The European Power Sector in 2017

State of Affairs and Review of Current Developments

ANALYSIS

30.0*

*RES-Share of Gross Electricity Generation

The European Power Sector in 2017

IMPRINT

ANALYSIS

The European Power Sector in 2017

State of Affairs and Review of Current Developments

AN ANALYSIS BY

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Preface

Dear reader,

The power sector will play a crucial role in attaining the European climate targets, which aim to cut greenhouse gases by at least 40% by 2030, compared to 1990. Tracking progress in the power sector is hence of utmost importance.

For the second year in a row, Sandbag and Agora Energiewende have joined forces to present the state of the energy transition in the European power sector, to update what happened in 2017. Key topics include renewables growth, conventional power generation, power consumption, and CO_2 emissions. We also make this data available to download in order to enable others to perform up-to-date analysis without needing to reinvent the wheel.

Overall, it is clear that whilst the energy transition in the power sector is generally heading in the right direction, a lot of work remains to ensure its implementation is as effective, cheap, secure and fair as possible.

We hope you will enjoy reading the report!

Kind regards
Patrick Graichen, Director, Agora Energiewende
Dave Jones, Electricity Analyst, Sandbag

Key findings:

1 **New renewables generation sharply increased in 2017, with wind, solar and biomass overtaking coal for the first time.** Since Europe's hydro potential is largely tapped, the increase in renewables comes from wind, solar and biomass generation. They rose by 12% in 2017 to 679 Terawatt hours, putting wind, solar and biomass above coal generation for the first time. This is incredible progress, considering just five years ago, coal generation was more than twice that of wind, solar and biomass.

2 **But renewables growth has become *even more uneven*.** Germany and the UK alone contributed to 56% of the growth in renewables in the past three years. There is also a bias in favor of wind: a massive 19% increase in wind generation took place in 2017, due to good wind conditions and huge investment into wind plants. This is good news since the biomass boom is now over, but bad news in that solar was responsible for just 14% of the renewables growth in 2014 to 2017.

3 **Electricity consumption rose by 0.7% in 2017, marking a third consecutive year of increases.** With Europe's economy being on a growth path again, power demand is rising as well. This suggests Europe's efficiency efforts are not sufficient and hence the EU's efficiency policy needs further strengthening.

4 **CO_2 emissions in the power sector were unchanged in 2017, and rose economy-wide.** Low hydro and nuclear generation coupled with increasing demand led to increasing fossil generation. So despite the large rise in wind generation, we estimate power sector CO_2 emissions remained unchanged at 1019 million tonnes. However, overall stationary emissions in the EU emissions trading sectors rose slightly from 1750 to 1755 million tonnes because of stronger industrial production especially in rising steel production. Together with additional increases in non-ETS gas and oil demand, we estimate overall EU greenhouse gas emissions rose by around 1% in 2017.

5 **Western Europe is phasing out coal, but Eastern Europe is sticking to it.** Three more Member States announced coal phase-outs in 2017 - Netherlands, Italy and Portugal. They join France and the UK in committing to phase-out coal, while Eastern European countries are sticking to coal. The debate in Germany, Europe's largest coal and lignite consumer, is ongoing and will only be decided in 2019.

Contents

1 Summary changes in 2017

1.1 Introduction to the data

This report uses the latest electricity data to the end of 2017, and is available to download for free (click to download the Excel sheet). The data is split into generation sources for each of the EU's 28 countries.

- Data for years 2000 to 2015 are aggregated from EUROSTAT.
- Data for 2016 and 2017 are estimated by us from a combination of sources, including ENTSO-E monthly data, ENTSO-E hourly data, and transmission system operator (TSO) data.

Further details on the methodology can be found in the Annex, including an assessment of the accuracy of last year's estimates.

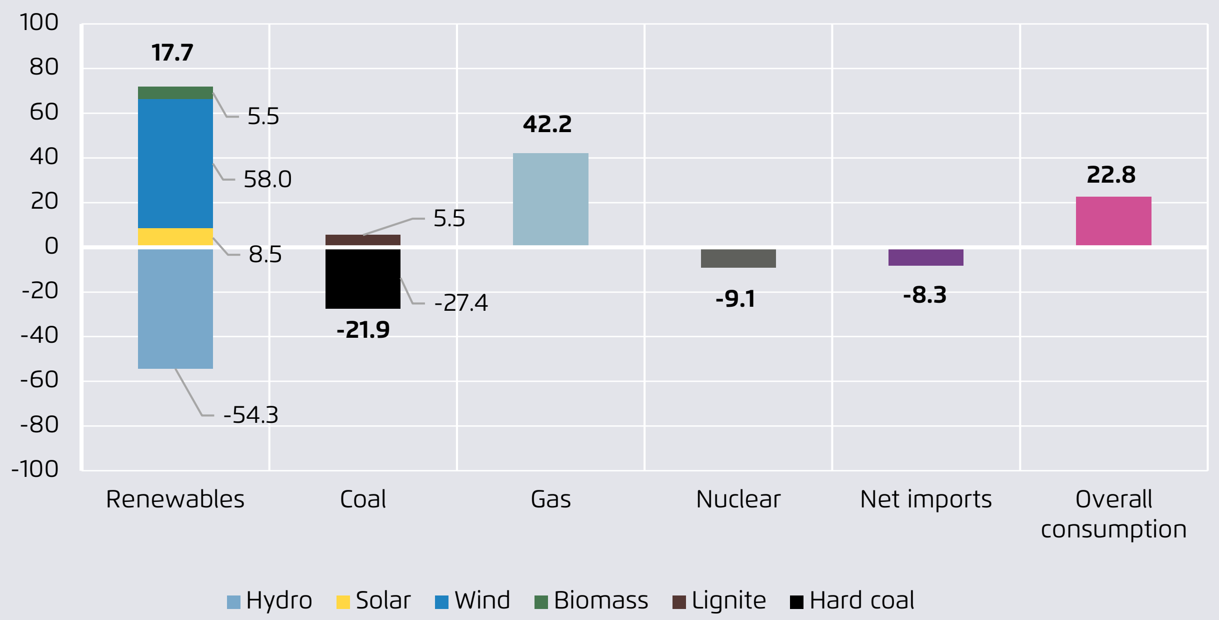
1.2 Key changes to the electricity mix in 2017

Figures 1, 2 and 3 below show the changes to the European fuel mix in 2017. Here, we briefly list a number of key changes that happened in Europe's electricity mix in 2017. All of these themes are explored in much more detail in the following chapters.

- **Electricity consumption** rose by 0.7% (+23 Terawatt hours), the third consecutive year of increases, raising questions over progress in energy efficiency.
- **Net electricity imports** into the EU fell slightly by 8 Terawatt hours, as Serbia, Bosnia, Macedonia and Albania all exported less electricity to EU countries.
- **Wind generation** increased by a massive 19% (+58 Terawatt hours). Two-thirds of this was in Germany and the UK.
- **Solar generation** rose by 8% (+9 Terawatt hours), which was only 1/6th of the rise in wind generation, despite huge recent price falls.
- **Biomass generation** rose only 3% (+5 Terawatt hours), providing some reassurance that biomass growth is in check.
- **Hydro generation** fell by 16% (-54 Terawatt hours) to the lowest level this century. All hydro regions in Europe experienced very low rainfall in various months throughout 2017.
- **Nuclear generation** fell 1% (-9 Terawatt hours), as safety authorities shut down several power plants in Germany and France. France had the lowest nuclear power production this century.
- **Gas generation** rose by 7% (+42 Terawatt hours), mostly due to the temporary need to fill the hydro deficit in Spain, Portugal, Italy and France.
- **Hard coal generation** fell 7% (-27 Terawatt hours), mostly displaced by more wind, especially in Germany and the UK.
- **Lignite generation**, however, actually increased by 2% (6 Terawatt hours), especially in South-East Europe.
- **Overall fossil generation** rose by 1.6% (+23 Terawatt hours), as gas generation rose faster than coal fell.
- **CO_2 emissions** for the EU power sector, we forecast, will be exactly unchanged at 1019 million tonnes, but overall EU ETS emissions are estimated to rise slightly.

Changes in electricity production and consumption, from 2016 to 2017

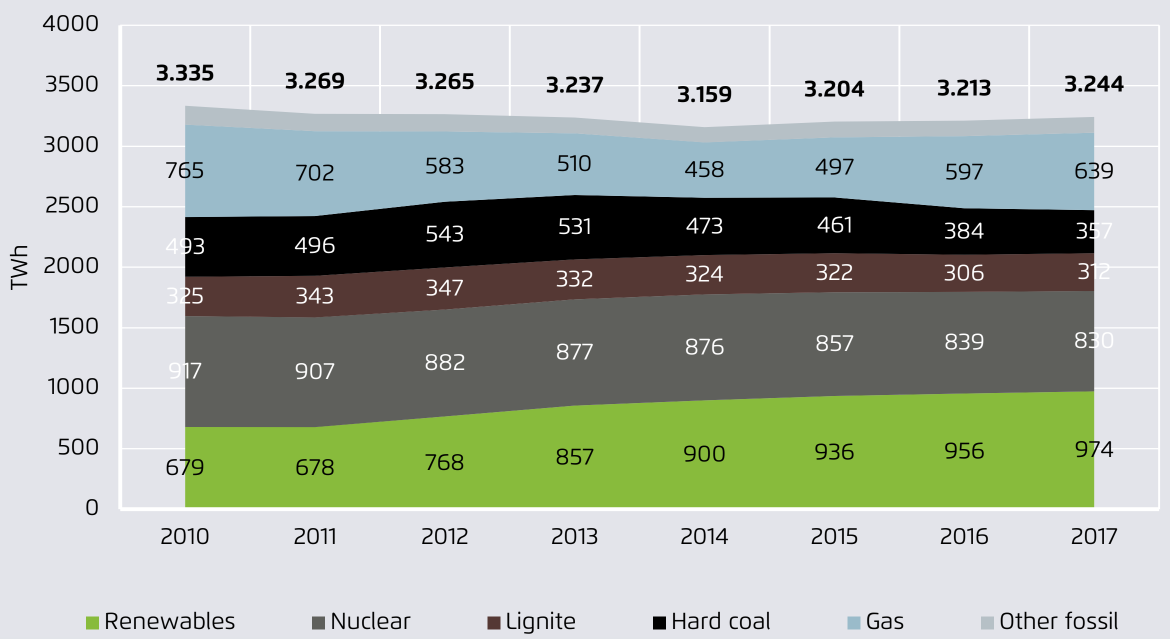
Figure 1



EUROSTAT data to 2015, 2016 and 2017 are own calculations

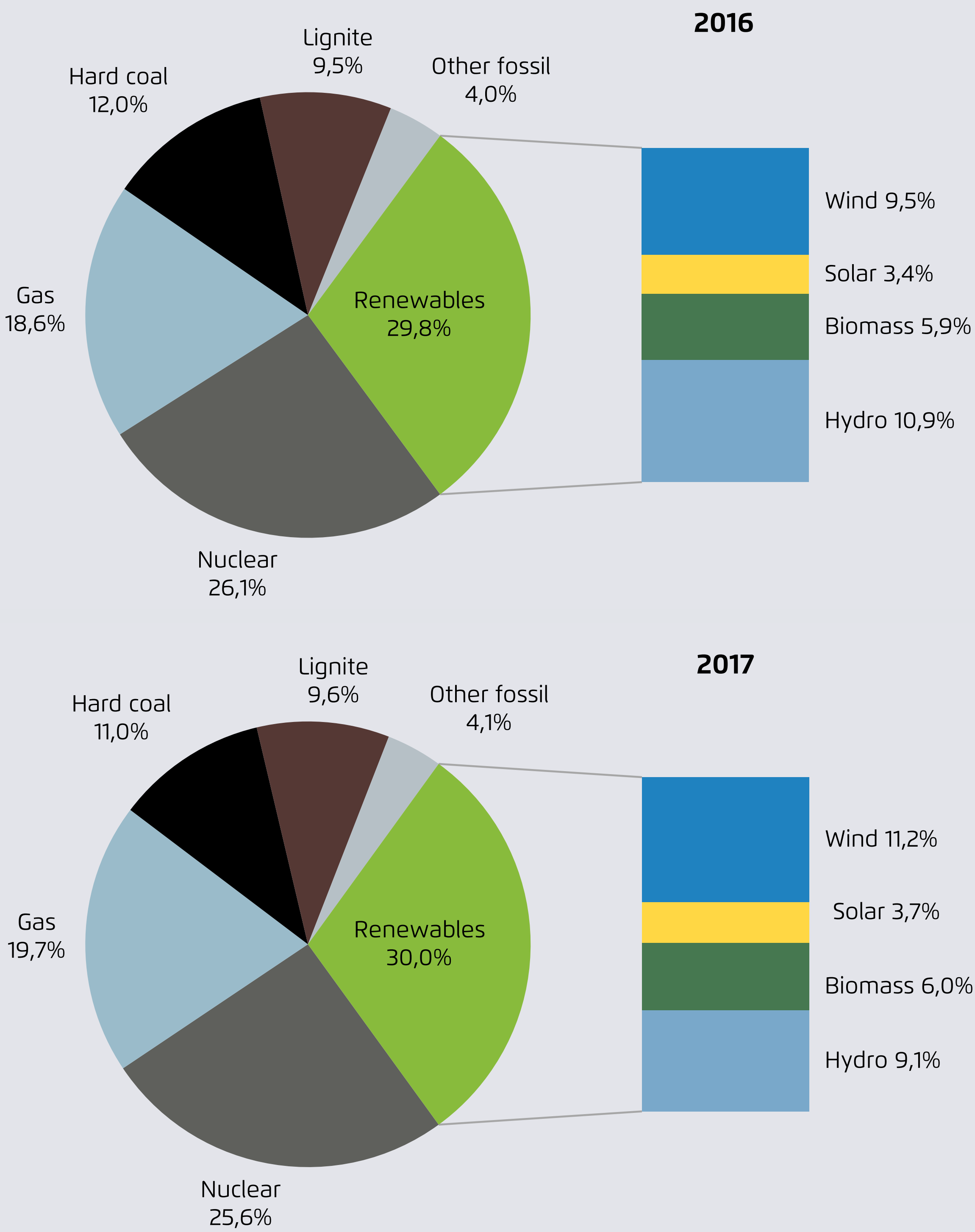
EU electricity generation, by fuel type

Figure 2



EUROSTAT data to 2015, 2016 and 2017 are own calculations

Generation mix in 2016 and 2017 — Figure 3



EUROSTAT data to 2015, 2016 and 2017 are own calculations

2 Electricity Consumption

Electricity consumption increased by 0.7% (23 Terawatt hours) in 2017, the third year in a row that overall European electricity consumption has increased. Electricity consumption rose in every country in 2017, we estimate, except in the UK. While from 2010-2014 there was a downward trend in power consumption, it is now almost back to 2010 levels. In the same time period, Europe's GDP rose and is now 10% above 2010 levels (see figure 4).

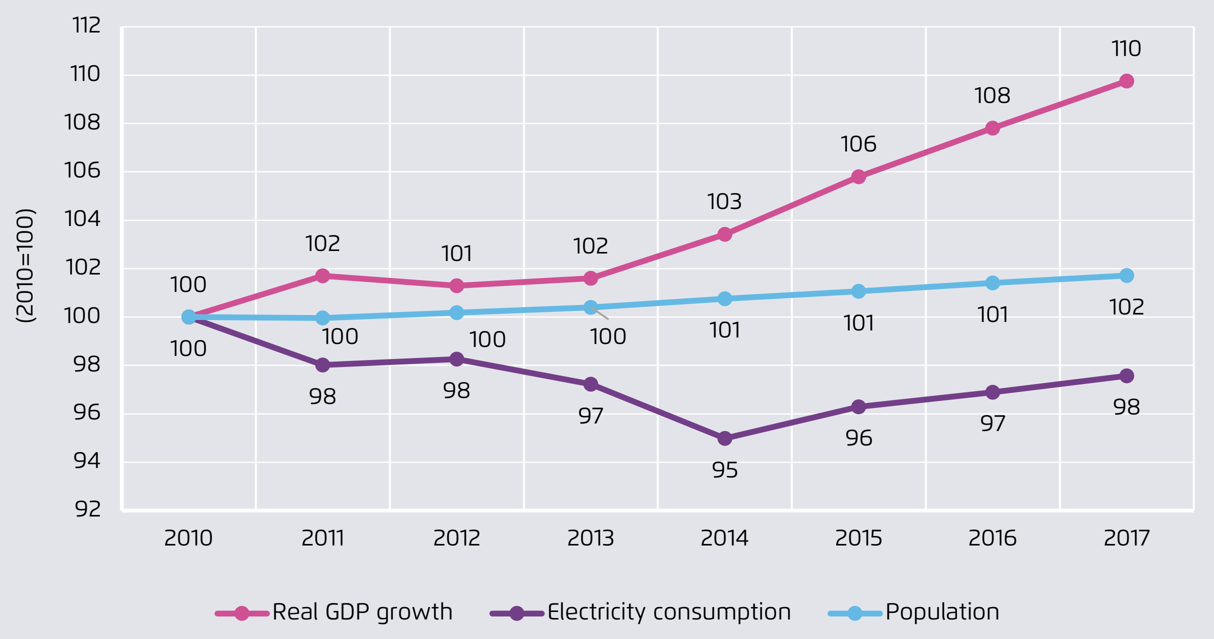
There are four reasons to explain rising electricity consumption:

First, and most importantly, **progress in energy efficiency seems to be insufficient to keep track with Europe's economy recovering**. Europe's GDP is growing at about 2% per year in the past three years – and power demand at about 1% per year. With GDP growth being about double the size of power demand growth, this suggests that energy efficiency is rising, but not enough to meet the European Union's overall efficiency targets.

Second, **industrial production rose faster than GDP**, meaning economic growth was more energy-intensive than normal. The EUROSTAT industrial production index for November 2017 is 4% higher than for November 2016 (Eurostat 2018). Especially industrial production in the struggling South Eastern European economies is regaining its pre-crisis level of output. EU steel production rose by a hefty 5% from Jan–Nov 2017, mostly in Germany, Italy and the Czech Republic (World Steel Association 2017).

Third, the **population of Europe is rising**, not least due to increased immigration in 2016 and 2017. The EU

EU electricity consumption (indexed) Figure 4



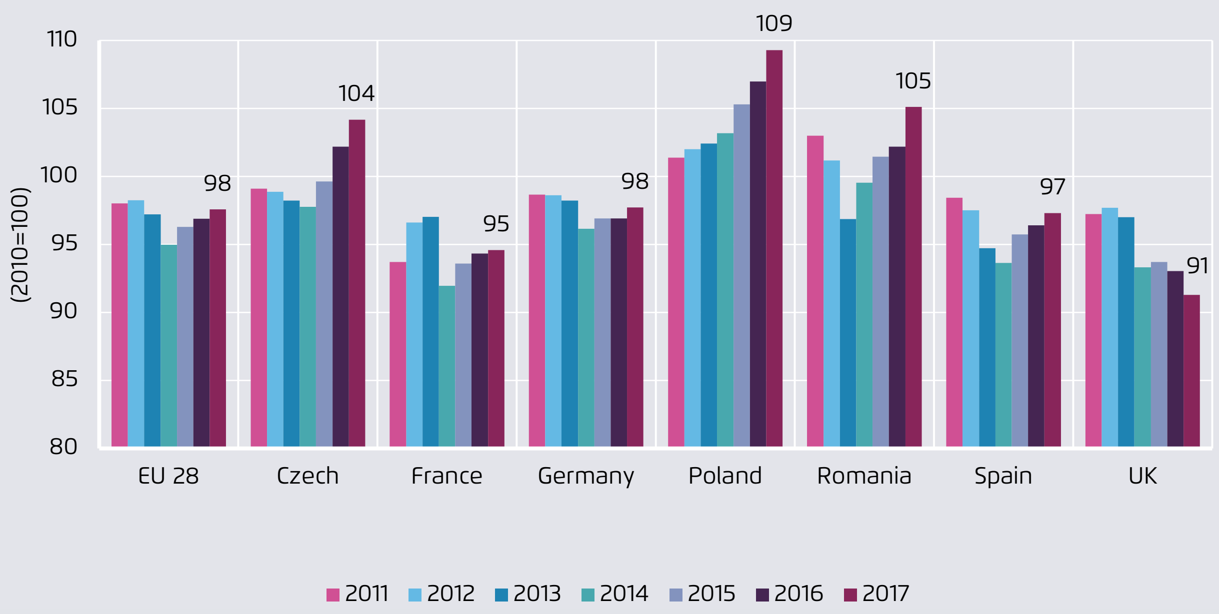
EUROSTAT 2018

population has increased by more than 3 million people over the last two years (Eurostat 2018). Although many of the EU's new inhabitants are unlikely to be large users of electricity, they of course also use electricity directly and indirectly.

And fourth, while still minimal at this stage, we are seeing the beginning of **additional power demand from new sectors**. The digital revolution means using more electricity, for example through the meteoric growth of video streaming and the increase in Bitcoin mining, as more and bigger server farms are commissioned. Additionally, the electric vehicle market is now kicking off, with electric and plug-in vehicles amounting to some 800,000 vehicles by the end of 2017. All of this does not add much to power demand in 2017, but could indicate the beginning of something big taking off.

Figure 5 shows the development of electricity consumption since 2010 of countries which showed the biggest changes. The differences over 7 years are big, but not great. The country with the biggest fall is the UK, with a 9% fall over 7 years. The country with the biggest rise is Poland, with a 9% rise over 7 years.

Electricity consumption by country (indexed) Figure 5



EUROSTAT data to 2015, 2016 and 2017 are own calculations

3 Renewables

3.1 Overall renewables growth

In 2017, renewables generated 30% of Europe's electricity for the first time. It was a rise of only 0.2% points – from 29.8% in 2016 to 30.0% in 2017 of electricity production (see figure 6). This was because the huge growth in wind generation was almost completely offset by the lowest hydro electricity generation in a decade (see chapter 3.5).

Wind, solar and biomass grew to 20.9% of the EU electricity mix. This is up from just 9.7% in 2010, and represents an average growth of 1.7 percentage points per year. If this rate continued, then it is just sufficient for total renewables to hit 50% of the EU electricity mix by 2030 (see figure 7). This is considered what is needed to hit the EU's current 2030 renewable target of a 27% share in final energy demand.

Given this, it is easy to envisage how the renewables deployment could be sped up to achieve the 35% renewable target that is currently under negotiation.

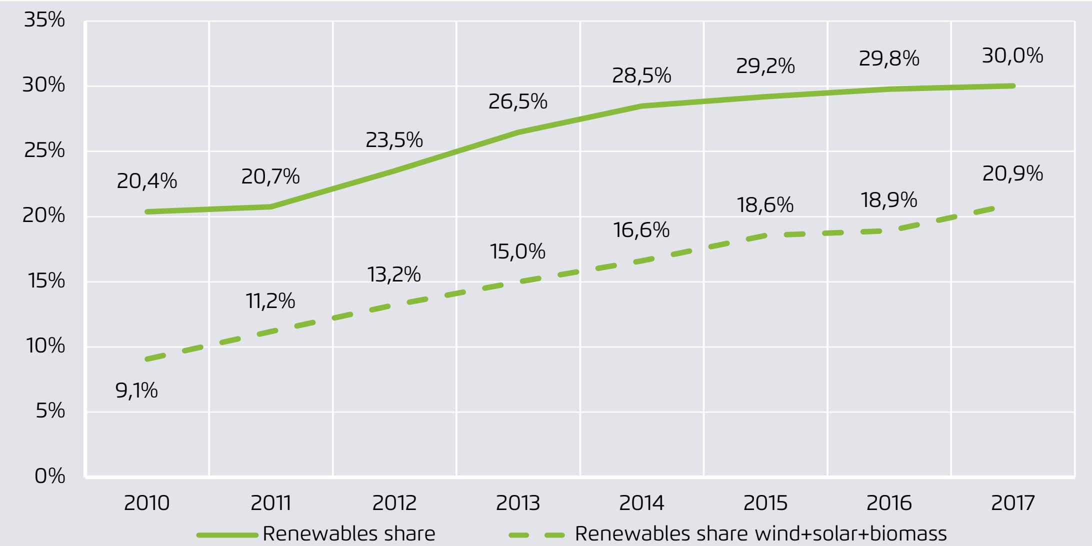
2017 saw a massive growth in wind power generation (see figure 8), driven by onshore and offshore capacity additions, and an above average wind yield in the fourth quarter in 2017. Wind generation grew by a massive 58 Terawatt hours, solar grew by 9 Terawatt hours and biomass grew by only 5 Terawatt hours.

That led to **wind, solar and biomass generation surpassing coal generation for the first time** (see figure 9). This is incredible progress, considering just five years ago, coal generation was more than twice that of wind, solar and biomass.

The increase in renewables has been approximately steady – with almost exactly the same growth from 2011 to 2014 (159 Terawatt hours), as from 2014 to 2017 (155 Terawatt hours). However, **renewables growth has become more concentrated – geographically and by technology**.

Geographically, the majority of that growth was in Germany and the UK alone (see figure 10). The

Renewables share as percentage of gross electricity production — Figure 6



EUROSTAT data to 2015, 2016 and 2017 are own calculations

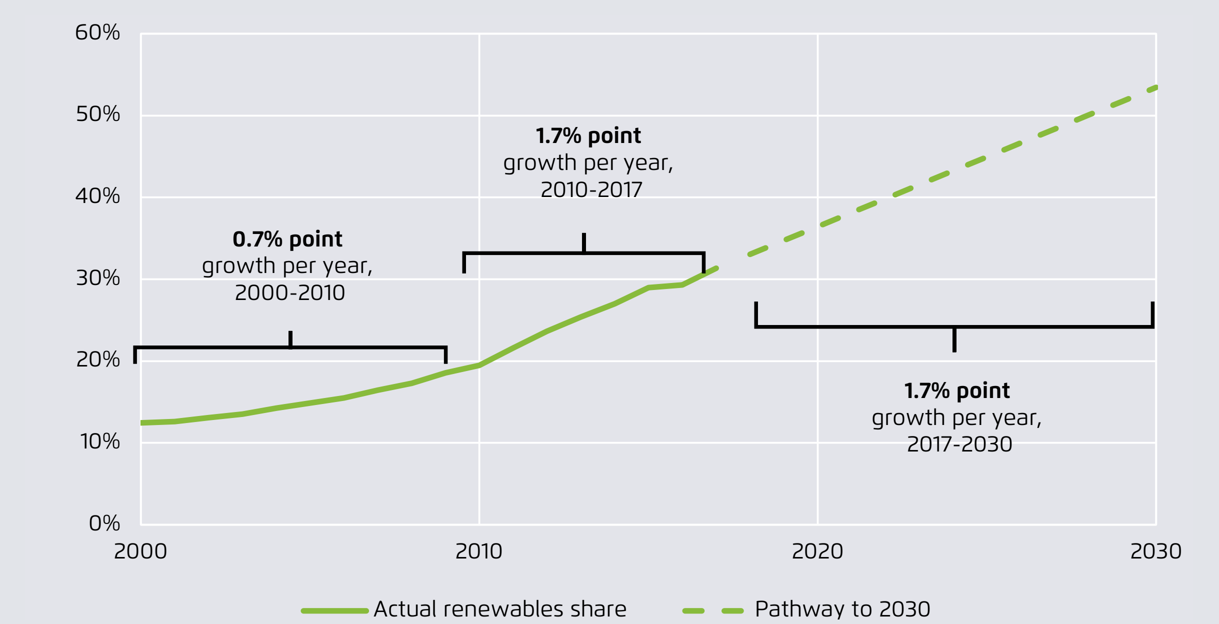
remaining 26 EU countries had 58% of the renewables growth from 2011 to 2014, but only 43% of the growth from 2014 to 2017. To some extent this may reflect the fact that some Member States have already reached their national 2020 targets under the EU Renewable Energy Directive (BG, CZ, DK, EE, FI, HR, IT, LT, SE, RO) (EU Commission RES Progress Report 2017). It is, however, also a reflection of unnecessarily high financing costs, particularly in Central and South-Eastern Europe, standing in the way of translating the dramatic decline in renewable energy technology costs into truly low cost renewable energy projects (DiaCore 2016; PriceTag 2017).

Technologically, the growth has gotten much more concentrated towards wind (see figure 11). Wind had 46% of the EU renewables growth from 2011 to 2014, but this increased to 72% of the growth from 2014 to 2017. Given the sustainability problems, it is welcome that the biomass boom is over in Europe, with just 15% of additional renewable electricity generation coming from biomass since 2014. However, it is disappointing that solar generation is still lagging so substantially.

Figure 12 shows how wind, solar and biomass has increased in every EU country in the last 7 years. In 2017, Denmark is the leader with the biggest rise and the highest penetration: wind+solar+biomass rose 7 percentage points from 67% to an incredible 74% of total electricity production. Of Denmark's 2017 rise, three quarters was from wind. In the last 7 years, wind+solar+biomass increased its share of electricity production in every country, but at very different rates. Since 2010, the countries with the biggest increase in penetration were Denmark (up 42 percentage points, to 74% in 2017), the UK (+22 to 28%), then Germany (+17 to 30%).

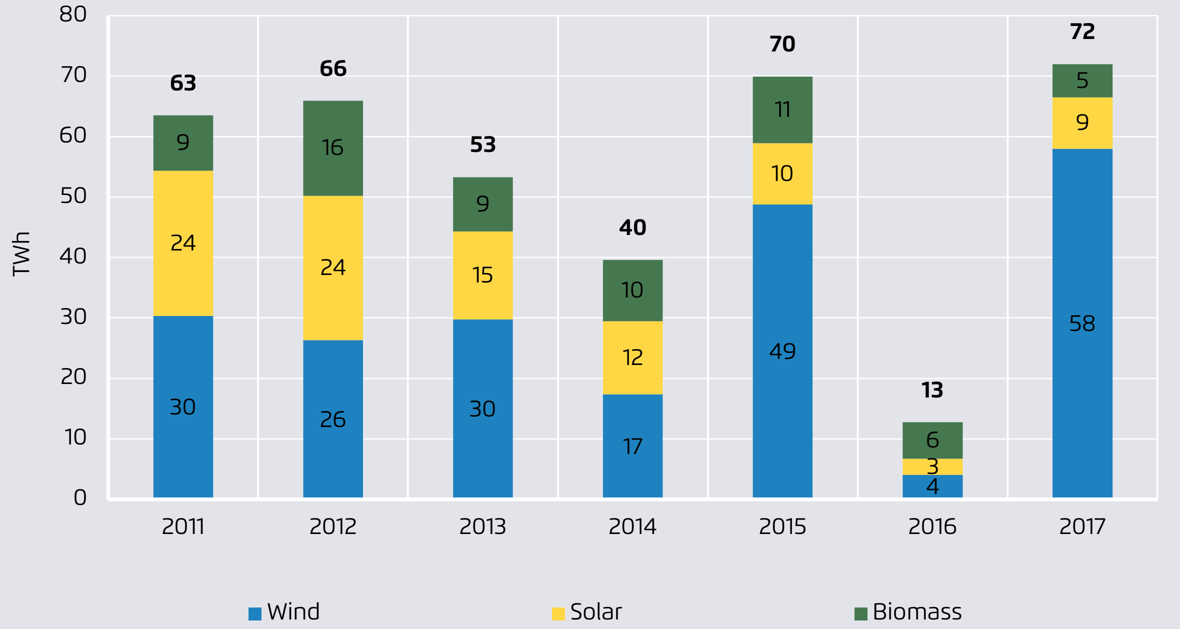
However, many countries did very little. Many countries had anaemic renewables growth throughout this decade like Slovenia, Bulgaria, France, Slovakia, the Czech Republic and Hungary; other countries had good growth at the start of the decade, but then gave up on renewables with almost no growth in the last three years, like Spain, Italy, Portugal, Belgium and Greece. There are six countries that still have <10% of their electricity production from wind+solar+bio-

Renewables share as percentage of gross electricity production: the trend to 2050 — Figure 7



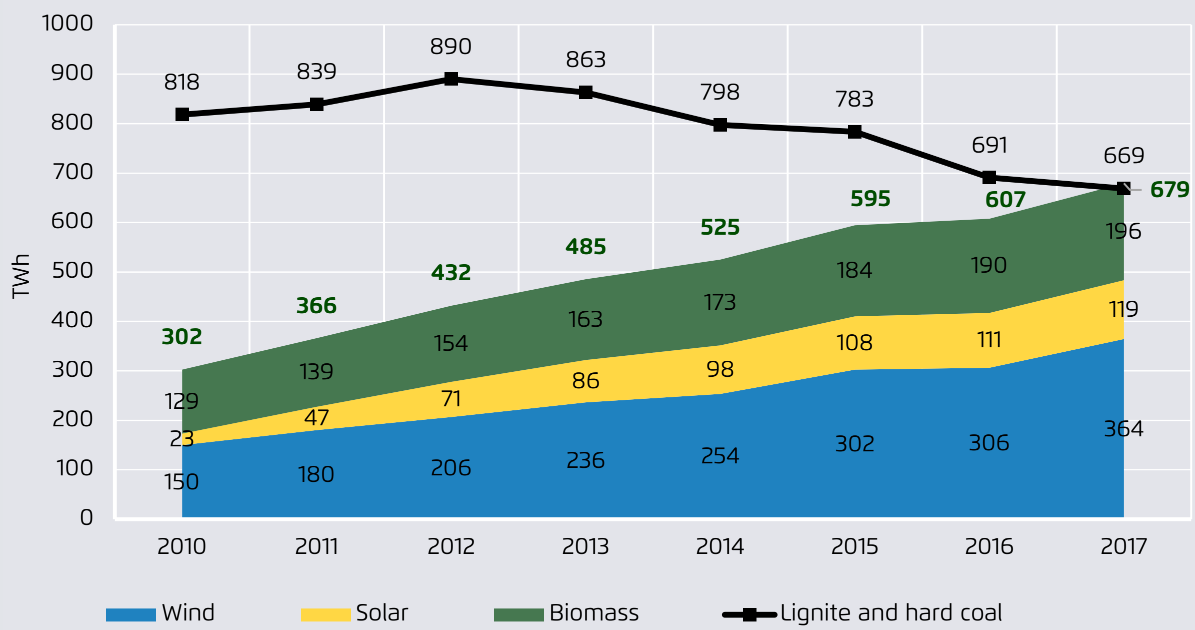
EUROSTAT data to 2015, 2016 and 2017 are own calculations, normalised hydro

Changes in renewable electricity generation — Figure 8



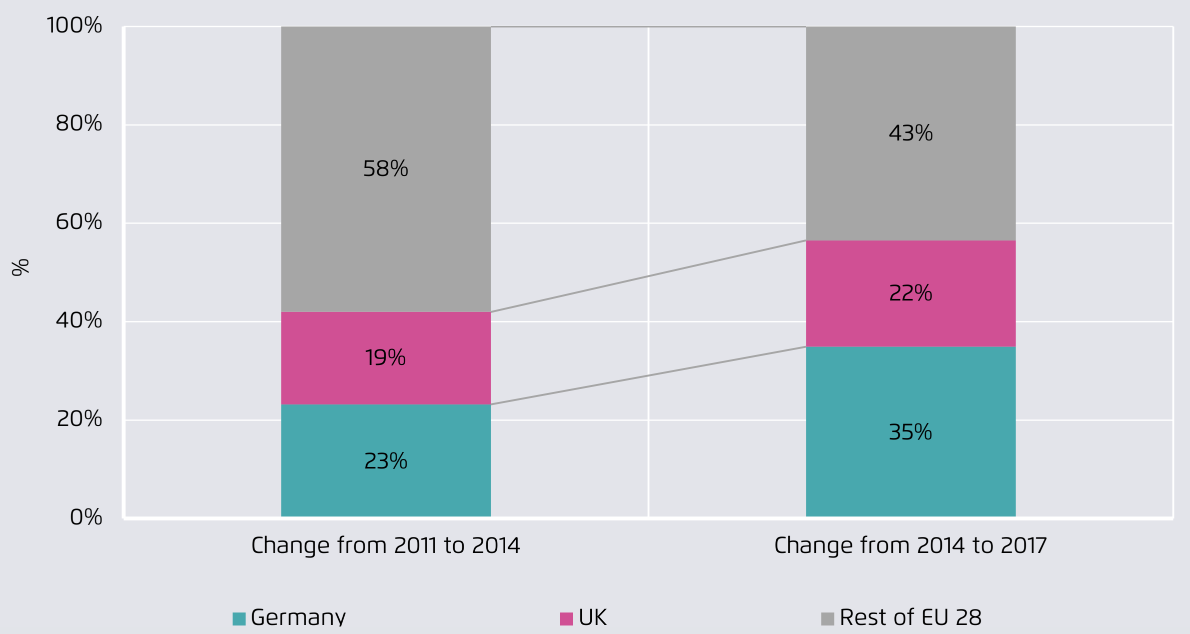
EUROSTAT data to 2015, 2016 and 2017 are own calculations

Renewables versus coal electricity generation — Figure 9



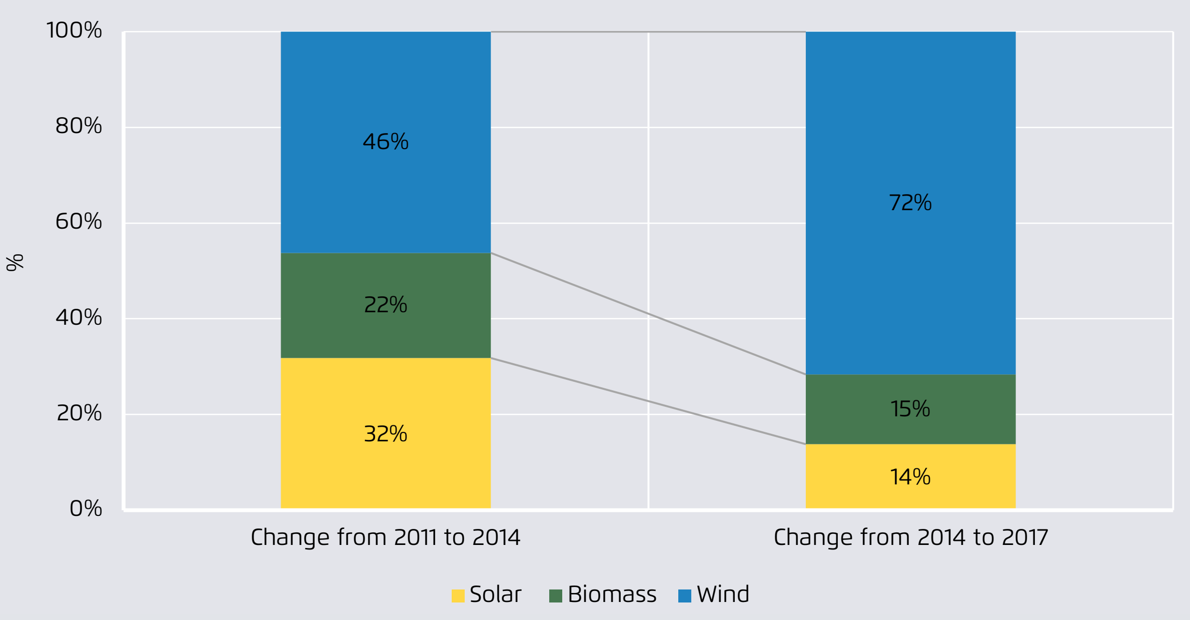
EUROSTAT data to 2015, 2016 and 2017 are own calculations

Changes in non-hydro renewables generation by country — Figure 10



EUROSTAT data to 2015, 2016 and 2017 are own calculations

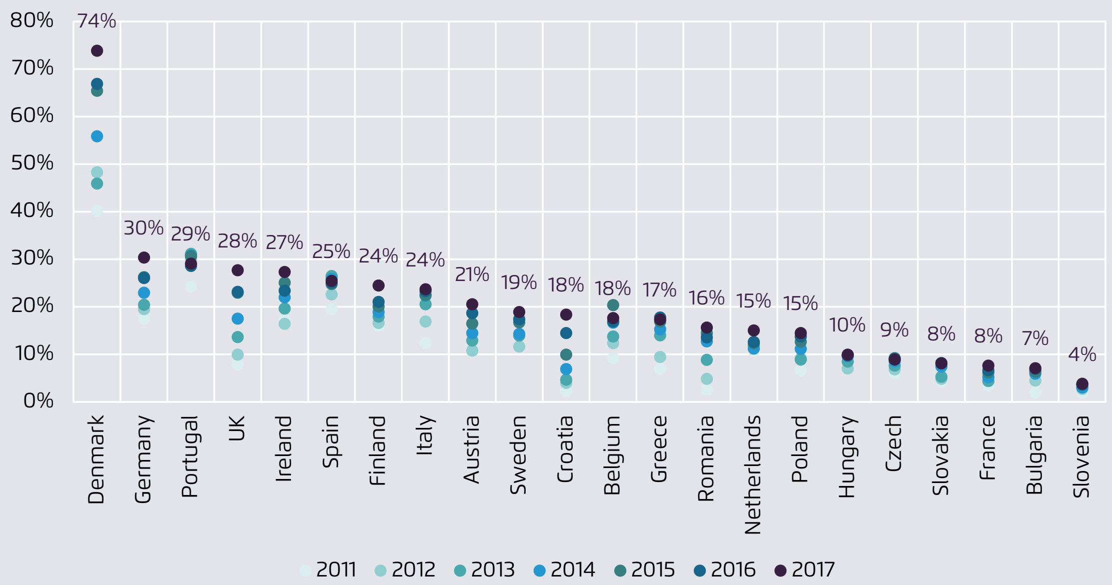
Changes in non-hydro renewables generation by type — Figure 11



EUROSTAT data to 2015, 2016 and 2017 are own calculations

Wind, solar and biomass as percentage of national electricity production

Figure 12



EUROSTAT data to 2015, 2016 and 2017 are own calculations; LT, LU, CY, EE, LV, M not included due to lower data quality

mass in 2017: these were Slovenia (4%), Bulgaria (7%), France (8%), Slovakia (8%), Czech Republic (8%) and Hungary (10%).

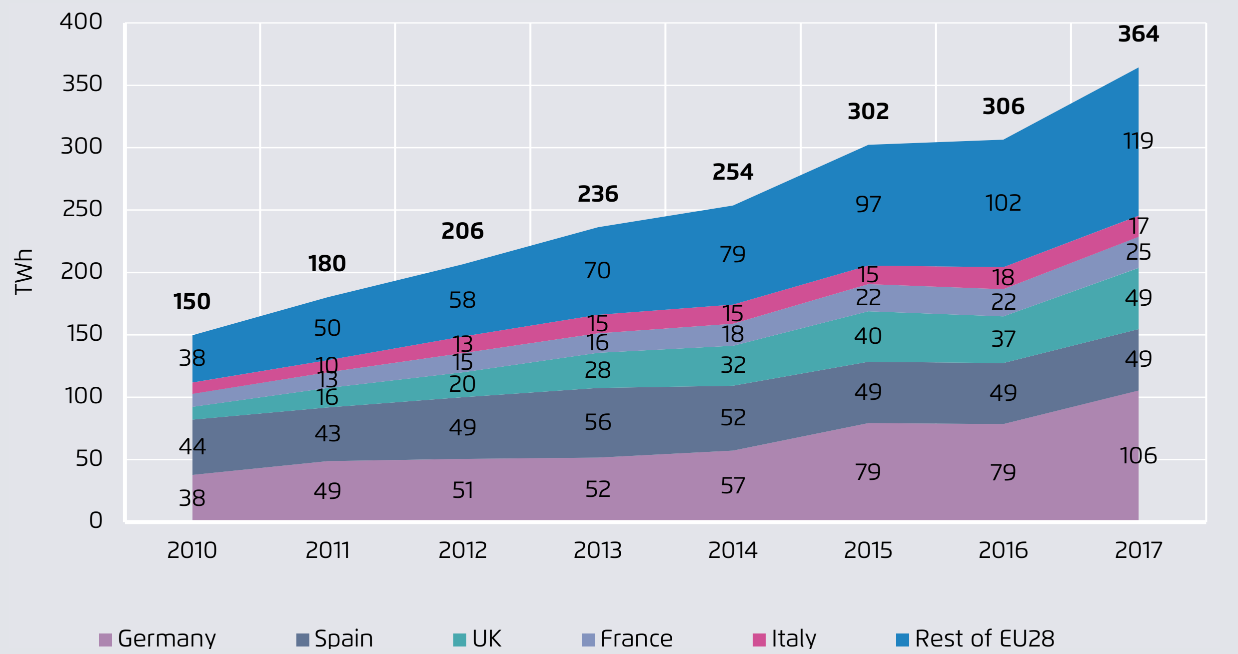
According to BNEF, fewer Euros were invested in renewables in 2017 - mostly caused by the fall in the cost of renewables, rather than the speed of deployment. Europe as a whole invested 57.4 billion dollars in clean energy technologies, which amounts to a 26%-decrease compared with 2016. While UK and German investments declined, Spain, Sweden, and the Netherlands realised the highest increases. Meanwhile, clean energy investment activity intensified in China (up 24%), the U.S (up 1%), Australia (up 150% due to large wind and solar projects), and Mexico (up 516%) (BNEF 2018).

3.2 A favourable year for wind

Wind generation overtakes hard coal generation for the first time. Wind generation increased by a massive 19% from 306 to 364 Terawatt hours in 2017 (see figure 13). This followed a poor wind year in 2016 and huge investments into onshore and offshore wind plants in 2017. In countries with the highest increases in wind electricity generation, namely Germany, the UK and the Netherlands, hard coal-based generation simultaneously fell, leading to falls in CO_2 emissions.

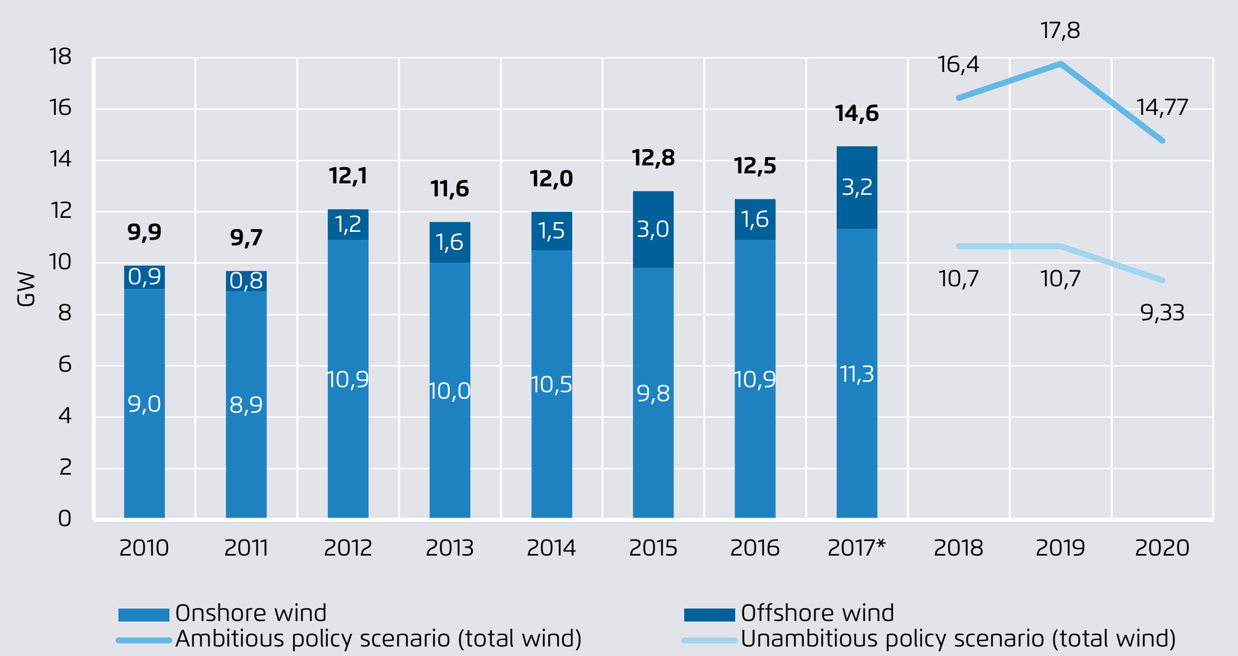
Installation rate: WindEurope estimated that 14 Gigawatt would be installed in 2017 (see figure 14) resulting in roughly 168 Gigawatt of cumulative capacity in Europe (WindEurope 2017). If their estimate is true, it would set a record not only for offshore wind deployment, but surprisingly also for onshore wind deployment. As mentioned above, this growth is very skewed towards Germany and the UK. New capacity will be scaled up in France, Spain and the Netherlands, which is good news, but far from an even transition. For instance, Germany added more than one Gigawatt offshore and more than 5 Gigawatt onshore capacity. As Wind Europe reported, 15 countries in the European Union experienced no capacity additions in the first half of 2017, while only 5 countries surpassed the mark of 100 MW.

Wind electricity generation (including split of top 5 countries) Figure 13



EUROSTAT data to 2015, 2016 and 2017 are own calculations

Annual wind installations Figure 14



WindEurope 2017, Wind energy in Europe: Outlook to 2020, *latest forecast

Wind auction prices — Table 1

Technology	Auction	Quarter	Year of Construction	Latest Realisation	Capacity Auctioned	Result in € ct/kWh, £ p/kWh (average, weighted clearing price)
Offshore	Borssele I & II (NL)	Q3 2016	2019	Q3 2021	760MW	7.27 (15 yrs) / 8.77* (incl. grid)
	Danish Near Shore (DK)	Q3 2016	2019	2020	350 MW	6.4 (17.5 TWh) / 7.3* (incl. grid)
	Kriegers Flak (DK)	Q4 2016	2019-2020	2021	600 MW	4.99 (30 TWh) / 6.49* (incl. grid)
	Borssele III & IV (NL)	Q4 2016	2020	Q4 2021	740 MW	5.45 (15 yrs) / 6.95* (incl. grid)
	German Offshore	Q2 2017	2024	Q4 2025	1,390 MW	0.44 (20 yrs, excluding grid)
	UK Offshore	Q3 2017	2021-2022	2021-2022	860 MW	7.48* (incl. grid)
		Q3 2017	2022-23	2022-2023	2,336 MW	5.75* (incl. grid)
Onshore	German Onshore I	Q2 2017	2018-2021	Q4 2019 - Q4 2021	807 MW	5.71 (20 yrs)
	German Onshore II	Q3 2017	2019-2022	Q1 2020 - Q1 2022	1,013 MW	4.28 (20 yrs)
	German Onshore III	Q4 2017	2020-2022	Q2 2020 - Q2 2022	1,000 MW	3.82 (20 yrs)
	Spain 2017 I	Q2 2017	2019	Q4 2019	2,979 MW	4.3 (20 yrs)
	Spain 2017 II	Q3 2017	2019	Q4 2019	1,128 MW	3.3 (20 yrs)

COM 2016, EU Reference Scenario 2016, BNetzA 2016,2017, Danish ENergy Agency 2016, WindEurope 2017, 4offshore 2017
*Based on NERA Consulting 2016, IEA-RETD 2017: €0.15 added to tariff to account for development and grid connection costs. €0.09 applied to Danish Near Shore due to lesser distance from shore.

Latest prices: Wind auction prices fell substantially from 2016 to 2017 (see Table 1). Onshore auction prices reached unexpectedly low levels of 3.8 Euro cents/Kilowatt hour in Germany, and an equivalent of 3.3 Euro cents/Kilowatt hour in Spain - at or below forward wholesale electricity prices. Offshore wind generation officially became unsubsidised as ENBW and Dong both submitted successful bids to build without any subsidy, selling only at wholesale electricity price (NB: estimated project costs are around 5-6 Cent/kWh and do not include grid connection costs; projects are to be built only by 2025). Spain auctioned around 4 Gigawatt of onshore wind, while with 3 Gigawatt the UK auctioned the biggest amount of offshore wind capacity.

3.3 Solar needs a kick

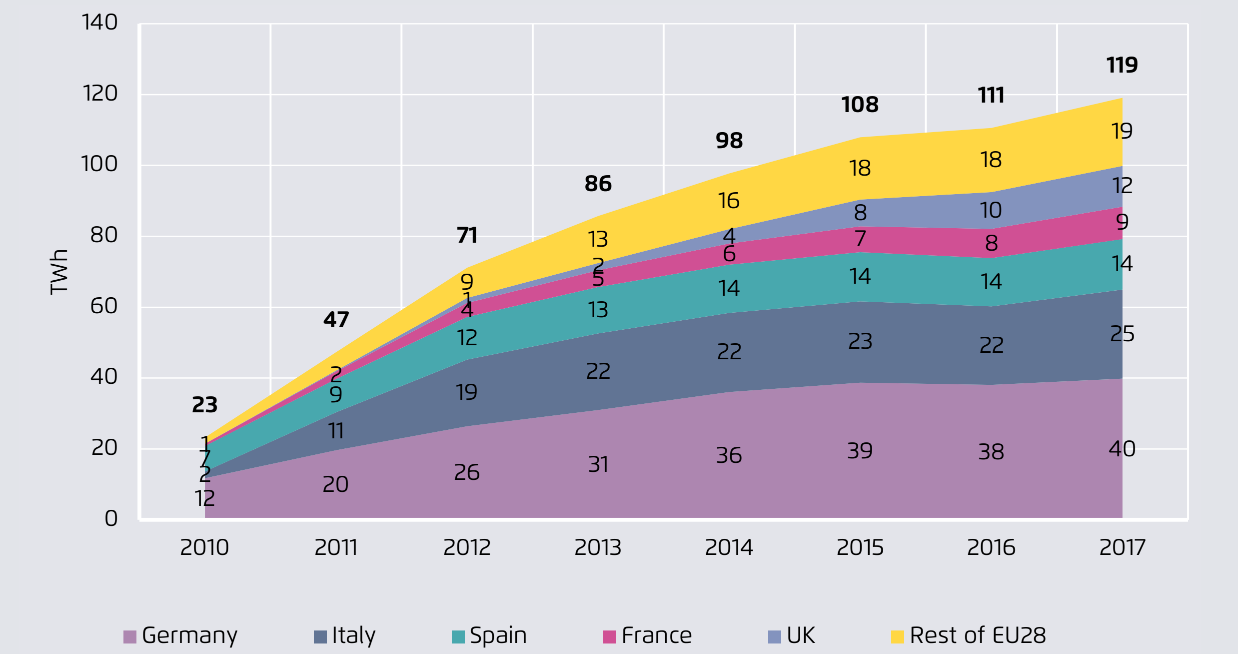
Where are you, solar? Generation from solar increased by only 8 Terawatt hours in 2017 (see figure 15). The reason is the low rate of new capacity installations.

Installation rate: Only about 9 Gigawatt of solar was installed in the EU in 2017, well-below the 23 Gigawatt peak installed in the EU in 2011 (see figure 16). This is less than 10% of the 100 Gigawatt installed globally, compared to 60% between 2004 and 2012.

The outlook is very uncertain: according to SolarPower Europe, the industry lobby group, the installation rate for 2018 will be somewhere from 7 Gigawatt to 17 Gigawatt, depending on how national governments react to the falling prices (SolarPower Europe 2017).

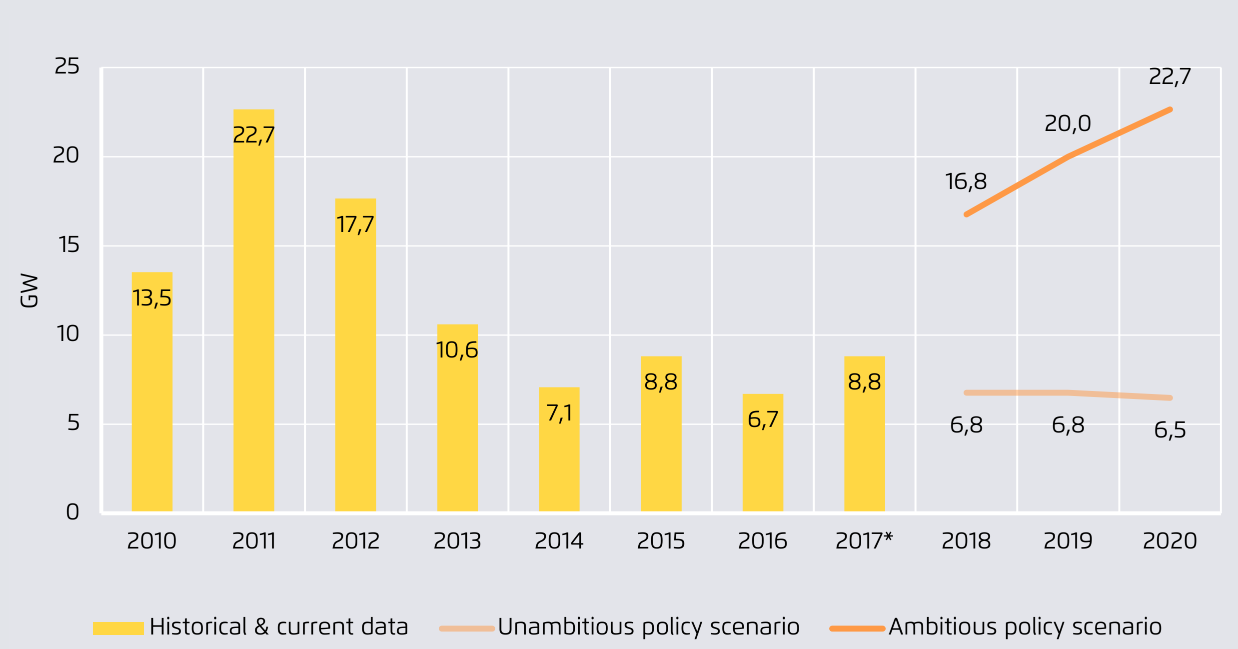
Latest prices: Prices for solar showed dramatic declines again in 2017. For instance, from December 2016 to October 2017, German auction prices fell by about 29% (see figure 17). Spanish auction prices averaged about 3.3 Euro cent per Kilowatt hour. As of January 2018, the average forward electricity prices from 2018 to 2021 were 4.8 Euro cents/Kilowatt hour, for both Spain and Italy. This is 46% above the Spanish solar auction price.

Solar electricity generation (including split of top 5 countries) Figure 15



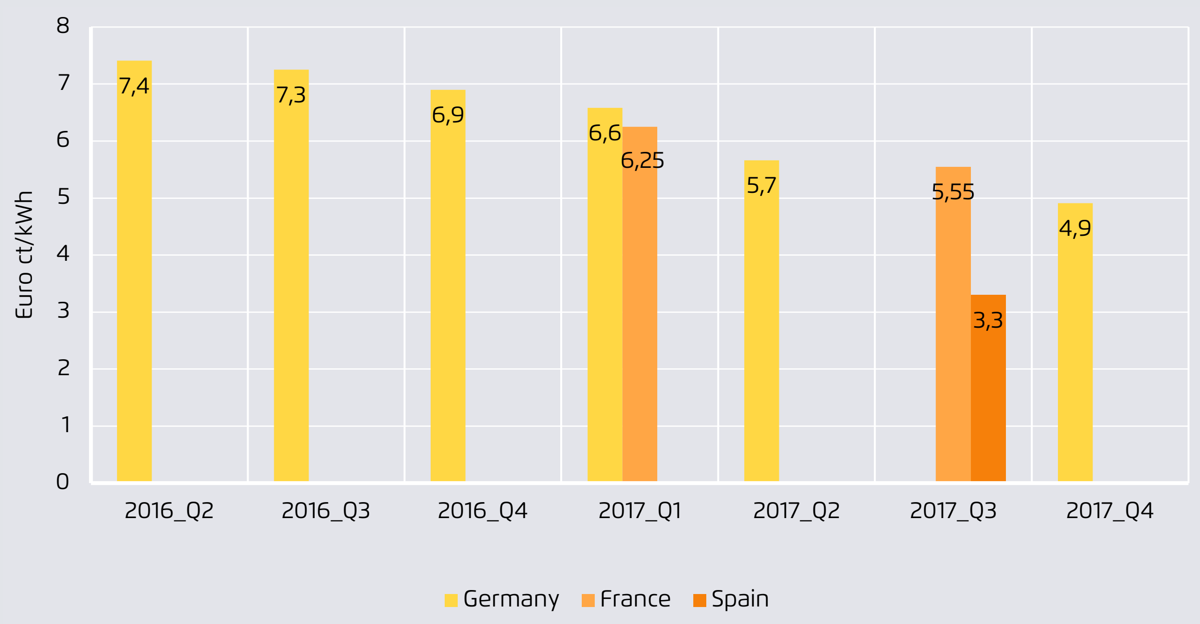
EUROSTAT data to 2015, 2016 and 2017 are own calculations

Annual solar PV installations Figure 16



Solar Power Europe 2017, *latest forecast

Solar PV auction results 2016-2017 (average prices, ground-mounted installations) Figure 17



BNetzA 2016/2017, globalfinance.solarenergyevents.com 2017, pv-tech 2017

With prices like these, it is high time for governments to set the right framework, to allow solar deployment to dramatically accelerate, to lower the cost of electricity for consumers. As well as auctions, another lever to kick-start solar at a broader scale may be a better articulation of rights of *prosumers* (individual households and energy communities) to self-generate, self-consume and feed surplus into the grid. This is being debated as part of the Clean Energy for All Europeans-package (see Section 6).

Given concerns over biomass sourcing - and, so often, the combustion of biomass in old, inefficient large coal plants - the slowdown is perhaps a relief. Co-firing in coal power plants is no longer rising, and the pipeline for planned conversion of coal power plants to run on biomass is quite small (Sandbag 2017).

As biomass growth slows, wind and solar alone will drive future renewable growth. This is another reason to ensure wind and solar deployment accelerates.

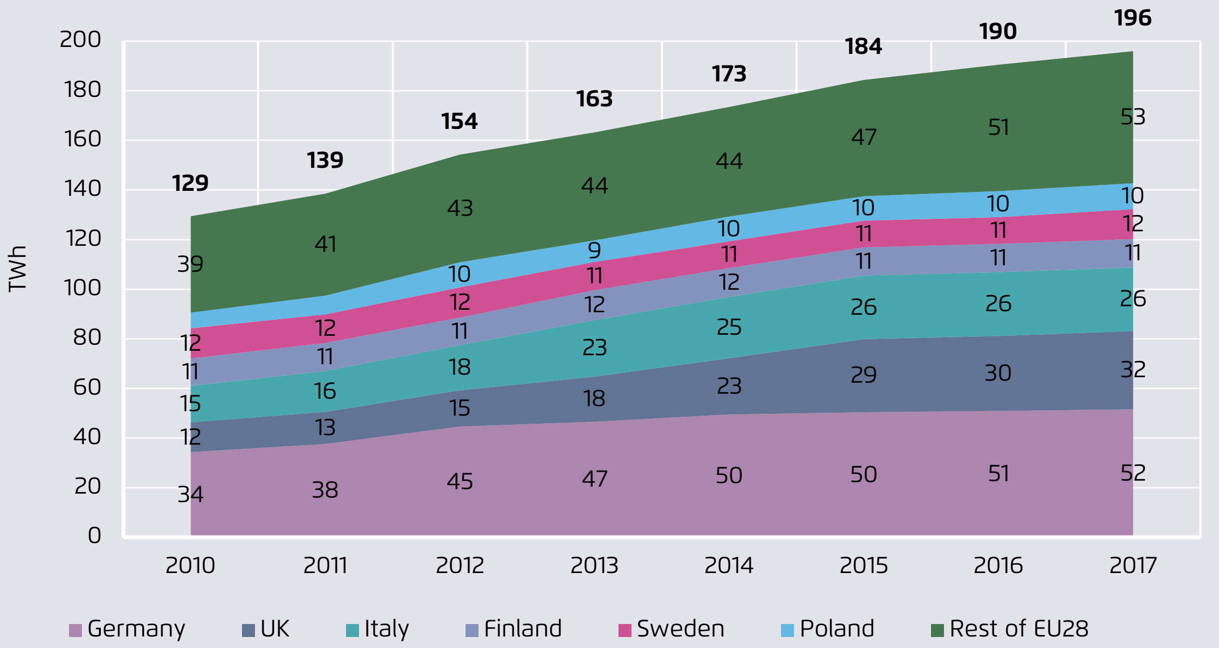
3.4 Biomass growth

The biomass boom is over. Biomass generation grew by only 3% in 2017, the same as in 2016. The growth of 5 Terawatt hours in 2017 is only half the growth observed from 2000-2015 (see figure 18). Half of this biomass growth was in Denmark and the UK; most other countries did not see any growth.

3.5 Hydro had the worst year this century

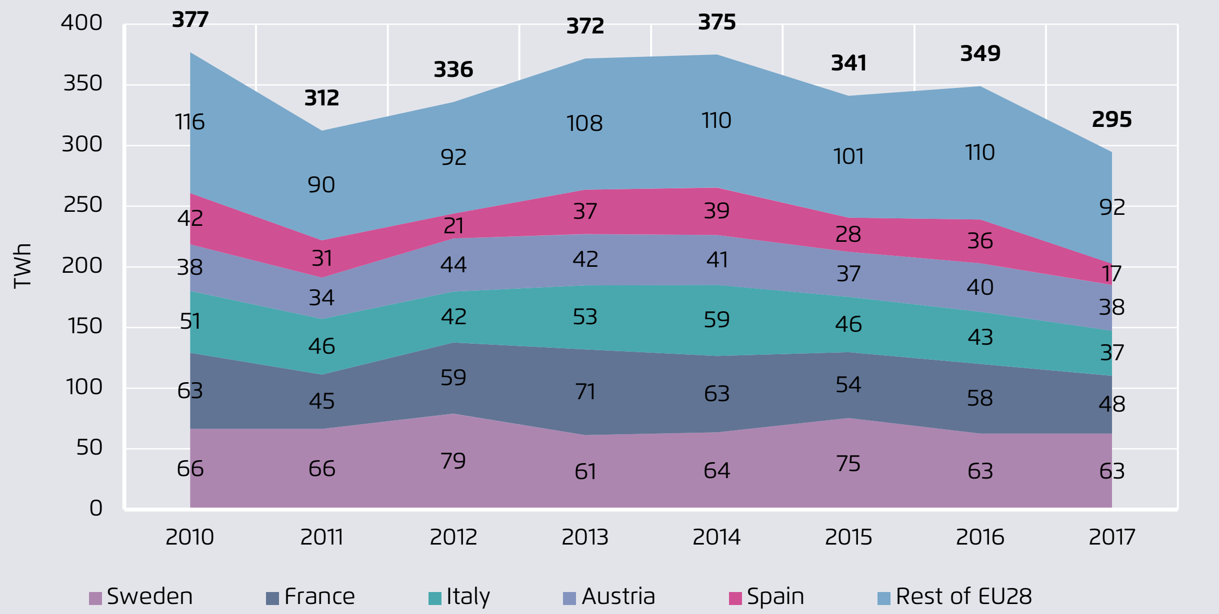
Unfavourable conditions for hydro power. 2017 was a dry year and saw the lowest level of hydro generation this century. Hydro generation fell by 54 Terawatt hours in 2017 (see figure 19). Every region in Europe saw very low levels of hydro generation – from Spain to Romania, from France to Bulgaria.

Biomass electricity generation (including split of top 5 countries) Figure 18



EUROSTAT data to 2015, 2016 and 2017 are own calculations

Hydro electricity generation, non-normalised (including split of top 5 countries) Figure 19



EUROSTAT data to 2015, 2016 and 2017 are own calculations

4 Conventional generation

4.1 Overall developments in conventional power production

In 2017, overall conventional generation rose again slightly and is now back at 2015 levels (see figure 20). The increase in power demand and one-off decline in hydro were the main reasons that overall conventional power production rose again.

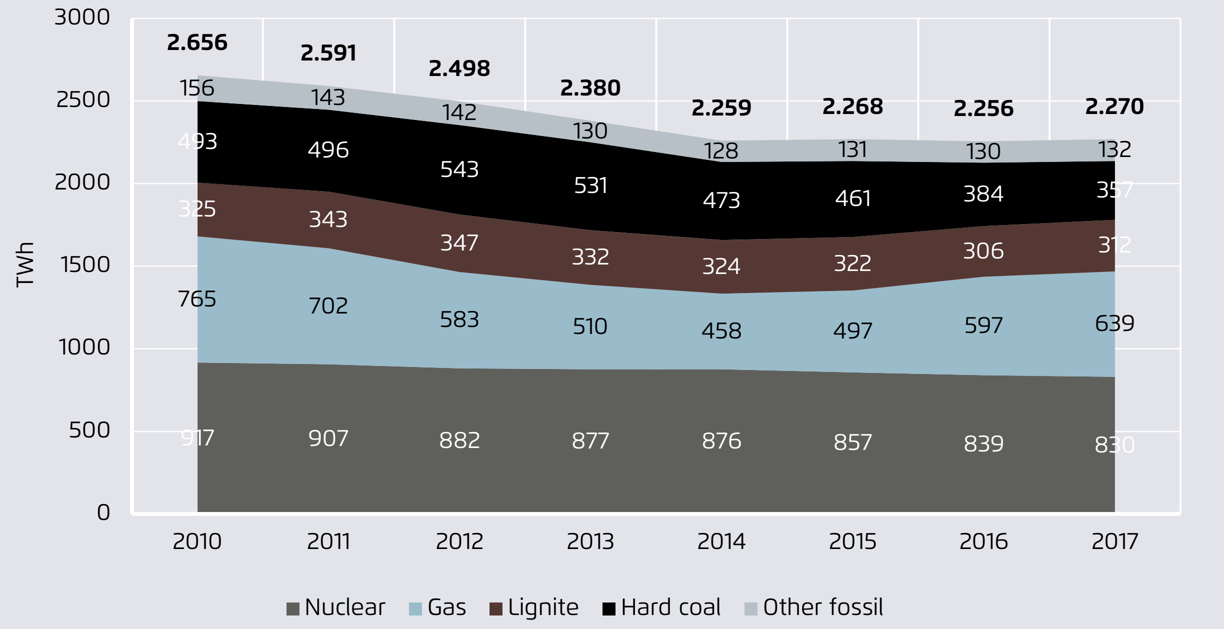
More importantly, 2017 saw rising fossil fuel power production (hard coal, lignite, gas, oil) for the third year in a row. Hence, Europe might enter into a structural problem: If there is a structural rise in electricity consumption and renewables growth stays at current levels, then the future decline in fossil generation will be slower than expected. As a consequence, CO_2 emissions might not fall as needed.

4.2 Phasing out hard coal made progress

Hard coal generation fell by 7% (27 Terawatt hours) in 2017. This follows on a 17% fall in 2016, and means hard coal generation is now 34% lower than high levels back in 2012 (see figure 21). The 2017 fall was due to a surge in wind generation: Germany, the UK, and Netherlands saw their coal generation fall by 29 Terawatt hours, while their wind generation increased by a massive 41 Terawatt hours. At the same time, the poor hydro generation led to higher coal generation in both Spain and Portugal.

The big news in 2017, however, related to **national coal phase-out plans**. Several countries have now committed to phase-out coal generation by 2030 or before (see figure 22). In 2017, the Netherlands committed to retiring all its coal plants by 2030 and to replace

Conventional electricity generation — Figure 20



EUROSTAT data to 2015, 2016 and 2017 are own calculations

them with renewable electricity, despite most of the coal plants currently being only two to three years old. Also in 2017, Italy committed to close its coal plants by 2025; it is however currently unclear if this is a complete move to renewables, or whether it might lead to an increased role for gas. Portugal confirmed it would ensure there is no coal generation by 2030.

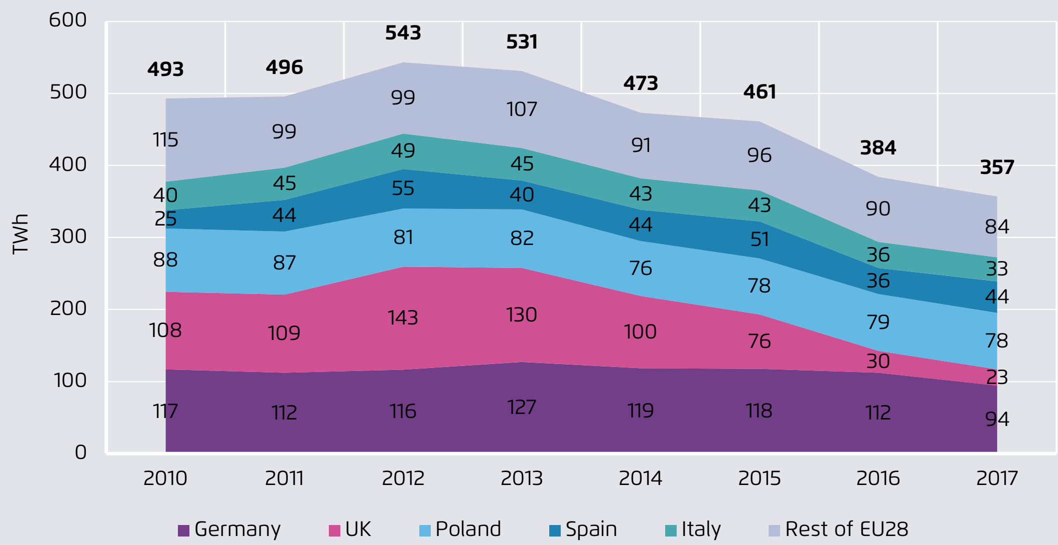
In Germany, the market-based shut down of hard coal generation capacities in 2017 continued. Due to low power market prices and the shrinking profitability of hard coal assets, about three gigawatts of capacity were taken out of the market in 2017, mostly by Steag. Additionally, several municipal utilities announced to end the coal generation for district heating purposes. The people of Munich voted for a local coal phase out by 2022, Berlin will shut down its last coal plants until 2030. Datteln power plant will be last hard coal plant to get connected to the grid in 2018 (1.1 gigawatts).

About 14 Gigawatt of EU coal plants have closed in 2016 or 2017 (see figure 23 and table 2). However, the future remains uncertain: there are only 7 Gigawatt of coal plants that have announced their intention to retire out of the 157 Gigawatt of remaining operational coal plants.

Figure 24 shows how the coal mix has evolved in every EU country - important given that 66% of CO_2 emissions from the power sector in 2017 are from hard coal or lignite. The biggest fall in 2017 was perhaps unsurprisingly the country with the biggest rise in renewables: Denmark. Its coal generation fell from 28% in 2016 to 21% in 2017; only back in 2010, it was 44% of electricity production. The two countries that have seen coal penetration fall the most since 2010, besides Denmark, are the UK (from 28% to 7%) and Greece (from 54% to 34%). Germany fell only 5 percentage points - from 42% in 2010 to 37% in 2017, leaving it still with the fourth most coal-intensive electricity production. Germany's coal-intensity is only eclipsed by Poland (77%), the Czech Republic (49%) and Bulgaria (46%).

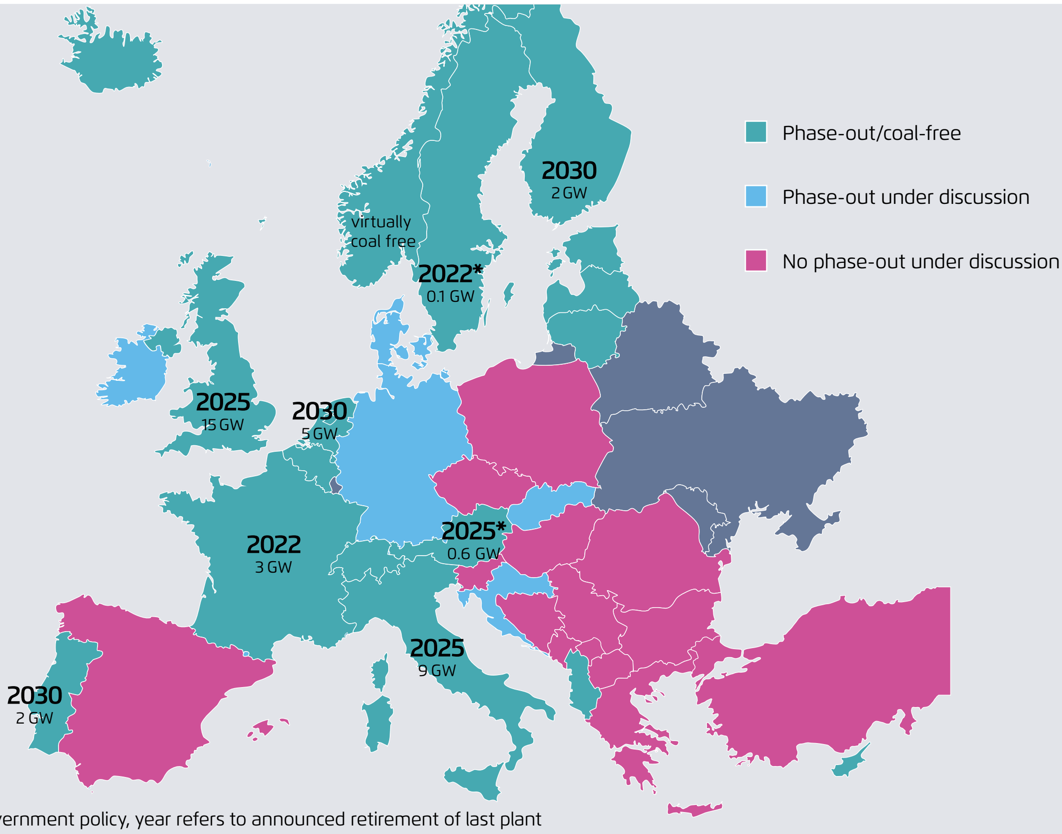
In December, Poland commissioned a brand new 1 Gigawatt unit at Kozienice, and Poland has another 5 units under construction projected to come online between 2018 and 2020 with a total capacity of around 3.5 Gigawatt.

Hard coal electricity generation (including split of top 5 countries) Figure 21



EUROSTAT data to 2015, 2016 and 2017 are own calculations

Coal phase-out years and operational capacity — Figure 22



*not explicit government policy, year refers to announced retirement of last plant

Europe Beyond Coal campaign 2018

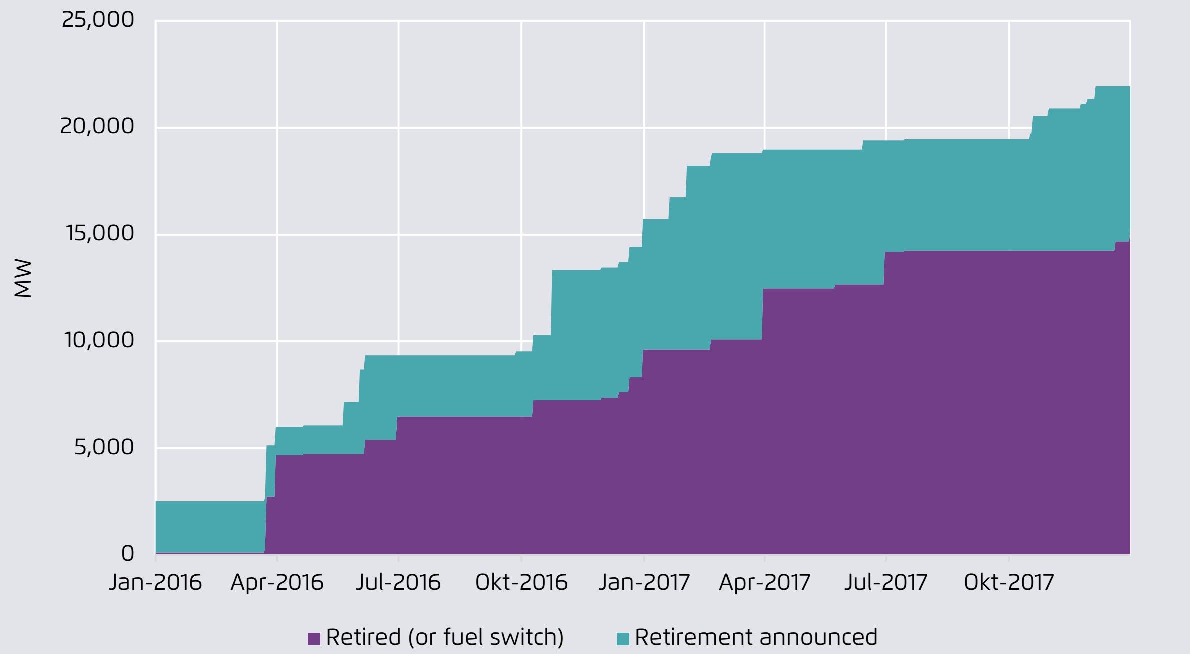
Retired coal plants in 2017 — Table 2

Country	Plant name	Coal type	Owner	Year opened	MW (gross)
Croatia	Plomin 1	Hard coal	HEP	1969	125
Finland	Kristiina 2	Hard coal	PVO	1983	242
Finland	Tahkoluoto	Hard coal	PVO	1976	225
Germany	Berlin-Klingenberg	Lignite	Vattenfall	1986	164
Germany	Ensdorf	Hard coal	RWE	1963	430
Germany	Herne 3, Marl II	Hard coal	STEAG	1966	378
Germany	Voerde	Hard coal	STEAG	1982	1522
Germany	Voerde West	Hard coal	STEAG	1971	712
Italy	Genova	Hard coal	Enel	1952	155
Netherlands	Maasvlakte	Hard coal	Uniper	1987	1207
Poland	Adamow B	Lignite	Zepak	1964	600

Europe Beyond Coal campaign 2018

Coal plants retired or announced to retire

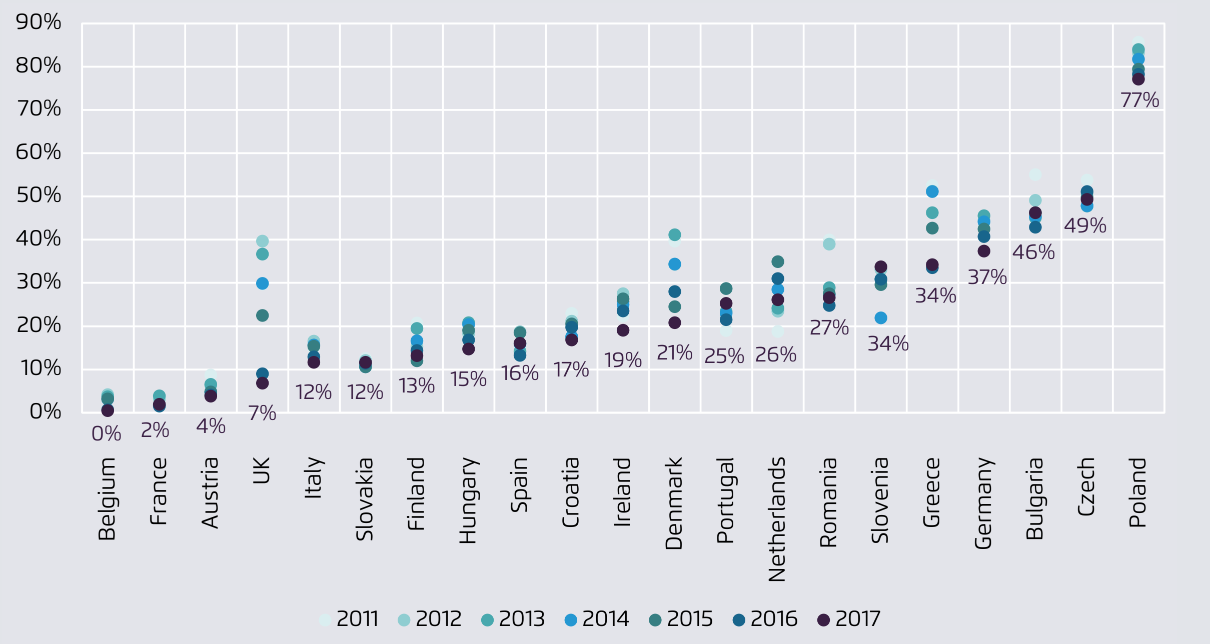
Figure 23



Europe Beyond Coal campaign 2018

Hard coal and lignite as percentage of national electricity production

Figure 24



EUROSTAT data to 2015, 2016 and 2017 are own calculations; LT, LU, CY, EE, LV, M, SE not included due to lower data quality

4.3 Lignite stays constant

Power production by lignite, the most CO_2-intensive fossil fuel, rose slightly by 6 Terawatt hours (2%) in 2017. German lignite generation fell by 1%, and there were small increases recorded in Greece, Bulgaria, Czech Republic and Romania (see figure 25). Since the marginal costs of the lignite generation are not exposed to price changes on international energy markets, impulses for the reduction of lignite use can only come from the European emission trading scheme or national initiatives. The current reform of the European emission trading scheme is not expected to cause significantly increasing CO_2 prices in the near future. If a European carbon floor price remains unlikely, national initiatives are the only way forward to limit the use of lignite.

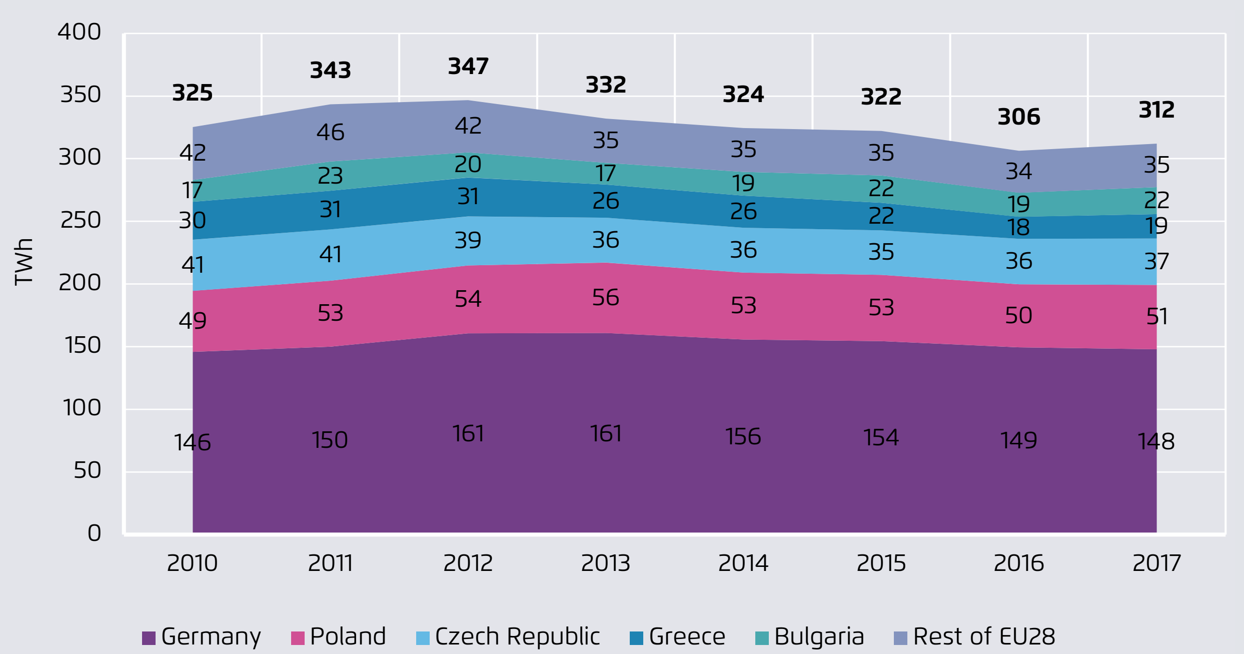
There was also little momentum on lignite units closing, other than Poland's Adamow (600MW) closed at the end of 2017. Two retirements in Germany were already known: Vattenfall's Berlin Klingenberg (188MW) retired, and Frimmersdorf P & Q units (635MW) entered into the lignite reserve. Hence, in 2018 a slight reduction in lignite power production might occur.

Overall, the situation of the lignite sector at the end of 2017 can be characterized as follows:

→ Despite being the most dirty fuel, the lignite sector seems so far to be unaffected by Europe's climate policy. The national coal phase-out plans mentioned above all relate to countries with hard coal, so do not touch lignite. And in 2017, the profitability of lignite power plants improved as higher hard coal and gas prices pushed up power prices, whilst CO_2 prices stayed low.

→ The EU debate on phasing out lignite began in 2017. In December 2017, the European Commission set up a platform to work out how to transition mainly lignite-intensive regions. And in Germany, the question of a lignite phase out played an important role

Lignite electricity generation (including split of top 5 countries) — Figure 25



EUROSTAT data to 2015, 2016 and 2017 are own calculations

in the coalition treaty discussions at the end of 2017 and beginning of 2018. The current state of play is that by the end of 2018 a government commission shall propose a phase-out plan which should then be signed into law and implemented as of 2019.

→ Tighter coal plant limits agreed in 2017. Tighter air pollution limits for NO_X, SO_2 and mercury were agreed for all power plants, coming into force in 2021. This implies that older coal and lignite power plants might need to invest in scrubber technologies. It's not yet clear how many lignite plants would close as a result.

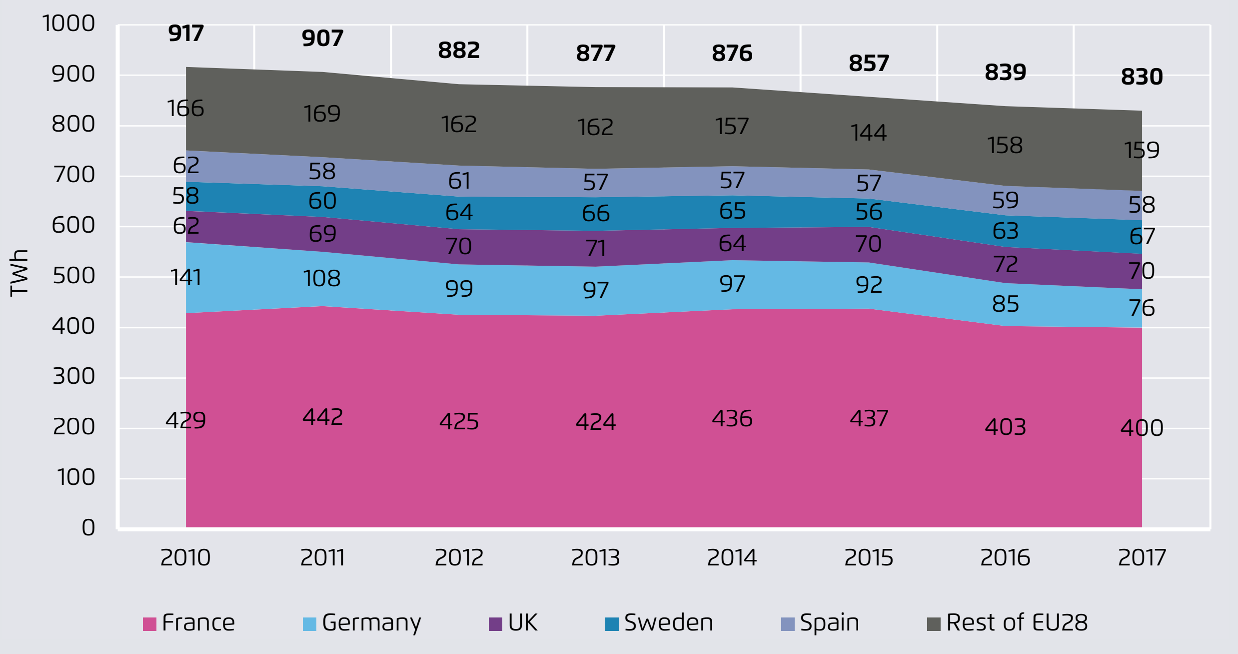
4.4 Nuclear availability continues to struggle

Nuclear generation fell again by 1% (9 Terawatt hours) in 2017. The biggest drops occured in Germany and in France, where nuclear authorities closed down several power plants in the first half of 2017 for safety reasons (see figure 26). France saw its lowest nuclear generation this century. Sweden and Czech Republic saw small increases in 2017.

Nuclear power production fell again as in previous years, leading to its lowest level in Europe since 2010. Since no nuclear power plant was closed in 2017, other reasons are responsible for the fall in power production. It seems that as nuclear power plants in Europe get older, more outages occur. Also the increase of renewable generation is causing nuclear plants to operate more flexibly, reducing their operating hours.

In 2018, Germany will experience another drop in nuclear generation. As part of Germany's nuclear phase-out, the Gundremmingen B reactor (1,284 megawatts) was shut down on 31 December 2017, after 33 years of operation.

Nuclear electricity generation (including split of top 5 countries) Figure 26



EUROSTAT data to 2015, 2016 and 2017 are own calculations

4.5 Gas fills in gaps

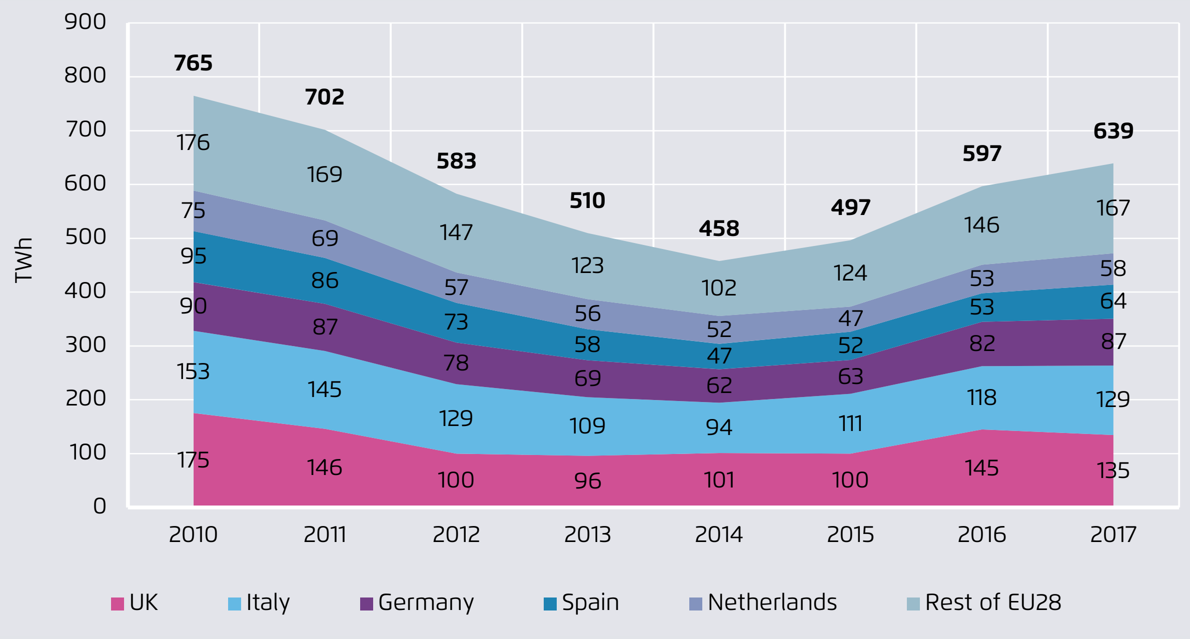
Gas generation rose by 7% (42 Terawatt hours) in 2017. This was mostly temporary, to make up for the very low hydro generation levels in Spain, Portugal, Italy, Austria and France. These five countries had 35 Terawatt hours of higher gas generation in 2017, compared to 45 Terawatt hours lower hydro generation.

2017 was the third year of rising gas generation, following on from a 20% rise last year. France has seen the largest increase in recent years, increasing its share of gas in the electricity mix from 4% to 7% in 2017. However, Europe's gas generation is still 20% below its peak in 2008 (see figure 27).

Throughout 2017, there was broadly the same level of coal-gas switching as in 2016 (see figure 28). Coal was broadly cheaper than gas, although the newest gas plants were cheaper to run than the oldest coal plants.

Because of the low 8 Euros/tonne carbon price, this general situation is true for every European country – with one exception: the UK, which has a domestic carbon price on top of the EU ETS, resulting in a total carbon price of around 30 Euros/tonne. Here, lower-carbon gas power production was cheaper than high-carbon coal power production.

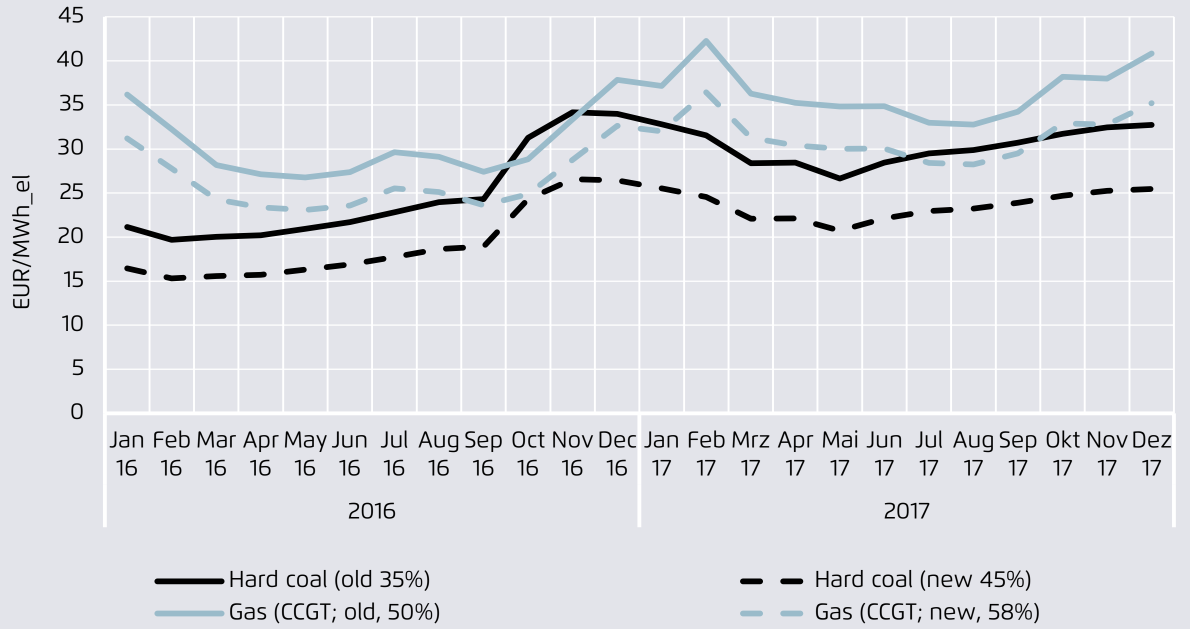
Gas electricity generation (including split of top 5 countries) Figure 27



EUROSTAT data to 2015, 2016 and 2017 are own calculations

Marginal cost of standard-type power plants 2016–2017

Figure 28



Worldbank 2018; Bundesbank 2018, UBA 2015, DEhSt 2018 (own calculations)

5 Interconnection

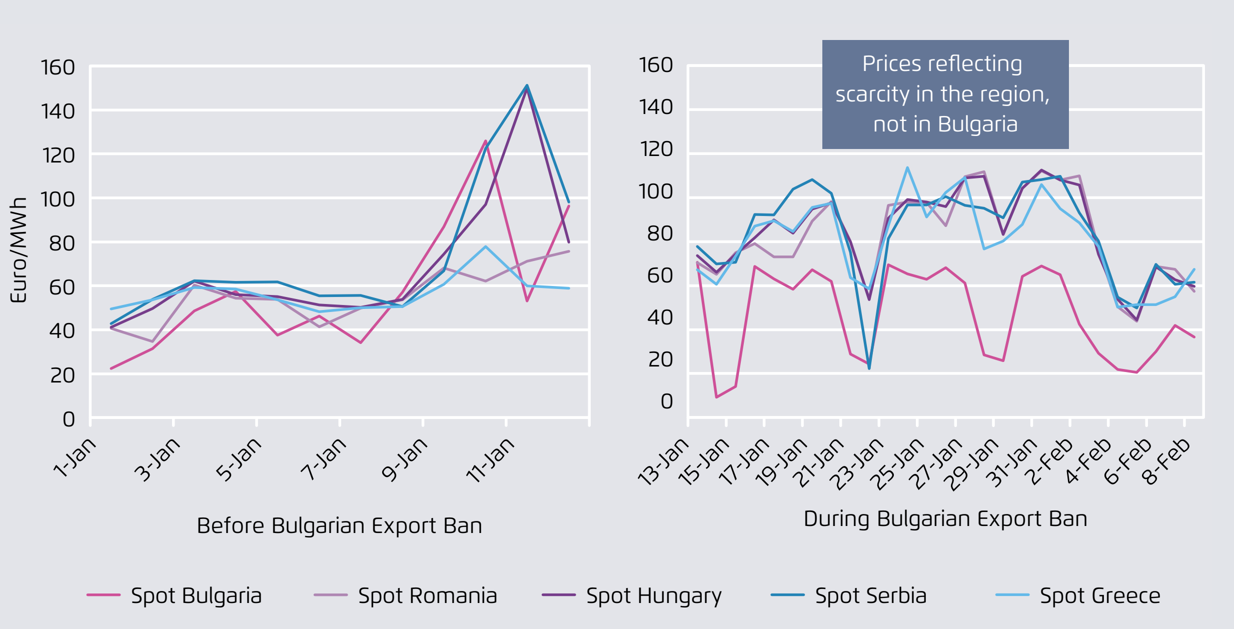
5.1 Surviving the cold spell in January

January 2017 was a big test of Europe's electricity transition. There was very prolonged cold weather throughout much of Europe, which coincided with very little wind, a large number of nuclear outages in Germany and France, and very low hydro-electric reserves throughout the Alps and central Europe. (For an elaborate report on actions taken by single countries see ENTSO-E 2017.)

The biggest problems actually happened in south-east Europe, where cold temperatures resulted in extraordinarily high electricity consumption levels, especially in Bulgaria and Romania. Bulgaria struggled to maintain supplies, because of the frozen Danube river, coal freezing and technical failures at its reserve plants, and restricted interconnector flows from Romania and Greece, which also simultaneously faced unprecedented tightness (CEPS 2017a). To secure their supply, the affected countries were taking exceptional measures, which were decided in times of relatively high loads, but implemented when loads were lower again. Greece curtailed exports from January 11 to 12, while Bulgaria imposed an export ban from January 13 through February 9. Surprisingly, the implementation of this measure lasted longer than the cold wave (for more details see S&P Global Platts 2017). In this period, Bulgarian spot prices dropped significantly relative to neighbouring countries' prices indicating an oversupply on the Bulgarian market (see figure 29).

Due to reduced nuclear availability and little hydro power production, France also struggled with supply security. As a consequence, net transfer capacity from France to Spain was reduced during peak hours

Day Ahead Power Prices in South-East Europe in January and February 2017 — Figure 29



PXE 2017, SEEPEX 2017, IBEX 2017, Lagie 2017 between January 14 and 20. However, compared to Bulgaria, the export reductions on the French interconnectors were limited to a shorter amount of time matching weather conditions. Market prices reached highs of more than 120 EUR/MWh (on January 20) and 200 EUR/MWh (on January 25), giving incentives for all available power plants to produce. Nevertheless, only parts of the oil-fuelled peaking power plants were operating in those hours (see table 3).

The cold spell in January 2017 demonstrated quite clearly that countries still deal with their individual supply situations on a national level. Thus, besides the emerging need for more sophisticated short-term forecast methods, increased energy efficiency and demand side flexibility, the January cold spell days emphasize the necessity of a stronger integration of European neighbours (CEPS 2017b). In addition, as the energy transition progresses, more peaking capacity will be needed, which is available in those hours of the year when it is cold and windless.

5.2 Electricity prices

Electricity prices across Europe were impacted by the poor hydro situation - and the driest countries of Spain and Italy were impacted most, recording the highest prices (see figure 30). Gas contributed to higher overall electricity prices not only because gas prices rose, but also because gas generation set the wholesale price of electricity more frequently as gas plants were required to run more often.

Increasing hard coal prices and slightly rising prices for CO_2 certificates also pushed power prices across Europe above 2016 levels. However, the north-south divide of the power prices in Europe remained. Lower shares of renewable energies in the southern countries and high shares of coal in the Eastern European countries and Germany foster the power price difference between northern and southern countries.

Situation in France in January 2017 — Table 3

	Installed Jan. 1, 2017	20-Jan-17	25-Jan-17
Price		€122/MWh	€206/MWh
Time		10 AM	9 AM
Demand		93.7	89.6
Fuel oil	7.1	4.0	2.5
Coal	3	2.6	2.3
Gas	11.7	9.3	9.1
Nuclear	63.1	55.6	56.6
Wind	11.7	2.7	1.2
Solar	6.7	0.5	0.1
Hydro	25.4	13.7	12.7
Other	1.9	0.9	0.8
Imports		4.2	4.3
UK		1	1
Spain		2.3	2.2
Italy		-1.3	0.2
Switzerland		0.8	1.4
Belgium/Germany		1.3	0.3
Adj		0.1	-0.8

RTE France 2017, EPEX Spot 2017

Another phenomenon occurring with high shares of renewables and coal are negative prices at the power exchange. In particular, Germany faced 146 hours of negative prices (-26.5 Euro/Megawatt hour on average) on the day ahead market in 2017. Intraday prices also plummeted below zero (-18.8 Euro/Megawatt hour on average) more often. During these times power producers paid to get rid of their electricity. However, frequent occurrences of negative wholesale prices also create incentives for market participants to adapt their production or/and consumption more flexibly to the availability of power from renewables. This was already observable in 2017: During windy times, hard coal plants went (sometimes almost entirely) off the grid in Germany.

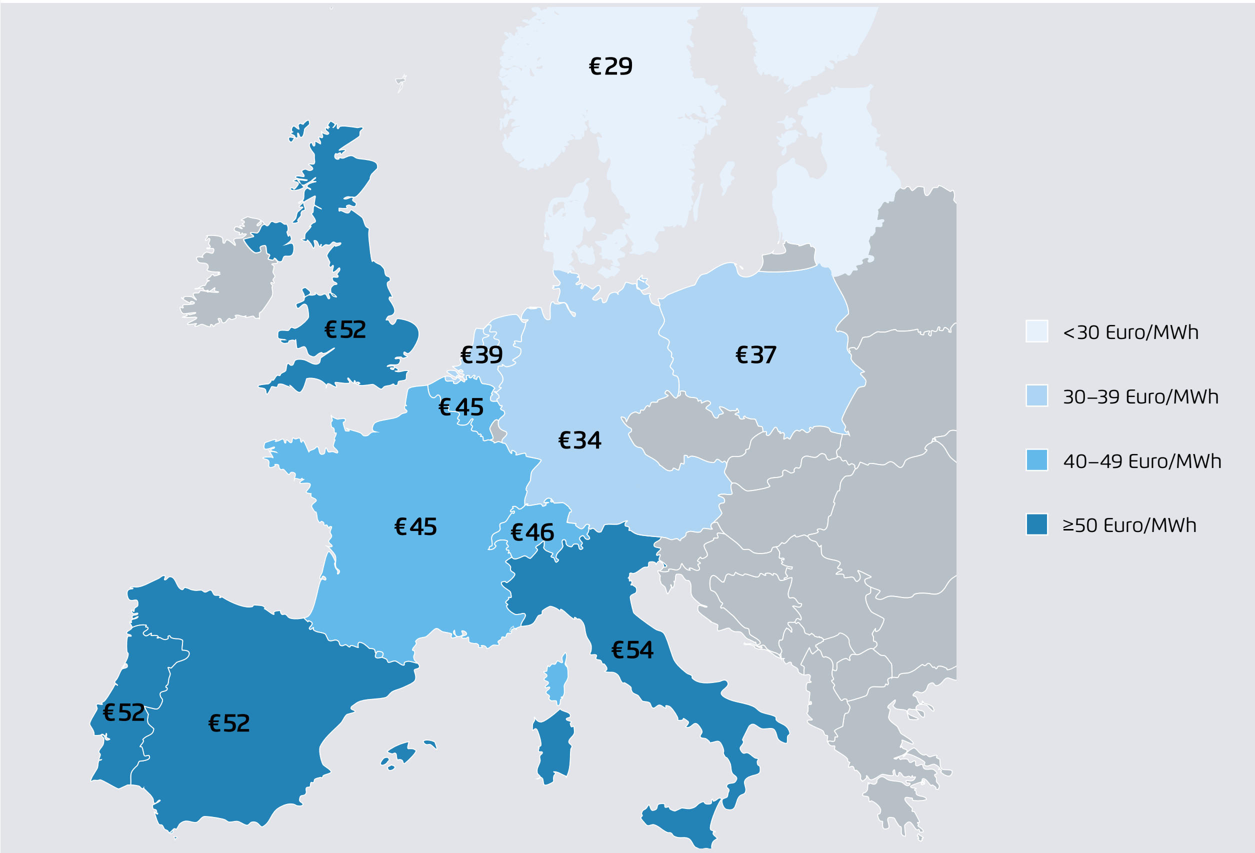
5.3 Interconnector flows

As always, interconnector flows changed quite substantially year-on-year, in line with the optimisation of hourly prices (see figure 31).

The changes in 2017 were not extra-ordinary, and most of the flows mirrored shortages in hydro conditions. The two biggest changes are:

→ Spain increased its net imports from France from 8 to 12 Terawatt hours, as poor Spanish hydro conditions led to higher electricity prices.
→ Sweden increased net exports from 12 to 19 Terawatt hours, as its nuclear condition returned to normal.

Average day-ahead wholesale electricity prices in selected countries in 2017 — Figure 30



EPEX-SPOT 2018, Nordpool 2018, Belpex 2018, OMEL 2018, Mercato Elettrico 2018, APX 2018, POLPX 2018 (own calculations)

The north-south divide in power prices also provides an explanation for why electricity flows within Europe tended to go from north-east to south-west with Italy and Spain remaining large net importers of electricity. Exceptions from these trends are the UK, Norway and Finland. In the UK, an additional carbon floor price of 18 British pound sterling per ton is raised on top of the EU CO_2 price. This causes higher wholesale market prices compared to its electric neighbors and net electricity imports. In Norway another dry year led to higher prices and net electricity imports mainly from Sweden. Finland has always been a power importer, mainly from Sweden and Russia. To overcome this situation, it has commissioned the construction of the Olkiluoto nuclear power station (1800 megawatts), that is expected to produce about 15 Terawatt hours of electricity when completed. However, the construction has experienced continuous delays. The current opening date of the nuclear plant is planned for 2019, a delay of almost 10 years.

Physical electricity flows in Terawatt hours

Figure 31

ENTSO-E 2018

6 Policy

A variety of policies relating to the power sector and the legal framework for EU climate and energy policy up to 2030 progressed through 2017. However, in a number of areas progress was slow, and generally ambition was muted. At a time, when the challenge of climate change becomes ever more pressing, there is a growing tendency to offer Member States increasing flexibility on policy ambition and the types of policy measures taken. This may enable already committed Member States to move ahead faster. However, it also creates the risk of fragmentation and renationalisation of climate and energy policy in Europe, signaling a fundamental challenge to the internal market. Not surprisingly then, the most positive policy advancements in the last year came from national initiatives - especially new announcements relating to coal phase-outs.

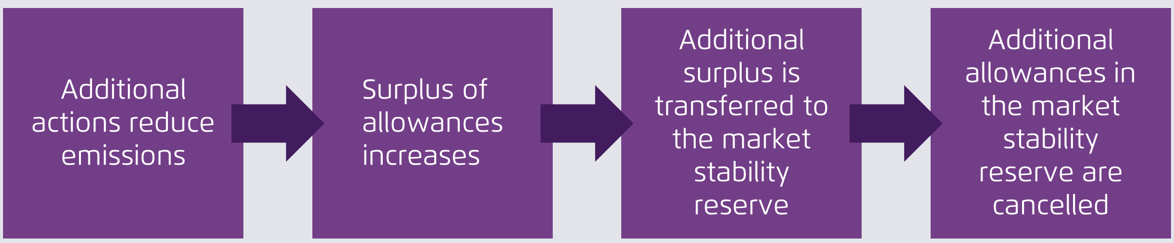
6.1 Reform of the European Emissions Trading Scheme

Finally, at the end of 2017 the reforms to the EU Emissions Trading System were agreed. They contain mainly three elements:

- → Further reducing the amount of certificates in the ETS as of 2021. The volume to be issued will decline by 2.2% per year as of then (whereas currently it decreases by 1.7% per year).
- → The huge surplus of certificates that exists shall flow into a market stability reserve at a quicker pace than previously envisaged: As of 2019, 24% of the surplus is to flow annually into the market stability reserve and shall thus not be available to the market any more.
- → As of 2023, the number of allowances kept in the market stability reserve will automatically be limited to the number of allowances auctioned in the previous calendar year; all further allowances in the reserve will be canceled.

These reforms are important steps to strengthen the EU Emissions Trading System, but before 2030 unlikely to bring CO_2 allowance prices up to levels needed for a stable switch from coal to gas. However, the cancellation of surplus allowances kept in the market stability reserve as of 2023 is of very high structural importance. First, this will lead to real emission reductions in the ETS, on top of the linear reduction factor of 2.2%. And second, this will enable national initiatives that reduce CO_2-emissions in the power sector faster than would otherwise happen under the ETS to have real and lasting value for climate protection. It puts an end to the so called *water-*

Why is the *waterbed effect* dampened? Figure 32



Sandbag 2018

bed effect under the ETS that saw additional emission savings in one Member State enable higher emission levels elsewhere in the EU. With the new rule, national initiatives e.g. on coal phase out or increased renewables will lead to an increased amount of certificates being canceled from the market stability reserve.

Figure 32 shows **how** the ETS reforms reduce the waterbed effect.

6.2 Europe's Clean Energy Package

On 30 November 2016, the European Commission proposed a set of new EU energy laws for the 2020-2030 decade, dubbed the *Clean Energy for All Europeans*-package. The package is supposed to implement the Paris Agreement on climate change and to advance EU energy policy, particularly the functioning of electricity markets in favour of decarbonisation.

Currently, the ordinary legislative procedure on the package is at an interim stage: Member States in the Council have agreed on all files how they want to engage in final negotiations with the European Parliament. The European Parliament in turn has determined its positions on energy efficiency, on renewable energy and on the new integrative EU climate and energy governance. Parliament positions on electricity market design, on risk preparedness in the power sector and on the Agency for the Cooperation of Energy Regulators will be adopted in a few weeks. It is expected that the Council and the Parliament will come to a final agreement on all files by the end of 2018.

Overall, Member States in the Council seem unable to agree on EU climate and energy legislation that is sufficiently ambitious to tackle dangerous climate change in line with the Paris Agreement, i.e. limiting global warming to well below 2 degrees Celsius and striving for 1.5 degrees Celsius. The positions of the European Parliament are more ambitious, foreshadowing difficult trilogue negotiations.

6.3 Electricity markets and decarbonisation

The Clean Energy Package will lead to a further tightening of EU rules on power market functioning. Whether this will advance decarbonisation remains unclear at the time of writing as Member States retain significant scope to protect incumbent interests.

Most Member States want to keep the door open to subsidising existing or new fossil fuel generators through *capacity payments*, in case markets do not provide sufficient investment signals. They also consider that national resource adequacy assessments should trump assessments with a regional or EU-wide perspective, despite increasingly integrated power markets in Europe.

A key question from a decarbonisation perspective is whether Council and Parliament will support the Commission's proposal to exclude hard-coal and lignite plants from being subsidised through capacity payments. On 18 December 2017 Member States in the Council voted to allow subsidies to build new coal-fired plant in capacity mechanims until 2025 and to subsidise existing coal-fired capacity in capacity mechanisms until 2030. This position is obviously inconsistent with the need to rapidly decarbonise Europe's power system and with the EU's long-standing policy to remove environmentally harmful subsidies. The position of the European Parliament on this issue has not yet been agreed, so it is currently unclear how this question will be resolved.

On a more positive note, the likely electricity market reforms will strengthen short-term markets and further develop balancing markets, providing renewable energy producers with more opportunities to fully participate in the market and thus lower the need for premium payments on market revenues. At the same time, existing privileges such as priority dispatch and priority access for renewable energy may largely be scrapped, meaning that renewable energy producers will face additional risks and costs wherever markets in Europe are not (yet) functioning well.

6.4 Europe's renewables target and policies

As regards renewable energy, the Clean Energy Package includes the proposal to increase the share of renewables in overall energy consumption to 27% by 2030, but does not contain national targets for Member State contributions to this overall goal. The Council supports this goal and would accept free-riding by unwilling Member States on the efforts of more ambitious Member States if the 27% are met. This seems worrying for the European energy transition, as it suggests the trend to a multi-speed Europe on renewables that we document in this report may become enshrined in EU legislation.

The rapid decline in costs for wind (offshore and onshore) and particularly for solar photovoltaics suggest a significantly higher than 27% share of renewables in 2030 would be needed to achieve the EU's climate targets in a cost-effective manner. The European Commission recently put its weight behind a 30% renewables share. The European Parliament will ask for a 35% renewables share in the trilogue negotiations.

Any increase in the collectively binding EU renewables target to 30% or higher implies a yearly average of more than 50% renewable *electricity* in the mix, with wind and solar having the largest shares. Currently, Germany, Denmark, Spain and Portugal are the countries within Europe that demonstrate day-by-day that managing a power system with large shares of variable power production is technically possible. Indeed, in windy and/or sunny days, already today shares of 70% and more variable power production is managed in those countries.

The experience of Austria, Denmark or Germany also shows how smaller scale renewable energy projects carried by individual households or energy communities can actively contribute to the energy transition. The proposed articulation of rights for *prosumers* in the recast of the EU Renewable Energy Directive has potential to help kick-start solar PV in Europe.

6.5 Energy efficiency policies

Energy efficiency measures are an important component of the energy transition in the power sector. The Commission's impact analysis showed that for every 1% extra energy savings by 2030, EU gas imports - and hence dependency - fall by 4%, greenhouse gas emissions decrease by 0.7% and more than 300,000 jobs are created. Advances in energy efficiency are also important for the electrification of transport and heating & cooling (so called 'sector coupling'), since less overall demand means that less zero-emissions generating capacity will be needed.

As regards energy efficiency, Member States in the Council confirmed the Commission's proposal for an *indicative* 30% EU-wide target, but created huge loopholes in the Commission's proposal to have *national flexibility* in implementation that - if fully exploited – may render the legislation almost meaningless (RAP 2017).

The European Parliament, in contrast, supports a *binding* 35% EU-wide energy efficiency target. It would also fully include energy use in transport after 2020.

The trilogue negotiations on energy efficiency will show whether the EU legislator is ready to move beyond the current stagnation on energy efficiency. Significantly, seven Member States (including France and Germany) issued a statement signalling their will to raise the ambition level during the trilogue.

6.6 National policies

National coal phase-out plans were newly announced in 2017 by **Italy** (for 2025), by the **Netherlands** (for 2030), by **Portugal** (for 2030). They add to earlier similar announcement by the **UK** (for 2025), by **Finland** (for 2030), and by **France** (for 2022) (Europe Beyond Coal campaign 2018). Clearly, momentum on coal is now spreading, and the UK and Canadian governments have helped set up an alliance to encourage others countries, regions and companies to go coal-free (Government of Canada 2017).

The European Commission set up a platform at the end of 2017 to address the regional transitions needed to get out of coal. The Commission says *it is designed to boost the clean energy transition by bringing more focus to social fairness, structural transformation, new skills and financing for the real economy* ("No region left behind" 2017).

In **Germany**, a political decision for a regulated phasing out of coal seems increasingly likely, although the conditions and the time-frame remain unclear. Important companies (including Siemens, EnBW, and E.ON) have publicly called for a firm commitment to a socially viable pathway for phasing out coal power (Stiftung 2Grad 2017). The ongoing negotiations between Christian Democrats and Social Democrats on a new coalition treaty so far suggest that a government coal commission is to be set up, which by the end of 2018 should propose a pathway and an end date for a coal phase out in Germany. This should then be implemented by law in 2019.

In **Poland**, national policy is still backing coal, although more recently with market forces shifting in favour of renewables, some nuances in government statements signal growing scepticism about the future role of coal. On 13 December 2017, the European Commission gave its state aid approval for competitive auctioning of overall 9.4 billion Euros to support renewable energy installations. However, the government also awaits approval by the European Commission for putting in place a capacity market to finance the building of six new coal units (4.6 Gigawatt) and possibly the modernisation of some existing assets. In September 2017, Energy minister Krzysztof Tchórzewski reportedly said the 1 Gigawatt coal-plan in Ostroleka would be the last new coal investment in Poland (Energetyka 2018).

6.7 Company policies

More and more power companies are changing their strategy towards renewables, in order to become active participants in future energy transition markets:

→ **Eurelectric**, the lobby group of European electricity companies, announced in a vision statement in December 2017 that it will *actively pursue efforts to become carbon-neutral well before mid-century* (Eurelectric 2017).
→ **Ørsted** (previously Dong) announced in February 2017 that they would phase out coal by 2023 (Clean Technica 2017).
→ **Iberdrola** announced in November 2017 that they would close all their coal plants. However, in an ironic twist the Spanish government has issued a Royal Decree to prevent their Spanish coal plants from closing, despite Spain being the most oversupplied country in Europe (Iberdrola 2017).
→ **EDF** have announced a plan to build 30 Gigawatt of solar in France from 2020 to 2035, providing a massive commitment to scale-up French renewable generation (EDF 2017).

On the other hand, there are some companies that are sticking to coal and gas power production. Most notably, the Czech investment company EPH, only founded in 2009, is aggressively buying coal and gas power plants all over Europe from those companies that are divesting from these assets (Sandbag 2016). EPH owns about 20 Gigawatt of power plants, which are mostly coal- and gas-fired. After buying all lignite assets from Vattenfall in 2016, EPH continued buying a lignite power plant in Hungary, a hard coal plant in

Germany and gas fired power stations in the UK in 2017. Next to these power plants, EPH now also owns several coal mines. Although EPH has entered the Italian biomass market (Biomass Magazine 2017), it seems that the company still focuses on reaping profits from dirty power plants as long as possible, while investing very little in those plants and not assuming responsibility for the renaturation of former mining sites (Leipziger Zeitung 2017). Since EPH has separated its business into more than 50 companies, it can let individual power companies go bankrupt if needed without having a significant effect on EPH's overall results.

7 CO_2 emissions

We estimate last year's power sector CO_2 emissions will be unchanged at 1019 million tonnes. The reasons for this are that fossil generation didn't fall, because of extremely low hydro generation, another low year for French nuclear generation and increasing electricity consumption. Growth in new renewables was strong, especially wind, but it was not strong enough to outweigh these other effects.

We estimate overall EU ETS stationary emissions in 2017 will slightly rise from 1750 to 1756 million tonnes. This would be the first year of rising EU ETS emissions since 2010. Industrial emissions are likely to show a small increase, driven by the first rise in steel production in three years, and driven by high industrial production growth of 3.7%. It is unlikely that energy efficiency improvements are sufficient to ensure the remaining industrial emissions fall. Steel production rose by about 4%, mostly in Germany, France and Poland. Hence, we estimate that industrial emissions in 2017 kicked back to 2015 levels.

Overall European greenhouse gas emissions are also likely to have increased in 2017 by approximately 1%. EUROGAS reported a 5.9% increase in gas consumption in 2017, of which only 1.6% can be explained by higher gas generation (Eurogas 2017). The reasons: Europe experienced a colder winter 2017 than 2016, and increasing demand for gas from industry. Also, the IEA estimated that European oil demand has risen by over 1% (IEA 2017), especially in the transport sector. Calculating the CO_2 changes by fuel, that means CO_2 from oil rose by 13 million tonnes, from gas rose by 50 million tonnes, and from coal fell by 13 million tonnes (taking into account extra coal demand from steel). That puts emissions 50 million tonnes higher against estimated 2016 GHG emissions of 4423 million tonnes including international aviation (EEA 2017), a rise of 1.1%.

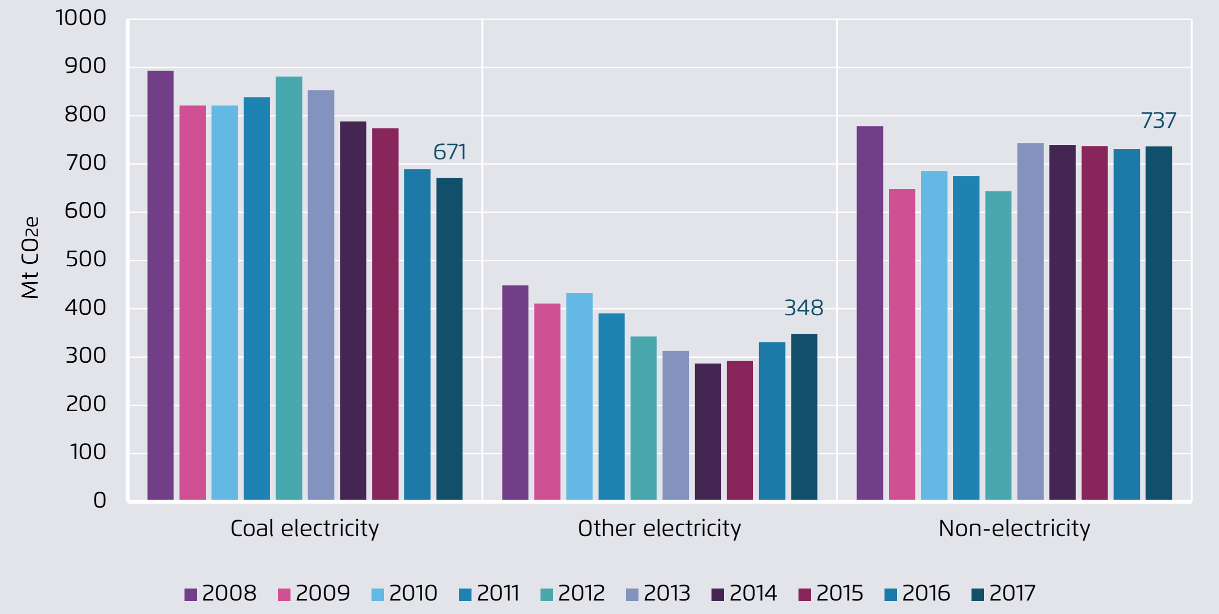
Figure 33 shows that the main driver behind falling EU ETS emissions in the last five years has been reducing coal generation. Since 2012, CO_2 from coal generators has fallen by 210 million tonnes, the remaining power sector is almost unchanged (5 million tonnes rise), and CO_2 from energy intensive industry actually increased by 95 million tonnes.

However, despite this fall in coal, Europe's 258 operational coal plants in 2017 still emitted 38% of all EU ETS emissions, or 15% of total EU greenhouse gases.

And despite the rise in EU ETS emissions in 2017, **the EU ETS cap is still 9% above actual emissions** (see figure 34). For every year since the third EU ETS trading period started in 2013, the cap has been 9 to 11% higher than actual emissions. This shows that the initial EU Commissions' calculations back in 2007 when proposing the rules for the third phase of the EU ETS system were fundamentally flawed, issuing too many certificates for the energy and energy intensive sectors.

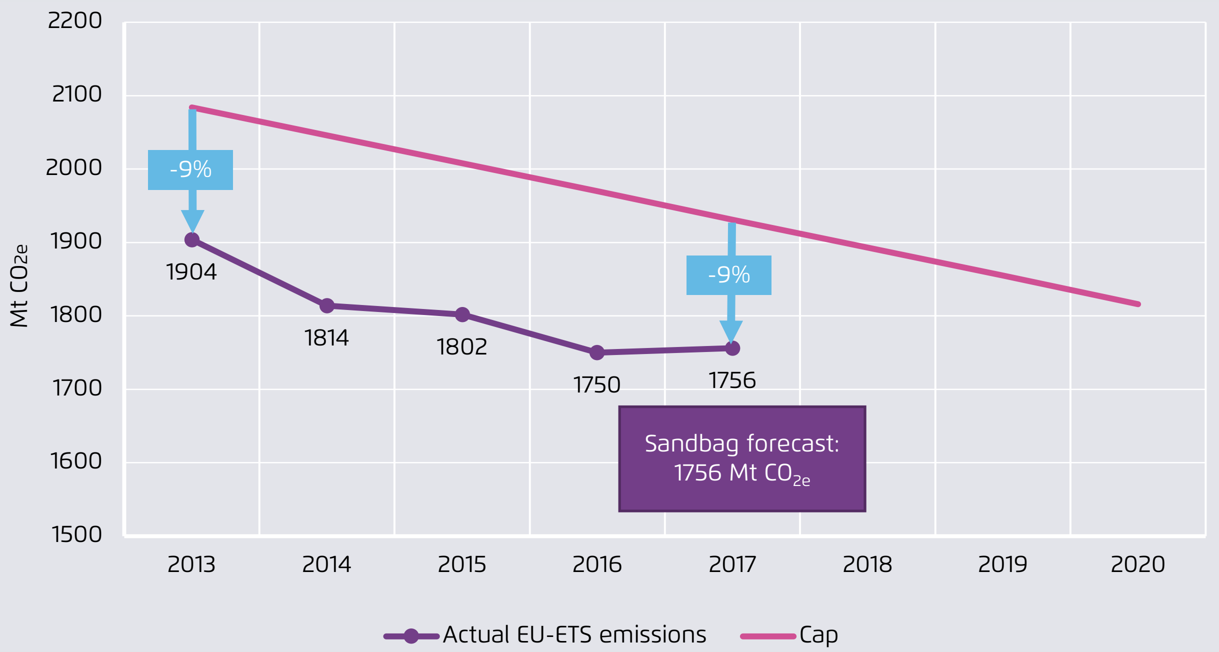
The consequence is that the EU "*cap-and-trade*"-system is actually not providing a real "*cap*" – there is simply no scarcity in the EU ETS. Figure 35 shows that **the cumulative EU ETS surplus has now risen to more than 3.3 billion tonnes of CO_2 – almost twice the annual emissions of the entire EU emissions trading system**. Since parts of this surplus are hidden in reserves (backloading, innovation fund, new entrants reserve, etc.) the surplus currently available to the market only rises slightly to 1557 million tonnes. The EU ETS reforms that will enter into force in 2019 are aiming to reduce both parts of the surplus – the surplus available to the market will slowly be reduced starting in 2019, and the cumulative surplus as of 2023. However, it is doubtful whether this will lead to CO_2 prices that reflect CO_2 abatement costs, as textbook economics suggest as the outcome of a "*cap and trade*" system.

Emissions from coal, other electricity and non-electricity sectors 2008–2017 — Figure 33



Sandbag 2018

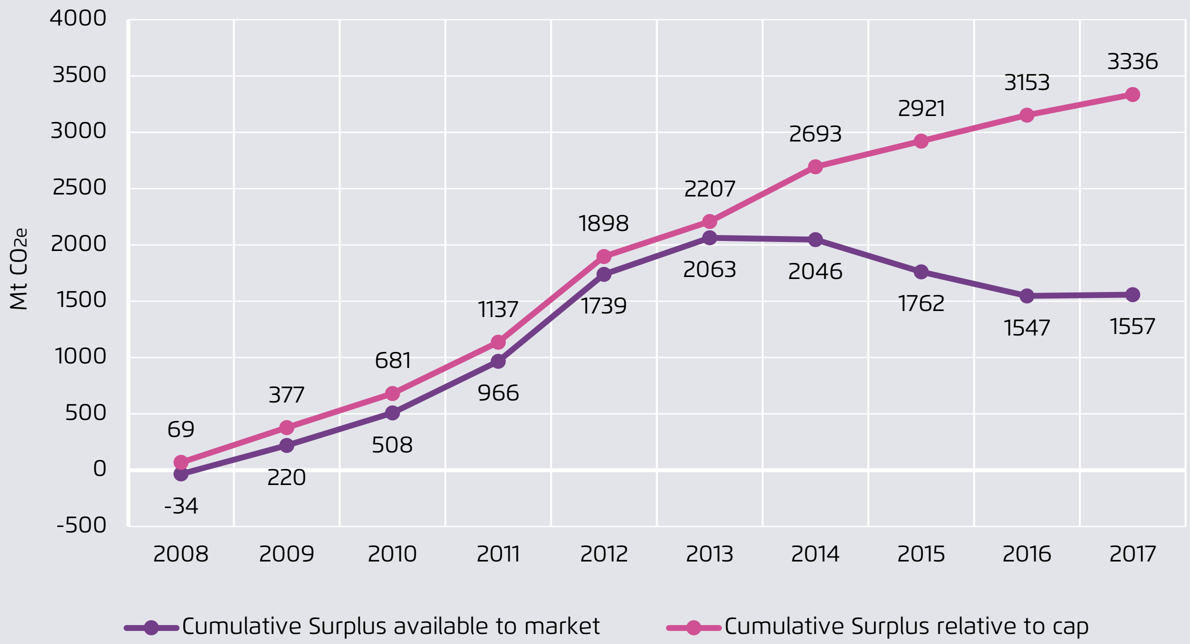
ETS cap 2013–2017 — Figure 34



Sandbag 2018

ETS surplus 2008–2017

Figure 35



Sandbag 2018

8 Outlook

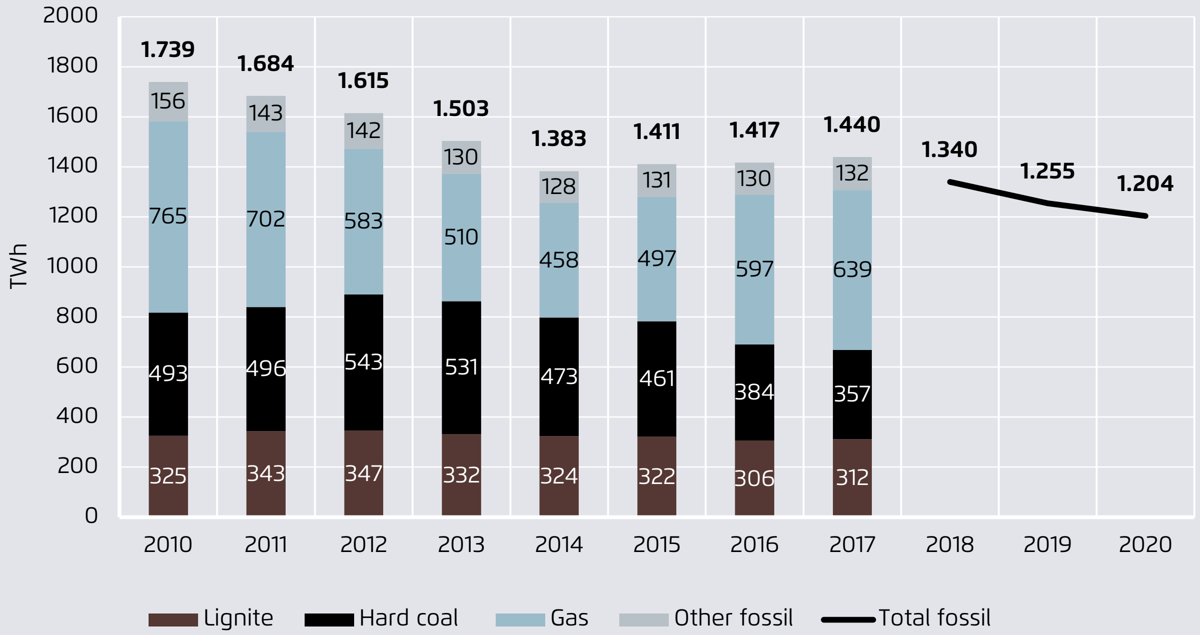
Renewables could provide a third of Europe's electricity in 2018. We expect hydro generation to normalise in 2018 (Nordic hydro reserves were already 16 Terawatt hours above average in January), which would give hydro a plus of 50 Terawatt hours in 2018. Assuming that the increase in wind, solar and biomass will continue in 2018, as in the previous years, would lead to another 50 Terawatt hours of renewable electricity being added. This is backed by expected additional wind installations (both onshore and offshore) of some 15 Gigawatts. By 2020, renewables should be providing some 36% of Europe's power demand – up from 20% in 2010.

Fossil generation should continue its fall, with a sharp decline in 2018. With an additional 100 Terawatt hours of renewables and some French nuclear plants to come back online, fossil fueled power plants will have less operating hours. The trend for fossil generation is clearly down, but the scale of the fall, and whether hard coal or gas falls most, are all yet to be determined. We make an optimistic forecast that fossil generation will fall by 16% in 2020 (see figure 36). This assumes constant electricity consumption and an aggressive renewables build rate.

On nuclear, generation will probably slightly rise in 2018 and then stay constant until 2020. Assuming that the availability of French nuclear power plants comes back to normal would increase nuclear power production by 30 Terawatt hours in 2018. On the other side, Germany's Gundremmingen B plant closed for good at the end of 2017; the next one on the German nuclear phase-out plan is Philippsburg 2 at the end of

Conventional electricity generation 2010–2017 and projected total conventional generation 2018–2020

Figure 36



Sandbag 2018

2019. Finland's 1.6 GW of new nuclear capacity, the plant Olkiluoto-3, was postponed another five months, and is expected to begin regular operation only from May 2019. EDF's Flamanville nuclear plant in France has confirmed that they are still on track to start-up their new third reactor in Q4-2018, with full operation of the reactor from November 2019. The new reactor is to replace Fessenheim, which has announced an eventual closure date of 1st January 2019.

CO_2 emissions in the European power sector should fall in 2018, given the projected decline in fossil generation. This leads again to another increase in the EU ETS surplus, which will surpass the mark of 4 billion CO_2 certificates by 2020. Future CO_2 prices are uncertain; whilst many analysts anticipate prices of 10-12 EUR/t or more by 2020, this rise is by no means guaranteed, especially if our more optimistic forecasts of renewables-build and coal retirements are realised.

On European energy policy, 2018 will see intense debates and a final decision on Europe's 2030 targets for renewables and energy efficiency. The legislative negotiations on the "Clean Energy for All Europeans"-package will be finalized by the end of 2018. We expect tough debates between the different institutions, especially on the targets for energy efficiency and renewables. On efficiency, member states' governments and the EU Commission are voting for a 30% increase by 2030, whereas the European Parliament is aiming for 35%. On renewables, member states are arguing for a 27% share of final energy demand by 2030, whereas the Commission is aiming at 30% and the EU parliament voted for 35%. The trilogue negotiations between these institutions are likely to be tough.

The EU targets imply a 50% to 65% share of renewables in the power sector in 2030, making wind and solar the dominant power sources. Depending on whether the final outcome of the renewables target is closer to the Councils position of 27% or that one of the European Parliament of 35%, the renewables share in the power sector will have to be half or two thirds of power production. This is because in heat and transport not many additional renewable sources are to be found, and biofuels has been proven to be a wrong strategy. The decarbonisation of heat and transport will result in using more electricity in those sectors – either directly through electric vehicles and heat pumps or indirectly by using hydrogen and other synthetic fuels. Hence, as the cheapest renewable resources , wind and solar power will become the backbone of Europe's power system. By 2030, wind and solar power production could either double or triple compared to 2017, depending on the outcome of the negotiations.

However, just deciding on the numbers will not be enough. A stable and reliable regulation coupled with smart financing tools to guarantee low risk premiums will be needed, so that Europe can reap the full potential of energy efficiency and renewables at low cost. Embarking on the road to a transition of the European power sector will also need a fully flexible power market and grid, for which flexible conventional back-up generation provides power in times without wind and sun, flexible demand is able to quickly react to price signals of the wholesale power market, and storage and new flexible users like electric vehicles increasingly help to stabilize the system. Hence, a full implementation of the *Clean Energy for all Europeans*-package will be key.

9 Annex

This report uses the latest electricity data to the end of 2017, and is available to download for free (click to download the Excel sheet). It contains data by fuel source from 2000 to 2017 for all EU countries.

9.1 Methodology

Data for 2000 to 2015 is from EUROSTAT, mapped according to categories in table 4 (Eurostat 2017). In late February 2017, EUROSTAT will publish 2016 data, and our excel download will be updated with this. Please note, all data used is "gross" not "net".

Data for 2016 and 2017 is our "best view" of what the EUROSTAT data will be when it is eventually published, by estimating the year-on-year changes in 2016 and 2017 from 2015 EUROSTAT data.

We use a combination of three data sources to produce this best view:

- → National (mostly TSO) data. The links for each country we used are here: (AT) (BE) (DE) (ES) (FR) (GR) (IT1) (IT2) (RO) (PT) (UK)
- → ENTSOE monthly data (ENTSO-E 2018)
- → ENTSO-E hourly generation, downloaded from the ENTSO-E Transparency platform (ENTSO-E 2018)

We welcome insights to better, more reliable, more recent data. Please email dave@sandbag.org.uk.

Classification of fuel types — Table 4

Electricity sources as used in this report	Detailed energy carriers used in EUROSTAT
Lignite	Lignite, peat, patent fuels and BKB.
Hard Coal	Anthracite, coking coal, other bituminous coal, sub-bituminous coal
Gas	LPG, natural gas liquids, gas work gas and other recovered gases
Other fossil	"Other sources", gas works, coke oven gas, blast furnace gas, other recovered gases, oil shale and oil sands, peat products, crude oil, natural gas liquids, refinery gases, LPG, Diesel oil, residual fuel oil, other oil products, industrial waste, municipal waste (non renewable).
Nuclear	Nuclear
Hydro	Hydro minus Pumps
Solar	Solar photovoltaic, solar thermal
Wind	Wind, and "Tide, Wave Ocean"
Biomass	Municipal waste (renewables), solid biofuels, biogases, biodiesels, other liquid biofuels, and geothermal.
Net imports	Imports minus Exports
Consumption	Production minus Net imports
Production	Sum of Lignite, Hard coal, Gas, other fossil, nuclear, hydro, solar, wind, biomass.

Öko-Institut 2016

9.2 Last year's accuracy

We hope this section gives some confidence in the quality of our forecasts.

Our 2015 forecast in last year's report (Sandbag 2017) was remarkably similar to the EUROSTAT data published in February. Our forecast of total electricity production was only 1TWh different to EUROSTAT, out of 3204TWh total electricity production. There were some slightly bigger differences between fuel types and countries, but all less than 1% different.

Our 2016 forecast that we made last year, we have changed only very slightly this year. The actual numbers will be published by EUROSTAT in February 2018, so we will compare our forecast then.

Our 2017 forecast hopefully is as robust. Data quality is at last getting better. Although ENTSO-E monthly data continues to lag significantly behind, and ENTSO-E real-time data has no easy platform for aggregating data.

9.3 Data for 2017

The terawatt hour changes for 2017 are published in full here: by country, and by fuel type. The historical absolute numbers from 2000 to 2017 can be downloaded from the accompanying spreadsheet.

Accuracy of last year's calculations — Table 5

2015 (TWh changes year-on-year)	Lignite	Hard Coal	Other fossil	Gas	Nuclear	Hydro	Solar	Wind	Biomass	Imports	Consumption	Production
Jan-17 forecast by Agora/Sandbag	0	-10	2	35	-18	-36	12	48	12	-4	40	44
Eurostat actuals	-2	-12	3	39	-19	-34	10	49	11	-1	44	45
Error	**-2**	**-2**	**2**	**4**	**-2**	**3**	**-2**	**0**	**-1**	**3**	**4**	**1**
2016 (TWh changes year-on-year)												
Jan-17 forecast by Agora/Sandbag	-16	-78	1	101	-18	6	4	4	3	6	15	8
Jan-18 forecast by Agora/Sandbag	-16	-77	-1	100	-18	8	3	4	6	12	20	8
Change in forecast	**0**	**1**	**-3**	**-1**	**0**	**2**	**-1**	**0**	**3**	**5**	**5**	**1**

Own calculations, see 8.1 for methodology

Terawatt hour changes by fuel type by country in 2017 versus 2016

Table 6

	Lignite	Hard Coal	Other fossil	Gas	Nuclear	Hydro	Solar	Wind	Biomass	Imports	Consumption	Production	CO2 (Mt)
EU28	6	-27	2	42	-9	-54	9	58	5	-8	23	31	0
Austria	0	0	0	3	0	-2	0	1	0	-1	1	2	1
Belgium	0	0	0	2	-2	0	0	1	0	0	1	1	0
Bulgaria	2	0	0	1	0	-1	0	0	0	-1	0	2	3
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0
Czech	1	0	0	-1	4	0	0	0	0	-3	1	4	0
Denmark	0	-2	0	0	0	0	0	2	1	-1	0	1	-2
Estonia	0	0	1	0	0	0	0	0	0	-1	0	1	0
Finland	0	-1	0	0	-1	-2	0	2	0	1	0	-1	-1
France	0	3	0	5	-3	-10	1	3	1	1	1	0	4
Germany	-2	-18	0	5	-9	-1	2	27	1	0	5	5	-15
Greece	2	0	0	3	0	-1	0	0	0	-3	2	4	3
Hungary	-1	0	0	1	0	0	0	0	0	0	1	1	0
Ireland	0	-1	0	1	0	0	0	1	0	-1	0	1	-1
Italy	0	-3	0	11	0	-6	3	-1	0	1	5	4	2
Latvia	0	0	0	0	0	1	0	0	0	-1	0	1	0
Lithuania	0	0	0	0	0	0	0	0	0	1	0	0	0
Netherlands	0	-5	0	5	-1	0	0	3	0	-2	1	2	-2
Poland	1	-1	0	1	0	0	0	2	0	1	4	3	1
Portugal	0	2	0	6	0	-9	0	0	0	2	1	-1	4
Romania	1	0	0	1	0	-4	0	1	0	2	2	0	1
Slovakia	0	0	0	0	0	0	0	0	0	1	1	0	0
Slovenia	0	0	0	0	0	-1	0	0	0	1	0	0	0
Spain	0	8	0	11	-1	-19	1	0	0	2	3	0	11
Sweden	0	0	0	-1	4	0	0	2	1	-7	0	7	0
United Kingdom	0	-8	1	-10	-2	0	1	12	1	-2	-7	-4	-10
Luxembourg	0	0	0	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0	0	0	0
Croatia	0	0	0	1	0	-1	0	0	0	1	1	0	0

Own calculations, see 8.1 for methodology

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