Energy Transition in the Power Sector in Europe: State of Affairs in 2015

Review of the Developments and Outlook for 2016

ANALYSIS

Agora Energiewende

*RES-Share of Gross Electricity Consumption

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IMPRINT

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Review of the Developments
and Outlook for 2016

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Preface

Dear Reader,

The energy transition – the transformation of the power sector from a fossil-based to a decarbonised world with renewables at the centre – is a joint European project. The power sector will play a crucial role in attaining the European climate targets, which aim to cut greenhouse gases by at least 40 percent by 2030 compared with 1990.

In this analysis, we present the state of affairs in the European power sector in 2015. Where are we coming from? Where do we stand today? These are the two key issues that need answering. Key topics include power generation, power consumption, emissions and prices. Overall, it is clear that the current power system is not yet fully equipped to deal with the main challenges ahead: securing power supply at a reasonable price with as little emissions as possible. However, Europe is on the right path: more than a quarter of the electricity produced already comes from renewable energy sources.

The following paper is mainly based on data retrieved from ENTSO-E and Eurostat. The data is still preliminary in nature or incomplete, which is often the case when it comes to European statistical data. We would therefore be glad to receive feedback and comments as to better data sources or methods concerning the available data sets.

Kind regards

Patrick Graichen,
Executive Director of Agora Energiewende

Key Findings at a Glance

1 **As of 2015, renewable energies are Europe's dominant power source, with a 29 percent share of the power mix.** Nuclear power comes in second with 27 percent, coal (hard coal and lignite) amount to 26 percent. Among RES, wind power increased significantly by more than 50 terawatt hours to 307 terawatt hours in total. Hydropower produced much less due to less precipitation.

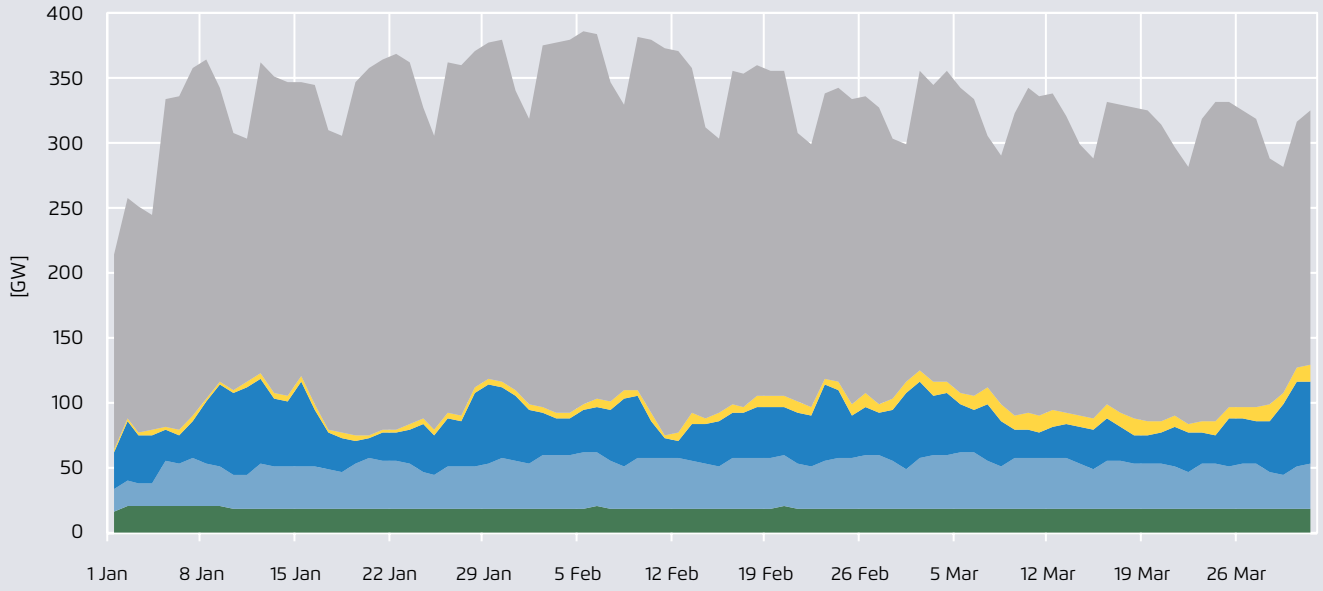
2 **Three key trends in European power production have emerged in 2010-2015: gas and nuclear power are losing ground, renewables are on the rise while coal is in 2015 back on 2010 levels.** From 2010 to 2015, gas demand fell by more than a third, while renewables increased by 35.9 percent. Nuclear power production decreased slightly (-6.3 percent) and, following a slight decrease in 2014, coal (hard coal and lignite) returned to the 2010 level in 2015.

3 **CO_2 emissions in the European power sector increased in 2015 by 2 percent. They could be lower by some 100 million tonnes if the decline in fossil power production since 2010 had been coal instead of gas.** The average price of a tonne of CO_2 in 2015 was 7.60 euros, which leads to coal-fired power plants having lower marginal costs than gas-fired power plants. Coal therefore outcompetes gas throughout Europe, which has resulted, for example, in the high coal power exports in 2015 from Germany to its neighbours.

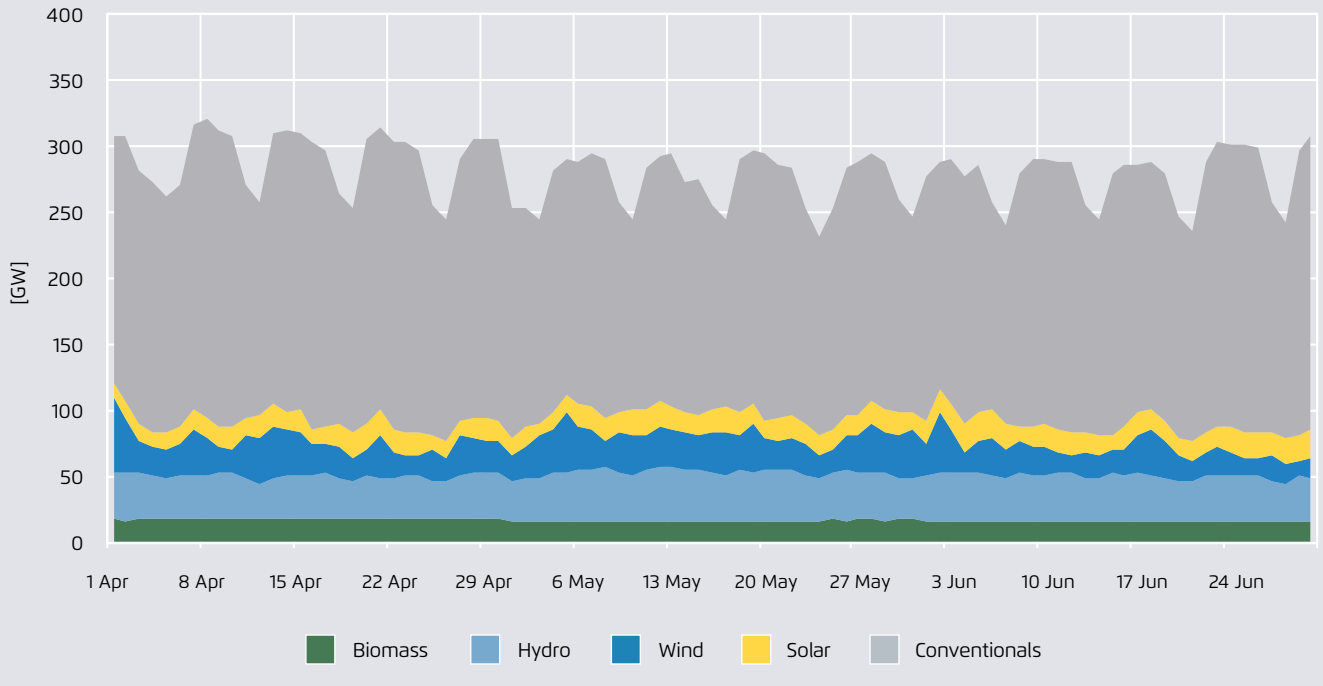
4 **Outlook: Four major developments will probably characterise 2016: more RES, less coal, less consumption and lower CO_2 prices.** Additional capacity in mainly the onshore and offshore wind energy sector will increase RES production by another 50 terawatt hours. The carbon floor price in the UK, yielding a CO_2 price signal of some 30 euros per tonne, will push out coal in the UK in favour of gas. Further efficiency developments and the relatively mild winter will lower power consumption. The demand for CO_2 allowances will therefore decrease, leading to lower CO_2 ETS prices in 2016 than in 2015.

Content

European net electricity production January-March 2015: High demand profile in winter (up to 386 GW), little solar power generation and modest wind power generation

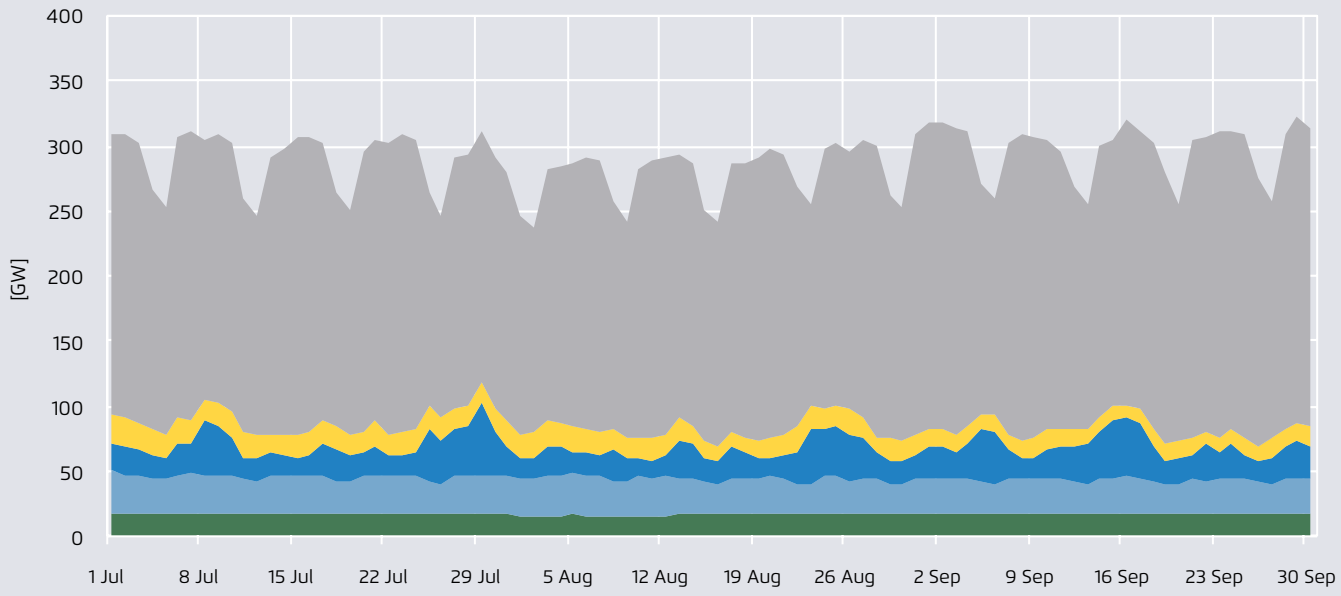


Net electricity production April-June 2015: Lower power demand, rising solar power production and less wind energy

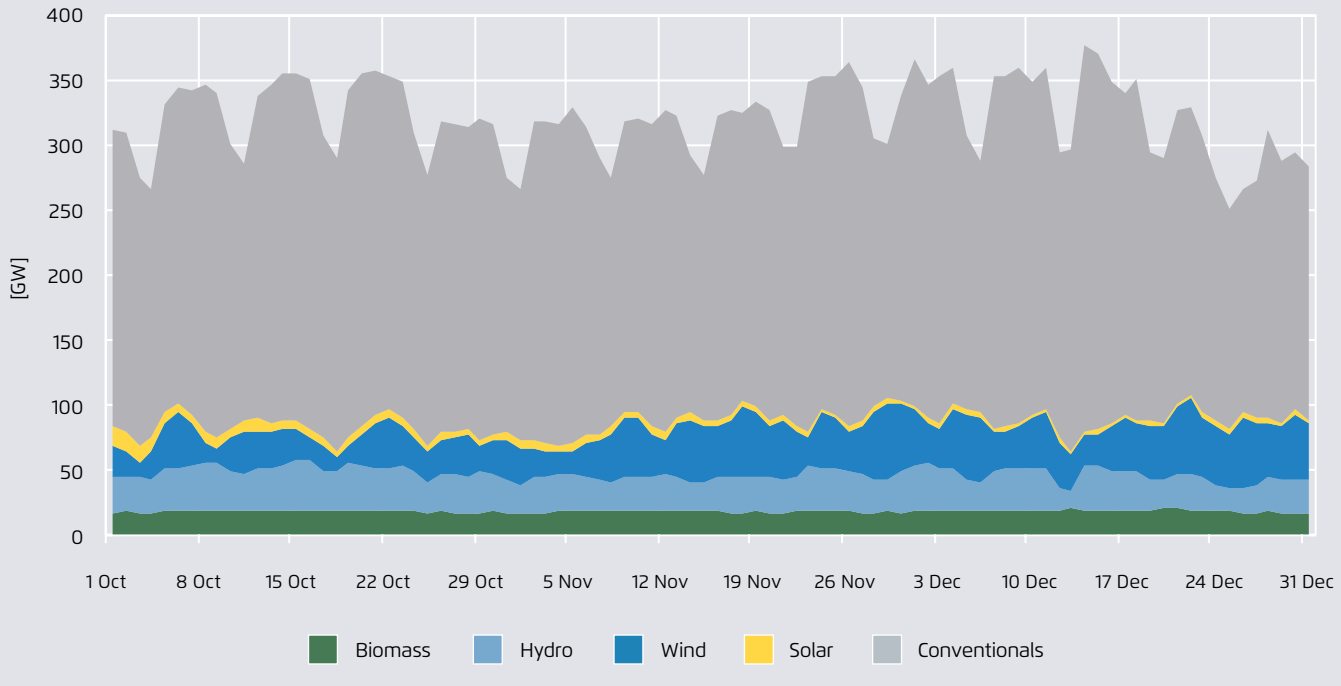


Data ENTSO-E 2016a, 2016b, Eurostat 2016b, 2016c; Calculation Öko-Institut, data for the first week of January is incomplete.

Net electricity production July-September 2015: Low hydropower and wind power production, relatively high shares of solar power production



Net electricity production October-December 2015: Power demand is rising again, low hydropower generation and little to none solar power production



Data ENTSO-E 2016a, 2016b, Eurostat 2016b, 2016c; Calculation Öko-Institut, data for November and December is incomplete.

1 Electricity production

The electricity generation mix within the EU did not change significantly from 2014 to 2015. Generally, most electricity was produced by renewable energy sources (28.8 percent), closely followed by nuclear power (26.8 percent). Hard coal and lignite made up a quarter of the electricity produced (26 percent) while gas, oil and other conventional sources made up the remaining 18.3 percent.

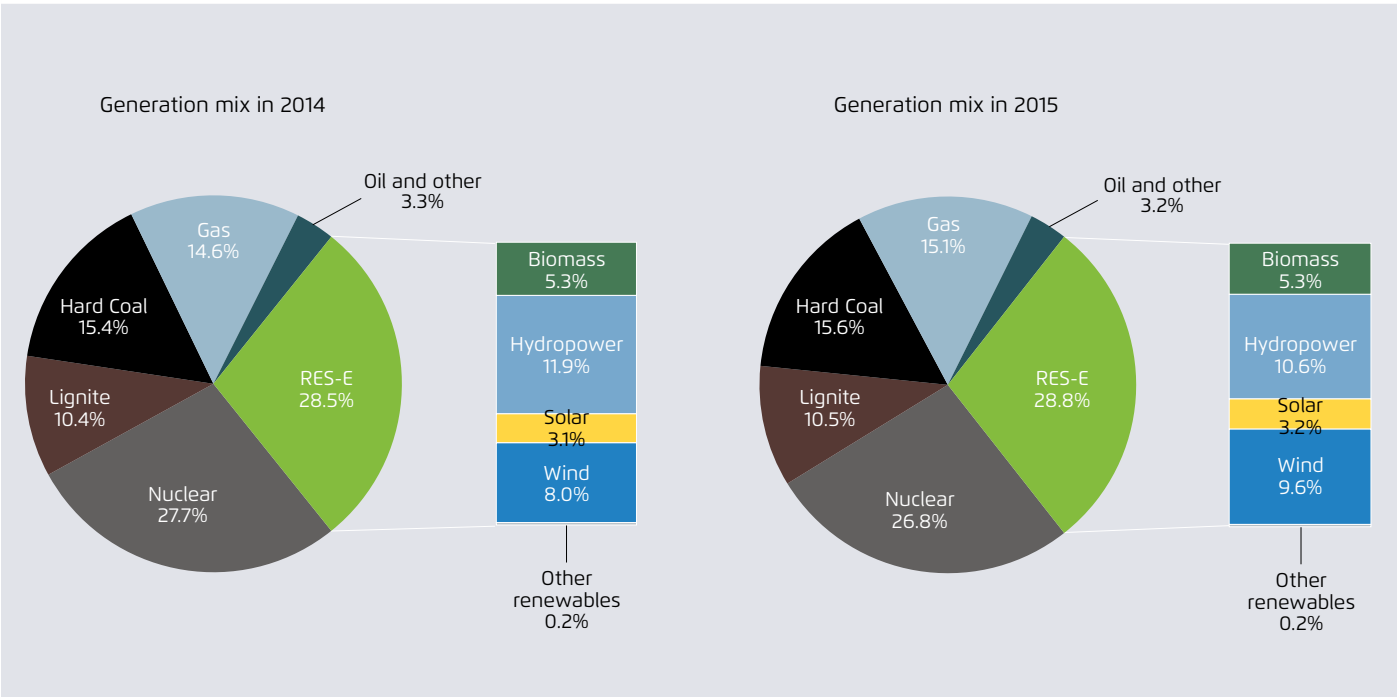
Compared with 2014, the RES share increased slightly from 28.5 percent in 2014 to 28.8 percent in 2015.[1] A remarkable aspect, however, is that the distribution among renewable energy sources changed substantially. Whilst in 2014 only 8.0 percent of the electricity was generated from wind energy, in 2015 this amounted to 9.6 percent. Due to a less precipitation, the share of hydropower decreased from 11.9 percent in 2014 to 10.6 percent in 2015.

Nuclear power was the only conventional power source to experience a reduction in its share: in 2015, 26.8 percent of the electricity generated was from nuclear power (2014: 27.7 percent). The share of coal and lignite remained the same, while the share of gas-generated power – after years of continued decline – increased slightly from 14.6 in 2014 to 15.1 percent in 2015 (see Figure 1).

The changes from 2014 to 2015 become clearer when the changes in hydropower are viewed separately from the rest of the renewable energy sources. Due to less precipitation, hydropower sources produced much less power in 2015

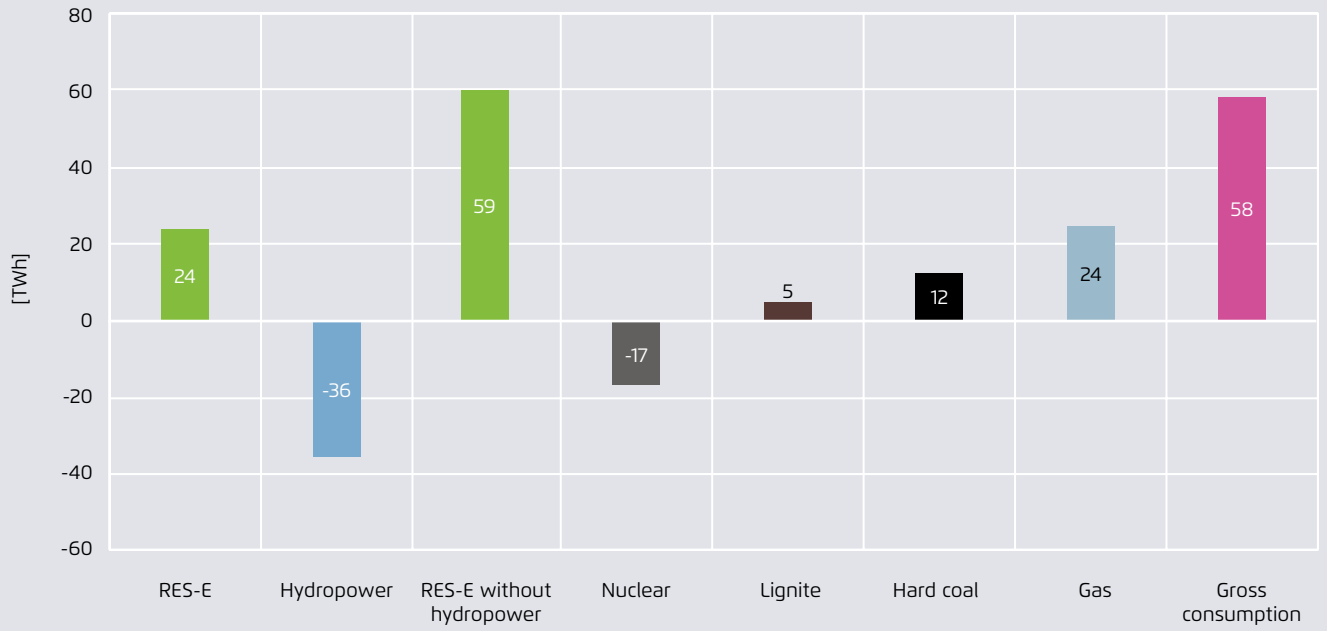
1 It is important to note that these RES shares deviate from the figures published by the European Commission. This is due to differing underlying data – while the EC uses normalised data which corrects actual hydropower and wind data to a "normalised weather year", we calculate the shares for all sources (RES plus conventionals) based on the actually observed power production.

Generation mix in 2014 and 2015 Figure 1



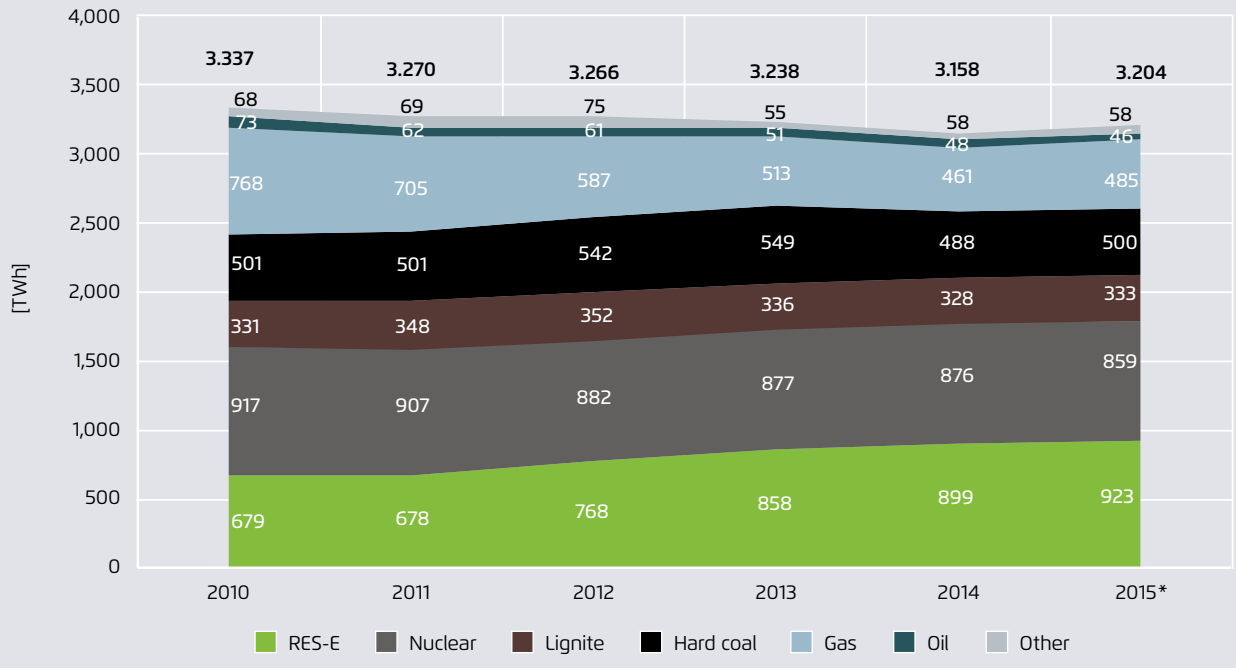
Data ENTSO-E 2016b, Eurostat 2016b, 2016c; Calculation Öko-Institut

Changes in gross electricity generation and consumption 2014 to 2015 Figure 2



Data ENTSO-E 2016b, Eurostat 2016b, 2016c; Calculation Öko-Institut

Gross Electricity generation by source 2010-2015 in the EU Figure 3



Data ENTSO-E 2016b, Eurostat 2016b, 2016c; Calculation Öko-Institut

*preliminary

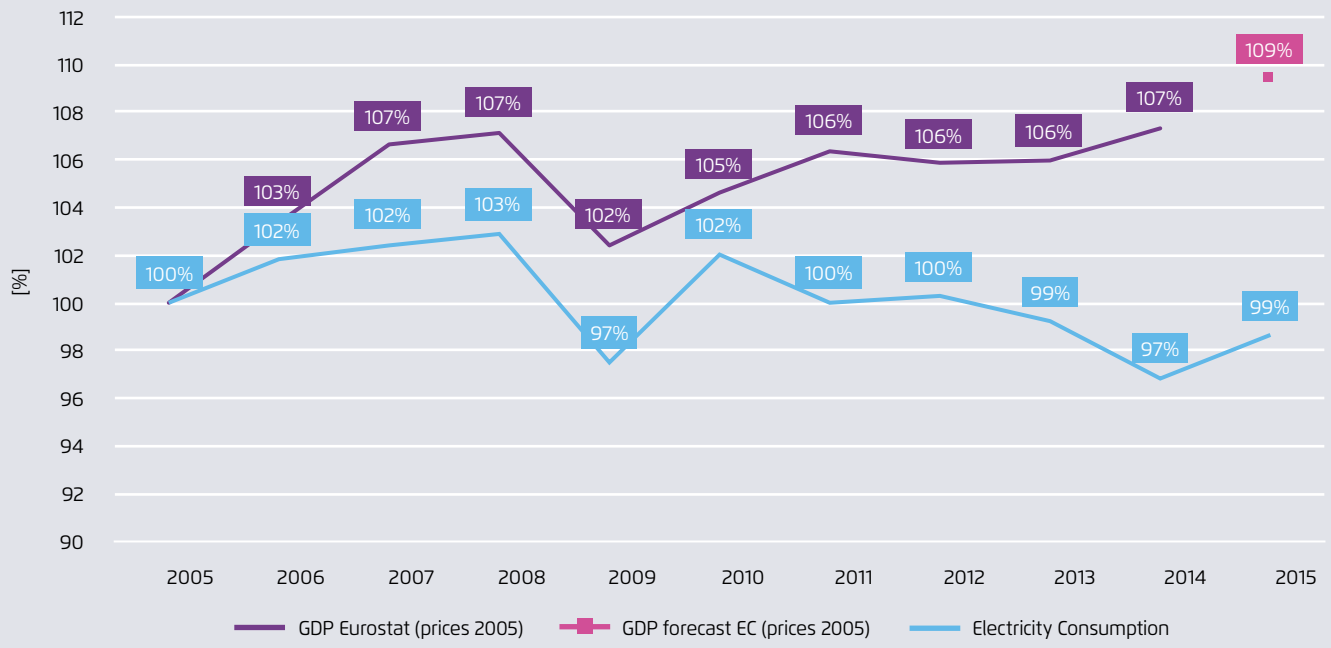
than in 2014. The large decrease in hydropower is masked by an even larger increase in power generation from other renewable energy sources: these sources produced 59 terawatt hours more electricity than in the previous year. Nuclear energy produced 17 terawatt hours less, coal 17 terawatt hours more, and gas power increased by 24 terawatt hours. Overall power demand increased by 58 terawatt hours, a 1.8 percent plus compared with 2014 (see Section 2). [2]

When viewing the trend for the past five years, there is one clear winner: renewable energy sources have increased production significantly, producing 36 percent more power in 2015 than in 2010. Coal (both hard coal and lignite) is in 2015 at the same level as in 2010, nuclear power decreased slightly – mainly due to the decision to phase-out nuclear power made in Germany in 2011. Most striking is the decreasing use of gas for electricity production, which is more than a third lower than in 2010.

2 Please note that generation data may deviate from other known datasets. This is due to different data sources. Data availability and methodology is discussed in Section 10.

2 Electricity consumption

Electricity consumption and gross domestic product of the EU — Figure 4



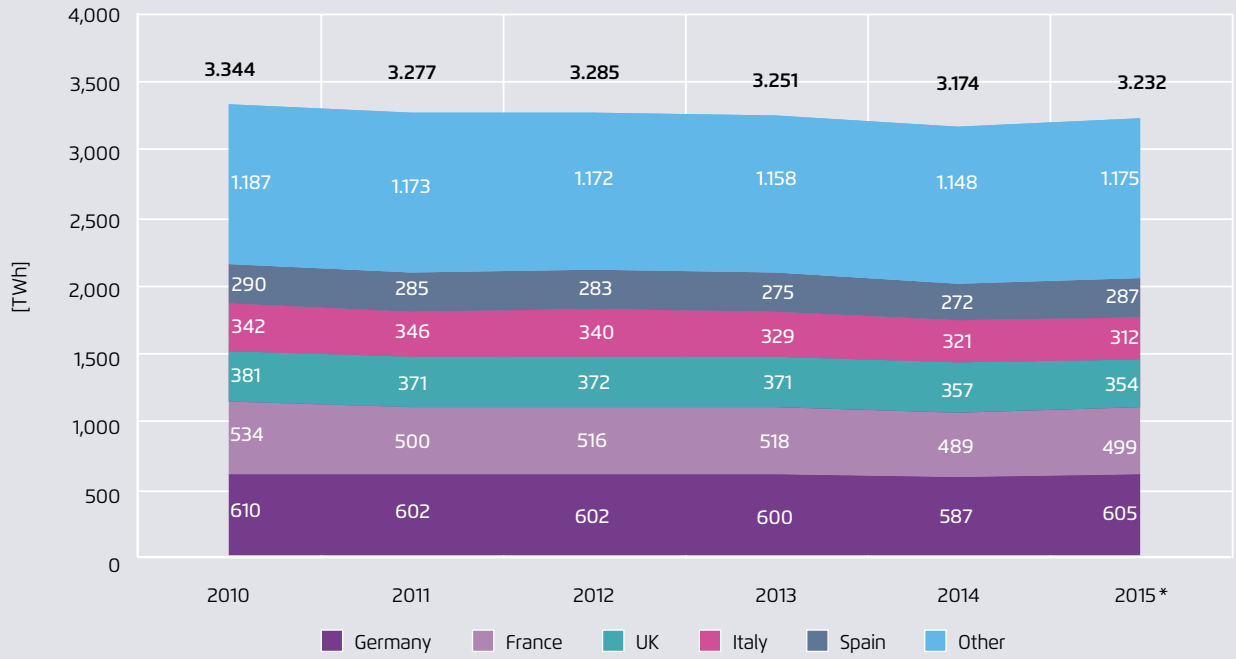
Data ENTSO-E 2016b; European Commission (EC) 2016a, Eurostat 2016a, 2016b, 2016c; Calculation Öko-Institut

The energy efficiency of the power sector has increased considerably over the past 10 years. Although in 2005 most experts predicted continuous growth in the power demand across Europe, demand actually peaked in 2008 and is now slightly below 2005 levels. This contrasts with the overall European GDP growth of 10 percent over the past 10 years. Electricity consumption and economic growth have therefore decoupled during the past few years – increasing gross domestic product is no longer automatically linked to increasing electricity consumption. Drivers for this trend include more efficient industrial processes, the effects of the European eco design directive and an overall increase in the energy efficiency of appliances. Nevertheless, more efforts are needed in order to achieve the 2020 efficiency target that foresees a 20 percent increase in the energy efficiency in Europe.

The top five countries, Germany, France, UK, Italy and Spain, consume more than half of the total electricity. In total, 2,851 terawatt hours of electricity were consumed in 2015, 112 terawatt hours or 3.3 percent less than in 2010. The increase of 56 terawatt hours compared with 2014 was mainly because Europe experienced a warm winter in 2014, which reduced the power demand. Nearly 20 percent of European electricity is consumed in Germany, and about 15 percent in France. These countries are followed by UK, Italy and Spain.

Gross electricity consumption from 2010 to 2015: European total and top 5 countries

Figure 5

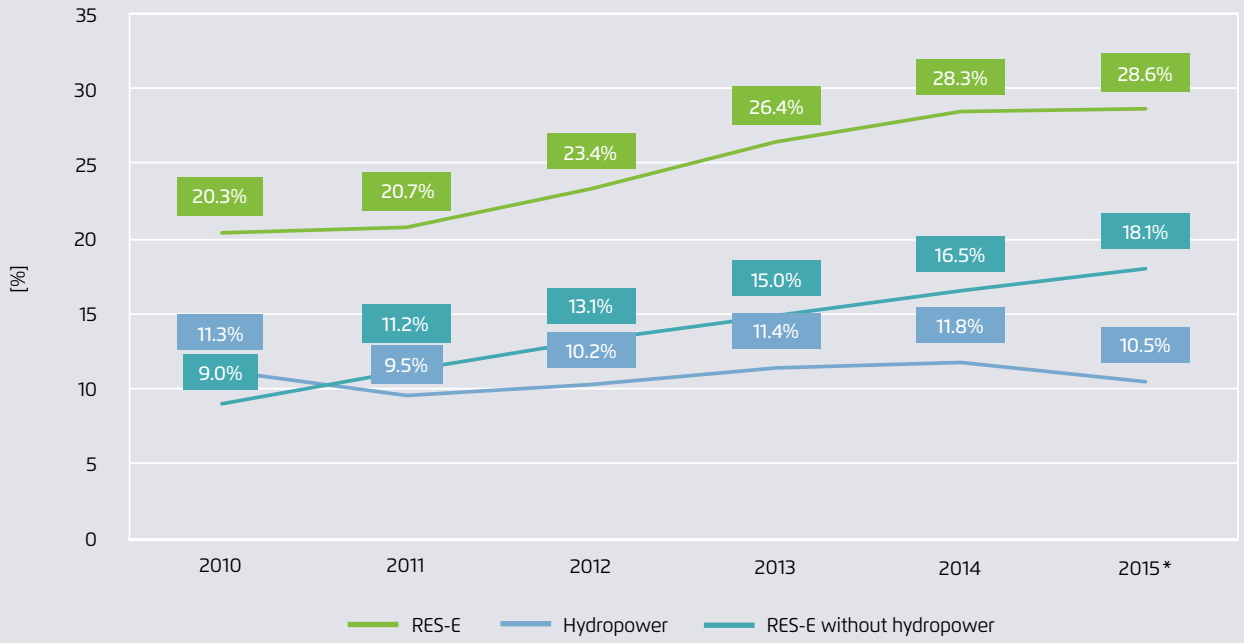


Data ENTSO-E 2016b, Eurostat 2016b, 2016c; Calculation Öko-Institut

*preliminary

3 Development of renewables

Renewables share of gross electricity consumption — Figure 6



Data ENTSO-E 2016b, Eurostat 2016b, 2016c; Calculation Öko-Institut

*preliminary

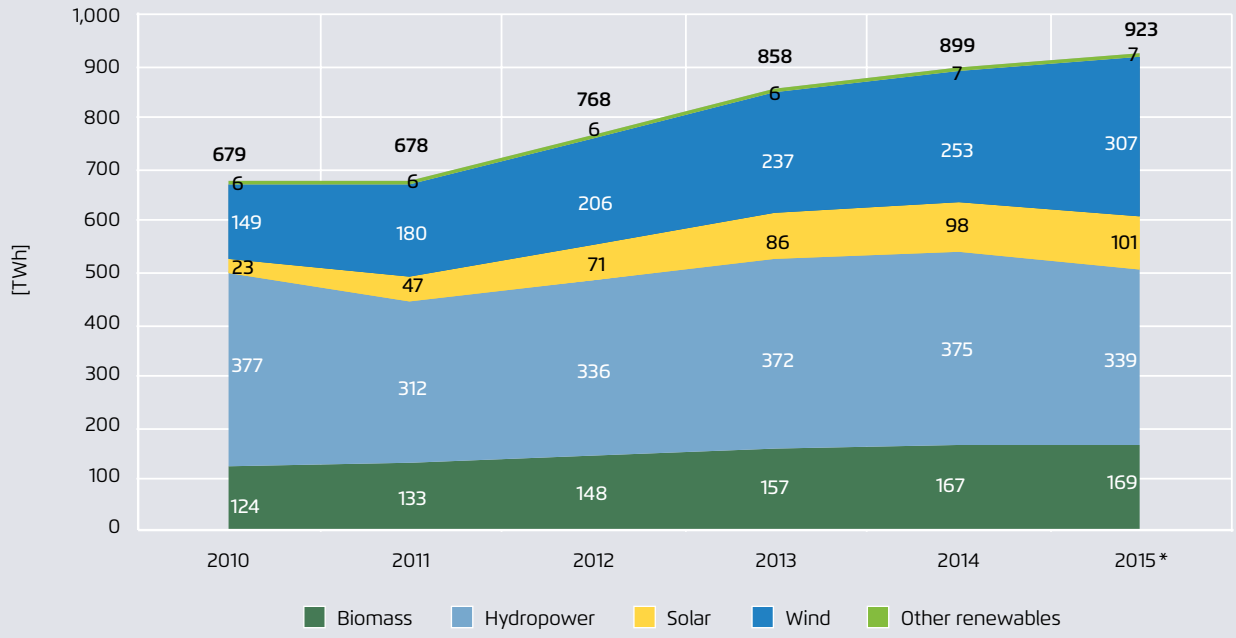
Figure 6 shows the increasing share of renewable energy sources relative to the gross electricity consumption. When looking at the total share of renewables, the steep increase from 2011–2014 does not continue in 2015, when there is an increase of only 0.3 percentage points. However, the poor precipitation in 2015 leading to poor hydropower exploitation masks the real increase – when looking at the share of renewables without hydropower, the steep increase continues in 2015 as well. The EU is on track to deliver the power sector's anticipated contribution to the overall EU RES target for 2020. The Commission's most recent progress report on the Renewable Energy Directive shows, however, that there might be difficulties in delivering the anticipated contributions from the transport and heating & cooling sectors.[3] As the indicative trajectory towards the EU RES target gets steeper towards 2020[4], this means that the power sector's contribution might have to be increased in order to meet the EU RES target for 2020.

In terms of the overall figures, the power generated from all renewable energy sources except hydropower has increased during the past five years. Wind energy produced more than twice as much energy in 2015 (307 terawatt hours) than in 2010 (149 terawatt hours); power generated from solar energy even increased almost fivefold from 23 terawatt hours in 2010 to 101 terawatt hours in 2015, and the power generated from biomass increased by about 45 terawatt hours to 169 terawatt hours in 2015. These three energy sources experienced tremendous capacity expansions, while the ca-

3 European Commission, Renewable energy progress report, COM(2015) 293 final of 15.6.2015.

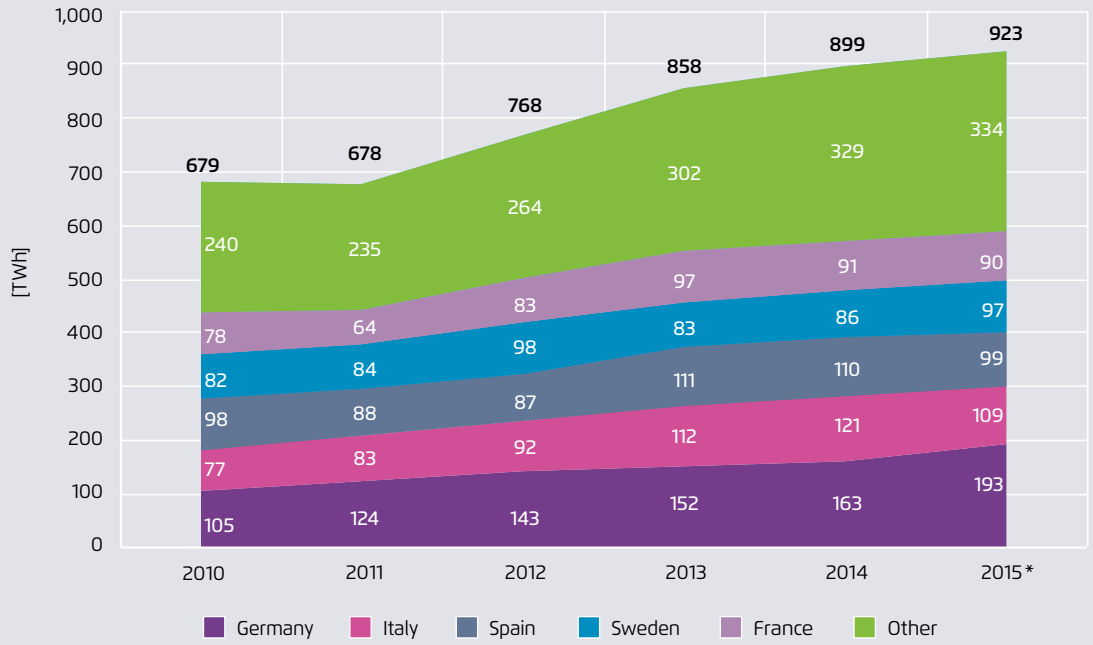
4 See Annex I.B to Directive 2009/28/EC.

RES production by source 2010-2015 Figure 7



Data ENTSO-E 2016b, Eurostat 2016b, 2016c; Calculation Öko-Institut *preliminary

RES production 2010-2015: European total and top five countries Figure 8



Data ENTSO-E 2016b, Eurostat 2016b, 2016c; Calculation Öko-Institut *preliminary

pacity of hydropower has not significantly changed during the past five years[5].

When the total renewable energy production is differentiated in terms of the five top producers, it becomes clear that almost two thirds of the total renewable energy produced comes from five countries. Germany produced about 20 percent of all renewable energy within the EU (193 terawatt hours), followed by Italy (109 terawatt hours), Spain (99 terawatt hours) and Sweden (97 terawatt hours) with about eleven percent, and France with about ten percent (90 terawatt hours). The main increases from 2010 to 2015 came from Germany and Italy, whereas in Spain the increase in wind and solar energy roughly balanced out the decrease in hydropower production.

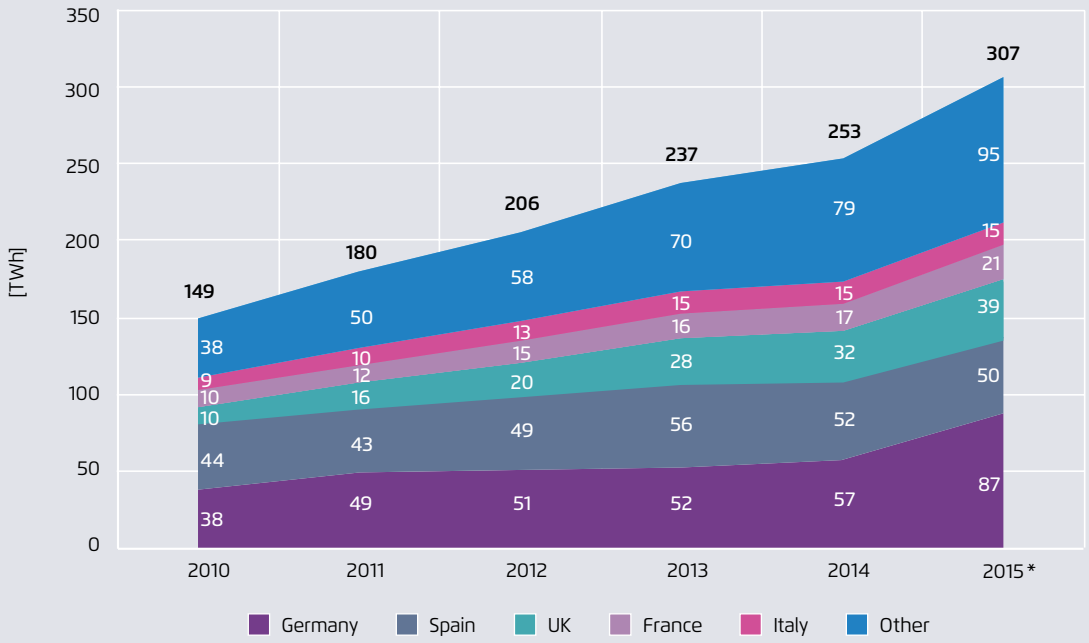
Electricity production from wind turbines has experienced a strong increase over recent years, with a particularly strong expansion from 2014 to 2015 (see Figure 9).

The Member States with the largest wind production are Germany, Spain, UK, France and Italy. The concentration of production from wind energy is relatively high: Germany (87 terawatt hours), Spain (50 terawatt hours) and UK (39 terawatt hours) are responsible for more than half the overall production within the EU. In 2014, Germany overtook Spain as the largest wind power producer. The production from wind turbines in Spain has even decreased from 2013 onwards.

Germany made the largest contribution to the increase in the overall wind production within the EU from 2014 to 2015, which was primarily due to large capacity increases in the offshore sector. In 2015, an additional 3,018.5 MW

5 Eurostat (2016d).

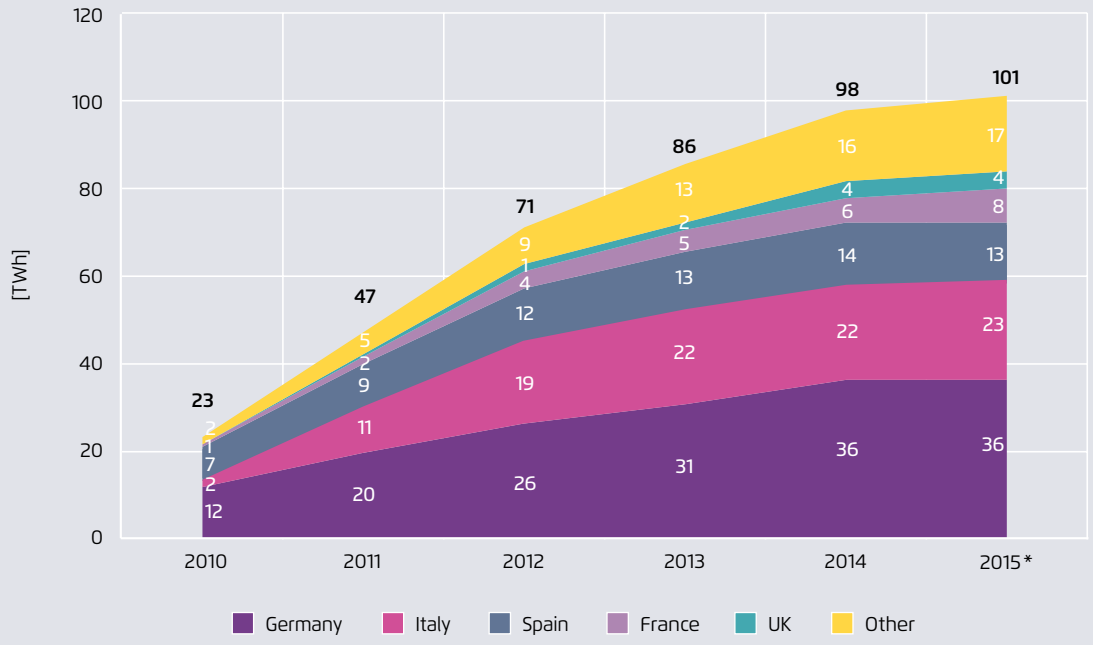
Wind power production 2010-2015: European total and top five countries — Figure 9



Data ENTSO-E 2016b, Eurostat 2016b, 2016c; Calculation Öko-Institut

*preliminary

Solar power production 2010-2015: European total and top five countries Figure 10



Data ENTSO-E 2016b, Eurostat 2016b, 2016c; Calculation Öko-Institut

*preliminary; Data for 2015 are own estimates on basis of ENTSO-E 2016.

of offshore wind capacity were connected to the grid, more than two thirds of it in Germany (2,282.4 MW)[6].

Although the electricity produced from solar energy, totalling 101 terawatt hours, has considerably increased since 2010, the annual growth rate has decreased recently, so that the increase from 2014 to 2015 has been reduced to a mere three terawatt hours. The largest increase was from 2010 to 2011, when an additional 24 terawatt hours were produced. The Member States with the largest solar production are Germany, Italy, Spain, France and the UK. Germany and Italy alone account for about 58 percent of the overall production from solar energy (see Figure 10).

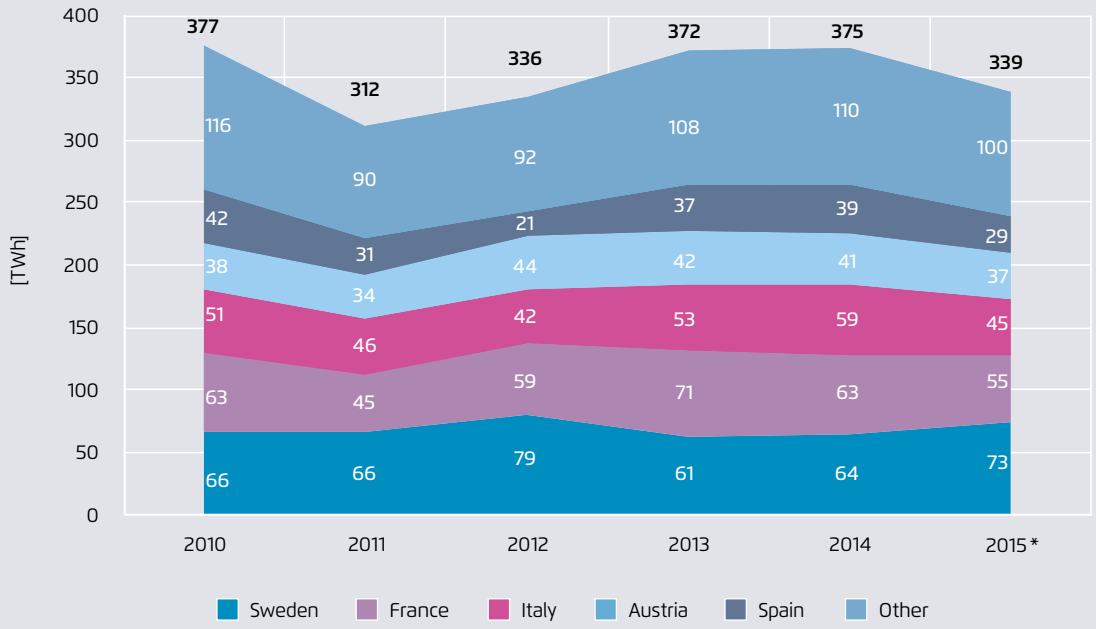
The electricity produced from hydropower plants is highly dependent on the overall precipitation each year. Whilst the installed capacity of hydropower plants has not changed significantly, the production has varied by 38 terawatt hours within the last five years. After years with considerable hydropower production in 2013 (372 terawatt hours) and 2014 (375 terawatt hours), there has been a significant decrease in the hydropower production from 2014 to 2015 (down to 339 terawatt hours).

The largest hydropower producers are Sweden, France and Italy. They account for about half of the overall production from hydropower.

6 EWEA 2016.

Hydropower production 2010-2015: European total and top five countries

Figure 11

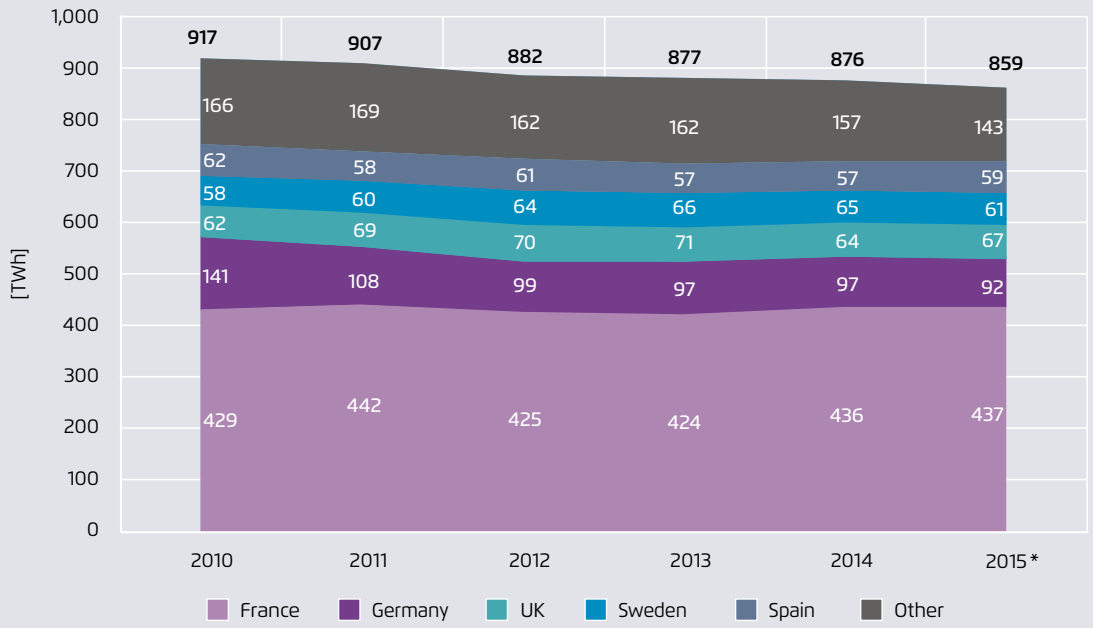


Data ENTSO-E 2016b, Eurostat 2016b, 2016c; Calculation Öko-Institut

*preliminary

4 Development of conventional power generation

Nuclear production 2010-2015: European total and top five countries — Figure 12



Data ENTSO-E 2016b, Eurostat 2016b, 2016c; Calculation Öko-Institut

*preliminary

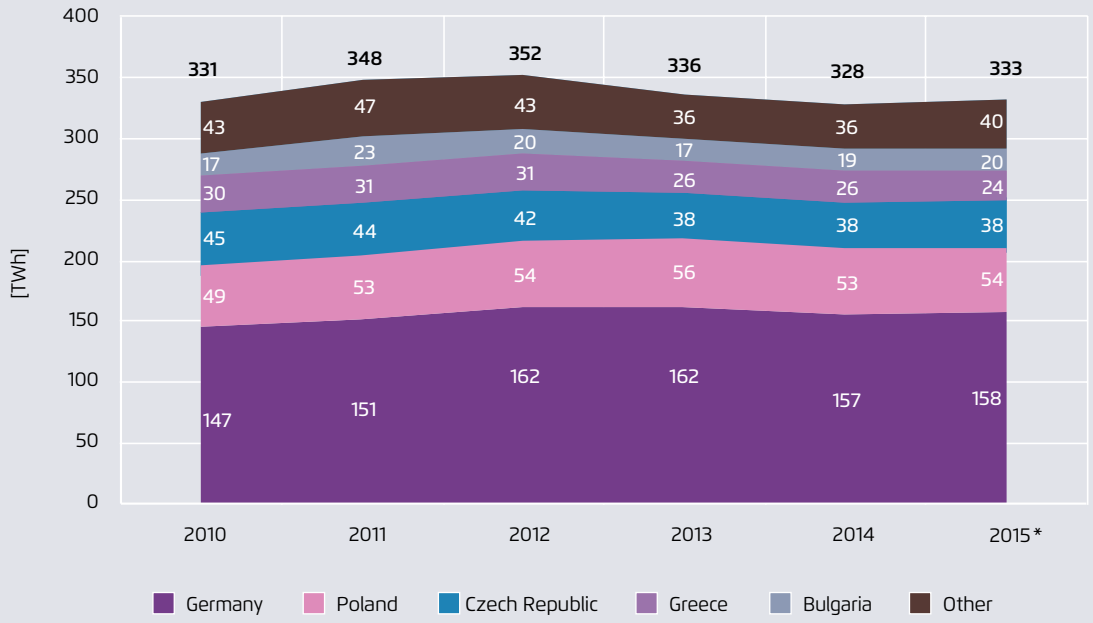
Europe's overall power production from nuclear power plants has slightly decreased, though the trend varies between Member States. Half of the EU's nuclear power production sources stems from France, which produced 429 terawatt hours in 2015, 8 terawatt hours more than in 2010. In contrast, Germany has decreased its nuclear power production from 141 terawatt hours in 2010 to 92 terawatt hours in 2015. This trend will continue, as Germany has decided to phase out nuclear power by 2022. Further important producers are the UK, Sweden and Spain, each generating around seven percent of the total.

The electricity production from lignite-fired power plants has stayed almost constant during the past five years with a slight peak in 2011 (348 terawatt hours) and 2012 (352 terawatt hours). Germany dominates the overall power production from lignite-fired plants and even increased its production from 147 terawatt hours in 2010 to 158 terawatt hours in 2015. It accounts for 47 percent of the overall European production from lignite in 2015. Other major producers of electricity from lignite power plants are Poland, the Czech Republic, Greece and Bulgaria.

The electricity production from hard coal-fired power plants peaked in 2012 and 2013 with over 540 terawatt hours before returning to the 2010 level in 2015 with 500 terawatt hours. Germany, the UK and Poland dominate the overall production from hard coal-fired plants and account for 58 percent of the overall production from hard coal in 2015. Other major producers of electricity from hard coal-fired power plants are Spain and Italy.

The UK has seen a decrease in the electricity produced from hard coal-fired plants during the past three years, which is linked to the implementation of the carbon floor price in 2013 and its annual increase.

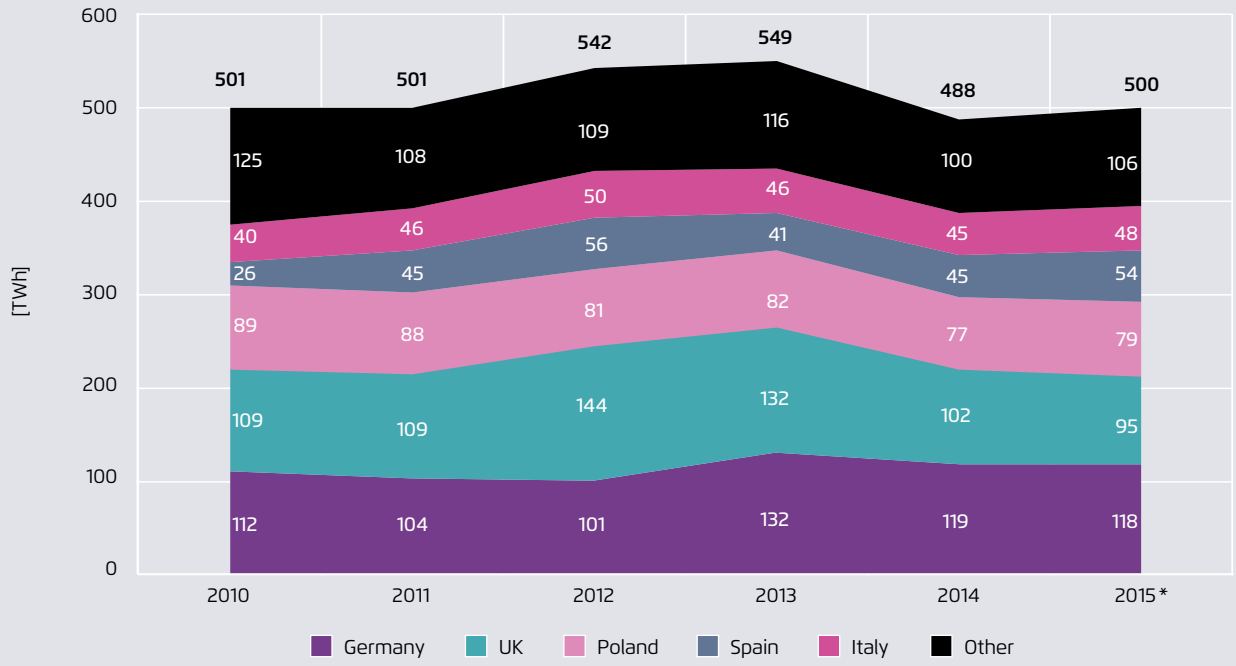
Lignite power production (including peat) from 2010-2015: European total and top five countries Figure 13



Data ENTSO-E 2016b, Eurostat 2016b, 2016c; Calculation Öko-Institut *preliminary

Whilst the production from other conventional power plants has stagnated, the electricity production from gas-fired power plants has constantly and significantly decreased from 2010 to 2014 by about 15 percent annually. The data for 2015 shows a slightly different picture: the production from gas-fired power plants increased by 24 terawatt hours, a five percent increase from 2014 to 2015. This was due to the increase in the power demand in 2015, which was partly met by gas and hard coal. Italy, the UK, Germany, the Netherlands and Spain were the main gas power producers in 2015, accounting for about 75 percent of the total gas power production.

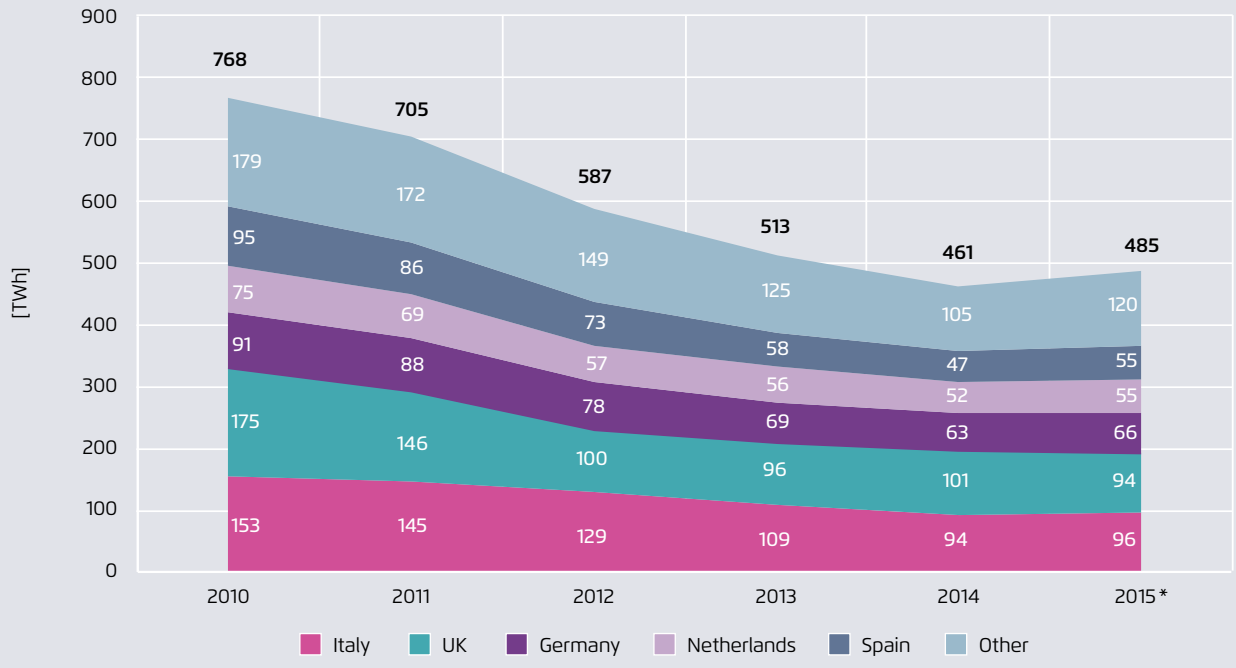
Hard coal power production from 2010-2015: European total and top five countries — Figure 14



Data ENTSO-E 2016b, Eurostat 2016b, 2016c; Calculation Öko-Institut

*preliminary

Power production from gas fired power plants 2010-2015: European total and top five countries — Figure 15

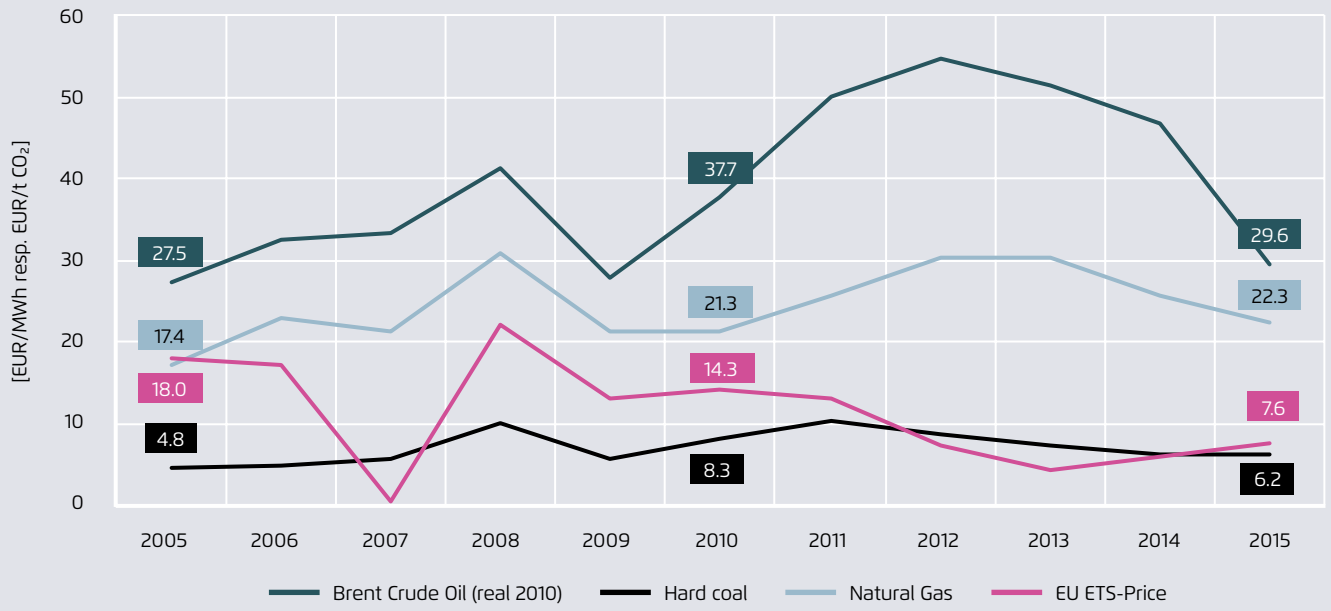


Data ENTSO-E 2016b, Eurostat 2016b, 2016c; Calculation Öko-Institut

*preliminary

5 Fuel prices and marginal costs

Nominal fuel prices in Europe 2000-2015 Figure 16



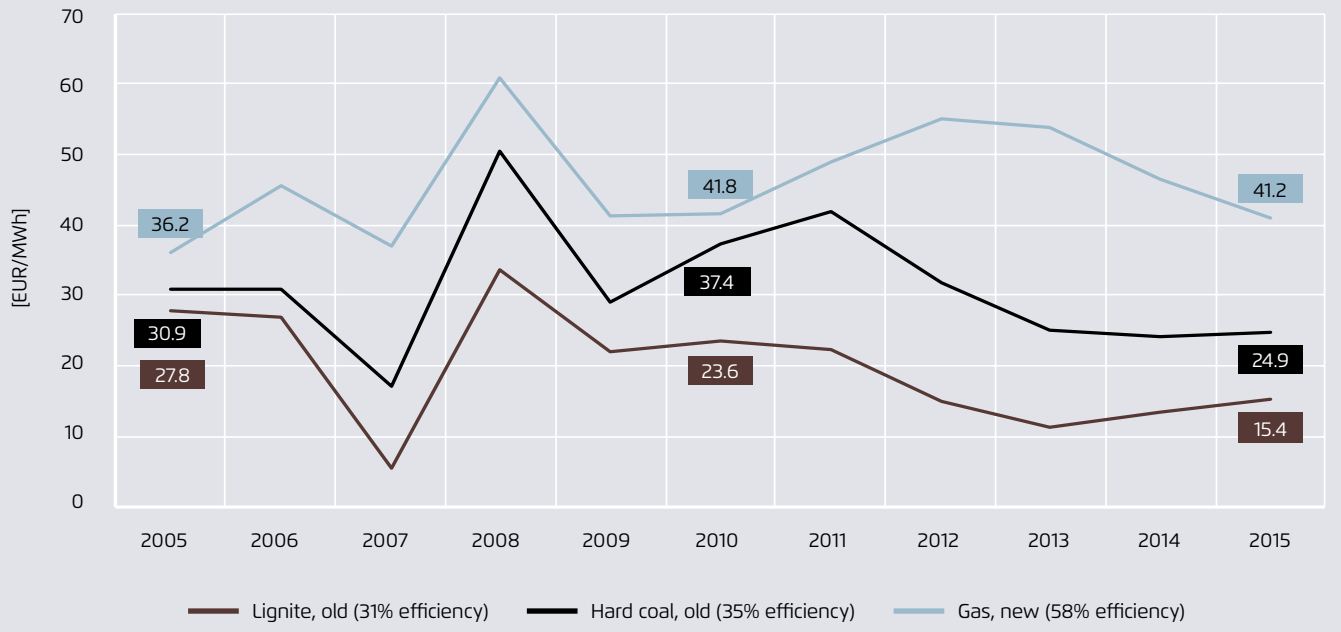
The World Bank 2016; BP 2016, Bundesbank 2016, DEhSt 2016; own calculations; Note: Hard coal prices are average Australian, Columbian and South African prices; Natural gas prices are European, all figures are nominal. Due to the 2015 exchange rate EUR-USD, price declines may appear less severe.

Fuel prices on the global markets significantly decreased in 2015. While the 58 percent decrease from 46.75 euros per megawatt hour in 2014 to 29.63 euros per megawatt hour in 2015 for oil was the highest, the decreases for hard coal (minus four percent) and natural gas (minus 15 percent) were less severe. The oil price is now at a similar level to the 2005 and 2009 prices.

In contrast, the CO_2 emission certificate price increased slightly from 2014 to 2015, from 5.95 euros per allowance to 7.62 euros per allowance.

This increase has impacted on the marginal costs of power plants: whilst the marginal costs for old lignite and old hard coal plants increased, the marginal costs for new gas-fired power plants decreased. Whilst in 2014 old lignite plants had marginal costs of 13.34 euros per megawatt hour, this increased to 15.41 euros per megawatt hour in 2015. Electricity from old hard coal power plants had average marginal costs of 24.06 euros per megawatt in 2015, which only slightly increased to 24.93 euros per megawatt hour in 2015. In contrast, gas-fired power plants had marginal costs of 46.58 euros per megawatt hour in 2014, which decreased to 41.15 euros per megawatt hour in 2015. If the CO_2 emission certificate price had been around 35 euros, the marginal costs of these power plants would have been at the same level: around 50 euros per megawatt hour. With even lower fuel prices in the first months of 2016, a CO_2 price level of around 30 euros would be sufficient for a switch in marginal costs.

Marginal costs of standard-type power plants 2000-2015 Figure 17

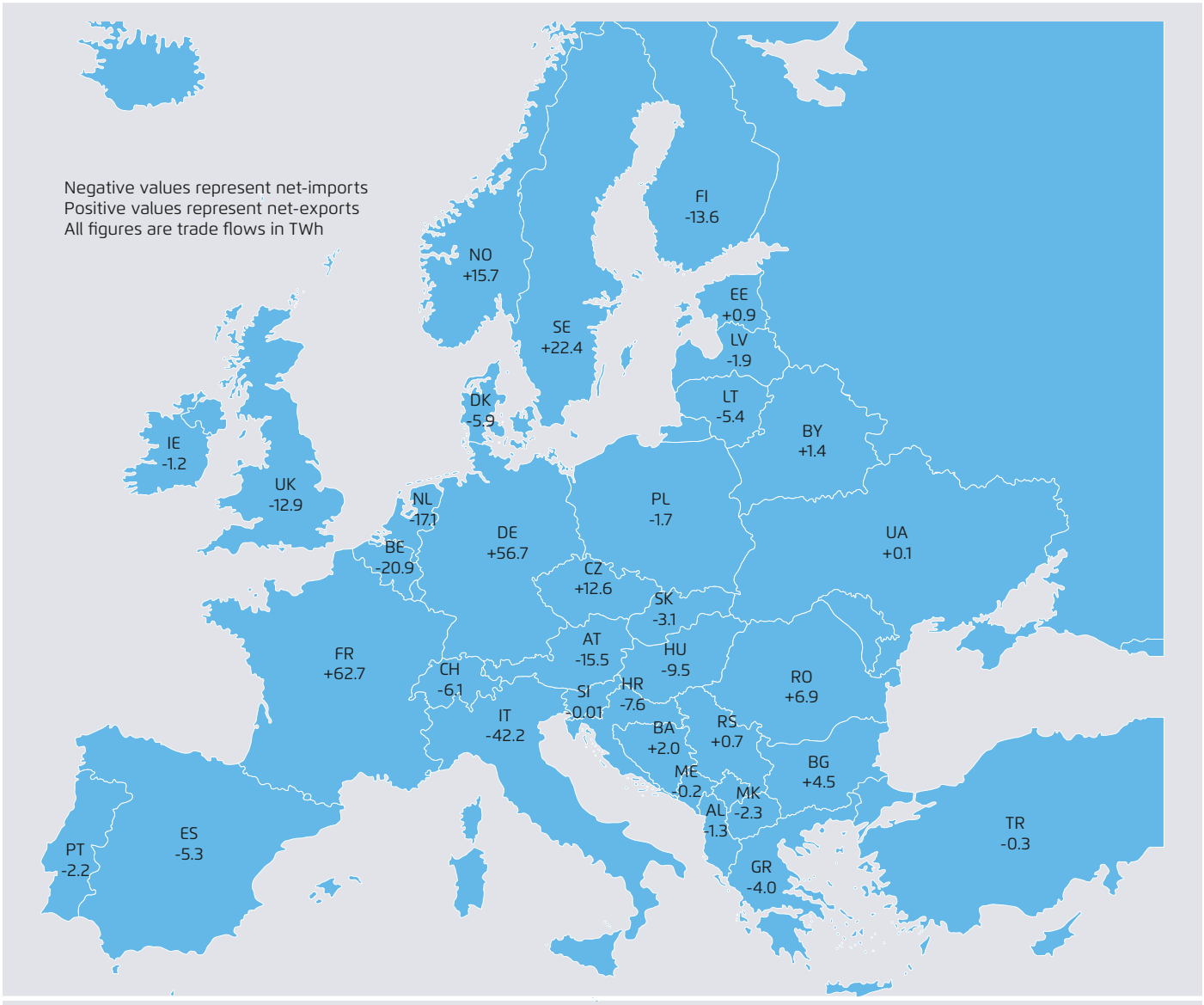


Worldbank 2016; BP 2016, Bundesbank 2016, UBA 2015, DEhSt 2016, own calculations

6 Cross-border trade

Net-cross border trades

Figure 18



ENTSO-E 2016

There is a lively cross-border power trade taking place in Europe. The overall volume of trades reported has increased in 2015. In total, the reporting countries imported 473 terawatt hours electricity and exported 476 terawatt hours. The difference is made up of trades made outside of Europe.

The countries with the largest net exports are France, Germany, and Sweden. Italy, Belgium and the Netherlands are the largest net importers. However, when this figure is viewed relative to the countries' consumption, the countries with the largest trade flows are Lithuania, which imports about 47 percent of its consumption, Croatia, which imports about 40 percent of its consumption and Latvia, which

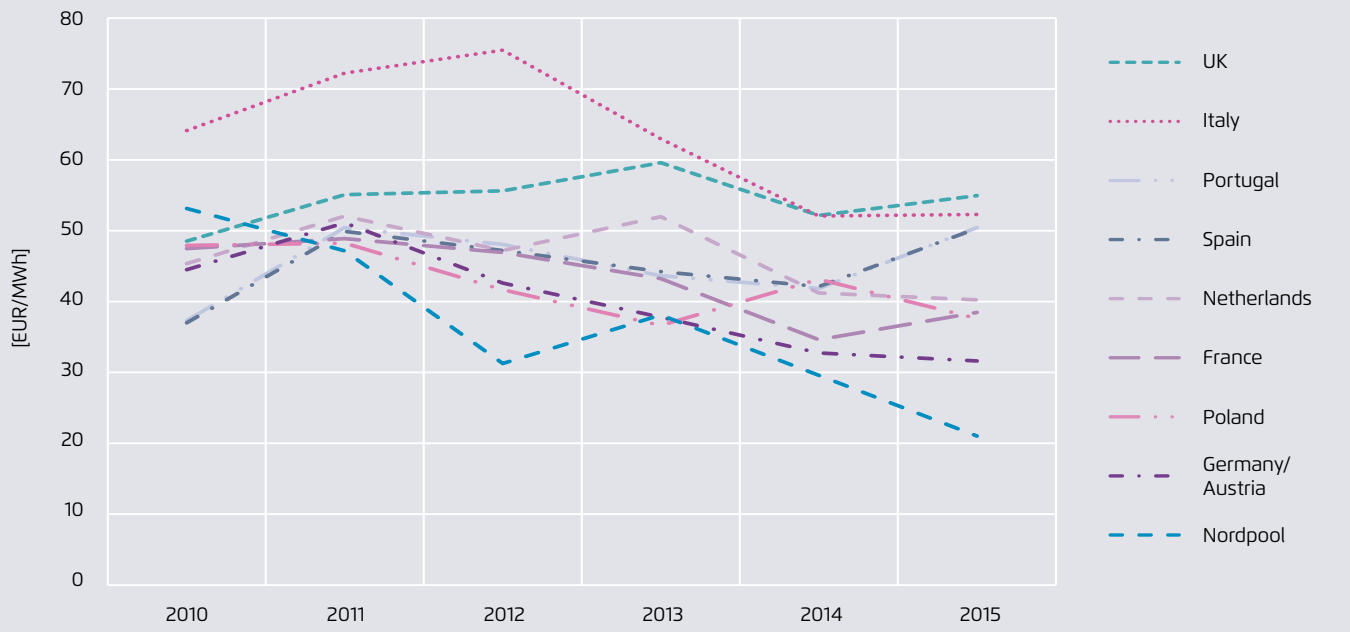
imports about a quarter of its consumption. Countries in a similar situation where a large part of the national consumption is covered by imports include Austria (20 percent of the consumption), Belgium (23 percent of the consumption), Denmark (16 percent of the consumption), Finland (16 percent of the consumption), Italy (13 percent of the consumption), the Netherlands (14 percent of the consumption) and Slovakia (10 percent of the consumption).

The biggest net export increase in 2015 came from Germany, which increased by 20.6 terawatt hours. This is due to the fact that although Germany saw large amounts of additional wind power, this did not lead to a decrease in German conventional power production but rather to exports: German coal power plants were outcompeting gas power plants in its neighbouring countries Austria, Netherlands and (via Switzerland) Italy.

7 Electricity exchange prices

Day-ahead prices in selected European countries

Figure 19

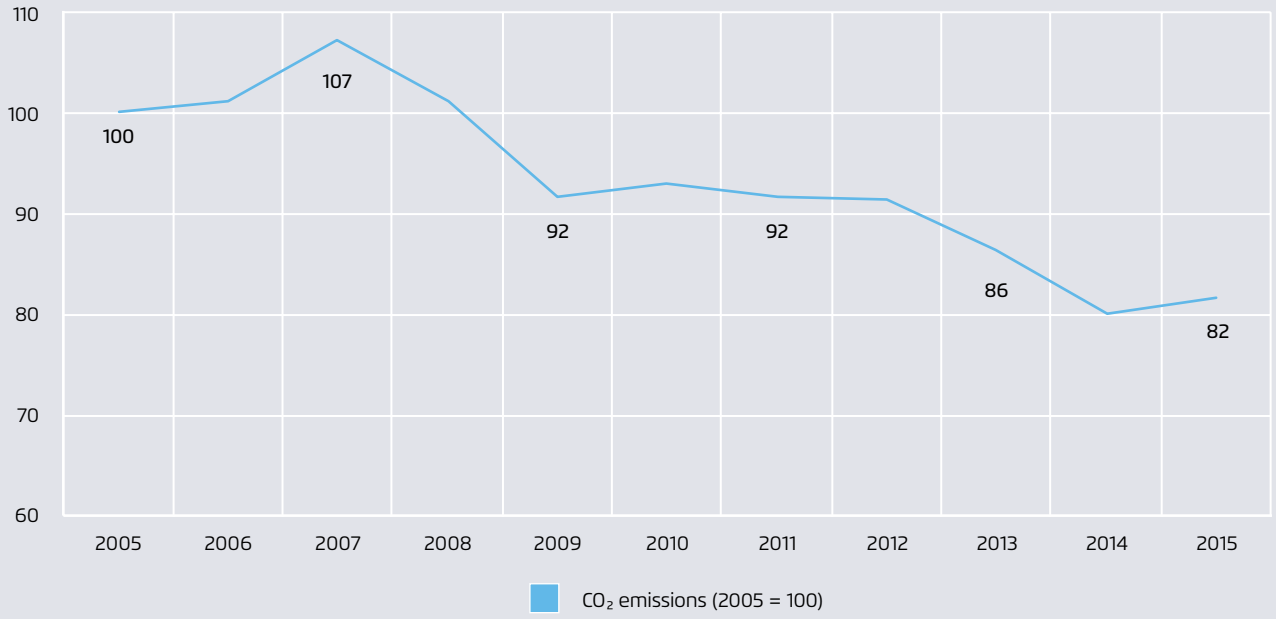


EEX 2016, EPEX 2016, APX 2016, OMEL 2016, GME 2016, PGE 2016, Nordpool 2016, Matthes 2016

Prices at the electricity exchanges showed an unclear pattern in 2015 after decreasing for three years in a row from 2011 to 2014. The mean price per megawatt hour within this sample for 2015 was 41.7 euros. This is more than 20 percent less than in 2011. Increases in 2015 were experienced in the UK, Spain and France, whereas power prices decreased in Scandinavia, Germany and Poland. Scandinavia had the lowest day-ahead prices with 21.04 euros per megawatt hour, followed by Germany and Austria with 31.63 euros per megawatt hour. On the upper end of the range were the UK (54.95 euros per megawatt hour) and Italy (52.31 euros per megawatt hour).

8 CO_2 emissions

Development of the power sector's CO_2 emissions since 2005 (2005=100) Figure 20



European Commission 2016b, Öko-Institut EU ETS Database; Calculation Öko-Institut; Note that the data is not normalised for EU accessions, i.e. the 2007 peak is due to the new membership of Bulgaria and Romania.

In 2015, CO_2 emissions from the power sector were 18.3 percent lower than in 2005 and 12 percent lower than in 2010. After decreasing from 2007 to 2014, emissions increased again in 2015.

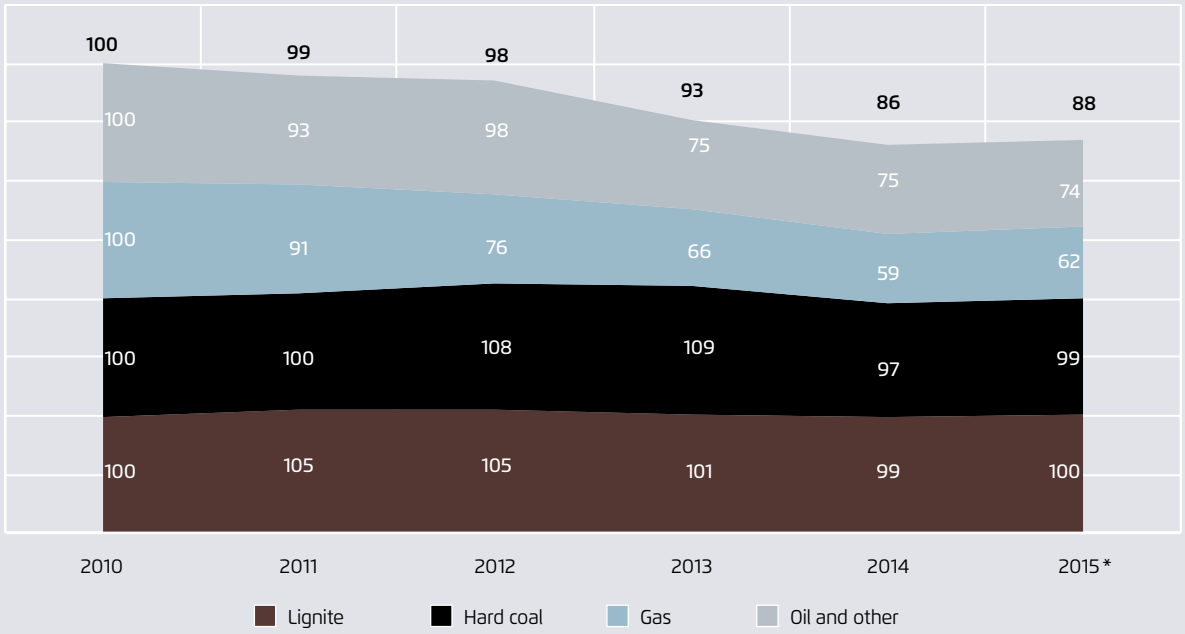
The decrease in emissions between 2010 and 2014 mainly stems from the large reduction in the electricity produced from gas-fired plants (see Figure 22). If this decrease in conventional power production had instead been taking place in coal-fired power plants, the emissions from the power sector in 2014 could have been lower by some 100 million tonnes of CO_2[7]. The increasing CO_2 emissions from 2014 to 2015 are mainly due to the increase in the electricity produced from hard coal- and gas-fired plants as a result of the increase in demand in 2015. In 2015, about three quarters of the total CO_2 emissions stem from coal- and lignite-fired power plants, even though they only make up one quarter of the total European electricity generation.

When looking at the overall greenhouse gas emissions trends within Europe, EEA data shows that in 2014 the EU already reached its 2020 target of minus 20 percent greenhouse gas emissions relative to 1990, with emissions 23 percent below 1990 levels.[8]

7 Assuming a difference in CO_2 intensity between coal and gas of 400 g/kWh

8 EEA 2015

Power sector CO_2 emissions relative to 2010, by energy source (2010=100) Figure 21



ENTSO-E 2016b, Eurostat 2016b, 2016c, UNFCCC 2015; Calculation Öko-Institut

*preliminary

9 Summary and outlook

The EU climate and energy targets for 2020 and 2030 are signposts on the way to achieving an almost complete decarbonisation of the power sector by 2050. Our analysis provides a snapshot of where Europe stands in this transition and tracks developments over the past few years.

Today, RES-e provides the largest share of the EU electricity production (28.7 percent), closely followed by nuclear power (26.8 percent) and coal (hard coal 15.6 percent, lignite 10.4 percent). The contribution of gas has decreased by one third during the past five years to a current share of 15.1 percent. These figures also indicate that the power sector in Europe seems on track in terms of delivering its anticipated contribution to the EU's overall RES target for 2020.

The share of RES-e in the gross electricity consumption has continuously increased during the last five years, but was somewhat slower in 2015. This is due to the comparatively low contribution of electricity from hydropower as a result of poor precipitation, which masks a continuously steep increase in power production from other renewable energy sources, in particular from wind and solar PV. The growing significance of wind and solar PV compared with other renewable energy technologies reflects the comparatively low costs of these two technologies (that are projected to decrease even further) as well as economic and natural constraints in increasing biomass and hydropower beyond current levels. This trend is most likely to continue.

Nuclear energy has seen a slight decrease during the past few years, driven by the planned and gradual closure of nuclear power plants in Germany, while the share of nuclear electricity produced in other member states has remained almost constant.

The electricity production from coal (lignite and hard coal) is currently at the same level as in 2010, with a slight peak in the electricity production from hard coal-fired power plants in 2012 and 2013.

In contrast, gas-fired electricity generation has seen a constant and significant decrease from 768 terawatt hours in 2010 to 485 terawatt hours in 2015, which is a decrease of more than one third.

These figures also show that while the EU has progressively reduced its CO_2 emissions from the power sector and already reached its overall greenhouse gas reduction target for 2020 in 2013, the power sector's contribution has not been achieved by reducing the relatively carbon-intensive power generation by coal, but by reducing the less CO_2-intensive gas-fired power generation.

This gradual decline of gas in the mix reflects a carbon price from the EU ETS that consistently remains below the price level needed to push for a fuel switch from coal to gas.

Looking ahead to 2016, we expect:

- → a further increase in the power generated by renewable energy sources of approximately 50 terawatt hours (+/- 10 terawatt hours depending on hydropower year) as a result of the newly established RES-e capacity that is just starting to generate power – this additional supply, however, will mostly stem from only a few countries
- → a slight decrease in the share of coal-fired generation as a consequence of the UK government's policy on coal, including the fact that the carbon floor price was raised to £18 in April 2015. Since this is added on top of the ETS price and gas prices are falling, this will lead to the shutdown of several hard coal-fired power plants in the UK in 2016
- → a continuous slight decrease in the production of electricity from nuclear power plants, as the shutdown of the Grafenrheinfeld nuclear power plant in Germany in mid-2015 will only show its full effect in 2016
- → power demand to slightly decrease again due to the overall energy efficiency trend and because of the relatively mild winter at the beginning of 2016

→ a decrease in CO_2 prices (after the slight increases in 2013–2015) due to the further increase in the ETS allowance surplus resulting from the RES, coal and demand trends outlined above

Looking beyond 2016, there is considerable uncertainty about future trends: both the further development of renewables in the power sector and the coal/gas mix will heavily depend on the outcome of the broad legislative package on climate and energy for the 2020–2030 decade. This will be negotiated between the European Parliament and Member States in the Council beginning in the summer of 2016. This package includes reforms of the emissions trading system, effort-sharing in the non-ETS sectors, new rules on the functioning of power markets in Europe, revisions of the EU legislation on energy efficiency and renewables, and more stringent rules on government interventions to ensure system adequacy.

Therefore, although Europe is generally still on track in 2015/2016 in gradually transforming its power sector, the outlook for the European energy transition beyond the next few years is still very uncertain. Without a reliable framework for RES investments post 2020 and a strong stance on old coal power plants, the decarbonisation pathway taken by the European power sector might slow down considerably.

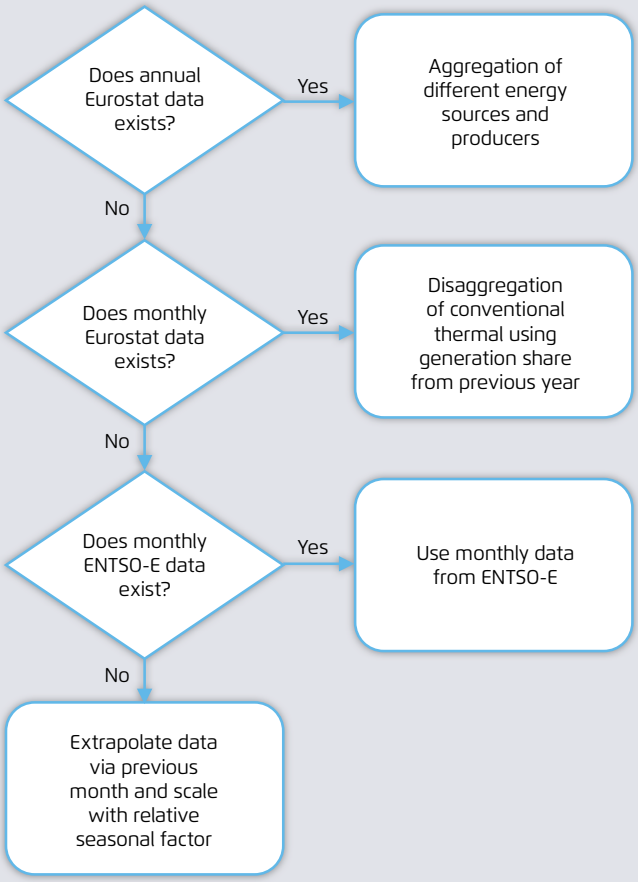
10 Methodology

When working with recent European power data, various obstacles occur. This applies mostly to generation data, but also export data is not always complete. Annual Eurostat data for generation is in most cases available until 2014, some only until 2013. Monthly Eurostat data is not available for separate conventional thermal power but only on an aggregated level. ENTSO-E did not start reporting all relevant data until mid-January 2015 and data is incomplete for some countries for November and December 2015.

However, we believe, that it is crucial for European power market politics to work with reliable and most recent data in order to react to developments of the past few years, evaluate whether certain regulation has impact or not and develop market frameworks for the next decades. This is why we asked the Oeko-Institut e.V. to develop a methodology, which grasps development of the last year and draws a picture of the status of the energy transition within the EU. All data for 2015 and in few cases for 2014 in this report is therefore preliminary and therefore marked. For some countries, recent and reliable data is already available, but in order to work with coherent data on an EU level, we have decided to use Eurostat and ENTSO-E data.

We welcome insights to better, more reliable, more recent data and to the used methodology for the EU. The following sections describe the applied methodology.

Flow chart: Calculation of annual electricity generation



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10.1 Calculation of annual data

Most data in this report is taken from the Eurostat databases. However, this data is sometimes incomplete or not yet available. To aggregate data in order to show a consistent picture, the following scheme has been applied. Where there was neither annual nor monthly Eurostat data available we used data from ENTSO-E or, in rare cases, relied on our own estimates.

If not indicated otherwise, all figures in this report are gross values. Gross consumption is calculated as follows:

Gross consumption = gross production – exports + imports – grid losses – pump storage losses

Eurostat reports annual data in a very detailed fashion. We aggregated the various energy sources according to the following table:

Energy sources as used in this report	Detailed energy carriers used in EUROSTAT
Lignite	Lignite, peat, patent fuels and BKB (Braunkohlebrikett)
Hard Coal	Hard coal, blast furnace gas, coke oven gas
Oil	Bitumen, crude oil, diesel, naphtha, kerosene, residual fuel oil
Gas	LPG, natural gas liquids, gas work gas and other recovered gases
Other	Industrial waste, non-renewable municipal waste, shale oil, oil sands, gas coke, coal tar, coke oven coke, coking coal, petroleum coke
Biomass	Gaseous, liquid and solid energy carriers plus the renewable share of waste, if reported separately
Other renewables	Geothermal plus tide, wave and ocean
Hydropower	Should include run-of-river and storage, but no pumped storage for our purpose. However, hydropower from annual EUROSTAT data includes generation from pumped storage. Therefore, hydropower is calculated from hydropower as reported by EUROSTAT minus pumped storage. Generation from pumped storage does not include energy from natural inflow; natural inflow is included in stored water.
Solar	Photovoltaic and solar thermal

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The monthly reported fossil generation from Eurostat is not as detailed. We disaggregated these values using the generation mix from the prior year based on Eurostat annual data. The retrieved monthly values were then weighted using the more comprehensive annual data.

If not available from previous steps, we retrieved monthly data for solar power and other energy sources from ENTSO-E. This data had to be weighted with a unique factor, as ENTSO-E reporting does not cover all production units in the countries. This factor is determined via the Eurostat monthly data and ENTSO-E monthly data from 2014. Data from the end of 2015 (mainly November and December) is still not available for several countries. We extrapolated these values from the last existing month using a relative seasonal factor derived as an average from the previous years.

10.2 Calculation of daily data

The daily data, which is used for the quarterly net production in the first part of this analysis, is based on ENTSO-E hourly values, which is partially incomplete. Reporting of these values started on 5 January 2015. Some countries reported before this date but the overall picture is not complete. Some countries have still not yet reported their data for the end of 2015. This means that the first week and the last two months of 2015 display incomplete data. Croatia, Luxembourg and Malta did not report any data. Because, however, these countries have a relatively small energy sector, no adjustments were implemented.

The reported data does not cover all production units in the countries. Therefore the production profiles per type have been scaled up for every country using the annual data on a monthly base. For biomass, only 40 percent of the generated electricity has been reported. The difference between the

reported biomass values and the annual data has been considered as a constant production. The main countries with missing biomass production are Italy (approx. 19 terawatt hours), the UK (approx. 20 terawatt hours) and Sweden (approx. 10 terawatt hours).

There are some errors in the national data sets where no values were reported. Obvious errors (dates shown) were extrapolated:

→ SI: 08.01.2016 until 13.01.2016
→ DE: 13.01.2016
→ RO: 29.01.2016 until 31.01.2016
→ BG: 23.08.2016 until 10.09.2016

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