.3	18.4	7.7	14.3	n.a.	n.a.	n.a.	n.a.
Croatia	42.1	20.2	2.2	19.1	n.a.	n.a.	n.a.	n.a.
Hungary	6.6	14.9	5.4	10.5	n.a.	n.a.	n.a.	n.a.
Ireland	22.2	6.6	5.3	8.6	22.7	6.6	5.2	8.6
Italy (*)	32.7	19.1	4.5	17.1	33.4	18.9	4.5	17.1
Lithuania	13.4	40.2	5.0	23.9	n.a.	n.a.	n.a.	n.a.
Luxembourg (*)	5.8	5.6	4.5	4.0	5.9	7.4	5.2	4.5
Latvia	47.9	49.5	3.0	36.9	51.1	52.2	3.2	38.7
Malta (*)	2.8	23.8	3.9	4.6	3.3	14.6	5.0	4.7
Netherlands	10.5	4.1	5.4	5.0	n.a.	n.a.	n.a.	n.a.
Poland	11.7	14.5	5.9	11.8	12.4	14.0	5.7	11.5
Portugal	51.1	32.0	0.7	25.0	n.a.	n.a.	n.a.	n.a.
Romania (*)	42.2	24.7	4.7	24.0	44.0	28.4	4.5	26.3
Sweden	63.4	65.2	18.4	51.1	63.3	68.1	19.2	52.6
Slovenia	32.3	34.4	2.0	21.9	33.9	33.3	2.6	21.9
Slovakia	21.1	7.4	5.3	9.8	n.a.	n.a.	n.a.	n.a.
United Kingdom (*)	16.0	3.3	4.7	6.2	17.8	4.5	3.2 (**)	7.0
EU-28	**26.9**	**16.6**	**5.5**	**15.2**	**n.a.**	**n.a.**	**n.a.**	**n.a.**

Note: The table shows RES shares for 2014 for electricity (RES-E), heating and cooling (RES-H&C), transport (RES-T), and the overall RES share (RES) — as approximated by EEA and its ETC/ACM — on the left side. On the right side (last four columns), national approximated estimates for the RES share for 2014 — as communicated by countries to EEA or (*) as extracted from their 2015 progress reports — are shown. For the United Kingdom (**), overall supply in the RES-T sector was low due to double counting certificates. The EEA–ETC/ACM RES proxies were estimated based on the information sources available at 31 July 2015; a limited update of RES proxies was done with OECD data at the end of November 2015. More recent estimates for the 2014 RES shares were produced by EurObserv'ER (EurObserv'ER, 2015a-g). Reported RES shares have been provided since by the European Commission (2016) and by Eurostat (2016).

Source: EEA (based on data from Eurostat; submissions by Member States during the Eionet consultation; national 2015 renewable energy progress reports under the RED and SEAI (2015)).

all Member States, except the Netherlands, the share of gross final renewable energy consumption in 2014 was higher than the indicative average RES share for the years 2013 and 2014 under the RED. Turning to expected NREAP targets, which are generally higher than the indicative ones under the RED, the approximated 2014 RES shares seem to be falling short of the expected 2014 NREAP targets in eight Member States (Cyprus, France, Ireland, Malta, the Netherlands, Portugal, Spain, United Kingdom). Further discussion of the main 2014/2013 changes by sector and country can be found in Annex 2.

Comparing EEA 2014 RES proxy shares with national 2014 RES, the data deviation for total RES share is below 1.0 percentage point for 12 of 16 available Member States. The largest deviation is for Romania (2.3 percentage points). On a sectorial basis, the transport sector shows the greatest consistency: EEA 2014 RES-T proxy shares deviate by less than 1 percentage point for 13 of 16 Member States (largest deviation: 2.3 percentage points for Bulgaria). In the electricity sector EEA 2014 renewable electricity proxy shares deviate by less than 1.0 percentage point for 10 of 16 Member States. For two Member States, the deviation is larger than 2.0 percentage points (Denmark 3.6 pp and Latvia 3.2 pp). The greatest deviations are found in the heating and cooling sector: only EEA 2014 RES-H&C proxy shares are within 1.0 percentage point deviation from national 2014 RES shares. Very large deviations were found for Austria (10.9 pp) and Malta (9.2 pp). In the case of Austria, however, a similar large deviation between Eurostat SHARES data and Austria's 2015 progress report data was found for the years 2011 to 2013 ([13]). Malta is a similar case, in which Eurostat SHARES data and Malta's 2015 progress report data also differ quite significantly ([14]). For four more Member States, the deviation is greater than 2.0 percentage points (Romania 3.7 pp, Sweden 2.9 pp, Latvia 2.7 pp and Denmark 2.1 pp).

Expected excess/deficit production of renewable energy in 2020

Every 2 years, the EU Member States report on their progress towards the EU's 2020 renewable energy goals in progress reports. These include an estimated excess and/or deficit production of renewable energy compared with the indicative RED trajectory ([15]). Based on these national progress reports, the European Commission produces an EU-wide report that gives an overview of renewable energy policy developments.

Member States that exhibit RES shares above their RED targets could, in principle, transfer the excess amount to other Member States whose RES shares are too low. Such transfers would then allow more Member States to reach their interim targets. However, the vast majority of Member States have indicated that they want to reach their 2020 RES target using their own support schemes (Kampman et al., 2015).

The reporting of a change in the excess and/or deficit in the latest progress reports (2013) compared with the NREAPs can give an indication of a change in the estimated trajectories. In their 2013 progress reports, five Member States reported a bigger excess than in their NREAPs (Estonia, Ireland, Italy, Romania and Sweden), two Member States reported a smaller excess (Malta, Spain) and Luxembourg reported no excess/deficit in its NREAP and a deficit in its 2013 progress report. The total changes in excess/deficit amount to 7.7 Mtoe for 2013 and to 1.2 Mtoe for 2020.

Nineteen Member States may fulfil their 2020 RES targets, assuming currently implemented and planned RES policies (Ecofys, 2014). The policies of other Member States, such as Luxembourg, the Netherlands and the United Kingdom, appear insufficient to reach their targets with domestically produced renewable energy. The modelling results suggest that the EU will not meet its binding RES share of 20 %, and a RES share of 18.5 % to 19.7 % is expected, based on implemented and planned policies.

2.2 Contributions by energy market sector and technology

2.2.1 Breakdown of RES share into energy market sectors

We distinguish the following market sectors: electricity, heating and cooling, and transport. At the country level, the significance of each renewable market sector differs considerably. Figure 2.4 shows the relative weight of each sector in terms of total gross renewable final energy consumption in the Member States in 2013.

In 2013:

- **renewable heating and cooling** represented more than half of all gross final consumption of renewables in 18 Member States (Belgium, Bulgaria,

([13]) RES-H&C shares in Eurostat versus progress report: 30.7 % vs 44.1 % in 2011; 32.4 % vs 44.7 % in 2012; 33.5 % vs 43.2 % in 2013.
([14]) RES-H&C shares in Eurostat versus progress report: 23.7 % vs 14.6 % in 2013.
([15]) Excesses and deficits are reported in Table 7 in the Progress Reports on the Promotion and Use of Renewable Energy from Renewable Sources under Article 22 of the Renewable Energy Directive.

Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Greece, Hungary, Italy, Latvia, Lithuania, Malta, Poland, Romania, Slovenia and Sweden);

- **renewable electricity** represented over half of all RES consumption in only five Member States (Spain, Croatia, Ireland, Portugal, United Kingdom);
- the contribution of **renewable transport fuels** varied from a maximum of 48 % of all RES consumption (Luxembourg) to 1 % or less (Estonia, Portugal and Spain).

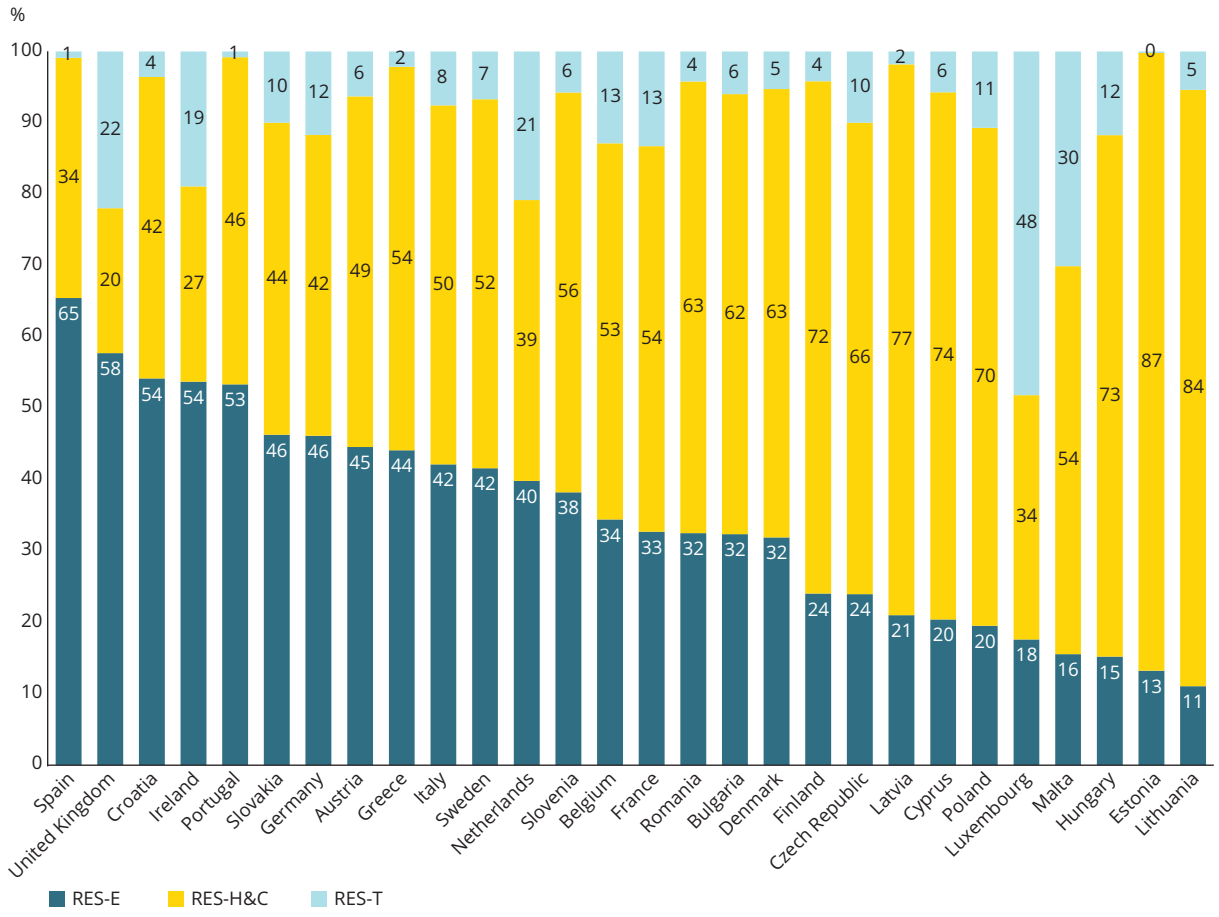
The observed variations across Member States in the relative importance of each market sector are due to specific national circumstances, including different starting points in the deployment of renewable energy sources, different availability of low-cost renewables, country-specific demand for heating in the residential sector and different policies to stimulate deployment. The splits in the relative importance of RES market sectors was similar in 2014.

2.2.2 Renewable electricity

The EU-wide share of renewable electricity (RES-E) was 25.4 % in 2013. Figure 2.5 and Table 2.6 show the consumption of renewable electricity up to 2013, approximated estimates for 2014 and the expected developments based on the NREAPs.

- The gross final consumption of renewable electricity was 70.8 Mtoe in 2013, an increase of 4.4 Mtoe compared with 2012.
- In 2013, the largest contributions came from hydropower (30.0 Mtoe, or 42 % of all RES-E), onshore wind (18.2 Mtoe, or 26 % of all RES-E) and solid biomass (8.6 Mtoe, or 12 % of all RES-E).
- Over the period 2005–2013, the compound annual growth rate of renewable electricity consumption was 7 %. To realise the expectations for 2020 in the NREAPs, a growth rate of 6 % per year will be required over the period 2013–2020. The compound annual growth rate was the highest

Figure 2.4 Breakdown of 2013 RES share into RES-E, RES-H&C and RES-T (%)

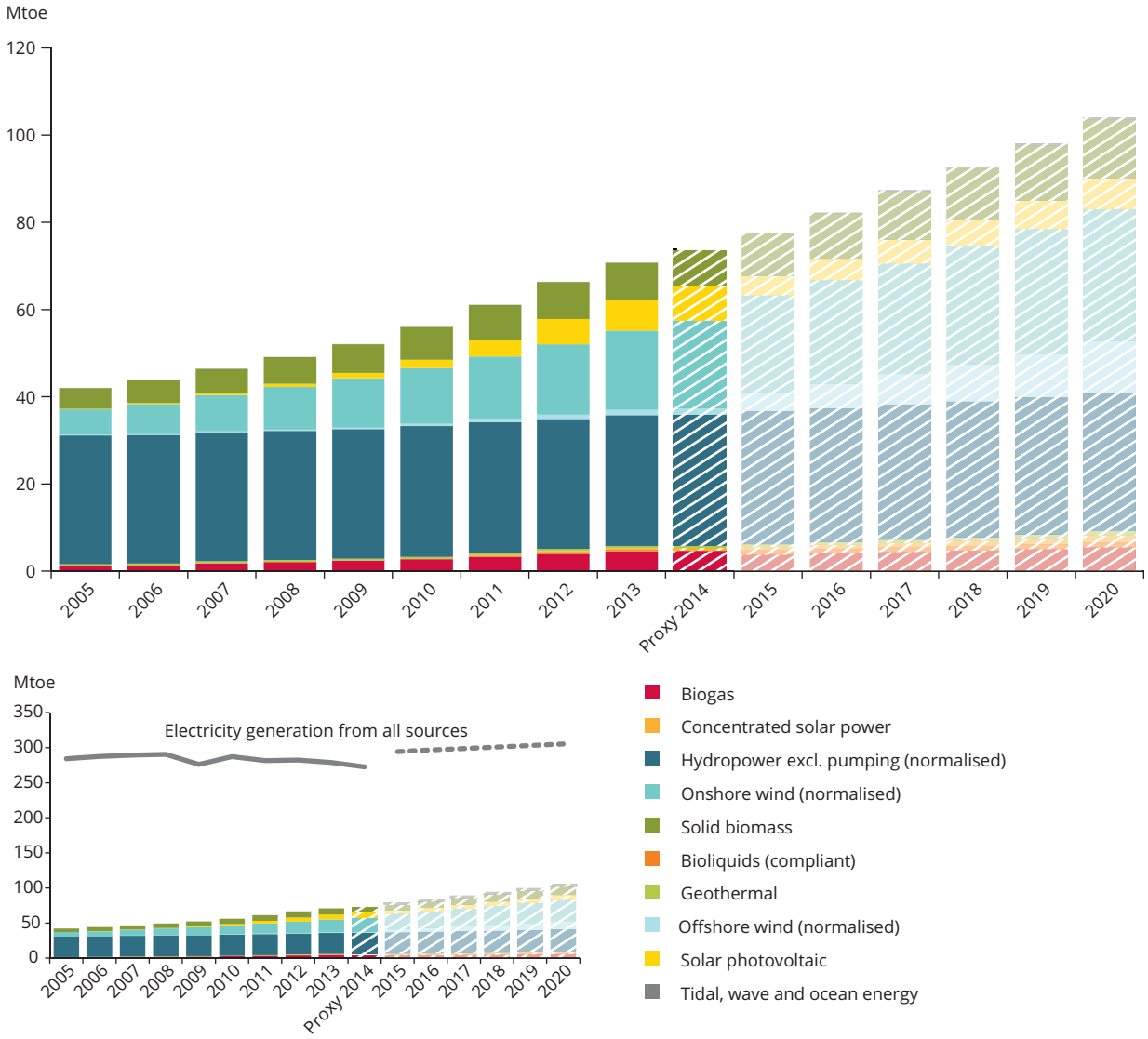


Source: EEA (based on Eurostat, 2015b).

for solar photovoltaic (65 %), offshore wind (27 %), biogas (19 %) and onshore wind (15 %). Hydropower had the lowest growth rate (0 %).

- According to proxy estimates, total renewable electricity generation increased in 2014 to 73 Mtoe, while total electricity consumption decreased to 273 Mtoe resulting in a share of renewable electricity consumption of 27 %. Almost two-thirds of the increase in renewable electricity generation was due the greater contribution of wind energy and almost one-third was due to the greater contribution of solar energy (both photovoltaic and concentrated solar power). These increases more than compensated for a stagnation in solid biomass. All other sources contributed only a little to the increase. The strong decrease in electricity consumption was, according to the European Network of Transmission System Operators for Electricity (ENTSO-E), due to 'combined effects of mild weather conditions, economic slowdown and energy efficiency efforts' (ENTSO-E, 2015).

Figure 2.5 Renewable electricity in the EU-28



Notes: This figure shows the realised final renewable energy consumption for 2005–2013, approximated estimates for 2014 and the expected realisations in the energy efficiency scenario of the NREAPs for 2015–2020. Wind power and hydropower are normalised. The consumption of RES accounts for only biofuels complying with the RED sustainability criteria.

Source: EEA (based on data from Eurostat and NREAP reports).

Table 2.6 Renewable electricity in the EU-28: breakdown by RES technologies

Technology	Final energy (ktoe)				Growth rate			
	2005	2012	2013	Proxy 2014	NREAP 2020	2005–2013	2012–2013	2013–2020
Hydropower excl. pumping (normalised)	29 582	29 822	29 987	30 171	31 786	0 %	1 %	1 %
Onshore wind (normalised)	5 784	16 110	18 189	20 110	30 303	15 %	13 %	8 %
Solid biomass	4 773	8 488	8 610	8 446	13 460	8 %	1 %	7 %
Solar photovoltaic	126	5 796	6 953	7 849	7 062	65 %	20 %	0 %
Biogas	1 101	3 994	4 550	4 627	5 493	19 %	14 %	3 %
Offshore wind (normalised)	174	966	1 201	1 377	11 740	27 %	24 %	39 %
Geothermal	464	496	510	535	943	1 %	3 %	9 %
Concentrated solar power	0	325	378	378	1 633	n.a.	16 %	23 %
Bioliquids (compliant)	0	290	346	290	1 096	n.a.	19 %	18 %
Tidal, wave and ocean energy	41	40	36	45	559	– 2 %	– 9 %	48 %
Total renewable electricity (normalised, compliant biofuels)	42 044	66 326	70 761	73 828	104 075	7 %	7 %	6 %
Total renewable electricity (normalised, including non-compliant biofuels)	42 196	66 348	70 784	73 906	104 075	7 %	7 %	6 %

Notes: This table shows the realised final renewable energy consumption for 2005, 2012 and 2013, approximated estimates for 2014 and the expected realisations in the energy efficiency scenario of the NREAPs for 2020. The growth rates are the realised compound annual growth rates in 2005–2013, the growth from 2012 to 2013 and the compound annual growth rates required to reach the expected realisation in the NREAPs for 2020. Wind power and hydropower are normalised.

Source: EEA (based on data from Eurostat and NREAP reports).

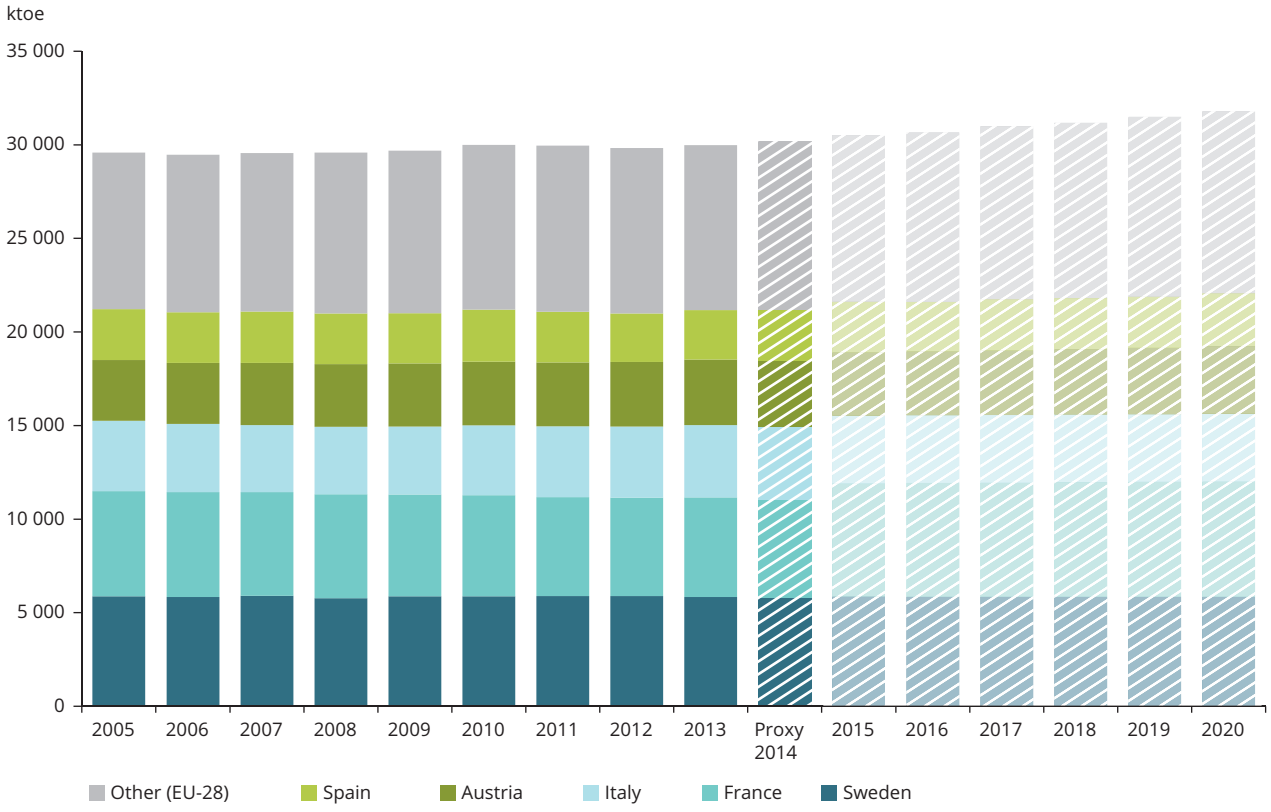
Hydropower

The normalised production of renewable hydroelectric power remained quite stable over the period 2005–2013 (Figure 2.6). In the NREAPs, limited growth from 30.0 to 31.8 Mtoe is expected for 2013–2020. In 2013, the five countries with the most hydropower (Sweden, France, Italy, Austria and Spain) had a share of 71 % of all hydropower in the EU-28. We estimate that in 2014, the normalised production of hydroelectricity increased slightly to 30.1 Mtoe. Hydropower capacities evolve only a little across Europe, therefore rainfall patterns determine annual changes in hydroelectricity production.

Investments in large-scale hydropower schemes (> 10 MW) were mainly made before 2000 (Ecofys, 2014), and most of the potential in the EU has already been realised. To a considerable extent, this also applies to small and medium run-of-river hydro plants (< 10 MW), for which most viable sites are already being utilised (EurObserv'ER, 2014). New constructions need to be assessed against the risk of a resulting decline in the quality European river environments.

Despite the low total growth rate anticipated up to 2020 at the EU level, the importance of hydropower may grow, because it brings flexibility that allows the integration of high levels of renewables (IRENA, 2014).

Figure 2.6 Renewable electricity in the EU-28: hydropower excluding pumping (normalised)



Notes: This figure shows the realised final renewable energy consumption for 2005–2013, approximated estimates for 2014 and the expected realisations in the energy efficiency scenario of the NREAPs for 2015–2020.

Source: EEA (based on data from Eurostat and NREAP reports).

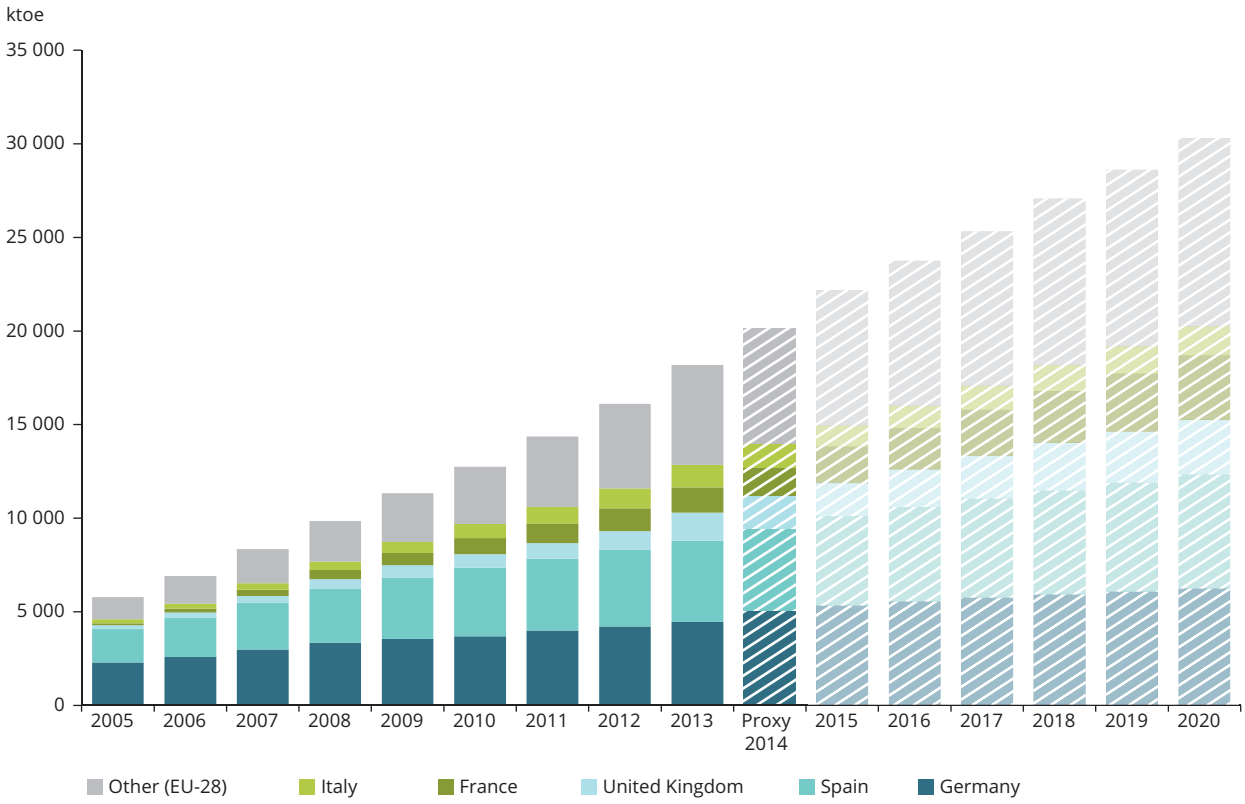
Onshore wind energy

Onshore wind power generation (Figure 2.7) increased from 5.8 Mtoe in 2005 to 18.2 Mtoe in 2013. The largest contributions came from Germany (4.5 Mtoe) and Spain (4.3 Mtoe).

In 2014, the normalised onshore wind production of electricity was estimated to be 20.3 Mtoe. The greatest increase in normalised onshore wind production at the Member State level was in Germany, which corresponds to an additional installed onshore capacity of 4.4 GW. Other Member States with very large absolute additions to capacity were France and Sweden with 1.0 GW each. A further four Member States (Austria, Poland, Romania and United Kingdom) added more than 0.4 GW in 2014. The largest relative capacity increases were in Slovenia (+ 42 %) and Finland (+ 40 %). Four Member States (Austria, Estonia, Croatia and Sweden) increased their installed capacity by more than 20 % in 2014 (EurObserv'ER, 2015g).

Onshore wind is a rather mature and lower-cost RES technology. The NREAPs indicate that onshore wind could increase to 30.3 Mtoe in 2020. The compound annual growth rate for onshore wind was 15 % in 2005–2013. Although a growth rate of 8 % in the period up to 2020 would be sufficient to meet the expectations in the NREAPs, in reality wind power could continue to grow rapidly until 2020, given the cost reductions that have taken place over the past ten years. Most Member States offer sufficient remuneration levels for onshore wind generation, but its deployment is often slowed down by barriers other than cost, such as spatial planning issues and long lead times for administrative and grid access procedures (Ecofys, 2014).

Figure 2.7 Renewable electricity in the EU-28: onshore wind (normalised)



Notes: This figure shows the realised final renewable energy consumption for 2005–2013, approximated estimates for 2014 and the expected realisations in the energy efficiency scenario of the NREAPs for 2015–2020.

Source: EEA (based on data from Eurostat and NREAP reports).

Solid biomass

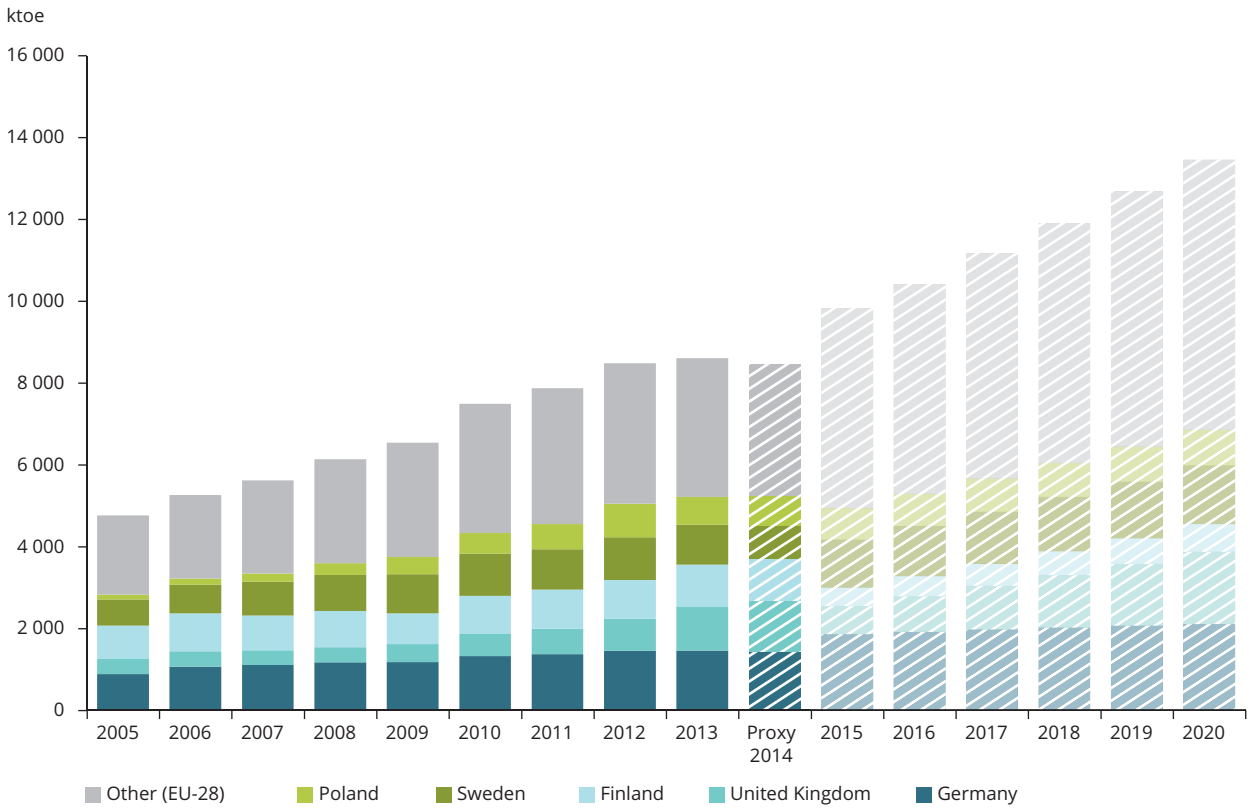
Electricity generation from solid biomass grew from 4.8 Mtoe in 2005 to 8.6 Mtoe in 2013 (Figure 2.8). The growth rate in 2005–2013 was 8 %. In 2013, Germany's share of the total electricity generation from solid biomass was 17 %. The United Kingdom and Finland had shares of 13 % and 12 %, respectively. In 2014, electricity generation from solid biomass is estimated to have decreased to 8.4 Mtoe. This is strongly linked to the exceptionally warm weather in 2014, which saw a very low demand for heating, as about two-thirds of all electricity generation from solid biomass takes place in combined heat and power plants.

The implementation of sustainability criteria could influence the future growth of solid biomass fuel. However, according to the European Commission, there are no plans to harmonise legislation of these criteria for solid and gaseous biomass before 2020.

For now, it is left up to Member States whether or not they introduce sustainability criteria for solid biomass and gain experience with these requirements on a national level (Kampman et al., 2015). The European Commission report *State of play on the sustainability of solid and gaseous biomass used for electricity, heating and cooling in the EU* (EC, 2014) describes the risks to the sustainability of biomass production and use. These risks include: unsustainable feedstock production; emissions from land use, land-use change and forestry (LULUCF); performance in terms of life-cycle GHG emissions; indirect impacts; inefficient bioenergy generation; and air emissions.

At present, new projects are announced regularly and it is expected that the development of major biomass and co-firing plants will continue over the next few years (EurObserv'ER, 2015f). To meet the NREAP expectations, a compound annual growth of 7 % over the period remaining up to 2020 would be necessary.

Figure 2.8 Renewable electricity in the EU-28: solid biomass



Notes: This figure shows the realised final renewable energy consumption for 2005–2013, approximated estimates for 2014 and the expected realisations in the energy efficiency scenario of the NREAPs for 2015–2020.

Source: EEA (based on data from Eurostat and NREAP reports).

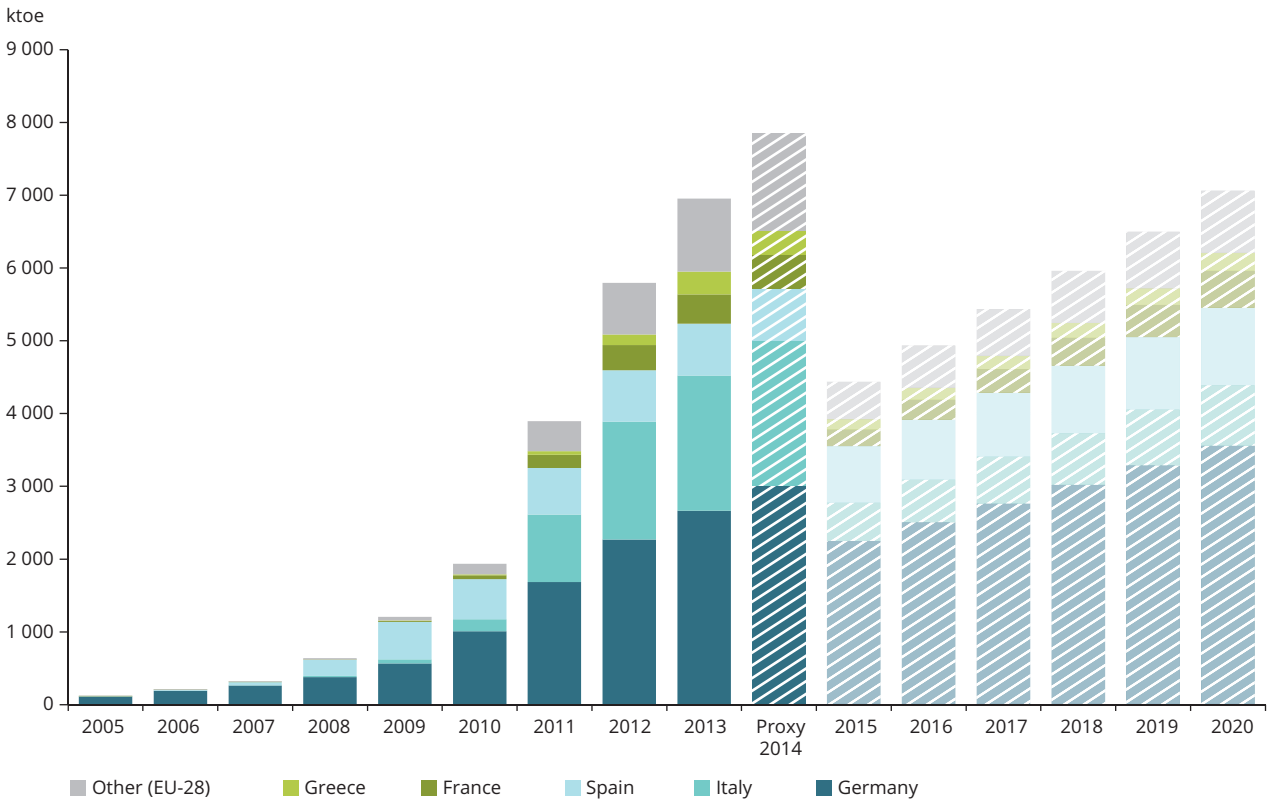
Solar photovoltaic

Solar photovoltaic (PV) electricity production reached 7.0 Mtoe in 2013 (Figure 2.9), which was almost the level that was expected for 2020 according to the NREAPs (7.1 Mtoe). In 2013, 38 % of the solar PV electricity was produced in Germany. Italy and Spain also had large shares, 27 % and 10 %, respectively.

In 2014, approximated estimates suggest that the production of solar PV electricity increased strongly again, overtaking the expected NREAP levels for 2020 and reaching 7.8 Mtoe. The greatest increase in solar PV electricity production at the Member State level was in Germany, which corresponded to an additional installed capacity of 4.4 GW. Other Member States with very large absolute capacity additions were Germany (1.9 GW) and France (1.0 GW). A further five Member States (Austria, Italy, Netherlands, Portugal and Romania) added more than 0.1 GW in 2014. The largest relative capacity increase was in Poland (by a factor of 5.8), and a further five Member States (Croatia, Cyprus, Malta, Sweden and United Kingdom) saw an increase of more than 80 % (EurObserv'ER, 2015d).

Solar-PV electricity generation has grown faster than the rate assumed in the NREAPs. The considerable growth in solar-PV electricity has been driven by rapid technological progress, cost reductions and the relatively short project development times (Ecofys, 2014). Several Member States revised their support levels in response to these cost reductions, and an increasing number of countries are taxing (or considering taxing) self-consumption (EurObserv'ER, 2015d).

Figure 2.9 Renewable electricity in the EU-28: solar photovoltaic



Notes: This figure shows the realised final renewable energy consumption for 2005–2013, approximated estimates for 2014 and the expected realisations in the energy efficiency scenario of the NREAPs for 2015–2020.

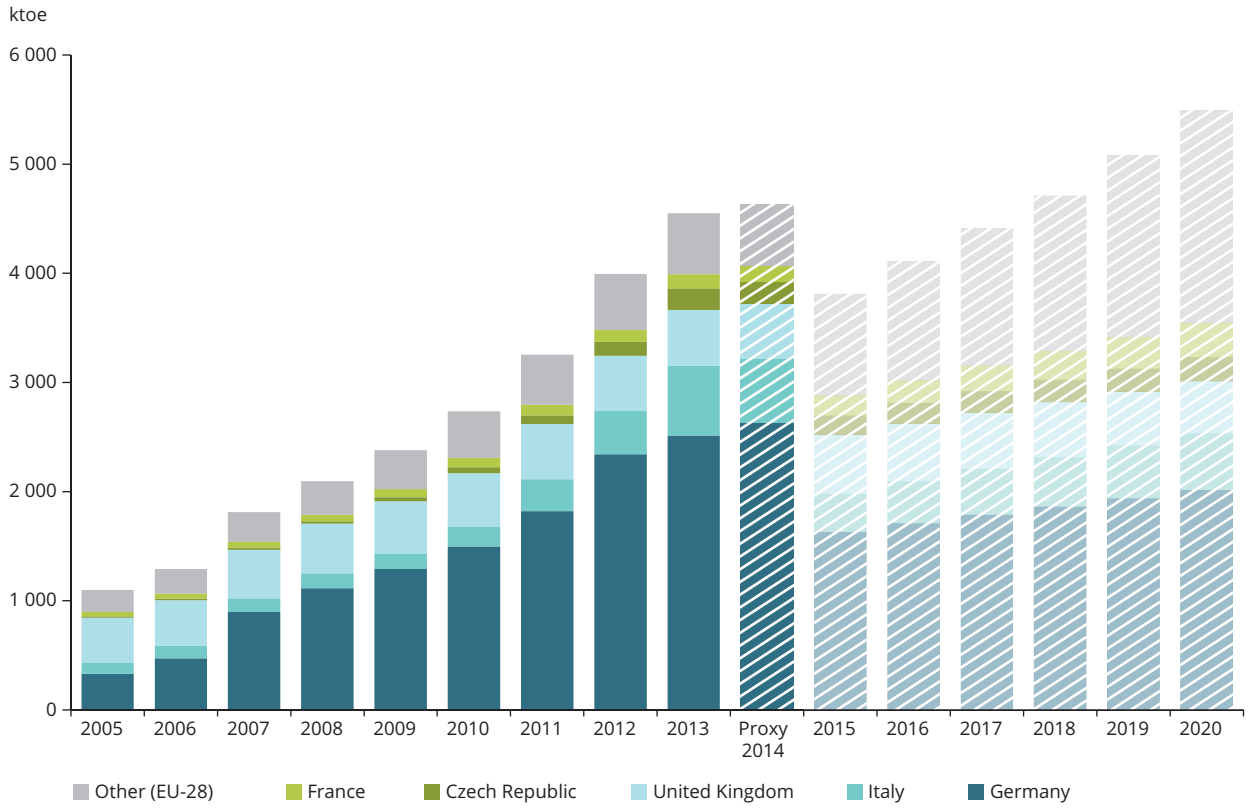
Source: EEA (based on data from Eurostat and NREAP reports).

Biogas

Electricity generation from biogas grew from 1.1 Mtoe in 2005 to 4.5 Mtoe in 2013 (Figure 2.10). The compound annual growth rate for biogas was 19 % in 2005–2013. Germany's share of electricity generation from biogas was 55 % of the total in the EU-28. Italy and the United Kingdom had shares of 14 % and 11 %, respectively. In 2014, electricity generation from biogas slightly increased to 4.6 Mtoe, according to the EEA estimate.

As such, the generation of electricity from biogas has grown faster than expected. However, given policy changes in Germany and Italy, that growth is expected to slow down in the next years (EurObserv'ER, 2015b). At the European level, the discussions over sustainability criteria are similar to those about solid biomass. The European Commission *State of play* report (EC, 2014a) highlights, specifically for biogas, the environmental issues stemming from the use of energy crops such as maize and the significant variations in the performance of biogas in terms of GHG emissions, depending on the biomass feedstock used. The European Commission has already indicated that a draft directive on these sustainability criteria is not expected before 2020 (EurObserv'ER, 2014). To realise the levels of electricity generation from biogas by 2020, anticipated in the NREAPs, a growth rate of only 3 % per year would be sufficient for the remaining period.

Figure 2.10 Renewable electricity in the EU-28: biogas



Notes: This figure shows the realised final renewable energy consumption for 2005–2013, approximated estimates for 2014 and the expected realisations in the energy efficiency scenario of the NREAPs for 2015–2020.

Source: EEA (based on data from Eurostat and NREAP reports).

Offshore wind

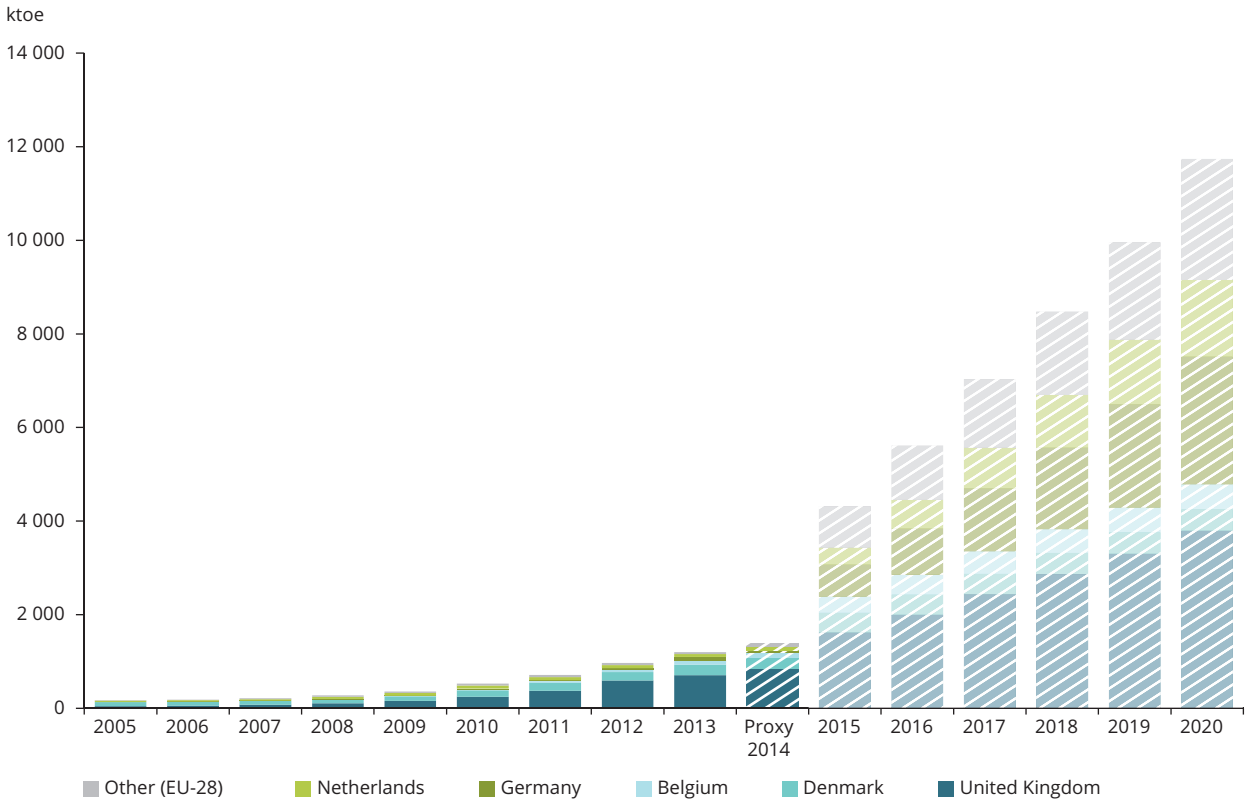
Offshore wind power grew from 1.0 Mtoe in 2012 to 1.2 Mtoe in 2013 (Figure 2.11) ([16]). In 2014, the normalised generation of electricity from offshore wind rose to 1.4 Mtoe. The largest increase in normalised offshore wind power at the Member State level was in the United Kingdom, which corresponded to an additional installed offshore capacity of 0.7 GW. The United Kingdom is currently the frontrunner, with a share of 59 % of the total normalised electricity generation from offshore wind power in the EU-28 in 2013. Germany installed an additional 1.4 GW — more than the United Kingdom. However, because of the normalisation rules (see footnote 11), normalised offshore wind production in Germany is estimated to have decreased in 2014. Further additions to offshore capacity were recorded in Belgium (0.09 GW) and Finland (0.002 GW) (EurObserv'ER, 2015d).

Offshore wind electricity may still be classified as an immature and high-cost technology (Ecofys, 2014). This technology has been deployed more slowly than anticipated in several Member States. The results of a forecasting study undertaken by a consortium led by Ecofys suggest that actual electricity generated from offshore wind power will be only around 20 % of the overall expected realisations for 2020 (Ecofys, 2014). Reductions in the cost of turbines, improved reliability and integration with the grid and effective support schemes can help to increase the investment in offshore wind power. Offshore wind power would needs to grow to 11.7 Mtoe in 2020 to reach the expected realisations in the NREAPs. This corresponds to a compound annual growth rate of 39 % per year.

Other sources of renewable electricity

- Concentrated solar power (CSP) technology is currently only realistically applicable in southern Europe. CSP provided 0.4 Mtoe of renewable energy in 2013 and no change was expected in 2014. Projects under development totalled about 608 MW at the beginning of 2015. However, some

Figure 2.11 Renewable electricity in the EU-28: offshore wind (normalised)



Notes: This figure shows the realised final renewable energy consumption for 2005–2013, approximated estimates for 2014 and the expected realisations in the energy efficiency scenario of the NREAPs for 2015–2020.

Source: EEA (based on data from Eurostat and NREAP reports).

([16]) Eurostat statistics are not separated into offshore and onshore wind power. The method for estimating offshore wind electricity production is based on EurObserv'ER data and has been slightly altered compared with the previous EEA report (EEA, 2015a).

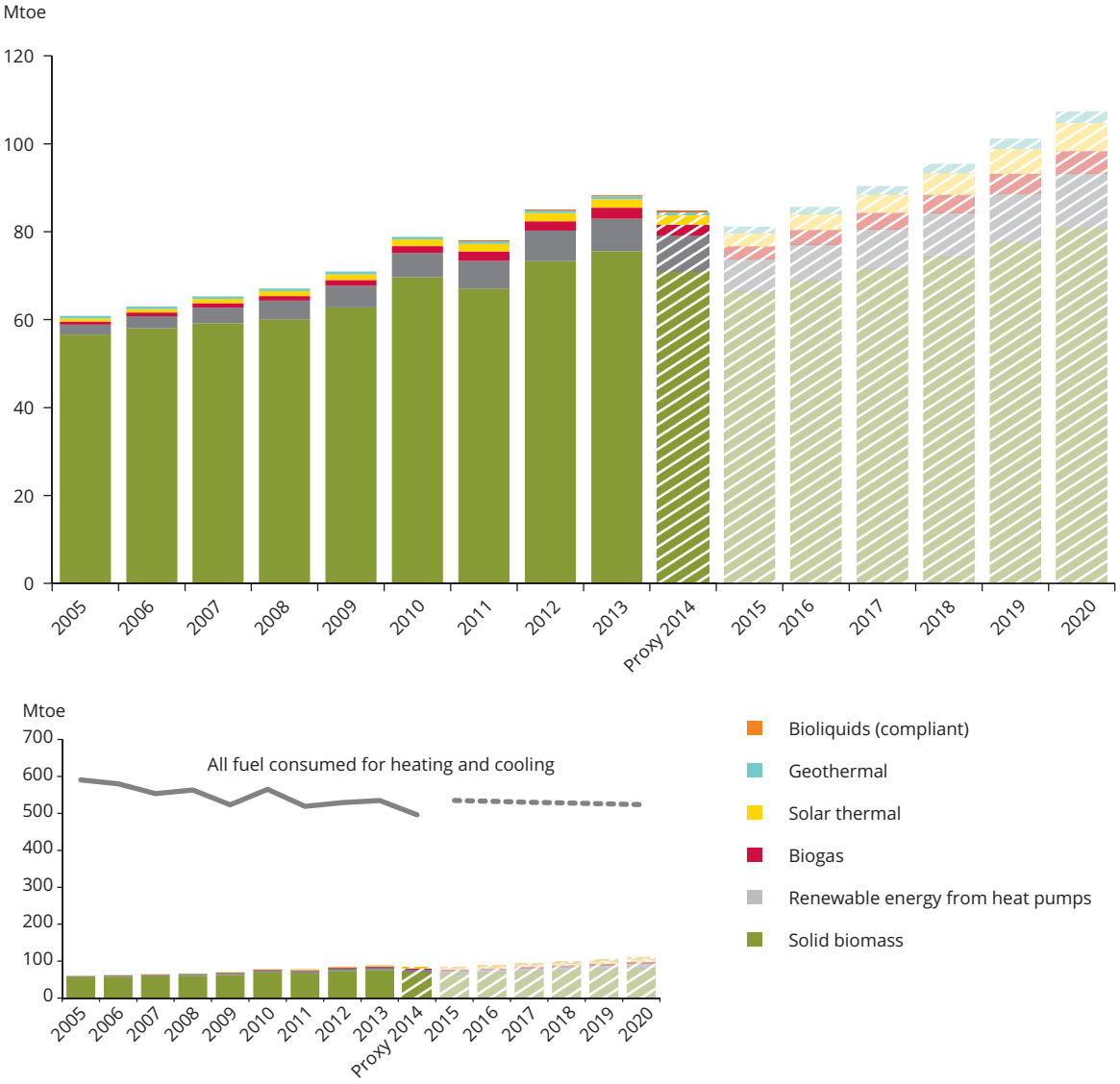
of these projects still need to be authorised or may depend on the implementation of incentive systems (EurObserv'ER, 2015e).

- Geothermal electricity grew by only 1 % per year in the period 2005–2013 to arrive at 0.5 Mtoe, and no significant change was expected in 2014. Reductions in costs have been lower than expected (Ecofys, 2014).
- Electricity generation from tidal, wave and ocean energy was still only 36 ktoe in 2013 and, according to an EEA estimate, increased to only 45 ktoe in 2014.
- Electricity production from compliant bioliquids was 0.3 Mtoe in 2013 and no significant change was expected in 2014.

2.2.3 Renewable heating and cooling

The share of renewable heating and cooling (RES-H&C) in the EU-28 was 16.5 % in 2013. Figure 2.12 and Table 2.7 show the development of renewable heating and cooling from 2005 to 2013, approximated estimates for 2014 and its expected development up to 2020 based on the NREAPs.

Figure 2.12 Renewable heating and cooling in the EU-28



Notes: This figure shows the realised final renewable energy consumption for 2005–2013, approximated estimates for 2014 and the expected realisations in the energy efficiency scenario of the NREAPs for 2015–2020. The consumption of RES accounts for only biofuels complying with the RED sustainability criteria.

Source: EEA (based on data from Eurostat and NREAP reports).

Table 2.7 Renewable heating and cooling in the EU-28

Technology	Final energy (ktoe)					Growth rate (%)		
	2005	2012	2013	Proxy 2014	NREAP 2020	2005–2013	2012–2013	2013–2020
Solid biomass	56 609	73 331	75 548	71 012	80 886	4	3	1
Renewable energy from heat pumps	2 239	6 897	7 385	8 134	12 289	16	7	8
Biogas	714	2 154	2 525	2 595	5 108	17	17	11
Solar thermal	702	1 833	1 947	2 045	6 455	14	6	19
Geothermal	559	609	658	697	2 646	2	8	22
Bioliquids (compliant)	0	239	228	228	4 416	n.a.	– 4	53
Total renewable heat (compliant biofuels)	60 824	85 063	88 292	84 710	111 801	5	4	3
Total renewable heat (including non-compliant biofuels)	60 990	85 251	88 478	84 897	111 801	5	4	3

Notes: This table shows the realised final renewable energy consumption for 2005, 2012 and 2013, approximated estimates for 2014 and the expected realisations in the energy efficiency scenario of the NREAPs for 2020. Also shown are the realised compound annual growth rates from 2005 to 2013, the growth from 2012 to 2013 and the compound annual growth rates required to reach the expected realisation in the NREAPs. The consumption of RES accounts for only biofuels complying with RED sustainability criteria.

Source: EEA (based on data from Eurostat and NREAP reports).

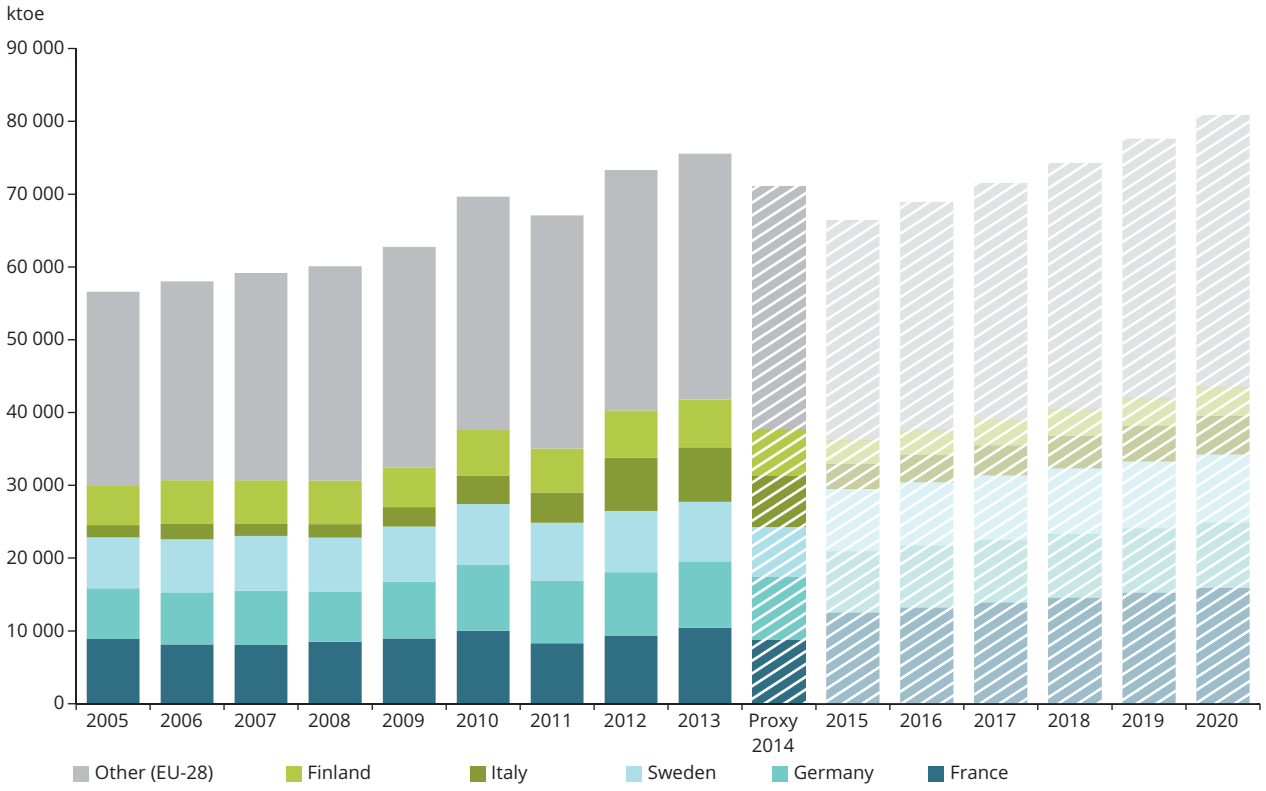
- The gross final consumption of renewable heating and cooling was 88.3 Mtoe in 2013, which corresponds to an increase of 3.2 Mtoe compared with 2012.
- In 2013, the largest contributions came from solid biomass (75.5 Mtoe, or 86 % of all RES-H&C), heat pumps (7.4 Mtoe, or 8 % of all RES-E) and biogas (2.5 Mtoe, or 3 % of all RES-H&C).
- Over the period 2005–2013, the compound annual growth rate of RES-H&C was 5 % per year. To realise the expectations in the NREAPs for 2020, a growth rate of 3 % per year would be required over the period 2013–2020.
- According to early proxy estimates, renewable heating and cooling increased to 84.7 Mtoe in 2014, while the amount of fuel consumed for heating and cooling decreased by 8 %, resulting in a renewable share of heating and cooling consumption of 18 % in 2014. Climate conditions — especially the very warm winter — had a strong impact on the demand for heating and cooling in 2014.

Solid biomass

Solid biomass remains the most important source of renewable energy for heating. The consumption of renewable heat originating from solid biomass increased from 73.3 Mtoe in 2012 to 75.6 Mtoe in 2013 (Figure 2.13). The compound annual growth rate for heat from solid biomass was 4 % from 2005 to 2013. Yet, the growth rates of other forms of renewable heat from heat pumps and biogas are considerably higher. In 2014, the consumption of solid biomass for renewable heat decreased to 71 Mtoe, according to an EEA estimate, due to exceptionally warm weather in 2014 and a very low demand for heating.

Most biomass heat generation takes place in decentralised units. The European Commission estimates that biomass imports will triple between 2010 and 2020, but it expects that until 2020 the demand for biomass for energy production will continue to be met largely through domestic raw materials (EC, 2014a). Future developments depend on the implementation of sustainability criteria for solid and gaseous biomass resources (see also Section 2.2.2). To realise the expected NREAP levels of solid biomass for 2020, a growth rate of only 1 % per year over the remaining period would be sufficient.

Figure 2.13 Renewable heating and cooling in the EU-28: solid biomass



Notes: This figure shows the realised final renewable energy consumption for 2005–2013, approximated estimates for 2014 and the expected realisations in the energy efficiency scenario of the NREAPs for 2015–2020.

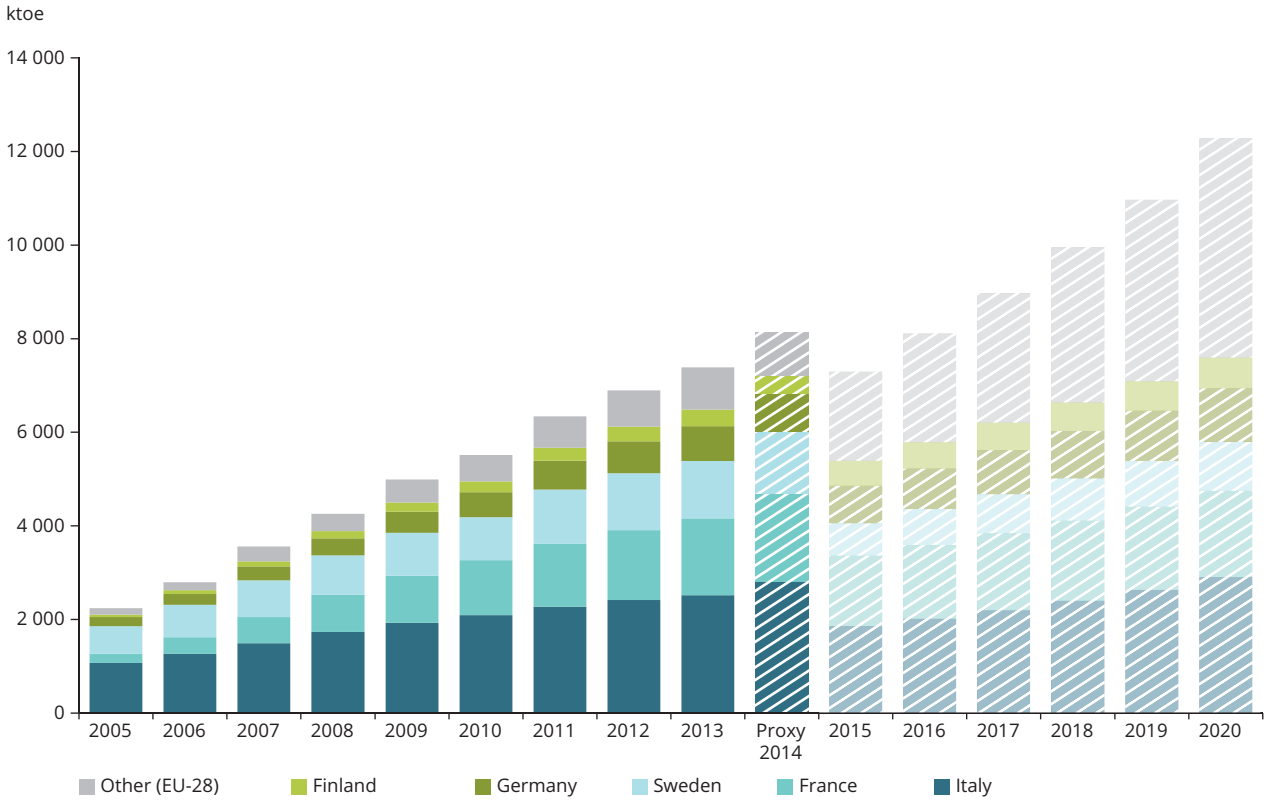
Source: EEA (based on data from Eurostat and NREAP reports).

Renewable energy from heat pumps

Renewable energy from heat pumps has grown from 2.2 Mtoe in 2005 to 7.4 Mtoe in 2013 (Figure 2.14). In 2013, Italy had a share of 34 % of final energy consumption. Most heat pumps sold in Italy are primarily used for cooling (EurObserv'ER, 2015c). France (22 %) and Sweden (17 %) also made significant contributions. Heat pumps are installed extensively throughout the houses in Sweden (EurObserv'ER, 2015c). In 2014, the renewable heat from heat pumps increased to 8.1 Mtoe according to an EEA estimate.

According to EurObserv'ER, which measures progress in renewable energies in the EU, sales of heat pumps have been hit by the economic slowdown, financial uncertainties and a reduction in the numbers of new houses being built over the past years (EurObserv'ER, 2015c). With a total growth rate over the period 2005–2013 of 16 % per year, the expectations in the NREAPs have already been exceeded. An 8 % compound annual growth rate would be sufficient to meet the expected contribution from heat pumps by 2020, according to the NREAPs. However, an Ecofys projection shows that, by 2020, renewable energy from heat pumps will be higher than anticipated by the NREAPs (Ecofys, 2014).

Figure 2.14 Renewable heating and cooling in the EU-28: renewable energy from heat pumps



Notes: This figure shows the realised final renewable energy consumption for 2005–2013, approximated estimates for 2014 and the expected realisations in the energy efficiency scenario of the NREAPs for 2015–2020.

Source: EEA (based on data from Eurostat and NREAP reports).

Solar thermal energy

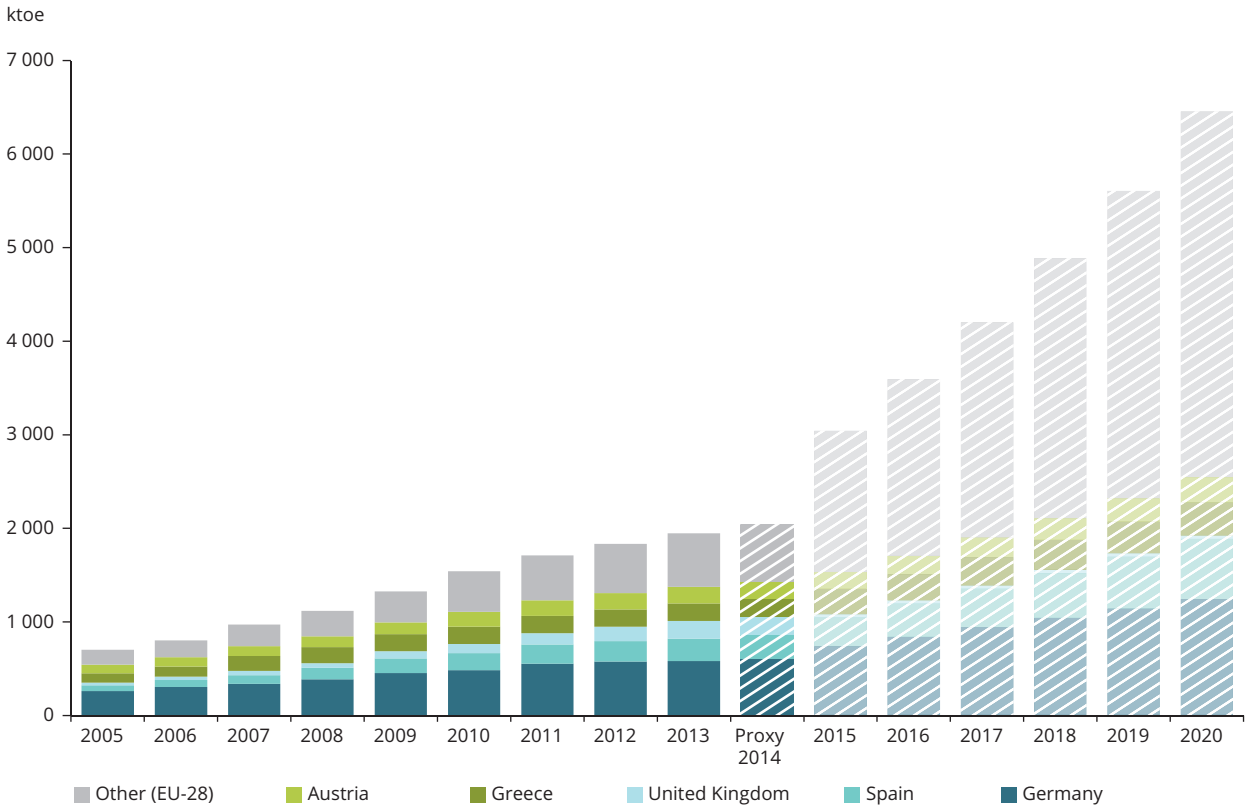
The production of renewable heat from solar thermal technology increased by 14 % per year over the period 2005–2013, growing from 0.7 Mtoe to 1.9 Mtoe (Figure 2.15). However, despite an estimated increase to 2.0 Mtoe in 2014 (with the largest absolute increase expected in Germany and the largest relative increase expected in Lithuania), solar thermal energy has not been able to keep up with the expectations in the NREAPs.

Solar thermal collectors 'harvest' heat from the sun for hot water or space heating. The annual installed surface of solar thermal collectors peaked in 2008 and has since then declined each year (EurObserv'ER, 2015e). This may be due, among other things, to a slowdown in the construction sector and ineffective investment support policies in several countries. A growth rate of 19 % per year would be needed to reach the NREAP expectations for 2020.

Other sources of renewable heating and cooling

- Renewable heat from biogas grew from 0.7 Mtoe in 2005 to 2.5 Mtoe in 2013. The overall trend was strongly influenced by Germany, which accounted for a 51 % share of the EU's total renewable heat from biogas in 2013. A slight increase to 2.6 Mtoe in 2014 was estimated.
- Geothermal heat would have to bridge a large gap to achieve the amount that was expected for 2020 — 2.6 Mtoe. In 2013, the production of geothermal heat was 0.7 Mtoe.
- The production of heat from liquid biofuels was 0.2 Mtoe in 2013, and no significant change was expected for 2014.

Figure 2.15 Renewable heating and cooling in the EU-28: solar thermal



Notes: This figure shows the realised final renewable energy consumption for 2005–2013, approximated estimates for 2014 and the expected realisations in the energy efficiency scenario of the NREAPs for 2015–2020.

Source: EEA (based on data from Eurostat and NREAP reports).

2.2.4 Renewable transport fuels

The share of renewable fuels in transport in the EU-28 (RES-T) was 5.4 % in 2013. Figure 2.16 and Table 2.8 show the development of the use of biofuels in transport up to 2013, approximated estimates for 2014 and their expected development based on the NREAPs.

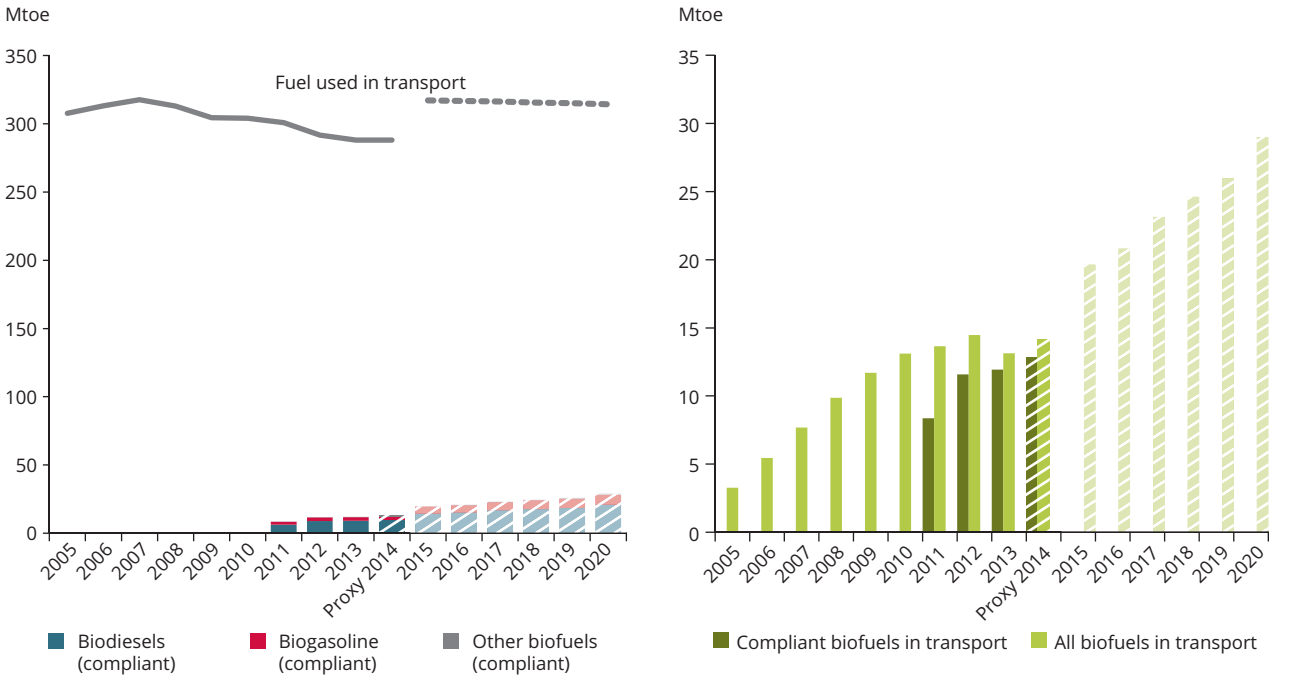
- The gross final consumption of compliant biofuels was 11.9 Mtoe in 2013, which corresponds to an increase of 0.3 Mtoe compared with 2012.
- According to 2014 proxy estimates, the RES-T share grew in 2014 to 5.5 %, because consumption of compliant biofuels grew by around 6 %.
- Over the period 2005–2013, the compound annual growth rate was 18 % per year. To realise the expectations in the NREAPs for 2020, a growth rate of 14 % per year over the remaining period would be required.

The use of renewable electricity in road transport in the EU-28 was 75 ktoe in 2013. The amount of electricity used in other transport modes was 5.4 Mtoe. For 2014, it was estimated that renewable electricity in transport would stay almost constant ([17]).

Since 2005, the gross final consumption of biofuels has increased strongly, but that growth has slowed and more or less stalled since 2010 (Figure 2.17). 2013 was the first year in which the total consumption of biofuels decreased compared with the previous year. Most countries are below the expected realisations in their NREAPs, but there is no clear EU-wide trend. Several countries have recently increased their consumption of biofuels in transport. The reduction in consumption in 2013 was mostly caused by Spain, which cut its biofuel incorporation targets (EurObserv'ER, 2015a). For 2014, it was expected that the consumption of compliant biofuels would increase again by about 6 %. The largest absolute increases were expected to be in Germany and France, while in a number of other Member States (most prominently Italy) a decrease in the consumption of compliant biofuels was expected.

The renewable transport sector has a separate RES target for 2020, which is equal to 10 % for each Member State. Because of concerns about the sustainability and benefits in terms of reductions in

Figure 2.16 Renewable transport in the EU-28: biofuels



Notes: This figure shows the realised final renewable energy consumption for 2005–2013, approximated estimates for 2014 and the expected realisations in the energy efficiency scenario of the NREAPs for 2015–2020. The consumption of RES accounts for only biofuels complying with the RED sustainability criteria.

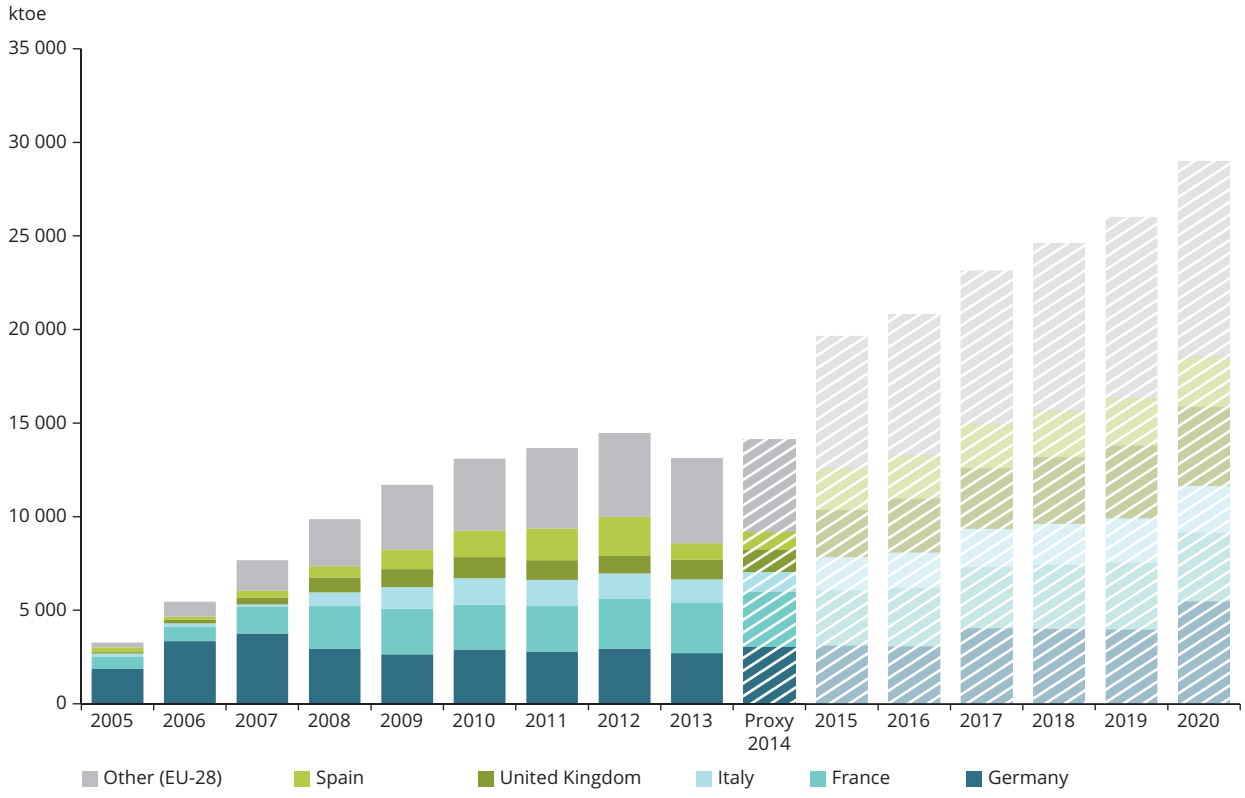
Source: EEA (based on data from Eurostat and NREAP reports).

([17]) This renewable electricity is produced by the energy technologies discussed in Section 2.2.2.

GHG emissions of first-generation biofuels, this target was controversial (Kampman et al., 2015). Furthermore, Member States have made different choices for the development of second-generation biofuels because of delays in adopting an EU directive with clear targets. In 2015 the EU Parliament and Council adopted the Directive to reduce indirect land use change for biofuels and bioliquids (ILUC Directive), which attempts to tackle — among others — these concerns: the directive limits the share of biofuels from crops grown on agricultural land to 7 % and obliges Member States to establish indicative national targets for advanced biofuels (second/third generation) for 2020, with a reference value of 0.5 %. Besides these provisions, the directive also harmonises the list of feedstocks across the EU whose contribution would count double towards the 2020 target of 10 % for renewable energy in transport (Annex IX); an increase in the multiplier factors for electricity produced from renewable energy sources consumed by electric road vehicles and rail transport for calculating the market share of renewables in transport; an increase in the minimum reduction threshold for GHG emissions applied to biofuels produced in new installations; and an obligation on fuel suppliers to report annually the provisional mean values of the estimated indirect land-use change emissions from biofuels traded ([18]).

In recent years, a significant volume of biofuels could not be demonstrated to be compliant with the sustainability criteria for inclusion in the calculation for the RED ([19]). It can be expected that the difference between the amount of compliant biofuels and the total amount will decline further, once the remaining countries have implemented their certification schemes (EurObserv'ER, 2015a).

Figure 2.17 Renewable transport in the EU-28: biofuels including non-compliant biofuels



Notes: This figure shows the realised final renewable energy consumption for 2005–2013, approximated estimates for 2014 and the expected realisations in the energy efficiency scenario of the NREAPs for 2015–2020.

Source: EEA (based on data from Eurostat and NREAP reports).

([18]) Directive (EU) 2015/1513.
([19]) Roughly 10 % of all biofuels consumed in transport in 2013 were not demonstrated to be compliant to the sustainability criteria in the Renewable Energy Directive.

Table 2.8 Renewable transport in the EU-28: biofuels

Technology	Final energy (ktoe)					Growth rate (%)		
	2005	2012	2013	Proxy 2014	NREAP 2020	2005–2013	2012–2013	2013–2020
Biodiesels (all)	2 565	11 492	10 293	11 076	20 920	19	– 10	11
Biogasoline (all)	560	2 858	2 717	2 700	7 324	22	– 5	15
Other biofuels (all)	155	117	126	357	746	– 3	7	29
Compliant biofuels	3 240	11 595	11 932	12 841	28 989	18	3	14
All biofuels	3 279	14 467	13 135	14 133	28 989	19	– 9	12

Notes: This table shows the realised final renewable energy consumption for 2005, 2012 and 2013, approximated estimates for 2014 and the expected realisations in the energy efficiency scenario of the NREAPs for 2020. Also shown are the realised compound annual growth rates for 2005–2013, the growth from 2012 to 2013 and the compound annual growth rates required to reach the expected realisation in the NREAPs. The consumption of RES accounts for only biofuels complying with RED sustainability criteria.

Source: EEA (based on data from Eurostat and NREAP reports).

2.3 Effects on energy consumption and greenhouse gas emissions

The EU's renewable energy targets are one important part of the combined efforts to decarbonise the energy system. Although the RES targets are expressed in relative terms (i.e. as a share related to the future levels of energy consumption), progressing towards them can effectively displace fossil fuels and complement the GHG reduction policies for the energy system. As energy efficiency improvements — another key dimension of the EU's decarbonisation efforts — gradually reduce our total energy needs, the growing share of renewables results in a progressively larger displacement of non-renewable alternatives.

To date, the consumption of RES has steadily increased, both as a relative share of final energy consumption and in absolute numbers, as shown in Table 2.3. Over the same timeframe, final energy consumption has slowly declined, from just over 1.2 Gtoe to 1.14 Gtoe (RES denominator in Table 2.1). This implies that the growth of renewable energy in the mix has already eroded market shares previously held by non-renewable sources, effectively reducing CO_2 emissions.

The following sections estimate the gross effect ([20]) of renewable energy on fossil fuel consumption and its associated GHG emissions and then — statistically — on primary energy consumption. The estimates were made by comparing actual growth in renewable energy since 2005 with a counter-factual scenario in which this growth would be delivered from non-renewable energy sources. Effectively, this assumes that the growth in renewable energy since 2005 has substituted for an equivalent amount of energy that would have been supplied by other sources. The method is described in detail in the EEA report *Renewable energy in Europe — approximated recent growth and knock-on effects* (EEA, 2015a).

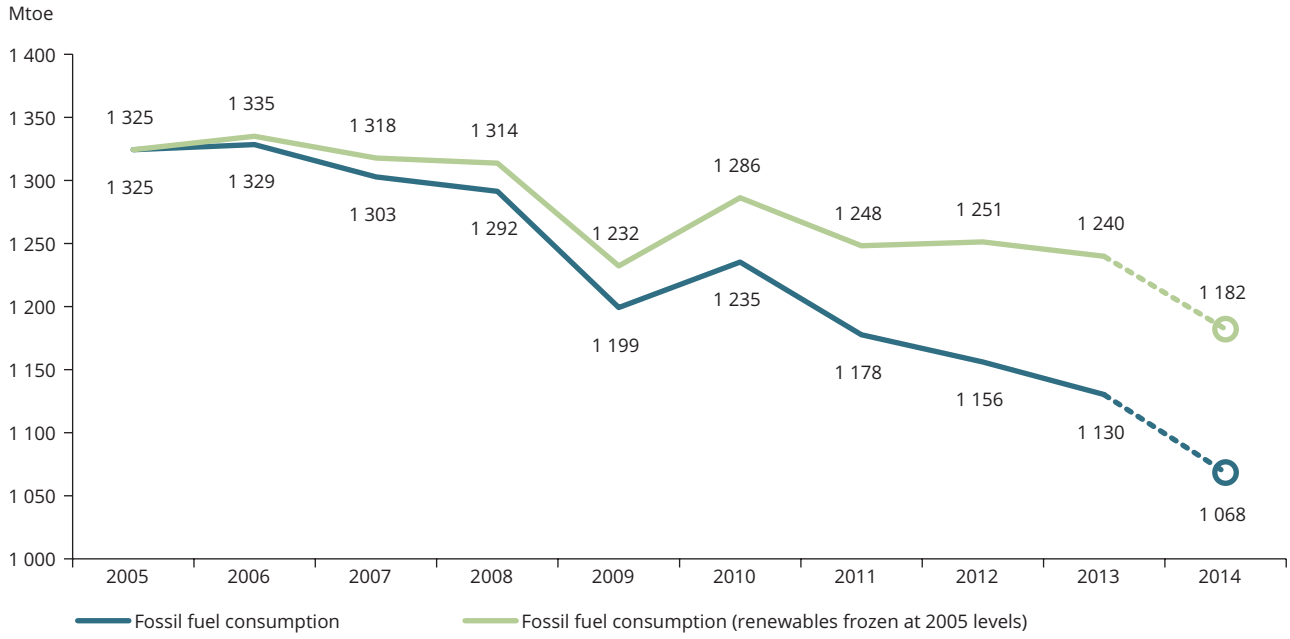
2.3.1 Effects at the EU-28 level

Avoided fossil fuel use

The additional use of renewable energy compared with the level of RES consumption in 2005 allowed the EU to cut its demand for fossil fuels by 110 Mtoe in 2013, and by an estimated 114 Mtoe in 2014 respectively (approximately 10 % of total fossil fuel consumption) (Figure 2.18 and Table 2.9). This amount is comparable to the fossil fuel consumption of France. The largest reductions were realised in the consumption of solid fuels (an estimated 53 Mtoe in 2014, or roughly 46 % of all avoided fossil fuels) and gaseous fuels (appriximately 32 Mtoe in 2014, representing about 29 % of all avoided fossil fuels).

([20]) The term 'gross' describes the theoretical character of the effects estimated in this way. The potential interactions between renewable energy deployment, on the one hand, and the need to reduce GHG emissions under the EU-wide cap set by the Emissions Trading System (EU ETS), as well as wider interactions with the energy and economic system, were not modelled.

Figure 2.18 Estimated effect on fossil fuel consumption in the EU-28



Notes: This figure shows the effect on fossil fuel consumption due to the increase in renewable energy consumption since 2005.

Source: EEA (based on data from Eurostat).

Table 2.9 Estimated effect on fossil fuel consumption in the EU-28 (Mtoe)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	Proxy 2014
Solid fuels	0	– 3	– 7	– 10	– 13	– 19	– 27	– 40	– 48	– 53
Gaseous fuels	0	– 2	– 4	– 8	– 13	– 22	– 23	– 29	– 33	– 32
Petroleum products	0	– 1	– 3	– 4	– 6	– 10	– 11	– 14	– 15	– 14
Gasoline	0	0	0	0	0	0	– 2	– 3	– 3	– 3
Diesel	0	0	0	0	0	0	– 6	– 9	– 9	– 10
Non-renewable waste	0	0	0	0	0	0	– 1	– 1	– 1	– 2
Total	0	– 7	– 15	– 22	– 33	– 51	– 70	– 95	– 110	– 114

Notes: This table shows the estimated reduction in fossil fuel consumption due to the increase in renewable energy consumption since 2005.

Source: EEA (author's compilation based on data from Eurostat).

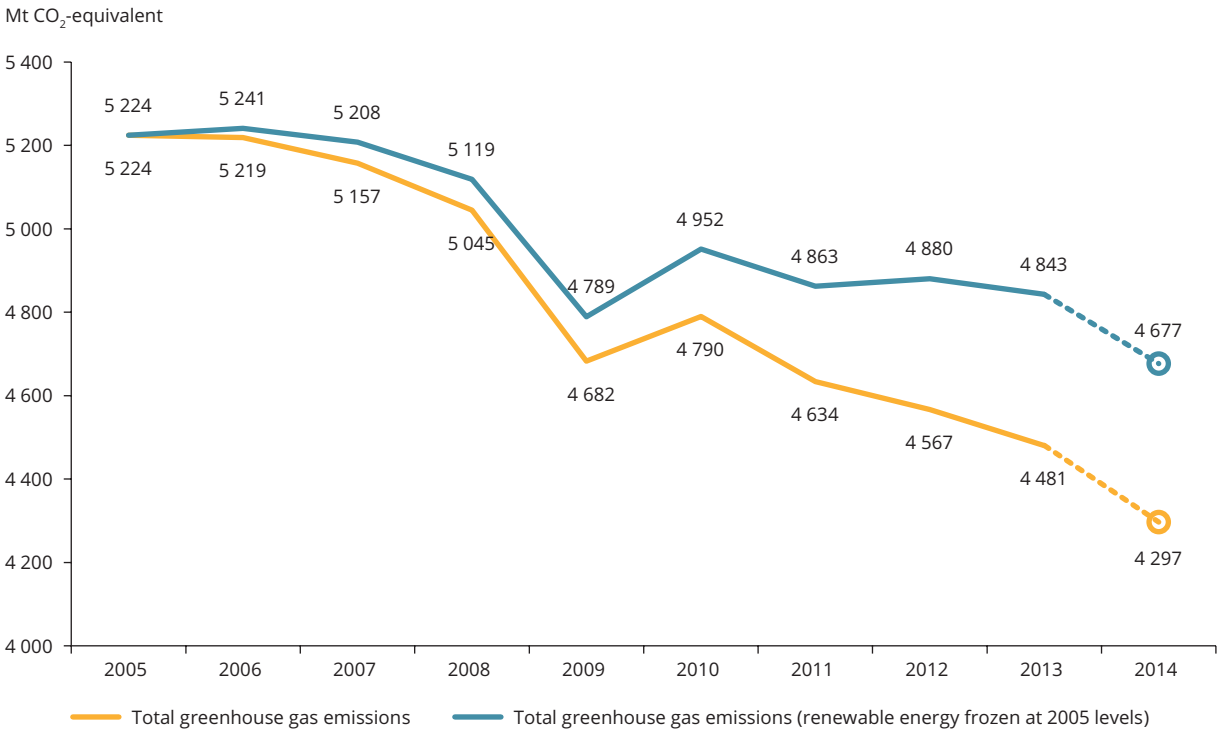
Gross avoided GHG emissions

According to the EEA, the growth in the consumption of renewable energy after 2005 resulted in an estimated 362 Mt of gross avoided CO_2 emissions at the EU level in 2013 and 380 Mt in 2014 (Figure 2.19) — a 5 % increase compared with 2013. This yearly amount is comparable to the GHG emissions of Poland. The contribution from renewable electricity (283 Mt CO_2 in 2014, or 75 % of all gross avoided emissions) is considerably larger than that of renewable heating and cooling (57 Mt CO_2 in 2014, or 15 % of all gross avoided emissions) and biofuels in transport (39 Mt CO_2, or around 10 % of total gross avoided emissions). This is because the increase in renewable electricity has reduced the need for uses of solid fuels — the most carbon-intensive fossil fuels — in the power sector.

In 2013, the total GHGs emissions (excluding international aviation and LULUCF) in the EU-28 was 4 481 Mt CO_2. Without the growth in renewables since 2005, the GHG emissions would have been roughly 7 % higher. In 2014, the gross avoided CO_2 emissions corresponded to a 9 % reduction in the total GHG emissions.

In 2014, the gross avoided emissions within the ETS were estimated to be approximately 296 Mt CO_2 (Figure 2.20 and Table 2.10). The gross avoided emissions in non-ETS sectors were estimated to be approximately 84 Mt CO_2 ([21]).

Figure 2.19 Estimated gross effect on GHG emissions in the EU-28

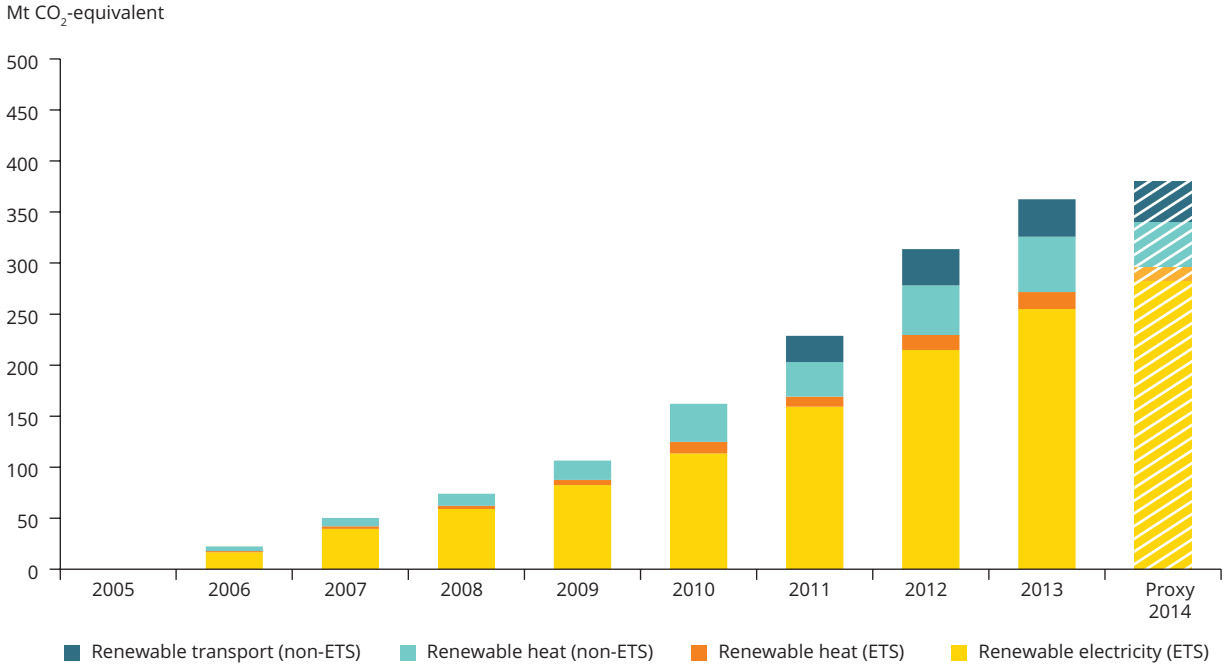


Notes: This figure shows the estimated gross reduction in GHG emissions (excluding international aviation) due to the increase in renewable energy consumption since 2005.

Source: EEA (based on data from Eurostat).

([21]) These estimates are based on the assumption that renewable electricity generation always replaces conventional centralised electricity generation, which takes place within the EU ETS; transport emissions occur outside the ETS; renewable heat can either replace heat that is produced in sectors falling under the ETS or heat that is produced in non-ETS sectors. We assume that the share of ETS emissions in the industry sector is an indicator for the share of renewable heat production in the industry that takes place under the ETS.

Figure 2.20 Estimated gross reduction in GHG emissions in the EU-28 (Mt CO_2-equivalent), by energy market sector



Notes: This figure shows the estimated gross reduction in GHG emissions due to the increase in renewable energy consumption since 2005.

Source: EEA (based on data from Eurostat).

Table 2.10 Estimated gross reduction in GHG emissions in the EU-28 (Mt CO_2)

		2005	2006	2007	2008	2009	2010	2011	2012	2013	Proxy 2014
ETS	Electricity	0	17	40	59	82	114	159	215	255	283
	Heating and cooling	0	1	2	3	5	11	10	15	17	13
	Transport	0	0	0	0	0	0	0	0	0	0
	All renewables	0	18	42	62	88	125	169	230	272	296
Non-ETS	Electricity	0	0	0	0	0	0	0	0	0	0
	Heating and cooling	0	4	8	12	19	37	34	48	54	44
	Transport	0	0	0	0	0	0	26	35	37	39
	All renewables	0	4	8	12	19	37	60	84	91	84
Total	Electricity	0	17	40	59	82	114	159	215	255	283
	Heating and cooling	0	6	11	15	24	48	44	63	71	57
	Transport	0	0	0	0	0	0	26	35	37	39
	All renewables	0	22	50	74	107	162	229	314	362	380

Notes: This table shows the estimated gross reduction in GHG emissions due to the increase in renewable energy consumption (normalised, compliant biofuels) since 2005.

Source: EEA (based on data from Eurostat).

Statistical impacts of RES on primary energy consumption

Primary energy consumption measures a country's total energy demand ([22]). Whereas the RED sets forth binding targets for 2020 for the share of renewables in GFEC, some energy policies put forward targets and objectives expressed in **primary** energy. This is the case for the recast Energy Performance of Buildings Directive (EPBD ([23])) and the Energy Efficiency Directive (EED ([24])). As the latter is part of the EU 20-20-20 climate and energy package ([25]), an assessment of interactions between different RES technologies and their statistical impacts on primary energy is presented further below. The methodology underpinning these findings was described in a previous EEA report (EEA, 2015a) ([26]).

At the EU level, primary energy consumption has been decreasing almost constantly since 2005 (EEA, 2015b). This downwards trend is the result of a number of interacting factors, sometimes with opposing effects in terms of statistical accounting rules and definitions in use. For example, factors driving the accounting of primary energy consumption downwards include:

- a decreasing share of nuclear energy and thermal generation (excluding combined heat and power (CHP);
- an increasing share of certain renewables, such as hydro- and wind power, in electricity generation.

This is because the statistical methodologies in use follow the common physical principle of the first measurable primary equivalent energy in order to estimate the primary energy of certain technologies or sources. For nuclear and geothermal energy, the first measurable primary equivalent energy is the heat that is being converted to electricity. In contrast, for solar PV and wind the first measurable primary energy equivalent is the resulting electricity, which thus amounts to a 100 % transformation efficiency for these technologies and thereby improves the overall conversion efficiency of the energy system.

Factors driving the accounting of primary energy consumption upwards include an increasing share of specific renewable energy technologies such as biomass-based electricity production. This is because the efficiency of electricity generation from biomass is, on average, lower than that from fossil fuels. Given these low efficiencies, converting the gross final electricity obtained from biomass into primary energy will, statistically, worsen the overall conversion efficiency of the energy system and thus increase the total primary energy consumption.

The EEA estimates that the deployment of renewables since 2005 reduced primary energy consumption by 32 Mtoe in 2014 (Figure 2.21 and Table 2.11). The estimated reduction in primary energy consumption in 2013 was 26 Mtoe. Without the growth of renewable energy since 2005, primary energy consumption in the EU-28 in 2013 could have been 2 % higher.

Knock-on effects by renewable energy technology

Table 2.12 shows the estimated impact of each renewable energy technology on GHG emissions, fossil fuel consumption and primary energy consumption.

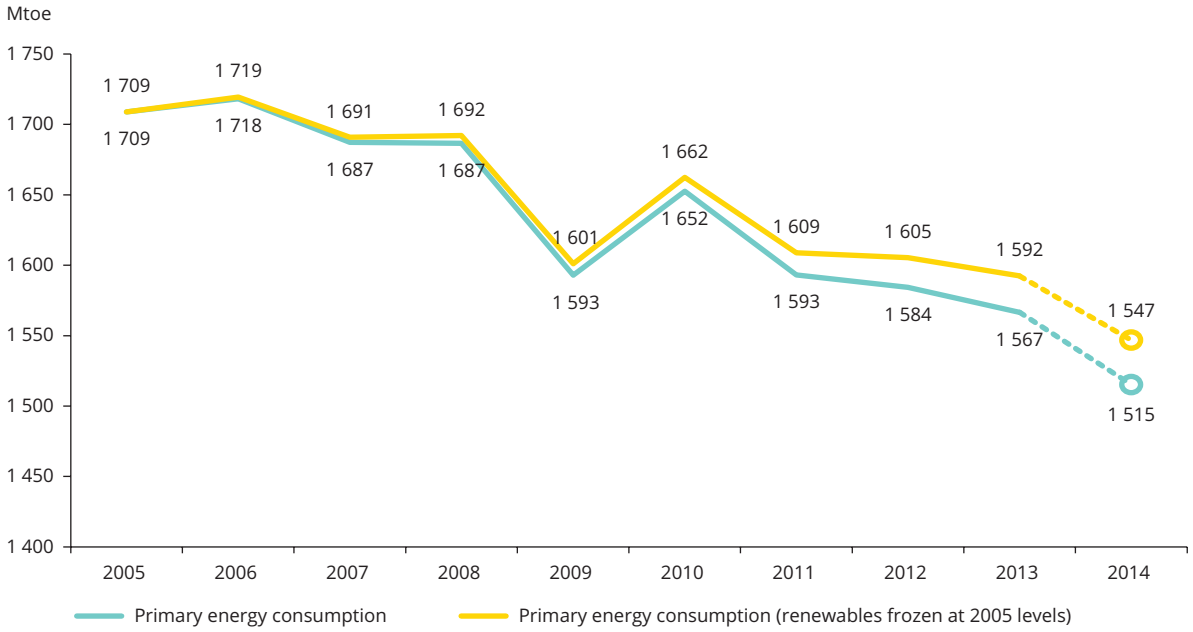
In 2014, the greatest amounts of gross avoided GHG emissions were attributable to onshore wind energy (126 Mt CO_2), solar PV energy (70 Mt CO_2) and heat from solid biomass (32 Mt CO_2) ([27]). Onshore wind and solar-PV energy are also the most important contributors to avoided fossil fuel consumption and avoided primary energy consumption. In contrast, heat from solid biomass increased primary energy consumption by 2.2 Mtoe.

The use of solid biomass for electricity and heating leads to a reduction in GHG emissions and fossil fuel consumption, but it drives up the primary energy consumption.

Owing to statistical conventions in place, consumption of concentrated solar power and geothermal energy can also increase primary energy consumption. For tidal, wave and ocean energy, there is a small positive effect on primary energy consumption, but this is because the final energy consumption of these sources has decreased since 2005.

([22]) Primary energy consumption is the gross inland consumption, excluding all non-energy use of energy carriers.
([23]) Directive 2010/31/EU.
([24]) Directive 2012/27/EU.
([25]) The three key EU climate and energy targets to be achieved by 2020 are: a 20 % reduction in EU GHG emissions compared with 1990; a 20 % share of renewable energy in final EU energy consumption; and a 20 % improvement in energy efficiency.
([26]) Some changes have been made to the methodology for calculating the effects of renewable energy on primary energy consumption. It is assumed that the use of renewable biofuels does not have an impact on primary energy consumption, because the use of fossil fuels (such as gasoline and diesel) is replaced by the same amount of biofuels. Heat extracted from the environment by heat pumps counts as renewable energy. To estimate the effect of heat pumps on fossil energy consumption and primary energy consumption, we assume a seasonal performance factor (SPF) for heat pumps of 3.0.
([27]) The impact of biomass consumption on the actual GHG emissions is uncertain in the absence of LULUCF accounting.

Figure 2.21 Estimated effect on primary energy consumption in the EU-28



Notes: This figure shows the estimated effect on primary energy consumption due to the increase in renewable energy consumption since 2005.

Source: EEA (based on data from Eurostat).

Table 2.11 Estimated effect on primary energy consumption in the EU-28 (Mtoe)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	Proxy 2014
Renewable electricity (normalised, compliant biofuels)	0.0	– 1.2	– 3.6	– 5.3	– 8.3	– 11.3	– 16.5	– 22.7	– 27.6	– 32.3
Renewable heating and cooling (compliant biofuels)	0.0	0.0	0.1	– 0.2	0.2	1.4	0.6	1.6	1.8	0.6
Renewable transport (compliant biofuels)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
All renewables (normalised, compliant biofuels)	0.0	– 1.2	– 3.5	– 5.4	– 8.1	– 9.9	– 15.9	– 21.1	– 25.8	– 31.7

Notes: This table shows the estimated effect on primary energy consumption due to the increase in renewable energy consumption since 2005.

Source: EEA (based on data from Eurostat).

Table 2.12 Effect of renewable energy on GHG emissions and energy consumption by technology in the EU-28

EU-28	Increase of renewable energy consumption since 2005 (ktoe)		Effect on greenhouse gas emissions (Mt CO_2)		Effect on fossil fuel consumption (ktoe)		Effect on primary energy consumption (ktoe)	
	2013	Proxy 2014	2013	Proxy 2014	2013	Proxy 2014	2013	Proxy 2014
Renewable electricity								
Biogas	3 449	3 526	– 33	– 34	– 8 552	– 8 759	– 341	– 364
Bioliquids (compliant)	346	290	– 3	– 2	– 818	– 686	– 35	– 29
Concentrated solar power	378	378	– 3	– 3	– 868	– 868	265	265
Geothermal	46	71	0	– 1	– 111	– 169	352	536
Hydropower excl. pumping (normalised)	406	589	– 4	– 6	– 978	– 1424	– 572	– 835
Offshore wind (normalised)	1 027	1 204	– 9	– 10	– 2 542	– 2 955	– 1 515	– 1 751
Onshore wind (normalised)	12 405	14 326	– 109	– 126	– 30 507	– 35 337	– 18 101	– 21 011
Solar photovoltaic	6 828	7 724	– 62	– 70	– 16 826	– 19 035	– 9 998	– 11 311
Solid biomass	3 837	3 673	– 33	– 32	– 9 328	– 8 902	2 300	2 227
Tidal, wave and ocean energy	– 5	4	0	0	14	– 10	9	– 6
Renewable heating and cooling								
Biogas	1 811	1 881	– 6	– 6	– 2 026	– 2 104	– 14	– 15
Bioliquids (compliant)	228	228	– 1	– 1	– 255	– 255	1	1
Geothermal	99	137	0	0	– 110	– 154	87	121
Renewable energy from heat pumps	5 146	5 895	– 1	– 1	– 2 136	– 2 464	– 2 136	– 2 464
Solar thermal	1 245	1 343	– 4	– 4	– 1 392	– 1 502	– 147	– 159
Solid biomass	18 939	14 403	– 59	– 45	– 21 206	– 16 122	4 046	3 082
Renewable transport								
Biodiesels (compliant)	9 229	9 939	– 29	– 31	– 9 229	– 9 939	0	0
Biogasoline (compliant)	2 569	2 537	– 7	– 7	– 2 569	– 2 537	0	0
Other biofuels (compliant)	134	366	0	– 1	– 134	– 366	0	0
Total renewables (normalised, compliant biofuels)	68 117	68 512	– 362	– 380	– 109 574	– 113 588	– 25 799	– 31 712

Notes: This table shows the estimated effect on GHG emissions, fossil fuel consumption and primary energy consumption due to the increase in renewable energy consumption since 2005.

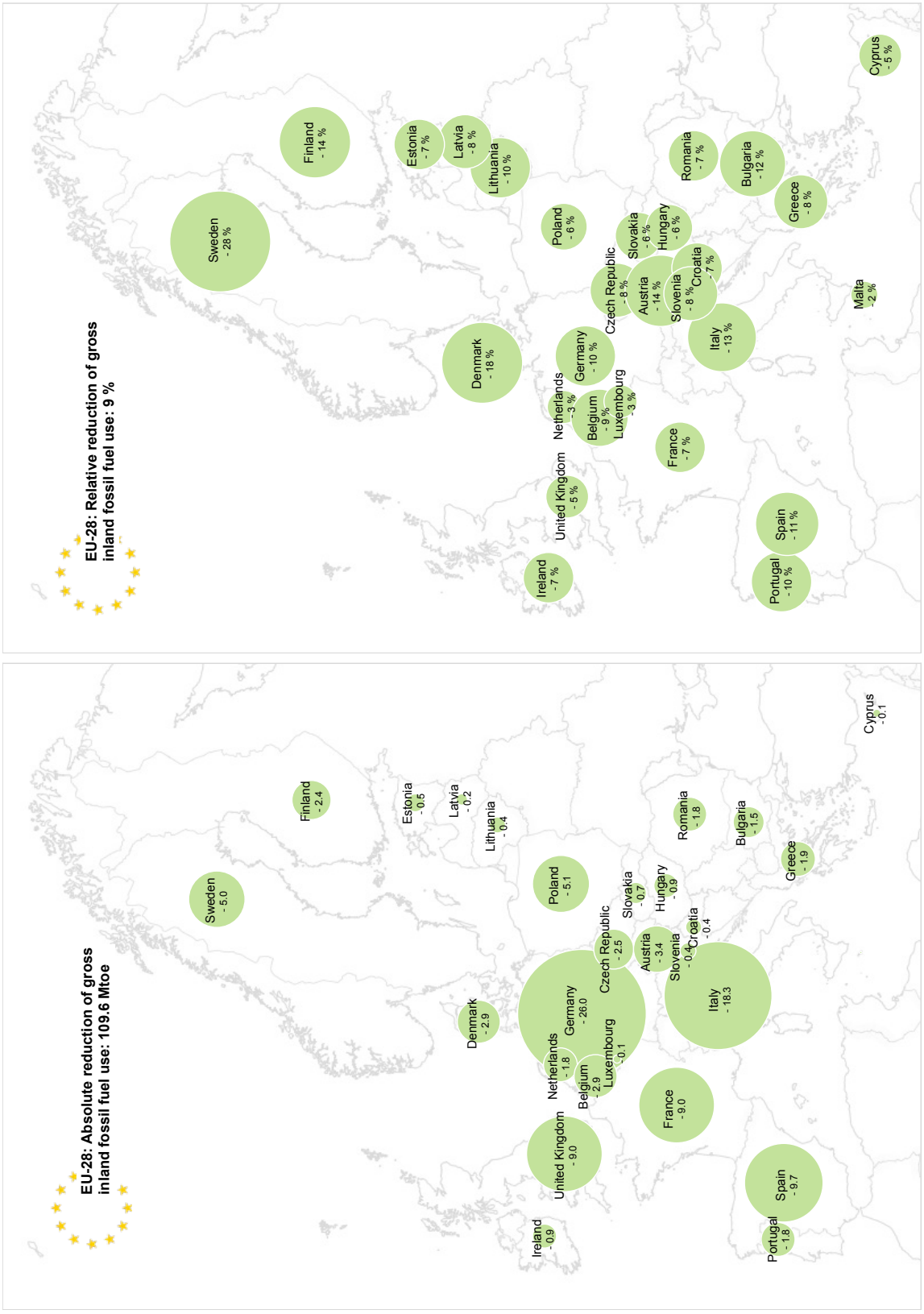
Source: EEA (based on data from Eurostat).

Effects at EU Member State level

The increase in renewable energy consumption in the Member States since 2005 has also had an impact on fossil fuel use and GHG emissions in the Member States themselves. According to EEA calculations, in 2013 the largest relative reductions of fossil fuels consumption were realised by Sweden (28 %), Denmark (18 %) and Austria (14 %), while in absolute terms the greatest quantities of fossil fuels were avoided in Germany and Italy (see Figure 2.22).

In terms of gross avoided GHG emissions in 2013, the Member States with the largest estimated gross reductions are Germany (95.6 Mt CO_2), Italy (54.0 Mt CO_2) and Spain (31.8 Mt CO_2). In relative terms, significant GHG emission reductions (of 10 % or more of the total national GHG emissions, excluding international aviation and LULUCF) were recorded in six Member States in 2013 (Sweden, Denmark, Austria, Finland, Italy and Portugal), as illustrated in Figure 2.23.

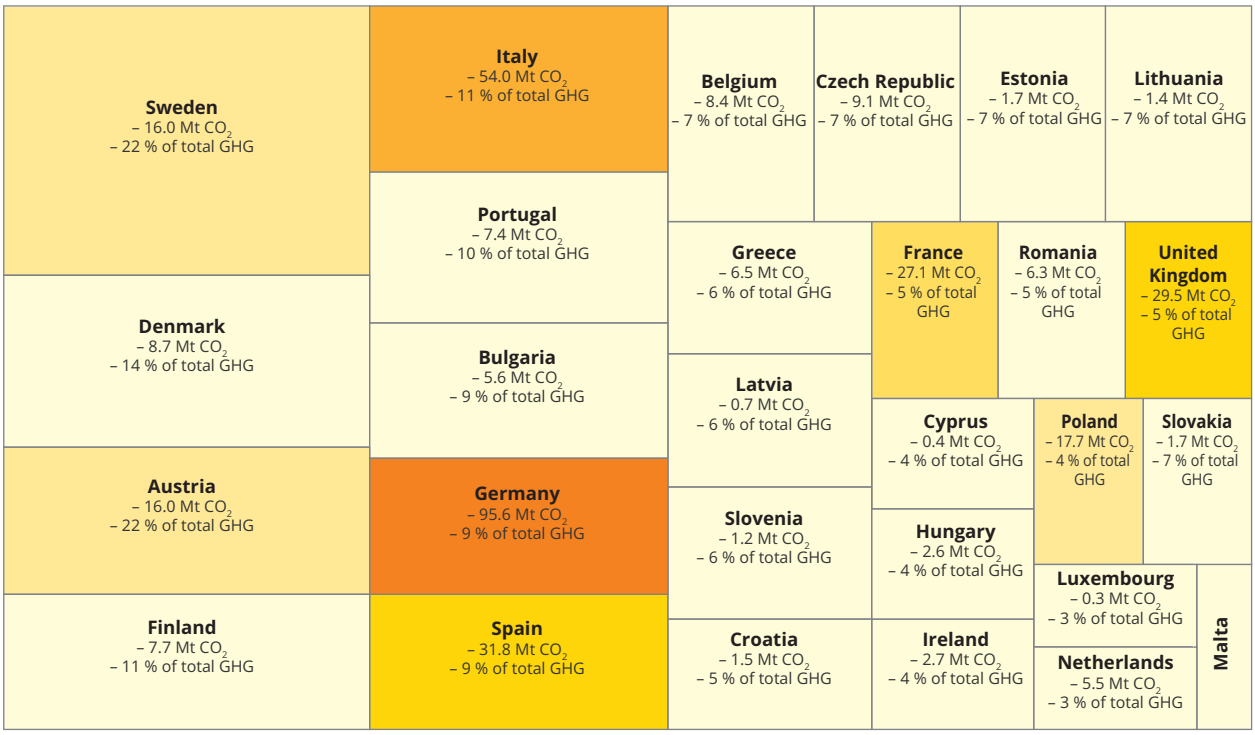
Figure 2.22 Absolute and relative reduction in gross inland fossil fuel use (p.a., in 2013)



Notes: Left side: absolute reduction in gross inland fossil fuel use in Mtoe due to the increase in renewable energy use per country since 2005. Right side: relative reduction in gross inland fossil fuel use per country (expressed as absolute reductions over total gross inland consumption of fossil fuels). Given the very small energy use in Malta, this country is not illustrated on the left side map.

Source: EEA (based on data from Eurostat).

Figure 2.23 Total and relative gross avoided GHG emissions (p.a., in 2013)



Note: Areas illustrate the relative RES impacts on total national GHG emissions. The larger an area, the more significant the share of a country's estimated gross avoided CO_2 within its total national GHG emissions (excluding international aviation and LULUCF). The colour scheme illustrates total gross avoided GHG emissions. The more intense the shading, the higher the RES effects in terms of gross avoided GHG emissions. Gross avoided EU GHG emissions in 2013: 362 Mt, equivalent to a 7 % reduction in total EU GHG emissions.

Source: EEA (baed on data from Eurostat).

The most important statistical effects of renewables on primary energy consumption are recorded for Portugal, Denmark and Greece, where reductions in primary energy consumption are visible (– 5.7 %, – 5.2 %, and – 4.3 %, respectively), whereas in Finland the statistical conventions in place result in a slight increase in primary energy consumption (0.3 %) due to the prevalence of biomass-based renewables. The effect of renewable energy on GHG emissions and energy consumption in 2013 are summarised by country in Annex 3.

2.4 R&D expenditure

Increasing the rate of clean energy innovation is crucial to moving away from fossil fuels and meeting the world's climate change goals. The transformation of the European energy system would greatly benefit from better, more advanced renewable energy technologies. In turn, this highlights the essential role of cross-cutting and strategic research and development (R&D) in renewable energy.

According to IEA's R&D statistics ([28]), public R&D funding for renewables has increased from EUR 338 million in 2005 to EUR 874 million in 2013 ([29]). Funding for fossil fuel technologies has grown much less in the same time, from EUR 215 million to EUR 256 million (both at 2010 prices). The share of carbon capture and storage (CCS) funding in this figure has been increasing and made up almost half (EUR 113 million at 2010 prices) of in the figure in 2013.

Of all subsectors, nuclear energy (fission and fusion) has been the single largest recipient of R&D funding in

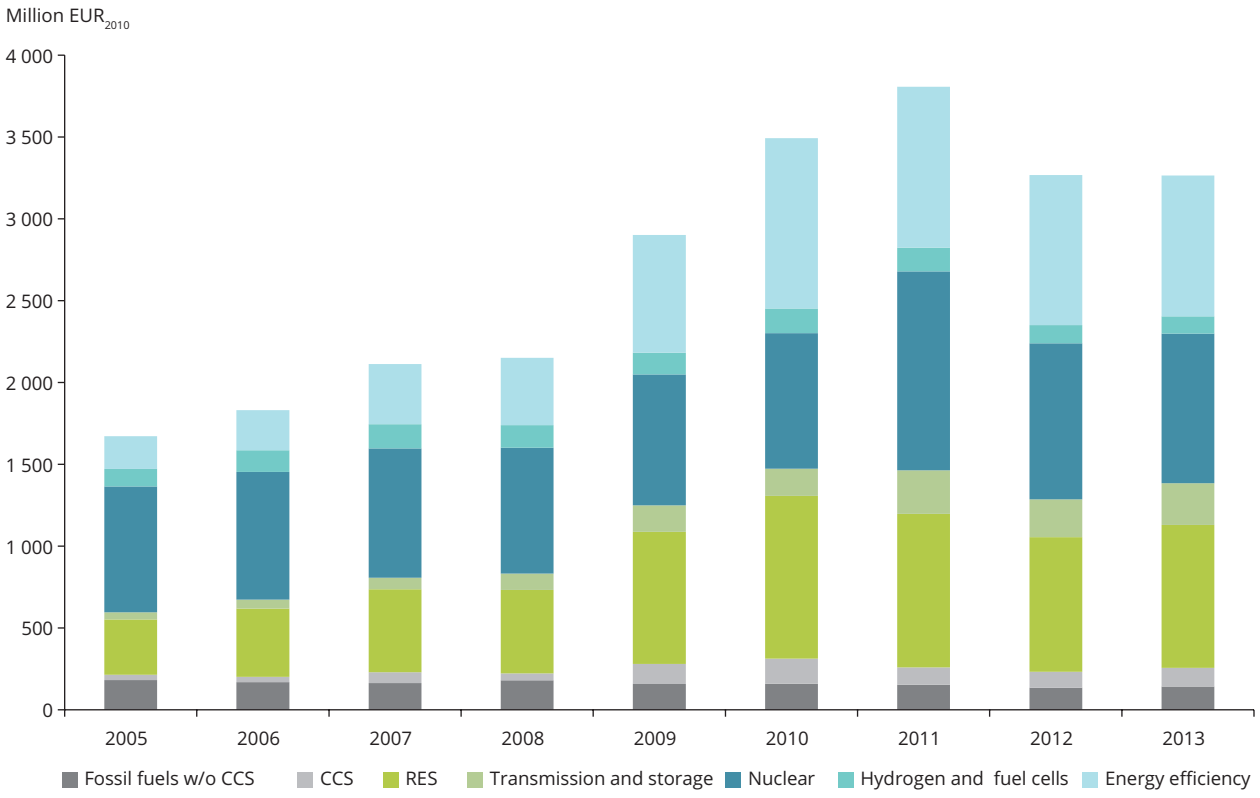
([28]) Data according to OECD and IEA, 2015. R&D data are available only following some delay. At the time of writing, full timelines were available for Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, the Netherlands, Poland, Portugal, Slovakia, Spain, Sweden and the United Kingdom.

([29]) This does not include EU or corporate funding. For a detailed breakdown of all funding sources in one year (2011), see the European Commission's 2015 capacity mapping report at https://setis.ec.europa.eu/sites/default/files/reports/Capacities-Map.pdf.

the EU, receiving EUR 915 million (2010 prices) in 2013 (Figure 2.24); almost half of this budget was funding for research into fission technology in France. Germany was the largest single source of funding for fusion research.

Measured as a share of total R&D expenditures, growth in RES funding has increased only slowly from 20.2 % to 26.8 %, while energy efficiency and transmission and storage technologies have, relatively, benefitted more from a net increase in funding. Without a doubt, efficiency and transmission and storage technologies will be important elements of the transition to renewable energy. However, the stagnating share of funding for RES R&D indicates a certain danger of missing some of the break-through technologies of tomorrow, to the point at which the IEA recommends tripling current levels of R&D spending on clean energy innovation (OECD/IEA, 2015).

Figure 2.24 Public R&D investment for energy technologies (15 EU Member States), million euros at 2010 prices



Note: R&D data are available only following some delay. At the time of writing, full timelines were available for Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, the Netherlands, Poland, Portugal, Slovakia, Spain, Sweden and the United Kingdom.

Source: IEA, 2016.

3 RES developments: a global perspective

Chapter 2 presented in detail the progress that the EU and Member States have made in terms of (gross final) renewable energy consumption and demonstrated that the EU and its Member States are making good progress towards the 2020 RES targets. This chapter focuses on global RES developments, as a way of contrasting European developments with the changes in renewable energy occurring in other parts of the world.

To understand this chapter more fully, it is important to realise that traditional biomass is still an important source of energy for a majority of the world's population (REN 21, 2015), despite the associated health and environmental impacts (see footnote 35). The available global data on gross RES consumption does not make it possible for traditional biomass fuels to be excluded. Yet, the aggregate numbers obscure underlying trends in modern renewable energy sources. To illustrate the rapid development in this area, this chapter complements the comparison of RES shares in gross inland consumption in world regions (in Section 3.1) with information about modern RES, such as installed RES capacity and investments.

The analysis in this chapter shows that:

- The EU-28 is one of the two world regions ([30]) that visibly increased its share of renewable energy in GIEC between 2005 and 2013.
- The EU-28 was the region exhibiting the highest new investments in renewable energy every single year from 2005 to 2012 and was only surpassed by China in 2013.
- Of world regions with sufficient available data, the EU-28 came in third regarding per capita employment in the area of renewable energy in 2014. Of the three countries with highest per capita employment in renewable energies, two were from Europe: Germany, with 0.9 % of its labour force working in jobs related to renewable energies; and France, with 0.58 % of the workforce being employed in the area of renewable energy.

3.1 Renewable energy shares by region and main source

3.1.1 RES shares by region

On a global scale, renewable energy consumption grew by 28 % (from 17 EJ to 76 EJ) between 2005 and 2013, while total energy consumption grew by only 18 % over the same period. As a result, the share of renewable energy in gross energy consumption increased from 13 % to 14 % between 2005 and 2013. Although in most world regions the absolute consumption of RES increased over this period too (even considerably in some world regions, such as in China), in relative terms a region's RES share could have decreased during the period if its energy consumption from non-renewable fuels increased by more than its RES energy consumption.

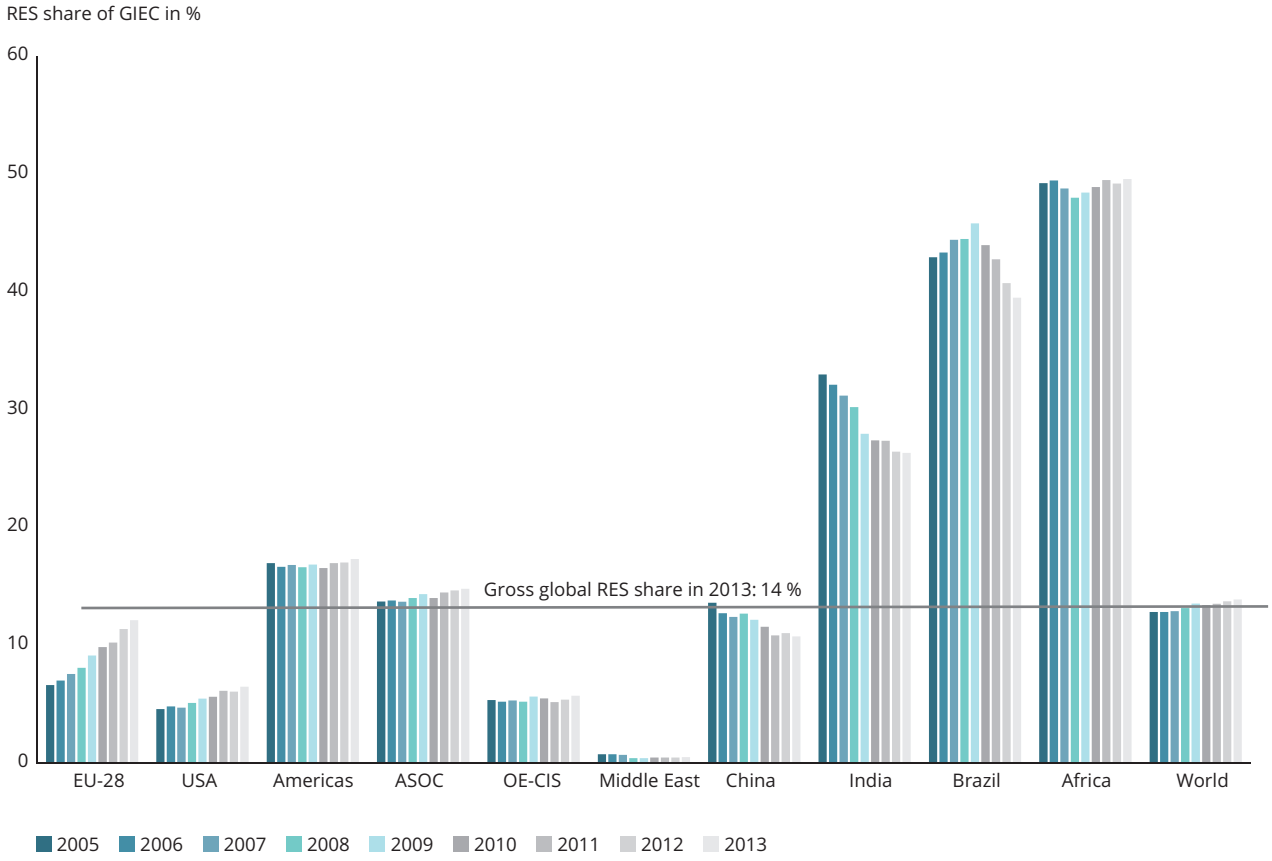
Figure 3.1 illustrates the development of renewable energy shares between 2005 and 2013. Based on their share of RES in gross domestic energy consumption, world regions can be grouped into:

- regions that visibly increased their RES share (EU, United States);
- regions that experienced little change in their RES share (Americas, Other Europe and CIS ([31]), Asia and Oceania (ASOC), Middle East);
- regions with decreasing RES shares (China, India); and
- regions with no clear trend (Brazil, Africa).

([30]) The other world region is the United States.

([31]) Non-EU Member States and countries belonging to the Commonwealth of Independent States. This aggregation was used to obtain a coherent picture for Europe throughout the chapter, in the context where some data (e.g. on RES investments) are not available for the EU-28 alone (for details, see list of abbreviations).

Figure 3.1 Renewable energy shares of GIEC in selected world regions, 2005–2013



Notes: ASOC refers to Asia and Oceania; OE-CIS refers to Other Europe and the Commonwealth of Independent States; information about the geographical coverage and regional aggregations is provided in the list of abbreviations.

Source: IEA, 2015.

The EU is one of the two world regions that increased their RES share significantly from 2005 to 2013. The EU's RES share exhibits the largest values and the steepest growth GIEC, having climbed 5 percentage points over the period (from 7 % to 12 %). By comparison, the share of gross inland RES consumption in the United States went up by roughly 2 percentage points during this time-frame (from 5 % to almost 7 %). Although different in magnitude, the underlying changes in the energy consumption structure of both regions were comparable between 2005 and 2013:

- The GIEC (all energy sources: fossil, nuclear and renewables) decreased by around 6 % in the United States and by 9 % in the EU.
- The gross consumption of RES increased by almost 34 % in the United States and by 67 % in the EU.
- In both regions, in 2005 solid biomass followed by hydroelectricity were the two most important renewable energy sources measured in GIEC ([32]). In the EU, this was still the case in 2013. In the United States, however, biogasoline had become more important than hydroelectricity by 2013, following an absolute growth that was stronger than that for wind energy and biodiesel. Although solar photovoltaic energy saw a strong increase between 2005 and 2013, both in the EU and in the United States, it currently provides only a small share of the gross inland consumption.

In a number of other world regions, RES shares changed less significantly between 2005 and 2013:

- in the Americas (excluding the United States and Brazil), RES shares stagnated around 17 %;

([32]) Please note that this refers to RES shares in gross **inland** consumption. In contrast, Chapter 0 discusses RES developments in the EU and its Member States in relation to GFEC because the 2020 RES targets under the Renewable Energy Directive are set in gross final consumption.

- in Asia and Oceania (excluding China, India and the Middle East), the share of RES increased from 13.7 % to 14.8 %;

- in the Middle East (excluding Turkey and Egypt), the RES share declined from 0.7 % in 2005 to 0.5 % in 2013, and in the Other Europe and CIS region it stagnated at about 5 %.

With the exception of the Middle East, in these regions the gross consumption of renewable energy sources increased by similar amounts, as total energy consumption from all fuels increased, leading to only small net changes in the RES share of GIEC.

In the two most populated countries, China and India, the RES shares in gross energy consumption actually decreased between 2005 and 2013, by 2.9 percentage points in China and by as much as 6.7 percentage points in India. This happened as the total gross energy consumption (from all fuels) grew much faster than the absolute growth in RES consumption in these countries. While solid biomass remains the most important renewable energy source in both countries, the mix of the various RES technologies has changed significantly in China ([33]).

Brazil and Africa were the two world regions with the highest RES shares in GIEC. But the development of RES shares in these two regions showed no clear trend between 2005 and 2013. In Brazil, the RES share increased from 42.9 % in 2005 to as much as 45.8 % in 2009, but it then decreased to 39.5 % in 2013. In Africa, the RES share decreased from 49.2 % in 2005 to 48.0 % in 2008 and then it increased to 49.6 % in 2013. The GIEC in Africa increased by one-quarter between 2005 and 2013, while in Brazil it grew more strongly (by 36 % since 2005). In Brazil, the peak in the consumption of solid biomass (the most important RES in Brazil) and of 'other bioliquids' ([34]) (the third most important RES in Brazil), around 2009/2010, explains its maximum RES share in 2009. Although hydroelectricity recorded strong growth (16 %) from 2005 to 2013, it could not fully compensate for the decline in biomass-based RES.

In Africa, renewable energy sources were dominated by the use of solid biomass (constant share of 97 %). The only notable other RES was hydroelectricity, with a constant share of 3 %. The minimum in 2007 can be explained by the fact that, until 2008, the GIEC of all fuels grew faster than the GIEC of only RES, but since then RES has been growing faster than total energy consumption.

Gross renewable energy consumption by source

The overall development of renewable energy is not homogeneous among the different parts of the world. For a majority of the world's population, traditional biomass energy is still an important energy source ([35]). Although in recent years this traditional use has started to level off due to increasing urbanisation and the uptake of modern energy sources, it still dominates national energy statistics in many developing countries, with a large share of the population in these countries lacking access to modern energy services (REN 21, 2015).

Together, traditional solid biomass and hydroelectricity still dominate renewable energy consumption on a global scale (Figure 3.2); in developing countries growth of renewable energy still happens mainly within these technologies, apparently driven by growth in total energy demand. By contrast, in developed countries, the absolute growth of more recent renewable technologies, such as wind energy and liquid biofuels, is already greater than that of these two technologies. This is the case in the EU and the United States, as well as in a number of other countries.

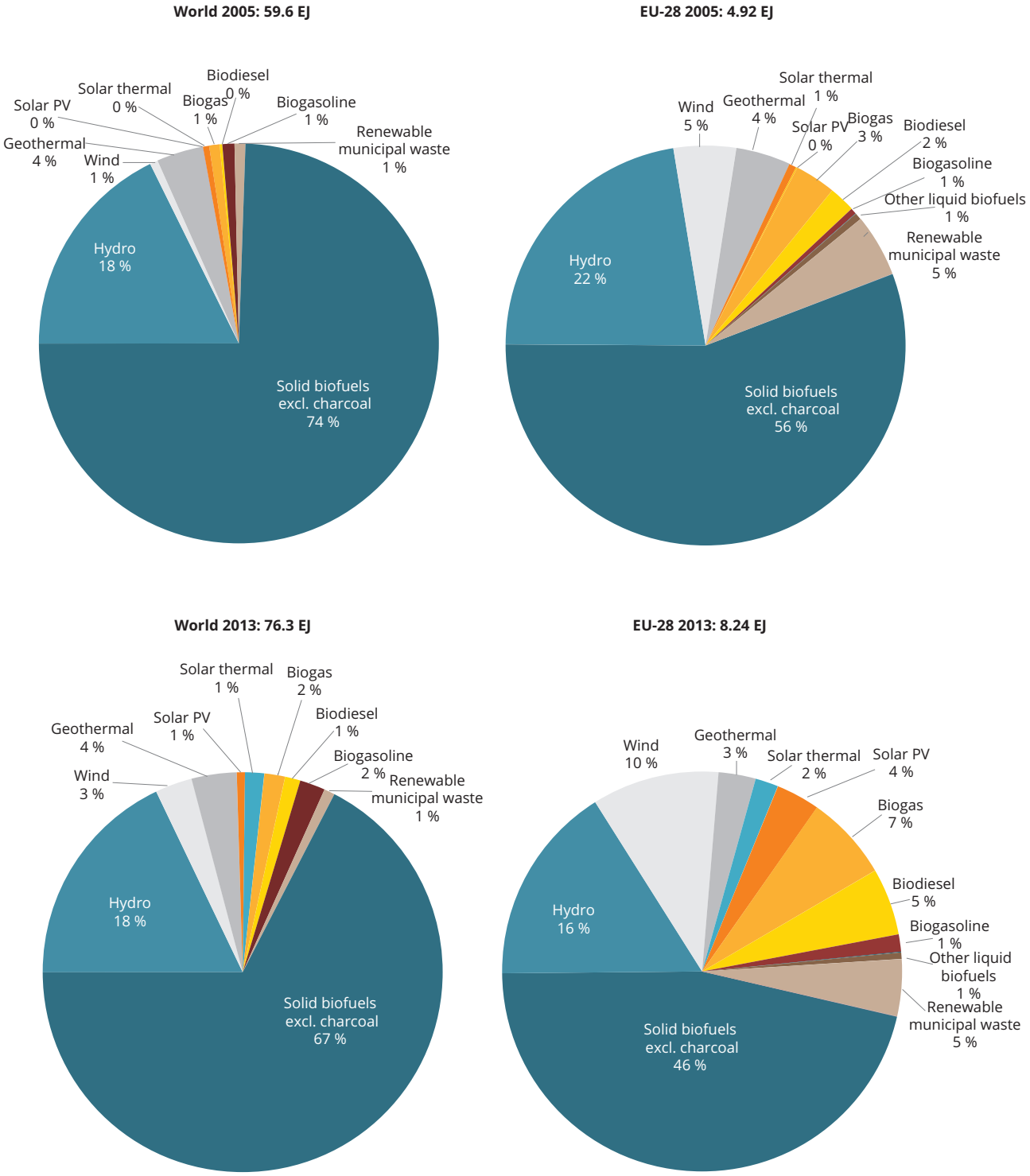
China has shown significant growth in both traditional and modern RES technologies. Comparing only 2012 and 2013, in China solar PV energy saw a growth rate of 144 %, whereas it grew by 60 % in the United States and by 20 % in the EU. Both solar thermal and wind energy showed a growth of 45 % each in China, while in the EU wind energy grew by 14 % and solar thermal energy by 11 %. In the United States wind energy grew by 20 % and solar thermal energy even decreased by 2 %.

([33]) In 2013 China generate 24 % of the world hydroelectricity production (IEA, 2015). By end of 2014 China had an installed hydro capacity of 282 GW and 21 GW were erected in 2014 alone; China is aiming to add 350 GW by 2020 and 510 GW by 2050, all numbers excluding pumped storage (International Hydropower Association, 2015). This is equivalent to building between 17 and 25 more dams the size of China's Three Gorges Dam (currently the largest in the world) in 2020 and in 2050 respectively. In comparative terms, hydroelectricity grew by 129 % in China but only by 31 % in India between 2005 and 2013. Solar thermal energy increased its share in China from 1 % to 6 % while it is still almost negligible in India. The share of wind energy in gross inland consumption increased from almost zero in both countries to 4 % in China, but only 1 % in India (IEA, 2015).

([34]) In the data source IEA, 'World — Renewable and Waste Energy Statistics: IEA Renewables Information Statistics (database)' it is not explicitly mentioned, but bioethanol which is strongly used for road transport in Brazil is presumably included in 'other bioliquids'.

([35]) Traditional biomass energy refers to the burning of fuel wood, charcoal, agricultural and forest residues or dung on open fires for cooking and heating. It is associated with considerable health and environmental impacts and it is still dominant in Africa (especially in Sub-Saharan Africa) and in Developing Asia (e.g. Bangladesh, Cambodia, Myanmar/Burma or Sri Lanka), where 67 % and 51 %, respectively, of the population in 2012 still relied on this energy form for cooking. It is estimated that roughly 70 % (8 805 TWh) of all biomass heat generation globally comes from traditional biomass (REN 21, 2015).

Figure 3.2 Gross renewable energy consumption at the global and EU-28 level



Source: IEA, 2015; Eurostat, 2015b.

3.2 Renewable energy investments and capacity additions

3.2.1 Global investments

Share in global renewable energy investments

Throughout the period 2005–2014 Europe (including CIS ([36])) exhibited the highest shares of global new investments in renewable energy (Table 3.1). However, investment activity spread rapidly to new markets. Viewed over time, Europe's investment share declined from roughly 50 % to 21 % between 2005 and 2014, highlighting its pioneering role in developing renewables, as well as the increasing interest and contributions of other world regions such as the United States, China and, more recently, emerging markets in Africa, the Middle East, the Americas and ASOC.

In 2013, for the first time, Europe came second as regards its share in global new investments in renewable energy, with the largest shares in new investments being taken by China (27 %), while ASOC came in third (19 %). It is worth noting that in 2013 China's additions of renewable energy technologies were larger than those of its thermal technologies. Together, China, Europe (including CIS) and ASOC accounted for close to 70 % of global new investments in renewable energy technologies in 2013.

Growth in renewable energy investments

Between 2005 and 2008, renewable energy investments saw a steady increase in most global regions. Between 2008 and 2009, the economic crisis affected liquidities and, as a consequence, renewable energy investments increased by less than in previous years. Although investments recovered shortly after the crisis, in 2011, for the first time, there was a decline in global investments in renewable energy. This took place against the backdrop of progress and significant cost reductions in certain technologies, policy uncertainties and retroactive policy changes (in Europe, where most investments were taking place, and in the United States, which had the second to third largest investments between 2005 and 2014), low natural gas prices in the United States and somewhat slower economic activity globally.

The steepest average annual growth in new investments in renewable energy between 2005 and 2013 took place in the combined region of the Middle East and Africa (34 %), followed by China (28 %) and ASOC (21 %, without China and India). However, despite the steep growth in investments in the combined region of the Middle East and Africa, that region's share of global new investments ranges between only 1 % and 4 % (see Figure 3.3). Furthermore, a significant increase in investments after 2011 contributed to these large average annual growth rates, so annual growth varies quite significantly in this region.

Table 3.1 Shares of global new investments (%) in renewable energy per region, 2005–2013

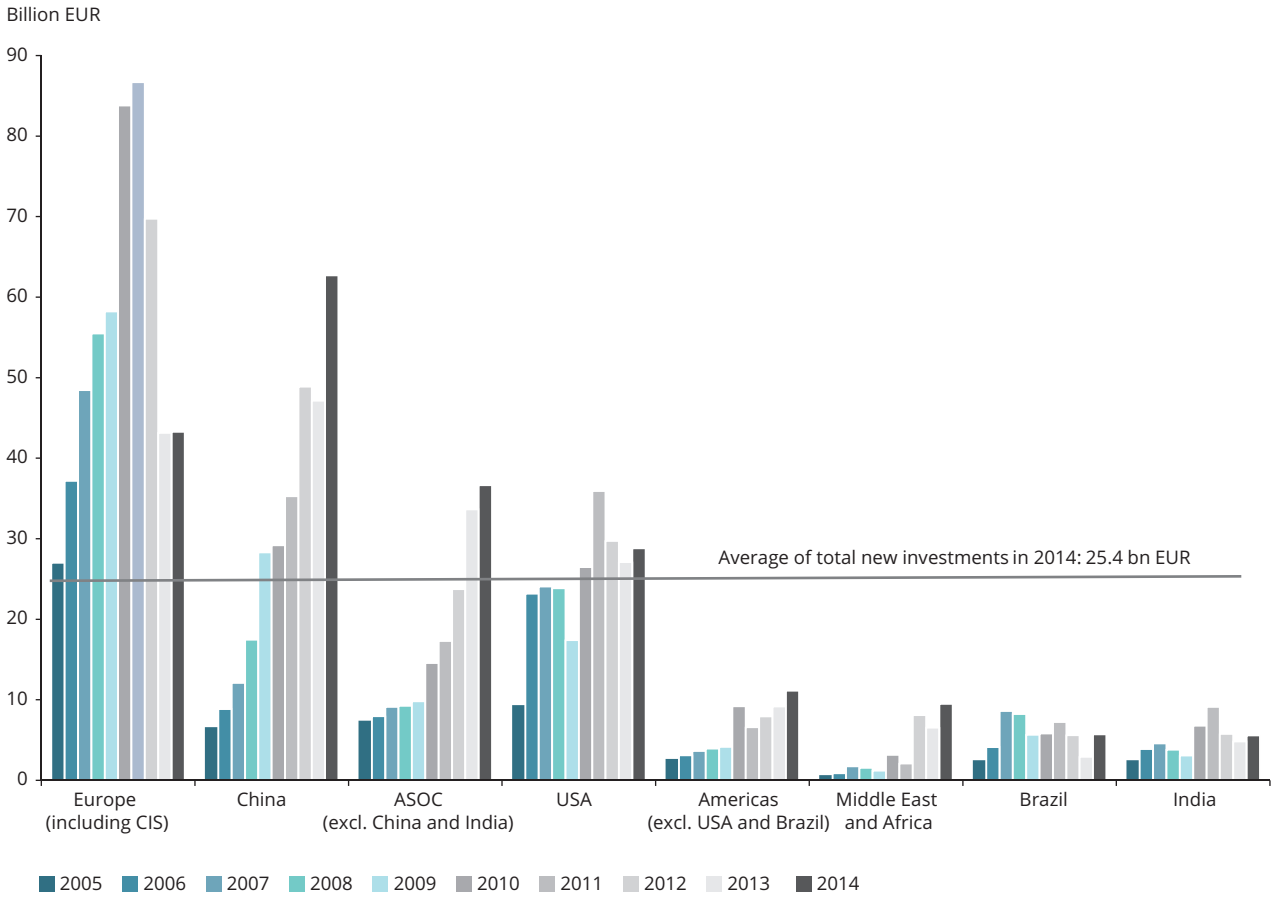
World region	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Europe (including CIS)	52	46	42	43	45	46	47	43	35	25	21
China	7	11	10	11	14	22	16	18	25	27	31
ASOC (excl. China and India)	16	13	9	8	7	8	8	9	12	19	18
United States	12	16	26	21	19	14	15	18	15	16	14
Americas (excl. United States and Brazil)	4	5	3	3	3	3	5	3	4	5	5
Middle East and Africa	1	1	1	2	1	1	2	1	4	4	5
Brazil	2	4	5	8	7	4	3	4	3	2	3
India	6	4	4	4	3	2	4	5	3	3	3

Notes: ASOC refers to Asia and Oceania; CIS refers to the Commonwealth of Independent States; information about the geographical coverage and regional aggregations is provided in the list of abbreviations. Dark green indicates the band of the highest shares; white denotes the band of the lowest; yellow illustrates the midpoint percentile.

Source: Frankfurt School-UNEP, 2015.

([36]) CIS refers to the Commonwealth of Independent States. For details, please see geographical notations in the list of abbreviations.

Figure 3.3 Total new investments by region, 2005–2014



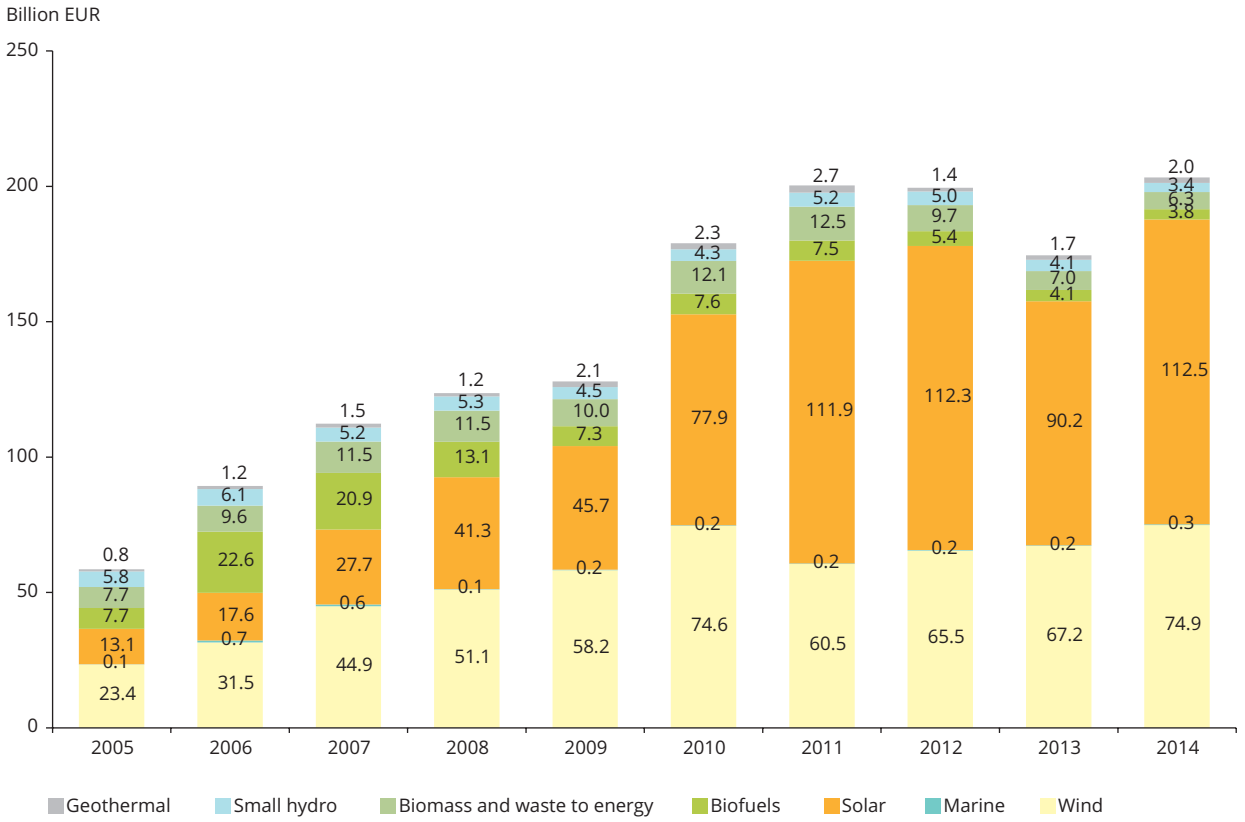
Notes: Figures converted to euros using annual exchange rates from Eurostat. ASOC refers to Asia and Oceania; CIS refers to the Commonwealth of Independent States; information about the geographical coverage and regional aggregations is provided in the list of abbreviations.

Source: Frankfurt School-UNEP, 2015; Eurostat, 2015a.

Taking into account the period from 2005 to 2011 in which policy uncertainties were not yet present, the strongest average annual growth in renewable energy investments was distributed as follows: China (32 %), United States (25 %), India (26 %).

Despite these growth rates, absolute numbers speak for themselves (Figure 3.4): in every single year between 2005 and 2012 Europe (incl. CIS) has been the region with the highest new renewable energy investments, being surpassed by China only in 2013.

Figure 3.4 Total global new investment shares by technology, 2005–2014



Source: Frankfurt School-UNEP, 2015.

Total new investments by technology

In 2014, the market was dominated by record investments in solar and wind energy, which, together, accounted for 92 % of the total global RES investments (Frankfurt School-UNEP, 2015). Total new investments in technology grew fastest for solar energy. New investments were 12 times higher in 2014 than in 2004. Investments in solar energy as a share of total new investments became the largest in 2010, when they accounted for 44 % of total new investments. Total new investments in wind power became second largest and were five times higher in 2013 than in 2004. Both of these technologies experienced policy support — to varying extents — and experienced rapid technological learning that led to growing confidence on the side of investors.

From 2004 to 2009, investments in wind power made up the largest share of total investments. In 2010, they moved to second place after solar energy took first place, but their share was always between 37 % and 43 % of total new investments.

Biofuels experienced a steady growth in new investment from 2004 to 2007, when first-generation biofuels were on the increase. After 2008, investments in biofuels started to decline and fluctuate at lower levels. In 2013 they were lower than in 2004. Plateauing of first generation capacity may explain this decline, including uncertainties over future legislation, the delayed development of second-generation biofuels and costs.

3.2.2 Wind and solar PV capacity deployment

Wind and solar PV energy are two of the progressive renewable energy technologies that are experiencing strong growth worldwide as a result of cost reductions achieved through innovation, technological learning and economies of scale. With realistic global wind and solar electricity potentials ranging between 730 and 3700 EJ per year — far above the world's gross energy consumption of 76 EJ per year in 2013 (see Figure 3.2) — the long-term contribution of wind and solar power to the world's energy needs could be vast, outstripping our energy needs (Deng et al., 2015).

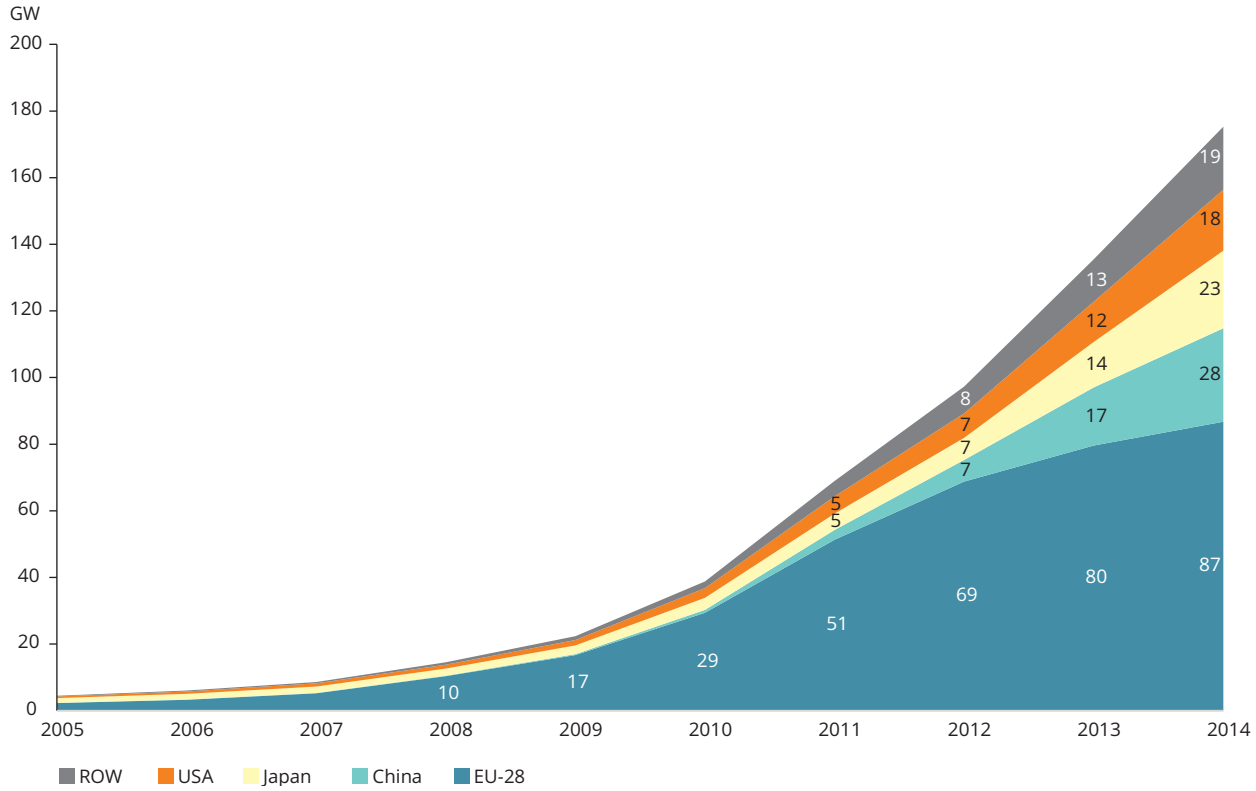
Only a handful of this vast potential has been realised to date, as deployment of these progressive renewables started only recently. By far the largest installed solar PV capacity in 2014 was in the EU-28 (three times as much as in China), followed by China, Japan and the United States. Together, the EU, China, Japan and the United States account for 89 % of the total installed solar PV capacity worldwide (Figure 3.5). Through its clear leadership since 2005, the EU-28 has contributed significantly to the demonstration and commercialisation of solar PV and wind power worldwide (Figure 3.5). These developments occurred essentially because of the implementation of various market-pull policy instruments. In contrast, a more balanced mix of market-pull and technological-push instruments (e.g. R&D investments), accompanied by greater focus on the quality and permanence of jobs created will ensure the development of a more sustainable industrial base in renewable energy across Europe (EEA, 2014).

It is worth noticing that, since 2010, solar PV deployment has also taken place at increasing speed in other parts of the world, with Australia, India, South Korea, Canada, Thailand, South Africa and Ukraine having contributed significantly to that growth. A detailed overview of installed capacity by country in 2014 is shown in Map 3.1.

In 2014, the EU had the largest total installed wind power capacity (both onshore and offshore). However, China is poised to overtake the EU within only a few years if it sustains its current addition rate for wind energy capacity (see Figure 3.6). The EU, China, the United States and India together accounted for 90 % of the total installed wind power capacity worldwide in 2014. Significant additions to wind power capacity were realised by Canada, Brazil, Australia, Japan, Mexico and Chile.

The total global installed solar PV and wind power capacities in 2014 — as shown in detail in Maps 3.1 and 3.2 — illustrate that only a very small share of the realistic potentials of these two technologies has been exploited to date.

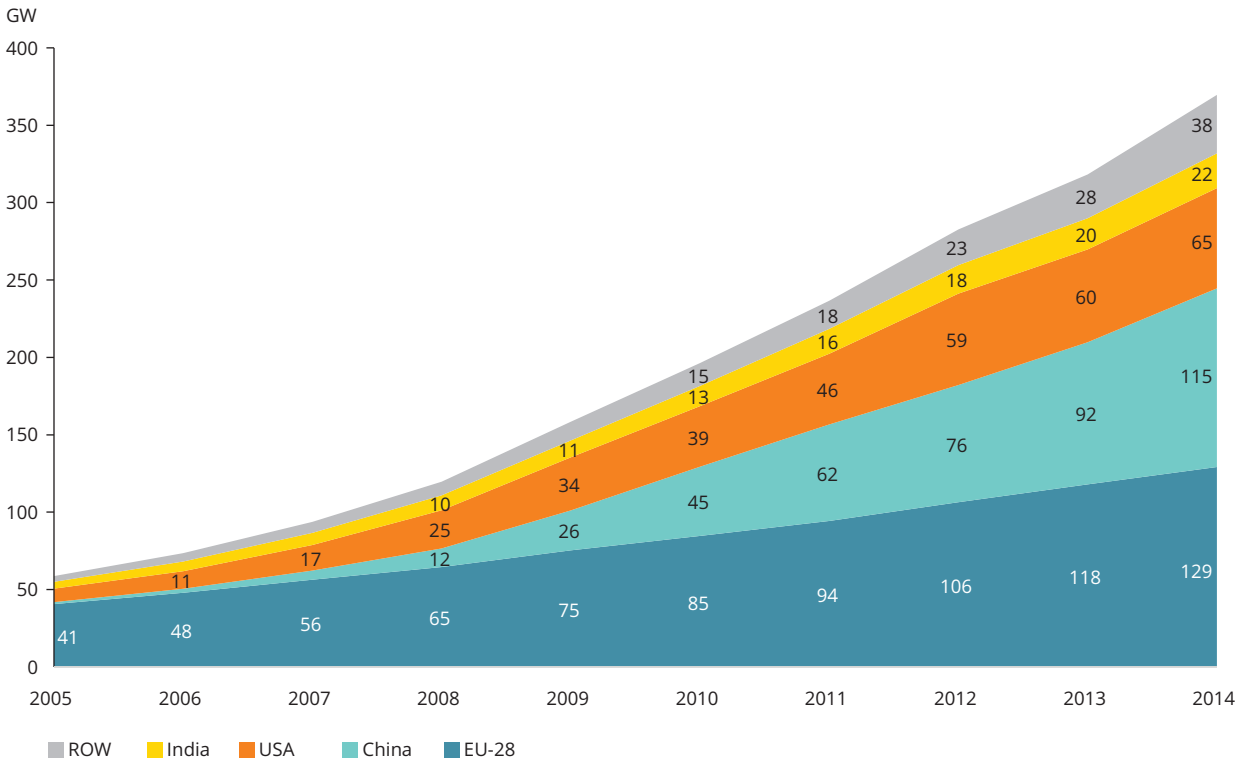
Figure 3.5 Growth in total solar PV capacity (GW) in the EU-28, the top three countries and the rest of the world (ROW), 2005–2014



Note: The figure shows the maximum net generation capacity installed and connected.

Source: IRENA, 2015a.

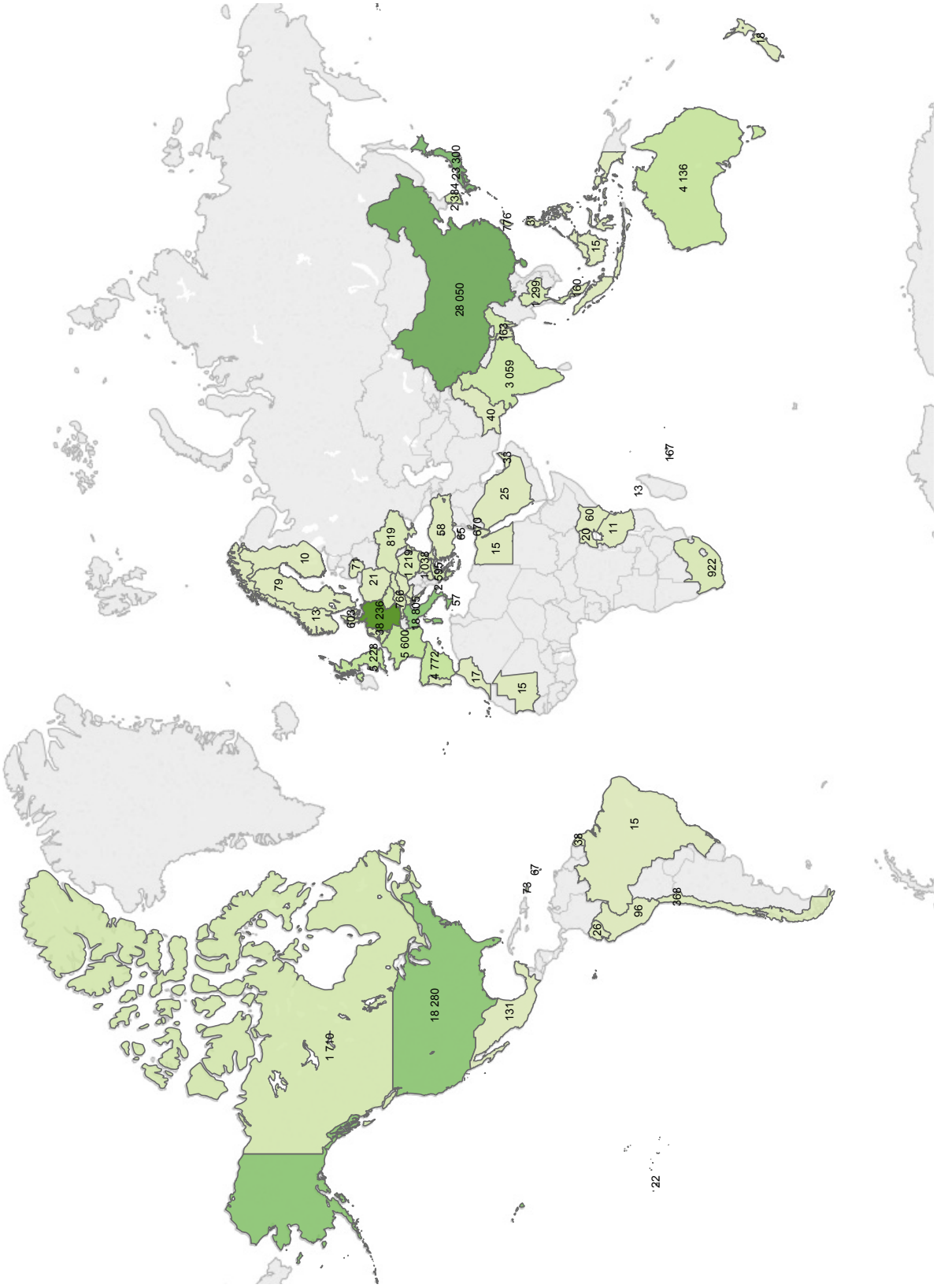
Figure 3.6 **Growth in total wind power capacity (GW) in the EU-28, the top three countries and the rest of the world (ROW), 2005–2014**



Note: The figure shows the maximum net generation capacity installed and connected.

Source: IRENA, 2015a.

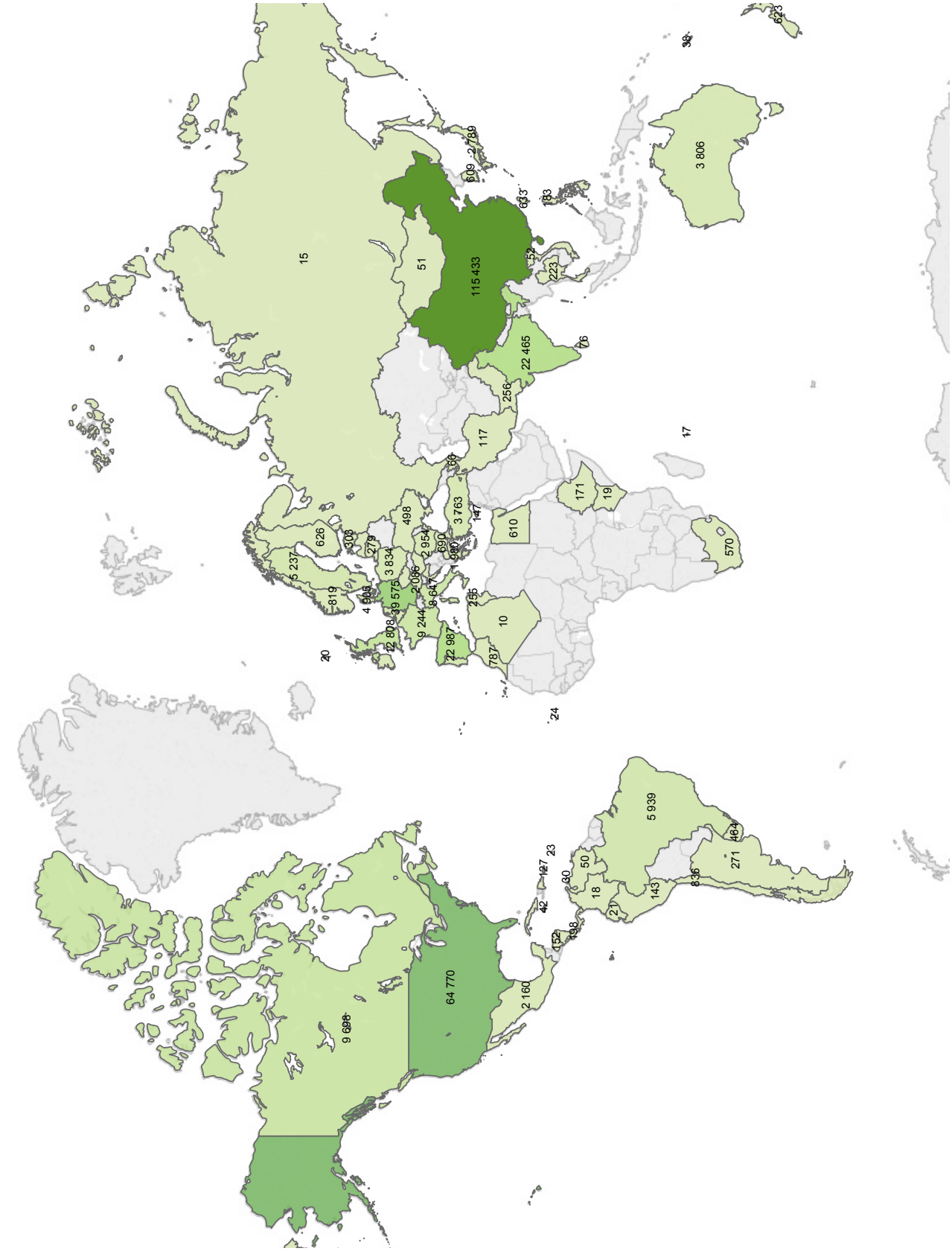
Map 3.1 Total installed solar PV capacity (MW) in 2014, by country



Note: The map shows the installed and connected capacity by country in 2014, for those with installed capacities of over 10 MW. Lighter shades illustrate lower installed capacity values, darker shades illustrate higher installed capacity values.

Source: IRENA, 2015a.

Map 3.2 Total wind power capacity (MW) in 2014, by country



Note: The map shows the installed and connected onshore and offshore capacity by country in 2014, for those with installed capacities of over 10 MW. Lighter shades illustrate lower installed capacity values, darker shades illustrate higher installed capacity values.

Source: IRENA, 2015a.

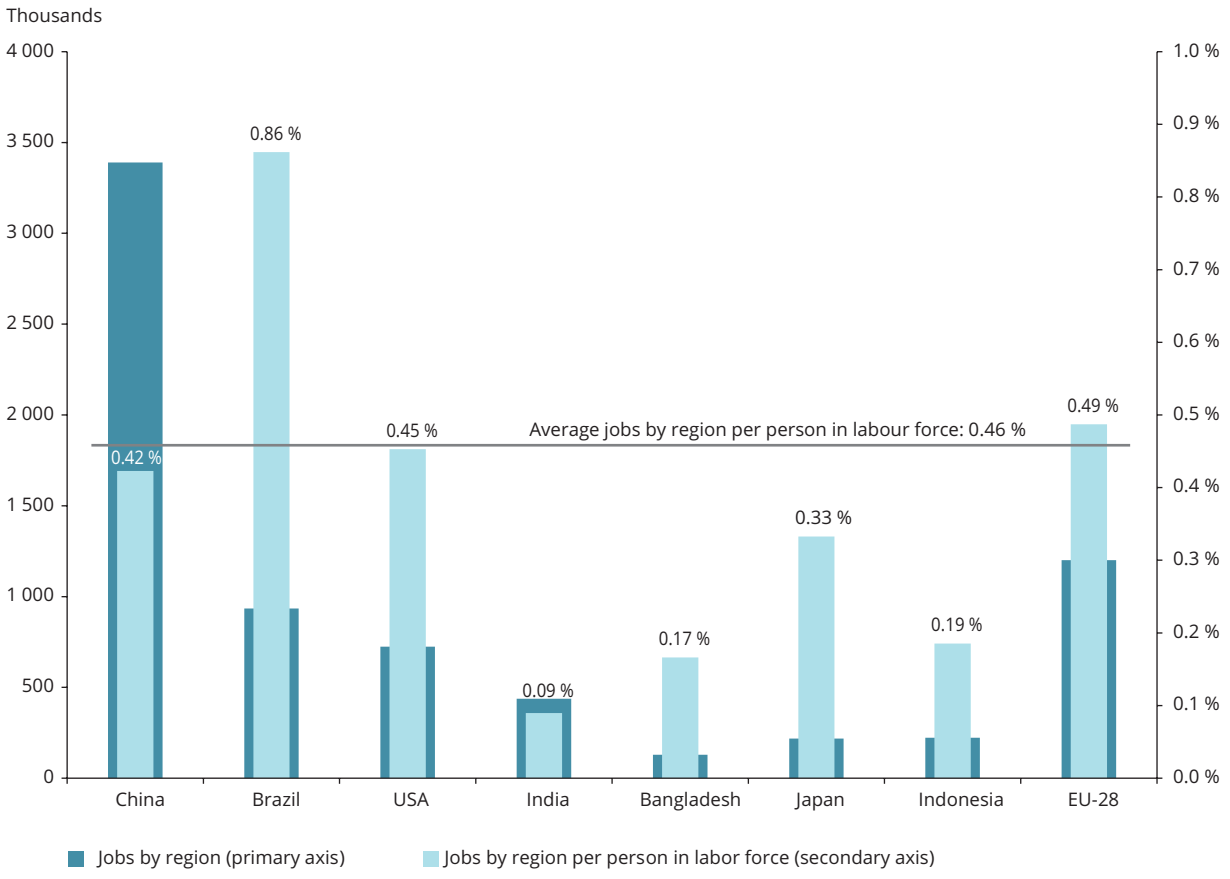
3.3 Renewable energy employment

In 2014, a total of 7.7 million jobs (direct and indirect ones) were related to renewable energies globally (IRENA, 2015b). The regional distribution of these jobs is depicted in Figure 3.7. In absolute terms, China, Brazil and the United States were the largest employers. However, in relative terms (i.e. as share of renewable energy jobs in the total workforce — the light blue bars in Figure 3.7), the regional distribution looks different:

- the EU-28 was among the key players, exhibiting the second highest number of renewable energy-related jobs per person in the labour force in 2014, with only one country, Brazil, exhibiting a greater share;
- within Europe, Germany was the number one **per capita (labour force) employer** (roughly one in 114 persons within the labour force was working in jobs related to renewable energies), at the same level as Brazil.

In Europe, the largest employers are the wind, solar PV and solid biomass industries. However, the solar PV industry did experience job losses over the past five years, including due to rising competition from China. Some job losses were experienced also in wind power, a sector which entered a consolidation phase in 2013 as competition from China continued to grow. Despite this competition, jobs per person in the workforce in the EU-28 remain, to date, larger than in China.

Figure 3.7 Direct and indirect jobs related to renewable energy in 2014 split by region — absolute and per person in labour force



Note: The primary y-axis displays absolute numbers (thousands of jobs) in 2014. The secondary y-axis relates the absolute number of jobs to the total labour force of each region, thus displaying jobs per person of labour force. The jobs displayed include both direct and indirect jobs along the value chain. The data on labour force used to calculate jobs per person in labour force was for 2013, as no data had been found for 2014 at the time of writing this report.

Source: Absolute jobs (IRENA, 2015b); jobs per person in workforce (World Bank, 2015).

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Annex 1 Methodology and data sources for calculating approximates RES shares

The methodology and the data sources to calculate the approximated RES shares are laid out in the report *Renewable energy in Europe — approximated recent growth and knock-on effects* (EEA, 2015a). The data were updated to reflect the most up-to-date values.

Some improvements in the methodologies were also made: as 2014 was an extraordinarily warm year in most parts of Europe, leading to significant changes in final energy consumption for heating and cooling, the change in fossil fuel consumption for heating and cooling was derived from the preliminary results of the EEA's approximated GHG inventory, using CO_2 emission data from the common reporting format (CRF) sectors manufacturing industry and construction (1A2), other sectors (1A4, which include commercial and residential activities) and other (1A5). Using these fossil fuel and renewable data, the total final energy consumption for heating and cooling (RES-H&C share denominator) was calculated using the below formula.

Methodologies for the normalisation of electricity generation from hydro and wind technologies were also improved to better fulfil the requirements of the RED. More Eurostat data were also used, instead of other data sources, e.g. data on hydroelectricity generation in this report is now from Eurostat, whereas last year ENTSO-E data were used. The cut-off date for all data sources was the beginning of August 2015, and the first approximated RES shares were then calculated directly after that. These first approximated RES shares were then used in the annual EEA report *Trends and projections in Europe 2015 — Tracking progress towards Europe's climate and energy targets for 2020* (EEA, 2015b).

In addition, OECD data were used as a new data source for geothermal energy and biofuels in both the renewable electricity and renewable heating and cooling sectors and for tidal energy in the renewable electricity sector. However, OECD data only cover 21 of the 28 EU member states ([37]). As a result of to the November update, approximated RES shares in this report differ slightly from the approximated RES shares in the 2015 report (EEA, 2015b).

$$Total\ H\&C_{2014} = (Total\ H\&C_{2013} - RES\ H\&C_{2013})\frac{GHG_{2014}}{GHG_{2013}} + RES\ H\&C_{2014}$$

([37]) Bulgaria, Croatia, Cyprus, Latvia, Lithuania, Malta and Romania are excluded from OECD data.

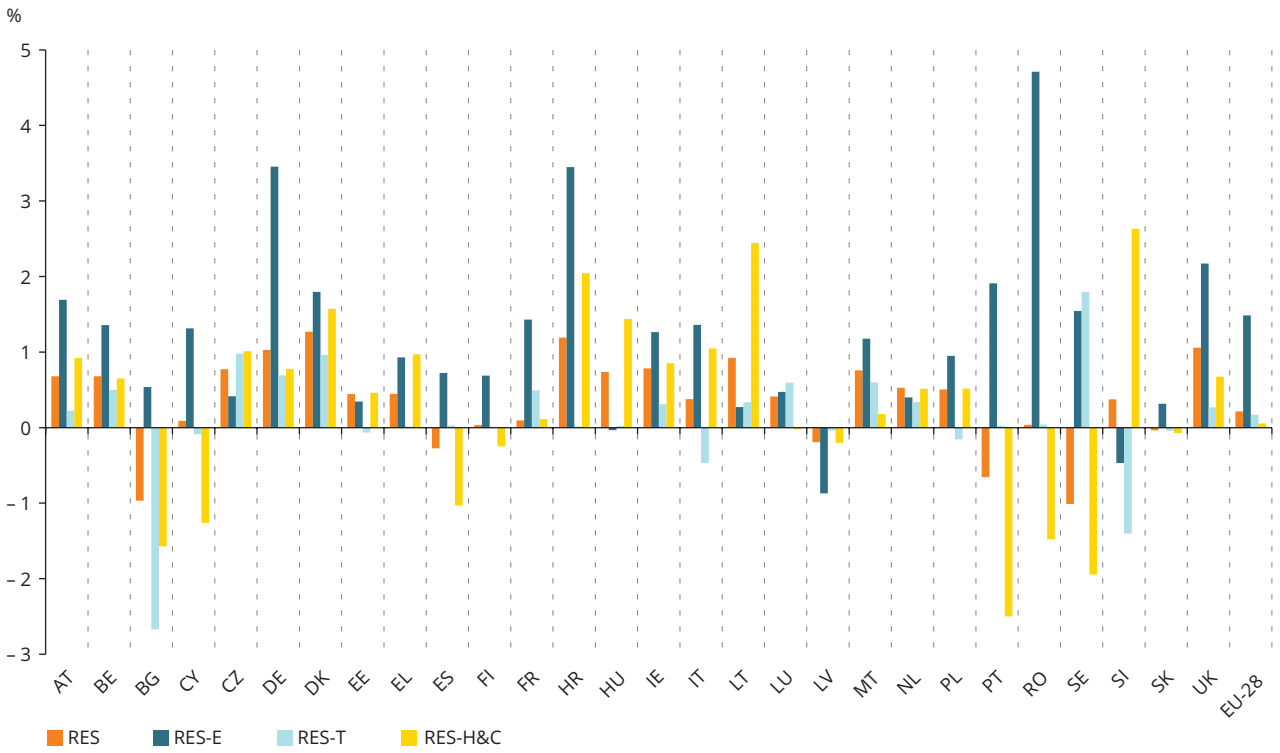
Annex 2 Discussion of main 2014/2013 changes by sector and country

As it is difficult to determine the uncertainties of the RES shares proxy methodology used, it is likewise difficult to determine the uncertainties of this calculation. Therefore, changes in calculated RES share proxies for the years 2014/2013 are compared with historically observed (2005–2013) changes in RES shares by way of descriptive statistics and a *t*-test to determine statistically significant deviations from the historical changes.

If in 2014/2013, changes in RES shares were significantly different but within the historically observed minima and maxima of changes in RES shares, the results were considered plausible without further analysis. If the 2014/2013 changes in RES shares were higher or lower than historically observed changes, further in-depth analysis was performed. The reasons for these strong decreases or increases were found and are described below.

Figure A2.1 shows the changes in approximated 2014 RES shares compared with the 2013 RES shares, while Table A2.1 provides detailed insights.

Figure A2.1 Changes in approximated RES shares in 2014 compared with those in 2013 (in percentage points)



Note: The country codes are defined in Table A2.1.

Source: EEA.

Table A2.1 Shares of renewable energies in 2013 and 2014

		RES (%)			RES-E (%)			RES-T (%)			RES-H&C (%)		
		2013	2014	Delta	2013	2014	Delta	2013	2014	Delta	2013	2014	Delta
AT	Austria	32.6	33.2	0.7	68.1	69.8	1.7	7.5	7.7	0.2	33.5	34.4	0.9
BE	Belgium	7.9	8.5	0.7	12.3	13.6	1.4	4.3	4.8	0.5	8.1	8.8	0.6
BG	Bulgaria	19.0	18.0	– 1.0	18.9	19.4	0.5	5.6	3.0	– 2.7	29.2	27.6	– 1.6
CY	Cyprus	8.1	8.2	0.1	6.6	8.0	1.3	1.1	1.0	– 0.1	21.7	20.4	– 1.3
CZ	Czech Republic	12.4	13.2	0.8	12.8	13.2	0.4	5.7	6.7	1.0	15.3	16.3	1.0
DE	Germany	12.4	13.4	1.0	25.6	29.0	3.5	6.3	7.0	0.7	10.6	11.3	0.8
DK	Denmark	27.2	28.5	1.3	43.1	44.9	1.8	5.7	6.7	1.0	34.8	36.3	1.6
EE	Estonia	25.6	26.1	0.4	13.0	13.4	0.3	0.2	0.2	– 0.1	43.1	43.6	0.5
EL	Greece	15.0	15.4	0.4	21.2	22.2	0.9	1.1	1.1	0.0	26.5	27.5	1.0
ES	Spain	15.4	15.1	– 0.3	36.4	37.1	0.7	0.4	0.5	0.0	14.9	13.9	– 1.0
FI	Finland	36.8	36.8	0.0	31.1	31.8	0.7	9.9	9.9	0.0	50.9	50.6	– 0.2
FR	France	14.2	14.3	0.1	16.9	18.3	1.4	7.2	7.7	0.5	18.3	18.4	0.1
HR	Croatia	18.0	19.1	1.2	38.7	42.1	3.4	2.1	2.2	0.0	18.1	20.2	2.0
HU	Hungary	9.8	10.5	0.7	6.6	6.6	0.0	5.3	5.4	0.0	13.5	14.9	1.4
IE	Ireland	7.8	8.6	0.8	20.9	22.2	1.3	5.0	5.3	0.3	5.7	6.6	0.9
IT	Italy	16.7	17.1	0.4	31.3	32.7	1.4	5.0	4.5	– 0.5	18.0	19.1	1.0
LT	Lithuania	23.0	23.9	0.9	13.1	13.4	0.3	4.6	5.0	0.3	37.7	40.2	2.4
LU	Luxembourg	3.6	4.0	0.4	5.3	5.8	0.5	3.9	4.5	0.6	5.6	5.6	0.0
LV	Latvia	37.1	36.9	– 0.2	48.8	47.9	– 0.9	3.1	3.0	0.0	49.7	49.5	– 0.2
MT	Malta	3.8	4.6	0.8	1.6	2.8	1.2	3.3	3.9	0.6	23.7	23.8	0.2
NL	Netherlands	4.5	5.0	0.5	10.1	10.5	0.4	5.0	5.4	0.3	3.6	4.1	0.5
PL	Poland	11.3	11.8	0.5	10.7	11.7	1.0	6.0	5.9	– 0.2	13.9	14.5	0.5
PT	Portugal	25.7	25.0	– 0.7	49.2	51.1	1.9	0.7	0.7	0.0	34.5	32.0	– 2.5
RO	Romania	23.9	24.0	0.0	37.5	42.2	4.7	4.6	4.7	0.0	26.2	24.7	– 1.5
SE	Sweden	52.1	51.1	– 1.0	61.8	63.4	1.5	16.7	18.4	1.8	67.2	65.2	– 1.9
SI	Slovenia	21.5	21.9	0.4	32.8	32.3	– 0.5	3.4	2.0	– 1.4	31.7	34.4	2.6
SK	Slovakia	9.8	9.8	0.0	20.8	21.1	0.3	5.3	5.3	0.0	7.5	7.4	– 0.1
UK	United Kingdom	5.1	6.2	1.1	13.9	16.0	2.2	4.4	4.7	0.3	2.6	3.3	0.7
EU-28	**European Union**	**15.0**	**15.2**	**0.2**	**25.4**	**26.9**	**1.5**	**5.4**	**5.5**	**0.2**	**16.5**	**16.6**	**0.1**

Source: EEA and SHARES 2013 (Eurostat, 2015b).

Renewable electricity (RES-E)

The change in the RES-E shares proxy for 2014 compared with that in 2013 (+ 1.5 %) for the whole EU was greater by 0.4 standard deviations than the average annual change in RES-E shares in the period from 2005 to 2013 (+ 1.2 %) (Figure A2.2). This is not a statistically significant deviation from the time series (p = 0.28) and still smaller than the 2012/2011 change (+ 1.8 %).

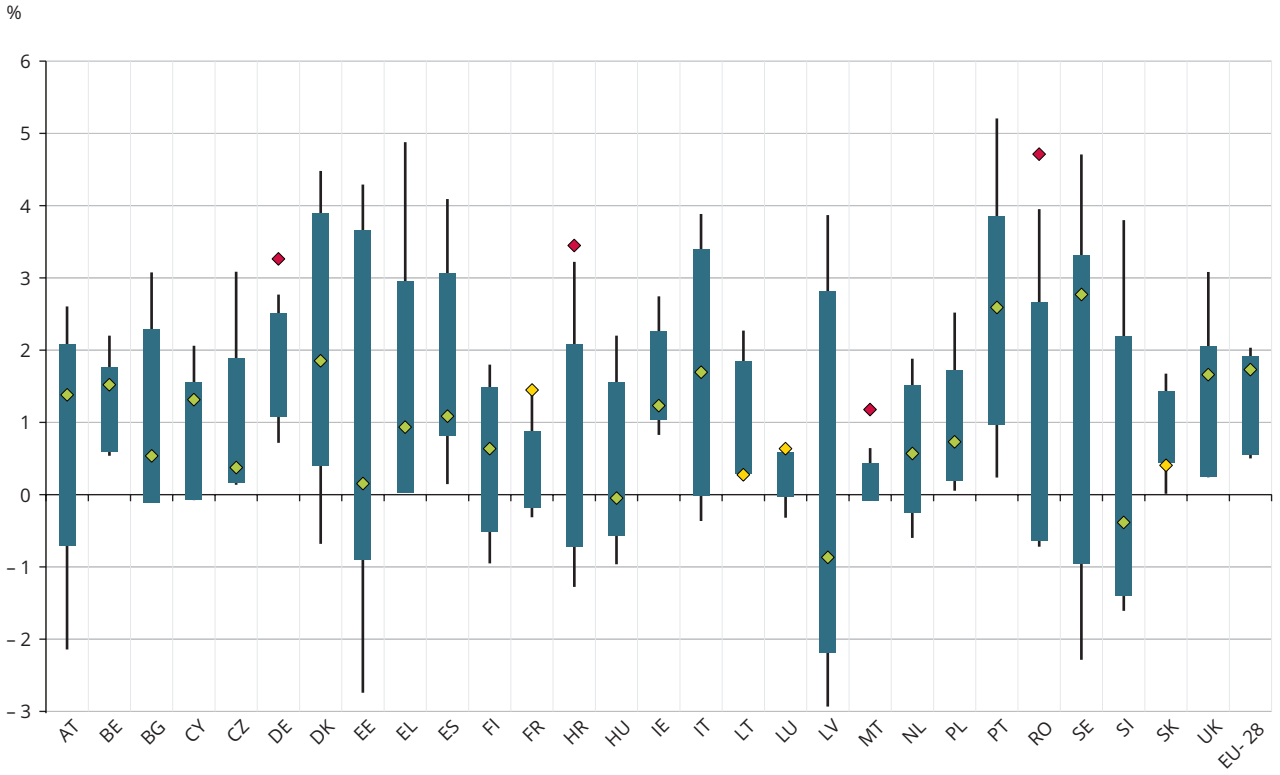
The calculated changes in the RES-E share proxies for 19 Member States were within 1 standard deviation of the average changes for the 2005–2013 period. In nine Member States, the 2014/2013 change was significantly different from the 2005–2013 average at the 5 % level (France, Germany, Ireland, Lithuania, Malta, Romania, Slovakia Spain and United Kingdom). Of those, five Member States showed changes in RES-E shares greater than the historically observed average ± 1 standard deviation, and four Member States showed a bigger change than any observed between 2005 and 2013.

The following five Member States showed changes greater than those historically observed.

Germany: Electricity production from wind (normalised) and solar photovoltaic energy each increased by more than 12 % following further additions to capacity in 2014 (EurObserv'ER, 2015g); (EurObserv'ER, 2015f). Meanwhile, electricity consumption decreased by almost 5 %.

Croatia: Installed wind capacity increased from 255 MW in 2013 to 340 MW in 2014, leading to an increase in electricity generation from wind energy of 36 % (EurObserv'ER, 2015g). Meanwhile, electricity consumption decreased by almost 4 %.

Figure A2.2 **Change in RES-E shares, 2014/2013, compared with historically observed annual changes in RES-E shares, 2005–2013 (all in percentage points)**



Note: Blue bars show the span from average of annual changes in RES-E shares between 2005 and 2013 ± 1 standard deviation. Thin black lines represent minimum and maximum year-to-year changes in this period. Diamonds show the change in proxy RES share in 2014 compared with 2013. Green: change 2014/2013 within 1 standard deviation of changes in the period from 2005 to 2013. Yellow: change 2014/2013 within minimum and maximum changes in the period from 2005 to 2013. Red: change 2014/2013 larger than changes in the period from 2005 to 2013.

The country codes are defined in Table A2.1.

Source: EEA.

Malta: Installed and connected photovoltaic capacity was increased from 9.5 MWp in 2013 to 26.0 MWp in 2014. Electricity generation from photovoltaics increased by 86.5 % (EurObserv'ER, 2015d).

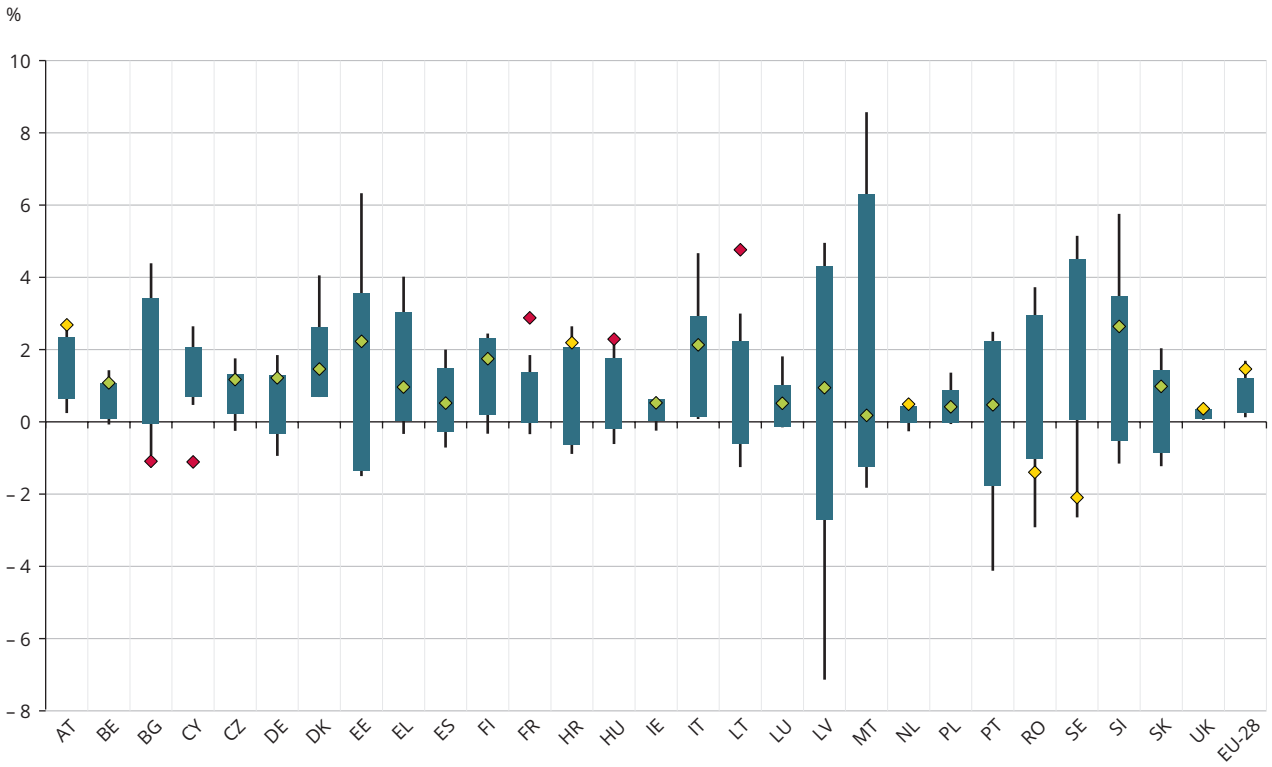
Sweden: As electricity consumption decreased much more strongly (–2.9 %) than total renewable electricity generation (–0.4 %), there was strong growth in the RES-E share. Hydroelectricity generation — the most important source of electricity — decreased by almost 1 %. Wind energy, the second most important renewable electricity source, increased by 19 %, while solid biomass (third most important source) decreased by 16 %.

Renewable heating and cooling (RES-H&C)

The change in the RES-H&C shares proxy for 2014 compared with 2013 (+ 0.1 %) for the whole EU was lower by 1.4 standard deviations than the average annual change in RES-H&C shares in the period 2005 to 2013 (+ 0.7 %) (Figure A2.3). This deviation is significant at the 5 % level (p = 0.001). However, it should be noted that 2014 was an exceptionally warm year, which considerably decreased total final energy consumption for heating and cooling (the denominator of the RES-H&C share) and therefore led to increased uncertainty in the RES-H&C shares.

The calculated changes in the RES-H&C share proxies for 17 Member States were within 1 standard deviation of the average changes for the period from 2005 to 2013. 14 Member States showed changes significantly different from the mean (Bulgaria, Croatia, Cyprus, Finland, France, Ireland, Lithuania, Luxembourg, Netherlands, Portugal, Romania, Spain, Sweden and United Kingdom). For six of these Member States, the changes were within the historical minimum and maximum, while six more were outside their historical variations. Two (Croatia and Luxembourg) remained within 1 standard deviation of the historical mean.

Figure A2.3 **Change in RES-H&C shares, 2014/2013, compared with historically observed annual changes in RES-H&C shares, 2005–2013 (all in percentage points)**



Note: Blue bars show the span from average of annual changes in RES-H&C shares between 2005 and 2013 ± 1 standard deviation. Thin black lines represent minimum and maximum year-to-year changes in this period. Diamonds show the change in proxy RES shares in 2014 compared with 2013. Green: change 2014/2013 within 1 standard deviation of changes in the period from 2005 to 2013. Yellow: change 2014/2013 within minimum and maximum changes in the period from 2005 to 2013. Red: change 2014/2013 larger than changes in the period from 2005 to 2013.

The country codes are defined in Table A2.1.

Source: EEA.

The following five Member States showed changes greater than those historically observed.

Bulgaria: While in most Member States total heating and cooling demand decreased, it increased strongly in Bulgaria, by 5.3 %, while renewables' contribution to heating and cooling decreased by only 2.0 %. A lack of available data on biomass for heating and cooling also plays a role, as Bulgaria is not included in OECD data.

Cyprus: Solar thermal capacity in Cyprus declined by 2 % between 2013 and 2014. As Cyprus is the Member State with the largest installed collector area per capita (0.782 m² per capita), this decrease had a strong impact on its RES-H&C share (EurObserv'ER, 2015e). Total consumption also increased by almost 5 %.

Spain: Total demand for heating and cooling dropped by about 6 %, while consumption of solid biomass dropped by 13 %.

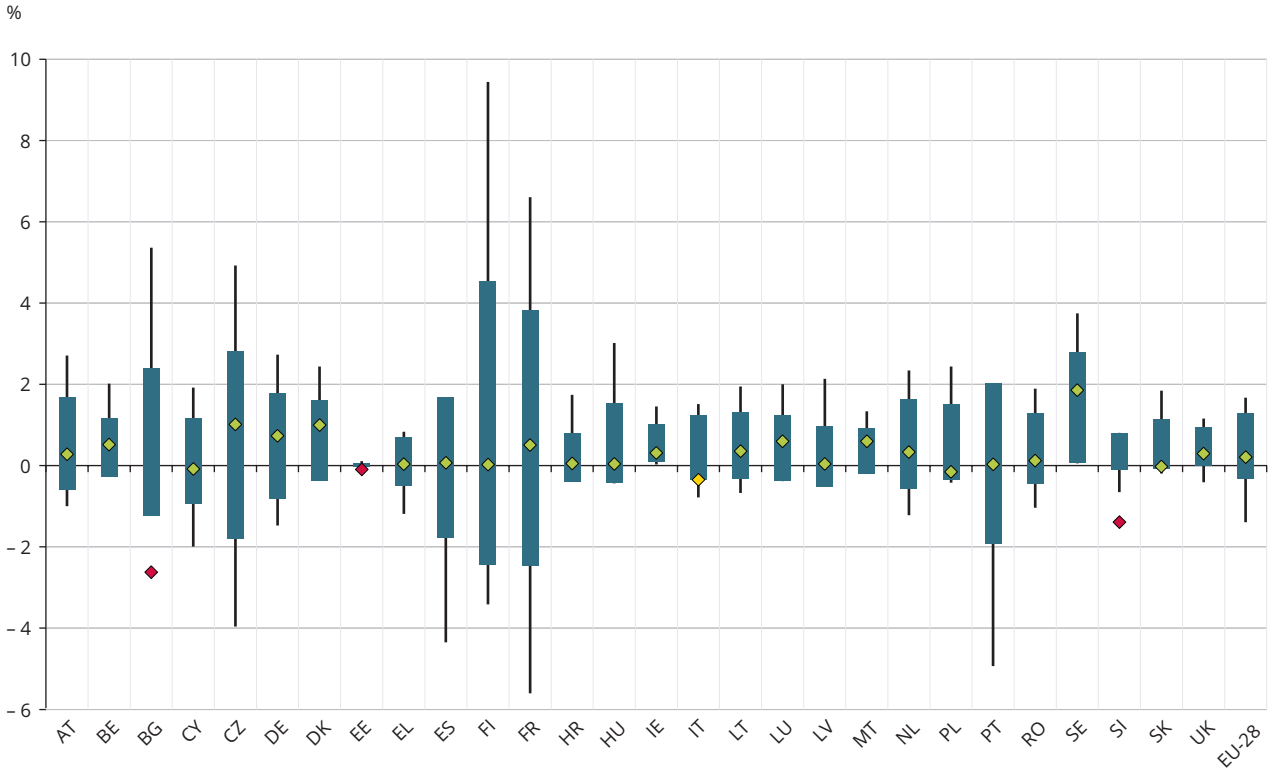
Ireland: The most important increases were in solid biomass (7 %) and heat pumps (14 %), while total consumption for heating and cooling decreased by 6 %.

United Kingdom: Consumption of solid biomass increased by 16 %, while total consumption for heating and cooling dropped by 11 %.

Renewable energy for transport (RES-T)

At the EU level, the RES-T shares proxy for 2014 compared with 2013 showed an increase (+ 0.2 %). This increase was lower by 0.4 standard deviations than the average annual change in RES-T shares over the period from 2005 to 2013 (+ 0.48 %), but not significantly different at the 5 % level (p = 0.27). The 2012/2011 change (+ 1.67 %) was an even greater change in the RES-T share (Figure A2.4).

Figure A2.4 Change in RES-T shares, 2014/2013, compared with historically observed annual changes in RES-T shares, 2005–2013 (all in percentage points)



Note: Blue bars show the span from average of annual changes in RES-T shares between 2005 and 2013 ± 1 standard deviation. Thin black lines represent minimum and maximum year-to-year changes in this period. Diamonds show the change in proxy RES shares in 2014 compared with 2013. Green: change 2014/2013 within 1 standard deviation of changes in the period from 2005 to 2013. Yellow: change 2014/2013 within minimum and maximum changes in the period from 2005 to 2013. Red: change 2014/2013 larger than changes in the period from 2005 to 2013.

The country codes are defined in Table A2.1.

Source: EEA.

The calculated changes in the RES-T share proxies for 24 Member States were within 1 standard deviation of the average changes for the 2005–2013 period; however, of those states, Slovakia's slight decrease (− 0.02 %) was still significantly different from its mean (+ 0.5 %; p = 0.01).

Of the six states that showed changes that were significantly different from the historical mean, the following three Member States recorded changes greater than those historically observed.

Bulgaria: The consumption of biofuels declined by 51 % between 2013 and 2014. While in 2013 8 380 toe of bioethanol and 95 880 toe of biodiesel were consumed, Bulgaria recorded consumption of only 53 429 toe biodiesel and none of bioethanol in 2014 (EurObserv'ER, 2015a).

Estonia: The proxy change was very close to the historic changes, but it was still an outlier (p < 0.01), because the RES-T share had stayed fairly constant throughout the period 2005–2013. There was no change in the consumption of compliant biofuels between 2013 and 2014 (none in both years) (EurObserv'ER, 2015a), so all changes were related to RES-T.

Slovenia: The use of compliant biofuels in transport between 2013 and 2014 declined by 44 % (EurObserv'ER, 2015a).

In total, seven Member States showed decreases in RES-T shares, and they are the same states that showed a contraction in absolute RES-T (Bulgaria, Cyprus, Estonia, Finland, Italy, Latvia, Poland, Slovenia and Slovakia). Absolute RES-T consumption increased in the other 21 Member States.

Total renewable energy sources

The change in the RES shares proxy for 2014 compared with 2013 (+ 0.2 %) for the whole EU was lower than the observed average annual change in RES shares in the

period from 2005 to 2013 (+ 0.7 %); this was significantly different at the 5 % level (p = 0.002) (Figure A2.5).

The calculated changes in the RES share proxies for 23 Member States were within 1 standard deviation of the average changes in the period from 2005 to 2013. In four of those (Croatia, Cyprus, Finland, Italy), the change was still significantly different from the historical mean (p < 0.05). For Spain, changes were significantly different from the mean but within the historical minimum and maximum. Only the following four Member States showed changes greater than those historically observed.

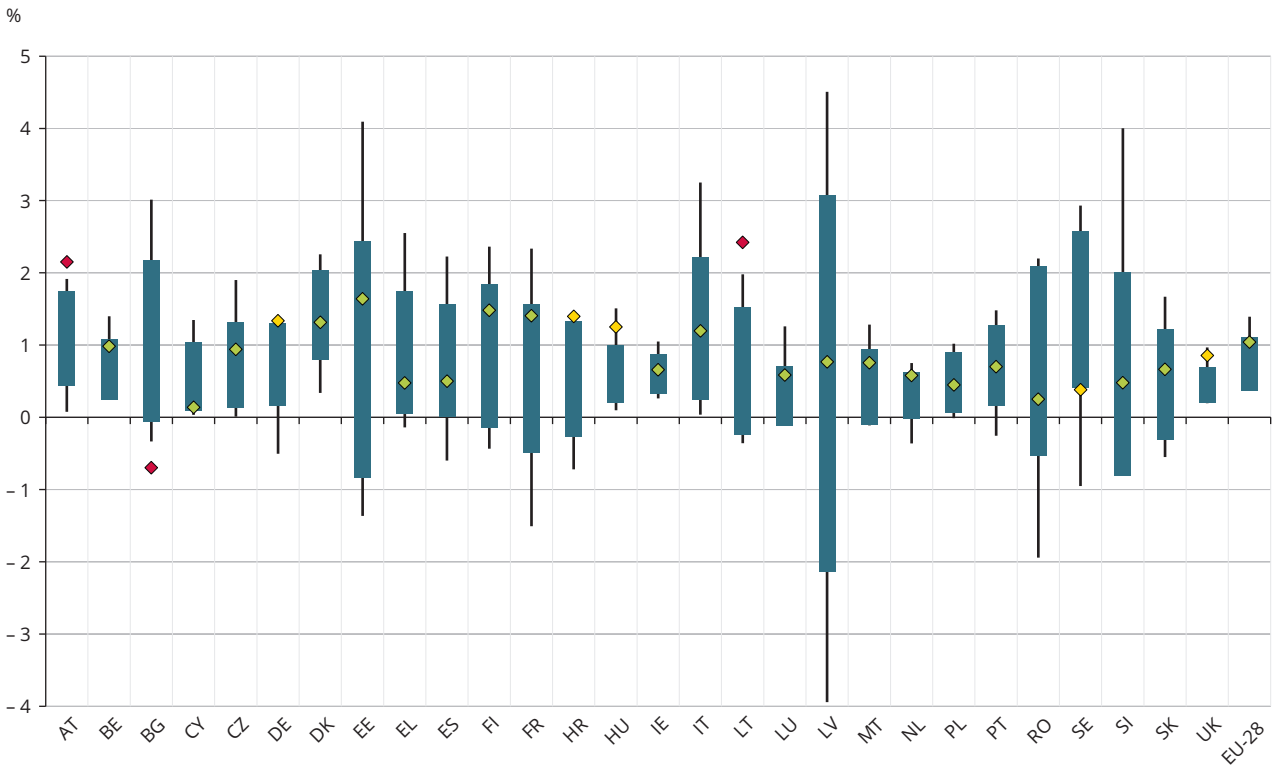
Bulgaria: The decline in the RES share observed was larger than that historically seen. The main explanatory factor is the strong decline in the use of renewable energies in the transport sector (− 47 %) compared with 2013 and the slight decrease in the RES shares in the electricity sector and the heating and cooling sector.

Portugal: The consumption of renewable energies in the electricity and transport sectors increased by more than 3 % each, but this did not balance out the 12 % decrease in renewable energies in the heating and cooling sector, mainly due to a strong decline in solid biomass consumption (− 13 %).

Sweden: Evolution of total renewable energy consumption was dominated by a 12 % reduction in renewable energy consumption in the heating and cooling sector, which is related to the 9 % reduction in total final energy consumption in this sector as a result of the exceptionally warm weather in 2014.

United Kingdom: A strong increase in absolute renewable energy consumption was seen in all three sectors, leading to an increase in (total) renewable GFEC of 16 %. The most important absolute increase was in wind energy.

Figure A2.5 Change in RES shares, 2014/2013, compared with historically observed annual changes in RES shares, 2005–2013 (all in percentage points)



Note: Blue bars show the span from average of annual changes in RES shares between 2005 and 2013, ± 1 standard deviation. Thin lines represent minimum and maximum year-to-year changes in this period. Diamonds show the change in proxy RES shares in 2014 compared with 2013. Green: change 2014/2013 within 1 standard deviation of changes in the period from 2005 to 2013. Yellow: change 2014/2013 within minimum and maximum changes in the period from 2005 to 2013. Red: change 2014/2013 larger than changes in the period from 2005 to 2013.

The country codes are defined in Table A2.1.

Source: EEA.

Proxy 2013 versus actual RES shares 2013

This is the first year when approximated RES shares could be compared with the historical realisation of RES shares. Table A2.2 provides insights into the differences between approximated 2013 RES shares (calculated in 2014) and realised 2013 RES shares (available for the first time in 2015).

At the EU-28 level, approximated RES shares differed by 0.1 percentage points for the total RES share, – 0.1 percentage points for the RES-E share, 0.9 percentage points for the RES-T share and 0.3 percentage points for the RES-H&C share.

The average deviation across Member States from observed historical values were 0.2 percentage points for total RES shares, – 0.3 percentage points for RES-E, 0.8 percentage points for RES-T and 1.2 percentage points for RES-H&C.

For the EU-28, the approximated RES shares in 2013 differed by a maximum of 0.9 percentage points from realised RES shares (RES-T). The maximum deviation at the Member State level was found in RES-H&C (an underestimate of 13.3 percentage points). As discussed in the previous report (EEA, 2015a), the heating and cooling sector may be particularly prone to underestimates of its approximated RES share; 23 of 29 (including the EU as a region) deviations refer to underestimates.

In general, the approximated 2013 RES shares underestimated rather than overestimated realised RES shares in 2013.

Table A2.2 2013 RES shares by sector compared with approximated RES shares by sector

		RES (%)			RES-E (%)			RES-T (%)			RES-H&C (%)		
		2013	2013 proxy	Delta	2013	2013 proxy	Delta	2013	2013 proxy	Delta	2013	2013 proxy	Delta
AT	Austria	32.6	34.5	– 1.9	68.1	67.8	0.3	7.5	8.4	– 0.9	33.5	34.9	– 1.4
BE	Belgium	7.9	7.4	0.4	12.3	13.6	– 1.3	4.3	4.3	0.0	8.1	6.7	1.4
BG	Bulgaria	19.0	17.2	1.8	18.9	19.5	– 0.6	5.6	0.2	5.4	29.2	27.5	1.7
CY	Cyprus	8.1	7.3	0.8	6.6	7.2	– 0.5	1.1	0.0	1.1	21.7	20.9	0.8
CZ	Czech Republic	12.4	11.4	1.0	12.8	12.0	0.7	5.7	5.1	0.6	15.3	13.7	1.7
DE	Germany	12.4	12.9	– 0.5	25.6	25.6	0.0	6.3	6.3	0.0	10.6	11.3	– 0.7
DK	Denmark	27.2	27.5	– 0.3	43.1	43.4	– 0.2	5.7	8.0	– 2.3	34.8	33.5	1.2
EE	Estonia	25.6	26.1	– 0.5	13.0	16.8	– 3.7	0.2	0.2	0.1	43.1	43.0	0.2
EL	Greece	15.0	16.0	– 1.0	21.2	23.5	– 2.2	1.1	0.6	0.5	26.5	24.6	1.9
ES	Spain	15.4	14.9	0.5	36.4	35.6	0.8	0.4	0.4	0.0	14.9	14.1	0.8
FI	Finland	36.8	34.7	2.1	31.1	29.9	1.2	9.9	0.5	9.4	50.9	48.6	2.3
FR	France	14.2	13.7	0.6	16.9	16.9	0.0	7.2	7.6	– 0.4	18.3	16.9	1.4
HR	Croatia	18.0	17.9	0.0	38.7	37.3	1.4	2.1	2.1	0.1	18.1	18.4	– 0.2
HU	Hungary	9.8	9.7	0.1	6.6	6.0	0.6	5.3	2.5	2.9	13.5	14.5	– 1.0
IE	Ireland	7.8	8.2	– 0.4	20.9	23.1	– 2.2	5.0	4.8	0.2	5.7	5.3	0.4
IT	Italy	16.7	14.6	2.1	31.3	30.4	0.9	5.0	5.5	– 0.5	18.0	13.9	4.2
LT	Lithuania	23.0	21.9	1.0	13.1	12.4	0.7	4.6	4.3	0.3	37.7	35.5	2.3
LU	Luxembourg	3.6	3.4	0.2	5.3	5.0	0.3	3.9	2.4	1.4	5.6	5.0	0.6
LV	Latvia	37.1	36.0	1.0	48.8	46.7	2.0	3.1	3.1	0.0	49.7	47.2	2.5
MT	Malta	3.8	1.5	2.3	1.6	1.7	– 0.1	3.3	0.0	3.2	23.7	10.3	13.3
NL	Netherlands	4.5	4.8	– 0.3	10.1	12.2	– 2.1	5.0	4.6	0.4	3.6	3.5	0.2
PL	Poland	11.3	11.4	– 0.1	10.7	11.7	– 0.9	6.0	6.5	– 0.5	13.9	13.6	0.3
PT	Portugal	25.7	26.0	– 0.3	49.2	51.9	– 2.8	0.7	0.5	0.1	34.5	33.1	1.5
RO	Romania	23.9	23.8	0.2	37.5	37.1	0.4	4.6	4.5	0.1	26.2	25.7	0.4
SE	Sweden	52.1	54.4	– 2.3	61.8	64.0	– 2.2	16.7	16.1	0.5	67.2	68.3	– 1.1
SI	Slovenia	21.5	20.7	0.8	32.8	32.3	0.5	3.4	3.1	0.3	31.7	30.7	1.0
SK	Slovakia	9.8	10.7	– 0.9	20.8	21.1	– 0.3	5.3	4.8	0.5	7.5	8.7	– 1.3
UK	United Kingdom	5.1	4.8	0.3	13.9	12.8	1.0	4.4	4.2	0.2	2.6	2.4	0.2
EU-28	**European Union**	**15.0**	**14.9**	**0.1**	**25.4**	**25.4**	**– 0.1**	**5.4**	**4.5**	**0.9**	**16.5**	**16.2**	**0.3**

Source: EEA and Eurostat data (Eurostat, 2015b).

Annex 3 Effect of renewable energy

Table A3.1 Effects of renewable energy on greenhouse gas (GHG) emissions and energy consumption by country in 2013, as discussed in Section 2.3.2 of this report

2013	Greenhouse gas emissions		Effect of renewables	Fossil fuel consumption		Effect of renewables	Primary energy consumption		Effect of renewables
	Mton CO_2– eq	Mton CO_2	%	Mtoe	Mtoe	%	Mtoe	Mtoe	%
Austria	79.6	– 11.1	– 12	20.6	– 3.4	– 14	31.9	– 0.3	– 0.8
Belgium	119.4	– 8.4	– 7	31.4	– 2.9	– 9	47.4	– 0.2	– 0.5
Bulgaria	55.8	– 5.6	– 9	11.3	– 1.5	– 12	16.3	– 0.6	– 3.5
Croatia	26.4	– 1.5	– 5	5.6	– 0.4	– 7	7.3	– 0.1	– 1.8
Cyprus	8.3	– 0.4	– 4	2.0	– 0.1	– 5	2.2	0.0	– 1.5
Czech Republic	127.3	– 9.1	– 7	29.3	– 2.5	– 8	39.6	– 0.4	– 1.1
Denmark	54.6	– 8.7	– 14	12.9	– 2.9	– 18	17.8	– 1.0	– 5.2
Estonia	21.7	– 1.7	– 7	5.9	– 0.5	– 7	6.5	– 0.1	– 1.1
Germany	950.7	– 95.6	– 9	242.7	– 26.0	– 10	302.5	– 6.9	– 2.2
Greece	105.1	– 6.5	– 6	20.9	– 1.9	– 8	23.7	– 1.1	– 4.3
Finland	63.1	– 7.7	– 11	15.2	– 2.4	– 14	32.8	0.1	0.3
France	490.6	– 27.1	– 5	116.1	– 9.0	– 7	245.8	– 2.4	– 1.0
Hungary	56.8	– 2.6	– 4	14.0	– 0.9	– 6	21.0	0.0	0.0
Ireland	58.8	– 2.7	– 4	12.4	– 0.9	– 7	13.4	– 0.3	– 2.4
Italy	437.3	– 54.0	– 11	122.5	– 18.3	– 13	153.7	– 3.2	– 2.0
Latvia	10.9	– 0.7	– 6	2.6	– 0.2	– 8	4.4	0.0	– 0.2
Lithuania	19.7	– 1.4	– 7	3.9	– 0.4	– 10	5.7	0.0	– 0.7
Luxembourg	11.4	– 0.3	– 3	3.7	– 0.1	– 3	4.3	0.0	– 0.2
Malta	2.8	– 0.1	– 2	0.8	0.0	– 2	0.8	0.0	– 0.8
Netherlands	195.9	– 5.5	– 3	59.5	– 1.8	– 3	65.9	– 0.3	– 0.4
Poland	394.9	– 17.7	– 4	84.6	– 5.1	– 6	93.2	– 0.2	– 0.2
Portugal	64.6	– 7.4	– 10	15.5	– 1.8	– 10	21.3	– 1.3	– 5.7
Romania	109.5	– 6.3	– 5	22.5	– 1.8	– 7	30.9	– 0.6	– 2.0
Slovakia	43.9	– 1.7	– 4	10.5	– 0.7	– 6	16.2	– 0.1	– 0.5
Slovenia	18.2	– 1.2	– 6	4.3	– 0.4	– 8	6.8	0.0	– 0.2
Spain	322.0	– 31.8	– 9	82.2	– 9.7	– 11	113.8	– 3.6	– 3.1
Sweden	55.8	– 16.0	– 22	13.1	– 5.0	– 28	47.1	– 0.9	– 1.8
United Kingdom	575.7	– 29.5	– 5	164.3	– 9.0	– 5	194.5	– 2.2	– 1.1
All 28 Member States	**4 480.7**	**– 362.4**	**– 7**	**1 130.3**	**– 109.6**	**– 9**	**1 566.6**	**– 25.8**	**– 1.6**

Notes: This table shows the estimated effect on GHG emissions, fossil fuel consumption and primary energy consumption of the increase in renewable energy consumption since 2005.

Source: EEA (based on data from Eurostat).

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