THE STATE OF RENEWABLE ENERGIES IN EUROPE

EDITION 2017

17th EurObserv'ER Report

This barometer was prepared by the EurObserv'ER consortium, which groups together Observ'ER (FR), ECN (NL), RENAC (DE), Frankfurt School of Finance and Management (DE), Fraunhofer ISI (DE) and Statistics Netherlands (NL).

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POWERHOUSE

Vincent Jacques le Seigneur, President of Observ'ER

...Germany carries the day! Once again, the European economy's powerhouse can claim that it deserves this title in the renewable energies sector, with a third of Europe's installed wind energy capacity. Germany is followed just as it was last year, by Spain and the UK. This threesome accounts for half the EU's wind power output. The situation is hardly any different in the solar photovoltaic ranking where 40% of the installed photovoltaic capacity is in Germany, while Italy replaces Spain in the top three PV producer countries that provide 70% of Europe's output.

German supremacy in the areas of photovoltaic, wind energy, solar thermal – half the collectors are mounted on German roofs –, not to mention biogas, biomass, or energy-from-waste is a timely reminder that public policies and the ensuing finances rather than natural amenities and weather conditions are what really underpin the growth of renewables.

We have used the data collected and analysed in this new barometer to refine our appraisal and classify the Member States into three categories. The first, in the minority, consists of "can doers", who year in year out, apply their conviction and resolve to developing a purposeful renewable energy mix. While contenders for Germany's position are few and far between, we should mention Denmark, Portugal and the UK, who have enjoyed the strongest growth in renewable energies over the past decade.

The second category – the "opportunists" – covers the countries that have plumped for one or other new energy source founded on natural availability, sometimes only to abandon it straight away. Patent examples of this are Spain's wind energy and Italy's photovoltaic power. As for the remainder, they are living off their natural asset-based givens, be they geothermal or hydraulic sources.

The last category comprises those "sitting on the bench" – countries like France, Poland and even Austria betting a little scattered over all the renewable energy sources and that primarily bank on their hydraulic capacities. The paradox of this situation can be summarized by a single figure. Germany's solar and wind power output is four times higher than that of France, yet the latter's climate and natural assets are better than its important neighbour the other side of the Rhine.

Now, this rating of the European situation is a little fuzzy, because being the champion of one or more specialities or producing a lot of electricity says nothing about the country's actual energy transition. The point that this barometer brings home is that the current growth pace across the European Union is too slow to achieve the 2020 target. When we now need +0,75 point every year, it was only 0,3 between 2015 and 2016. While eleven Member States have already met the target set on the basis of their original situations, their renewables energy potentials and economic performance levels and most of the others are on track with their indicative trajectories for 2016, some of the EU heavyweights, such as France and the UK are respectively 7 and 5.7 points away from their goals... which taxes the final result to an unwarranted degree.

While the EU's 17% share of renewable energy in its final energy consumption is twice its 2004 level (8.5%), the missing 3 points seem difficult to achieve in the short window of four years if no new policies are put in place in the countries lagging behind. It is all the more important that the European Parliament and the Council reach a new and challenging agreement in the next Climate & Energy Package. This higher target would send a strong signal of renewed collective resolve and set a shared ambitious goal in line with the Paris agreement that would generate hope, business and jobs, all of which Old Man Europe sorely needs.

ENERGY INDICATORS

EurObserv'ER has been collecting data on the European Union's renewable energy sources for eighteen years to describe the state and thrust of the various sectors in theme-based barometers. The first part of this assessment is a summary of the barometers published in 2017 for the wind energy, photovoltaic, solar thermal, concentrated solar power, biogas, biofuel and solid biomass sectors. The data drawn from these barometers has been consolidated with the official data available at the very end of the year.

The sectors that were not covered by individual barometers have also been analysed in detail and statistically monitored using data published in 2016. They cover small hydropower, heat pumps, geothermal energy, the incineration of renewable municipal waste and ocean energies.

This work offers a full synopsis of the energy dimension of the twelve renewable sectors now developed at an industrial scale within the European Union.

Methodological note

The tables reproduce the most recent figures available for each sector. In publishing this edition, the EurObserv'ER data was fully reconciled with the Eurostat data provided by the SHARES (Short Assessment of Renewable Energy Sources) tool published on 26 January 2018. This reconciliation covers the indicators for electricity output, electrical capacity, final energy consumption and derived heat from heating or cogeneration plants. Since the SHARES tool does not provide indicators on primary energy and primary energy consumption, no statistical reconciliation was attempted.

As for market indicators, such as market data for different types of heat pumps or solar thermal collectors, the EurObserv'ER source or indicators was exclusively used.

As for the "heat" data, a distinction is made between derived heat from the processing sector and final energy consumption in line with Eurostat definitions. Derived heat covers the total production of heat in heating plants and cogeneration plants (combined heat and power plants). It includes heat used by the auxiliaries of the installation which use hot fluid (space heating, liquid fuel heating, etc.) and losses in the installation/network heat exchanges. For auto-producing entities i.e. entities generating electricity and/or heat wholly or partially for their own use as an activity which supports their primary activity) the heat used by the undertaking for its own processes is not included.

Final energy consumption is the total energy consumed by end users, such as households, industry and agriculture. It is the energy which reaches the final consumer's door and excludes that which is used by the energy sector itself including for deliveries, and transformation. It also excludes fuel transformed in the electrical power stations of industrial auto-producers and coke transformed into blast-furnace gas where this is not part of overall industrial consumption but of the transformation sector. Final energy consumption in «households, services, etc.» covers quantities consumed by private households, commerce, public administration, services, agriculture and fisheries.

A distinction is also made with regard to electricity and derived heat production data between output from plants solely producing either electricity or heat and the output from cogeneration plants simultaneously producing heat and electricity.

WIND POWER

MULTISPEED EUROPE

Undeterred by the difficulties created by weak demand and production overcapacity in the electricity market, the European Union wind energy market pushed ahead by commissioning almost 13 000 MW in 2016 (12 939 MW to be precise) of additional capacity (installed capacity less decommissioned capacity). This took total wind turbine capacity to 154.4 GW at the end of 2016. Once again, the buoyant German market spearheaded the installation drive. According to AGEE-Stat, it installed 5 292 MW and decommissioned 280 MW. The resulting additional capacity of 5 012 MW took the German wind turbine base to 49.6 GW at the end of 2016. The United Kingdom is the second largest European market. According to the BEIS (the Business, Energy and Industrial Strategies Department) it installed an additional 1 901 MW including 200 MW offshore for 16 217 MW of capacity to date.

The French market finally picked up again in 2016. Data released by the French Ministry of Ecological and Solidarity Transition's Statistics Division, SDES, shows that nett installed capacity outstripped the 1 GW mark (1 250 MW) setting a new installation record. Other EU markets performed particularly well including the Netherlands, which joined the ranks of the global wind energy market Top 10 with 866 MW (according to Statistics Netherlands), on the strength of hooking up the second biggest offshore wind energy farm ever installed (the 600-MW Gemini project). Finland, which also broke its own installation record by adding 560 MW (according to Statistics Finland), increased its wind turbine base by more than 50% over the twelve-month period. Sweden, for its part, added almost 594 MW (according to Statistics Sweden). We should point out that in relation to their size, the market momentum of these countries is outstanding and has been setting new trends with regards to their electricity mix.

This upbeat news contrasts sharply with the apathy that reigns in several European Union markets. We

Stiftung Offshore-Windenergie

have counted nine countries that hardly installed any new capacity and Romania's capacity contracted sharply. Spain, for example, which has the second highest installed capacity to date in Europe (23 033 MW according to the IDAE), added just 90 MW of capacity in 2016. After a series of good years, the Italian market slowed down significantly and installed 247 MW in 2016, according to the Ministry of Economic Development.

A LITTLE TURBULENCE IN THE OFFSHORE MARKET

Our consolidated data shows that connected offshore capacity only increased by 1 648 MW in 2016, which is a much lower figure than in 2015, when almost 3 000 MW of capacity was connected. Germany increased its offshore capacity by 850 MW, the Netherlands by 600 MW and the UK by 200 MW. A handful of offshore demonstration wind turbines were dismantled across the European Union – namely the 10 MW of the Béatrice farm, the Windfloat floating wind turbine project off Portugal (2 MW) and the 5.0-MW Bard wind turbine of Germany's Hooksiel project.

In 2016, only three new offshore farms were fully installed and connected in 2016. The biggest, the Gemini farm (600 MW), sited 85 km off the Dutch coast in the North Sea (and thus invisible from the coast), is the world's second largest offshore wind farm (just behind London Array and its 630 MW). It should produce about 2.6 TWh per annum (i.e. 2.5% of the country's electricity). The two other farms are

1

Installed wind power capacity in the European Union at the end of 2016 (MW)

	2015	2016
Germany	44 580	49 592
Spain	22 943	23 033
United Kingdom	14 316	16 217
France	10 217	11 467
Italy	9 137	9 384
Sweden	5 840	6 434
Poland	4 886	5 747
Denmark	5 076	5 245
Portugal	4 937	5 124
Netherlands	3 391	4 257
Romania	3 130	3 025
Ireland	2 440	2 827
Austria	2 489	2 730
Belgium	2 176	2 370
Greece	2 091	2 370
Finland	1 005	1 565
Bulgaria	699	699
Lithuania	436	509
Croatia	418	483
Hungary	329	329
Estonia	300	310
Czech Republic	281	282
Cyprus	158	158
Luxembourg	64	120
Latvia	69	70
Slovenia	5	5
Slovakia	3	3
Malta	0	0
Total EU 28	141 415	154 354

** Overseas departments not included for France.*
Source: EurObserv'ER 2017, checked with SHARES data

Gode Wind 1 (330 MW) and Gode Wind 2 (252 MW), which are also in the North Sea, 40 km off the German coast. Dong Energy, which invested 2.2 billion euros in these two projects, claims that the two farms will supply electricity equivalent to the needs of 600 000 German households.

PRODUCTION HINDERED BY THE WEATHER

European Union wind energy output in 2016 will not make history. EurObserv'ER show that it will only have increased slightly (0.3%) over the previous year, to give total production of 302.9 TWh, which is negligible given the increase in installed production capacity (table 4). In contrast to 2015, the weather was very bad for wind energy from Northern Europe to the UK, and not so good in either Germany or France. Southern Europe, apart from Spain, had slightly better winds than in 2015. According to EurObserv'ER, the output of 14 European Union countries declined.

Output contracted by 9.6% in Denmark (12.8 TWh), 7.3% in the UK (37.4 TWh) and 0.8% in Germany (78.6 TWh) and Spain (48.9 TWh). It increased significantly in Italy, by 19.2% (17.7 TWh), and Poland, 15.9% (12.6 TWh). France's output picked up slightly (by 0.7%) to 21.4 TWh. This contrasts with 2017, which was much windier and should cause a very strong surge in wind turbine output, especially in Germany and the Northern European countries... further amplified by the increase

2

Installed offshore wind power capacities in European Union at the end of 2016 (MW)

	2 015	2 016
United Kingdom	5 093.0	5 293.0
Germany	3 280.0	4 130.0
Denmark	1 271.1	1 271.1
Netherlands	357.0	957.0
Belgium	712.2	712.2
Sweden	201.7	201.7
Finland	32.0	32.0
Ireland	25.2	25.2
Spain	5.0	5.0
Portugal	2.0	0.0
Total EU 28	10 979.2	12 627.2

Source: EurObserv'ER 2017

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in installed new capacity. Preliminary results released by AGEB (AG Energiebilanzen), suggest that Germany generated 105.5 TWh in 2017 (including 18.3 TWh offshore), which amounts to a 34.2% increase. It is important to remember that the renewable energy directive targets for 2020 make allowance for normalized production for wind energy and hydropower to even out the variations caused by climate events.

2030 – SIGHTS ARE SET ON ELECTRIFYING THE HEAT AND TRANSPORT SECTORS

The European Commission reckons that the renewable energy share could be as much as 50% of electricity production and that wind energy could well claim the lion's share of that by the 2030 timeline. WindEurope forecasts that wind energy alone could cover 24–28% of electricity demand (i.e. about 778 TWh), in the case of a "central scenario" of 320 GW.

Yet there are some lingering uncertainties because the wind energy deployment pace will depend on the robustness of the European energy policy and the implementation of new operating rules for the electricity market. Another key factor is the roll-out and commitment of the investments needed in the grid infrastructures and electricity supply management systems. The straitjacket of weak European electricity growth will also have to be gotten rid of by implementing new policies that encourage the electrification of other energy sectors, namely heat, refrigeration and transport,

3

Electricity production from wind power in the European Union in 2015 et 2016 (TWh)

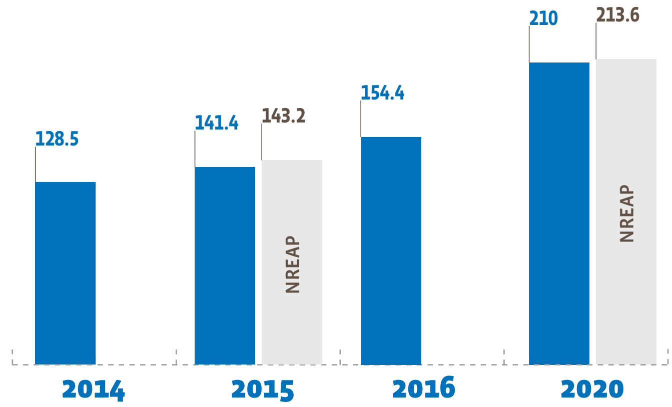
	2015	2016
Germany	79.206	78.598
Spain	49.325	48.906
United Kingdom	40.317	37.367
France**	21.249	21.400
Italy	14.844	17.689
Sweden	16.268	15.479
Denmark	14.133	12.782
Poland	10.858	12.588
Portugal	11.607	12.474
Netherlands	7.550	8.170
Romania	7.063	6.590
Ireland	6.573	6.149
Belgium	5.574	5.436
Austria	4.840	5.235
Greece	4.621	5.146
Finland	2.327	3.068
Bulgaria	1.452	1.425
Lithuania	0.810	1.136
Croatia	0.796	1.014
Hungary	0.693	0.684
Estonia	0.715	0.594
Czech Republic	0.573	0.497
Cyprus	0.221	0.226
Latvia	0.147	0.128
Luxembourg	0.102	0.101
Slovakia	0.006	0.006
Slovenia	0.006	0.006
Malta	0.000	0.000
Total EU 28	301.877	302.893

** Overseas departments not included for France.*
Source: EurObserv'ER 2017, amended with SHARES data

with a view to decarbonizing the energy market. Gradual conversion of these sectors to producing renewable electricity would open new horizons for the sector, which has no long-term limits. ■

4

Comparison of the current trend against the NREAP (National Renewable Energy Action Plans) roadmaps (in GW)



Source: EurObserv'ER 2017

PHOTOVOLTAIC

While China and the USA took full advantage of the price competitivity of solar PV power and enjoyed a twofold increase in their markets (China rose to 34.5 GW in 2016 compared to 15.1 GW in 2015 and the USA to 14.8 GW in 2016 compared to 7.5 GW in 2015), the European Union's newly connected installed capacity dropped sharply again in 2016. According to EurObserv'ER, it increased by only 6 122 MW in 2016 compared to 8 006 MW in 2015, which equates to a 23.5% slower growth pace. The slowdown in the connection pace of the British and French markets is largely to blame. Nonetheless the additional capacity took the EU's PV base past the 100 GW market at the very end of the year with 100 800 MW.

THE UK'S CONNECTION PACE FALLS

For the third year running, the UK has led the European market. According to the BEIS (Department for Business, Energy & Industrial Strategy), solar PV capacity increased by 2 364 MW in 2016, but the year-on-year grid connection pace dropped by 41%. Most of the new connections were from Renewable Obligation-accredited sites and occurred during the first quarter of the year, before the RO system closed on 1 April 2016. The connection pace was much slower over the following three quarters and was essentially made up of connections of smaller sites remunerated by the Feed-in Tariff system.

SIGNIFICANT FALL IN BID PRICES FOR SOLAR POWER IN GERMANY

The year 2016 ended on a high note in Germany, putting an end to the steady decline in the amount of capacity connected annually since 2013. According to the German Environmental agency that now coordinates the working group on renewable energy statistics (AGEE-Stat), the country added 1 471 MW of additional capacity in 2016 (compared to 1 345 MW in 2015), which took its total base up to 40 714 MW. The increase in the number of connections at the end of the year was caused in part by the sharp drop in the market price of PV panels, and in part by a change to

Stockholms Hamnar

1

Installed solar photovoltaic capacity in the European Union at the end of 2016 (MW)

	2015	2016
Germany	39 243	40 714
Italy	18 901	19 283
United Kingdom	9 535	11 899
France	6 755	7 320
Spain	4 856	4 973
Belgium	3 122	3 300
Greece	2 604	2 604
Czech Republic	2 075	2 068
Netherlands	1 515	2 049
Romania	1 326	1 372
Austria	937	1 096
Bulgaria	1 029	1 028
Denmark	782	851
Slovakia	533	533
Portugal	447	462
Slovenia	238	233
Hungary	168	208
Poland	108	187
Sweden	104	153
Luxembourg	116	122
Malta	74	93
Cyprus	76	84
Lithuania	69	70
Croatia	48	56
Finland	15	35
Ireland	2	6
Latvia	0	1
Estonia	0	0
Total EU 28	94 678	100 800

** Overseas departments not included for France.*
Source: EurObserv'ER 2017, amended with SHARES data

the regulations. The new provisions of the EEG 2017 law, applicable on 1 January effectively imply that henceforth, all power plants with >750 kW capacities, will be selected by a bidding procedure, regardless of whether they are ground- or roof-mounted. The Feed-in Tariff system still applies for <750 kW installations. The FiT tariffs have not been changed since 1 September 2015 and as the annual target of 2 500 MW has not been exceeded, they will be pegged until at least the end of April 2017.

In November 2017, Bundesnetzagentur, the Federal grid agency, published the results of the 3rd call for photovoltaic tenders for >750 kw systems under the terms of the new EEG 2017 law. One hundred and ten projects were selected for a total volume of 753.6 MW. The mean FiT tariff was € 52.3 per MWh ranging from € 72 per MWh to € 42.9 per MWh. These results should be compared with the result of the first bid to be launched under the terms of the new law in March 2017 when 38 projects were selected for a total volume of 200 MW. The mean FiT tariff was € 65.8 per MWh, the top tariff at € 67.5 per MWh and the lowest tariff was € 60 per MWh.

FRANCE CLARIFIES ITS SOLAR ROAD MAP

In 2016, France just managed to hold off the Netherlands and keep its No. 3 rank in the European solar market league. It did so despite a sharp drop in the amount of capacity connected. According to the SDES, the French Department of Data and Statistical Studies, only 565 MW of additional capacity was hooked up in mainland France in

2

Electricity production from solar photovoltaic in the European Union countries in 2015 and 2016 (in GWh)*

	2015	2016
Germany	38 726	38 098
Italy	22 942	22 104
United Kingdom	7 546	10 420
France	7 262	8 160
Spain	8 267	8 069
Greece	3 900	3 930
Belgium	3 053	3 086
Czech Republic	2 264	2 131
Romania	1 982	1 820
Netherlands	1 122	1 559
Bulgaria	1 383	1 386
Austria	937	1 096
Portugal	796	822
Denmark	604	744
Slovakia	506	533
Slovenia	274	267
Hungary	123	200
Cyprus	127	146
Sweden	97	143
Malta	93	125
Poland	57	124
Luxembourg	104	100
Lithuania	73	66
Croatia	57	66
Finland	10	18
Ireland	2	4
Latvia	0	0
Estonia	0	0
Total EU 28	102 306	105 220

** Overseas departments not included for France.*
Source: EurObserv'ER 2017, amended with SHARES data

2016, which is the lowest annual volume recorded since 2009. The reasons for this situation are the dearth of projects that went into development at the end of 2014 and at the beginning of 2015, and the erratic timing of calls for tender.

The energy roadmap was finally clarified at the end of 2016 when a 3-year tendering process was set up for annual volumes of 1.45 GW. This target was upscaled in December 2017 by the new Minister for the Ecological and Solidarity Transition, Nicolas Hulot, who announced a 1-GW increase in the tendering volume, which took it to 2.45 GW per annum. This increase will be gradually phased in, as and when the forthcoming tendering rounds are launched, i.e. in March 2018 for systems on buildings and in June 2018 for ground-based plants. A bi-technology tender pitching the PV and onshore wind power sectors against each other has also been announced following the request of the European Commission to comply with its guidelines on state aid. The experimental tender should assess the relative competitivity of the ground-based PV and onshore wind power sectors. It covers a total volume of 200 MW for individual project capacities of 5–18 MW.

LESS SUNSHINE OVER THE YEAR

Solar power output in 2016 will not make the history books. All in all, across the European Union, the weather was not conducive to generating solar power. Drops in output were recorded in several countries (Germany, Italy, Spain, Romania and the Czech Repu-

blic). The most active markets leaving aside Germany – the UK and France – had the highest outputs. According to EurObserv'ER, European Union PV output rose to 105.2 TW in 2016, which represents 2.8% year-on-year growth. Yet while output increased by almost 10 TWh between 2014 and 2015, it only increased by 2.9 TWh between 2015 and 2016.

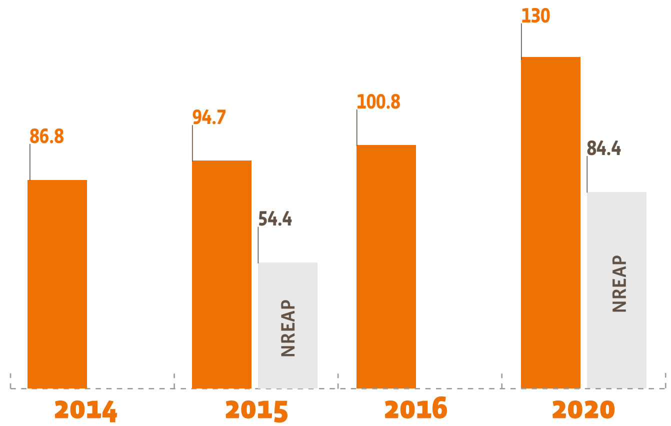
CONSUMERS WILL BE AT THE CENTRE OF THE FORTHCOMING ENERGY UNION

Current developments in support mechanisms, which are geared to market mechanisms, have an impact on the grid connection figures. The auction system, which has become the rule for medium- and high-capacity installations, gives Member States better control of their markets while limiting the increase in the price of electricity to consumers. It also prepares the ground for the next installation rounds that will be required to achieve the individual country renewable energy targets, which were set under the terms of the European RES Directive. Additionally, it meets the demand from the major utilities to limit the financial burden on the profitability of their production means caused by generating variable renewable electricity. In effect, the influx of solar or wind power onto the market at zero marginal cost, exerts downward pressure on the price of electricity and may even lead to negative prices during periods of overproduction. PV development has been faster than most of the Member States expected when they set their National Renewable Energy Action Plan PV targets. Most of these countries have exceeded their production forecasts. Furthermore, if we add up all the European Union countries' photovoltaic targets for 2020, the combined target was outstripped at the end of 2015 and could reach 130 GW by 2020 compared to the initial combined forecast of 84.4 GW.

The PV sector is now adjusting to a new market structure, where "prosumers" (consumer-producers) will play an increasing role. The movement is inspired by eco-citizenship… wanting to produce the electricity to cover their needs locally as well as for financial gain. It is in consumers' interests to produce their own electricity for less than the purchase price invoiced by the utility companies and sell their surplus electricity onto the electricity market. ■

3

Comparison of the current trend of photovoltaic capacity installed against the NREAP (National Renewable Energy Action Plans) roadmap (in GWp)



Source: EurObserv'ER 2017

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SOLAR THERMAL

The European solar thermal market's foundations are being increasingly eroded, as the European Union market now stands at 2.6 million m^2, which is 2 million m^2 less than it was in the reference year, 2008 (4.6 million m^2). EurObserv'ER puts the thermal capacity of newly-installed solar thermal facilities at 1 810 MWth in 2016, which is 5.1% less than in 2015. Taking 2008 as the reference year, the market has been contracting by an annual average of 7%. Flat plate collectors still account for most of the installed surface area (92.3%), followed by vacuum collectors (6.4%) and unglazed collectors (1.3%). The total surface area of the European Union's solar thermal base was about 50.4 million m^2 (35 287 MWth), which is 3.6% more than in 2015.

The underlying reasons for the trend decline are constant. The solar thermal market is directly hit by the low prices of natural gas and heating oil that affect solar heat's ability to compete by giving the advantage to the multiservice condensing gas boiler market. The stop-start, degressive subsidy policies operating in some countries have also hit solar thermal's momentum in the residential sector segment. Solar thermal also competes badly with other easier-to-install, renewable solutions whose purchase price is lower, such as thermodynamic hot water heaters and AGHP. PV's continuing appeal to private homeowners and investors also stands in the way of solar thermal's development. As photovoltaic power self-consumption has been given the green light, PV is also entering the domestic hot water production segment as an electric hot water tank can use any surplus electricity generated.

Market forces are roughly the same as they were last year. The German market is still well placed in European solar thermal market; as yet again, it accommodates almost 30% of the newly-installed collector area in the European Union. However, it has failed to stem its own domestic market's decline. Denmark, which promotes the construction of vast collector fields to supply heating networks, is clearly blazing the trail for solar thermal. The main change with regard to last year has been felt in the Polish market, which having grown in 2015, took a nose dive in 2016. The state of play in France is now causing great concern, where as a result of the policy of promoting electrical hot water production systems (such as thermodynamic hot water heaters) that are attractive for installers who consider this type of system easier to install, solar thermal has become a niche market for domestic hot-water production or solar heating. In a couple of markets – Spain and Italy – where solar thermal is a priority energy source in new build, the low level of construction activity also casts a shadow over the prospects for sector development. Only Greece is a safe bet and can be trusted to maintain a 270 000-m^2 installation level from year to year, partly as it needs to replace existing equipment.

SOLAR HEAT WARMS UP DANISH NETWORKS

Denmark had an exceptional year in 2016. It installed 478 297 m^2 of collectors, 99% of which were intended to supply heating networks while the remaining one percent was for individual

domestic hot water production. This newly-installed area is almost double the previous year's figure (260 161 m^2). Denmark has built 31 new solar heating networks and extended the collector field to 5 other networks. It had already built 15 heating networks and extended 3 networks the previous year. According to PlanEnergi calculations there are 104 solar heating networks in Denmark supplied by 1 301 000 m^2 of collectors. The town of Silkeborg holds the record for the biggest solar heating network in the country (and the world) since December 2016.

THE GERMAN MARKET CONTINUES TO SLIDE

Despite the efforts made to prop up the sector, the solar thermal market's downward trend could not be stemmed. According to AGEE-Stat, the Working Group on Renewable

1

Annual installed surfaces in 2015 per type of collectors (in m²) and power equivalent (in MWth)

	Glazed collectors		Unglazed collectors	Total (m²)	Equivalent power (MWth)
	Flat plate collectors	Vacuum collectors			
Germany	729 000	77 000	25 000	831 000	581.7
Poland	225 000	52 000		277 000	193.9
Greece	271 000	600		271 600	190.1
Denmark	260 161			260 161	182.1
Spain	226 138	11 121	3 375	240 634	168.4
Italy	201 810	27 520		229 330	160.5
France*	139 850		6 000	145 850	102.1
Austria	134 260	2 320	890	137 470	96.2
Czech Republic	22 000	9 000	30 000	61 000	42.7
Portugal	45 304	830		46 134	32.3
Belgium	38 250	6 750		45 000	31.5
Netherlands	17 548	3 971	2 621	24 140	16.9
Ireland	12 720	9 953		22 673	15.9
Croatia	19 000	2 500		21 500	15.1
United Kingdom	16 935	3 306		20 241	14.2
Cyprus	18 000	600		18 600	13.0
Romania	6 800	11 000		17 800	12.5
Hungary	10 080	5 570	1 250	16 900	11.8
Sweden	4 928	1 643		6 571	4.6
Bulgaria	5 100	500		5 600	3.9
Luxembourg	4 700	750		5 450	3.8
Slovakia	4 500	800		5 300	3.7
Finland	3 000	1 000		4 000	2.8
Slovenia	2 200	600		2 800	2.0
Lithuania	800	1 400		2 200	1.5
Estonia	1 000	1 000		2 000	1.4
Latvia	1 580	330		1 910	1.3
Malta	742	186		928	0.6
Total EU 28	**2 422 406**	**232 250**	**69 136**	**2 723 792**	**1 906.7**

** Including 41 248 m² in overseas departments.* ***Source: EurObserv'ER 2017***

2

Annual installed surfaces in 2016 per type of collectors (in m²) and power equivalent (in MWth)

	Glazed collectors		Unglazed collectors	Total (m²)	Equivalent power (MWth)
	Flat plate collectors	Vacuum collectors			
Germany	677 000	67 000	22 000	766 000	536,2
Denmark	478 297			478 297	334,8
Greece	271 400	600		272 000	190,4
Spain	201 793	7 076	3 321	212 190	148,5
Italy	186 647	25 043		211 690	148,2
France**	114 600		5 500	120 100	84,1
Poland	111 700	3 700		115 400	80,8
Austria	109 600	1 440	760	111 800	78,3
Belgium	39 000	7 500		46 500	32,6
Portugal*	45 300	800		46 100	32,3
Czech Republic	22 000	9 000		31 000	21,7
Netherlands	20 137	5 179	2 621	27 937	19,6
Croatia*	19 000	2 500		21 500	15,1
Ireland	11 204	8 564		19 768	13,8
Hungary*	13 050	5 592	188	18 830	13,2
Cyprus	18 000	600		18 600	13,0
Romania*	6 800	11 000		17 800	12,5
United Kingdom	10 900	3 010		13 910	9,7
Slovakia	8 000	1 600		9 600	6,7
Bulgaria*	5 100	500		5 600	3,9
Finland*	3 000	1 000		4 000	2,8
Luxembourg	3 759			3 759	2,6
Sweden	2 763	336	75	3 174	2,2
Slovenia	2 300	400		2 700	1,9
Lithuania*	800	1 400		2 200	1,5
Estonia*	1 000	1 000		2 000	1,4
Latvia*	1 500	300		1 800	1,3
Malta	614	154		768	0,5
Total EU 28	**2 385 264**	**165 294**	**34 465**	**2 585 023**	**1 810**

** No data available, Observ'ER estimation based on the 2016 Estif market figure. ** Including 47 082 m² in overseas departments.*
Source: EurObserv'ER 2017

3

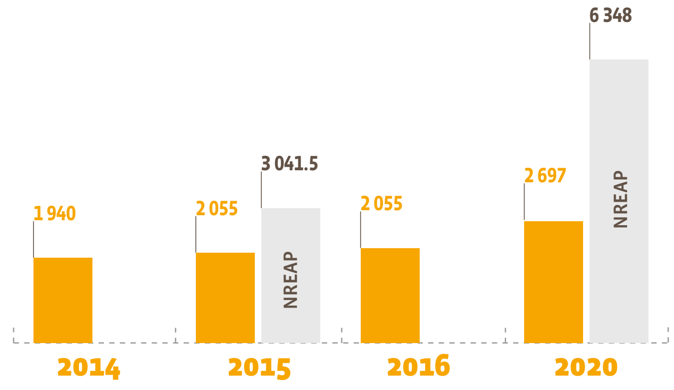
Cumulated capacity of thermal solar collectors installed in the European Union in 2015 and 2016** (in m² and in MWth)*

	2015		2016	
	m²	MWth	m²	MWth
Germany	18 625 000	13 038	19 121 000	13 385
Austria	5 221 342	3 655	5 210 202	3 647
Greece	4 390 375	3 073	4 477 375	3 134
Spain	3 693 638	2 586	3 905 928	2 734
Italy	3 724 000	2 607	3 891 000	2 724
France***	2 929 960	2 051	3 018 040	2 113
Poland	2 017 337	1 412	2 132 467	1 493
Danemark	1 016 000	711	1 369 000	958
Portugal	1 121 104	785	1 167 204	817
Czech Republic	1 106 542	775	1 137 542	796
United Kingdom	702 342	492	715 252	501
Belgium	661 000	463	705 000	494
Netherlands	647 397	453	652 205	457
Cyprus	659 224	461	647 824	453
Sweden	478 000	335	475 000	333
Ireland	320 000	224	343 000	240
Hungary	269 000	188	287 296	201
Slovenia	238 800	167	241 500	169
Romania	203 670	143	221 300	155
Croatia	183 000	128	204 500	143
Slovakia	171 420	120	181 020	127
Bulgaria	84 800	59	85 000	60
Luxembourg	55 590	39	59 349	42
Finland	50 000	35	55 000	39
Malta	50 904	36	51 671	36
Latvia	20 920	15	22 720	16
Lithuania	15 750	11	17 950	13
Estonia	12 120	8	14 120	10
Total EU 28	48 669 235	34 068	50 409 465	35 287

** All technologies including unglazed collectors. ** Estimate. *** Overseas department included.* ***Source: EurObserv'ER 2017***

4

Comparison of the current trend against the NREAP (National Renewable Energy Action Plans) roadmap (in ktoe)



Source: EurObserv'ER 2017

Energy-Statistics, 766 000 m² (including 22 000 m² unglazed) of collectors were installed in Germany in 2016, compared to 831 000 m² in 2015 (including 25 000 m² of unglazed collectors), which equates to a 7.8% decline. The full raft of aids targeting the residential, collective segments and industrial heating were to no avail. BAFA (the Federal Office for Economic Affairs and Export Control) ascribes the solar thermal market contraction to low heating oil and gas prices which erode the competitiveness of solar thermal solutions.

THE POLISH MARKET PLUMMETS IN THE ABSENCE OF INCENTIVES

Although the Polish solar thermal market was resilient in 2015, expanding by 6.5% to 277 000 m², it took a nose dive in 2016 plummeting to 115 400 m² according to data released by SPIUG (Association of Manufacturers and Importers of Heating Appliances). The market was expected to decline but on a much smaller scale. The reason for this fall is that the subsidies awarded to solar thermal under the "transient" national Prosument programme were discontinued in the summer of 2016. The remaining funds of the NFOSiGW (National Fund for Environmental Protection and Water management) residential subsidy programme that formed the basis of the Prosument programme were transferred to regional funds responsible for setting up this policy.

SOLAR THERMAL IS LOSING GROUND

The downward trend of the market witnessed since 2009 has seen the gap with the National Renewable Energy Action Plan (NREAP) trajectory open up. What is of even more concern, is that in a few countries (Austria, Sweden and Cyprus) the area of collectors in service is tending to contract as their newly-installed areas do not make up for the areas that have been decommissioned. The capacity and surface area of decommissioned installations tends to rise every year, because the solar thermal market built up gradually in the second half of the 1990s, peaking at about one million m2 of newly-installed collectors per annum. As the service life of these collectors ends and if market recovery does not come about, growth in the contribution of solar heat can only decline.

The intermediate trajectory of the NREAP plans was set at 3 Mtoe for solar heat in 2015, yet it only scraped past the 2.1-Mtoe mark in 2016. EurObserv'ER reckons that if nothing is done to reverse the trend quickly, the difference between reality and the targets could be much wider than previously feared and could even fall below 50% of the NREAP commitments for 2020 (graph 2).

While the outlook is grim, it is not disastrous, for while the individual home segment cannot deliver to expectations, the growth prospects for solar thermal in the collective housing hot water production, industrial heat production and district heating are much more promising. In fact, they are underpinned by stricter European regulations and the offer of suitable equipment by the manufacturers to slash production costs (large collectors, suitable technologies). ■

SMALL HYDROPOWER

This sector includes installations of up to 10 MW of capacity that usually operate as run-of-the-river plants, without a retaining dam in place. Yet they are generally equipped with a small dam that does not store water but creates a vertical drop. The height of the water created, combined with the speed at which it flows determine the amount of energy produced.

This method offers several advantages such as positive contribution to grid stability. It enables local energy sources to be used, which secure the local power supply. However, the potential for developing small hydropower is hampered by environmental legislation, such as the framework directive, Natura 2000, which covers water and planning protected areas.

The European Commission and the public powers seek to reconcile the issues of producing renewable electricity while applying the best conservation practices to watercourses. The regulations concerning hydropower facilities focus on the best possible energy optimisation combined with mitigating the impacts on biodiversity as much as possible.


Pixabay

EurObserv'ER puts the net capacity of small hydropower facilities in the European Union at 14 294 MW based on official data. Yet again, capacity rose in 2016 by 282 MW, which equates a 1.9% increased (it rose by 256 MW in 2015). By way of comparison, at the end of 2016, the combined net capacity of large, >10 MW hydropower facilities, excluding pumped-storage plants was 90 384 MW (89 549 MW at the end of 2015). Thus, at the close of 2016 small- and large-scale hydropower in the European Union offered combined capacity of 104 678 MW (103 561 MW a year earlier). This capacity is of the same magnitude as the European Union's solar capacity (PV and CSP), but with a much higher load factor and thus much higher output (see further on).

The top three countries for small hydropower capacity are Italy (3 299 MW), France (2 096 MW) and Spain (1 947 MW). In 2016 Austria (1 332 MW) managed to overtake Germany (1 326 MW) to take fourth place. Looking at the main changes, Italy enjoyed the most significant

1

Small hydraulic capacity (≤10 MW) in running in the European Union countries in 2015 and in 2016 (in MW)*

	2015	2016
Italy	3 208	3 299
France	2 065	2 096
Spain	1 953	1 947
Austria	1 280	1 332
Germany	1 327	1 326
Sweden	961	961
Romania	518	535
United Kingdom	368	426
Portugal	394	404
Czech Republic	335	337
Bulgaria	301	321
Finland	306	307
Poland	279	279
Greece	223	223
Slovenia	157	155
Slovakia	75	77
Belgium	66	69
Ireland	41	41
Croatia	36	37
Luxembourg	34	34
Latvia	29	29
Lithuania	27	27
Hungary	16	16
Denmark	7	10
Estonia	6	6
Total EU 28	**14 012**	**14 294**

Source: EurObserv'ER 2017, amended with SHARES data growth in the amount of capacity harnessed (91 MW), ahead of the UK (which added 58 MW) and Austria (which added 52 MW).

Having plummeted in 2015 by 13.1%, small hydropower output in the European Union increased slightly in 2016 (by 4.2%). It grew by 1.9 TWh to 47.2 TWh in 2016, after losing 6.8 TWh. The fortunes of large-scale hydropower output are similar and also suffer from the dearth of rainfall. It increased by 2.4% between 2015 and 2016 to 303 TWh, after recording an 8.4% drop in 2015. The combined output of small- and large-scale hydropower excluding pumped storage output amounted to 350.1 TWh (2.4% more). Once again hydropower was the top source of renewable electricity production in the European Union ahead of wind power.

If we focus on small hydropower only, Italy comfortably occupied the top producer slot (10.8 TWh), ahead of France (6.6 TWh) and Austria (6 TWh). The most significant changes to report are an increase of 802 GWh by France (6 552 GWh), 600 GWh by Austria (6 033 GWh) and a drop of 1 081 GWh by Sweden.

DEVELOPMENT BELOW EXPECTATIONS

It is hard to follow small hydropower trends because they can be subject to statistical variations and upgrading of plant status through redevelopment work. Electricity price variations can also influence the commissioning of some sites whose production costs approach break-even point, the installed capacity being higher than

2

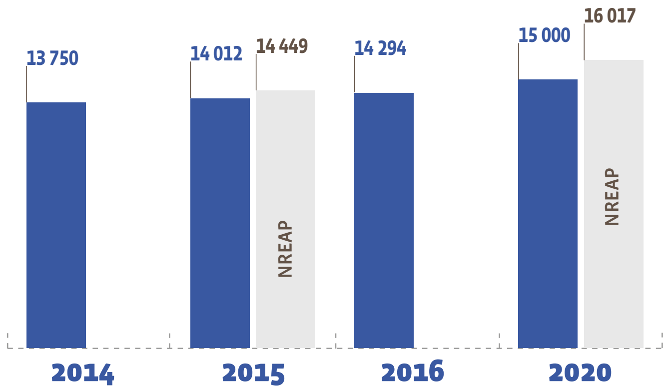
Small hydraulic gross electricity production (≤10 MW) in the European Union (in GWh) in 2015 and 2016

	2015	2016
Italy	10 864	10 814
France	5 750	6 552
Austria	5 433	6 033
Spain	5 014	5 409
Germany	4 672	5 062
Sweden	4 087	3 006
Romania	1 261	1 379
Portugal	795	1 310
United Kingdom	1 299	1 285
Finland	1 287	1 189
Czech Republic	1 002	1 053
Bulgaria	1 063	1 034
Poland	821	909
Greece	708	722
Slovenia	327	432
Belgium	185	222
Slovakia	117	147
Luxembourg	99	115
Croatia	101	114
Ireland	124	106
Lithuania	70	86
Hungary	59	69
Latvia	74	62
Estonia	27	35
Denmark	18	19
Total EU 28	45 257	47 165

Source: EurObserv'ER 2017, amended with SHARES data

3

Comparison of the current trend of small hydraulic capacity installed against the NREAP (National Renewable Energy Action Plans) roadmap (in MW)



Source: EurObserv'ER 2017

the capacity exploited. A major line of sector development is the redevelopment of certain sites. Accordingly, the European Commission supports the RESTOR (Renewable Energy Sources Transforming Our Regions) project, which seeks to identify the most promising sites for restoration or recommissioning. The project leaders claim that in Europe there is untapped hydropower potential... thousands of old mills, unused weirs and disused hydropower plants. Recommissioning abandoned sites would allow renewable energy to be produced close to the points of consumption and thus generate grid savings. The idea behind this project is also to develop a new economic model by creating regional cooperatives that include a community-based share ownership development plan.

Despite these efforts, the current trend is out of step with the capacity targets defined by the National Renewable Energy Action Plans. Its development is hampered by lengthy and costly procedures, local opposition and often the lack of political support. ■

GEOTHERMAL ENERGY

This form of energy is drawn from the subsoil as hot water or steam. It is used for space heating, space cooling and producing electricity. Geothermal techniques and uses vary in line with the temperature of the aquifer from which the water is drawn. When it ranges from 30° to 150°C (from a depth of a few hundred to approximately 2 000 metres), geothermal heat can be used for district heating (heating networks) or be supplied directly to heat single-family homes, multi-occupancy buildings or for use on farms. One or more very high capacity heat pumps (HP) may be coupled with a geothermal heating network system to improve its performance by increasing the temperature range that can be harnessed by the network, thus optimizing the use of the available geothermal energy.

When the aquifer temperature ranges from 90 to 150°C, electricity can also be produced. In this case, the water drawn from the subsoil, which is liquid when it reaches the surface, transfers its heat to another liquid that vaporises at below 100°C. The steam obtained by this technique drives a turbine to generate electricity. These plants can be run as combined heat and power plants producing heat for heating networks and power at the same time. Water drawn from depths of more than 1 500 metres above 150°C (up to 250°C), reaches the surface as steam and can be used directly to drive electricity generating turbines. This is what is called high-energy geothermal power. It is found in volcanic regions and at plate boundaries. Heat pump systems that extract the superficial heat from the soil and surface aquifers are dealt with specifically and by convention are excluded from official geothermal energy data.

HEAT PRODUCTION

The uses of geothermal heat are manifold. The main application is for heating dwellings and commercial premises, but it can also be applied to agriculture (heating greenhouses, drying crops, etc.), fish-farming, industrial processes, the spa industry or heating pools. Refrigeration is another area of use. Faced with so many solutions, accurate and regular monitoring of the thermal capacity by the official statistical bodies can be dogged by shortcomings. The most accurate monitoring is currently conducted by the EGEC exclusively within the scope of geothermal heating networks. Compared with 2012, the number of heating networks has increased sharply as 51 new networks have been commissioned, corresponding to 550 MWth of additional capacity over the past 5 years. This additional capacity equates to mean annual growth of 10% across the European Union. Incidentally, while the urban heating network market trend revolves around renovation and expanding existing systems, the trend is reversed for geothermal heating networks. EGEC claims that 77% of the district heating systems installed over the past five years have been for new geothermal plants, while the remaining

1

Capacity installed and net capacity usable of geothermal electricity plants in the EU in 2015 and 2016 (in MWe)

	2015		2016	
	Capacity installed	Net capacity	Capacity installed	Net capacity
Italy	915.5	768.0	915.5	767.2
Germany	34.0	26.0	40.0	29.0
Portugal	29.0	25.0	29.0	25.0
France*	17.1	17.1	17.1	17.1
Austria	1.0	1.0	1.0	1.0
Total EU 28	**996.6**	**837.1**	**1 002.6**	**839.3**

French overseas department included (15 MW in Guadeloupe).
Source: EurObserv'ER 2017

2

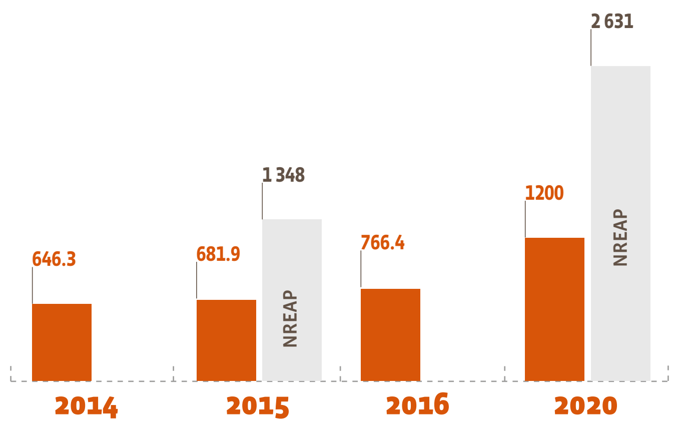
Heat consumption from geothermal energy in the countries of the European Union in 2015 and 2016

	2015			2016		
	Total heat consumption	of which final energy consumption	of which derived heat*	Total heat consumption	of which final energy consumption	of which derived heat*
Italy	132.8	114.1	18.6	144.1	124.7	19.3
France	121.7	29.5	92.1	134.6	29.5	105.0
Hungary	95.7	53.5	42.3	115.0	50.5	64.5
Germany	83.3	68.4	15.0	100.1	81.1	19.0
Netherlands	58.5	58.5	0.0	67.9	67.9	0.0
Slovenia	38.5	38.0	0.5	43.9	43.4	0.5
Bulgaria	33.4	33.4	0.0	34.6	34.6	0.0
Romania	25.7	19.7	6.0	31.7	25.6	6.1
Poland	21.7	21.7	0.0	22.2	22.2	0.0
Austria	21.0	7.2	13.8	20.4	7.2	13.3
Spain	18.8	18.8	0.0	18.8	18.8	0.0
Greece	9.9	9.9	0.0	10.1	10.1	0.0
Croatia	8.9	8.9	0.0	9.1	9.1	0.0
Slovakia	4.2	1.3	2.9	4.9	1.6	3.3
Denmark	1.7	0.0	1.7	2.7	0.0	2.7
Belgium	1.5	0.0	1.5	1.6	0.0	1.6
Cyprus	1.6	1.6	0.0	1.6	1.6	0.0
Portugal	1.5	1.5	0.0	1.4	1.4	0.0
Lithuania	0.8	0.0	0.8	1.0	0.0	1.0
United Kingdom	0.8	0.8	0.0	0.8	0.8	0.0
Czech Republic	0.0	0.0	0.0	0.0	0.0	0.0
Estonia	0.0	0.0	0.0	0.0	0.0	0.0
Ireland	0.0	0.0	0.0	0.0	0.0	0.0
Latvia	0.0	0.0	0.0	0.0	0.0	0.0
Luxembourg	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
Finland	0.0	0.0	0.0	0.0	0.0	0.0
Sweden	0.0	0.0	0.0	0.0	0.0	0.0
Total EU 28	681.9	486.8	195.1	766.4	530.0	236.4

Source: EurObserv'ER 2017, amended with SHARES data

3

Comparison of the geothermal heat generation trend against the NREAP (National Renewable Energy Action Plan) roadmap (in ktoe)



Source: EurObserv'ER 2017

23% activity focused on renovation or extending existing systems.

The year 2016 was very busy for commissioning new heating networks and network extensions involving 15 plants, essentially in France, but also in Germany, Italy, the Netherlands, Romania and Slovakia. The combined additional capacity of these systems is about 139 MW. France is currently the most active European Union country in this area, having connected and extended nine heating networks, eight of which are in Greater Paris (Bagneux 12 MWth, Ivry sur Seine 12.5 MWth, Le Blanc Mesnil 12 MWth, Clichy Batignolles 5 MWth, Tremblay en France 13.9 MWth, Val d'Europe 19.5 MWth, Villejuif 10 MWth and Villepinte 10 MWth and one located in the Grand-Est region at Rittershoffen which is a deep, EGS (Enhanced Geothermal System) geothermal project. The plant was inaugurated by Électricité de Strasbourg, Roquette and Caisse des Dépôts. It uses geothermal fluid at 165°C extracted at a depth of 2 500 m to supply heat to the industrial processes of a factory located 15 km away. Its 24-MW capacity will reduce the factory's CO_2 emissions by 39 000 tonnes. As the first of a kind in the world and a model for energy transition, the plant marks a major step towards the more widespread development of Enhanced Geothermal Systems, which enable deep geothermal energy to be tapped in new areas. In 2016, two geothermal networks were also inaugurated in Bavaria, Germany – one at Munich Freiham (20 MWth) and the

4

Capacity of geothermal district heating systems installed in the European Union in 2015 and 2016 (in MWth)

	2015	2016
France	389.5	492.5
Germany	262.6	300.6
Hungary	271.1	253.6
Italy	137.6	156.5
Netherlands	121.8	126.8
Romania	83.0	85.0
Poland	100.2	63.6
Austria	52.6	59.9
Sweden	33.0	48.0
Denmark	33.2	33.2
Croatia	19.9	19.9
Slovakia	14.2	16.0
Lithuania	13.6	13.6
Belgium	10.0	10.0
Czech Republic	3.2	6.5
Slovenia	3.7	3.7
United Kingdom	2.8	2.0
Total EU 28	**1 551.8**	**1 691.2**

Source: EGEC Market report 2015, Market Report 2016

other at Kirchweidach (12 MWth). The other newly-commissioned networks were at Vierpoldeers in the Netherlands (15.7 MW), the Friuli-Venezia-Giulia-Grado (2 MW) pilot project in Italy, the Balotesti site (2 MW) in Romania and Velky Meder (1.8 MWth) in Slovakia.

Geothermal heat output data is regularly monitored by the national statistical offices and Eurostat. The official data collected by EurObserv'ER, which includes geothermal heat distributed by networks and the heat directly used by the final user, suggest 766.4 ktoe of output in 2016, i.e. 12.4% year-on-year growth (5.5% growth between 2014 and 2015).

IMPLEMENTING SMART HEATING NETWORKS

Geothermal energy is performing well below the trajectory level mapped out in the National Renewable Energy Action Plans. The EU report on renewable energies notes that the deployment of geothermal energy is under par and that the EU has generally fallen behind its planned trajectory for renewable energies. Various factors are to blame for this poor progress towards achieving the NREAP targets… primarily the recession at the start of the 2010s and inconsistency in EU heating and cooling policy. Nonetheless, the sector's recovery over the past five years, gives grounds for more optimism when we consider the deployment trajectory of geothermal energy.

One of the promising trends for the future is the development and installation of smart heating networks. Smart grids do not only involve production, but also the heat production of networks capable of combining a variety of renewable energies, while utilising electricity surpluses. Geothermal energy, in the same way as solar thermal, currently plays a very important role in the development of smart heating networks, both for producing heat and hot water but also refrigeration for the summer season, or for industry. The challenges faced by smart cities are not only that each one has its own specific characteristics, but that they comprise different zones and levels of urban density (city centre, districts, suburbs, parks, etc.). Covering the heating and air-conditioning consumption of smart cities calls for smart thermal networks to respond to this and other energy transition challenges for a low-carbon economy.

THE THRESHOLD OF 1000 MW OF ELECTRICITY HAS BEEN PASSED

EurObserv'ER puts the combined geothermal power capacity of the European Union at a slightly higher level with installed capacity standing at 1003 MW (a 5.5 MW increase). Net capacity, which is the maximum capacity presumed to be exploitable, is put at 839.3 MW (2.2 MW more), including 15 MW in Guadeloupe. Gross electricity output rose to 6.7 TWh in 2016, compared to 6.6 TWh in 2015. If we leave out the French overseas departments (which are excluded by Eurostat), output increased from 6.5 TWh in 2015 to 6.6 TWh in 2016. EurObserv'ER claims that Germany is the only country to have increased its geothermal capacity by connecting the Traunreut plant in Bavaria equipped with a 5.5-MW electric turbine. This cogeneration plant was already supplying 12 MWth of heat to the town back in 2014. AGEEstat reports that Germany's net exploitable electrical capacity is now 29 MW, for about 40 MW of installed capacity. The reasons for the difference are plant operating problems, restrictive operating permits and the fact that self-consumption is a major reality in geothermal plants. Italy is the main European geothermal energy leader with 915.5 MW installed. This figure was stable between 2014 and 2015. According to the Ministry of Economic Development data, net exploitable capacity is 767.2 MW which is very slightly less than in 2015.

CAPACITY INCREASES DASH EXPECTATIONS

Data from the EGEC 2016 report suggests that European Union geothermal energy capacity should increase in the next few years and could rise to 1 185 MW by 2020. By that time new European Union countries should be able to establish a production sector, such as Croatia (26 MW), Greece (23 MW), Hungary (22 MW) and the Czech Republic (10 MW). Yet this forecast for 2020 falls far short of the planned targets set out in the National Renewable Energy Action Plans that provided for 1627.9 MW of combined geothermal capacity in 2020. As it stands, output will be unable to pass the 8 TWh mark, while the trajectory forecast was for 10.9 TWh in 2020. ■

5

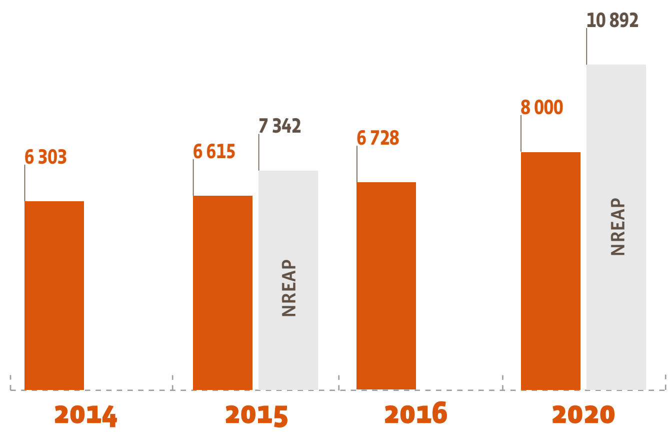
Gross electricity generation from geothermal energy in the European Union countries in 2015 and 2016 (in GWh)

	2015	2016
Italy	6185.0	6288.6
Portugal	203.6	171.6
Germany	134.1	174.7
France*	92.0	93.0
Austria	0.06	0.02
Total EU	**6614.7**	**6727.9**

The data of France include DOM (Guadeloupe), the recorded production in metropolitan France was 0 GWh in 2015 and 4 GWh in 2016.
Source: EurObserv'ER 2017

6

Comparison of the current geothermal electricity generation trend against the NREAP (National Renewable Energy Action Plan) roadmap (in GWh)



Source: EurObserv'ER 2017

HEAT PUMPS

If we are to grasp how the market is developing, we must identify the various types of heat pumps (HPs). They are differentiated both by the energy source used (ground, water, air), by the types of heating unit used (fan-coil unit, underfloor heating, low- or high-temperature radiators), and also their application. Heat pumps can be used solely for heating purposes, but if they are reversible, can expel a dwelling's heat to cool it down.

Heat pumps are generally grouped into three main categories, namely ground source heat pumps (GSHPs), which extract heat from the ground (via horizontal or vertical sensors), hydrothermal HPs, that draw heat from water (the water table, rivers or lakes), and air source (ASHPs), whose heat source is air (outside, exhaust or indoor air). We have amalgamated the hydrothermal and ground source HP statistics for the sake of convenience

AIR-SOURCE TECHNOLOGIES DOMINATE THE MARKET

If we look at the ground-source and air-source heat pump market for home heating with or without the cooling option, the recovery started in 2015 was clearly pursued in 2016. According to EurObserv'ER, more than 3.3 million units were sold in the European Union in 2016, which equates to 26.1% growth (compared to 20% between 2014 and 2015). This estimate includes all HP systems including those primarily used for cooling purposes provided that the countries consider that the energy efficiency criteria set by the European Directive are upheld and that these units actually produce renewable heat.

Amprion/Achim Blazy

Most of the HP sales on the European market – 2 990 133 units in 2016 – were of the air-to-air type… amounting to 28.6% growth Their heat transfer unit is the fan coil (that blows hot or cold air). The success of this type of HP can be ascribed to their low installation costs, easier installation and the increasing demand from householders for space cooling.

Practically all the air-to-air HPs sold nowadays are reversible, but their main application as meeting heating or cooling needs can differ widely between the Northern European and Southern European regions near the Mediterranean. The real picture in the various European Union markets often defies direct comparison. This may also apply within a single country, such as France where the uses differ between the north and the south. For the time being, some countries such as Germany and Austria have decided not to include air-to-air HPs in their statistics, which also contributes to bias in market comparisons.

Just as in 2015, the 2016 market took advantage of the summer heat waves in countries such as Italy, France, Spain and Portugal, as sales of reversible air-to-air systems are very closely correlated to the need for air-conditioning. In Northern Europe – Sweden and Denmark – the air-to-air HP market essentially meets heating requirements with products that are perfectly suited to cold climates. The 2016 market performed well but was generally stable in Sweden and Finland, while it dipped slightly in Denmark.

The market for hydrothermal HPs that transfer heat through water via radiators or underfloor pipes primarily caters for heating needs. Their market, which includes geothermal HPs and air-to-water HPs is also expanding. The air-to-water HP market expanded by 11.7% with 251 471 units sold (a 12.3% increase in 2015) and the geothermal HP segment gained 1.5% with 84 374 units sold in 2016 after several years of decline. Some countries introduced new policies that account for significant variations in their sales figures. A new incentive system has been in force since 1 January 2016 in the Netherlands for renewable heating appliances for homeowners and small companies, known as ISDE, which has proven to be very positive. The amount of grant awarded depends on the type of appliance and its energy performance. It ranges from € 1 000 to € 2 500 for heat pumps.

THE EUROPEAN HP BASE WAS 32 MILLION IN 2016

Gauging the size of the HP base in service is a difficult exercise, as it depends on the assumptions made, the availability of statistics from the Member States and professional HP associations. Furthermore, the statistics are heavily skewed by the inclusion of small reversible mono-split HP systems by countries such as Italy and France. EurObserv'ER puts the installed HP base to date in the European Union at about 32 million units (30.5 million aerothermal and 1.5 million geothermal HPs).

As for the renewable energy output generated by HP (all technologies taken together), EurObserv'ER bases its estimates on the statistics provided by each Member State as part of the Eurostat SHARES (SHort Assessment of Renewable Energy Sources) project. For 2016, the contribution was 9.8 Mtoe (9 830 ktoe), compared to 9.1 Mtoe in 2015 (9 108 ktoe)... a 7.8% increase.

THE LIGHTS HAVE TURNED GREEN

In 2016, after several years of relative stagnation, the HP market pursued the recovery started in 2015 that was driven by the air-to-air HP segment. The lights have turned to green for the next few years. The sector should take off from a combination of favourable factors such as the improved price ratio between electricity

1

Market of aerothermal heat pumps in 2015 and 2016 (number of units sold).*

	2015				2016			
	Aerothermal HP	of which air-air HP	of which air-water HP	of which exhaust air HP	Aerothermal HP	of which air-air HP	of which air-water HP	of which exhaust air HP
Italy	997 400	972 200	25 200	0	1 541 000	1 511 000	30 000	0
Spain	742 999	734 199	8 800	0	792 088	781 116	10 972	0
France	405 680	332 110	73 570	0	446 745	372 270	74 475	0
Portugal	77 591	77 132	459	0	129 136	128 611	525	0
Sweden	73 608	52 000	8 040	13 568	75 413	52 000	8 099	15 314
Netherlands	49 176	43 541	5 635	0	69 797	58 618	11 179	0
Germany	52 331	0	39 831	12 500	58 147		45 647	12 500
Finland	49 515	45 027	2 704	1 784	51 672	45 742	3 709	2 221
Denmark	26 674	23 442	3 163	69	25 209	21 396	3 784	29
United Kingdom	17 013	0	17 013	0	16 058	0	16 058	0
Estonia	15 010	13 700	1 280	30	15 010	13 700	1 280	30
Austria	11 603	0	11 554	49	12 158	0	12 076	82
Czech Republic	7 304	0	7 304	0	10 862	0	10 827	35
Poland	8 513	4 500	3 916	97	8 756	3 546	5 160	50
Belgium	33 099	27 542	5 557	0	7 439	1 977	5 462	0
Slovenia	5 800	0	5 800	0	5 200	0	5 200	0
Ireland	3 489	0	3 465	24	4 457	0	4 398	59
Slovakia	721	0	721	0	1 888	158	1 730	0
Lithuania	605	0	605	0	890	0	890	0
Hungary	815	432	381	2	0	0	0	0
Luxembourg	100	0	100	0	0	0	0	0
Total EU 28	**2 579 046**	**2 325 825**	**225 098**	**28 123**	**3 271 924**	**2 990 133**	**251 471**	**30 320**

*Note: Datas from italian, french and portuguese aerothermal heat pump market are not directly comparable to others, because they include high part of reversible heat pumps whose principal function is cooling. **Source: EurObserv'ER 2017***

2

Market of geothermal (ground source) heat pumps in 2015 et 2016 (number of units sold)*

	2 015	2 016
Sweden	26 377	22 843
Germany	17 000	20 700
Finland	9 210	8 491
Poland	5 567	5 390
Austria	5 897	5 228
Netherlands	2 086	4 065
France	3 810	3 095
Denmark	1 885	2 248
United Kingdom	2 388	1 920
Slovakia	234	1 920
Estonia	1 750	1 750
Belgium	1 404	1 600
Czech Republic	1 570	1 521
Italy	952	860
Hungary	85	800
Lithuania	785	770
Slovenia	913	700
Ireland	337	371
Spain	72	77
Portugal	59	25
Bulgaria	532	0
Luxembourg	87	0
Total EU 28	**83 000**	**84 374**

** Hydrothermal heat pumps included. **Source: EurObserv'ER 2017***

3

*Total number of heat pumps in operation in 2015 and 2016**

	2015			2016		
	Aerothermal heat pumps	Ground source heat pumps	Total FIP	Aerothermal heat pumps	Ground source heat pumps	Total FIP
Italy	18 436 500	14 000	18 450 500	19 045 000	14 200	19 059 200
France	4 638 908	148 675	4 787 583	5 085 653	151 770	5 237 423
Spain	1 497 344	1 216	1 498 560	2 289 432	1 293	2 290 725
Sweden	988 191	497 658	1 485 849	1 057 666	514 038	1 571 704
Germany	567 327	330 244	897 571	612 820	349 623	962 443
Finland	577 808	94 504	672 312	629 480	102 995	732 475
Denmark	245 291	56 023	301 314	272 470	60 691	333 161
Netherlands	248 051	47 407	295 458	316 899	50 943	367 842
Portugal	254 944	832	255 776	384 080	857	384 937
Bulgaria	214 971	4 272	219 243	214 971	4 272	219 243
Austria	66 907	95 860	162 767	79 065	101 088	180 153
United Kingdom	114 794	27 263	142 057	130 852	29 183	160 035
Estonia	101 707	10 625	112 332	116 717	12 375	129 092
Belgium	84 499	7 774	92 273	91 938	9 374	101 312
Czech Republic	44 148	21 628	65 776	54 975	23 149	78 124
Poland	21 982	36 605	58 587	45 361	41 995	87 356
Slovenia	19 800	9 350	29 150	24 900	10 050	34 950
Ireland	9 027	3 453	12 480	13 484	3 824	17 308
Slovakia	6 607	3 073	9 680	8 495	4 993	13 488
Hungary	5 200	510	5 710	5 200	1 310	6 510
Lithuania	1 870	3 693	5 563	2 760	4 463	7 223
Luxembourg	1 195	420	1 615	1 195	420	1 615
Total EU 28	**28 147 071**	**1 415 085**	**29 562 156**	**30 483 412**	**1 492 906**	**31 976 318**

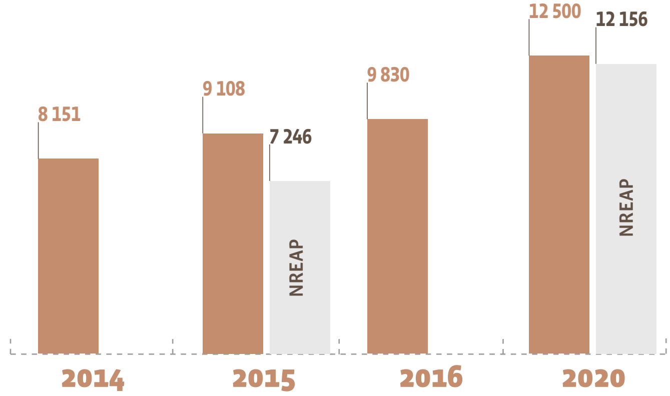
Note: Data from Italian, French and Portuguese aerothermal heat pump markets are not directly comparable to others, because they include the heat pumps whose principal function is cooling. ***Source: EurObserv'ER 2017***

and gas, the economic recovery that increases homeowners' investment capacities and the more stable construction market. We share this optimism with the EHPA (European Heat Pump Association). Its figures differ from ours as the association only includes HP primarily dedicated to heating applications, leaving aside those systems essentially used for air-conditioning. EHPA estimates that in 2016 one million units were sold for heat production purposes (12% more than in 2015). It is confident about the outlook for future sales. Its forecasts point to market growth for the next three years of 14%, 14% and 13% respectively.

Development of the HP market could also profit from the advent of the PV self-consumption market as the production of solar power is the perfect match to the cooling requirements of reversible HP technologies. The unused surplus solar power could also be channelled to top up HPs assigned to domestic hot water and heating production. The air source HP market should also take advantage of the implementation of new thermal regulations as ventilation technologies become more integrated, in conjunction with the improvements to building air quality. The run of generally milder winters resulting from climatic warming, should also be beneficial to the development of aerothermal technologies. ■

4

Current trend of renewable energy from heat pumps compared with the National renewable energy action plans (NREAP) (in ktoe)



Source: EurObserv'ER 2017

BIOGAS

Methanization is a natural process that results in the biological breakdown of organic matter through the action of many micro-organisms in an oxygen-deprived environment. We divide methanization biogas from anaerobic fermentation into three segmented sub-sectors in line with the waste feedstock's origin and treatment. It includes methanization of wastewater treatment plant sludge (sludge digestion gas), biogas from non-hazardous waste facility storage (landfill biogas) and methanization of non-hazardous waste or raw plant matter (other biogas). A fourth internationally classified biogas sub-sector is monitored, for biogas produced by a heat treatment process (biogas from thermal processes) by pyrolysis or gasification of solid biomass (wood, forestry logging slash, solid and fermentable household waste). These thermal processes produce hydrogen (H_2) and carbon monoxide (CO), which when recombined produce a synthetic biogas that can substitute natural gas (CH_4). Finland and Italy use these thermal processes and new projects are being developed in the Netherlands. EurObserv'ER has included this low level of output in the "other biogas" category for the time being in the interests of convenience.

THE EUROPEAN UNION PRODUCES 16.6 MTOE

In 2016, European Union primary energy production from biogas pursued its upward trend, (adding 4.4% to 16.6 Mtoe) however, it has been losing pace since 2011 (adding 22.4%, 17%, 14.3%, 7.3% and 6.0% respectively). The main reasons for this decline are the implementation of regulations that discourage the use of energy crops, which had boosted output in those countries that originally embarked on developing the farm biogas sector (primarily Germany, Italy and the UK) and are compounded by less attractive biogas electricity payment terms.

All the EU Member States have a biogas energy recovery sector, but only three of them generate three-quarters (75.8%) of all European output, namely Germany (8.1 Mtoe), the UK (2.6 Mtoe) and Italy (1.9 Mtoe).

For many years, European Union biogas primary energy production has been dominated by the "other biogas" category. In 2016, it accounted for 74.8% (including 0.3% of thermal biogas, i.e. 56 ktoe) (73.8% in 2015, including 0.3% of thermal biogas) and for several years has accounted for most of the increase in total production. The landfill biogas share has tended to dwindle (from 17.3% to 16%). While wastewater sludge biogas increased slightly (from 7.0 to 7.6%) in 2016.

Output as electricity, regardless of whether it is generated in CHP plants, is still the main form of energy recovery. In 2016, it amounted to 62.6 TWh, which is a 2.7% year-on-year increase. Germany alone produces more than half the EU's biogas electricity (33.7 TWh), followed by Italy (8.3 TWh) and the UK (7.7 TWh).

Derived heat (from the processing sector) increased by 7.9% to 694.8 ktoe in 2016. Final energy consumption (outside the proces-

1

Primary energy production from biogas in the European Union in 2015 and 2016 (in ktoe)

	2015					2016				
	Landfill gas	Sewage sludge gas[4]	Others biogas from anaerobic fermentation	Thermal biogas	Total	Landfill gas	Sewage sludge gas[5]	Others biogas from anaerobic fermentation	Thermal biogas	Total
Germany	94	452	7 308	0	7 854	84	463	7 548	0	8 094
United Kingdom	1 451	330	556	0	2 337	1 401	345	855	0	2 601
Italy	369	54	1 442	6	1 871	365	53	1 450	7	1 875
France	282	73	370	0	725	286	72	402	0	760
Czech Republic	27	40	546	0	613	25	42	534	0	601
Netherlands	19	55	252	0	327	16	58	245	0	319
Austria	4	11	284	0	300	4	13	296	0	313
Poland	51	97	82	0	229	58	120	84	0	261
Spain	141	70	51	0	262	132	66	47	0	245
Belgium	26	24	177	0	227	22	26	179	0	227
Denmark	4	22	127	0	153	5	25	189	0	218
Sweden	6	75	86	0	167	7	76	91	0	174
Slovakia	3	15	130	0	149	3	15	130	0	148
Finland	28	15	20	40	103	23	15	25	49	112
Greece	70	16	6	0	91	72	17	13	0	102
Latvia	8	2	77	0	88	8	3	79	0	90
Hungary	14	20	45	0	80	14	20	46	0	81
Portugal	71	3	9	0	83	68	3	9	0	80
Bulgaria	5	14	0	0	19	0	60	0	0	60
Ireland	41	8	6	0	55	40	8	7	0	56
Croatia	5	3	27	0	36	6	4	33	0	43
Lithuania	8	7	8	0	23	9	8	16	0	32
Slovenia	5	2	22	0	30	4	2	24	0	30
Luxembourg	0	2	16	0	18	0	2	18	0	20
Romania	1	0	17	0	18	1	0	17	0	18
Cyprus	0	0	12	0	12	0	0	12	0	12
Estonia	12	2	0	0	13	7	4	0	0	11
Malta	0	0	2	0	2	0	0	2	0	2
Total EU 28	2 746	1 412	11 680	46	15 884	2 659	1 519	12 350	56	16 585

Source: EurObserv'ER 2017

sing sector) must be added to that and is put at about 2 882 ktoe in 2016 (8.4% up on the 2015 figure).

Biogas can also be purified and converted into biomethane. It is then converted in the same way as natural gas can be, namely as electricity in CHP plants and by natural gas vehicles (NGV) or even injected into the natural gas grid. In recent years, biomethane injection has gradually taken on importance in the biogas market. At the end of 2016, the sector had some 480 plants injecting biomethane into Europe's natural gas grids, in the 9 countries monitored by the European Biomethane Observatory. The number of injection plants increased by 13% in 2016, and Germany has made the most progress in biomethane injection. According to the DENA (German environmental agency) biomethane barometer, 194 plants were counted at the end of November 2016 that produce a little less than 1 billion Nm^3 of gas. DENA claims that the injected biomethane energy content was about 9.4 TWh in 2016 compared to 8.5 TWh in 2015. In Sweden, much of the biomethane output is used as fuel for natural gas-driven vehicles. According to Statistics Sweden, roughly 100 000 toe of biomethane was used (1 150 GWh to be precise) for road transport in 2016.

OUTPUT COULD DOUBLE BY 2030

Growth scenarios have been hard hit by the main European producer countries' decision to reduce their use of energy crops. Nowadays, optimized use of waste underpins the growth scenarios more than

2

Gross electricity production from biogas in the European Union in 2015 and 2016 (in GWh)*

	2015			2016		
	Electricity only plants	CHP plants	Total	Electricity only plants	CHP plants	Total
Germany	8 845	24 228	33 073	9 223	24 480	33 703
Italy	3 139	5 073	8 212	3 073	5 186	8 259
United Kingdom	6 528	710	7 238	6 988	718	7 706
Czech Republic	51	2 560	2 611	49	2 540	2 589
France	713	1 106	1 819	641	1 260	1 901
Poland	0	906	906	0	1 028	1 028
Netherlands	43	993	1 036	34	959	993
Belgium	87	867	955	93	893	986
Spain	743	239	982	726	180	906
Austria	580	44	624	591	56	647
Slovakia	117	424	541	114	462	576
Denmark	1	475	476	1	514	515
Latvia	0	392	392	0	397	397
Finland	203	154	357	222	175	397
Hungary	72	221	293	90	243	333
Portugal	279	16	295	268	17	285
Greece	34	197	230	33	237	270
Croatia	25	151	176	26	211	237
Ireland	172	30	201	168	44	212
Bulgaria	34	85	119	97	94	191
Slovenia	3	129	132	2	140	142
Lithuania	0	86	86	0	123	123
Luxembourg	0	62	62	0	73	73
Romania	29	32	61	33	32	65
Cyprus	0	51	51	0	52	52
Estonia	0	50	50	0	45	45
Sweden	0	11	11	0	11	11
Malta	0	7	7	0	8	8
Total EU 28	**21 697**	**39 299**	**60 996**	**22 473**	**40 175**	**62 649**

Source: EurObserv'ER 2017, amended with SHARES data

3

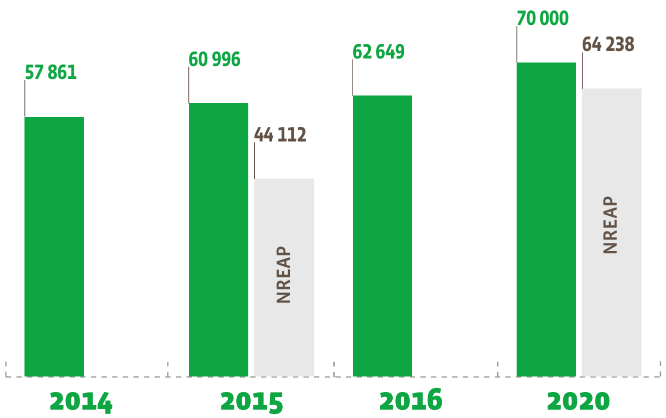
*Gross heat production from biogas in the European Union in 2015 and in 2016 (in ktoe) in the transformation sector**

	2015			2016		
	heat only plants	CHP plants	Total	heat only plants	CHP plants	Total
Germany	71.8	150.0	221.8	72.5	150.0	222.5
Italy	0.3	205.2	205.5	0.2	207.8	208.0
Denmark	11.2	46.3	57.6	14.1	68.0	82.1
France	2.7	31.7	34.3	2.9	37.7	40.6
Latvia	0.0	21.3	21.3	0.0	22.7	22.7
Finland	6.8	11.4	18.2	7.0	12.9	19.8
Czech Republic	0.0	14.9	14.9	0.0	14.3	14.3
Poland	0.3	10.1	10.4	0.3	13.7	14.1
Slovakia	0.0	11.3	11.3	0.0	11.2	11.2
Belgium	0.0	9.3	9.3	0.0	10.2	10.2
Croatia	0.0	5.2	5.2	0.0	6.8	6.8
Slovenia	0.0	7.3	7.3	0.0	6.6	6.6
Sweden	3.0	3.6	6.5	3.1	3.5	6.5
Netherlands	0.0	1.1	1.1	0.0	6.5	6.5
Austria	1.6	1.9	3.5	1.6	3.7	5.4
Romania	0.0	3.7	3.7	0.0	3.9	3.9
Hungary	1.3	1.8	3.1	1.6	2.3	3.9
Bulgaria	0.0	0.6	0.6	0.0	3.2	3.2
Lithuania	0.0	2.2	2.2	0.0	2.2	2.2
Luxembourg	0.0	1.9	1.9	0.0	2.1	2.1
Cyprus	0.0	1.2	1.2	0.0	1.2	1.2
Estonia	0.0	2.7	2.7	0.0	0.6	0.6
Malta	0.0	0.1	0.1	0.0	0.2	0.2
Greece	0.0	0.0	0.0	0.0	0.0	0.0
Ireland	0.0	0.0	0.0	0.0	0.0	0.0
Portugal	0.0	0.0	0.0	0.0	0.0	0.0
Spain	0.0	0.0	0.0	0.0	0.0	0.0
United Kingdom	0.0	0.0	0.0	0.0	0.0	0.0
Total EU 28	**98.9**	**544.9**	**643.8**	**103.4**	**591.4**	**694.8**

** Corresponds to "Derived heat" (see Eurostat definition). Source: EurObserv'ER 2017,amended with SHARES data*

4

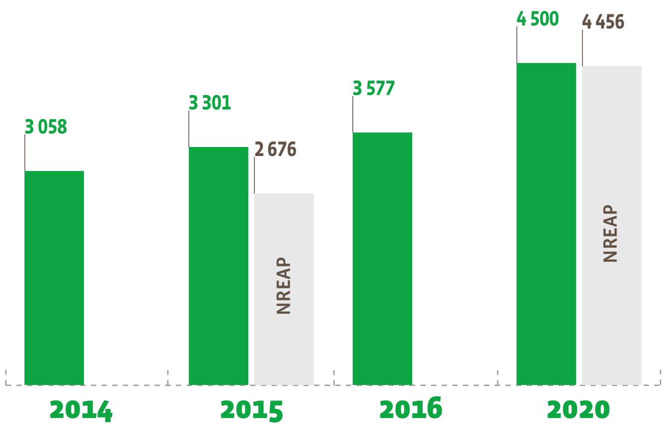
Comparison of the current trend of electricity biogas generation against the NREAP (National Renewable Energy Action Plans) roadmap (in GWh)



Source: EurObserv'ER 2017

5

Comparison of the current trend of biogas heat consumption against the NREAP (National Renewable Energy Action Plans) roadmap (in ktoe)



Source: EurObserv'ER 2017

greater use of energy crops or developing gasification biogas. In February 2017, the European Commission published a study entitled "Optimal use of biogas from waste streams. An assessment of the potential of biogas from digestion in the EU beyond 2020" commissioned to gauge this potential.

The originality of this paper comes from the fact that it concentrated exclusively on the production of biogas from the digestion of local waste flows, such as wastewater sludge, landfill gas and organic waste from farming, the food industry and households. Biomass gasification and renewable methane production from energy crops were excluded from the study's scenario modelling section. Four scenarios covering different biogas development assumptions were analysed. The first scenario, "Local use + electricity", assumes local use of the biogas via cogeneration combined with regular deployment of feedstocks, reduction in investment costs and an increase in energy yields. The second scenario "Local use + electricity, with accelerated deployment and innovation" is based on the assumption of local use of the biogas via cogeneration and accelerated deployment of raw materials, reduction in investment costs and an increase in conversion yields. A third scenario, "Biomethane to grid" is based on the purification of the biogas injected into the grid, used in the transport of building sectors, with regular deployment of feedstocks, reduction in investment costs and conversion efficiency. The last scenario, "Biomethane to grid, with accelerated deployment and innovation" relies on the conversion of the biogas into injected biomethane combined with accelerated deployment of raw materials, reduction in investment costs and enhanced conversion efficiency. Based on these potentials, the assessment demonstrates that biogas production in the European Union could rise from 14.9 Mtoe in 2014 to 28.8 (scenarios 1 and 3) or to 40.2 Mtoe (scenarios 2 and 4) in 2030, depending on the quantity of useable raw material and the learning effects taken into consideration. Compared to the 2016 level (16 Mtoe), this represents multiplication by 1.8 and 2.5 times respectively of the primary energy produced. These scenarios would lead to 2030 biogas and biomethane output levels of between 2.7 and 3.7% of the EU's energy consumption. ■

BIOFUELS

Development of the European Union biofuel market for transport up to 2020 is now regulated by the 2015/1513 directive of 9 September 2015, known as the ILUC directive. As a result, the energy share sourced from agrofuels (produced from cereals and other food crops rich in starch, sugar and vegetable oil) has been capped at 7% of final energy consumption in transport until 2020. The European Union has decided to maintain its main goal of achieving a 10% renewable energy share in transport fuel by 2020. The remaining 3% can be obtained through electric mobility or using biofuel produced from specific raw materials eligible for double counting. These include biofuel produced from used oil that has been thermochemically treated with hydrogen, in addition to synthetic biomass-derived biodiesel and "biopetrol" (wood, straw, household refuse, etc.). The Directive stipulates that each Member State must work towards achieving a national target of a minimum percentage of advanced biofuel produced from the raw materials listed in Annex IX, part A. The reference value for this target is 0.5 of a percentage point in terms of energy content of the share of energy produced. Member States can set a lower target than this value, if comparable financial resources are allocated to transport to develop energy efficiency or the use of renewable electricity, if the technical characteristics of the vehicle fleet (composition and state) are inappropriate for using advanced biofuel or if objective factors limit the availability of this type of fuel at competitive prices.

EUROPEAN UNION BIOFUEL CONSUMPTION STANDS AT 14.2 MTOE

The European Union's biofuel consumption has flattened out after increasing steadily from the early 2000s until 2012. Official consolidated data indicate that biofuel consumption intended for transport, certified as sustainable and otherwise, remained stable in 2016, at 14.2 Mtoe. The growth in biofuel consumption certified as sustainable – the only type that can be included in the directive's renewable energy and transport targets – is different. It increased by almost one million tonnes of oil equivalent between 2015 and 2016, from 13.1 to 14.1 Mtoe, which equates to a 7.5% increase. Thus, sustainably certified consumption now accounts for 99% of biofuel consumption in EU transport compared to 92% in 2015. The reason for this increase is the effective roll-out of the administrative system in Spain at the end of 2016, to account for sustainably-certified biofuel consumption. The country can now factor its biofuel consumption into its 2020 renewable energy targets.

Novozymes

The breakdown between the various major families of biofuel is only available for all biofuel consumption – certified and otherwise. However, the slight difference between the two indicators shows that their momenta are totally identical. Bearing in mind that their energy content has hardly changed, the respective shares of bioethanol, biodiesel and biogas biofuel energy content in 2016 were: 19.1% for bioethanol (19.2%

1

Biofuels consumption for transport in the European Union in 2015 (in toe)

	Bioethanol	Biodiesel	Biogas fuel	Vegetable oil*	Total consumption	% compliant**
Germany	744	1 792	30	1	2 567	100%
France	434	2 562	0	0	2 996	100%
United Kingdom	408	534	2	0	944	100%
Spain	189	775	0	0	964	0%
Italy	25	1 142	0	0	1 167	100%
Poland	153	500	0	0	653	100%
Sweden	164	913	100	0	1 177	100%
Netherlands	142	156	0	0	297	99%
Austria	60	585	1	0	646	97%
Portugal	22	302	0	3	328	100%
Hungary	43	133	0	0	175	100%
Czech Republic	63	233	0	0	297	100%
Belgium	38	217	0	0	255	100%
Finland	66	432	2	0	500	99%
Greece	0	161	0	0	161	20%
Slovakia	23	121	0	0	144	100%
Lithuania	10	58	0	0	68	100%
Romania	61	141	0	0	202	100%
Ireland	30	98	0	0	128	100%
Luxembourg	7	74	0	0	81	100%
Bulgaria	32	114	0	0	146	99%
Slovenia	7	23	0	0	29	100%
Cyprus	0	10	0	0	10	97%
Denmark	0	232	0	0	232	100%
Estonia	3	0	0	0	3	0%
Latvia	8	17	0	0	25	100%
Malta	0	5	0	0	5	100%
Croatia	0	24	0	0	24	100%
Total EU 28	**2 732**	**11 353**	**134**	**4**	**14 224**	**92%**

** Pure used vegetable oil and unspecified biofuel. ** Compliant with Articles 17 and 18 of Directive 2009/28/EC.*
Source: Eurobserv'ER 2017, SHARES 2017 for% compliant

2

Biofuels consumption for transport in the European Union in 2016 (in toe)

	Bioethanol	Biodiesel	Biogas fuel	Vegetable oil*	Total consumption	% compliant**
Germany	745	1 792	32	2	2 572	99%
France	474	2 641	0	0	3 115	100%
United Kingdom	415	601	0	0	1 017	100%
Spain	133	1 031	0	0	1 164	100%
Italy	33	1 009	0	0	1 041	100%
Poland	168	290	0	0	457	100%
Sweden	159	1 202	116	0	1 477	100%
Netherlands	121	121	0	0	242	96%
Austria	57	475	1	0	533	97%
Portugal	22	236	0	2	260	100%
Hungary	44	143	0	0	187	100%
Czech Republic	48	253	0	0	300	100%
Belgium	40	391	0	0	431	100%
Finland	68	109	2	0	178	100%
Greece	0	147	0	0	147	43%
Slovakia	16	124	0	0	140	98%
Lithuania	6	50	0	0	57	100%
Romania	81	176	0	0	257	100%
Ireland	32	86	0	0	118	100%
Luxembourg	9	78	0	0	87	100%
Bulgaria	33	130	0	0	163	100%
Slovenia	4	14	0	0	18	100%
Cyprus	0	9	0	0	9	100%
Denmark	0	236	0	0	236	100%
Estonia	3	0	0	0	3	0%
Latvia	8	4	0	0	12	100%
Malta	0	6	0	0	6	100%
Croatia	0	1	0	0	1	100%
Total EU 28	**2 718**	**11 354**	**151**	**4**	**14 227**	**99%**

** Pure used vegetable oil and unspecified biofuel. ** Compliant with Articles 17 and 18 of Directive 2009/28/EC.*
Source: Eurobserv'ER 2017, SHARES 2017 for% compliant

in 2015), 79.8% for biodiesel (79.8% in 2015) and 1.1% for biogas (0.9% in 2015). The share of the other types of biofuel is unrepresentative.

If we analyse the changes in consumption of the various types of biofuels of the different Member States, we note that the changes have been far more contrasted than across the European Union, in terms of total consumption, and distribution between the types consumed. In 2016, biofuel consumption in half of the countries (15 of the 28) was lower than the previous year. Some of them even decided to radically reduce their biofuel consumption. The drops in energy content were particularly sharp in Finland (64.3%), Poland (30%), Portugal (20.7%), the Netherlands (18.7%), Austria (17.5%), Greece (8.9%) and many of the Eastern European countries such as Croatia, Latvia, Estonia, Slovenia, Lithuania and Slovakia. These sharp falls were offset by increased use of biofuel in the major consumer countries such as France (4%), the UK (7.7%), Spain (20.8%), Belgium (69.2%), Sweden (25.4%), and even Romania (27%) and Bulgaria (11.6%).

In some countries, the decline in consumption hit a specific type of biofuel. Accordingly, biodiesel consumption contracted significantly in Finland (by 74.8%), Poland (by 42%) and Italy (by 11.7%) while their bioethanol consumption rose (by 3.1% in Finland, by 9.2% in Poland, by 31.2% in Italy). The reverse applies to Spain (29.5% less bioethanol, 33% more biodiesel), the Czech Republic (24.5% less bioethanol, 8.3% more biodiesel) and Slovakia (32.2% less bioethanol, 2.9% more biodiesel).

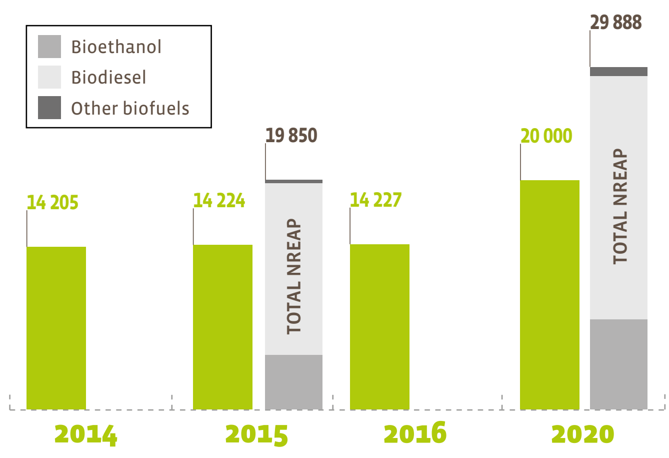
We can conclude that some sort of redistribution occurred in the European Union.

STRUGGLE FOR INFLUENCE OVER BIOFUEL'S FUTURE

The ILUC Directive adopted in September 2015 clarified the requirements, which should naturally enable those Member States that have not already done so, to set their incorporation rate roadmap through to 2020. EurObserv'ER believes that if Europe's commitments are met, the effective (conventional and advanced) biofuel incorporation rate should range from 7 to 8% by that timeline. However, the lack of clear prospects for the future of edible crop feedstock biofuel after 2020 is leading some States – those whose economies are least affected by agrofuel production – to

2

Comparison of the current biofuel consumption for transport trend against the NREAP (National Renewable Energy Action Plans) roadmap (in ktoe)



Source: EurObserv'ER 2017

revise their commitments or defy the 2009 renewable energy directive's demands for transport. Certain Member States' consumption woes would appear to lend their weight to this theory. According to the Eurostat estimates released at the end of January 2018, the renewable energy share in transport fuel, factoring in the accounting adjustments and electricity consumption amounted to 7.1% in 2016 (6.6% in 2015).

The European Commission's policy formulated in the new draft Directive is to offer the Member States greater freedom on how they achieve their national targets. They will have to be negotiated under the terms of a common European Union-wide target. So which types of biofuel will be available on the market from 2021 and through to 2030 and in what proportion? The answer is at the crux of the on-going political negotiations within the European institutions. The European Commission's draft renewable energies directive revision of 30 November 2016 removes the renewable energy target for transport and leaves countries free to choose the proportion devoted to transport, producing renewable electricity and heat, as part of a common European Union target (with efforts negotiated between the Member States) of at least 27% of renewable energy in the European Union's total energy consumption by 2030.

Additionally, the European Commission wants to impose a gradual reduction in the "agrofuel" share and cap it at 3.8% by 2030. The proposal is to introduce an annual 0.3 of a percentage point reduction from 2021 to 2025 and increase this reduction to 0.4 of a percentage point from 2026 to 2030. Another important aspect of the project is that the Member States are obliged to demand their fuel suppliers to include a minimum share of renewable energy and low-carbon fuels in the total quantity of fuel used for transport. These include advanced biofuel, non-biologically sourced fuels (e.g. hydrogen), fuels produced from waste or renewable electricity-sourced fuel. The minimum share must be no less than 1.5% in 2021 and must rise to at least 6.8% in 2030 along a pre-2021 trajectory.

For its part the European Parliament made new proposals on 17 January 2018 for revising the Renewable Energies Directive that set the targets to be achieved by 2030. By that date, each Member State will have to ensure that 12% of the energy consumed in transport is renewably-sourced. The contribution of so-called "first-generation" biofuel (subsistence and fodder crops) should be capped at 2017 levels with a maximum of 7% in road and rail transport. The MPs also want to ban palm oil from 2021 onwards. The share of advanced biofuel (that has less impact on land use than those based on subsistence crops), non-organic renewable transport fuel, non-fossil waste-based fuel and renewable electricity should be at least 1.5% in 2021 and increase to 10% in 2030. The next stage will be to embark on negotiations with the European Council, which will have the final word. ■

RENEWABLE MUNICIPAL WASTE

Primary renewable energy output recovered by household refuse incineration plants (waste-to-energy plants) approached 10 million tonnes of oil equivalent (Mtoe) across the European Union. According to the official data gathered by EurObserv'ER, the figure was 9 698 ktoe in 2016, which represents 3.2% growth (or 301 ktoe of additional output than in 2015). These figures do not incorporate all the energy production recovered by these plants, only the biodegradable part of household refuse. Energy recovery from non-renewable urban waste (plastic packaging, water bottles, etc.) amounts to similar, albeit slightly less, energy output. According to CEWEP (the Confederation of European Waste-to-Energy Plants), European plants can now produce electricity for 18 million inhabitants and supply heat to 15.2 million inhabitants. These estimates are extrapolated from the waste volume processed in 2015 of 90 million tonnes (household and similar waste).

The sector has an advantage in that most incineration plants are located close to major conurbations,

which not only provide the waste but are major energy consumers. This proximity naturally favours optimizing the local use of the energy, be it heat, electricity or the two combined through cogeneration. Heat can also be more easily exported to supply urban heating networks or industrial sites across short distances.

Thus, more than half (52.2%) of the 21 TWh of renewable electricity, i.e. 11 TWh, produced by incineration plants in 2016 (2.6% more than in 2015), came from CHP plants Derived heat, which covers total heat production in heating and CHP plants amounted to 2 975 ktoe, which is close to its 2015 level (0.5% more). CHP plants generated the bulk of this heat (– 74.1% in 2016).

Within the European Union, we note wide differences in the amount of energy recovered from urban waste. If we use a per capita primary energy output indicator, the Nordic countries are far and away the most committed to recovering energy from their household

1

Primary energy production of renewable municipal waste in the European Union in 2015 and 2016 (in ktoe)

	2015	2016
Germany	2 994	3 105
France	1 212	1 240
Italy	846	871
Sweden	908	832
United Kingdom	670	820
Netherlands	841	794
Denmark	452	460
Belgium	373	381
Finland	273	309
Spain	252	235
Austria	182	175
Portugal	97	104
Czech Republic	80	86
Poland	40	77
Hungary	66	66
Ireland	57	64
Bulgaria	8	29
Lithuania	16	22
Slovakia	15	15
Luxembourg	12	13
Romania	1	1
Cyprus	0	0
Total EU 28	**9 397**	**9 698**

Source : EurObserv'ER 2017

waste (84.5 toe/1 000 inhabitants for Sweden, 80.5 toe/1 000 inhabitants for Denmark, and 56.3 toe/1 000 inhabitants for Finland) along with the Netherlands (46.7 toe/1 000 inhabitants). This approach is less developed in countries like France (18.6 toe/1 000 inhabitants), where many, older-design plants were not designed specifically to produce energy, but simply to dispose of waste by incineration. Central Europe's and some of Southern Europe's countries such as Spain, have so far invested very little in recovering energy from their household waste, with ratios usually below 10 toe/1 000 inhabitants.

The UK is actively pursuing an ambitious incineration plant construction programme. The Department for Business, Energy & Industrial Strategy (BEIS) claims that UK energy output from renewable municipal waste increased by 22.4% between 2015 and 2016, and by 59.1% over the last two years (2014–2016). Most of this energy was recovered in the form of electricity whose output amounted to 2.7 TWh in 2016 (6.0% more than in 2015). Several waste-to-energy plants were commissioned in 2016 including the biggest on Teeside (49 MW) which treats both household and commercial waste. The site's treatment capacity is 450 000 tonnes. It can supply electricity to 63 000 homes. In June 2016, the Greatmoor plant came on stream in Buckinghamshire, with 300 000 tonnes of treatment capacity and 22 MW of installed electrical capacity. According to the BEIS, the capacity of incineration plants increased by 10% in 2016 to reach about 1 017 MW by the end of 2016. It has almost doubled since 2012 (513 MW). The underlying reason for this expansion can be ascribed to the UK landfill tax, which has risen annually since 1996. In 2016, the tax levied per tonne had risen to 84.4 GBP (99.1 EUR).

Finland is another country pioneering waste-to-energy recovery. In October 2016 the Riikinvoima Ekovoimalaitos plant was commissioned near the town of Varkaus in Eastern Finland. This CHP plant has annual treatment capacity of 145 000 tonnes and will produce 90 GWh of electricity and 180 GWh of heat for district heating. One of the reasons for the growth in energy recovery from "renewable" household waste is the increase in landfill tax, which rose to 70 euros per tonne (as against the previous 55 euros) on 1 January 2016, coupled with the ban on dumping organic waste which came into force on

2

Gross electricity production from renewable municipal waste in the European Union in 2015 and 2016 (in GWh)*

	2015			2016		
	Electricity only plants	CHP plants	Total	Electricity only plants	CHP plants	Total
Germany	3 530	2 238	5 768	3 602	2 328	5 930
United Kingdom	2 096	489	2 585	2 226	514	2 741
Italy	1 207	1 136	2 343	1 218	1 198	2 415
France	1 142	855	1 997	1 157	1 006	2 163
Netherlands	0	1 997	1 997	0	2 005	2 005
Sweden	0	1 749	1 749	0	1 681	1 681
Denmark	0	919	919	0	863	863
Belgium	396	473	869	374	497	871
Spain	673	96	768	641	94	736
Finland	35	436	471	40	479	519
Portugal	292	0	292	305	0	305
Austria	239	50	289	191	80	271
Hungary	130	77	207	179	66	245
Czech Republic	0	87	87	0	99	99
Ireland	77	0	77	76	0	76
Lithuania	0	42	42	0	47	47
Luxembourg	40	0	40	42	0	42
Slovakia	0	22	22	0	26	26
Poland	0	0	0	0	13	13
Total EU 28	9 857	10 665	20 522	10 052	10 995	21 047

Source: EurObserv'ER 2017, amended with SHARES data

the same day. According to Statistics Finland, primary energy output increased by 13.3% between 2015 and 2016 to 309 ktoe. As a result, electricity output from these plants increased by 10.2% (i.e. 519 GWh) and heat by 16% (i.e. 167.7 ktoe).

THE TARGETS ARE ON TRACK TO BEING ACHIEVED

Overall, energy recovery from renewable urban waste is gaining impetus. Since 2010, the sector has passed from 7 864 ktoe of primary energy output to 9 698 ktoe in 2016. As early as 2017 it could cross the 10-Mtoe line, spurred on by a policy that aims to increase landfill taxes and ban the dumping of organic waste.

Compliance with the framework waste directive that has established a "waste hierarchy" (prevention, preparation for reuse, recycling, recovery, disposal) should divert an increasing portion of recyclable waste away from incineration plants (carton, paper, packaging, milk carton, etc. recycling). In time, only the biodegradable fraction of waste that is unsuitable for recycling or quality composting, such as soiled cartons and multilayer packaging that is too complex to recycle, will be incinerated. Nonetheless, there is still huge growth potential across the European Union.

3

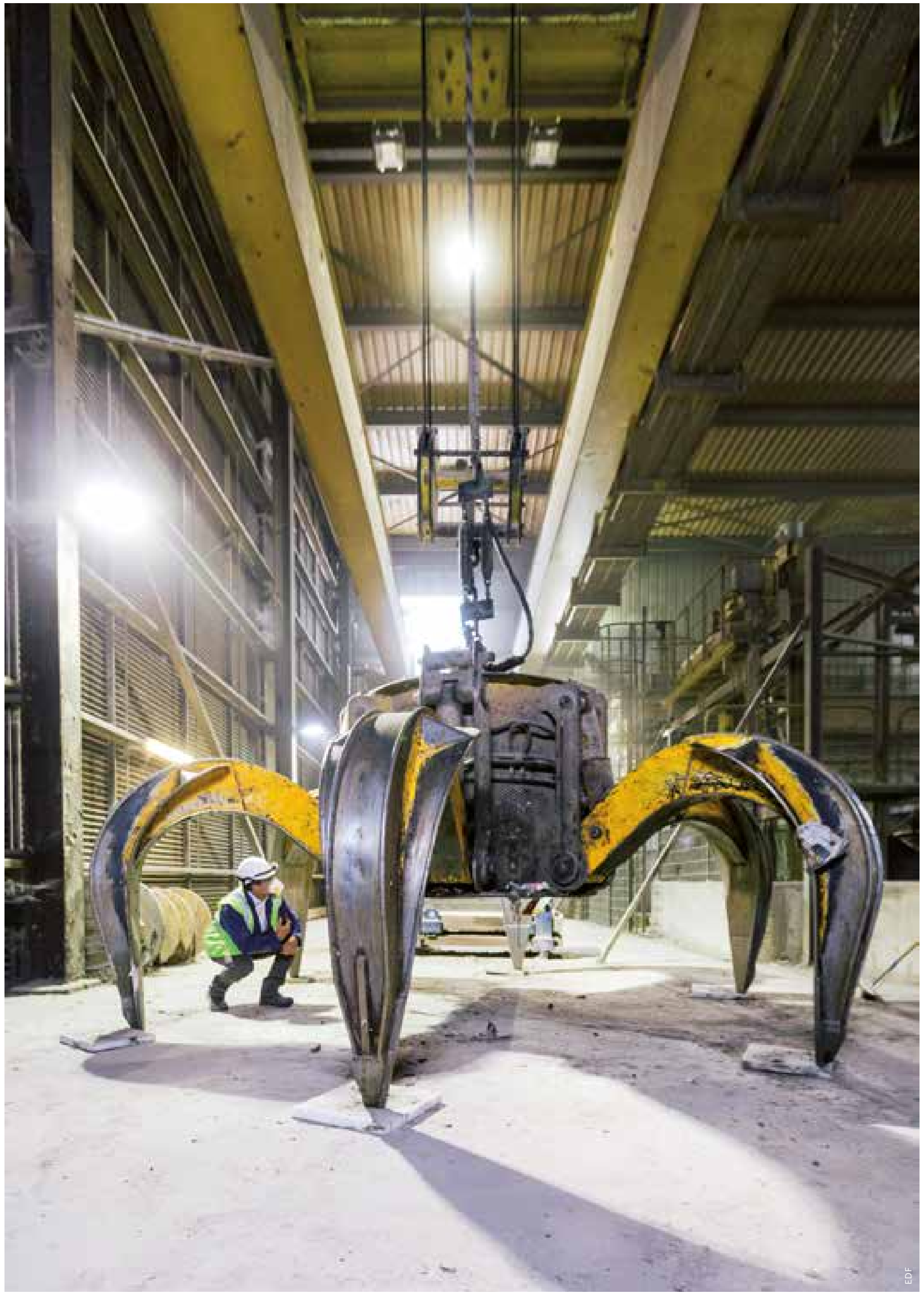
*Gross heat production from renewable municipal waste in the European Union in 2015 and in 2016 (in ktoe) in the transformation sector**

	2015			2016		
	Heat only plants	CHP plants	Total	Heat only plants	CHP plants	Total
Germany	280.9	442.4	723.3	271.5	461.0	732.4
France	347.3	210.2	557.5	346.5	255.4	602.0
Sweden	57.8	575.1	632.9	56.3	509.8	566.1
Denmark	39.0	318.6	357.6	45.9	321.4	367.3
Netherlands	0.0	279.2	279.2	0.0	265.2	265.2
Finland	19.2	125.3	144.5	22.4	145.3	167.7
Italy	0.0	107.9	107.9	0.0	117.1	117.1
Austria	13.6	43.3	56.9	14.0	43.7	57.7
Czech Republic	0.0	37.3	37.3	0.0	35.9	35.9
Belgium	0.0	29.2	29.2	0.0	26.8	26.8
United Kingdom	12.4	0.0	12.4	12.5	0.0	12.5
Hungary	0.0	11.5	11.5	0.0	12.1	12.1
Lithuania	0.0	9.1	9.1	0.0	10.4	10.4
Slovakia	0.0	0.0	0.0	1.5	0.0	1.5
Poland	0.2	0.0	0.2	0.0	0.4	0.4
Romania	0.1	0.0	0.1	0.0	0.0	0.0
Total EU 28	**770.4**	**2 189.2**	**2 959.6**	**770.7**	**2 204.4**	**2 975.1**

** Corresponds to "Derived heat" (see Eurostat definition).* ***Source: EurObserv'ER 2017, amended with SHARES data***

According to CEWEP, twelve Member States still bury most of their municipal waste. This has major consequences for GHG emissions such as methane, and, when badly managed, potential leachate pollution with associated health issues. However, the association reckons that if they are to achieve their targets these countries will require financial support and European Union aid.

Looking to forecasts for 2020, CEWEP believes that the energy contribution of waste towards the renewable energy directive targets could realistically reach 67 TWh by 2020, with 25 TWh of electricity and 42 TWh (3.6 Mtoe) of heat output. EurObserv'ER reckons that in 2016, total heat consumption (heat from the processing sector and final heat consumption) had already reached 3.8 Mtoe (including 3 Mtoe of heat sold to networks). The CEWEP 2020 heat target, which is perfectly realistic, could easily be exceeded. The forthcoming commissioning of new incineration plants in the UK, combined with improved energy efficiency at the existing plants, should also ensure that the desired 25 TWh is achieved by 2020. ■



SOLID BIOMASS

Solid biomass is an umbrella term for all solid organic components to be used as fuels. They include wood, wood chips, timber industry by-products (off-cuts, sawdust, etc.) black liquor from the paper industry, wood pellets, straw, bagasse, animal waste and other solid plant residues. Charcoal, derived from solid biomass, is subject to specific statistical treatment and is not included in our study data. By the same token, renewable municipal waste which is similar to solid biomass, and treated in incineration plants, is also subject to specific statistical treatment.

The succession of mild years and winters in Europe – a quantifiable consequence of climate warming – obfuscates efforts to read the impact of the policies introduced to promote the use of solid biomass in high-performance heating appliances, as heating needs are directly correlated with the average temperature level. According to the World Meteorological Organization (WMO) readings, the last three years – 2014, 2015 and 2016 – have been the hottest on record in Europe… the hottest being 2014, followed by 2015 and 2016, the third hottest. The hapless record for being the hottest year ever registered on the planet goes to 2016, which was amplified by a strong El Niño event, with a record temperature level more than 1.1°C higher than normal for the preindustrial period.

Another factor to be considered is that in a number of Northern European countries logging is a major economic activity, and the European market's requirements for timber products (construction, pulping, furniture, etc.) governs the availability of solid biomass for conversion into energy (wood offcuts, black liquor, conversion of valorisation logging residue). Therefore, part of the available biomass energy is linked to the forestry industry's activity level, although another part is totally earmarked for supplying biomass to the energy sector.

Lastly, we need to bear in mind that new studies, mostly surveys on household wood energy consumption have improved solid biomass consumption monitoring. Incidentally, over and above climate conditions, average home consumption of wood is falling, mainly because of improved appliance performance. Sometimes these surveys lead to significant statistical consolidations over several years.

SIGHTS SET ON 100 MTOE OF BIOMASS CONSUMPTION

This preamble considers changes over a longer number of years. Nonetheless, it can be confirmed that solid biomass production and consumption have returned to cruising speed across the European Union. Solid biomass consumption has contracted only twice since the start of the millennium… in 2011 and in 2014. These falls were directly linked to the significant drops in heating needs compared to the previous years 2010 and 2013. The trend over the past two years confirms that solid biomass consumption is picking up. It is caused by an increase in the demand for heat.

According to the official data gathered by EurObserv'ER, the 28 European Union Member States' gross consumption of biomass primary energy, measured at 98.4 Mtoe in 2016 is now at the 100-Mtoe threshold, and equates to a 3% (2.9-Mtoe) rise over 2015. Over the past two years, consumption has increased by 7.2 Mtoe which is a strong sign that consumption has picked up.

The production of solid biomass primary energy, equating to solid biomass sourced on European Union soil, has increased at a slightly faster pace – 3.4% – to 95 Mtoe (an increase of 3.1 Mtoe between 2015 and 2016). The difference, comprising net imports, mainly consists of wood pellet imports from the USA, Canada or the Ukraine. Incidentally after steadily rising from 2009 to 2014 (from 1.3 Mtoe in 2008 to 3.9 Mtoe in 2014), the net import balance has tended to slip over the past two years, settling at 3.5 Mtoe in 2016.

EurObserv'ER distinguishes between final energy use originating from solid biomass, namely

EUROBSERV'ER – THE STATE OF RENEWABLE ENERGIES IN EUROPE – 2017 EDITION

1

Primary energy production and gross inland consumption of solid biomass in the European Union in 2015 and 2016 (in Mtoe)

	2015		2016	
	Production	Consommation	Production	Consommation
Germany	12.062	12.062	12.181	12.181
France	9.667	9.667	11.097	11.097
Sweden	9.129	9.129	9.418	9.418
Italy	7.340	8.578	7.232	8.441
Finland	7.901	7.927	8.309	8.333
Poland	6.597	6.884	6.415	6.620
United Kingdom	3.835	6.109	3.840	6.370
Spain	5.261	5.261	5.304	5.304
Austria	4.500	4.664	4.698	4.792
Romania	3.521	3.514	3.521	3.514
Czech Republic	2.954	2.874	2.970	2.906
Denmark	1.631	2.584	1.588	2.793
Hungary	2.510	2.479	2.983	2.586
Portugal	2.603	2.340	2.605	2.403
Belgium	1.171	1.942	1.292	2.058
Latvia	2.005	1.262	2.311	1.296
Croatia	1.532	1.258	1.532	1.258
Netherlands	1.357	1.179	1.366	1.209
Lithuania	1.205	1.204	1.200	1.206
Bulgaria	1.160	1.035	1.120	1.056
Estonia	1.209	0.825	1.396	0.898
Slovakia	0.890	0.879	0.890	0.879
Greece	0.952	1.013	0.797	0.855
Slovenia	0.590	0.590	0.608	0.608
Ireland	0.201	0.228	0.226	0.271
Luxembourg	0.057	0.066	0.063	0.069
Cyprus	0.007	0.010	0.007	0.010
Malta	0.000	0.001	0.000	0.001
Total EU 28	**91.848**	**95.563**	**94.970**	**98.433**

** Excluding charcoal.* ***Source: Eurobserv'ER 2017***

2

Gross electricity production from solid biomass in the European Union in 2015 and 2016 (in TWh)*

	2015			2016		
	Electricity only	CHP	Total	Electricity only	CHP	Total
United Kingdom	19.418	0.000	19.418	19.597	0.000	19.597
Germany	4.795	6.238	11.033	4.775	6.019	10.794
Finland	1.217	9.372	10.589	1.004	9.599	10.603
Sweden	0.000	8.977	8.977	0.000	9.750	9.750
Poland	1.957	7.070	9.027	2.052	4.861	6.913
Italy	2.089	1.858	3.947	2.226	1.899	4.125
Spain	3.126	0.888	4.014	3.212	0.836	4.048
Austria	1.232	2.264	3.497	0.896	2.789	3.685
Denmark	0.000	2.803	2.803	0.000	3.481	3.481
Belgium	2.298	1.256	3.554	2.156	1.233	3.390
France	0.098	2.051	2.149	0.405	2.664	3.069
Portugal	0.795	1.723	2.518	0.760	1.721	2.481
Czech Republic	0.049	2.042	2.091	0.014	2.053	2.068
Netherlands	1.724	0.173	1.897	1.116	0.791	1.907
Hungary	1.011	0.650	1.661	0.827	0.666	1.493
Slovakia	0.004	1.095	1.099	0.003	1.126	1.129
Estonia	0.069	0.641	0.710	0.127	0.713	0.840
Romania	0.107	0.355	0.462	0.077	0.388	0.466
Latvia	0.000	0.378	0.378	0.000	0.427	0.427
Ireland	0.184	0.013	0.197	0.377	0.016	0.393
Lithuania	0.000	0.318	0.318	0.000	0.262	0.262
Croatia	0.000	0.089	0.089	0.000	0.194	0.194
Bulgaria	0.003	0.148	0.151	0.003	0.160	0.163
Slovenia	0.000	0.131	0.131	0.000	0.137	0.137
Luxembourg	0.000	0.024	0.024	0.000	0.025	0.025
Greece	0.001	0.000	0.001	0.005	0.000	0.005
Cyprus	0.000	0.000	0.000	0.000	0.000	0.000
Malta	0.000	0.000	0.000	0.000	0.000	0.000
Total EU 28	**40.177**	**50.556**	**90.734**	**39.632**	**51.811**	**91.443**

** Excluding charcoal.* ***Source: Eurobserv'ER 2017, amended with SHARES data***

electricity and heat. Solid biomass heat is broken down by direct use by the final consumer in heating appliances (boilers, wood-burners, inserts, etc.), that account for most of the consumption, to distinguish it from heat supplied by the processing sector and distributed via heating networks. EurObserv'ER reckons that the consumption of heat directly used by final consumers increased by 2.7% (1.8 Mtoe) in the twelve-month period to achieve 68.4 Mtoe in 2016. Gross production of solid biomass heat sold to heating networks appears to have increased by 9.9% (0.9 Mtoe), driven by the higher demand for heating. It reached 10.3 Mtoe in 2016 and 61% of the production facilities were cogeneration plants. If these two elements are taken together, total final energy consumption as biomass heat increased by 3.6% between 2015 and 2016 to 78.8 Mtoe (an additional 2.7 Mtoe).

European Union solid biomass electricity production is less vulnerable to vagaries of climate, and more dependent on the policies of certain member countries to develop biomass electricity, either by converting former coal-fired power plants or by developing biomass cogeneration. However, the new European biomass electricity policy, unveiled in the "clean energy" package should severely curb the conversion of coal-fired power plants into biomass power plants not operating as CHPs after 2020. Serious statistical consolidations were made at the end of the year, showing that the increase in electricity output was less than anticipated in 2016. It only increased by 0.8% between 2015 and 2016, to reach 91.4 TWh (i.e. an additional 0.7 TWh). This is a much slower growth pace than was observed between 2014 and 2015 when growth was assessed at 6.9% based on 90.7 TWh of output (i.e. an additional 5.9 TWh). The lacklustre performance in 2016 was partly down to much less growth in the UK's biomass electricity output, but primarily due to the drop in Poland's biomass electricity output (which fell 23,4% from its 2015 level), i.e. a 2.1-TWh drop in contribution. The reason for this drop was the fall in the price of green certificates – the system set up to encourage the production of renewable electricity and can be explained by the Polish Government's decision to restrict the demand for certificates (and thus the country's renewable electricity requirement). The outcome was a glut of certificates. This surplus that can be used in successive years will no longer be able to finance the production of biomass electricity, which is falling through lack of profitability.

2030... AN INCREASE IN SOLID BIOMASS CONTRIBUTION IS POSSIBLE

All things considered, 2016 was positive for expanding the solid biomass sectors as it consolidated the previous year's pick-up in consumption even though heating requirements have dwindled in recent years. Solid biomass heat consumption is ahead of the trajectory set out for it in the European Union National Renewable Energy Action Plans (NREAP) (see graph). The reason for this important positive difference is that the member countries have made efforts to develop solid biomass heat, for individual, collective and industrial use and have also been assisted in this by initially having underestimated their consumption. We note that since the NREAP plans were published in 2010, many countries have revised their estimates of biomass heat consumption upwards and retroactively, primarily on the strength of more detailed surveys of household wood energy consumption. The forthcoming European directive target dates for 2020 generally encourage the countries to improve their appraisals of solid biomass consumption and the impacts of their energy policies. These statistical consolidations are usually revised upwards up and have had a positive impact on the renewable energy trajectory of the countries in question.

Turning to electricity production, the countries with major forestry industries are politically committed to keeping up their major drives to develop biomass cogeneration and to making better use of their forestry potential (by implementing Climate Plans), which should also result in steady growth. It is difficult to make accurate forecasts for 2020 because several operators have or are in the process of converting their thermal power plants so that they can be relatively flexible in their use of feedstocks. Biomass electricity production may well accelerate over the last two to three years of the decade, as AEBIOM projections suggest. The forecast of 130 TWh made by EurObserv'ER (which includes household waste-to-energy recovery) is more

3

Gross heat production from solid biomass in the European Union in 2015 and in 2016 (in Mtoe) in the transformation sector***

	2015			2016		
	Heat only plants	CHP plants	Total	Heat only plants	CHP plants	Total
Sweden	0.704	1.614	2.318	0.711	1.765	2.477
Finland	0.599	1.012	1.612	0.668	1.092	1.760
Denmark	0.451	0.602	1.053	0.473	0.664	1.137
France	0.325	0.398	0.722	0.423	0.497	0.920
Austria	0.496	0.347	0.843	0.535	0.335	0.870
Germany	0.184	0.399	0.583	0.217	0.399	0.616
Italy	0.070	0.461	0.531	0.078	0.464	0.542
Lithuania	0.346	0.100	0.445	0.392	0.095	0.487
Poland	0.029	0.268	0.297	0.030	0.289	0.319
Estonia	0.075	0.140	0.215	0.157	0.150	0.308
Latvia	0.095	0.106	0.201	0.114	0.137	0.251
Czech Republic	0.030	0.123	0.153	0.023	0.138	0.161
Slovakia	0.043	0.076	0.119	0.045	0.080	0.125
Hungary	0.050	0.055	0.106	0.064	0.060	0.124
Romania	0.034	0.035	0.069	0.037	0.035	0.072
Netherlands	0.018	0.014	0.032	0.027	0.022	0.049
Slovenia	0.008	0.018	0.027	0.009	0.019	0.028
Croatia	0.000	0.015	0.015	0.000	0.022	0.022
Bulgaria	0.007	0.004	0.011	0.010	0.005	0.015
Luxembourg	0.004	0.009	0.013	0.004	0.009	0.013
Belgium	0.000	0.006	0.006	0.000	0.006	0.006
United Kingdom	0.004	0.000	0.004	0.003	0.000	0.003
Total EU 28	3.572	5.802	9.375	4.022	6.284	10.305

** Excluding charcoal. ** Corresponds to "Derived heat" (see Eurostat definition).* ***Source: EurObserv'ER 2017, amended with SHARES data***

4

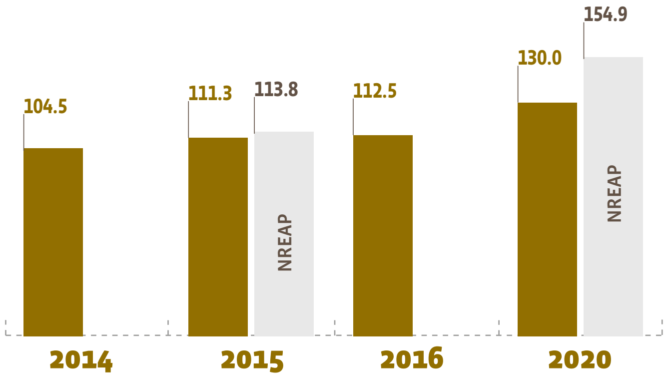
Heat consumption from solid biomass in the countries of the European Union in 2015 and 2016*

	2015			2016		
	Total	of which final energy consumption	of which derived heat**	Total	of which final energy consumption	of which derived heat**
France	8.936	8.214	0.722	9.822	8.902	0.920
Germany	9.254	8.671	0.583	9.565	8.949	0.616
Sweden	7.689	5.371	2.318	7.852	5.376	2.477
Italy	7.331	6.800	0.531	7.123	6.582	0.542
Finland	6.432	4.820	1.612	6.897	5.137	1.760
Poland	4.896	4.599	0.297	5.170	4.851	0.319
Austria	3.826	2.983	0.843	4.085	3.215	0.870
Spain	3.926	3.926	0.000	3.981	3.981	0.000
Romania	3.375	3.306	0.069	3.465	3.393	0.072
United Kingdom	2.606	2.602	0.004	2.864	2.861	0.003
Czech Republic	2.405	2.251	0.153	2.438	2.278	0.161
Denmark	2.222	1.169	1.053	2.347	1.210	1.137
Hungary	2.026	1.921	0.106	2.013	1.889	0.124
Portugal	1.719	1.719	0.000	1.773	1.773	0.000
Belgium	1.217	1.211	0.006	1.318	1.312	0.006
Croatia	1.207	1.192	0.015	1.171	1.149	0.022
Latvia	1.107	0.906	0.201	1.121	0.870	0.251
Lithuania	1.065	0.620	0.445	1.109	0.621	0.487
Bulgaria	1.003	0.992	0.011	1.008	0.993	0.015
Greece	1.010	1.010	0.000	0.849	0.849	0.000
Netherlands	0.685	0.653	0.032	0.712	0.662	0.049
Estonia	0.692	0.477	0.215	0.711	0.404	0.308
Slovenia	0.565	0.538	0.027	0.585	0.556	0.028
Slovakia	0.564	0.445	0.119	0.513	0.388	0.125
Ireland	0.193	0.193	0.000	0.192	0.192	0.000
Luxembourg	0.060	0.047	0.013	0.063	0.050	0.013
Cyprus	0.008	0.008	0.000	0.006	0.006	0.000
Malta	0.001	0.001	0.000	0.001	0.001	0.000
Total EU 28	76.020	66.646	9.375	78.755	68.450	10.305

** Excluding charcoal. ** Essentially district heating (see Eurostat definition). **Source: EurObserv'ER 2017, amended with SHARES data***

5

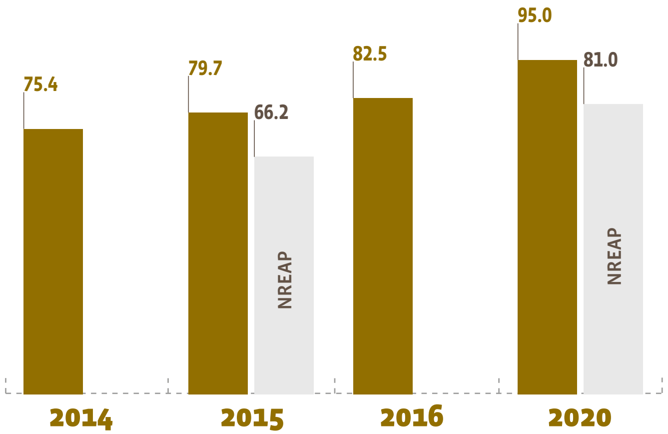
Comparison of the current trend of electricity production from solid biomass against the NREAP (National Renewable Energy Action Plans) roadmap (in TWh)



*These data include an estimate of the renewable electricity from waste incineration units. **Source: EurObserv'ER 2017***

6

Comparison of the current trend of heat consumption from solid biomass against the NREAP (National Renewable Energy Action Plans) roadmap (in Mtoe)



*These data include an estimate of the renewable heat from incineration plants of municipal waste. **Source: EurObserv'ER 2017***

conservative and is based on the current growth trend. As it stands, the trend is too weak to achieve the initial NREAP solid biomass electricity deployment targets.

The development pace for the forthcoming years and the longer term after 2020 will primarily depend on new measures to implement energy policies in line with the member countries' Climate Plans, and primarily those that aim to gradually levy heavy carbon taxes. Many experts believe that solid biomass is most likely to increase its contribution significantly in the forthcoming years and decades with the same forested area, through more rational exploitation and the development of agroforestry, a farming practice that consists of replanting trees in the middle of crops and also on restoring hedgerows. This development will have to be controlled to ensure that the biodiversity of forest environments remains unchanged, to qualify as sustainable, with impacts on forestry management methods and the tree species chosen for planting. From 2020 to 2030, solid biomass should mainly be used for heating buildings and to a lesser extent for producing methane by gasification for injection into the natural gas grid – a technology that will become more profitable as the rate of carbon tax rises. ■

CONCENTRATED SOLAR POWER

Combined European concentrated solar power plant capacity has remained at the same level since 2014. The construction of a series of new, ambitious projects is a long time coming. A new project should finally come on stream in France in 2018, on the Italian island of Sardinia a couple of projects should be brought to fruition.

Despite the storage and grid stability advantages that the concentrated solar power sector offers, it has ground to a halt in Europe. According to EurObserv'ER, the European Union's CSP installed capacity meter has been stuck at 2 313.7 MW since 2014 (including prototype project capacity). According to Eurostat, the officially recognized capacity has been stable since 2013, at 2 302 MW (2 300 MW in Spain and 2 MW in Germany).

For the time being, Spain is the only European Union country to have developed a commercial CSP sector. But since 2013, no additional capacity has been added and no new project has been announced. Nonetheless, the sector functions as a reliable national electricity production base. According to IDAE, gross output injected into the grid has remained stable. It amounted to 5 593 GWh in 2015 and 5 579 GWh in 2016. While there is a moratorium on new projects, the Spanish authorities are currently embroiled in disputes with groups that invested in Spanish CSP plants. Four international investors, Masdar, Abu Dhabi's leading clean energy company, the German institutional asset management services company Deutsche Asset & Wealth Management, the British equity fund manager Eiser Infrastructure, (formerly RREEF Infrastructure) and Antin Infrastructure Partners of BNP Paribas, France have filed claims against Spain at the World Bank Group's ICSID, International Centre for the Settlement of Investment Disputes, for losses of earnings caused by policy changes affecting the profitability of their investments. This claim follows successive decisions by the Spanish Government in 2012 and 2013, confirmed in 2014, to retroactively change the remuneration system for Spain's CSP plants, that resulted in an approximately 33% decline in their earnings.

The construction of new projects in Italy has been delayed, primarily because the developers feel that the payment terms are unattractive and because the time it takes for the regional authorities to issue licences. ANEST (the Italian CSP industry association), claims that the latest ministerial decree published on 29 June 2016 setting the framework for renewable power plant incentives (excluding photovoltaic), was mainly positive for <5 MW CSP facilities, but unconvincing for medium-capacity CSP plants. At the end of November 2016, the GSE (Gestore dei Servizi Energetici) published a list of 8 successful bids for <5 MW projects (with 20 MW of combined capacity) that had applied for aid with production. However, there were no >5 MW projects subject to the GSE tender procedure. ANEST reckons that a new decree may yet be published in 2017 that is likely to finance medium-size plants and hopes that this will lead to the construction of several power plants before the end of 2017. The association claims that there are

1

Concentrated solar power plants in operation at the end of 2016

Projects	Technology	Capacity (MW)	Commisionning date
Spain			
Planta Solar 10	Central receiver	10	2006
Andasol-1	Parabolic trough	50	2008
Planta Solar 20	Central receiver	20	2009
Ibersol Ciudad Real (Puertollano)	Parabolic trough	50	2009
Puerto Errado 1 (prototype)	Linear Fresnel	1,4	2009
Alvarado I La Risca	Parabolic trough	50	2009
Andasol-2	Parabolic trough	50	2009
Extresol-1	Parabolic trough	50	2009
Extresol-2	Parabolic trough	50	2010
Solnova 1	Parabolic trough	50	2010
Solnova 3	Parabolic trough	50	2010
Solnova 4	Parabolic trough	50	2010
La Florida	Parabolic trough	50	2010
Majadas	Parabolic trough	50	2010
La Dehesa	Parabolic trough	50	2010
Palma del Río II	Parabolic trough	50	2010
Manchasol 1	Parabolic trough	50	2010
Manchasol 2	Parabolic trough	50	2011
Gemasolar	Central receiver	20	2011
Palma del Río I	Parabolic trough	50	2011
Lebrija 1	Parabolic trough	50	2011
Andasol-3	Parabolic trough	50	2011
Helioenergy 1	Parabolic trough	50	2011
Astexol II	Parabolic trough	50	2011
Arcosol-50	Parabolic trough	50	2011
Termesol-50	Parabolic trough	50	2011
Aste 1A	Parabolic trough	50	2012
Aste 1B	Parabolic trough	50	2012
Helioenergy 2	Parabolic trough	50	2012
Puerto Errado II	Linear Fresnel	30	2012
Solacor 1	Parabolic trough	50	2012
Solacor 2	Parabolic trough	50	2012
Helios 1	Parabolic trough	50	2012
Moron	Parabolic trough	50	2012
Solaben 3	Parabolic trough	50	2012
Guzman	Parabolic trough	50	2012
La Africana	Parabolic trough	50	2012
Olivenza 1	Parabolic trough	50	2012
Helios 2	Parabolic trough	50	2012
Orellana	Parabolic trough	50	2012
Extresol-3	Parabolic trough	50	2012
Solaben 2	Parabolic trough	50	2012
Termosolar Borges	Parabolic trough + HB	22,5	2012
Termosol 1	Parabolic trough	50	2013
Termosol 2	Parabolic trough	50	2013
Solaben 1	Parabolic trough	50	2013
Casablanca	Parabolic trough	50	2013
Enerstar	Parabolic trough	50	2013
Solaben 6	Parabolic trough	50	2013
Arenales	Parabolic trough	50	2013
Total Spain		**2303,9**	
Italy			
Archimede (prototype)	Parabolic trough	5	2010
Archimede-Chiyoda Molten Salt Test Loop	Parabolic trough	0,35	2013
Freesun	Linear Fresnel	1	2013
Zasoli	Linear Fresnel + HB	0,2	2014
Rende	Linear Fresnel + HB	1	2014
Total Italy		**7,55**	
Germany			
Jülich	Central receiver	1,5	2010
Total Germany		**1,5**	
France			
La Seyne sur mer (prototype)	Linear Fresnel	0,5	2010
Augustin Fresnel 1 (prototype)	Linear Fresnel	0,25	2011
Total France		**0,75**	
Total EU 28		**2313,7**	

Legend of 2016. ***Source: EurObserv'ER 2017*** some fifteen projects that have construction permits for 259.4 MW of capacity in all, including Lentini (55 MW, parabolic trough), Flumini Mannu (55 MW, parabolic trough), Gonnosfanadiga (55 MW, parabolic trough), Solecaldo (41 MW, Fresnel), Reflex Solar Power (12.5 MW, parabolic trough), San Quirico CSP (10.8 MW, hybrid parabolic trough) and San Severo (10 MW, tower plant).

Progress is being made on some projects. At the end of November 2017, the regional government of Sardinia gave the go-ahead for the construction of the San Quirico hybrid CSP facility in Oristano province. The facility comprises roughly 131 000 square metres of collector area and a woody biomass plant. The facility's total capacity is 10.8 MWe. On 5 October 2017, the first Italian CSP plant connected to the national grid, with a collector surface of 10 000 square metres, was commissioned at Ottana, Sardinia. The project, which was completed by CSP-F of the Fera Group, uses linear Fresnel collectors, Archimede Solar Energy receiver tubes and has a 600-kW Turboden ORC turbine.

In France, the first two power plant projects accepted in the first tender (CRE 1) in 2012 that were scheduled for commissioning in 2015, have met with mixed success. The Alba Nova 1 (12 MW) project bearer, Solar Euromed, was put into liquidation on 6 September 2016 which makes the project's fulfilment dependent on a hypothetical sale of assets. Making up for this, Suncnim (a CNIM Group and Bpifrance subsidiary), the Llo project bearer in the Pyrenees-Orientales (9 MW), finally started construction work at the end of December 2016 with commissioning due in February 2018. This 9-MW plant will have 4 hours of thermal storage at full load. The sector's players hope that project completion will lead to the launching of a new tender. Last year the sector voiced its disbelief at the absence of any CSP target in the new PPE (Multi-annual energy programming plan) of October 2016 although the previous targets for the end of 2020 were set at 540 MW.

THE LONG-TERM STORAGE ADVANTAGE OF CSP

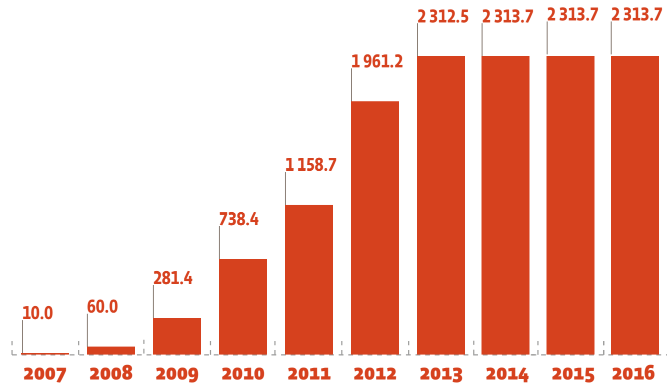
The National Renewable Energy Action Plans set under the terms of the European directive planned for installed capacity of 6 765 MW (4 800 in Spain, 600 in Italy, 540 in France, 500 in Portugal, 250 in Greece and 75 in Cyprus) equating to 20 TWh of output by the 2020 timeline. It is now clear that these targets will not be met, as the relevant countries have contained the financial impacts of developing this new production sector by halting or downsizing their programmes to give priority to the more mature renewable technologies whose costs are manageable.

However, the sector players, especially the European CSP sector association (Estela), emphasize that development in Europe has eloquently proven its efficiency as demonstrated by Spain's results. They also stress the crucial advantage of the CSP sector's storage abilities that obviate grid management problems.

In the European association's view, major CSP deployment programmes in Europe must be rolled out as a key step towards reducing production costs. Deployment is also deemed important to maintain the European players' increasingly fragile lead of the global market. It puts forward a final priority – that of developing cooperation mechanisms between European countries to ensure the mobility of solar thermal power from the best production sites to the main consumption regions. ■

2

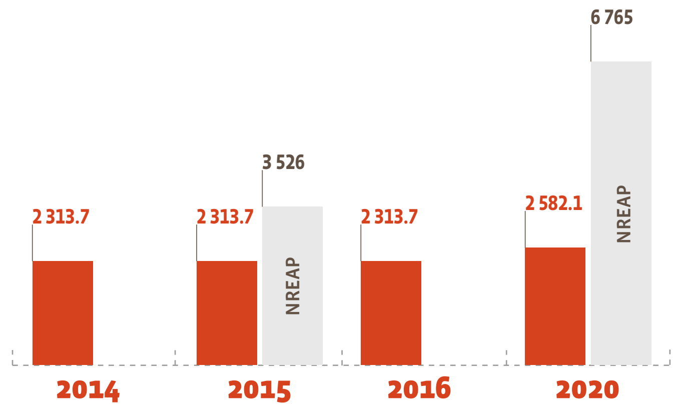
CSP plant capacity trend in the European Union (MW)



Source: EurObserv'ER 2017

3

Comparison of the current trend against the NREAP (National Renewable Energy Action Plans) roadmap (MW)



Source: EurObserv'ER 2017

OCEAN ENERGY

Europe, with its many kilometres of continental and far-flung coastlines, leads the world in harnessing the various forms of energy that the seas have to offer. Tidal energy (tidal power), currents (underwater turbines) or waves (wave energy converters), energy recovered from temperature (thermal) or salt content differences between two bodies of water (osmosis)… all offer enormous potential. The Ocean Energy Forum verdict that it gave in the ocean energy roadmap delivered to the European Commission in 2016, is that these sources could meet up to 10% of the EU's electricity demand by 2050.

Tidal power is the only commercially harnessed form of ocean energy. Since 1966, France's 240-MW la Rance (Ille-et-Vilaine) tidal barrage has been operating across the Rance river estuary. More recently, the Netherlands successfully commissioned its Eastern Scheldt storm surge barrier with five 250-kW T2 turbines (1.25 MW) in November 2015. Then in January 2017, the former UK Energy Minister, Charles Hendry, published his tidal lagoon review that came out in favour of experimental tidal power projects. This prompted the Duchy of Lancaster to grant a long-term lease to Atlantis Resources and its co-developer Natural Energy Wyre (NEW) in November 2017 to construct a tidal 160-MW barrage across the River Wyre estuary, near Fleetwood, North-West England.

Other technologies are under development to harness tides, essentially through tidal lagoon projects. Construction on a 320-MW prototype led by Tidal Lagoon Power should commence in 2018 in the UK's Swansea Bay.

As commercially viable projects take time to get off the ground, the other forms of ocean energy are still in research and development or industrial pilot phase. Work on osmotic and thermal energy remains limited, while experimentation on underwater turbine and wave energy converter technologies is well underway. Several countries have prototype machines installed off their coasts, but the particularly strong potential of the UK and French waters means that they dominate most of this activity.

The hotspot is the European Marine Energy Centre (EMEC) in Scotland, which was set up over a decade ago, and regularly accepts different types of test machines or devices hooked up to the grid to put them through their paces. In the summer of 2018, the American company GWave should be deploying its 9 MW power generation vessel at the Wave Hub in Cornwall.

The UK's generous marine resources enables it to accommodate other large-scale pilot projects such as the Atlantis Resources Corporation 398-MW tidal array project MeyGen, which is being developed in the waters off Stroma Island (construction of the first 4-machine pilot phase is nearing completion pending the launch of the commercial phase). Last November, the Australian developer Bombora announced that it would be investing 20 million euros in a wave energy project to be run off South Wales.

In France, the prefecture of Manche signed several authori-

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sations in March 2017 for the installation of the Normandie Hydro tidal farm in the Raz Blanchard. EDF Energies nouvelles and Naval Energies will be working together to install seven Openhydro 2-MW tidal turbines. They are scheduled to be immersed and connected to the grid in 2020.

The sector's expectations were dashed at the end of 2017, because the French government had not launched a single commercial call for tender for marine turbines. This led to job losses and financial hardship for several players. Naval Energies, for example, announced lay-offs yet is pursuing the construction of its marine turbine manufacturing plant in Cherbourg, which is due for delivery in March 2018 and should produce the turbines for the Normandie Hydro project.

At European level, 2017 marked the start of an important task to develop standards and certifications through the "MET-Certified" project aimed at securing marine power's profitability, primarily in the English Channel and the North Sea. The project is co-financed by the European Fund for Regional Development and covers the UK, France, the Netherlands and Belgium. The three-year project (2017-2019) could contribute significantly to achieving the long-awaited transition from pre-commercial to commercial phase. ■

1

List of plants harnessing ocean energy in the event at the end of 2017

Projects	Capacity (MW)	Commissioning date	Current state
United Kingdom			
Limpet	0.25	2000	Connected
Naval Energies Open Center Turbine	0.25	2006	Connected
Wello Oy-Penguin	0.6	2012	Connected
Nova 30	0.03	2014	Connected
Minesto-Deep GreenOcean	0.03	2013	Connected
WaveNET Series-6	0.022	2014	Being tested
Scotrenewables Tidal Power	2	2016	Connected
Nova 100	0.3	2016	Connected
Andritz TTG#1-Meygen	4.5	2016	Connected
Atlantis AR 1500	1.5	2017	Connected
SME -PLAT 1	0.28	2017	Connected
Total UK	9.8		
Portugal			
OWC Pico	0.4	2004	Connected
Total Portugal	0.4		
France			
Barrage de La Rance	240	1966	Connected
Hydro Gen 2	0.02	2010	Being tested
HydroQuest River 1.40	0.04	2014	Connected
Hydrotube Énergie H3 V2	0.02	2017	Connected
Total France	240.1		
Spain			
Mutriku OWC – Voith Wavegen	0.3	2011	Connected
Oceantec WEK MARMOK-A-5	0.03	2016	Connected
Magallanes Atir	2	2017	Connected
Total Spain	2.3		
Italy			
GEM	0.02	2014	Being tested
R115	0.1	2014	Connected
H24	0.05	2015	Connected
ISWEC	0.1	2015	Connected
Total Italy	0.27		
Netherlands			
REDstack Friesland/Afsluitdijk	0.05	2014	Connected
Afsluitdijk tidal barrage Tocardo T1	0.3	2015	Connected
Easten Scheldt Tocardo T2	1.25	2015	Connected
Texel Island Torcado T2	0.25	2016	Connected
Total Netherlands	1.85		
Sweden			
Seabased Sotenäs Wave Energy Plant	3	2016	Being tested
Total Sweden	3		
Denmark			
Wavepiston	0.012	2017	Being tested
Weptos	n.c.	2017	Connected
Total Denmark	0.012		
Total EU 28	**257.7**		

Source: EurObserv'ER 2017

Continues Overleaf

INTEGRATION OF RES IN THE BUILDING STOCK AND URBAN INFRASTRUCTURE

Currently, heating and cooling is mainly provided by onsite technologies integrated in buildings. For the further decarbonisation of the heating sector especially in highly populated areas, the integration of RES in district heating grids is gaining in importance. The consumption and market indicators on RES integration in the building stock and urban structure are designed to show the status quo of RES use and the development of RES deployment in this respect. Due to the large building stock and the long life cycle of heating systems, the consumption shares changes slowly while the market shares reflects changes at the margin.

RES integrated in buildings or urban infrastructure comprises various technologies that are applied to provide heating, cooling and electricity. Decentralized technologies in buildings include heat pumps, biomass boilers, and solar thermal collectors. Relevant urban infrastructure for the integration of RES comprises mainly district heating plants including biomass CHP and heat only plants, geothermal plants, innovative applications such as solar thermal collector fields and large-scale heat pumps.

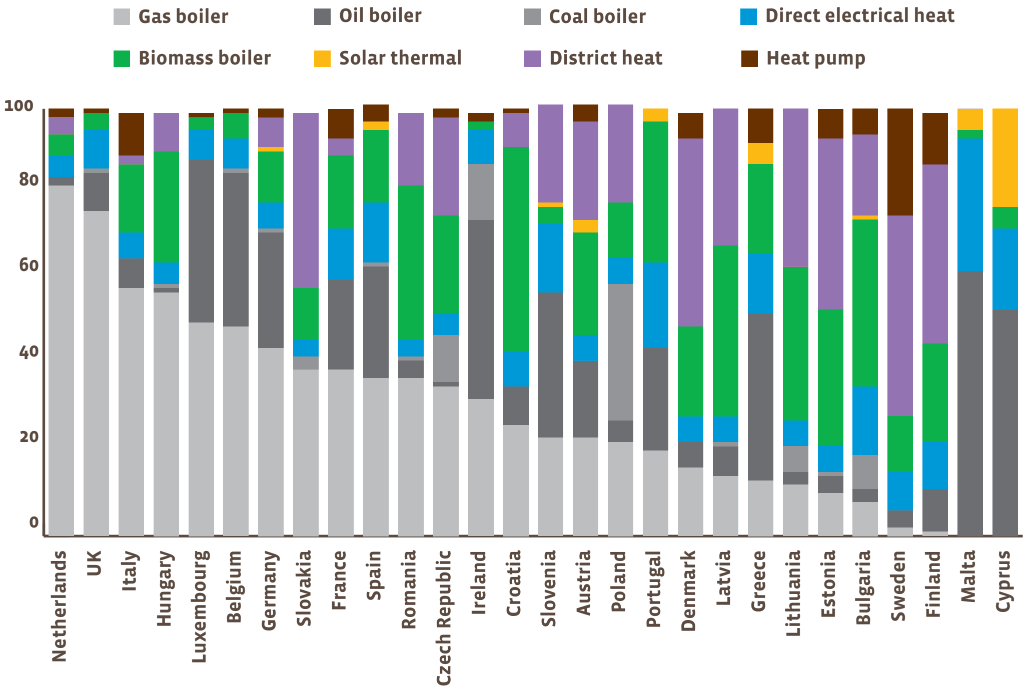
Methodological approach

The consumption shares of RES in the building stock shows the significance of the respective RES in the building sector, and its use. It is the quotient of final renewable energy demand for heating and cooling in building and total final energy demand in buildings including electricity for heating.
In addition, the market stock shares of RES are depicted. They show the installed heating units as a percentage of all dwellings. As solar power is mainly applied in combination with other technologies, it is not counted here as an alone standing system. In contrast, electric heating is included in the market stock share as an alone-standing system. It is an important technology for heating in some countries.
In contrast to consumption shares of RES, market sales shares of RES depict the dynamics and development of RES at the edge. Market shares show the share of technologies sold in relation to the total of all sold heating units. They may vary from year to year in each country. As data on sales were not available for all technologies or countries, the number of system exchanges is assessed based on the average exchange rate of systems of those countries, for which data was available. Although solar thermal energy is mainly used in combination with other systems, it is separately listed here to show its significance and dynamics.
A more detailed description on the methodological approach of the market and consumption shares can be found under (eurobserv-er.org) and on Eurostat's methodology on consumption shares (see http://ec.europa.eu/eurostat/web/energy/data/shares). Because Eurostat data for 2016 were not published at the time this chapter was written, the shares are shown for 2015 only.

RESULTS AND INTERPRETATION

1

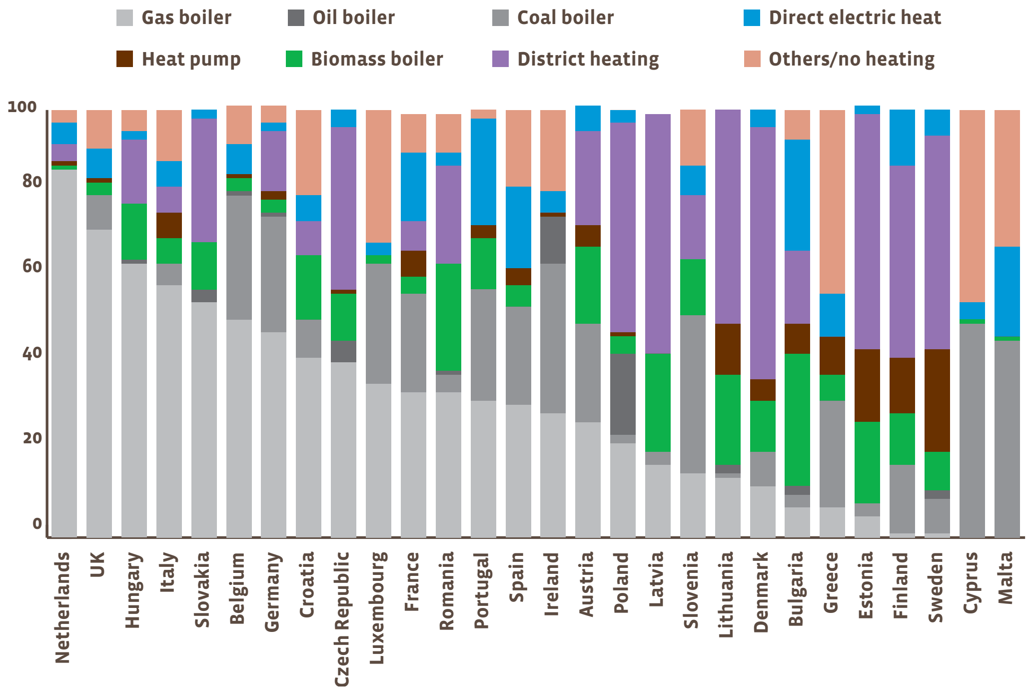
RES consumption shares in 2015



Source: EurObserv'ER 2017 – own assessment based on diverse sources.

2

RES market stock shares in 2015



Note: solar is not counted as an alone standing system as it is used mainly in combination with other systems.
Source: EurObserv'ER 2017 – own assessment based on diverse sources.

CONSUMPTION SHARES OF RES

Figure 1 presents the consumption shares of heating and cooling with renewable energies in 2015. Basically, this share is a combined indicator for the integration of renewable energies in buildings and urban infrastructure. It depicts the final renewable energy demand for heating and cooling as a share of total final energy demand for heating and cooling. Annual exchange rates for heating/cooling systems range around two to four percent, thus the consumption share shows only small changes from one year to the other. Thus, the situation in 2016 is expected to be similar to 2015.

In the Netherlands and the United Kingdom, and to a smaller share in Italy, Hungary, Luxemburg and Belgium, gas is still dominating the heating system. Oil boilers are mainly used in Malta and Cyprus, and in Ireland, Luxemburg, Belgium, Greece, Slovenia, Portugal and Germany they still represent an important technology or source for heat.

District heating is strong especially in Sweden, Finland, Denmark and Slovakia and other East European countries. Especially in the latter countries, district heating has a long history and can rely on existing infrastructure.

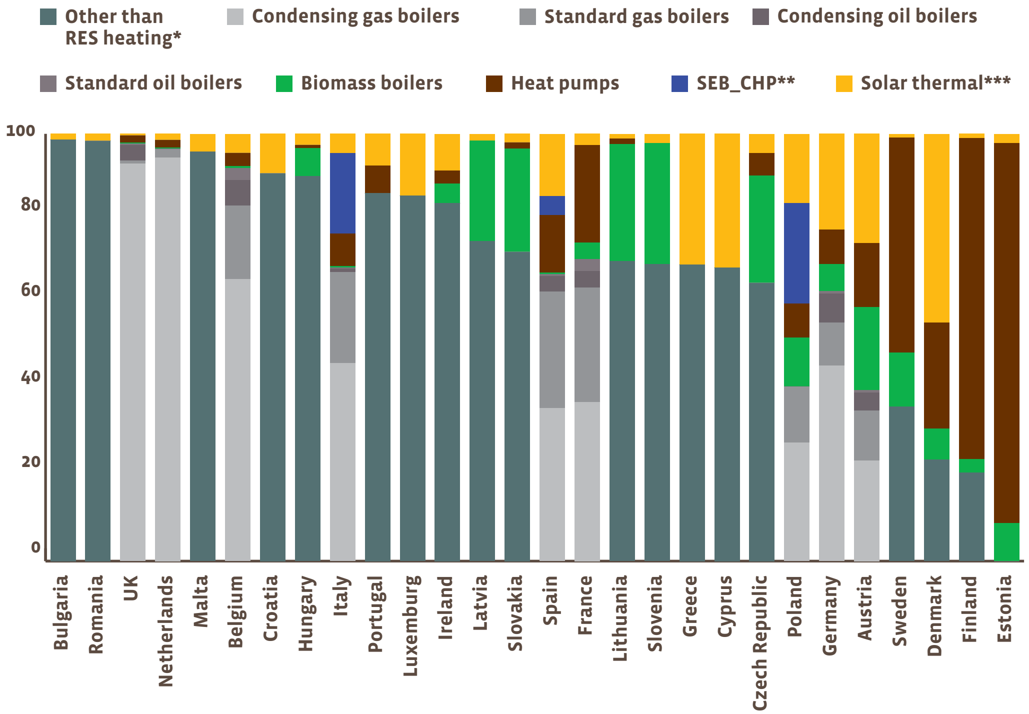
RES dominate in Croatia (54%) and Bulgaria (55%). This domination is only due to the high use of biomass, which represents a rather cheap fuel for heating in these countries. It is also used in Portugal (41%) and Lativa (42%). Albeit the growth of heat pumps in some countries, they display still a minor share apart from Sweden (27%) and Finland (13%) and Italy (11%). Overall, solar thermal displays the smallest shares and is mainly used to a small extent in Southern European countries, where the solar radiation is stronger than in the north. It is highest in Cyprus (29%), and lowest in the Balitc States and Romania and Finland. In Poland a large share of coal (32%) is used for heating while electric heating plays a role in Malta, Portugal, Cyprus, Bulgaria and Slovenia but also in Spain, France and Greece.

Figure 2 depicts the technology shares in the building stock, i.e. for all dwellings. In contrast to Figure 1 above, it shows the share of households with another or unknown heating system or no heating system at all. This share is very high for Cyprus, Greece, and high for Malta and Luxemburg, and also considerable for Croatia, Ireland and Spain. Due to climatic conditions some dwellings might have only a small heater, stove etc., which is not accounted in the statistics. Further, the high share could reflect data problems in this group. As solar thermal is not included here as separate system, dwellings which use only solar thermal energy for heating are part of this group as well.

With respect to rising RES shares in the power sector, electric heating gains in significance. In

3

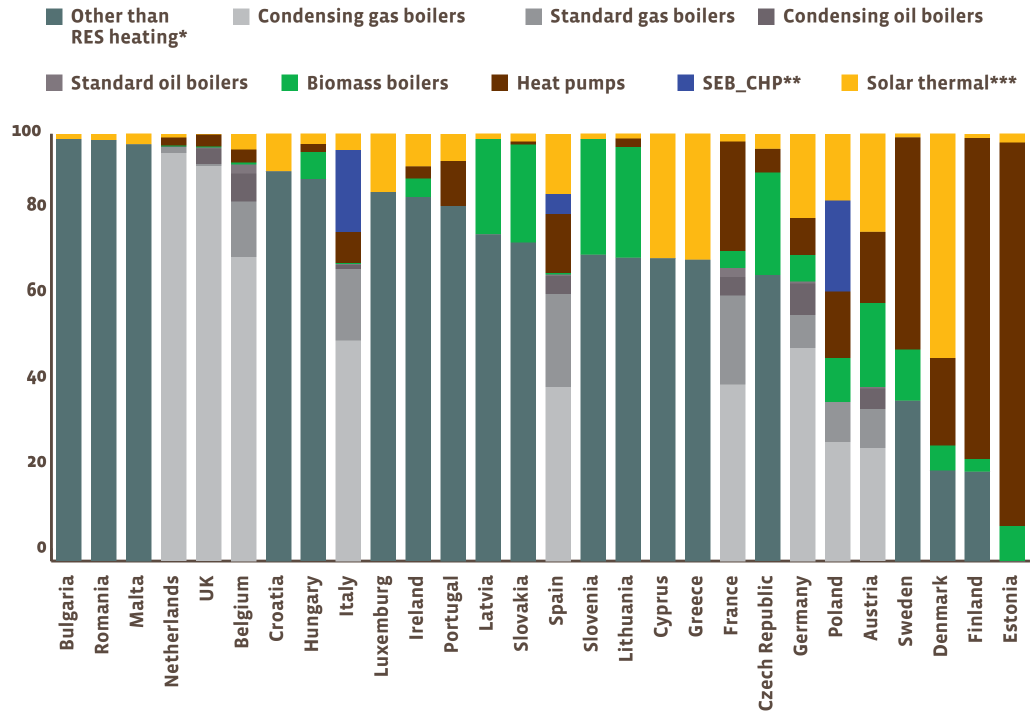
RES market sales shares in 2015



** Gas, oil and SEB_CHP, calculated for all EU countries based on average share of sales of AT, BE, FR, DE, IT, NL, PL, ES, UK.*
*** Stoves, electric panel heaters, coal boilers, micro-CHP etc.*
**** One unit of solar thermal contains 4 m2 per household (added just for visualization purposes).*
Source: EurObserv'ER 2017 – own assessment based on diverse sources.

4

RES market sales shares in 2016



** Gas, oil and SEB_CHP, calculated for all EU countries based on average share of sales of AT, BE, FR, DE, IT, NL, PL, ES, UK.*
*** Stoves, electric panel heaters, coal boilers, micro-CHP etc.*
**** One unit of solar thermal contains 4 m2 per household (added just for visualization purposes).*
Source: EurObserv'ER 2017 – own assessment based on diverse sources.

Bulgaria, Portugal and Malta the shares range significantly above ten percent, while in Spain, Ireland, France and Finland they are slightly above this threshold. This means a rising RES share in electricity contributes to low-carbon heating/cooling in these countries.

MARKET SALES SHARES OF RES

Figure 3 and Figure 4 depict the market sales share of RES technologies used for heating and cooling. In contrast to Figure 2 above, Figure 3 shows the recent developments in RES by illustrating the sales shares of RES heating/cooling in the respective year. Thus, it shows the dynamic in the market. Heat pumps show a very high dynamic in Estonia, Finland, Sweden and France. Biomass boilers, although at a lower level than heat pumps, display a high dynamic in the Baltic States, Slovakia, Slovenia and Czech Republic. Solar thermal energy shows a high dynamic in countries where it has already a high share, such as Cyprus and Greece. But it displays the highest dynamic in Denmark (solar district heating) while Austria, Germany, Poland and Spain reveal a moderate development.

Overall, in many EU countries, the dynamic of RES in the heating/cooling sector is low.

CONCLUSIONS

Overall, natural gas is the most commonly used heating system, followed by oil boilers, while coal boilers are slowly disappearing as the consumption shares as well as

5

Heating systems exchange rates as a percentage of households

Country	2015	2016
Austria	2.60%	2.67%
Belgium	5.16%	5.36%
France	3.14%	3.17%
Germany	1.73%	1.82%
Italy	4.72%	4.73%
Netherlands	4.92%	5.43%
Poland	2.53%	2.81%
Spain	1.89%	1.85%
Sweden	2.24%	2.31%
United Kingdom	5.68%	6.36%
Total EU (10)	**3.37%**	**3.55%**

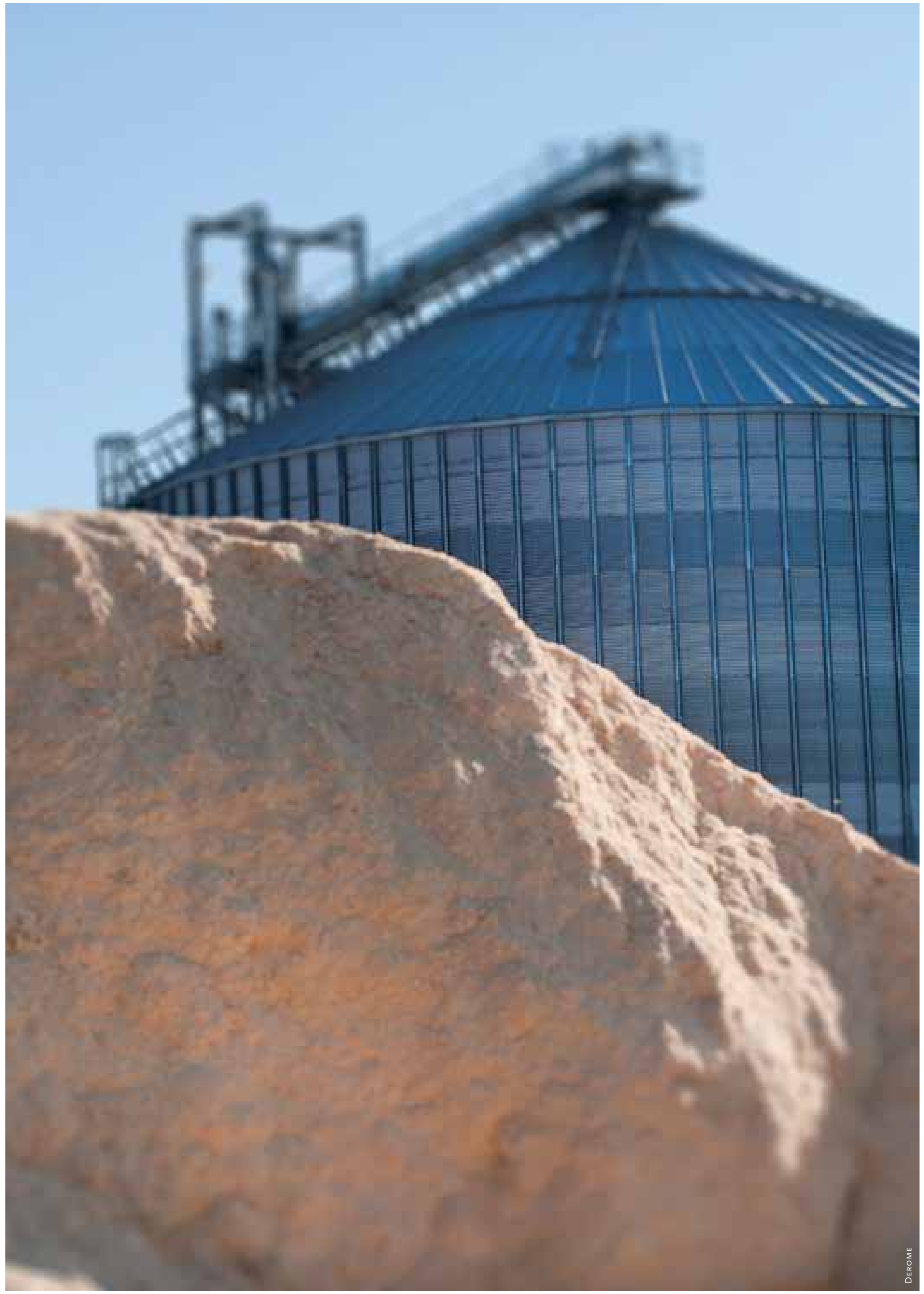
Source: EurObserv'ER 2017 – own assessment based on diverse sources.

the market sale shares indicate. In addition, there is a high dynamic in sales of condensing gas and oil boilers, indicating that they will play a significant role in heating even in the future.

Albeit the relatively high dynamic of heat pumps in some of the countries, the consumption shares are small compared to fossil fuel based heating. Solar thermal power has quite some potentials even in northern countries as the case of Denmark shows but its dynamic as well as share in the stock is low.

In Table 5 an overview of the heating systems exchange rates for the selected EU MS is presented. It can be observed that in countries like Belgium, Italy, Netherlands, and the UK where the share of district heating is very low, the exchange rates are higher than in the countries with high shares of households supplied by a district heating network.

In summary, in some countries, RES consumption as well as the dynamic in sales of RES systems is high. In particular, heat pumps are increasingly employed in Scandinavian countries while biomass plays an increasingly role in some Eastern European countries. In Romania, Bulgaria and Hungary the dynamics in RES-H seems to be low, but traditionally heating relies already to a certain share on biomass. In light of the decarbonisation of heating and cooling, electricity is gaining in significance if it is based on renewable energy source. However, deployment rates of electric heating are still low. ■



JUST THREE POINTS SHORT OF THE 2020 TARGET

According to the World Meteorological Organization (WMO) readings, Europe's last three years – 2014, 2015 and 2016 – have been the hottest on record in ascending order. These climate events have affected the final energy consumption trends for heating. The data released through the Eurostat SHARES (SHort Assessment of Renewable Energy Sources) tool shows that after bottoming out at 1 100.6 Mtoe in 2014, gross final energy consumption gradually picked up in 2015 (1 126 Mtoe) and 2016 (1 147.4 Mtoe) to return to a level resembling its 2011, 2012 and 2013 levels. This upturn can be correlated to a relative increase in heating requirements across the European Union, and the rebound in the actual GDP growth of the EU-of-28 (2.3% in 2015 and 2.0% in 2016, according to Eurostat). Total final energy consumption remained below the levels recorded between 2004 and 2008, prior to the financial and banking crisis of Autumn 2008.

ALMOST 1 000 TWH OF RENEWABLE ELECTRICITY GENERATED IN 2016

Weather conditions were generally unconducive to producing renewable electricity in 2016. The latest data on actual renewable electricity output (updated in January 2018), i.e. non-normalized for wind energy and hydropower, shows a 1.7% increase between 2015 and 2016, resulting in total electricity output of 951.4 TWh in 2016 (graph 1). This growth amounts to a year-on-year gain of 15.8 TWh and is much lower than the previous years' – increases of 4.0%, or 35.8 TWh in 2015 and of 5%, or43 TWh in 2014. Part of the explanation for this poor performance can be ascribed to the low winds across the European Union. The wind energy sector only increased output by 1 TWh between 2015 and 2016 to reach 302.9 TWh (0.3% more than in 2015), compared to the increase of 48.8 TWh between 2014 and 2015 for 301.9 TWh of output (19.3% more than in 2014). The 2015 weather conditions were far more conducive, primarily in Northern Europe and the British Isles. The growth in wind energy output in 2016 was lower although the additional wind energy capacity connected was high, i.e. 12.9 GW (a similar level of additional capacity was connected in 2015). This lower growth hit the wind energy share in the total renewable electricity share with the loss of 0.4 of a percentage point to 31.8%. Preliminary estimates available in January 2018 suggest that 2017 will be much more positive for the sector. The imbalance appears to have been corrected, with production records announced in the main producer countries, Germany and the UK as well as the Northern European countries.

The adversity that hit wind energy was partly offset by the positive hydropower production trend, although it must be admitted that having plummeted in 2015 (because of historically low rainfall), hydropower output only made up part of its loss of production in 2016. SHARES data reports that hydropower output excluding pumped-storage output[1], increased by 2.7% between 2015 and 2016 (9 TWh) to reach 350.1 TWh. This should be viewed against the historic 9% decline between 2014 and 2015 (33.8 TWh less output than in 2014). Pumped-storage output remained stable at 30.1 TWh.

The year 2016 can also be described as lacklustre for solar energy production. Solar PV only contributed another 2.9 TWh in 2016 (2.8% more than in 2015) to reach 105.2 TWh. In 2015 performance was much better with 10.8% growth and 10 TWh more output than in 2014. Part of photovoltaic's weaker growth can be ascribed to a reduction in the capacity connected in 2016, i.e. 6.1 GW, compared to 8 GW in 2015, compounded by slightly poorer sunshine conditions. In contrast, CSP capacity remained the same and is still concentrated in Spain (2 302 MW) where production is stable at 5.6 TWh. The combined solar power output figure was 110.8 TWh, and its share of total renewable electricity increased slightly (by 0.1 of a percentage point) to 11.6%.

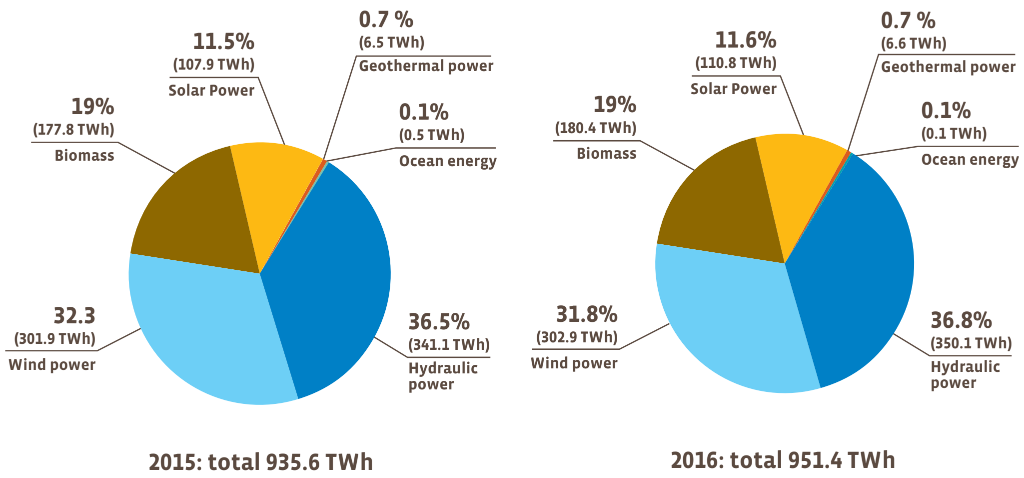
Taking biomass energy as a whole, its electricity output for 2016 reached 180.4 TWh, which is 1.5% (2.7 TWh) more than in 2015. Once again, the European Union-wide growth pace slowed down. In 2015, biomass electricity had increased by 6.3% compared to 2014, which equated to 10.6 TWh more output.

When we break down the results of the various biomass sectors we find in order of magnitude: biogas electricity whose output increased by 1.7 TWh in 2016 to 62.6 TWh (a 2.7% gain). The biogas sector is a long way ahead of the solid biomass sector which only added 0.7 TWh to 91.4 TWh (0.8%) over the twelve-month period. Part of the explanation for the weaker growth of solid biomass electricity can be put down to the significant drop (2.1 TWh) in Poland's output, because of the curb on incentives (see the sector article) and lower growth in output in the UK, primarily through maintenance downtime in the country's main production plant, Drax. The renewable waste sector maintained its 2.6% growth pace, which enabled it to add a further 0.5 TWh, resulting in a total of 21 TWh. While the liquid biomass contribution declined by 3.9% (0.2 TWh) to 5.3 TWh, the global biomass share did not change and still accounts for 19% of total renewable electricity output. Geothermal energy output also increased very slightly with an additional 116 GWh (compared to 6.6 TWh in 2015) and the renewable ocean energy contribution, essentially

1. Pumped-storage is an electrical energy storage technique based on the principal of pumping water to stock it in impoundment basins when energy demand is low. When demand is high, this water is later released through turbines to generate electricity.

1

Share of each energy source in renewable electricity generation in the EU 28 (in %).



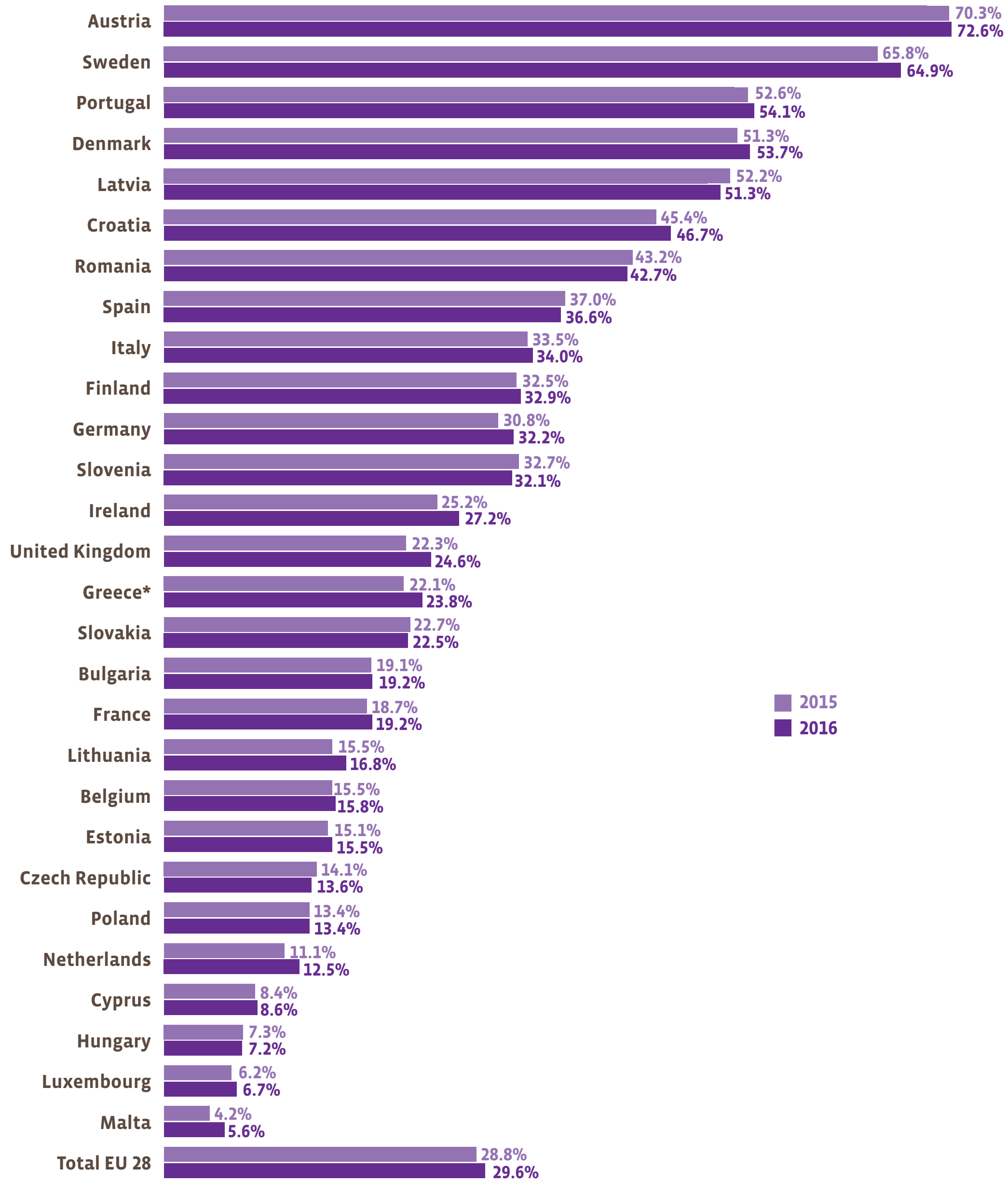
Note:** Figures for actual hydraulic and wind generation (no normalisation). **Source : EurObserv'ER 2017

generated by the Rance tidal power station in France which added a further 11 GWh to its output in 2016.

The renewable electricity output monitoring indicator used for calculating the Renewable Energy Directive (2009/28/EC) target differs in that it factors in normalized production for hydropower and wind energy (the normalization formula is defined in annex II of the directive), to even out the climatic variations, at least for rainfall and wind, thereby giving a more representative indicator of the efforts made by each Member State. It is also more accurate because it takes into account an estimate of the renewable electricity output generated by the biomethane that is injected into the natural gas grid and only includes the electricity output from sustainably-certified liquid biomass. The normalized hydropower output figure adopted was 350 TWh in 2016 (349.6 TWh in 2015) and the normalized wind energy figure adopted was 311.2 TWh (285.3 TWh in 2015). The total electricity output (conventional and renewable), reflecting the adjustments for normalized wind energy and hydropower outputs increased slightly in 2016 (by 0.7% year-on-year). It reached 3 243.1 TWh in 2016 compared to 3 219.3 TWh in 2015. Total "normalized" renewable electricity output increased faster (by 3.5% between 2015 and 2016) from 927.6 to 959.9 TWh (compared to 6.5% growth 6.5% between 2014 and 2015). This trend increases the renewable energy share of total electricity output, which rose from 28.8% in 2015 to 29.6% in 2016 (0.8 of a percentage point). If we take 2005 as the reference year (14.8%), the "normalized" renewable electricity share has increased exactly twofold. If we focus on this reference period (2005–2016), we can see that the increase in the renewable share has been considerable in many European Union countries, with far-ranging changes to the electricity production mix. The biggest increases can be ascribed to Denmark (29.1 percentage points), Portugal (26.4 percentage points), Germany (21.7 percentage points), the UK (20.5 percentage points), Ireland (19.9 percentage points), Italy (17.7 percentage points) and Spain (17.5 percentage points). The renewable electricity share has only slightly increased in countries including Hungary (2.8 percentage points), Slovenia (3.4 percentage points), Luxembourg (3.5 percentage points), France (5.5 percentage points) and the Netherlands (6.2 percentage points).

2

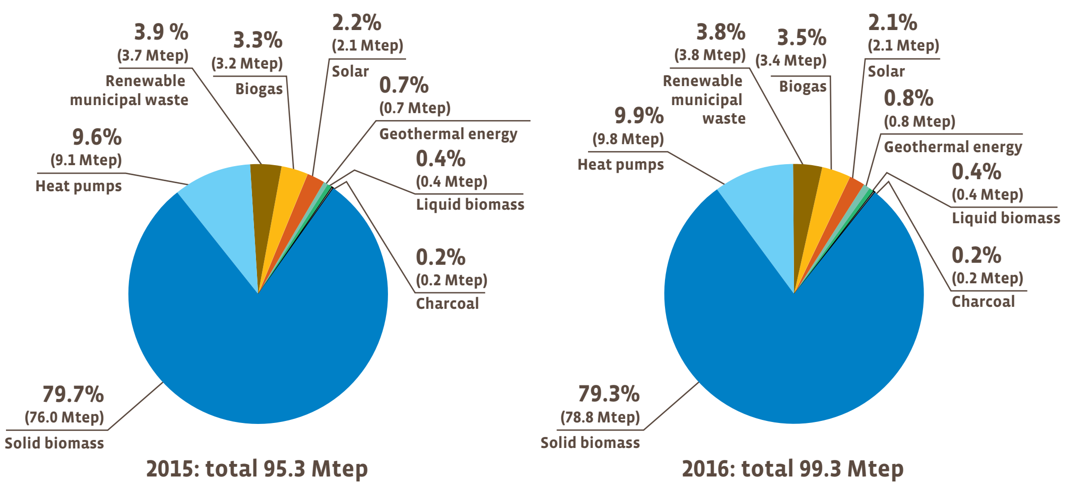
Share of renewable energy in the electricity generation of EU countries in 2015 and 2016



*** Year 2016 for Greece estimated by Eurostat.***
Notes for calculation:** Hydro is normalised and excluding pumping. Wind is normalised. Solar includes solar photovoltaics and solar thermal generation. All other renewables includes electricity generation from gaseous and liquid biofuels, renewable municipal waste, geothermal, and tide, wave & ocean. **Source: SHARES 2016, published 26th January 2018

3

Share of each energy source in renewable heat and cooling consumption in the EU 28 (in %).



Source : EurObserv'ER 2017

Graph 2 shows that the renewable electricity share can vary wildly in line with the Member States' potential and renewable energy support policies. Renewable production dominates in the top five ranked countries: Austria (72.6% in 2016), Sweden (64.9%), Portugal (54.1%), Denmark (53.7%) and Latvia (51.3%). However, it is less than 10% in the four bottom-ranking countries: Cyprus, Hungary, Luxembourg and Malta.

ALMOST 100 MTOE OF RENEWABLE HEAT

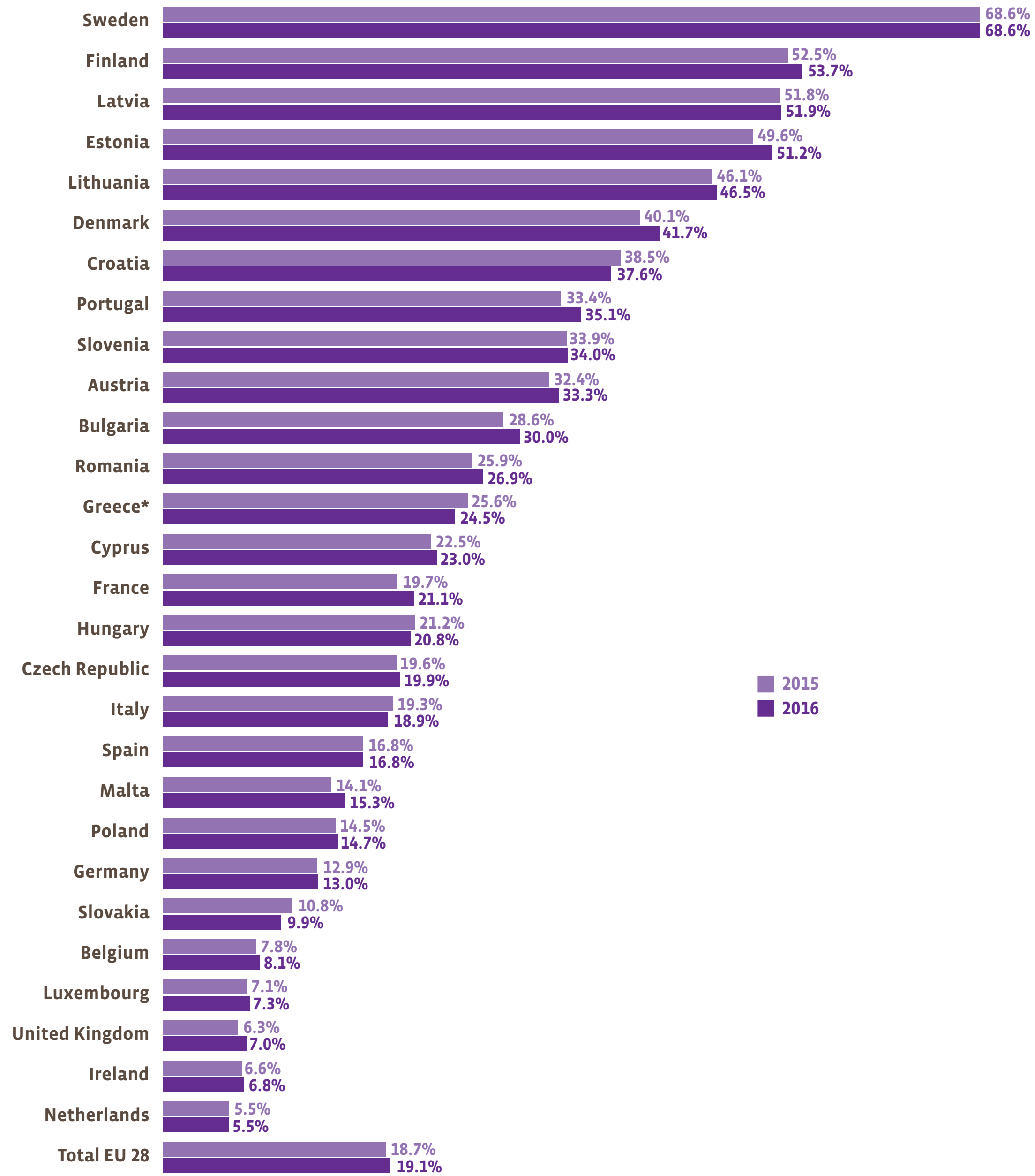
The data released through the Eurostat SHARES tool shows that the main renewable energy contribution in 2016 was achieved by the heat and cooling sector. The sector excludes processing sector heat but includes the energy directly used by the final user (e.g.: the consumption of wood energy by households in domestic heating appliances), derived heat from heating and cogeneration plants and the renewable output delivered by heat pumps. Heat and cooling output thus contributed 99.3 Mtoe in 2016, which represents 4.2% growth (an additional 4 Mtoe). This increase is lower than it was the previous year, when 5.7 Mtoe was added (a 6.2% increase between 2014 and 2015 to 95.3 Mtoe).

The variations in renewable heat consumption should be analysed as a trend. Since the succession of mild years and winters in Europe – a quantifiable consequence of climate warming – obfuscates efforts to read the impact of the policies introduced to promote the use of renewable heat. Heating needs can be directly correlated to mean temperature levels. Another major element to be considered in the trend and analysis of renewable heat is that new studies, mostly surveys on household wood energy consumption have improved solid biomass consumption monitoring and the monitoring of the amount of renewable energy produced by heat pumps, primarily reversible ASHPs of the air-to-air type. Until recently, several Southern European countries did not include them in their renewable energy statistics. Over and above climate conditions, efforts to improve building insulation and appliance and heating plant performance enhance primary renewable energy yield.

If we examine the individual sector trends, the additional solid biomass contributions (of 2.7 Mtoe) provided the main source of the increase is and to

4

Share of renewable energy in heating and cooling of EU countries in 2015 and 2016



** Year 2016 for Greece estimated by Eurostat. Source: SHARES 2016, published 26th January 2018*

5

Share of energy from renewable sources in gross final energy consumption in 2015 and 2016 and 2020 targets (in %)

Year 2016 for Greece estimated by Eurostat.
Source: SHARES 2016, published 26th January 2018
SHARES tool version 2016 that takes into account specific calculation provisions as in place in Directive 2009/28/EC following its amendment by Directive (EU) 2015/1513 of the European Parliament and of the Council of 9 September 2015 amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources.

a lesser extent the heat pump (0.7 Mtoe) and biogas (0.3 ktoe) sectors. The additional contributions of the solar thermal, geothermal and renewable municipal waste sectors were less than 0.1 Mtoe.

The calculations that EurObserv'ER has made demonstrate that the distribution between the various renewable heat sectors hardly changed between 2015 and 2016 (graph 3). Solid biomass is still the main source of renewable heat (79.3% of the 2016 total) with 78.8 Mtoe. Heat pumps, both air source and ground source are the second source of renewable heat in the European Union with a 9.9% share and 9.8 Mtoe output. They are followed by renewable municipal waste (3.8% share and 3.8 Mtoe output), biogas (3.5%, 3.4 Mtoe), solar (2.1%, 2.1 Mtoe), geothermal energy (0.8%, 0.8 Mtoe) and liquid biomass (0.4%, 0.4 Mtoe).

In view of the total increase in heat consumption which rose from 510.2 Mtoe in 2015 to 521 Mtoe in 2016 (by 2.1%), the renewable heat share reached 19.1%, which is a 0.4 percentage point year-on-year increase. If we take 2005 as the reference year (10.9%), the increase rises to 8.1 percentage points.

The highest renewable heat share increases from 2005 to 2016 can be ascribed to Estonia (19 points), Denmark (18.9 points), Lithuania (17.2 points), Sweden (16.7 points), Bulgaria (15.7 points), Slovenia (15.1 points) and Finland (14.6 points). They contrast with the lowest progress made in: Portugal (3 points), the Netherlands (3 points), Ireland (3.3 points), Luxembourg (3.7 points) and Poland (4.5 points).

Across the Member States, the forested countries naturally have the highest share of renewable heat in their total heat consumption, and biomass is far and away the main source of renewable heat. It outweighs or almost outweighs the proportion of non-renewably-sourced heat in Northern Europe (68.6% in Sweden, 53.7% in Finland) and the Baltic States (51.9% in Latvia, 51.2% in Estonia and 46.5% in Lithuania). However, it is very much in the minority in the Benelux (8.1% in Belgium, 7.3% in Luxembourg and 5.5% in the Netherlands) and in the British Isles (6.8% in Ireland and 7% in the UK).

JUST THREE POINTS SHORT OF THE 2020 TARGET

In 2016, the European Union moved up a level towards achieving the main 2020 target set in the Renewable Energies Directive. According to Eurostat, the renewably-sourced energy share of European Union final gross energy consumption was 17% in 2016, which is exactly twice its 2004 level (8.5%), the first year for which data was registered. The European Union is now only 3 points short of its target for 2020, bearing in mind that this share must be at least 27% in 2030, and even more if the European Parliament and Council come to a new agreement when they adopt the next Energy Climate Package (see below).

Although the renewable energy share is constantly rising, the gains have been smaller in the last two years. They have risen from 0.94 of a percentage point in 2014, to 0.55 in 2015 and to 0.37 in 2016. The gain could have been lower, 0.1 of a percentage point less, had it not been for the fact that Spain's sustainably-certified biofuel output was factored in for the first time. This output had not been included in the previous years' accounting in the absence of regulatory monitoring.

We need to remember that each Member State has its own individual target that allows for the differences in their initial situation and the renewables energy potentials and economic performance levels. The Member States' situations can be poles apart depending on their natural reserves of renewable energy sources. The major forestry countries and/or those

6

Share of energy from renewable sources in gross final energy consumption in 2015 and 2016 and indicative trajectory

Countries	2015	2016	*Indicative trajectory 2015-2016*
Sweden	53.8%	53.8%	43.9%
Finland	39.2%	38.7%	32.8%
Latvia	37.6%	37.2%	35.9%
Austria	32.8%	33.5%	28.1%
Denmark	31.0%	32.2%	22.9%
Estonia	28.6%	28.8%	21.2%
Portugal	28.0%	28.5%	25.2%
Croatia	29.0%	28.3%	15.9%
Lithuania	25.8%	25.6%	18.6%
Romania	24.8%	25.0%	20.6%
Slovenia	21.9%	21.3%	20.1%
Bulgaria	18.2%	18.8%	12.4%
Italy	17.5%	17.4%	10.5%
Spain	16.2%	17.3%	13.8%
France	15.1%	16.0%	16.0%
Greece*	15.4%	15.2%	11.9%
Czech Republic	15.0%	14.9%	9.2%
Germany	14.6%	14.8%	11.3%
Hungary	14.4%	14.2%	8.2%
Slovakia	12.9%	12.0%	10.0%
Poland	11.7%	11.3%	10.7%
Ireland	9.2%	9.5%	8.9%
Cyprus	9.4%	9.3%	7.4%
United Kingdom	8.5%	9.3%	7.5%
Belgium	7.9%	8.7%	7.1%
Malta	5.0%	6.0%	4.5%
Netherlands	5.8%	6.0%	7.6%
Luxembourg	5.0%	5.4%	5.4%
Total EU 28	**16.7%**	**17.0%**	-

Year 2016 for Greece estimated by Eurostat
Note :** SHARES tool version 2016 that takes into account specific calculation provisions as in place in Directive 2009/28/EC following its amendment by Directive (EU) 2015/1513 of the European Parliament and of the Council of 9 September 2015 amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources. **Source: SHARES 2016, published 26th January 2018

with high hydropower potential are inherently at an advantage. This applies to Sweden, whose share of renewably-sourced gross final energy consumption is dominant, at 53.8% in 2016. Three other countries produce more than one third of their final energy consumption with renewable sources, namely Finland (38.7%), Latvia (37.2%) and Austria (33.5%). Denmark is very close to joining this group with a 32.2% share. At the other end of the scale, the renewably-sourced energy share of seven countries is less than 10%, namely Ireland (9.5%), the UK (9.3%), Cyprus (9.3%), Belgium (8.7%), the Netherlands (6%), Malta (6%) and Luxembourg (5.4%).

A progress report for 2016 shows that most of the countries are on track to make their target, i.e. that they have either reached their target or that they are sticking to their indicative trajectory defined by the Renewable Energy Directive. The following Member States have already achieved the level required to make their national 2020 targets: Bulgaria, the Czech Republic, Denmark, Estonia, Croatia, Italy, Lithuania, Hungary, Romania, Finland and Sweden. Furthermore, Austria is less than 1 percentage point from its 2020 target. The countries lagging furthest behind are the Netherlands (8 percentage points short of target), France (7 points), Ireland (6.5 points), the UK (5.7 points) and Luxembourg (5.6 points). If we now consider the indicative trajectory set for 2015–2016 by the Renewable Energy Directive for each country, only the Netherlands is behind (by 1.6 points). In 2016, France and Luxembourg reached the lower threshold of their 2015–2016 trajectory, taking advantage of the fact that the indicative trajectory percentage only changes every two years. The new indicative trajectory percentage set for 2017 and 2018 will require these two countries to redouble their efforts if they are to be on track to make their 2020 targets.

The current growth pace across the European Union is too slow to achieve the 2020 target. While it dropped to 0.3 point in 2016, it should be at least 0.75 point every year between 2017 and 2020. Yet, while some countries are experiencing difficulty in achieving their national target, the common European Union target of 20% is still within reach. This especially true as the energy policy in some countries, primarily in Northern Europe, should enable them to sail past their national targets.

In the longer term, the European Parliament intends to create new momentum by drawing up the next Energy Climate Package. On 17 January 2018, the MEPs agreed to negotiate new, more ambitious targets with the governments for 2030 than the 27% renewable energy in the current draft directive proposed by the European Commission. The MEPs expressed support for raising the renewable energies share to 35% of EU energy consumption in 2030 in the new draft law. This common target would be linked to national indicative targets, with a maximum 10% deviation allowance available to Member States under certain circumstances. The final negotiations with the European Council will at last be able to start as on 18 December 2017, the Council adopted its position on the implementation of a new directive aiming to promote the use of renewable energies throughout the EU, with a target aimed at achieving renewably-sourced share of at least 27% of its overall energy consumption by 2030. ■

SOCIO-ECONOMIC INDICATORS

The following chapter sheds a light on the European renewable energy sectors in terms of socioeconomic impacts. All 28 Member States are covered for 2015 and 2016. Figures for 2015 are different than those given for 2015 in the 2016 edition of "The State of Renewable Energies in Europe" as the methodology has been reviewed in depth (see below).

Methodological note

For the socio-economic indicators, an important methodological change has been implemented in the 2017 Edition of 'The State of Renewable Energy in Europe' by setting up a modeling environment that formalises the assessment procedure of employment and turnover. The model was developed by the Energy research Centre of the Netherlands (ECN).

The new methodological approach is based on an evaluation of the economic activity of each renewable sector covered, which is then expressed into full-time equivalent (FTE) employment. This new approach focuses on money flows from four distinct activities:

1. Investments in new installations;
2. Operational and maintenance activities for existing plants including the newly added plants;
3. Production and trading of renewable energy equipment;
4. Production and trading of biomass feedstock.

Proper characteristics of the economic sectors of each EU Member State are taken into account when determining the renewable employment and turnover effects by using input-output tables. ***The new methodology uses a consistent and mathematical approach to define the employment and turnover effects, allowing for a comparison between the European Union Member States.*** *Underlying used databases stem from Eurostat, JRC and EurObserv'ER. Employment related to energy efficiency measures is outside of the scope of the analysis. Below, some important methodological issues are briefly highlighted:*

- *Employment data presented in each RES chapter refers to* ***gross employment,*** *i.e. not taking into account developments in non-renewable energy sectors or reduced expenditure in other sectors.*
- ***Data include both direct and indirect employment.*** *Direct employment includes RES equipment manufacturing, RES plants construction, engineering and management, operation and maintenance, biomass supply and exploitation. Indirect employment refers to secondary activities, such as transport and other services.*
- *Socio economic indicators for the bioenergy sectors (biofuels, biomass and biogas)* ***include the upstream activities in the agricultural, farming and forestry sectors.***
- *Turnover figures are expressed in current million euros (€m). Turnover data found in non-Euro currency countries were converted into Euro, based on averaged annual conversion rates for 2016 as published by Eurostat.*
- *Taking data accuracy into account, the socio-economic indicators have been rounded to 100 for employment figures and to 10 million euros for turnover data.*

In consideration of the methodological change, the 2015 employment and turnover figures, published in the Edition of "The State of Renewable Energy in Europe", have been re-evaluated for the present edition in order to have coherent 2015 and 2016 series for all RES sectors in the EU28.

The employment and turnover data were obtained from a 'living model', still under development and open for comments and further improvement. One of the challenging issues when setting up a model is to incorporate the numerous remarks received from modeling experts, the renewable energy industry, policy makers and country representatives. Therefore, the methodology used will be enhanced in the following months, incorporating improvements of the data presented in the current release.

The socio-economic chapter of this edition includes a new indicator: the employment effects in the fossil fuel chains based on the energy replaced by increased renewables production. This indicator only takes into account direct jobs in fossil sectors, not replaced investment or the indirect effects.

For more information regarding the methodology used in this chapter, interested readers are referred to a separate methodology paper that explains the new approach in more detail. This paper can be downloaded from the EurObserv'ER project website.

WIND POWER

Wind power sector remains an important contributor to the EU-wide socioeconomic figures. While ***turnover amounts to an estimated € 39.3 billion in 2016*** (a decrease of € 1 billion from the 2015 estimate of € 40.3 billion), EurObserv'ER estimates the resulting employment at ***309 000 jobs for the same year,*** down from 315 900 in 2015. The new model (see methodology note) used to estimate socio-economic indicators in this chapter considers three main activities: investments in new installations, operation and maintenance activities for existing and newly installed turbines, and the production and trading of renewable energy equipment. This has been assessed for both the onshore wind sector as well as for the offshore wind power sector.

With an estimated ***121 700*** full time equivalent jobs (FTE) and a € 16 billion turnover, the ***German*** wind power sector remains the European leader representing 39% of the EU-wide wind sector employment. These results are in line with the German renewable energy statistics working group (AGEE-Stat) that claims investments of € 10.1 billion for 2016 and a further economic stimulus from operation of wind power plants of € 2.3 billion. Typical for this country are the important offshore wind activities, combined with a strong wind power equipment manufacturing sector, resulting in significant trade figure. However, despite German market performed well in 2016 (4 625 MW of onshore wind turbine capacity newly connected), the estimated total sector employment has seen a significant reduction with a -22% decrease compared to 2015. This phenomenon is mainly due to the slow-down observed in the offshore sector which is much more capital-intensive than the onshore sector. In 2017, employment figures should be improved. BWE, the German Wind Energy Association, is expecting a 2017 for onshore installation level of 4 500 – 5 000 MW and for offshore wind, based on the project pipeline. EurObserv'ER can announce a recovery in the installation pace for 2017.

Second comes ***United Kingdom with 42 900 jobs***, representing around 14% of the EU-wide

employment and a sector turnover of ***€ 4.5 billion***. The underlying pattern is similar to the German one (a strong reduction in the offshore market combined with onshore uptake, the market of which almost tripled in 2016). The difference however is that the UK market has a net growth, resulting in an increased estimated employment effect (+26%).

Next is ***Denmark with a labour force estimated at 26 600 persons and a € 4,6 billion turnover***. The country was in many ways pioneering in wind power industry but since nearly a decade its domestic onshore market is saturated. The activity is continuing through repowering operations, offshore plants and a national manufacturing players, as Vestas, which is still among top world players.

These dynamic countries are dogged by the apathy that prevails in a few European Union markets. ***Spain*** for example, which is the second European country regarding

Employment and turnover

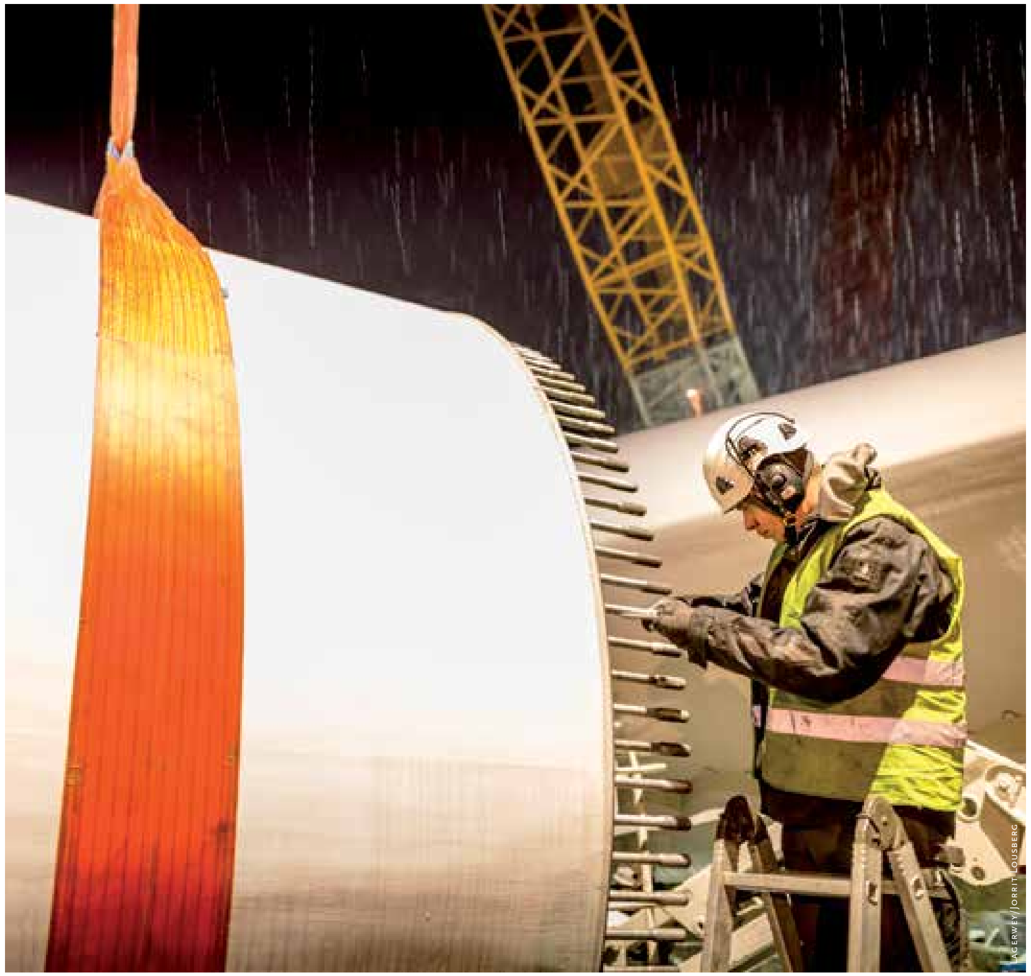
	Employment (direct and indirect jobs)		Turnover in € m	
	2015	2016	2015	2016
Germany	155 200	121 700	20 030	16 060
United Kingdom	34 100	42 900	3 670	4 490
Denmark	29 100	26 600	5 010	4 600
Spain	22 000	23 500	2 660	2 820
Netherlands	10 300	21 500	1 340	2 680
France	10 800	18 800	1 610	2 790
Poland	12 100	11 400	830	790
Portugal	3 600	6 400	320	500
Italy	9 400	6 300	1 360	950
Sweden	5 100	4 900	1 040	1 010
Ireland	3 200	4 200	350	440
Greece	2 200	3 700	190	300
Finland	2 500	3 500	370	520
Romania	2 500	2 500	150	150
Belgium	2 300	2 300	450	450
Austria	3 000	1 700	450	280
Estonia	1 600	1 600	90	90
Lithuania	2 600	1 600	90	60
Czech Republic	900	900	60	60
Croatia	1 400	900	70	50
Hungary	800	800	40	50
Bulgaria	500	600	30	30
Luxembourg	<100	200	<10	30
Cyprus	200	<100	20	<10
Latvia	<100	<100	<10	<10
Malta	<100	<100	<10	<10
Slovenia	<100	<100	<10	<10
Slovakia	<100	<100	<10	<10
Total EU 28	**315 900**	**309 000**	**40 280**	**39 250**

Source: EurObserv'ER 2017

installed capacity to date, has only installed some tens of MW (38.2 MW in 2016) since January 2012 when it imposed a moratorium on aid to renewable energies. However the country generates a significant turnover (€ 2 815 millions) and is home to some 23 550 employees, thus being the fourth main country. The Spanish wind sector can count on firms as Gamesa (9 400 employees reported for 2016) which are among the European's largest manufacturer and exporter.

The Netherlands, that saw some promising market dynamics and a doubling of wind sector employment, primarily in its offshore sector, ranks fifth in terms of employment showing an estimated ***21 500 jobs***, equaling 7% of the EU-wide employment and a sector volume of nearly ***€ 2.7 billion***. Here, offshore added capacity quadrupled in 2016, while onshore new plants halved compared to the previous year.

Despite the decline in EU wind employment, the sector have reason to stay optimistic. The high growth scenario published by WindEurope – the European Wind Energy Association- of 366 000 by 2030 based on ambitious post 2020 renewables policies is still in reach. Also global installation trends over the past years might be beneficial for EU wind industry players if they achieve to get a hold in the new emerging markets in Asia, South America and Africa. ■



PHOTOVOLTAICS

The European Union continues to lose ground in the international PV sector. In 2016, The annually connected capacity contracted by 22.7% compared to 2015. The British market's lower connection figures are largely responsible for this decline but more generally, European markets are in the throes of a transition phase that aims to introduce new renewable electricity production support mechanisms. The latter are outlined by the new European Commission guidelines set out in 2014, to promote greater integration of renewable energies into the electricity system by subjecting them to market-based regulation. These changes mainly hit the development of medium and high capacity power plants that form the mainstay of European growth. Overall, The European PV industry in 2016 still represented a € 10.7 billion market (compared to € 12.7 billion in 2016) and a workforce of 95 900 employees (down from 113 400 in 2015).

For the third year running the ***United Kingdom*** topped European photovoltaic league. However, according to the figures released in the PV thematic EurObserv'ER barometer in April 2017, solar photovoltaic capacity increased by 2.4 GW in 2016 albeit with a 36.9% drop in the number of connections in comparison with the previous year. In correspondence with this trend, EurObserv'ER estimates the British workforce at around ***29 000 persons***, a 21% decrease compared with the 2015 level. Turnover is developing in a similar trend with a 2016 activity assess at € 2.8 billion, down from, € 3.5 billion in 2015.

Second comes ***Germany with 27 100 jobs***, representing 28% of the EU-wide employment in the sector. The PV market reduced significantly (and more than in the UK), but the relative and absolute effect on employment is smaller because of the larger installed park in Germany (40.9 GW in Germany and 11.9 GW in the UK by the end of 2016) inducing larger O&M effects. The estimated turnover of the German PV sector ***(€ 3.4 billion)*** is well in line with projections by the Energy Ministry (BMWi) that assumes € 1.6 billion in new investments and € 1.5 billion in economic stimuli from operation of PV plants.

Next is ***Italy with workforce of 10 700 employees***, representing 11% of the EU-wide PV employment. As the Italian market was growing from 2015 to 2016 the employment effect is found to be positive, with some 700 additional jobs in 2016. With ***5 200 jobs, France*** contributes with 5% to the EU-wide employment for PV. The French market however was contracting strongly and therefore the employment effect is negative, approximately halving both the number of jobs and the turnover from 2015 to 2016.

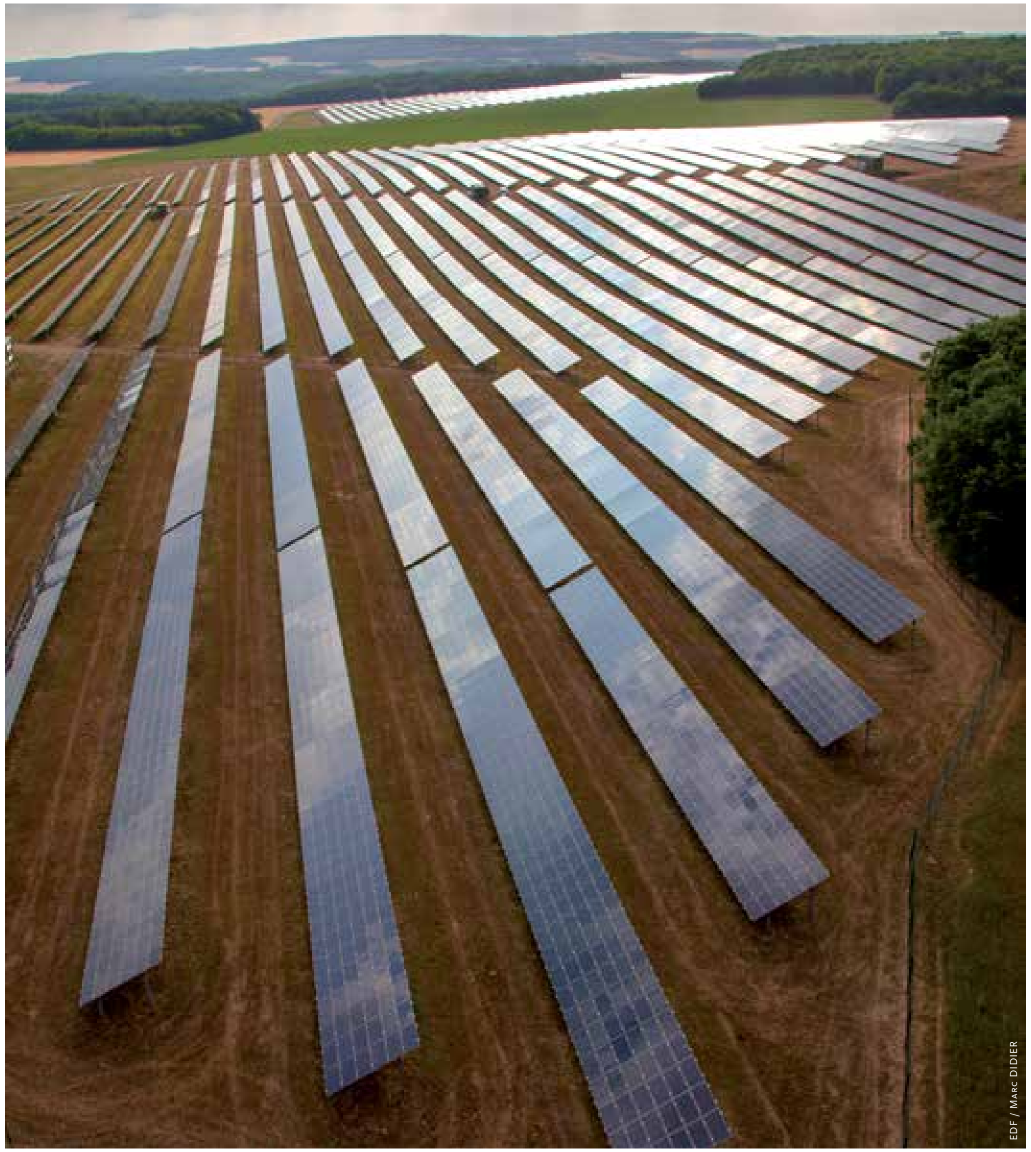
Despite many European PV firms globally active, we are witnessing the ongoing shift of PV value creation away from Europe towards emerging markets, primarily located in South East and East Asia. Japan, China and India are now the epicentres of PV application, turnover and employment creation. Despite some stabilization in some EU member state markets in terms of new installations, there are no signs of a reversal of this trend. However, European

Renewable Energy Association

Employment and turnover

	Employment (direct and indirect jobs)		Turnover in € m	
	2015	2016	2015	2016
United Kingdom	36 800	29 000	3 540	2 810
Germany	32 200	27 100	4 020	3 400
Italy	10 000	10 700	1 310	1 400
France	10 400	5 200	1 410	710
Netherlands	4 200	4 700	490	560
Belgium	1 300	2 400	240	440
Spain	3 000	2 200	290	220
Hungary	1 800	2 000	80	90
Romania	1 800	1 800	80	90
Czech Republic	2 100	1 700	130	110
Poland	1 200	1 500	80	90
Austria	1 500	1 300	230	190
Denmark	1 900	1 200	300	200
Greece	1 200	1 100	100	90
Bulgaria	700	800	30	30
Portugal	800	700	50	40
Finland	500	400	100	80
Slovakia	200	400	20	20
Lithuania	<100	300	<10	10
Sweden	300	300	50	60
Slovenia	300	300	20	20
Estonia	100	200	<10	10
Cyprus	100	<100	<10	<10
Croatia	400	<100	20	<10
Ireland	<100	<100	<10	<10
Luxembourg	<100	<100	<10	10
Latvia	<100	<100	<10	<10
Malta	200	100	10	<10
Total EU 28	113 400	95 900	12 660	10 730

Source: EurObserv'ER 2017



EDF / Marc Didier

PV sector is also different from the Asian market by many other aspects. The photovoltaic sector is adjusting to a new market structure, where the "prosumers" (producer-consumers) will play an increasingly important role. This move is motivated not only by an eco-citizen initiative to produce the electricity needed to satisfy their needs locally but by economic interest. It is in consumers' interest to produce their own electricity at lower cost than the price invoiced by the network, and to cash in on any surplus electricity they produce on the electricity market. The aim of the European Commission's Clean Energy Package presented in November 2016 is to encourage and formalize the implementation of this framework. ■

SOLAR THERMAL AND CONCENTRATED SOLAR POWER

Since 2009, the European Union's solar thermal market has been contracting by an annual average of 6.9%. For 2016, the solar thermal segment dedicated to heat production (domestic hot water and space heating) contracted by a further 4.6% in 2016 down to 2.6 million m², a figure far away from the peak reached in 2008 with more than 4.6 million m². The solar thermal market is directly hit by the low price of oil and natural gas and the stop-start, declining subsidy policies in place in several European countries. To compensate the under-performing individual home segment, the sector is pinning its hopes on the development of the collective solar segment that includes industrial solar heat and solar district heating. Total solar thermal employment in the European Union is estimated at ***29 000 jobs in 2016*** (30 900 in 2015, -6%) and turnover was found to have gone down approximately 1% (from € 3.45 billion in 2015 to ***€ 3.4 billion in 2016***). These figures also include Concentrated Solar Power (CSP) technologies for electricity but only few European countries are operating in this specific sector.

With regard to the employment figures, ***Spain*** is the largest European player. For end 2016, EurObserv'ER evaluates the Spanish solar thermal and CSP labour force at ***8 000 workers and € 980 million in turnover***. This result is, to a large extent, in line with the maintenance and operation of the CSP plants implemented in the country (2.3 GW) which represents more than 98% of the total power plants in operation in Europe. However, employment, as well as turnover figures, went down in 2016 due to a declining solar thermal market and stopped CSP activity where no new installations occurred as of 2013. For the solar thermal heating sector, reasons for such decline are found in the slow property construction and discontinuation of regional subsidy schemes. Also, competition from heat pumps is an explaining factor.

Germany is also a big player in the European solar thermal world. The country owns a strong solar industry just like Denmark and accommodated almost 30% of the newly installed collector area in the European Union in 2016. With an

added capacity of 536 MWth (2016) and a 13 385 MWth cumulative capacity the country is at the same time characterised by the largest share of investment-related employment. Still, the full raft of aids targeting the residential, collective segments and industrial heating were of no avail in the support of the German activity in 2016 and a 7.8% decline was observed. Thus, the 2016 total solar thermal employment figure of ***6 400 jobs*** is the result of a 12% decline towards the 2015 estimate of 7 200 workers. In the same period the solar thermal turnover in Germany came down from 870 to ***€ 760 million***.

Denmark is one of the few exceptions where employment and turnover went up in 2016. Implementation of numerous solar district heating applications was the back bone of the Danish solar growth. This trend could be illustrated by the town of Silkeborg, which with a collector area of 156 694 m² (110 MWth) holds the record for the biggest solar heating network in the country (and world-

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Employment and turnover

	Employment (direct and indirect jobs)		Turnover in € m	
	2015	2016	2015	2016
Spain	8 400	8 000	1 010	980
Germany	7 200	6 400	870	760
Denmark	1 300	3 200	210	530
Austria	2 600	2 000	420	330
Greece	1 700	1 500	130	110
Italy	1 400	1 400	170	170
Bulgaria	1 500	1 300	40	40
Poland	2 200	1 100	130	70
France	1 400	1 100	190	150
Czech Republic	600	400	30	20
Hungary	200	400	<10	20
Portugal	500	200	30	10
United Kingdom	200	200	20	10
Belgium	100	200	30	30
Romania	100	200	<10	<10
Croatia	200	100	<10	<10
Ireland	200	100	10	10
Netherlands	100	100	10	10
Cyprus	100	100	<10	<10
Slovenia	<100	200	<10	<10
Sweden	<100	<100	<10	20
Estonia	<100	<100	<10	<10
Finland	<100	<100	<10	<10
Latvia	<100	<100	<10	<10
Lithuania	<100	<100	<10	<10
Luxembourg	<100	<100	<10	<10
Malta	<100	<100	<10	<10
Slovakia	<100	<100	<10	<10
Total EU 28	**30 900**	**29 000**	**3 450**	**3 380**

Source: EurObserv'ER 2017

wide) since December 2016. Accordingly, EurObserv'ER estimates the Danish sector at ***3 200 jobs and € 530 million in turnover***.

One of the main changes with regard to last year has been observed in ***Poland***, where the solar thermal water heater market more than halved from 2015 to 2016, yielding a similar pattern for employment (from ***2 200 jobs in 2015 to 1 100 in 2016***) and sector turnover (from ***€ 130 to 70 million***). Multiple reasons account for this: reducing subsidies, low gas prices, competition from electric thermodynamic hot water heaters and an increased interest in heat pumps and PV.

Although solar heat is still losing ground, the European Union is trying to keep this sector on the map. The Commission reiterates that heating and cooling amount to 50% of the EU's energy demand and that 75% of this demand is met by fossil fuel. The lack of coordinated renewable heating and cooling policy has resulted in highly fragmented markets and curbed investor confidence. One of the possible changes could be the introduction of a new dedicated tool to stimulate the deployment of renewable heat technologies such as solar thermal energy. Article 23 of the revised directive proposes that each Member State should try to increase the share of the energy produced from renewable sources for heating and cooling purposes by at least one percentage point (of the national final energy consumption share) every year until 2030. Article 24 opens rights of access to local heating networks and cooling systems to renewable energy producers– which opens up significant development prospects for solar district heating. The sector has given a warm welcome to this legislative roadmap but market players are waiting for the practical implementation of regulatory and subsidy measures. ■


Paul Langrock

HYDROPOWER

For hydropower, the scope of the analysis has changed compared to last years' method. The new approach covers the complete hydropower sector. Large hydropower plants (with an installed plant capacity of more than 10 MW) as well as small hydropower plants (10 MW and below) are considered in the provided data. Roughly speaking, this results in some tens of thousand additional jobs throughout the European Union compared to the previous indicators which were only related to small hydropower plants activity.

EurObserv'ER reports a ***2016 labor situation at around 75 900 jobs***, down from an estimated 94 800 jobs in 2015. For turnover, the trend is similar with a decrease from 9.5 to ***€ 8.6 billion***. These results are mainly driven by a decline observed in installation capacities, for large as well as small hydro plants, in most of the European Union Member States. Although most suitable hydropower sites are already utilised and new constructions being hindered by numerous regulation constraints or environmental obstacles, a minimum activity level is maintained with the repowering of the oldest plants.

Italy, Spain and France make up the European top three in terms of jobs. These countries have in common significant installed capacities (around 20 GW and more) combined with a quite active hydropower industry.

Italy maintains its top slot in hydropower for years both in terms of installed capacity as well as in socioeconomic impacts for its economy. Estimated 2016 employment for small and large hydropower plants in Italy amounts to ***13 400 persons and a turnover of € 1.8 billion*** (down from 19 100 jobs and up from € 1.5 billion), a result from lower installation activities. For ***Spain*** EurObserv'ER reduces its estimate from ***16 000 to 10 900 workers and € 1.5 to 1.1 billion turnover***. France, on the other hand, shows a stable employment and turnover estimate slightly above ***10 thousand people employed and € 1.5 billion turnover***. The ***German*** estimate finds a reduction from ***6 300 jobs in 2015 to 5 200 in 2016*** with a small negative effect on turnover (from € 0.8 to ***0.7 billion***). These four countries together represent more than half of the 2016 hydropower employment estimate for the European Union.

The future of hydropower activity is much more in the side of small plants sector rather than on the largest dams. A comprehensive roadmap has been compiled and coordinated by ESHA (European Small Hydropower Association). The report reckons that installed small hydropower capacity could rise to 17.3 GW by 2020 yielding 59.7 TWh of energy generated, which is higher than the NREAP forecasts. Not surprisingly, the most promising countries are Italy, France, Spain, Austria, Portugal, Romania and Greece. However, this development over the next five is also not assured as it faces increasingly often to the implementation of the Framework Directive on water quality and lack of political support. ■

Employment and turnover

	Employment (direct and indirect jobs)		Turnover in € m	
	2015	2016	2015	2016
Italy	19 100	13 400	1 490	1 760
Spain	16 000	10 900	1 520	1 080
France	10 500	10 200	1 510	1 460
Germany	6 300	5 200	790	650
Sweden	5 800	4 800	1 140	940
Austria	5 200	4 800	830	770
Romania	5 100	4 400	270	240
Portugal	7 200	3 800	450	260
Bulgaria	3 100	2 900	130	120
United Kingdom	2 500	2 200	270	240
Czech Republic	1 900	1 700	120	110
Greece	1 900	1 700	160	150
Croatia	1 800	1 600	100	90
Poland	1 300	1 300	100	100
Slovakia	1 300	1 300	90	90
Finland	1 200	1 200	190	190
Latvia	1 000	1 100	50	50
Slovenia	900	900	60	60
Lithuania	800	800	30	30
Luxembourg	500	500	70	70
Belgium	400	400	80	80
Ireland	400	200	30	20
Cyprus	< 100	< 100	< 10	< 10
Denmark	< 100	< 100	< 10	< 10
Estonia	< 100	< 100	< 10	< 10
Hungary	< 100	< 100	< 10	< 10
Malta	< 100	< 100	< 10	< 10
Netherlands	< 100	< 100	< 10	< 10
Total EU 28	94 800	75 900	9 540	8 620

Source: EurObserv'ER 2017

GEOTHERMAL ENERGY

Geothermal energy is a renewable source that for many years was mainly developed in a few European countries, with Italy as a frontrunner for electricity generation and accompanied by France for heat production. However, over the past few years the picture moved and other Member States have been picking up this technology, reason for which currently **Hungary, Germany, Romania, Slovakia, the Netherlands, Bulgaria and Poland** are standing out in geothermal energy statistics, mainly opting for geothermal heat production. Electricity generation remains a technology for the countries with the best geologic geothermal potentials, i.e. Italy, Portugal, Germany, France and Austria.

With an estimated ***8 600 jobs*** in 2016, deep geothermal energy is, in terms of employment and turnover, the smallest sector amid all renewable technologies developed in the European Union. Its activity trend was decreasing in 2016 with a significant jobs reduction (12 200 in 2015) and a turnover also downward oriented, from € 1 400 to ***950 million*** between 2015 and 2016. The largest share of economic activity and employment is based on the operation and maintenance part of the existing power plants and heat generating facilities.

Italy, with an estimated deep geothermal employment figure of ***2 300 jobs*** is keeping the European lead. The 767 MW of net capacity operating in the country represent over 90% of the EU total power capacity. However, employment is in decline compared to 2015 due to a reduction of the newly installed geothermal capacity. Turnover in 2016 is estimated at ***€ 310 million***, a decrease from € 450 million. ***Germany and Hungary***, each with an employment estimate of ***1 200 jobs*** for both countries are following. In these Member States, geothermal energy is, for a large part, dedicated to heat production and its economic activity is on a positive trend, especially in Germany with a growth from € 80 to 150 million in 2016.

In ***France*** the reduction in labour was substantial (down ***to a mere 600 jobs*** in 2016 from 3 500 in 2015). The reason for this fall may be found in the much lower newly added capacity in 2016 compared to the year 2015. Employment for operation and maintenance remained stable. Of all remaining European Union Member States, only ***Denmark*** and the ***Netherlands*** showed an upward trend. In the Netherlands, the job figure increased roughly from ***400 to 500 employees*** and turnover from € 50 to ***70 million*** in 2016. In Denmark turnover rose from 10 to ***€ 50 million*** and employment reached 300 jobs.

Deep geothermal energy - next to solid biomass - is well suited to source heating networks in the residential sector. This positive characteristic remains into force, and the future eventually will point out whether deep geothermal energy has sufficient competitive advantages to see a further growth and reap part of its potential. ■

Employment and turnover

	Employment (direct and indirect jobs)		Turnover in € m	
	2015	2016	2015	2016
Italy	3 300	2 300	450	310
Germany	600	1 200	80	150
Hungary	1 100	1 200	50	60
France	3 500	600	480	90
Netherlands	400	500	50	70
Denmark	< 100	300	< 10	50
Romania	200	200	10	10
Poland	300	200	20	10
Bulgaria	600	200	20	< 10
Slovakia	100	100	10	10
Slovenia	< 100	100	< 10	< 10
Austria	300	< 100	40	10
Belgium	< 100	< 100	< 10	< 10
Cyprus	< 100	< 100	< 10	< 10
Czech Republic	< 100	< 100	< 10	< 10
Estonia	< 100	< 100	< 10	< 10
Greece	< 100	< 100	< 10	< 10
Spain	< 100	< 100	< 10	< 10
Finland	< 100	< 100	< 10	< 10
Croatia	< 100	< 100	< 10	< 10
Ireland	< 100	< 100	< 10	< 10
Lithuania	< 100	< 100	< 10	< 10
Luxembourg	< 100	< 100	< 10	< 10
Latvia	< 100	< 100	< 10	< 10
Malta	< 100	< 100	< 10	< 10
Portugal	< 100	< 100	< 10	< 10
Sweden	< 100	< 100	< 10	< 10
United Kingdom	< 100	< 100	< 10	< 10
Total EU 28	**12 200**	**8 600**	**1 390**	**950**

Source: EurObserv'ER 2017

HEAT PUMPS

The employment and turnover estimates in this chapter refer to the activities for the main three heat pump categories, namely the total of ground source heat pumps (GSHPs), hydrothermal heat pumps and air source heat pumps (ASHPs). The latter considers multiple variants, amongst others, the refrigerating heat pump, mainly used for space cooling.

Mainly driven by a growing activity in the building sector, both in new construction and renovation, nearly all European countries saw an increase in their newly installed capacity for heat pumps in 2016. Total heat pump employment in the European Union is estimated at ***249 400 FTE in 2016*** (240 300 in 2015, +4%) and turnover was found to have increased approximately by 2% (from € 29.6 billion in 2015 to ***€ 30.2 billion in 2016***). Italy, Spain, France, Germany and Sweden have the highest employment figures resulting from heat pump activities.

Employment and turnover estimates have been made for the heat pump sector as a whole, thereby only incorporating the effects in

Thermia/Danfoss

capital expenses for newly installed equipment and the effects resulting from operation (except from auxiliary energy) and maintenance activities (see methodology note for more info). According to Eurostat, manufacturing of heat pumps in the European Union increased, which partly explains the growth in employment and turnover from 2015 to 2016.

From all EU Member States, the heat pump activities in ***Italy*** are most pronounced, with an estimated labour force at ***94 000 workers in 2016***, slightly downward from 100 600 jobs in 2015 (-7%). In terms of turnover, a similar trend was found (-6%, from € 13.1 to ***12.3 billion***). The estimates for the largest part are resulting from new investments (68%) compared to operational employment (32%). The reason for this being the high installation rate and share of aerothermal heat pump applications in the country.

Second in terms of heat pump employment ranks ***Spain*** with an estimated ***60 800 jobs in 2016***, up

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Employment and turnover

	Employment (direct and indirect jobs)		Turnover in € m	
	2015	2016	2015	2016
Italy	100 600	94 000	13 080	12 280
Spain	48 400	60 800	4 580	5 800
France	32 900	32 800	4 670	4 630
Germany	14 400	14 500	1 910	1 920
Sweden	9 800	10 400	2 010	2 110
Portugal	7 300	7 400	440	440
Finland	4 500	4 500	690	700
Bulgaria	2 900	3 900	100	130
Netherlands	3 800	3 600	480	450
Poland	2 000	2 200	130	140
Denmark	2 000	2 100	320	340
Estonia	1 900	2 100	110	120
Austria	1 700	1 900	260	300
Czech Republic	1 700	1 800	100	110
United Kingdom	1 700	1 800	170	170
Belgium	1 400	1 500	260	280
Greece	1 300	1 400	110	110
Hungary	400	500	20	20
Slovenia	<100	500	<10	30
Ireland	300	400	30	40
Lithuania	300	400	<10	10
Romania	300	300	10	10
Slovakia	100	100	<10	10
Cyprus	100	100	<10	10
Croatia	<100	<100	<10	<10
Luxembourg	<100	<100	<10	<10
Latvia	<100	<100	<10	<10
Malta	<100	<100	<10	<10
Total EU 28	**240 300**	**249 400**	**29 560**	**30 200**

Source: EurObserv'ER 2017

from 48 400 jobs in 2015 (+26%). In absolute terms the newly added capacity in Spain is comparable to the Italian one, but the main difference is the installed base: Spain has a much smaller amount of heat pumps installed compared to Italy, resulting in double digit estimated employment growth. Most of the employment (93%) was found to originate from new installation activities. Turnover increased at a similar pace, with an estimated € 4.6 billion in 2015 increasing to ***€ 5.8 billion in 2016***.

France is also a big player on the European heat pumps market with an estimated ***32 800 jobs in 2016***, from a comparable 32 900 in 2015 and a turnover which remained stable around € 4.7 billion. Like in Italy or Spain, these results are largely due to the growing air heat pumps market in new building. That trend is supported by the French thermal regulation (RT2012), especially for individual houses.

Thermia/Danfoss

In ***Germany***, the heat pumps work force remained stable at 14 500 employees and so did the turnover stabilize at € 1.9 billion. A quite similar trend can be observed in ***Sweden***, where the job count of the heat pump sector is evaluated at around ***10 400 in 2016*** (up from 9 800 in 2015) and with an estimated annual turnover growing from € 2.0 to 2.1 billion. All together, these five countries represent 85% of the total heat pump related employment in the European Union and a comparable 89% of all heat pump turnover. Besides the leading countries, several Member States show remarkable growth in employment. With a focus on countries with an estimated employment between one and ten thousand jobs, considerable growth for heat pump employment was found in Bulgaria (from 2 900 to 3 900 jobs, +36%), Austria (from 1 700 to 1 900, +16%), Poland (from 2 000 to 2 200, +11%) and Estonia (from 1 900 to 2 100, +9%).

The lights are set to green for the next few years, firstly due to a recovery in the construction market. Beyond, the European Commission presented its strategy for heating and cooling and together with the newly introduced Heat pump Keymark – a single and uniform quality assurance label valid throughout the European Union that is facilitating eligibility for support schemes across borders. This might further stimulate the market development over the coming years. ■

BIOGAS

Nowadays, every EU country has a biogas energy recovery sector, but about 77 % of the European total output is concentrated in three countries, namely Germany (8 Mtoe), the UK (2.4 Mtoe) and Italy (2 Mtoe). In 2016, European Union primary energy production from biogas continued its upward trend (growing by 3 % to 16.1 Mtoe) although the pace has been on a steady decline since 2011. The main reasons for this decline are regulations hostile to the use of energy crops that initially boosted output in those countries that decided to develop farm biogas (primarily Germany, Italy and the UK) and the setting of less attractive financial terms for biogas electricity. On the back of this downward trend, investment in new plants also slowed down over the past few years which impacted employment and turnover. So the estimated overall total EU employment decreased from 83 700 jobs in 2015 to 76 300 in 2016 (-9%). The estimated turnover decreased from € 8.7 to 7.6 billion (-12%).

Most of current biogas production across the European Union is originating from methanization plants. These are purpose-designed for energy recovery and are grouped under the term “Other biogas from anaerobic fermentation”.

Germany represents 47% of the total EU biogas employment, with an estimated labor force of 35 700 workers in 2016 (down from 43 400 in 2015, -18%). In the same time, turnover decreased similarly, from € 5.1 to 4.1 billion. While operational and supply activities did not really change, the activities in newly installed biogas capacity fell considerably in 2016 compared to 2015. The dwindling numbers of newly commissioned biogas plants since 2011 are due to legislative changes in the renewable energy sources act (EEG 2014, EEG 2017) which have capped the use of corn as a feedstock. The introduction of even more restrictive measures on the use of energy crops, less lucrative feed-in tariffs, the discontinuation of premiums for producing electricity via biomethane and using energy crops (Nawaro Bonus) have also contributed to slow down the Germany biogas sector.

Employment and turnover

	Employment (direct and indirect jobs)		Turnover in € m	
	2015	2016	2015	2016
Germany	43 400	35 700	5 070	4 120
United Kingdom	9 600	11 800	910	1 120
Italy	8 000	8 000	890	880
Czech Republic	4 600	4 300	270	240
Poland	2 500	3 100	130	160
France	2 400	1 800	290	220
Hungary	700	1 500	30	70
Spain	1 900	1 300	150	90
Bulgaria	1 300	800	40	30
Greece	700	800	40	40
Lithuania	300	800	10	20
Latvia	1 000	800	50	40
Netherlands	1 000	800	150	120
Portugal	900	800	40	30
Croatia	1 000	600	50	30
Slovakia	1 000	600	70	40
Austria	500	500	70	80
Belgium	700	400	160	100
Finland	400	400	50	50
Denmark	500	300	80	50
Ireland	200	300	20	30
Romania	200	200	<10	<10
Slovenia	200	200	10	20
Estonia	300	100	20	<10
Cyprus	<100	<100	<10	<10
Luxembourg	<100	<100	<10	10
Malta	<100	<100	<10	<10
Sweden	<100	<100	<10	<10
Total EU 28	83 700	76 300	8 650	7 640

Source: EurObserv'ER 2017

Interestingly, the ***United Kingdom*** is a rare European case where the socio-economic indicators for 2016 have moved into a positive direction. The employment level is rated at around 11 800 workers (+24% compared to 2015) and a € 1.1 billion turnover (€ 0.9 billion for the previous year). This good situation is mainly driven by new installation dynamics in the British biogas electricity sector. Biogas electricity production from anaerobic digestion increased by 40% between 2015 and 2016 and the capacity of these plants increased by 30%.

Italy is also home to a strong and steadily growing biogas industry. EurObserv'ER evaluates the Italian sector size at 8 000 workers and estimates a € 880 million turnover for 2016. However, as observed over most of the European Union Member States, the development of new biogas plants slightly went down in 2016 compared to 2015.

In total, biogas remains a rather small niche sector of renewable energy deployment throughout the EU, despite the unchallenged inherent advantages of energy production that is independent of climatic conditions that can provide electricity, heat end gas for the grid. The sector might even play a much more crucial role in that it can level grid fluctuations, and even provide transport fuels in the form of gaseous biomethane.

On this topic, in February 2017 the European Commission published a study entitled "Optimal use of biogas from waste streams. An assessment of the potential of biogas from digestion in the EU beyond 2020". The paper is original in that it concentrates on the production of biogas only from the digestion of local waste streams such as sewage sludge, landfill gas and organic farming waste, the food industry and households. The report found that biogas production in the European Union could increase to a size from 28.8 to 40.2 Mtoe in 2030, depending on the quantity of useable raw material and the learning curve effects taken into account. This represents a 1.8 fold and a 2.5 fold increases respectively of the primary energy produced compared to 2016 (16 Mtoe). These scenarios would lead to biogas and biomethane production levels in 2030 of 2.7–3.7% of the EU's energy consumption. Although this is a quite positive perspective, the study results also shed a light on the vast and so far unexploited biogas potential in the European Union. ■

BIOFUELS

The European Union's biofuel consumption has flattened out after increasing steadily from the early 2000s until 2012. In 2016, biofuel consumption in the transport sector slightly increased by 1.3% compared to 2015 and EurObserv'ER estimated the consumption at 14.4 million toe. Biodiesel still accounts for roughly 80% of overall European biofuel consumption.

Based on this situation, EurObserv'ER assumes that the European Union cumulative biofuels workforce increased from 2015 (178 200 jobs) to 2016 (205 100 jobs). Estimated biofuels turnover went up to € 13.1 billion (2016) from € 11.7 billion (2015). Regarding the methodology used to evaluate socio-economic indicators (see the methodology note), it has to be noted that, like for the solid biomass sector, the approach used for biofuels also covers biomass supply activities, i.e. in the agricultural sector. Accordingly, the leading countries in terms of employment are not necessarily the largest biofuel consumers such as France and Germany, but more notably Member States with large share of agricultural areas such as Romania, Hungary, Lithuania and Poland. The latter one even being the top player in terms of biofuel activities, mainly due to substantial biomass feedstock supply and export activities. Hence, ***Poland*** defended its top slot estimated at ***34 800 jobs*** and with a € 1.3 billion turnover - an encouraging signal for the Eastern European Member States' renewable energy sectors that still have not realized their potential to the fullest.

France remains one of the leading biofuels producers and consumers in the EU-28. The industry creates turnover of € 3.2 billion and with 33 200 jobs employs a significant share of the total European biofuels workforce.

The modeling approach also put emphasis on the contribution of ***Romania*** in the field of biomass supply, with only few activities in new investment and operation and maintenance. Cumulative employment went up from 19 600 FTE in

Employment and turnover

	Employment (direct and indirect jobs)		Turnover in € m	
	2015	2016	2015	2016
Poland	29 500	34 800	1 140	1 310
France	28 100	33 200	2 690	3 160
Romania	19 600	23 800	620	750
Germany	19 400	21 800	2 060	2 300
Hungary	14 600	15 700	690	750
Spain	12 800	15 100	770	900
Lithuania	7 500	9 200	240	290
Czech Republic	6 700	8 000	360	420
Sweden	7 000	7 600	300	330
Italy	7 000	6 500	740	630
Greece	3 600	4 500	120	150
United Kingdom	4 200	4 500	340	370
Slovakia	3 400	4 000	260	300
Latvia	2 600	3 100	110	130
Bulgaria	2 700	3 000	100	110
Austria	2 800	2 900	380	390
Finland	2 600	2 900	280	300
Croatia	1 500	1 900	80	100
Belgium	900	900	240	240
Netherlands	400	400	70	70
Portugal	400	400	30	20
Denmark	200	200	30	30
Estonia	200	200	<10	<10
Cyprus	<100	<100	<10	<10
Ireland	<100	<100	<10	<10
Luxembourg	<100	<100	<10	<10
Malta	<100	<100	<10	<10
Slovenia	<100	<100	<10	<10
Total EU 28	178 200	205 100	11 710	13 110

Source: EurObserv'ER 2017

2015 to 23 800 FTE in 2016 and turnover increased from € 620 million to € 750 million.

The German Environment Agency (UBA – Umweltbundesamt), which coordinates the German Working Group on Renewable Energy – Statistics (AGEE-Stat), claims that biofuel consumption remained stable in 2016 (around 2.6 million toe). Socio-economic indicators in **Germany** slightly increase: from 19 400 jobs in 2015 to 21 800 in 2016 and an estimated turnover rise from around € 2.1 billion (2015) to € 2.3 billion in 2016. Tracing back into the modeling approach, the underlying reason can be found by a reduction in investment related work combined with an increase of the biomass supply activities.

The EU biofuel industry is confronted with the crux of the on-going political negotiations within the European institutions. The draft renewable energies directive of November 2016 removed the 10% renewable energy target for transport and leaves countries free to choose the proportion devoted to transport, producing renewable electricity and heat, as part of a common European Union target of at least 27% of renewable energy in the European Union's total energy consumption by 2030. Beyond that, future employment trends are hard to predict as long as sustainability concerns (palm oil, 7 million tonnes imported to the EU and blamed as the most devastating biofuel source, primarily because of the massive deforestation in Indonesia) are not adequately addressed. ■

RENEWABLE MUNICIPAL WASTE

According to the accounting rules of the Renewable Energy Directive, the biomass share contained in municipal waste and incinerated in Waste-to-Energy (WtE) plants is considered to contribute to the renewable energy share. The amount of total primary energy production in the EU (electricity and heat) from Renewable Municipal Waste (RMW) increased from 9 397 ktoe in 2015 to 9 698 ktoe in 2016. France, Germany, Italy, Sweden, and the Netherlands are major energy producing countries using renewable municipal waste.

In line with the new methodology, job impact is assessed through three activity areas: investment activities, operation and maintenance activities and fuel-related activities. The figures are also dependent on the volume of thermally treated waste in a country. However, the job impacts from the collection and transport of waste are not incorporated in the approach.

For RMW, EurObserv'ER estimates around ***25 000 labor forces*** in the European Union, and a turnover involved slightly above ***€ 3 billion***, with a minor upward trend. In its latest available report, the Confederation of European Waste-to-Energy Plants (CEWEP) counts 460 Waste-to-Energy plants operated in 2015 in Europe, thermally burning 85.7 million tons of waste. CEWEP claims that its members from 22 countries represent about 80% of the Waste-to-Energy market in Europe.

The largest European player is ***Germany***, with an estimated ***7 000 jobs in 2016*** and a ***€ 1 billion*** turnover. Second country is ***France***, which grew from an estimated 1 900 in 2015 to ***4 000 jobs in 2016*** due to new capacities implemented. Also the turnover proxy doubled in this period, to slightly more than ***€ 0.5 billion***. ***Italy (3 800 jobs and € 500 million sector turnover)*** compares well to the French figures.

The World Energy Council (WEC) in its 2016 Waste-to-Energy report expected a continued growth of WtE plants globally, with a strong deployment increase in Asia and a moderate but still pronounced increase in Europe. Based on the current trends in the European Union, such a scenario might become reality, potentially resulting in increased socio-economic job and turnover impacts. More specifically in Europe, CEWEP in their latest Waste-to-Energy Industry Barometer 2017 that tracks waste industry and plant operators' business expectations (not to be confused with the EurObserv'ER Municipal Solid Waste Barometers!), monitors quite positive trends in the near and mid-term future. In 2017, 16% of the operators foresee an increase in the number of their employees, with only 5% expecting growing job figures in 2016. ■

Employment and turnover

	Employment (direct and indirect jobs)		Turnover in € m	
	2015	2016	2015	2016
Germany	6 000	7 000	910	1 030
France	1 900	4 000	260	550
Italy	2 300	3 800	310	500
United Kingdom	3 900	2 300	440	270
Netherlands	2 200	2 000	310	290
Hungary	1 500	1 000	60	40
Sweden	1 300	900	250	160
Spain	800	700	90	80
Finland	500	700	90	120
Portugal	1 000	500	70	40
Denmark	600	500	130	110
Belgium	600	300	100	60
Lithuania	200	300	< 10	< 10
Austria	200	200	50	30
Czech Republic	200	200	10	10
Bulgaria	< 100	< 100	< 10	< 10
Cyprus	< 100	< 100	< 10	< 10
Estonia	< 100	< 100	< 10	< 10
Greece	< 100	< 100	< 10	< 10
Croatia	< 100	< 100	< 10	< 10
Ireland	< 100	< 100	< 10	< 10
Luxembourg	< 100	< 100	< 10	< 10
Latvia	< 100	< 100	< 10	< 10
Malta	< 100	< 100	< 10	< 10
Poland	< 100	< 100	< 10	< 10
Slovenia	< 100	< 100	< 10	< 10
Slovakia	< 100	< 100	< 10	< 10
Romania	< 100	< 100	< 10	< 10
Total EU 28	**24 500**	**25 700**	**3 220**	**3 430**

Source: EurObserv'ER 2017

SOLID BIOMASS

Solid biomass turns out to be the largest renewable energy sector in the EU in terms of jobs. EurObserv'ER arrives at a slightly increased (2%) head count of over **352 500 jobs** (346 100 in 2015) and a growing EU wide industry turnover of over **€ 31.9 billion**. The most important players are located in the markets with the highest shares of biomass in terms of installed generating capacity and the top five countries are Germany, France, Italy, Finland and Poland. Moreover, a number of European Member States are pursuing policies to substitute part of their coal consumption by solid biomass.

Solid biomass is an umbrella term for all solid organic components to be used as fuel. It includes wood, wood chips, timber industry by-products (off-cuts, sawdust, etc.) black liquor from the paper industry, wood pellets, straw, bagasse and other solid plant residues that cater to the needs of biomass use for heating and electricity production in the residential, commercial, industrial and energy sector. The economic activity stemming from solid biomass sector is large and diverse. It includes among others, equipment manufacturers, service providers, operation and maintenance activities of existing plants but also production and trading of biomass feedstock fuel. Imports, such as wood pellets from North America, have also been considered in the methodology used to evaluate the figures presented here (see the the methodology note).

Regarding the solid biomass activity in 2016, primary energy production increased from 95.6 to 98.5 Mtoe partly due to a growing policy support of European policies but also as a result of a colder winter compared to 2015. Solid biomass now carries a lot of weight compared to the other renewable sectors, as it accounts for just under 50% of total renewable energy consumption. On the wood fuel part, the European Union's pellet production remained stable in 2016 at 14 million tonnes (0.4% less than in 2015), a third of which was imported (mainly from the United States, Canada but also from European countries such as Ukraine).

Germany remains the European leader in terms of solid biomass employment with **42 500 jobs** (representing 12% of EU-wide employment) and more than € **5.1 billion in turnover**. The German market expanded in 2016 compared to 2015 (+15% on employment), which mainly finds its origin in increased new installations and to a lesser extent in growth in biomass supply.

France is also an important country where biofuels has always been a notable renewable energy pillar. The French labour force is evaluated at **35 400 workers**, representing 10% of the EU-wide employment in solid biomass. One can observe an increase in employment from 2015 of 8%, as the turnover increased **from € 3.8 to 4.1 billion**. The solid biomass sector is supported through a large program dedicated to heat production and annual calls for tender organised by the French energy Commission (CRE). Next is **Italy with 32 600 jobs** (a 17% growth compared to 2015) and an estimated increase in turnover **from € 2.1 to 2.5 billion**. The Italian upward dynamic is mainly driven by the wood fuel activity rather than new added plants.

The two other countries that made up the top European leading pool are Poland and Finland. The ***Polish*** biomass sector accounts for more than **26 000 workers and a € 1 billion turnover in 2016**. However, a decrease is noted which can be explained by substantially lower installation activity in 2016 as compared to the year before. Estimated at **25 400 jobs *Finland's*** well-established forestry sector covers 7% of the EU-wide employment in solid biomass and is characterised in the employment model by a growing market (+10% compared to 2015, with an increase in turnover from € 3.9 billion to 4.3 billion). Over the past few years, Finland benefits from a strong growth. Together, these five countries represent 46% of the total solid biomass sector in Europe. However, compared to other renewable sectors, employment and turnover are more equally balanced amongst Member States where only a few countries

Employment and turnover

	Employment (direct and indirect jobs)		Turnover in € m	
	2015	2016	2015	2016
Germany	37 100	42 500	4 450	5 110
France	32 900	35 400	3 800	4 090
Italy	27 900	32 600	2 050	2 540
Poland	33 500	26 100	1 380	1 010
Finland	22 800	25 400	3 900	4 320
Latvia	18 800	21 800	620	720
Sweden	20 200	18 700	4 380	4 090
Spain	22 100	18 400	1 120	770
Croatia	14 400	15 000	330	380
United Kingdom	18 600	12 600	1 670	1 090
Hungary	10 800	12 000	300	350
Czech Republic	10 900	11 400	680	690
Romania	12 500	11 400	350	330
Estonia	8 200	10 000	460	560
Bulgaria	7 500	9 600	200	270
Slovakia	9 700	8 700	390	340
Austria	9 100	8 600	1 820	1 740
Denmark	5 900	8 500	1 020	1 450
Portugal	8 200	6 500	710	580
Lithuania	4 000	4 700	220	260
Netherlands	3 600	3 900	450	480
Greece	2 600	3 400	100	150
Slovenia	2 000	2 300	110	130
Ireland	900	1 700	110	200
Belgium	1 600	1 000	380	260
Cyprus	<100	<100	<10	<10
Luxembourg	<100	<100	<10	<10
Malta	<100	<100	<10	<10
Total EU 28	**346 100**	**352 500**	**31 030**	**31 940**

Source: EurObserv'ER 2017

provide the bulk of jobs and economic volume (i.e. wind or PV).

Some words can be said about countries such as Latvia or Spain where employment is quite high compared to the turnover evaluation. In these cases, jobs figures stem mainly from the biomass fuel production which is strongly dynamic. As an example, **Latvian** labour force is largely due to the national vast pellet production base and increasing export activities.

Since the NREAP plans were published in 2010, many countries have revised their estimates of biomass heat consumption upwards. The latest EurObserv'ER Solid Biomass Barometer (December 2017) observed a positive trend and projected 94 Mtoe of solid biomass energy production in the EU Member States, against initial projections of 81 Mtoe. In this respect the European biomass industry is not only a major contributor to reaching the 2020 and 2030 targets, but also well positioned in the international competition. Solid biomass provides and maintains numerous jobs in the forestry sectors and plant installation and O&M. Beyond that the expert knowledge gained over the past decades might translate in further jobs based on stable export opportunities from the well-established biomass technology value chain for the decade to come. ■

CONCLUSIONS

For both employment and turnover estimates, an important methodological change has been implemented. The details have been reported in the methodological note at the beginning of this chapter. The new methodological approach is based on an evaluation of the economic activity of each renewable sector covered, which is then expressed into full-time equivalent (FTE) employment and turnover. It uses a consistent and mathematical approach, allowing for a comparison between the European Union Member States. The 2015 employment and turnover figures, published in the previous Edition of 'The State of Renewable Energy in Europe', have been re-evaluated for the present edition in order to have coherent 2015 and 2016 series for all RES sectors in the EU 28. In effect, the job and turnover figures from last year cannot directly be compared to the current ones.

Following the new approach, which consistently assesses employment initiated from renewable investments, operation and maintenance activities, production and trading of equipment and biomass feedstock, it is found that, with ***1.4 million persons employed in 2016***, employment was very similar to the renewable jobs in 2015. All in all, a slight reduction occurred, with an employment reduction of almost 1% (i.e. a reduction of 12 600 jobs in absolute terms).

Technologies for which the 2016 estimates are below the 2015 jobs are the following: wind energy decreased from 315 900 to 309 000 jobs (-2%), solar PV from 113 400 to 95 900 jobs (-15%), hydropower from 94 800 to 75 900 jobs (-20%), biogas from 83 700 to 76 300 jobs (-9%), solar thermal from 30 900 to 29 000 jobs (-6%) and finally geothermal from 12 200 to 8 600 jobs (-30%). On the opposite, other technologies saw an increase: solid biomass grew from 346 100 to 352 500 jobs (+2%), heat pumps increased from 240 300 to 249 400 jobs (+4%), biofuels from 178 200 to 205 100 jobs (+15%) and finally renewable municipal solid waste from 24 500 to 25 700 jobs (+5%).

Looking at what happened in the EU Member States, ***Germany***, even at an estimated overall reduction of 12% (38 700 fewer jobs in 2016 compared to 2015) still has the highest employment of all countries: ***283 100 jobs***, for the largest part in wind power (43%). Second is ***Italy, with 179 000 jobs in 2016***, more than half of them (53%) in the heat pump sector. Like Germany, also Italy faced a reduction in jobs of 10 000, representing a 5% decrease. Third comes ***France***, which unlike the former countries, increased its estimated renewable energy induced employment by 6% (+8 300 jobs), comparable to fourth country ***Spain*** increasing in estimated employment by 4% (+5 500 jobs). In France the main labour force is active in solid biomass (25%), heat pumps and biofuels (each 23%). In Spain, main labour can be found in heat pumps (43%). Next largest player is the ***United Kingdom***, with an estimated job reduction of 3,8%, following from an estimated reduction of 4 300 jobs. In the United Kingdom, most labour can be found in the wind sector (40%) and in solar photovoltaics (27%).

Despite the overall decrease in workforce, renewable energy sectors has strengthened their position in the European economy, which becomes visible from the impact of manufacturing industry. For example, in the wind enegy sector, early movers have today a significant share of their labour forces involved in operation and maintenance of the running plants but they also have competitive wind industry firms (turbines, foundation, etc.) providing both european markets and worldwide export.

Regarding the economic activity, combined turnover of the ten renewable energy sectors covered in the 28 EU Member States reached ***149 billion euros in 2016***, slightly down from 2015 (151 billion euros, -1%). Sorted by technology, wind energy maintained its leading role in generating turnover (39 billion euros, equivalent to 26% of total EU RES sector turnover), followed by solid biomass (32 billion euros, 21%), and the heat pump sector (30 billion euros, 20%).

Looking at the turnover estimations by country, 20 out of 28 EU Member states increased or maintained their industrial turnover. However, this positive status is slightly overbalanced by job decline in the 8 other countries. The twenty Member States with zero or a positive growth (France, Spain, Romania, Denmark, Finland, Hungary, Czech Republic, Netherlands, Latvia, Croatia, Bulgaria, Lithuania, Greece, Estonia, Belgium, Ireland, Slovenia, Luxembourg and Malta) grew on average at 11% (absolute growth: + 5 billion euro). The countries going downward (Germany, Italy, United Kingdom, Poland, Sweden, Portugal, Austria, Slovakia and Cyprus) showed a 7 billion euros cumulatively decline. ■

2015 EMPLOYMENT DISTRIBUTION BY SECTOR

	Country Total	Biomass	Wind	Heat pumps	Biofuels	PV	Hydro	Biogas	Solar thermal	Waste	Geothermal
Germany	321 800	37 100	155 200	14 400	19 400	32 200	6 300	43 400	7 200	6 000	600
Italy	189 000	27 900	9 400	100 600	7 000	10 000	19 100	8 000	1 400	2 300	3 300
Spain	135 500	22 100	22 000	48 400	12 800	3 000	16 000	1 900	8 400	800	<100
France	134 800	32 900	10 800	32 900	28 100	10 400	10 500	2 400	1 400	1 900	3 500
United Kingdom	111 700	18 600	34 100	1 700	4 200	36 800	2 500	9 600	200	3 900	<100
Poland	84 700	33 500	12 100	2 000	29 500	1 200	1 300	2 500	2 200	<100	300
Sweden	49 800	20 200	5 100	9 800	7 000	300	5 800	<100	<100	1 300	<100
Romania	42 400	12 500	2 500	300	19 600	1 800	5 100	200	100	<100	200
Denmark	41 700	5 900	29 100	2 000	200	1 900	<100	500	1 300	600	<100
Finland	35 200	22 800	2 500	4 500	2 600	500	1 200	400	<100	500	<100
Hungary	32 000	10 800	800	400	14 600	1 800	<100	700	200	1 500	1 100
Portugal	30 000	8 200	3 600	7 300	400	800	7 200	900	500	1 000	<100
Czech Republic	29 700	10 900	900	1 700	6 700	2 100	1 900	4 600	600	200	<100
Austria	26 900	9 100	3 000	1 700	2 800	1 500	5 200	500	2 600	200	300
Netherlands	26 100	3 600	10 300	3 800	400	4 200	<100	1 000	100	2 200	400
Latvia	24 000	18 800	<100	<100	2 600	<100	1 000	1 000	<100	<100	<100
Croatia	21 000	14 400	1 400	<100	1 500	400	1 800	1 000	200	<100	<100
Bulgaria	20 900	7 500	500	2 900	2 700	700	3 100	1 300	1 500	<100	600
Slovakia	16 100	9 700	<100	100	3 400	200	1 300	1 000	<100	<100	100
Lithuania	16 000	4 000	2 600	300	7 500	<100	800	300	<100	200	<100
Greece	15 400	2 600	2 200	1 300	3 600	1 200	1 900	700	1 700	<100	<100
Estonia	12 700	8 200	1 600	1 900	200	100	<100	300	<100	<100	<100
Belgium	9 400	1 600	2 300	1 400	900	1 300	400	700	100	600	<100
Ireland	5 600	900	3 200	300	<100	<100	400	200	200	<100	<100
Slovenia	4 000	2 000	<100	<100	<100	300	900	200	<100	<100	<100
Luxembourg	1 400	<100	<100	<100	<100	<100	500	<100	<100	<100	<100
Cyprus	1 100	<100	200	<100	<100	100	<100	<100	100	<100	<100
Malta	1 100	<100	<100	<100	<100	200	<100	<100	<100	<100	<100
Total EU 28	1 440 000	346 100	315 900	240 300	178 200	113 400	94 800	83 700	30 900	24 500	12 200

Source : EurObserv'ER 2017

EUROBSERV'ER – THE STATE OF RENEWABLE ENERGIES IN EUROPE – 2017 EDITION

2015 TURNOVER BY SECTOR (€m)

	Country Total	Wind	Biomass	Heat pumps	PV	Biofuels	Hydro	Biogas	Solar thermal	Waste	Geothermal
Germany	40 190	20 030	4 450	1 910	4 020	2 060	790	5 070	870	910	80
Italy	21 850	1 360	2 050	13 080	1 310	740	1 490	890	170	310	450
France	16 910	1 610	3 800	4 670	1 410	2 690	1 510	290	190	260	480
Spain	12 200	2 660	1 120	4 580	290	770	1 520	150	1 010	90	<10
United Kingdom	11 040	3 670	1 670	170	3 540	340	270	910	20	440	<10
Sweden	9 200	1 040	4 380	2 010	50	300	1 140	<10	<10	250	<10
Denmark	7 120	5 010	1 020	320	300	30	<10	80	210	130	<10
Finland	5 690	370	3 900	690	100	280	190	50	<10	90	<10
Austria	4 550	450	1 820	260	230	380	830	70	420	50	40
Poland	3 950	830	1 380	130	80	1 140	100	130	130	<10	20
Netherlands	3 360	1 340	450	480	490	70	<10	150	10	310	50
Portugal	2 150	320	710	440	50	30	450	40	30	70	<10
Belgium	1 950	450	380	260	240	240	80	160	30	100	<10
Czech Republic	1 770	60	680	100	130	360	120	270	30	10	<10
Romania	1 520	150	350	10	80	620	270	<10	<10	<10	10
Hungary	1 290	40	300	20	80	690	<10	30	<10	60	50
Greece	970	190	100	110	100	120	160	40	130	<10	<10
Latvia	890	<10	620	<10	<10	110	50	50	<10	<10	<10
Slovakia	880	<10	390	<10	20	260	90	70	<10	<10	10
Estonia	740	90	460	110	<10	<10	<10	20	<10	<10	<10
Bulgaria	700	30	200	100	30	100	130	40	40	<10	20
Croatia	690	70	330	<10	20	80	100	50	<10	<10	<10
Lithuania	640	90	220	<10	<10	240	30	10	<10	<10	<10
Ireland	590	350	110	30	<10	<10	30	20	10	<10	<10
Slovenia	260	<10	110	<10	20	<10	60	10	<10	<10	<10
Luxembourg	160	<10	<10	<10	<10	<10	70	<10	<10	<10	<10
Cyprus	110	20	<10	<10	<10	<10	<10	<10	<10	<10	<10
Malta	100	<10	<10	<10	10	<10	<10	<10	<10	<10	<10
Total EU 28	151 470	40 280	31 030	29 560	12 660	11 710	9 540	8 650	3 430	3 220	1 390

Source : EurObserv'ER 2017

2016 EMPLOYMENT DISTRIBUTION BY SECTOR

	Country Total	Biomass	Wind	Heat pumps	Biofuels	PV	Biogas	Hydro	Solar thermal	Waste	Geothermal
Germany	283 100	42 500	121 700	14 500	21 800	27 100	35 700	5 200	6 400	7 000	1 200
Italy	179 000	32 600	6 300	94 000	6 500	10 700	8 000	13 400	1 400	3 800	2 300
France	143 100	35 400	18 800	32 800	33 200	5 200	1 800	10 200	1 100	4 000	600
Spain	141 000	18 400	23 500	60 800	15 100	2 200	1 300	10 900	8 000	700	<100
United Kingdom	107 400	12 600	42 900	1 800	4 500	29 000	11 800	2 200	200	2 300	<100
Poland	81 800	26 100	11 400	2 200	34 800	1 500	3 100	1 300	1 100	<100	200
Sweden	47 900	18 700	4 900	10 400	7 600	300	<100	4 800	<100	900	<100
Romania	44 900	11 400	2 500	300	23 800	1 800	200	4 400	200	<100	200
Denmark	43 000	8 500	26 600	2 100	200	1 200	300	<100	3 200	500	300
Finland	39 200	25 400	3 500	4 500	2 900	400	400	1 200	<100	700	<100
Netherlands	37 600	3 900	21 500	3 600	400	4 700	800	<100	100	2 000	500
Hungary	35 200	12 000	800	500	15 700	2 000	1 500	<100	400	1 000	1 200
Czech Republic	30 500	11 400	900	1 800	8 000	1 700	4 300	1 700	400	200	<100
Latvia	27 400	21 800	<100	<100	3 100	<100	800	1 100	<100	<100	<100
Portugal	26 800	6 500	6 400	7 400	400	700	800	3 800	200	500	<100
Austria	24 000	8 600	1 700	1 900	2 900	1 300	500	4 800	2 000	200	<100
Bulgaria	23 200	9 600	600	3 900	3 000	800	800	2 900	1 300	<100	200
Croatia	20 500	15 000	900	<100	1 900	<100	600	1 600	100	<100	<100
Greece	18 300	3 400	3 700	1 400	4 500	1 100	800	1 700	1 500	<100	<100
Lithuania	18 300	4 700	1 600	400	9 200	300	800	800	<100	300	<100
Slovakia	15 500	8 700	<100	100	4 000	400	600	1 300	<100	<100	100
Estonia	14 600	10 000	1 600	2 100	200	200	<100	<100	<100	<100	<100
Belgium	9 500	1 000	2 300	1 500	900	2 400	400	400	200	300	<100
Ireland	7 300	1 700	4 200	400	<100	<100	300	200	100	<100	<100
Slovenia	4 800	2 300	<100	500	<100	300	200	900	200	<100	100
Luxembourg	1 500	<100	200	<100	<100	<100	<100	500	<100	<100	<100
Cyprus	1 000	<100	<100	<100	<100	<100	<100	<100	100	<100	<100
Malta	1 000	<100	<100	<100	<100	100	<100	<100	<100	<100	<100
Total EU 28	1 427 400	352 500	309 000	249 400	205 100	95 900	76 300	75 900	29 000	25 700	8 600

Source : EurObserv'ER 2017

EUROBSERV'ER – THE STATE OF RENEWABLE ENERGIES IN EUROPE – 2017 EDITION

2016 TURNOVER BY SECTOR (€m)

	Country Total	Wind	Biomass	Heat pumps	Biofuels	PV	Hydro	Biogas	Solar thermal	Waste	Geothermal
Germany	35 500	16 060	5 110	1 920	2 300	3 400	650	4 120	760	1 030	150
Italy	21 420	950	2 540	12 280	630	1 400	1 760	880	170	500	310
France	17 850	2 790	4 090	4 630	3 160	710	1 460	220	150	550	90
Spain	12 750	2 820	770	5 800	900	220	1 080	90	980	80	<10
United Kingdom	10 580	4 490	1 090	170	370	2 810	240	1 120	10	270	<10
Sweden	8 740	1 010	4 090	2 110	330	60	940	<10	20	160	<10
Denmark	7 370	4 600	1 450	340	30	200	<10	50	530	110	50
Finland	6 300	520	4 320	700	300	80	190	50	<10	120	<10
Netherlands	4 740	2 680	480	450	70	560	<10	120	10	290	70
Austria	4 120	280	1 740	300	390	190	770	80	330	30	10
Poland	3 690	790	1 010	140	1 310	90	100	160	70	<10	10
Portugal	1 930	500	580	440	20	40	260	30	10	40	<10
Belgium	1 950	450	260	280	240	440	80	100	30	60	<10
Czech Republic	1 780	60	690	110	420	110	110	240	20	10	<10
Greece	1 120	300	150	110	150	90	150	40	110	<10	<10
Romania	1 610	150	330	10	750	90	240	<10	<10	<10	10
Hungary	1 460	50	350	20	750	90	<10	70	20	40	60
Estonia	840	90	560	120	<10	10	<10	<10	<10	<10	<10
Latvia	1 000	<10	720	<10	130	<10	50	40	<10	<10	<10
Slovakia	840	<10	340	<W10	300	20	90	40	<10	<10	10
Ireland	780	440	200	40	<10	<10	20	30	10	<10	<10
Bulgaria	780	30	270	130	110	30	120	30	40	<10	<10
Croatia	700	50	380	<10	100	<10	90	30	<10	<10	<10
Lithuania	710	60	260	10	290	10	30	20	<10	<10	<10
Slovenia	310	<10	130	30	<10	20	60	20	<10	<10	<10
Luxembourg	180	30	<10	<10	<10	10	70	10	<10	<10	<10
Cyprus	100	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Malta	100	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Total EU 28	149 250	39 250	31 940	30 200	13 110	10 730	8 620	7 640	3 380	3 430	950

Source : EurObserv'ER 2017

RES DEVELOPMENT IMPACT ON FOSSIL FUEL SECTORS

The deployment of renewable energy technologies has an impact on the economic activity in the fossil based energy sector.

For the first time in the EurObserv'ER barometer project, the socio-economic chapter includes a dedicated indicator **to take the effects of the growing shares of renewables on the European fossil fuel sector into account.** As a first introduction, only eight countries are evaluated in this year's edition (Austria, Belgium, Czech Republic, Germany, Spain, France, Italy and the Netherlands). Next year 10 more Member States will be added (Denmark, Finland, Greece, Ireland, Luxembourg, Poland, Portugal, Romania, Sweden and United Kingdom) followed by a complete coverage of the European Union Member States in the 2019 edition.

The results presented here are for 2016, and evaluate the impact of renewables on the fossil fuel sector . The impact is analysed in the following six subsectors: power generation, mining, oil for power generation, refining, heat production and extraction and supply of crude oil and natural gas. These results are expressed in direct jobs only. Our approach only covers the effects on operation and maintenance (O&M) and fuel production activities (effects on O&M are assumed to be proportional with to the reduced/avoided production). It must be noted that reduced construction activities of new conventional plants are not considered. The total RES development impact on the fossil fuel sector is therefore not fully monitored.

1

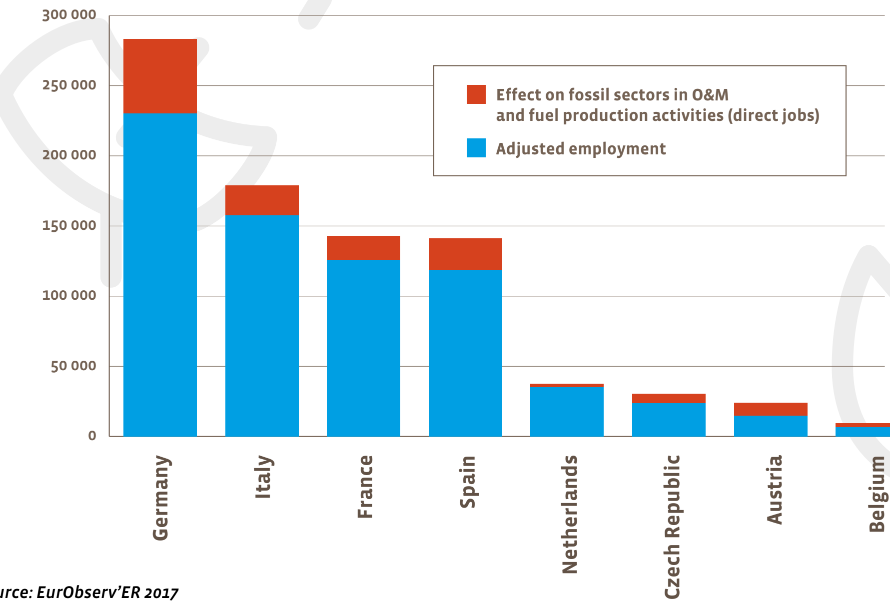
Details of RES development effect on fossil sectors for 8 European countries (figures for 2016)

	Employment (direct and indirect jobs)	Effect on fossil sectors in O&M and fuel production activities only direct jobs	Adjusted employment
Germany	283 100	52 800	230 300
Italy	179 000	21 600	157 400
France	143 100	17 400	125 700
Spain	141 000	22 300	118 700
Netherlands	37 600	2 400	35 200
Czech Republic	30 500	6 900	23 600
Austria	24 000	9 100	14 900
Belgium	9 500	2 900	6 600
Total	**847 800**	**135 400**	**712 400**

Source: EurObserv'ER 2017

1

RES development effect on fossil sectors (figures for 2016)



Source: EurObserv'ER 2017

The graph shows that the impact on the fossil fuel sector varies significantly between Member States. The relative impact on the fossil sector, when compared to the total employment, is, for example, greater in **Austria** than in **the Netherlands**. The reason for this lies in the differences in characterisation of the fossil fuel sector and in the type of renewable technologies that is deployed. Countries that have coal mining activities are more susceptible to the influence of renewables development than countries that import coal for power generation, as can be seen for the **Czech Republic, Germany and Spain[1].**

The type of renewable technology deployed, is also an important factor. Technologies that use feedstock (biogas, biofuels and MSW[2]) generate a relatively high amount of jobs per MW. Therefore, development of employment in the production of feedstock for such renewable technologies results in a proportionnaly smaller impact on the fossil fuel sector than the development of e. g. wind industy. For example, **France** experiences a relatively low negative impact on its fossil fuel sector from RES deployment, which is due to its feedstock production for biofuels, combined with a lack of mining activities. ■

1. The employment affected by reduced use of natural gas is assumed to be negligible. It is not likely that installations for natural gas extraction, conversion and transports are taken out of operation due to the uptake of renewables. O&M staffing of the existing installations is not likely to be affected by reduced gas demand.

2. Note that solid biomass is an exception because a high amount of solid biomass consists of fuel wood used by households, which is often not obtained via official retail channels and therefore does not contribute to (official) employment.

INVESTMENT INDICATORS

In this chapter, EurObserv'ER presents indicators that shed light on the financing side of RES. In order to show a comprehensive picture, the investment indicators cover two broader aspects:

- The first group of indicators relates to investment in the application of RE technologies (e.g. building power plants).
- The second group of indicators shifts the focus towards the development and the production of the technologies themselves (e.g. producing solar modules).

First of all, investments in new built capacity for all RES sectors in all EU member states are covered under asset finance. Asset finance data is derived from the Bloomberg New Energy Finance (BNEF) data base as well as other data sources and covers utility-scale investments in renewable energy, i.e. investment in power plants. Furthermore, average investment expenditures per MW of capacity are compared to main EU trading partners In order to capture the involvement of the public sector in RES financing, information on national and EU-wide financing programmes for RES will be presented.

It should be mentioned that the data on asset finance and VC/PE investment presented in this edition cannot be compared to the data in the previous overview barometers. The reason is that the database evolves continuously. This means that, whenever information on investment deals in previous years is found, it is added to the database to make it as comprehensive as possible. Hence, the investment figures for 2015 presented in last year's edition and this edition naturally differ.

The second part starts to analyse investment in RE technology by providing venture capital and private equity (VC/PE) investment data as derived from BNEF and other sources for all RES for the EU as a whole in order to capture the dynamics of the EU market for new technology and project developing companies. Then, RES stock indices are constructed which cover the largest European firms for the major RES. This indicator captures the performance of RES technology companies, i.e. companies that develop / produce the RES components needed for RES plants to function. The data used for the construction of the indices is collected from the respective national stock exchanges as well as public databases. In addition, YieldCos, i.e. infrastructure assets, e.g. renewable energy plants, where the ownership is offered on public markets, will be included in this chapter.

Investment in Renewable Energy Capacity

In this section, the EurObserv'ER investment indicators focus on investment in RES capacity, i.e. investments in utility-size RES power plants (asset finance). Hence, an overview of investments in capacity across RES in the EU Member States is provided. Furthermore, average investments costs per MW of capacity are calculated for the EU and compared with main EU trading partners. Finally, information in public financing programmes for RES is presented.

Methodological note

Asset finance covers all investment into utility-scale renewable energy generation projects. It covers wind, solar PV, CSP, solid biomass, biogas, and waste-to-energy projects with a capacity of more than 1 MW and investments in biofuels with a capacity of more the one million litres per year. Furthermore, the underlying data is deal-based and for the investment indicators presented here, all completed deals in 2015 and 2016 were covered. This means that for all included projects the financial deal was agreed upon and finalised, so the financing is secured. Note that this does not give an indication when the capacity will be added. In some cases the construction starts immediately, while in several cases a financial deal is signed for a project, where construction starts several months (or sometimes years) later. Hence, the data of the associated capacity added shows the estimated capacity added by the asset finance deals closed in the respective year. This capacity might be added either already in the respective year or in the following years. In addition to investments in RES capacity in the Member States, an overview of investment expenditures per MW of RES capacity will be calculated for the EU and main trading partners in order to compare investment costs.

Asset finance is differentiated by three types: balance-sheet finance, non-recourse project finance, and bonds and other instruments. In the first case, the respective power plant is financed from the balance-sheet of typically a large energy company or a utility. In this case the utility might borrow money from a bank and is – as company – responsible to pay back the loan. Non-recourse project finance implies that someone provides equity to a single purpose company (a dedicated project company) and this project company asks for additional bank loans. Here, only the project company is responsible to pay back the loan and the project is largely separated from the balance sheet of the equity provider (sponsor). Finally, the third type of asset finance, new / alternative financing mechanisms are captured as bonds (that are issued to finance a project), guarantees, leasing, etc. These instruments play so far a very minor role in the EU, particularly in comparison to the US, where the market for bond finance for RES projects is further developed. Nevertheless, these instruments are captured to monitor their role in the EU.

WIND POWER

2016 was another very positive year for investments in wind capacity. In 2015, wind investments, including both onshore and offshore wind, reached an already impressive € 31 billion and grew to € 34 billion in 2016, which corresponds to an increase by almost 10%. In contrast to total investments, the number of wind projects decreased notably from 795 in 2015 to 455 in 2016. In spite of the increase in investments, however, the capacity added associated with asset finance went down by 10% from 15.2 GW in 2015 to 13.7 GW in 2017. This observation indicates an increase of investment expenditures per MW of wind capacity. As will be shown below, this increase in investment expenditures is mainly driven by a substantial increase in the share of offshore wind, which is typically more expensive.

The way wind power projects were financed changed marginally between both years. On-balance-sheet financing is the dominant source in both years and even increased from 60% in 2015 to 68% in 2016. A reverse trend can be observed for other financing instruments, as e.g. bonds or guarantees, which declined notably between the two years from a share of more than 10% in 2015 to only 1.3% in 2016. The share of non-recourse project finance remained relative stable around 30%. The shares of the number of project financed investments in both years indicate that the on average larger investments are projects financed while smaller wind power plants are financed through on-balance-sheet finance. Although project finance is associated with around 30% of financing volumes in both years, only 9.4% (2015) and 15.4% (2016) of all projects are covered by project financing.

OFFSHORE DRIVES WIND INVESTMENTS IN 2016

Comparing onshore and offshore wind investments shows that the positive investment trend in the sector is substantially driven by a massive upsurge in offshore wind investments. Overall, offshore investments increased from an already impressive € 13.9 billion in 2015 to € 22.3 billion in 2016. Hence, compared to previous years, offshore was the main driver in wind investments. Its share increased from 45% in 2015 to more than 65% in 2016. The relatively low numbers of offshore wind projects, namely 11 in 2015 and 15 in 2016, indicate the substantially larger size of these investments compared to the average onshore wind

1

Overview of asset finance in the wind power sector (onshore + offshore) in the EU Member States in 2015 and 2016

	2015			2016		
	Asset Finance - New Built (in € m)	Number of Projects	Capacity (in MW)	Asset Finance - New Built (in € m)	Number of Projects	Capacity (in MW)
United Kingdom	13 024.19	75	4 138.7	15 410.79	80	4 311.1
Germany	10 901.69	442	58 73.0	8 984.05	179	3 890.4
Belgium	880.50	28	339.4	2 509.30	18	835.6
France	1 283.68	54	988.0	1 604.21	63	1 106.2
Denmark	354.70	20	281.1	1 283.15	15	601.9
Sweden	525.68	23	416.6	1 078.55	21	806.1
Italy	491.59	17	374.3	804.33	14	532.4
Finland	777.81	19	578.9	703.81	20	446.2
Ireland	777.07	16	521.3	674.25	14	467.0
Austria	395.60	18	298.3	352.23	10	213.1
Spain	25.15	2	9.6	176.37	8	125.9
Estonia	0.00	0	0	166.65	1	102.0
Greece	300.01	5	215.9	153.08	3	107.7
Poland	1 011.28	46	798.2	93.39	3	61.4
Netherlands	250.07	23	196.5	89.03	5	63.6
Lithuania	1.89	1	1.5	10.51	1	7.5
Portugal	103.17	4	89.7	0.00	0	0
Luxembourg	26.50	1	21.0	0.00	0	
Cyprus	12.62	1	10.0	0.00	0	
Total EU	**31 143.19**	**795**	**15 152.0**	**34 093.68**	**455**	**13 678.2**

Source: EurObserv'ER 2017

project. The average project size of an offshore investment was € 1.26 billion in 2015 and € 1.49 billion in 2016. In contrast, onshore investments totalled on average € 22 million in 2015 and € 26 million in 2016. Compared to onshore, non-recourse project finance is used more frequently in the offshore sector due to the high financing volumes of these projects.

Capacity added associated with offshore investments grew from 3.01 GW in 2015 to 5.49 GW in 2016. Offshore capacity grew at a faster pace than investment expenditures, which indicates that expenditures per MW of offshore

2

Share of different types of asset finance in the wind power sector (onshore + offshore) in the EU Member States in 2015 and 2016

	2015		2016	
	Asset Finance - New Built (in %)	Number of Projects	Asset Finance - New Built (in %)	Number of Projects
Balance Sheet	59.9%	89.6%	68.0%	82.9%
Project Finance	29.9%	9.4%	30.7%	15.4%
Bond/Other	10.2%	1.0%	1.3%	1.7%
Total EU	100.0%	100.0%	100.0%	100.0%

Source: EurObserv'ER 2017

capacity dropped between the two years. In 2015, investment expenditures per MW were € 4.6 million compared to only € 4.1 million in 2016. As indicated above, the data shows that investment costs for onshore capacity are substantially lower than for offshore. For onshore, investment expenditures per MW are marginally above € 1.4 million in both years.

HIGHEST INVESTMENTS IN THE UK AND GERMANY DUE TO OFFSHORE

After having taken over the lead from Germany in 2015, the UK remains the biggest player in terms of wind investments in 2016. Wind investments in the UK increased from € 13 billion in 2015 to € 15.4 billion in 2016. In contrast to the UK, investments in Germany dropped from € 10.9 billion to € 8.9 billion. As in previous years, wind investments are very concentrated in these two Member States. The high investments in both Member States are largely driven by offshore investments, in particular in the UK, where the share of offshore in total investments was 74% in 2015 and even 87% in 2016. In Germany, this share is lower, but also increasing, namely from 32% in 2015 to 62% in 2016.

INCREASING INVESTMENTS IN SEVERAL MEMBER STATES, BELGIUM TAKES THIRD POSITION

In France, asset finance increased from € 1.28 billion on 2015 to € 1.6 billion in 2016 and also the number of wind projects grew from 54 to 63. In spite of this very positive trend, France lost its third rank in wind investments in 2016 to Belgium, which saw a particularly high upsurge in wind investments. The increase of investments in Belgium from € 881 million in 2015 to € 2.5 billion in 2016 is almost entirely driven by two very large offshore projects accounting for more than 90% of the 2016 investments.

Three other Member states experienced high and increasing investments in wind power plants. In Denmark investments more than tripled from € 355 million in 2015 to almost € 1.3 billion in 2016. This increase was driven by two large offshore investments in 2016. Both in Italy and in Sweden, wind investments grew notably between the two years, namely from € 526 million to almost € 1.1 billion in Sweden and from € 492 million to more than € 800 million in Italy. In both countries, wind investments consist of onshore only.

Spain and Estonia also experienced significant increases in wind investments, however to substantially lower levels compared to the aforementioned three Member States. In Spain, investments grew from only € 25 million in 2015 to € 176 million in 2016. In Estonia, no wind investments were recorded in 2015, whereas in 2016 a relatively large wind investment of € 167 million could be observed.

STABLE AND DECREASING INVESTMENTS IN SEVERAL MEMBER STATES

In three Member States, wind investments remained quite stable on a relatively high level. Finland and Ireland saw almost identical investment amounts in the wind sector in 2015, namely € 778 million and € 777. In both countries, investments marginally dropped in 2016. While investments amounted to

3

Overview of asset finance in the wind power sector offshore in the EU Member States in 2015 and 2016

	2015			2016		
	Asset Finance - New Built (in € m)	Number of Projects	Capacity (in MW)	Asset Finance - New Built (in € m)	Number of Projects	Capacity (in MW)
United Kingdom	9 700.00	6	1 999.2	13 334.93	6	2 893.9
Germany	3 526.60	4	847.0	5 534.67	4	1 439.0
Belgium	655.81	1	165.0	2 288.85	2	679.0
Denmark				1 048.04	2	434.0
Finland				108.41	1	40.0
Total EU	13 882.41	11	3 011.2	22 314.90	15	5 485.9

Source: EurObserv'ER 2017

€ 704 million in Finland, they dropped below the € 700 million mark in Ireland. The number of wind power projects also remained relatively stable in both Member States. In Austria, wind investments totalled € 352 million in 2016 compared to almost € 400 million in 2015. In contrast to Finland and Ireland, the number of wind projects dropped notably in Austria.

The most dramatic decline in asset finance can be observed in Poland. While Poland was the Member State with the fourth highest wind investment in 2015, totalling more than € 1 billion, investments in 2016 only amounted to € 93 million. This trend looks even more dramatic, when considering the number of wind projects which dropped from 46 plants in 2015 to only 3 in 2016. Further Member States with declines in asset finance for wind power are Greece and the Netherlands. In Greece investments in wind power halved from € 300 million in 2015 to € 153 million in 2016. In the Netherlands, wind investments dropped from € 250 million to € 89 million and the number of new wind projects dropped from 23 in 2015 to only 5 in 2016. Finally, in three Member States financial deals for wind projects were only closed in 2015, namely Cyprus, Luxemburg, and Portugal. ■

4

Share of different types of asset finance in the wind power sector offshore in the EU Member States in 2015 and 2016

	2015		2016	
	Asset Finance - New Built (in %)	Number of Projects	Asset Finance - New Built (in %)	Number of Projects
Balance Sheet	58.1%	58.3%	53.6%	60.0%
Project Finance	41.9%	41.7%	33.3%	26.7%
Bond/Other	0.0%	0.0%	13.1%	13.3%
Total EU	100.0%	100.0%	100.0%	100.0%

Source: EurObserv'ER 2017

SOLAR PHOTOVOLTAIC

When analysing solar PV investments, two points are particularly important to be kept in mind. First of all, asset financing only contains utility-scale investments. Hence, all small-scale investments as rooftop installations, which make up the largest share in PV installations in most of the EU countries, are not included in the asset finance data. As in the last editions, EurObserv'ER reports overall EU investments in small-scale PV installations, i.e. PV installations with capacities below 1 MW.

DRAMATIC SLUMP IN PV INVESTMENTS

A considerable decrease in investments in photovoltaic power plants could be observed between 2015 and 2016. Investments in utility-scale PV (>1 MW) fell from more than € 4.6 billion in 2015 to only € 1.7 billion in 2016. This is a decline by more than 64%. The number of utility-scale PV projects, however, fell at a slower pace, namely by 47% from 383 projects in 2015 to 202 in 2016. This indicates that the average project size decreased between the two years. An average PV project in 2015 amounted to € 12.1 million compared to € 8.2 million in 2016. As shown in the last edition, no considerable change in PV investment costs could be observed between 2014 and 2015. Comparing 2015 and 2016, however, shows a considerable decline in investment expenditures per MW of PV capacity from € 1.43 million per MW to € 1.12 million per MW. This corresponds to decrease in investment costs by 21%. Similar

1

Overview of asset finance in the PV sector in the EU Member States in 2015 and 2016 (PV Plants)

	2015			2016		
	Asset Finance - New Built (in € m)	Number of Projects	Capacity (in MW)	Asset Finance - New Built (in € m)	Number of Projects	Capacity (in MW)
United Kingdom	3 513.79	296	2 463.0	1 039.64	153	953.7
France	349.71	18	241.5	204.72	22	182.5
Germany	282.12	44	215.7	145.21	15	95.6
Italy	135.54	5	79.6	82.20	3	75.2
Netherlands	3.32	1	2.3	66.46	2	60.8
Ireland	0.00	0	0	50.28	1	46.0
Denmark	254.38	5	176.4	41.49	1	38.0
Cyprus	4.33	1	3.0	14.64	2	13.4
Spain	0.00	0	0	13.67	2	12.5
Greece	0.00	0	0	4.81	1	4.4
Portugal	23.18	3	17.3			0
Hungary	23.07	1	16.0			0
Sweden	21.03	4	14.6			0
Romania	18.03	1	12.5			0
Poland	3.61	2	2.5			0
Belgium	2.88	1	2.0			0
Malta	2.65	1	1.9			0
Total EU	4 637.63	383	3 248.3	1 663.12	202	1 482.0

Source: EurObserv'ER 2017

to overall asset finance for PV power plants, the assisted capacity added of these investments declined. While capacity added totalled 3.25 GW in 2015, it only reached 1.48 GW in 2016, which is a decline in capacity added by 54%. With respect to the sources of finance for PV power plants, there is no substantial change observable. In both years, the majority of PV power plants were financed through on-balance-sheet financing. Between 2015 and 2016, the share of balance sheet financed PV investments increased marginally from 72% in 2015 to 77% in 2016, while the share of non-recourse project financing dropped from

2

Overview of investment in distributed PV capacity (commercial and residential PV) in the UE in 2015 and 2016

	2015		2016	
	Investment (in € m)	Capacity (in MW)	Investment (in € m)	Capacity (in MW)
Total EU	5 178.64	3 231	4 322.55	2 992

Source: EurObserv'ER 2017


EDF/Marc Didier

27% to 23%. Bonds or other financing mechanisms were not used for PV investments in 2016 and only played a negligible role in 2015.
In 2016, small-scale PV investments totalled € 4.23 billion and hence by far succeed utility-scale PV investments in that year. In 2015, however, small-scale PV investments were higher at € 5.18 billion. Hence, investments in small-scale PV dropped by around 17% between both years. Compared to investments, the associated capacity only dropped by 7% from 3.23 GW to 2.99 GW. This indicates that also the investment costs per MW of distributed PV capacity dropped between the two years by almost 10%.

3

Share of different types of asset finance in the PV sector in the EU Member States in 2015 and 2016 (PV Plants)

	2015		2016	
	Asset Finance - New Built (in %)	Number of Projects	Asset Finance - New Built (in %)	Number of Projects
Balance Sheet	72.3%	72.3%	77.4%	81.2%
Project Finance	27.4%	27.2%	22.6%	18.8%
Bond/Other	0.3%	0.5%	0%	0%
Total EU	100.0%	100.0%	100.0%	100.0%

Source: EurObserv'ER 2017

UK DOMINATES PV INVESTMENTS, FRANCE REMAINS IN SECOND PLACE

Since 2012, there is a strong concentration of PV investments in the UK. Although UK investments in utility-scale PV dropped dramatically from € 3.5 billion in 2015 to around € 1 billion in 2016, this trend seems to continue. In 2016, more than 65% of all utility-scale PV investments in the EU were conducted in the UK. In 2015, however, this share was even 76%. Compared to asset finance, the associated capacity added decreased at a slower pace from 2.46 GW in 2015 to 954 MW in 2016. France is ranked second in terms of PV investments, while the investment amounts are notably smaller. Similar to the UK, also France saw a negative trend in PV investments, which dropped from € 350 million in 2015 to € 242 million in 2016, whereas the number of PV projects marginally increased from 18 to 22.


Renewable Energy Association

FALLING INVESTMENTS THROUGHOUT MOST OF THE EU

Similar developments as in the top two Member States with respect to PV investments can be observed throughout the EU. In Germany, Denmark, and Italy, who were in the top five in 2015, 2016 saw decreases in PV investments. The decrease was particularly strong in Denmark, where investments dropped from € 254 million in 2015 to only € 41 million in 2016. Furthermore, in seven Member States PV investments were only recorded in 2015. In contrast, Ireland, Spain, and Greece, only experienced PV investments in 2016. In all those cases, however, investments were relatively small. ■

BIOGAS

In the biogas sector, the following four types of biogas utility-scale investments are tracked: (i) electricity generation (new) – new built biogas plants with 1MWe or more that generate electricity, (ii) electricity generation (retrofit) – converted power plants such that they can (at least partly) use biogas (also includes refurbished biogas plants), (iii) heat – biogas power plants with a capacity of 30MWth or more generating heat, and (iv) combined heat & power (CHP) – biogas power plants with a capacity of 1MWe or more that generate electricity and heat. In addition to power plants for heating and / or electricity that use biogas, there are also plants that do not produce electricity, but rather produce biogas (biomethane plants), which is injected into the natural gas grid. The latter are by far the minority in the data. However, to allow for distinguishing between these two types of biogas investments, two tables are presented, one with asset finance for biogas power plants and one for facilities producing biogas.

INVESTMENTS IN BIOGAS POWER PLANTS REMAIN STABLE

After having grown between 2014 and 2015, asset finance for biogas – including biogas power plants as well as biogas production plants – halved from € 109 million in 2015 to € 54 million in 2015. Both values, however, are substantially lower than investments in previous years, e.g. 2013, where € 330 million were invested.

Investments in biogas power plants fell rather modestly compared to overall biogas investments. In 2016, € 54 million were invested in biogas power plants compared to € 66 million in the previous year. The associated capacity added of these investments fell even stronger from 19.8 MW in 2015 to only 9.4 MW. The resulting increase in investment expenditures per MW of biogas capacity, however, should be interpreted with care due to the very observations – 4 biogas projects in 2015 and 2016, respectively. In contrast to the investments in biogas power plants, investments in biogas production plants were only observed in 2015. In that year, € 43 million were invested into bio-

1

Overview of asset finance in the biogas sector in the EU Member States in 2015 and 2016 (biogas power plants)

	2015			2016		
	Asset Finance - New Built (in € m)	Number of Projects	Capacity (in MW)	Asset Finance - New Built (in € m)	Number of Projects	Capacity (in MW)
United Kingdom	61.07	3	17.8	54.21	4	9.4
Germany	5.03	1	2			
Total EU	66.10	4	19.8	54.21	4	9.4

Source: EurObserv'ER 2017

2

Overview of asset finance in the biogas sector in the EU Member States in 2015 and 2016 (biomethane)

	2015			2016		
	Asset Finance - New Built (in € m)	Number of Projects	Capacity (in m³/hr)	Asset Finance - New Built (in € m)	Number of Projects	Capacity (in m³/hr)
United Kingdom	43.12	2	450	0	0	0
Total EU	43.12	2	450	0	0	0

Source: EurObserv'ER 2017

gas production plants. Concerning the capacities of these production plants, however, it is important to mention that there is no information about the capacity for one of the 2015 biogas production plants

In the case of biogas power plants, there are minor differences in the source of financing between 2015 and 2016. In both years, the majority of all investments were project financed, while the share of project finance increased from 67% to 81%. In contrast, balance sheet finance was used for all investments in biogas production plants.

INVESTMENTS MAINLY IN THE UK

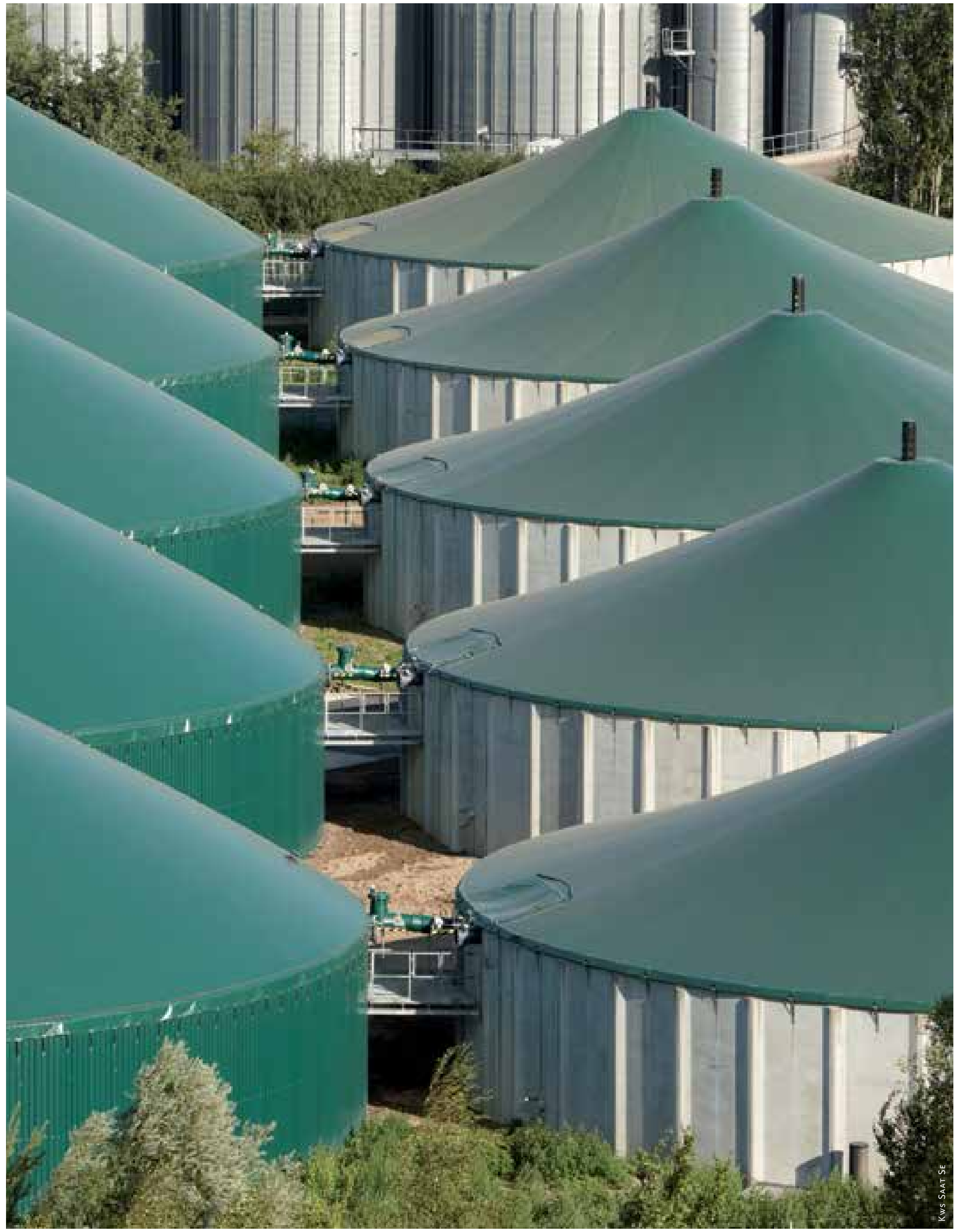
With respect to investments in plants producing biogas, all observed 2015 investments occurred in the UK. In the case of biogas power plants, the UK is also the dominant Member State with respect to investments. In 2016, all € 54 million were invested into biogas plants in the UK, which is less than the € 61 million invested in 2015. The only other Member State with asset finance for biogas power plants in 2015 is Germany with an investment of € 5 million. ■

3

Share of different types of asset finance in the biogas sector in the EU in 2015 and 2016 (biogas power plants)

	2015		2016	
	Asset Finance - New Built (in %)	Number of Projects	Asset Finance - New Built (in %)	Number of Projects
Balance Sheet	33.5%	75.0%	18.7%	75.0%
Project Finance	66.5%	25.0%	81.3%	25.0%
Bond/Other	0.0%	0.0%	0.0%	0.0%
Total EU	100.0%	100.0%	100.0%	100.0%

Source: EurObserv'ER 2017



GEOTHERMAL ENERGY

This technology uses geothermal energy for heating and/or electricity generation. Before discussing the asset financing for geothermal plants in the EU, the types of investments included in the underlying data have to be differentiated. The data includes four types of geothermal investments, namely: (i) conventional geothermal energy, (i) district heating, (iii) combined heat and power (CHP), and (iv) enhanced geothermal systems. Geothermal energy has a strong regional focus in the EU. By far the largest user of geothermal energy is Italy, although other EU countries also use this energy source to a certain extent.

NOTABLE GEOTHERMAL INVESTMENTS IN THE EU

In 2015, € 135 million were invested in geothermal capacity in the EU. In the subsequent year, investments dropped by 45% to € 80 million. Geothermal investments in both years are rather high compared to the investment volumes in the last years. As shown in the last two editions, e.g., only € 31 million were invested in 2014 and no geothermal investments were recorded in 2013. The number of geothermal projects decreased from 5 projects in 2015 to 3 in 2016. Hence, the average investment size of a geothermal plant remained relatively constant betweenthe two years. It totalled € 29 million per geothermal plant in 2015 and € 26.6 million in 2016.

The way geothermal projects are financed changed notably between the two years. In 2015, around two thirds of all investments were project financed, while the remaining third used on-balance-sheet finance. In contrast, more than 76% of investments in 2016 used on-balance-sheet finance, while only 24% were project financed. In both years, bonds and other financing instruments did not play a role in geothermal investements.

EDF / David Queyrel

1

Overview of asset finance in the geothermal sector in the EU Member States in 2015 and 2016

	2015			2016		
	Asset Finance - New Built (in € m)	Number of Projects	Capacity (in MW / MWth)	Asset Finance - New Built (in € m)	Number of Projects	Capacity (in MW / MWth)
Germany				52.85	1	26
Netherlands	58.81	3	45	18.79	1	16
Portugal				8.13	1	4
France	46.23	1	24			5
Croatia	30.31	1	10			0
Total EU	135.35	5	79	79.77	3	51

Source: EurObserv'ER 2017

MOST INVESTMENTS IN THE NETHERLANDS

With respect to the allocation of investments in the EU, half of the geothermal projects over 2015 and 2016 are located in the Netherlands, which is at the same time the only Member State with investments in both years. In 2015, € 58 million were invested in the Netherlands into three plants. In the following year, investments dropped to € 19 million. The associated capacity added was 45 MWth in 2015 and 16 MWth in 2016.

The highest investments in 2016 were conducted in Germany, where € 53 million were invested into a 26 MW geothermal plant. In the same year, € 8 million were invested in Portugal. Finally, there are two Member States with one geothermal investment in 2015, respectively. In France, € 46 million were invested, while Croatia saw investments totalling € 30 million. ■

2

Share of different types of asset finance in the geothermal sector in the EU in 2015 and 2016

	2015		2016	
	Asset Finance - New Built (in %)	Number of Projects	Asset Finance - New Built (in %)	Number of Projects
Balance Sheet	34.2%	20.0%	76.4%	66.7%
Project Finance	65.8%	80.0%	23.6%	33.3%
Bond/Other	0%	0%	0.0%	0.00%
Total EU	100.0%	100.0%	100.0%	100.0%

Source: EurObserv'ER 2017

SOLID BIOMASS

Asset financing for solid biomass discussed here solely includes investment into solid biomass power plants. Hence, there are no investments in biomass production capacity in the data. The data contains four types of biomass utility-scale investments: (i) electricity generation (new) – new built biomass plants with 1 MWe or more that generate electricity, (ii) electricity generation (retrofit) – converted power plants such that they can (at least partly) use biomass (also includes refurbished biomass plants), (iii) heat – biomass power plants with a capacity of 30MWth or more generating heat, and (iv) combined heat & power (CHP) – biomass power plants with a capacity of 1MWe or more that generate electricity and heat.

FALLING BIOMASS INVESTMENTS

Between 2015 and 2016 asset finance for utility-scale biomass dropped by 46%. EU-investments totalled € 2 billion in 2016 compared to € 3.7 billion in 2015. The 2016 investments, however, are still higher than those in 2014. The number of biomass projects that reached financial close fell as well. Compared to investments, the decrease in associated capacity added was weaker. Capacity added fell by 33% from around 1 GW in 2015 to 686 MW in 2016. Hence, there was a decrease in investment expenditures per MW of installed capacity. Investment costs in 2015 were on average € 3.6 million per MW of biomass capacity installed compared to only € 2.9 million per MW in 2016.

There is a small shift in the source of financing for solid biomass plants between the years. In 2016, the share of project financed (51%) and balance sheet financed (49%) investments was balanced. In 2015, the share of project financed biomass investments was larger with almost 62% compared to 38% on-balance-sheet financed plants. In both years, the size of project financed investments was on average significantly larger than those financed from balance sheets, which is the typical observation that can often be made across RES.

1

Overview of asset finance in the solid biomass sector in the EU Member States in 2015 and 2016

	2015			2016		
	Asset Finance - New Built (in € m)	Number of Projects	Capacity (in MW)	Asset Finance - New Built (in € m)	Number of Projects	Capacity (in MW)
United Kingdom	1 791.42	10	289.2	1 079.96	4	337.1
Denmark	184.13	2	324.0	667.83	1	150.0
Finland	1 471.64	2	334.0	145.45	1	170.0
France	37.47	1	14.9	124.97	2	28.83
Ireland	180.30	1	42.5			0
Czech Republic	49.21	1	15.0			0
Netherlands	9.96	1	3.9			0
Total EU	3 724.12	18	1 023.5	2 018.21	8	685.93

Source: EurObserv'ER 2017

THE UK KEEPS POLE POSITION, DIVERSE DEVELOPMENTS ACROSS THE EU

In both 2015 and 2016, the largest investments in biomass capacity can be observed in the UK and, although UK investments halved from € 1.8 billion 2015 to € 1.1 billion in 2016. The associated capacity added, however, marginally increased from 289 MW to 337 MW, which could have been driven by substantially larger biomass plants with lower investment costs per MW in 2016.

As in the previous years, new investments in biomass capacity developed very heterogeneously within and across EU Member States. The second highest biomass investments in 2016 could be observed in Denmark, where € 668 million were invested in one biomass plant compared to two plants totalling € 184 million in 2015. The larger capacity added in 2015 is due the fact that one of the two 2015 investments in Denmark is the retrofit of an existing power plant, which typically involves significantly less expenditures per MW compared to new built plants. In France, biomass investments more than tripled from € 37 million to € 125 million thanks for a call for tender that was held in summer.

2

Share of different types of asset finance in the solid biomass sector in the EU in 2015 and 2016

	2015		2016	
	Asset Finance - New Built (in %)	Number of Projects	Asset Finance - New Built (in %)	Number of Projects
Balance Sheet	38.4%	55.6%	50.9%	62.5%
Project Finance	61.6%	44.4%	49.1%	37.5%
Bond/Other	0%	0%	0%	0%
Total EU	100.0%	100.0%	100.0%	100.0%

Source: EurObserv'ER 2017

Next to the three Member States mentioned above, Finland is the only country that saw biomass investments in both years. In Finland, however, biomass investments dropped notably from € 1.47 billion to € 145 million. Furthermore, there are three Member States, where investments in biomass capacity were only conducted in 2015. These were Ireland, the Czech Republic, and the Netherlands with respectively € 180 million, € 49 million, and € 10 million were invested. ■

RENEWABLE URBAN WASTE

Similar to the solid biomass data, the asset financing data on waste-to-energy data includes four types of utility-scale investments: (i) electricity generation (new) – new built plants with 1MWe or more that generate electricity, (ii) heat – thermal plants with a capacity of 30MWth or more generating heat, and (iii) combined heat & power (CHP) –power plants with a capacity of 1MWe or more to generate electricity and heat. Another element to note is that waste to energy plants burn municipal waste, which is conventionally deemed to include a 50% share of waste from renewable origin. This part presents investments related to plants, not to the production of renewable waste used for energy production.

The most striking observation in the waste-to-energy sector is

1

Overview of asset finance in the waste sector in the EU Member States in 2015 and 2016

	2015			2016		
	Asset Finance - New Built (in € m)	Number of Projects	Capacity (in MW)	Asset Finance - New Built (in € m)	Number of Projects	Capacity (in MW)
United Kingdom	856.07	5	68.6	905.99	7	175.9
Total EU	856.07	5	68.6	905.99	7	175.9

Source: EurObserv'ER 2017

that investments solely occurred in the UK in both years. However, already in 2014, where investments occurred in three Member States, there was a strong concentration of investments in the UK, where more than 70% of investments were conducted. After the substantial decrease in asset finance for waste-to-energy plants between 2014 and 2015, investments stabilised in 2016. Asset finance for utility-scale waste-to-energy totalled € 906 million in 2016 compared to € 856 million in 2015. This corresponds to an increase of investments by almost 6%. The number of waste-to-energy projects reaching financial close increased from 5 projects in 2015 to 7 projects in 2016. Compared to investments, the capacity added increased substantially from 69 MW to 176 MW. The main reason for the high volume of capacity added in 2016 is that the largest plant in that year (70MW) is a retrofit of an existing power plant, which typically involves significantly less expenditures per MW compared to new built plants. Finally, there was a notable change in the way waste-to-energy projects are financed. In 2015, the majority of all investments used were on-balance-sheet finance, while the reminder was project financed. In 2016, the picture was reversed. ■

2

Share of different types of asset finance in the waste sector in the EU in 2015 and 2016

	2015		2016	
	Asset Finance - New Built (in %)	Number of Projects	Asset Finance - New Built (in %)	Number of Projects
Balance Sheet	73.4%	60%	35.0%	57.1%
Project Finance	26.6%	40%	65.0%	42.9%
Bond/Other	0%	0%	0%	0%
Total EU	100.0%	100.0%	100.0%	100.0%

Source: EurObserv'ER 2017

INTERNATIONAL COMPARISON OF EU INVESTMENT COSTS

In this section, EurObserv'ER presents RES investment costs in the EU and major EU trading partners. This comparison is based on investments in utility-size RES power plants. Investment costs are defined as the average investment expenditures per MW of capacity in the respective RES sector. These average investment expenditures per MW are calculated for the EU as well as for some major EU trading partners, namely China, Canada, India, Japan, Norway, Russian Federation, Turkey and the United States. However, there are several cases, where some of these countries did not experience investments in capacity in certain RES sectors. Hence, the number of countries, where investments costs can be calculated and reported, differs across RES technologies.

PONSSE

WIND ONSHORE AND OFFSHORE INVESTMENT EXPENDITURES

Investments expenditures per MW of onshore wind capacity almost remained constant in the EU with € 1.42 million in 2015 and € 1.44 million in 2016. These investment costs are marginally higher than the average non-EU investment costs. However, in most of the analysed non-EU countries, the investment expenditures per MW increased stronger than in the EU, e.g. in Canada and the United States. Hence, the difference between the EU and the non-EU investment costs per MW onshore declined, as the latter increased from € 1.27 million to € 1.4 million.

In contrast to onshore, only very few of the analysed non-EU countries experienced offshore wind investments, namely Japan and the United States in 2015 only as well as China in both years. Due the very few underlying offshore wind projects – e.g., Japan and the United States saw one offshore wind investment, respectively – it is difficult to compare the investment costs. In both countries, the 2015 investments were demonstration / first of their kind projects, which might explain the very high costs per MW.

1

Wind Onshore Investment Expenditures (€ m per MW)

	2015	2016
Canada	1.56	1.65
China	1.26	1.25
India	1.01	1.04
Japan	1.26	1.91
Norway	1.26	1.18
Russian Federation	1.26	1.40
Turkey	1.26	1.33
United States	1.32	1.45
Average EU	1.42	1.44

Source: EurObserv'ER 2017

2

Wind Offshore Investment Expenditures (€ m per MW)

	2015	2016
China	2.89	2.43
Japan	5.19	
United States	9.39	
Average EU	4.61	4.07

Source: EurObserv'ER 2017

INVESTMENT EXPENDITURES FOR PV AND BIOMASS

In contrast to the wind sector, investment expenditures per MW for solar PV plants dropped notably in the EU, namely from € 1.43 million in 2015 to only € 1.12 million in 2016. The same trend could be observed in the analysed non-EU countries. On average investment expenditures per MW of PV dropped from € 1.67 million to € 1.28 million. Hence, in both years, investment costs for PV are notably below the average of the analysed non-EU economies, but the situation is contrasted when considering the different countries. India shows the lowest rate with € 0,88 million per MW while Japan and Canada are above €1.70 million per MW.

In the biomass sector, the investment costs for one MW of capacity in the EU was € 3.64 million per MW in 2015 and € 2.73 million in 2016. These expenditures were higher than the average of the considered non-EU countries, which were € 2.63 million per MW in 2015 and € 2.51 million in 2016. However, the difference notably declined between both years. Analogue in the case of offshore wind, however, these numbers have to be interpreted with care due to, in some cases, very few observations. In the United States, e.g., only one biomass investment was recorded per year.

Overall, the analysis shows a heterogeneous picture across RES technologies. While investment costs per MW of capacity seem to be below the average of the considered non-EU countries for some technologies, e.g. photovoltaic, they seem to be higher for others, e.g. onshore wind. Investment costs seemed to have decreased between 2015 and 2016 in most of the analysed RES sectors in the EU and among its competitors. ■

3

Solar PV Investment Expenditures (€ m per MW)

	2015	2016
Canada	2.75	1.74
China	1.40	1.17
India	1.00	0.88
Japan	1.82	1.79
Russian Federation	1.70	1.09
Turkey	1.35	1.09
United States	1.69	1.20
Average EU	1.43	1.12

Source: EurObserv'ER 2017

4

Biomass Investment Expenditures (€ m per MW)

	2015	2016
China	1.77	1.60
Japan	2.51	3.41
United States	3.61	2.52
Average EU	3.64	2.73

Source: EurObserv'ER 2017

PUBLIC FINANCE PROGRAMMES FOR RES INVESTMENTS

To capture the involvement of the public sector in RES financing, EurObserv'ER gathered information on national and EU-wide financing or promotion programmes. In general, public finance institutions can play an important role in catalysing and mobilising investment in renewable energy. There are numerous instruments which are used by these institutions, which are typically either state-owned or mandated by their national government or the European Union. The instruments range from providing subsidies/grants or equity to classic concessional lending (loans with favourable conditions / soft loans) or guarantees. The dominant instrument in terms of financial volume is concessional lending. The loans provided by public finance institutions are typically aimed at projects that have commercial prospects, but would not have happened without the public bank's intervention.

In this section, an overview of public finance programmes for RES investments available in 2015 and/or 2016 is presented. This overview only contains programmes, where financial instruments, as debt / equity finance or guarantees, are offered. Hence, it is complementary to the country profiles on RES policies and regulations. As the overview concentrates on dedicated RES financing programmes or funds focussing on RES, it might omit public finance institutions that provide RES financing without having explicitly set up a programme or dedicated fund. An example is the Nordic Investment Bank (NIB) that also offers loans for RES investments to its member countries, namely Denmark, Finland, Iceland, Norway, Sweden, Estonia, Latvia, and Lithuania. The overview comprises both programmes and funds that only provide finance for RES investments as well as those, with other focus areas next to renewables, as energy efficiency investments. An example of the latter is the Slovak Energy Efficiency and Renewable Energy Finance Facility that, next to RES investments, also targets residential and industrial energy efficiency.

OVERVIEW OF INSTITUTIONS

There are a number of public finance institutions with dedicated financing programmes for RES in the EU. These include, but are not limited to, the two European public banks – the European Investment Bank (EIB) and the European Bank of Reconstruction and Development (EBRD) – as well as numerous regional and national public banks such as the KfW (Kreditanstalt für Wiederaufbau), Cassa Depositi e Prestiti, or the Croatian Bank for Reconstruction and Development (HBOR). Furthermore, there are numerous funds, which provide financing for RES investments. These include EU-wide funds, as the European Regional and Development Fund (ERDF) or the Cohesion Fund of the EIB, as well as national funds, as the Slovenian Environmental Public Fund (Eco-Fund) or the Lithuanian Environmental Investment Fund (LEIF). Finally, there are also dedicated financing facilities that provide lending for RES investments and typically also offer technical assistance to private banks. Examples are the Polish Sustainable Energy Financing Facility (PolSEFF[2]) or the Slovak Energy Efficiency and Renewable Energy Finance Facility (SLOVSEFF III) of the EBRD.

FINANCING SCHEMES AND INSTRUMENTS

The presented public finance programmes differ with respect to financing instruments used, financing amounts, and types of final beneficiaries. Most of the programmes and funds offer concessional financing. In some cases, also loan guarantees are offered.

There are also substantial differences in the way financing is provided for RES investments of the final beneficiaries. In many

cases, as the KfW Renewable Energies Programme, direct lending is available, i.e. the borrower directly receives a loan from the public finance institution. The loans might also be tied to certain conditions, e.g. that private banks also provide financing for the respective RES investment. In the KfW Programme Offshore Wind Energy, direct public loans are given in the framework of bank consortia, where private banks have to provide at least the same amount of debt financing. Alternatively, there are cases, where financing is provided indirectly, i.e. via a private partner institution. Such a structure is being used within EBRD's Polish Sustainable Energy Finance Facility (PolSEFF) that offers loans to SMEs for investments in sustainable energy technologies. PolSEFF, however, is not lending directly to SMEs, but rather provides credit lines to private partner banks, which then on lend to the final beneficiaries.

Finally, there are considerable differences in the financing volumes across programmes. The KfW Funding Initiative Energy Transition, e.g., focuses on large-scale RES investments with loans ranging from € 25 to € 100 million. In contrast, the Polish programme PROSUMER focuses on micro-installations, e.g. small RES electricity installations of up to 40kWe. Overall, a wide variety of financing schemes, used instruments, and focused final borrowers can be observed in the EU.

It is possible that public involvement in financing RES projects in the EU will slow down in the next years, similar to other RES support mechanisms. The need of public finance might decline as different RES technologies mature over the years. However, RES investments will remain highly dependent on services provided by capital markets. As they are typically characterised by high up-front and low operation costs, the cost structure of RES projects is dominated by capital costs. ■

1

Public Finance Programmes for RES

Programme	Involved Institutions / Agencies	Date effective	Country	Targeted RES Sector	Short Discription RES Financing Scheme
EIB European Regional and Development Fund (ERDF)	European Investment Bank (EIB)	2014	EU 28	Multiple RES (and other non-RES focus areas)	Provision of loans, guarantees, and equity for RES projects in all EU Member States
EIB Cohesion Fund	European Investment Bank (EIB)	2014	EU Member States with GNI per capita below 90% of EU average.	Multiple RES (and other non-RES focus areas)	Financial support (guarantees, loans, (quasi-) equity participation and other risk-bearing mechanisms).
Loan Programme	Environmental Protection and Energy Fund (EPEEF)	2003	Croatia	Multiple RES	Loans, subsidies, financial assistance, and grants for RES (and environmental protection and waste management)
Loan Programme for Environmental Protection, Energy Efficiency and Renewable Energy	Croatian Bank for Reconstruction and Development (HBOR)	1992	Croatia	Multiple RES	Loans for RES investments
Loan guarantees for local initiatives for the construction of wind-energy plants	Energinet.dk	2009	Denmark	Onshore Wind	Provision of loan guarantees
Heat Fund	French Agency for Environment and Energy Management (ADEME)	2009	France	Solar thermal, biomass, geothermal, biogas, waste heat and district heating	Subsidies for large RES heating installations
Funding Initiative Energy Transition	Kreditanstalt für Wiederaufbau (KfW)	2012	Germany	Multiple RES	Loans for large scale RES investments
Programme Offshore Wind Energy	Kreditanstalt für Wiederaufbau (KfW)	2011	Germany	Offshore Wind	Direct loans of KfW in the framework of bank consortia for offshore wind
Renewable Energies Programme	Kreditanstalt für Wiederaufbau (KfW)	2009	Germany	Solar Thermal	Loans for RES (with different conditions based on RES technology)
Market Incentive Programme	Kreditanstalt für Wiederaufbau (KfW), Federal Ministry of Economic Affairs	1999	Germany	Solar photovoltaic, biomass, geothermal,	Soft loans for larger/commercial RES installations
Environment Innovation Program	The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB); Kreditanstalt für Wiederaufbau (KfW)	1997	Germany	Multiple RES	Loans / interest rate subsidies for large scale RES plants with demonstration character
Fondo Kyoto	Cassa Depositi e Prestiti (CDP)	2007	Italy	Biogas, biomass, geothermal, solar thermal	Soft loans for RES investments
The Lithuanian Environmental Investment Fund (LEIF)	The Lithuanian Environmental Investment Fund (LEIF)	1996	Lithuania	Multiple RES	Soft loans for RES investments
Loans from the National Fund for Environmental Protection and Water Management	National Fund for Environmental Protection and Water Management (NFEPWM)	2015	Poland	Biomass, geothermal, solar PV	Loans for RES investments
BOCIAN - support for distributed renewable energy sources	National Fund for Environmental Protection and Water Management (NFEPWM)	2014	Poland	Multiple RES	Provision of soft loans for distributed RES
PROSUMER - programme supporting deployment of RES microinstallation	The National Fund for Environmental Protection and Water Management	2014	Poland	Multiple RES	Loans for micro-installations of RES. Beneficiaries: individuals, housing associations and communities, local governments.
Sustainable Energy Financing Facility (PolSEFF²)	European Bank for Reconstruction and Development (EBRD)	2011	Poland	Multiple RES	Provision of credit lines that are available through partner banks
Slovak Energy Efficiency and Renewable Energy Finance Facility (SLOVSEFF III)	European Bank for Reconstruction and Development (EBRD)	2014	Slovakia	Multiple RES	Loans for RES investments (and energy efficiency)
Slovenian Environmental Public Fund (Eco-Fund)	Slovenian Environmental Public Fund (Eco-Fund)	2000	Slovenia	Multiple RES	Soft loans for RES projects of SMEs and large-scale companies
Commercial Loans to Start-up Energy Companies	Swedish Energy Agency	2006	Sweden	Multiple RES	Loans for start-up RES-companies
Energy Saving Scotland Small Business Loans scheme	Energy Saving Trust	1999	United Kingdom	Multiple RES	Soft loans for SMEs for RES measures

Source: EurObserv'ER 2017

Investment in Renewable Energy Technology

The EurObserv'ER investment indicators also focus on investments related to the development and production of RES technologies as well as the performance of RES firms and assets. Hence, information of venture capital and private equity investments is presented. Additionally, RES indices based on EU RES firms are constructed and the performance of YieldCos is tracked.

Methodological note

VENTURE CAPITAL & PRIVATE EQUITY

EurObserv'ER collects data investments of venture capital and private equity funds into renewable energy technology developing firms. Venture capital (VC) focuses on very young start-up companies typically with high risks and high potential returns. Venture capital can be provided to back an idea of an entrepreneur before the business has started. It may be used to finalize technology development or to develop initial business concepts before the start-up phase. Venture capital can be also used in the subsequent start-up phase to finance e.g. product development and initial marketing or the expansion of a business. Basically, venture capital funds finance risky start-ups with the aim to sell the shares with a profit. Private equity (PE) is a type of equity that is not traded on stock markets. Generally, PE aims at more mature companies than VC and can be divided into two types. PE expansion capital is financing companies that plan to expand or restructure their operations or enter new markets. While expansion capital is usually a minority investment, PE buy-outs are investments to buy a company. These investments are often accompanied by large amounts of borrowed money due to the usually high acquisition costs.

Summing up, venture capital investments target renewable energy technology firms at the start-up phase, while private equity aims at relatively mature companies. While VC investments are typically small, private equity deals are usually larger than VC deals. PE-buyouts are in general and by far the largest deals since in such a deal a mature company is acquired. All these investments together shed a light on the activity of start-up and young renewable energy technology firms, while it is essential to distinguish between the typically large PE buy-outs and the other investments when analysing the VC/PE investments in the RES sectors. Hence, a breakdown of VC/PE investments by investment stage will be provided to show a more comprehensive picture.

Performance of RES technology firms and assets on public markets

The RES indices are intended to capture the situation and dynamics on the EU market for equipment manufacturers and project developers. The methodological approach is to include EU RES firms that are listed on stock markets and where the firms' revenues were (almost) entirely generated by RES operations. Hence, there might be important large firms that are not included in the indices. The reason is that there are numerous (partly very large) companies that produce renewable energy technologies but are also active in other sectors (e.g. manufacturers producing wind turbines, but as well turbines for conventional power plants). These are not included since their stock prices might be largely influenced by their operations in other areas than RES. Furthermore, there is also a large group of small firms that are not listed on stock markets which hence are also not included here. For the sectoral indices, RES firms are allocated if they are only (or mainly) active in the respective sector. The final choice among the firms in each sector is done by the firm size measured in revenues. Hence, the indices contain the ten largest quoted RES firms in the EU in the respective sector.

The indices are constructed as Laspeyres-Indices. The aim of a Laspeyres-Index is to show the aggregated price changes, since the weighting is used based on the base values. Hence, firms are weighted by their revenues in the respective previous period. In 2015, the firms are weighted by their 2014 revenues whereas in 2016, the 2015 revenues are applied. So the weighting is adjusted every year in order to keep the structure appropriate. The reason for this approach – in contrast to weighting the firms according to their market capitalisation – is that this approach reflects less the short term stock market fluctuations but rather focuses on long-term developments as it is in this analysis that concentrates on the development of two years. The top ten firms for the respective RES Technology Indices are selected based on their 2015 revenues.

Furthermore, EurObserv'ER collects and analyses data on YieldCos. YieldCos are entities that own cash-generating infrastructure assets, e.g. renewable energy plants, where the ownership is offered on public markets. Hence, YieldCos are also listed on stock markets. As there are only very few YieldCos currently operational in the EU, the stock prices of these will be captured rather than constructing an index as in the case of RES firms.

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VENTURE CAPITAL – PRIVATE EQUITY

Total venture capital (VC) and private equity (PE) investments in renewable energy companies remained stable between 2015 and 2016. VC/PE in the EU totalled € 2.04 billion in 2015 and € 2.02 billion in 2016. The VC/PE investment amounts in both years are, however, substantially below the very high investments of € 3.67 billion in 2014. This development in VC/PE investments in the RES sectors is overall in line with the observed trends across all other sectors in the EU. According to the data of the European Private Equity and Venture Capital Association (EVCA), overall EU-wide VC/PE investments (covering all sectors) showed a decrease in investments by 1.2% compared to a 0.8% decrease of VC/PE investments in RES.

BREAKDOWN OF VC/PE INVESTMENT STAGES

For this analysis, the overall VC/PE investments for all RES in the EU are disaggregated into four investment stages: (i) VC Early Stage, (ii) VC Late Stage, (iii) PE Expansion Capital, and (iv) PE Buy-outs. Early-stage venture capital is provided to early-stage / emerging young companies, e.g., for research and development in order to develop a product or business plan and make it marketable. Late-stage VC is typically used to finance initial production capacities or marketing activities. PE is typically used in later stages of a firm's life cycle. PE Expansion Capital is typically used by mature / established companies to expand their activities by, e.g., scaling-up production facilities. Finally, PE Buy-outs are investments to buy (a majority of) a RES company and often imply high investments compared to the other PE and particularly VC deals.

Between 2015 and 2016, PE investments fell by almost 9%. In particular PE Buy-outs decreased notably from € 1.85 billion to € 1.67 billion. As it could also be observed in the last years, the share of PE Buy-outs is relatively large in overall VC/PE investments. Their share totalled almost 91% in 2015 and decreased to 83% in 2016. A similar pattern can also be observed for overall VC/PE investments as reported by the EVCA, where the share of PE Buy-outs is around 70% in both years. PE Expansion Capital remained relatively stable.

In contrast to PE, VC investments tripled from € 78 million in 2015 to € 231 million in 2016. Early-stage VC investments almost doubled from € 75.5 million in 2015 to € 129 million in 2016. The increase in late-stage VC investments was particularly large. These investments increased from only € 2 million in 2015 to more than € 102 million in 2016. This indicates that the attractiveness of investments into young RES technology for venture capital funds seems to have increased between both years.

SOLAR PV OVERTAKES WIND VC/PE INVESTMENTS

When taking a more detailed look at the respective renewable energy technologies, it should be pointed out that biogas, biomass, and waste-to-energy are not disaggregated. The main reason is that the data includes several companies that are either project developer active in at least two of these sectors or equipment developers/producers that provide technologies for two or more sectors.

Overall, VC/PE investments were conducted in more RES sectors in 2015 compared to 2016. The most striking change in the sectoral distribution of VC/PE investments is the significant increase in the relative importance of the solar PV sector. From 2015 to 2016, investments of VC/PE funds in solar firms increased by almost € 1 billion from € 347 million to € 1.33 billion. The dominance of the wind sector in overall 2016 investments, however, can be mainly explained by a very large PE Buy-out deal of more than € 1 billion. Hence this increase in solar PV investments should not be over-interpreted.

In contrast to the solar PV sector, VC/PE investments in the wind sector dropped notably from € 1.5 billion in 2015 to € 663 million. As with the increase in solar PV investments, the decrease in wind investments is mainly drivel by PE Buy-outs. In 2015, there was one large PE Buy-out deal in the wind sector amounting to more than € 1 billion. With respect to all other types of VC/PE investments, there was even a notable increase in investments in the wind sector.

The only other sectors that experienced VC/PE investments in 2016 are biogas, biomass, and waste. In 2016, VC/PE investment in biogas, biomass, and waste totalled € 32 million compared to € 13 million in 2015. In the biofuels, the geothermal, and the small hydro sectors, VC/PE investments were only observed in 2015. For biofuels, these totalled almost € 113 million which rendered this sector to be ranked third in that year. In the geothermal and the small hydro sectors VC/PE investments in 2015 amounted to € 58 million and € 18 million, respectively. ■

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1

Venture Capital and Private Equity Investment in RES per Technology in the EU in 2015 and 2016

	2015		2016	
	Venture Capital / Private Equity (in € m)	Number of Projects	Venture Capital / Private Equity (in € m)	Number of Projects
Solar PV	346.91	14	1326.30	19
Wind	1490.00	7	663.25	9
Biogas, Biomass & Waste	12.71	5	32.13	4
Biofuels	112.83	3		
Geothermal	57.72	2		
Small Hydro	18.40	1		
Total EU	2038.56	32	2021.68	32

Source: EurObserv'ER 2017

2

Venture Capital and Private Equity Investment in RES per Investment Stage in the EU in 2015 and 2016

	2015		2016	
	Venture Capital / Private Equity (in € m)	Number of Projects	Venture Capital / Private Equity (in € m)	Number of Projects
VC Early Stage	75.53	14	128.69	8
VC Late Stage	2.19	2	102.49	7
PE Expansion Capital	112.86	5	118.48	7
PE Buy-out	1847.98	11	1672.01	10
Total EU	2038.56	32	2021.68	32

Source: EurObserv'ER 2017

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PERFORMANCE OF RES TECHNOLOGY FIRMS AND RES ASSETS

In this section, EurObserv'ER presents indices based on RES company stocks to capture the performance of RES companies, i.e. companies that develop / produce the RES technology. The RES indices are an indicator of current and expected future performance of EU RES companies listed on stock markets. As in the last edition, four indices are presented, i.e. a Wind, a Solar, a composite Bio-Energy Index, and an aggregate RES Index.
The former three indices consist of 10 firms that are (almost) entirely active in the respective RES sectors. The latter is an aggregate index based on all RES firms included in the other indices. The Bio-Energy Index includes firms that are active in the biofuels, biogas, biomass, and / or the waste sector. All these firms are included in one joint index as these firms are of the active on several of these sectors, which would make an allocation of firms to only one specific sector almost impossible.

When analysing these indices it is essential to bear in mind that they only capture companies that are listed on stock exchanges. Entities that are owned by parent companies or limited liability companies (e.g. Enercon) are not listed on stock markets and hence not reflected. Furthermore, there are numerous companies that are not only active in RES. Examples are Abengoa, a Spanish company that is active in RES, but also in other fields as water treatment and hence does not satisfy the criteria of the RES indices. As in the last edition, the EURO STOXX 50 index is used to compare the performance of RES companies to the whole market.

COMPOSITION OF RES INDICES

Compared to the last edition, some firms in the indices were replaced. A notable change is the removal of Enel Green Power from the Wind Index, as this firm merged with Enel SpA, a large Italian utility, and hence is not a RES-only company. Six out of the ten companies in Bio-Ebergy Index are based in Germany.
Furthermore, there are three French and one UK Bio-Tech Firms. It is further noteworthy that the two largest companies by far with respect to revenues, Cropenergies and Verbio Bioenergie, are (mainly) active in the biofuels sector. More Member States are represented in the PV and the Wind Indices. The largest company in the Solar PV Index is by far SMA Solar Technology AG, while in the Wind Index, the dominant company is Vestas.

HETEROGENEOUS PERFORMANCE OF FIRMS ACROSS RES SECTORS

In 2014 the trend differs between the three RES indices. For solar, 2014 was a very contrasted year with a steep rise in S1, followed by a deep change in S2. For the other two sectors the growth took place later in the year and then the indices returned to the start value of 100 at the end of the year.
In 2015, the trend of all three RES indices was quite similar, while this picture changed notably in 2016. Between the beginning of January and the end of December the Wind Index grew from 120 to 230 points. In 2016, the level remained relatively stable although the index is quite volatile. At the end of 2016, the Wind Index closes at 223 points. The Bio-Energy Index developed similarly, but at a lower level compared to the Wind Index.
In 2015, the positive trend is even stronger among the included bio-energy firms. The index starts at 66 points at the beginning of 2015, which is notably below the 100 points in the beginning of 2014. During 2015, however, there is a strong positive trend such that the Bio-Energy Index reaches 167 points at the end of that year.

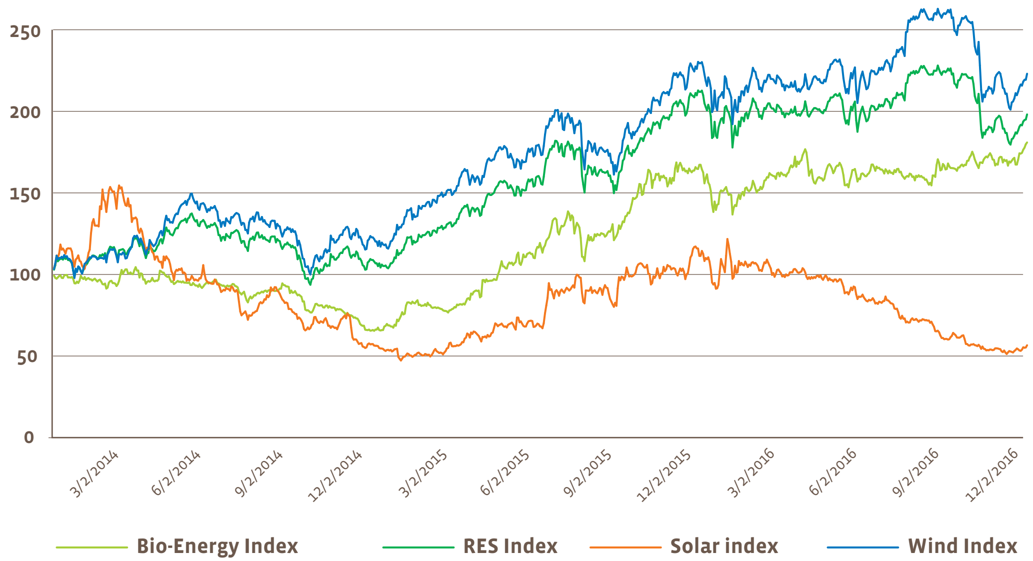
The Solar Index shows substantially different development compared to the other two RES indices. In 2015, the Solar PV Index shows a positive trend, however, with a smaller magnitude compared to the other two indices and closes only marginally above the 100 points mark by the end of 2015. In 2016, however, the performance of listed solar firms declines notably and the Solar Index closes at almost the same level as it started in the beginning of 2015, namely at 56 points.

The aggregate RES Index and the Wind Index differ in the level, but show very similar fluctuations. The reason is that the three RES Technology Indices are weighted by aggregate revenues in the respective sectors. As aggregate revenues are relatively high in the wind sector compared to the solar PV and bio-technology sectors – covering around 75%-80% of the aggregate revenues generated by all RES firms in the indices – the Wind Index dominates the aggregate RES Index. Hence, the RES Index shows an overall positive trend in spite of the negative development of the Solar Index in 2016.

Overall, the RES indices show that the years 2016 and, in particular, 2015 were rather prosperous for

1

Evolution of RES Indices during 2014, 2015 and 2016



Wind Index: *Vestas (DK), Siemens Gamesa (ES), Nordex (DE), EDP Renovaveis (PT), Falck Renewables (IT), Energiekontor (DE), PNE Wind (DE), Good Energy (UK), ABO Wind (DE), Futuren (FR)*
Photovoltaic Index: *SMA Solar Technology (DE), Solarworld (DE), Ternienergia (IT), Centrotherm Photovoltaics (DE) , Enertronica (IT), PV Crystalox Solar (UK),7C Solarparken (DE), Solaria Energia (ES), Etrion (SE) , E4U (CZ)*
Bio-Energy Index: *Cropenergies (DE), Verbio Bioenergie (DE), Albioma (FR), Envitec Biogas (DE), 2G Energy (DE), KTG Energie (DE), Active Energy (UK), BDI-BioEnergy International (DE), Cogra (FR), Europlasma (FR)*

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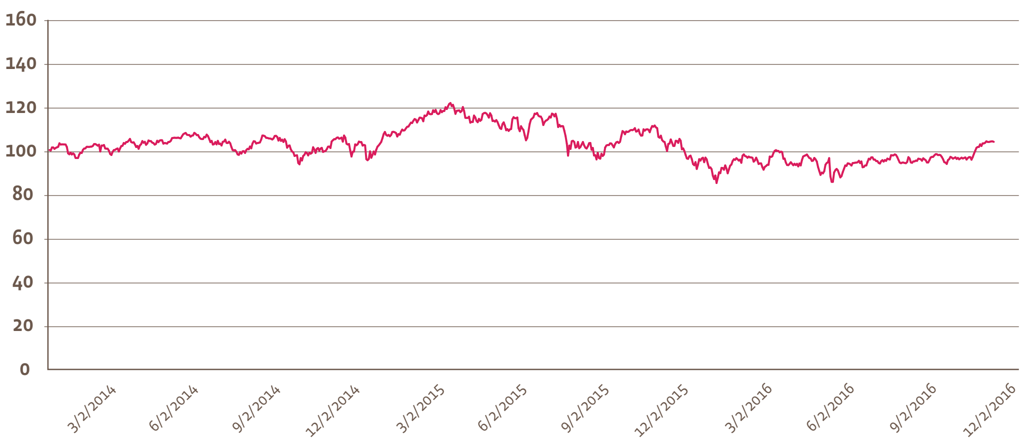
2

Evolution of the Euro STOXX 50 index during 2014, 2015 and 2016



listed RES companies. The EURO STOXX 50 shows a positive trend in the first half of 2015, as can also be observed for the RES Indices, however drops again until the end of 2015 and closes at 108 points at the end of 2015. In 2016, the level of the index remains rather constant. The particularly good development of technology firms and developers in the wind sector is in line with the developments in investments in capacity in 2015 and 2016. In contrast, solar PV firms face a rather tough environment. Investments in solar capacity dropped notably between 2015 and 2016. Overall, one should be careful to draw conclusions for the overall situation of RES technology firms in the EU. As explained above, many important RES technology firms and developers are not listed on stock exchanges.

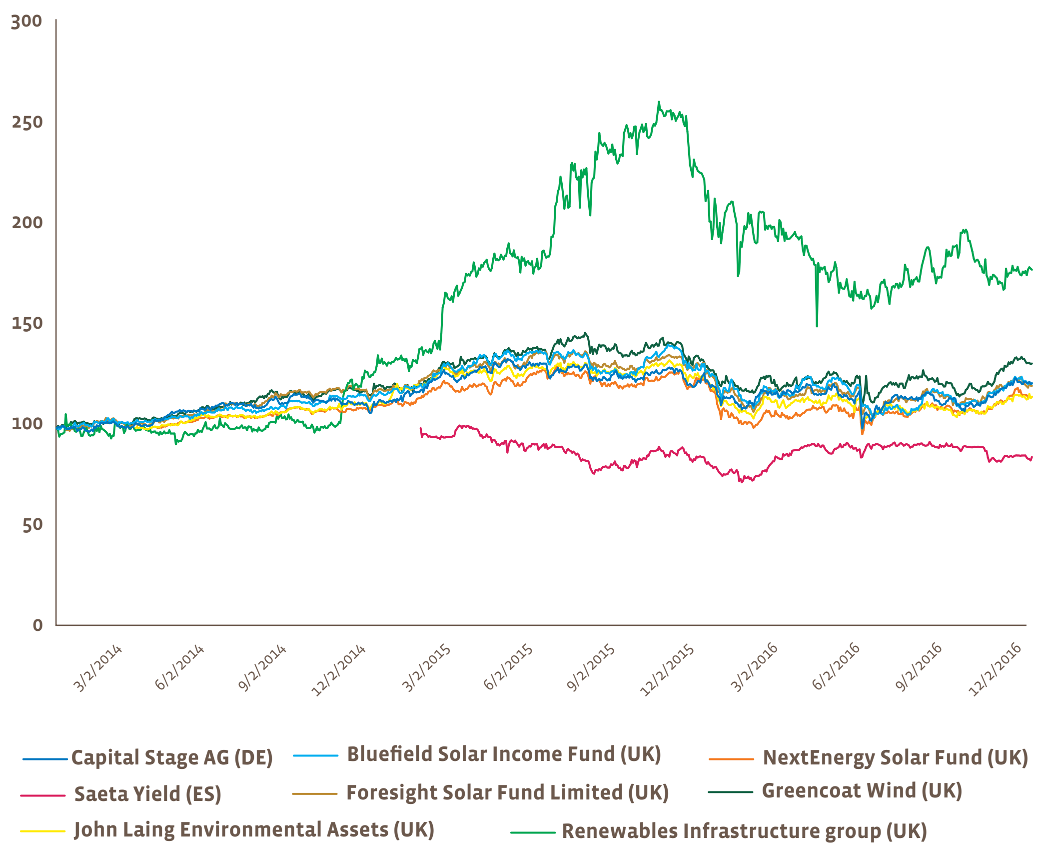
YIELDCOS

YieldCos are own cash-generating infrastructure assets offered on public markets. These assets are RES plants with typically long-term energy delivery contracts with customers.
The YieldCo concept is based on risk profile splitting, where the de-risked operational projects are bundled in a separate company and equity stakes are sold on public markets, while the renewable energy projects in the development stage stays with the energy company. The rationale behind this spin-off is that YieldCos can raise capital at lower cost due their low risk profile and predictable cash flows.

In the analysed period, only eight YieldCos were publicly traded in the EU. Six of these are based in the UK, while the two remaining ones are German and Spanish. The figure on YieldCos shows the evolution of their stock prices that, for comparison, were normalised to 100 at the base date (beginning of 2014). The stock prices of all UK based YieldCos develop quite similarly. There seems to be a positive trend until autumn 2015, followed by marginal decline of stock prices until the end of 2016, where a positive trend seems to start. The German YieldCo seems to show similar trends, however, with a larger magnitude. In early 2015, a Spanish YieldCo was initially offered on the public market. It is the only YieldCo with an overall negative trend in the analysed period.

3

Evolution of EU YieldCos during 2014, 2015 and 2016



It remains to be seen whether the positive development EU YieldCos continues in the long run. On the one hand, they provide attractive yields to investors. On the other hand, many of the largest utilities are still reluctant to create YieldCos. Hence, although it is still an early and rare concept, EurObserv'ER will continue to track the role of YieldCos for RES in the EU. ■

ON THE WHOLE

INVESTMENT IN RENEWABLE ENERGY CAPACITY

The indicators on investment in renewable energy projects capture asset finance for utility-scale renewable energy generation projects. Aggregating asset finance for all RES sectors shows that investment in energy generation capacity fell marginally between 2015 and 2016. After the very impressive year 2015, where EU investments in RES capacity totalled € 40.6 billion, investments amounted to € 38.8 billion in 2016, which is a decrease by around 4%. In spite of this decline, the overall investment level in 2016 is still very high compared to many previous years.

The analysis of the respective RES sectors has revealed a very heterogeneous picture. With respect to overall investment amounts, it is not surprising that investments in onshore and offshore wind are by far the highest. In 2015, wind investments, including both onshore and offshore wind, totalled € 31 billion and grew to € 34 billion in 2016, which corresponds to an increase by almost 10%. This increase in wind investments was mainly driven by offshore, which even overtook onshore investments in 2016. Its share increased from 45% in 2015 to more than 65% in 2016. Due to this upsurge in wind investments, its share in overall RES investments increased even further.

In contrast to the wind sector, the PV sector experienced a dramatic reduction in investments in utility-scale capacity. Asset finance in the sector decreased from € 4.6 billion to € 1.6 billion, which is the lowest level in the last years. In contrast to these utility-size investments, investments in small scale PV installations dropped less dramatically, namely from € 5.2 billion in 2015 to € 4.3 billion in 2016. A similar negative trend could be observed in the biomass sector, where investments dropped from € 3.7 billion to € 2 billion. On a positive note, it is worth mentioning that geothermal investments in both years are rather high compared to the investment volumes in the last years, where geothermal investments were very scarce in the EU.

With respect to investment costs, there were also notably different trends across RES sectors. While investments expenditures per MW of onshore wind capacity remained almost constant in the EU with € 1.42 million in 2015 and € 1.44 million in 2016, investment costs for offshore wind fell between the two years. In contrast to onshore wind, investment expenditures per MW for solar PV plants dropped notably in the EU, namely from € 1.43 million in 2015 to € 1.12 million in 2016. As in the last edition, investment costs for utility-scale RES capacity in the EU were compared to selected trading partners of the EU, namely China,

Canada, India, Japan, Norway, Russia, Turkey and the United States. Overall, the analysis shows a heterogeneous picture across RES technologies. In the wind sector, e.g., investment costs seem to be marginally higher than the average non-EU investment cost. For PV, however, EU investment expenditures per MW are notably below the average of the analysed non-EU countries. RES investment costs seemed to have decreased between 2015 and 2016 in most of the analysed RES sectors in the EU.

VENTURE CAPITAL & PRIVATE EQUITY

Total venture capital (VC) and private equity (PE) investments in renewable energy companies seemed to have stabilized between 2015 and 2016 after the substantial decline between 2014 and 2015. VC/PE in the EU totalled € 2.04 billion in 2015 and € 2.02 billion in 2016, while the developments were quite different between PE and VC investments. While PE investments fell by almost 9%, VC investments tripled from € 78 million in 2015 to € 231 million in 2016.

Overall, VC/PE investments were conducted in more RES sectors in 2015 compared to 2016. The overall development of RES VC/PE investments is quite similar to the observed trends across all other sectors in the EU. Data from the European Private Equity and Venture Capital Association (EVCA) shows that overall EU-wide VC/PE investments (covering all sectors) decreased by 1.2% compared to a 0.8% decrease of VC/PE investments in RES.

PERFORMANCE OF RES TECHNOLOGY FIRMS AND ASSETS ON PUBLIC MARKETS

In order to capture the performance of RES technology companies, i.e. companies that develop / produce the RES components needed for RES plants to function, EurObserv'ER constructed several indices based on RES company stocks. The three presented indices, the Wind Index, the Solar PV Index, and the Bio-Energies Index, comprise the ten largest quoted RES companies in the respective sectors.

In 2015, the trend of all three RES indices was quite similar, while this picture changed notably in 2016. The Wind Index shows by far the most positive development, in particular in 2015. The Bio-Energy Index developed similarly, but at a lower level compared to the Wind Index. Both indices show a clear positive trend in 2015 and seem to stay on a relatively stable level in 2016. The Solar Index shows a substantially different development. In 2015, the Solar PV Index shows a positive trend, but the performance of listed solar firms declines notably in 2016. Due to the dominance of wind firms, the aggregate RES Index shows an overall positive trend in spite of the negative development of the Solar Index in 2016.

As in the previous editions, a non-RES stock index, the EURO STOXX 50, is captured in order to assess how RES companies perform relative to the whole market. Overall, the RES indices show that the years 2016 and, in particular, 2015 were rather prosperous for listed RES companies. In 2015, quoted RES companies seemed to have performed better than the whole market, approximated by the EURO STOXX 50 Index.

In order to track the performance of RES assets on public markets, EurObserv'ER tracked the development of YieldCos in the EU. YieldCos are own cash-generating infrastructure assets, e.g. renewable energy plants, where the ownership is offered on public markets. In the anaysed period, only eight YieldCos were publicly traded in the EU, which overall performed rather well. However, it remains to be seen whether the positive development EU YieldCos continues in the long run. ■

RENEWABLE ENERGY COSTS, REFERENCE PRICES AND COMPETITIVENESS

The past few years have proven that electricity generation from offshore wind energy has rapidly come down in generating costs, leading to tender bids nearly without subsidy appeal in Germany and the Netherlands. A trend that is similarly spectacular is the cost reduction observed in solar PV, which has been ongoing for decades already, and which has led to competitiveness in various demand sectors. Next to an overview of current costs, approximate historic costs are estimated in this chapter for a number of technologies, based on a backward-looking approach.

The overarching question whether renewable technologies are competitive or not depends, among others, on the reference prices paid for energy. In some demand sectors in a number of EU Member States various renewables are already competitive, and in some not yet.

In this section, levelised costs of energy (LCoE) are estimated for various renewable energy technologies and their cost competitiveness is assessed by comparing the LCoE to reference prices. As one can expect though, this is not a black-and-white issue: firstly, there is not a 'single technology cost' (many factors determine the costs, notably locational and operational aspects, but also quality and financing characteristics); secondly the energy yield from various renewables differs widely across Europe; and finally, reference prices can vary significantly.

QUANTIFYING COSTS: PRESENTATION IN DATA-RANGES

Among the EU countries, differences will occur in the costs of renewable energy carriers. These differences are driven by multiple factors. For example, heat from solar energy can be generated cheaper in Southern Europe than in Northern Europe due to the higher average harvested thermal energy. Likewise, electricity from wind is usually cheaper in areas with high average wind resources. One also has to take into account where the wind farm is located, e.g. is it located onshore or offshore, in a remote mountainous area or close to the grid. These factors influence costs significantly. Consequently, even within a single country, renewable energy generation costs can vary considerably. Therefore, the costs are presented there in data-ranges, thereby considering country-specific yields, financing characteristics and biomass fuel costs.

METHODOLOGY

This chapter assesses renewable energy competitiveness by presenting aggregate results for the European Union. The estimated renewable energy production costs (expressed in euro per megawatt-hour, MWh) are presented in comparison to the energy price of the relevant conventional energy carriers. To transparently report all inputs and disclose the methodology applied a set of data is provided in a separate methodology paper, available from the EurObserv'ER website.

The levelised cost of energy (LCoE) of renewable energy technologies refers to the cost estimate of renewable energy production. The LCoE enables reporting the cost information of different renewable energy technologies in all Member States in a comparable manner.

The renewable energy technology LCoE analysis requires a significant amount of data and assumptions, such as the capital expenditures, operational expenditures, fuel costs, economic life, annual energy production auxiliary energy requirements and fuel conversion efficiency. For calculating capital expenditures, project duration and the weighted average cost of capital (WACC) are required parameters. The estimated WACC rates are country and technology specific, the estimated WACC rates are displayed in Figure 1. A Monte Carlo analysis is applied in the LCoE calculation approach (5000 simulations per LCoE value). Important to note is that the costs presented here have been estimated based on literature sources (JRC, 2014; Elbersen et al, 2016). An update of (JRC 2014) is expected, which will be referred to in the next release of The State of Renewable Energy (Edition 2018). Due attention is paid to the monetary year of the cost data. The euros in the graphs refer to EUR 2015.

The conventional energy carrier costs are based on statistical sources (Eurostat) and own calculations. For heating technologies the reference fuels (a Member State specific mix) are exposed to an assumed reference thermal energy conversion efficiency of 90% (capital and operational expenses are currently neglected in this approach).

TECHNOLOGIES CONSIDERED

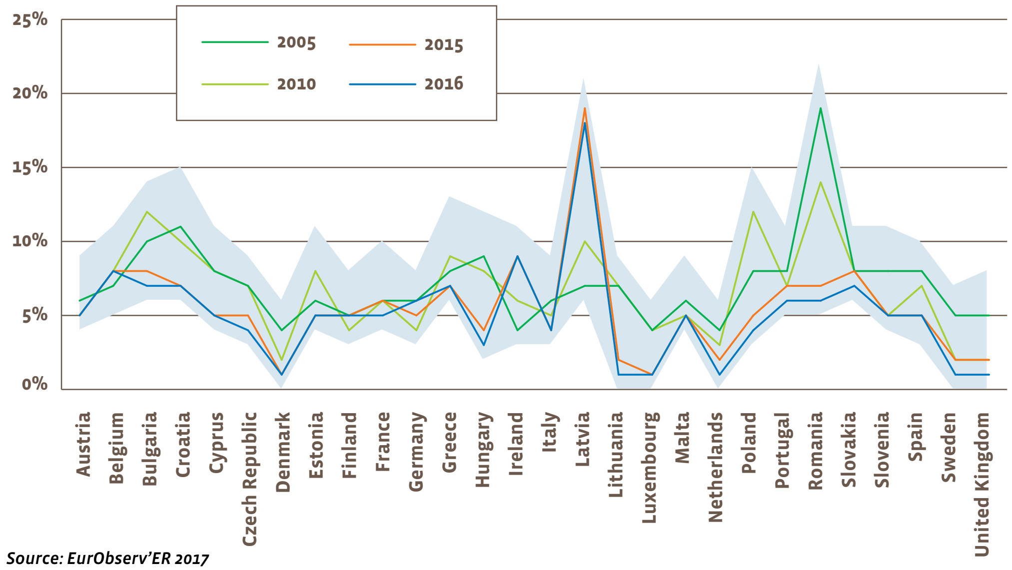
The technologies addressed are: residential ambient heat from heat pumps (an average of ground source, air source and water source heat pumps), bioenergy (biofuels for transport, power derived from biogas and liquid biomass, heat and power from solid biomass), geothermal power, hydropower, ocean energy, solar PV (commercial and residential), solar thermal water heaters, concentrating solar power and wind energy (both onshore and offshore).

COST-COMPETITIVENESS OF RENEWABLE ENERGY TECHNOLOGIES

As mentioned above, the cost-competitiveness of renewable energy technologies varies per technology per Member State and varies with differences in reference energy prices in Member States. Mature technologies such as hydropower and solid biomass can provide, in principle, low-cost power that is comparable to the reference electricity prices in some of the Member States. Likewise onshore-wind and large scale commercial solar PV can be cost-competitive in countries with good wind resources or high insolation and relatively high electricity prices. Heat generation from solid biomass is already cost-competitive

1

Estimated average WACC rates in EU Member States for four reference years



Source: EurObserv'ER 2017

when compared with the reference heat prices.

LCOE RESULTS AND THE COST-COMPETITIVENESS

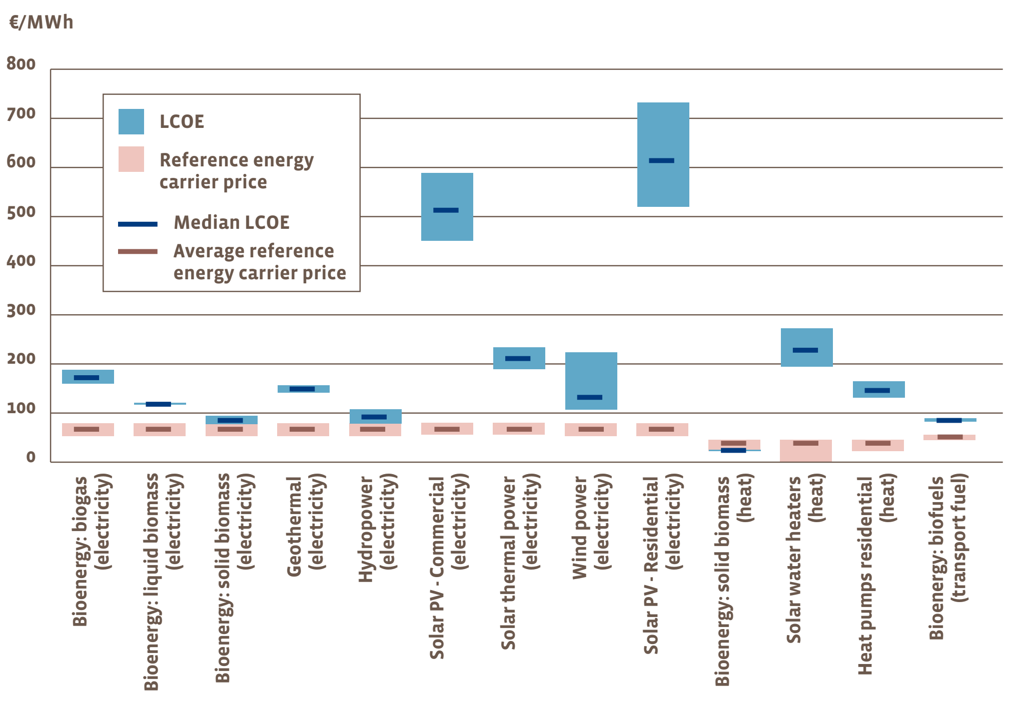
Because the LCoE's from renewable sources vary across Member States, and also because the reference energy carrier prices vary, the outcomes here are presented in data ranges, thus aggregating Member State differences into a single bandwidth. In order to display the costs and prices associated to the individual reference years, separate graphs are shown. Estimates for historic costs have been calculated using ECN data on cost development. The reference energy prices have been presented in the graphs as well in order to be able to indicatively compare them with the calculated LCoEs. The reference prices have been presented without taxes and levies, for large consumer types. Estimated electricity prices for 2005 data have been defined by Eurostat using a different method than for the years 2010 – 2016, therefore they cannot easily be compared. Electricity prices for industrial consumers are defined without taxes for medium size industrial consumers (annual consumption between 500 and 2 000 MWh, source: Eurostat). Heat prices are all excluding taxes and levies and based on large consumers and have been calculated based on the country-specific average fuel mix and assumptions on the conversion efficiency (90% for fossil energy to heat). Where data were missing, average EU-data were used, which is also the case for the transport fuel.

Renewable electricity

Looking at the development over time, biomass and hydropower are assumed to have been quite stable in their level of LCoE. Geothermally sourced electricity and power from PV and wind have seen considerable decreases in LCoE values from 2005 onwards, indicatively displayed in the figures below. Variations among Member States are mostly a result

2

LCoE and reference energy carrier (€/MWh) EU ranges derived from Member State analysis for 2005



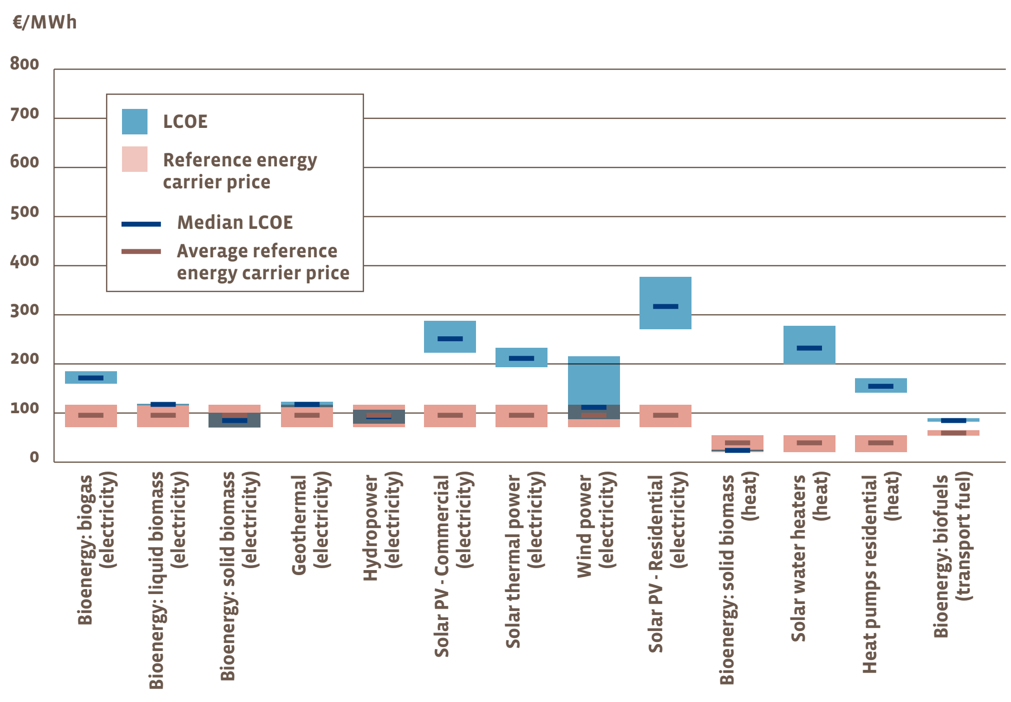
Source: EurObserv'ER 2017

of differences in assumed yield and financing conditions. The graphs depicted here only show aggregates, but a separate paper, available on the EurObserv'ER website, allows to see the country-specific costs and prices.

Among the technologies producing electricity from bioenergy (via biogas, liquid and solid biomass), the LCoE for technologies based on solid biomass are found to be the least expensive, and in the same range as the reference electricity price. For electricity from deep geothermal energy all countries have estimated LCoE values displayed, although no realisations might have occurred in the period under consideration, and potential might be non-existent. Both PV variants are assumed to have realised important cost reductions, making this technology more and more competitive. In the residential sector, PV is in multiple countries competitive compared to residential electricity prices. Wind energy LCoE levels are assumed to have decreased rapidly since 2005, both for onshore and offshore. For offshore wind, the most recent cost developments have not yet been considered yet in the graph; in a few countries offshore wind bid prices in recent tenders demonstrate that perhaps offshore wind LCoE is undercutting onshore wind LCoE levels.

3

LCoE and reference energy carrier (€/MWh) EU ranges derived from Member State analysis for 2010



Source: EurObserv'ER 2017

Renewable heat

For the technologies producing heat, the LCoE for solid biomass is overlapping the reference heat range, indicating it is competitive in many countries. The LCoE range for solar water heaters and heat captured from ambient heat via heat pumps shows, according to the analysis, relatively high LCoE levels.

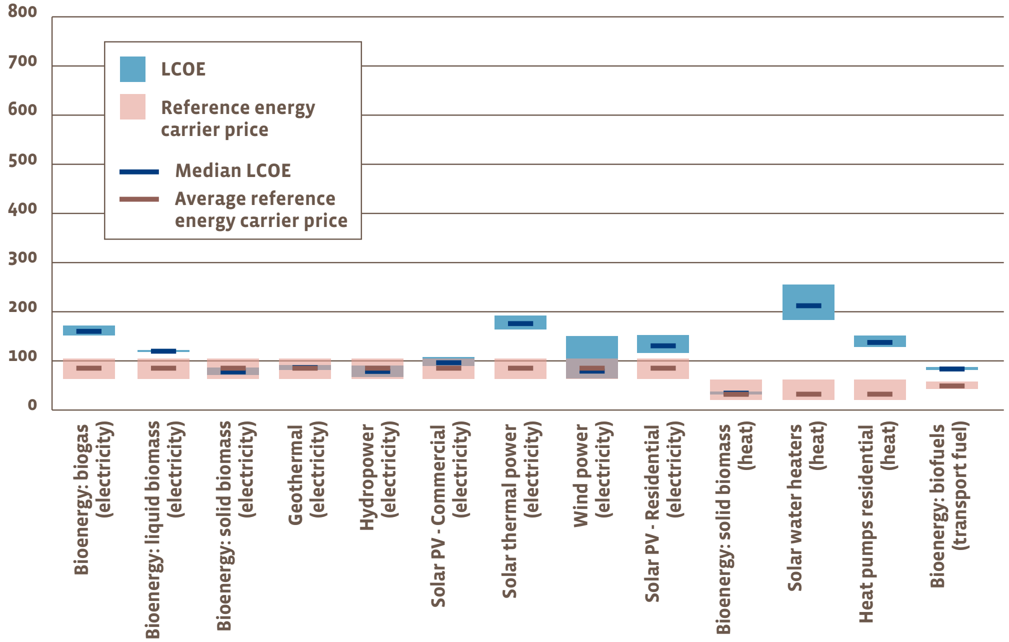
Renewable transport

LCoEs for biofuels for transport show quite a narrow range, above the reference transport fuel price levels.

Note: Overview of the LCoE assessment on a European Union level; ranges derive from the Member State differentiation. The graph also presents, based on large consumer tariffs, the ranges of reference electricity, reference heat and reference transport fuel prices, all excluding taxes and levies. The LCoE ranges represent median values, the ranges were defined based on the interval between 25% and 75% of all values resulting from the Monte Carlo analysis. Data refer to the years 2005, 2010 and 2016 (monetary values are defined in EUR2015).

4

LCoE and reference energy carrier (€/MWh) EU ranges derived from Member State analysis for 2016



Source: EurObserv'ER 2017

EUROBSERV'ER – THE STATE OF RENEWABLE ENERGIES IN EUROPE – 2017 EDITION

AVOIDED FOSSIL FUEL USE AND RESULTING AVOIDED COSTS

LESS CONVENTIONAL ENERGY CARRIERS, AVOIDED BY RENEWABLE ENERGY

Avoided fossil fuels represent conventional non-renewable energy carriers (hereafter fossil fuels and non-renewable waste are collectively named as fossil fuels) not consumed – both domestic and imported fuels – due to development and use of renewable energy.

Avoided costs refer to the expenses that do not occur as a result of avoided fossil fuels. Thus, cumulative amounts of avoided fossil fuels multiplied by the corresponding fuel price levels observed in the various countries represent the avoided costs.

Methodological notes

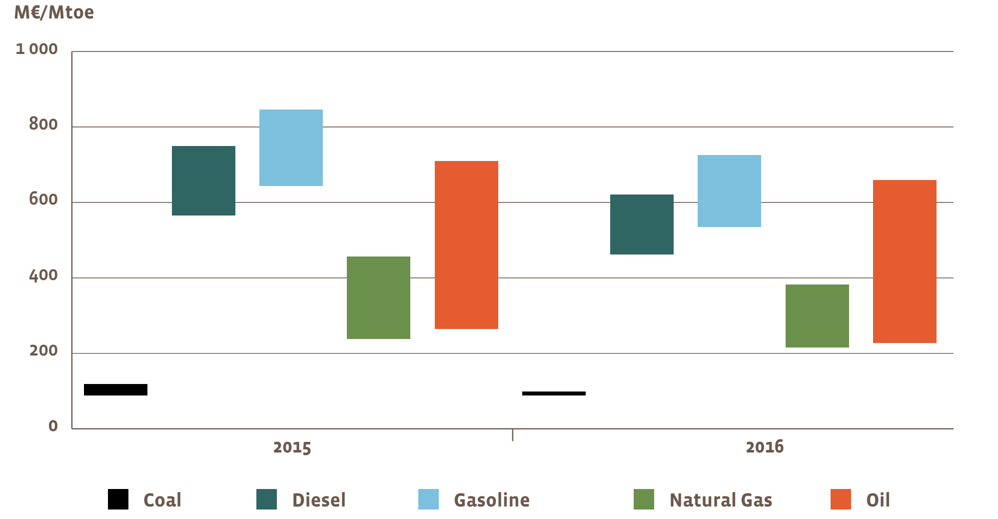
- *The focus of the analysis is on the national level, quantifying the avoided costs in the case where all fossil energy carriers are being purchased abroad. As a consequence, all fuel prices considered exclude taxes and levies.*
- *For countries producing their own fossil fuels the analysis is similar and no correction is made for the indigenous resources.*
- *The avoided costs through the substitution of natural gas by synthetic natural gas (SNG) is not quantified explicitly.*
- *Only the impact on fossil fuel displacement is being addressed: in the electricity mix nuclear energy is not considered.*
- *Pricing non-renewable waste is not straightforward; therefore this impact is not quantified in monetary terms.*
- *For liquid biofuels only the biofuels compliant with the Directive 28/EC/2009 are included.*
- *Data refer to values not normalised for hydropower and wind power.*
- *Energy data [Mtoe] may vary from totals mentioned elsewhere in this EurObserv'ER Barometer because a different base data set was used. The 2016 estimates are proxies.*

The amount of avoided fossil fuels has been analysed by the European Environment Agency and presented in the report "Renewable energy in Europe 2018 - Recent growth and knock-on effects", (EEA 2018, (still to be published at the time of drafting this text). The fossil fuel types assumed to be substituted are transport fuels (diesel and gasoline), fuels used for heating (gaseous fuels, petroleum products and non-renewable waste) and fuels used for the production of electricity (a mix of gaseous, solid and oil products). This section makes use of the EEA data.

The avoided fossil fuel costs are based on the country specific fuel prices derived from multiple sources (Eurostat, European Commission, BP). Figure 1 highlights the fuel price ranges observed in the 28 EU Member States for 2015 and 2016 for five energy carriers: coal, diesel, gasoline, natural gas and oil. These five fuels are assumed to reasonably cover the fuels reported in (EEA, 2017). Note that non-renewable waste has not been priced here (usually the tariff setting of waste is a local issue and not so much driven by a global market).

1

Fossil fuel price ranges in the European Union (excluding taxes and levies)

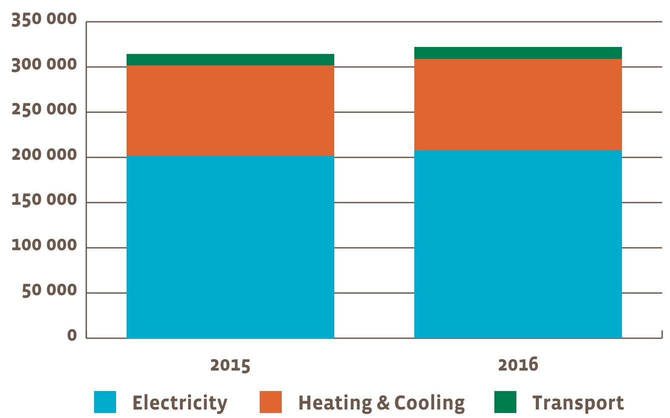


Source: Eurostat, European Commission, BP (2017)

Looking at the individual energy carriers and their ratios, it becomes clear that the downward trend, which was also observed from 2014 to 2015, is continuing during 2016. Fossil fuel prices in 2016 are generally lower than the prices in 2015.
The ranking remains unchanged with coal being the least expensive fuel, next natural gas, followed by (heating) oil. Diesel and gasoline are the most expensive fuels. Compared to 2015, prices in 2016 were not only lower but also the observed data spread for most fuels is smaller.

2

Avoided fossil fuels per sector (ktoe)



Source: EurObserv'ER 2017 based on EEA data

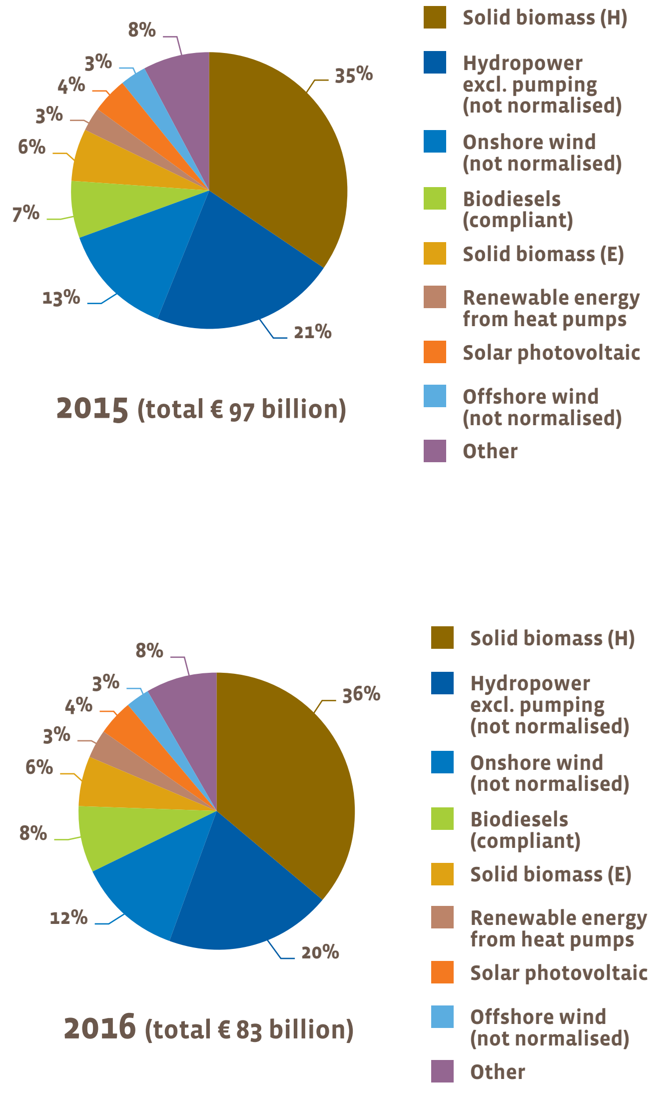
AVOIDED FOSSIL FUEL USE & AVOIDED COSTS PER TECHNOLOGY

In 2015 and 2016 renewable energy substituted around 314 Mtoe and 322 Mtoe of fossil fuels respectively. These figures correspond to an avoided annual cost of EUR 97 billion for EU28 collectively in 2015, decreasing to € 83 billion in 2016. This decrease is due to lower fossil fuel prices in 2016 compared to 2015. The largest contributions derive from renewable electricity and renewable heat (at approximately equal contributions together representing about 90% of the avoided expenses).

The use of renewable electricity contributed to 64% of the total avoided fossil fuels (the share is equal for 2015 and 2016). This is followed by renewables in the heating and cooling sector contributing to approximately 32% (2015) and 31% (2016) of the total avoided fossil fuels and the remaining 4% (similar share for both years) was substituted through renewable transport fuels (only fuels compliant with Directive 2009/28/EC are included). In monetary terms, the avoided costs were € 49.7 billion in 2015 and € 42.4 billion in 2016 in the electricity sector. Second, renewable heat contributed to avoided costs reaching to € 39.2 billion in 2015. In 2016 this fell to € 33.4 billion. Third is renewable transport fuels which contributed to avoided costs of € 8.3 billion in 2015 and € 7.1 billion in 2016. For correctly interpreting these results it is important to take note of a number of methodological issues, referred to in the methodological note (see page 201).

3

Avoided expenses in EU-28 through renewables



Source: EurObserv'ER 2017 based on EEA data

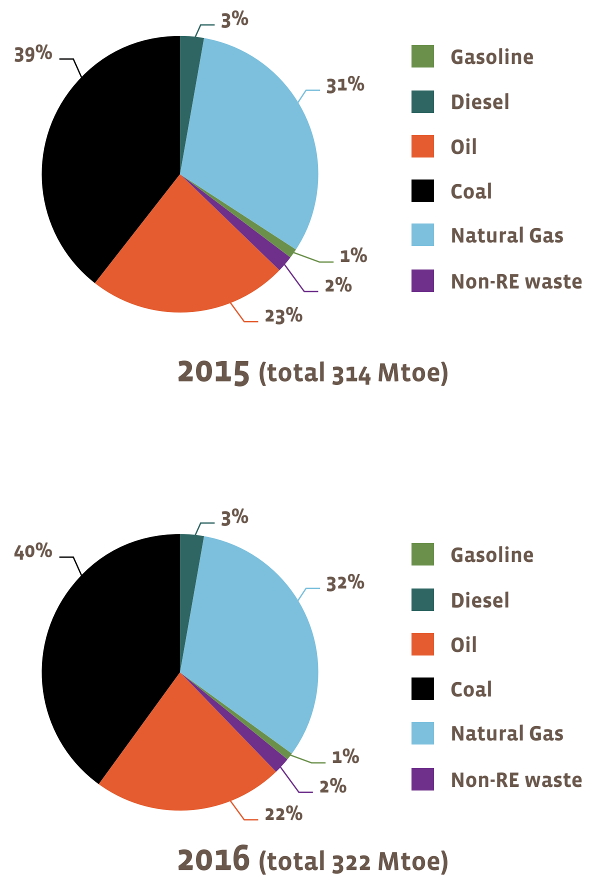
Although the penetration of renewable energy (expressed in avoided fossil fuels) expanded by approximately 2.5% in 2016, the cumulative effect of the avoided fossil fuel costs is lower than in 2015. Underlying reason can be found in the decreasing fossil fuel prices in 2016 compared to 2015. Among the RES technologies, solid biomass for heating purposes avoided the purchase of fossil fuels at an amount of € 37.7 billion in 2016 € 33.7 billion in 2015). Next, hydropower has been responsible for € 20.4 billion in 2016 (€ 20.8 billion in 2015). Onshore wind is third in the row with € 12.6 billion in 2016 (€ 13.0 billion in 2015).

In a graphical manner, the graph and the pie charts of the figure 3 show how each technology contributes to the total avoided costs.

The largest share of avoided fossil fuels comes from solid fuels (mainly coal, 39% for 2015 and 40% for 2016), followed by natural gas (31% and 32% for 2015 and 2016). Next are oil products, with a contribution of 23% in 2015 and 22% in 2016. The remaining fuels (transport fuels and non-renewable waste) cover the remaining share (figure 4).

4

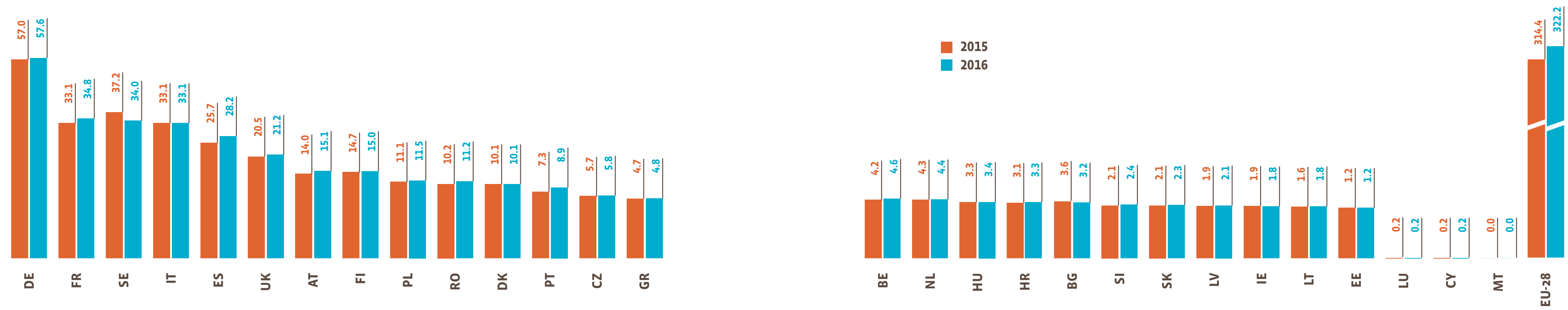
EU substituted fossil fuels during 2015 and 2016



Source: EurObserv'ER 2017 based on EEA data

5

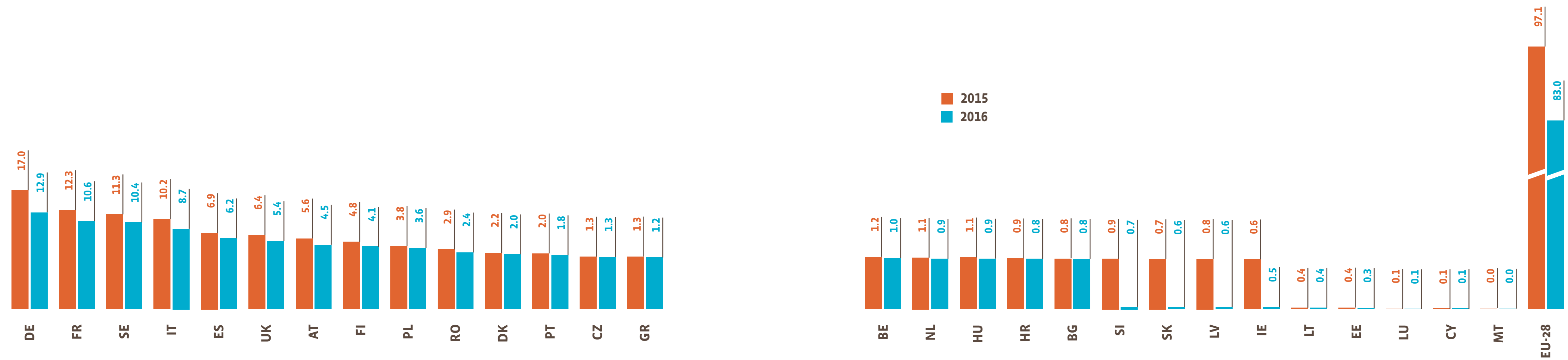
Avoided fossil fuels per country [Mtoe]



Source: EurObserv'ER 2017 based on EEA data

6

Avoided expenses per country [billion euro]



Source: EurObserv'ER 2017 based on EEA data

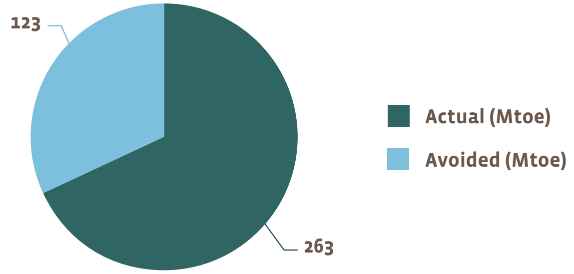
AVOIDED FOSSIL FUELS & EXPENSES PER MEMBER STATE

At Member State level, the avoided costs have been estimated as displayed in graph 6. Note that there is a strong correlation between the avoided amount and the size of a country. As can be expected, the avoided cost follow the fuel price development: with fossil fuel prices lower in 2016 compared to 2015, almost all counties show a similar pattern. Four Member States show a decreasing trend in avoided fossil fuels due to decreased renewable energy deployment in 2016 compared to 2015. These countries are Bulgaria, Estonia, Ireland and Sweden. See also the methodological notes.
The data have been displayed graphically in the figures above.

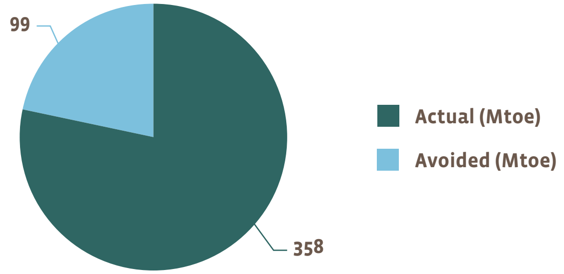
Next, the visuals below indicate how the amounts of estimated avoided fuel relate to the total fuel EU use. The relevant parameter for comparing the avoided fuel use with is the primary energy consumption, which indicates the gross inland consumption excluding all non-energy use of energy carriers (e.g. natural gas used not for combustion but for producing chemicals). For the transport fuels the comparison is not possible because these are not primary fuels (but instead secondary fuels). Reference year depicted 2015, because it regards final data. ■

7

Contributions per fuel 2015 compared to total

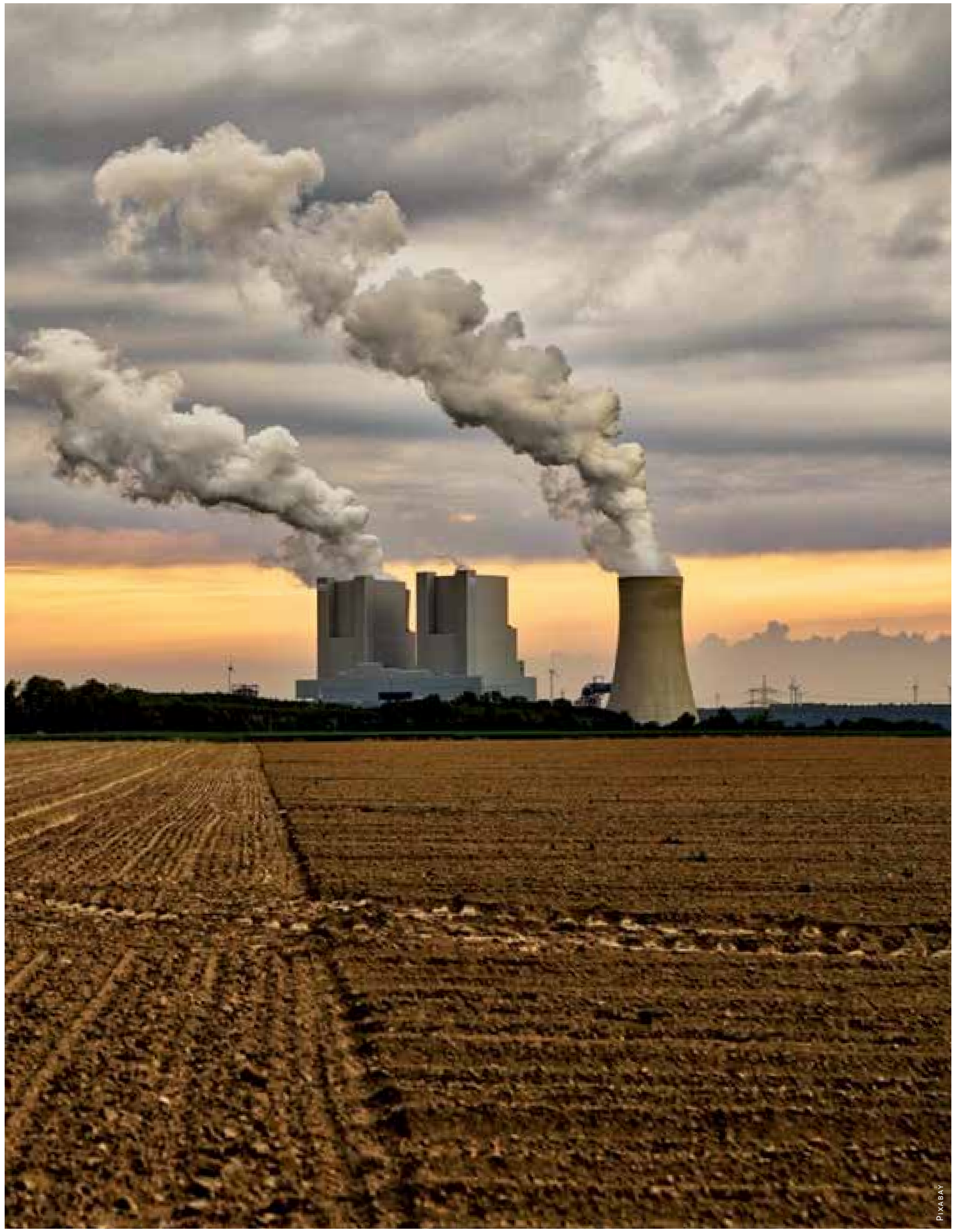


Gross inland coal consumption in 2015



Gross inland gas consumption in 2015

Source: EurObserv'ER 2017 based on EEA data



INDICATORS ON INNOVATION AND COMPETITIVENESS

The Energy Union strives to provide a secure, sustainable, affordable energy supply by increasing renewable energy uses, energy efficiency, internal energy market integration and competitiveness. Wiser energy use, the European Commission states, is both a spur for new jobs and growth, and an investment in the future of Europe. Economic theory underpins this understanding. Expenditures for research and development are seen as investments into new or better processes, products or services that might create new markets or increase market shares and strengthen competitiveness of firms, sectors and nations. Regarding RET, R&D investments spur innovations in RET, which are often measured by the number or share of patent applications in the respective technology field. How well the R&D output translates into a strong market position, i.e. competitiveness in RET, is measured for example by the trade share in RET products. These three indicators are depicted in the following chapters: R&D expenditures (public & private) showing the efforts or investments of countries w.r.t. RET, patent applications reflecting the output of R&D efforts and finally trade shares in RET displaying how competitive a country is in RET products.

R&D Investments

In general, investments into R&D and innovation are commonly seen as the basis for technological changes and hence competitiveness. Therefore, they are an important factor for or driver of economic growth. From a macro-economic perspective, R&D investments can be viewed as a major indicator to measure innovative performance of economies or innovation systems. The indicator is able to display the position of a country in international competition with regard to innovation.

Methodological approach

Overall, R&D expenditures are financed by private and public resources, while R&D is performed by both, business (private), government and higher education sector (public). This differentiation into financing and performing is depicted in Figure 1. In this section, we will analyze public and private R&D expenditures of a selected set of countries with regard to renewable energy technologies, i.e. research investments originating from the public sector (see dark grey area in Figure 1) as well as from the business sector are taken into account (see light grey area in Figure 1).

R&D investments from the public sector are supposed to spur innovation in the private sector. Although the specific returns to public-sector R&D investments are largely unknown, the basic idea is to create follow-up investments from the private sector and generate spill-over effects.
For this report, the data on public and private R&D investment were provided by JRC SETIS. Its R&D data relies on IEA statistics , which collects and depicts national R&D investments. They address 20 of the EU Member States with varying regularity and granularity of technology detail. However, there is a 2 year time delay in reporting for most Member States, thus data is available for 2015, while only a few are available in 2016. For the data on private R&D, the time delay is even longer (2012 and 2013) as JRC's assessment is based on patent data. The methodology is described in more detail in the JRC Science for Policy Report "Monitoring R&D in Low Carbon Energy Technologies: Methodology for the R&D indicators in the State of the Energy Union Report, - 2016 Edition". Data gaps are supplemented by the Member States through the SET Plan Steering Group or through targeted data mining.

Besides providing absolute figures for R&D expenditures (Euro) of the given countries, the share of R&D expenditures on GDP (%) is calculated to get an impression of the relative size of a country's investments in RET technologies. Blanks in the table mean that no data was available.

1

Sectors by financing and performing of R&D

	Total R&D spending		
Financing sectors	Business	Government	
Performing sectors	Business	Government	Higher education

1. IEA. International Energy Agency RD&D Online Data Service. Available from: http://www.iea.org/statistics/RDDonlinedataservice/
2. A. Fiorini, A. Georgakaki, F. Pasimeni, E. Tzimas, "Monitoring R&D in Low-Carbon Energy Technologies", EUR 28446 EN (2017). Available from: https://setis.ec.europa.eu/related-jrc-activities/jrc-setis-reports/monitoring-ri-low-carbon-energy-technologies

PUBLIC R&D INVESTMENTS

Public R&D investments are depicted by RE technologies.

PRIVATE R&D INVESTMENTS

Private R&D investments are depicted by RE technologies. Data are only available for the countries of the EU-28 in 2012 and 2013.

PUBLIC R&D INVESTMENTS
WIND ENERGY

	Public R&D Exp. (in € m)		Share of Public R&D Exp. by GDP	
	2015	2016	2015	2016
EU 28				
Germany	53.0	49.7	0.0017%	0.0017%
Denmark	26.1	22.7	0.0096%	0.0087%
Spain	22.6		0.0021%	
Netherlands	16.1		0.0024%	
United Kingdom	10.0	9.9	0.0004%	0.0005%
France	9.6		0.0004%	
Belgium	4.3		0.0011%	
Sweden	3.7	2.3	0.0008%	0.0005%
Finland	2.6		0.0012%	
Poland	0.8	0.2	0.0002%	0.0000%
Austria	0.5		0.0002%	
Portugal	0.3		0.0002%	
Ireland	0.2		0.0001%	
Czech Republic	0.1	0.1	0.0001%	0.0001%
Slovakia	0.0	0.0	0.0000%	0.0000%
Hungary	0.0	0.0	0.0000%	0.0000%
Italy	0.0		0.0000%	
Total EU	150.0	84.9	0.0010%	0.0006%
Other Countries				
Japan	215.7	199.8	0.0055%	0.0045%
Korea	31.5		0.0025%	0.0000%
United States	77.4	67.7	0.0005%	0.0004%
Australia	0.3	0.1		
Canada	4.5	7.0	0.0008%	0.0005%
New Zealand	0.0	0.0		
Norway	18.0	17.0	0.0052%	0.0048%
Switzerland	1.8	1.8	0.0003%	0.0004%
Turkey	0.7	1.3	0.0001%	0.0002%

Source : JRC SETIS, Eurostat, WDI Database

In wind energy, Japan scores first with regard to public R&D spending, followed by the EU 28 (although data for many countries is not available in 2016). The U.S. ranks third, however, with less than half of the budget of Japan. Within the EU 28, it is Germany, Denmark as well as Spain (2015) and the Netherlands with the largest public R&D budget (2015). This can be explained by the fact that main players among the wind power manufacturers are located in these EU countries. In terms of GDP shares, the values are by far largest for Denmark, followed by Japan, Korea (2015) and Germany. ■

PUBLIC R&D INVESTMENTS
SOLAR ENERGY

	Public R&D Exp. (in € m)		Share of Public R&D Exp. by GDP	
	2015	2016	2015	2016
EU 28				
Germany	82.0	78.6	0.0027%	0.0028%
France	71.1		0.0033%	
Netherlands	51.7		0.0076%	
Spain	15.2		0.0014%	
United Kingdom	14.3	15.5	0.0006%	0.0007%
Denmark	11.5	8.5	0.0042%	0.0033%
Austria	9.1		0.0027%	
Finland	6.8		0.0032%	
Belgium	6.6		0.0016%	
Sweden	6.5	6.2	0.0015%	0.0015%
Poland	4.7	0.6	0.0011%	0.0001%
Portugal	1.9		0.0011%	
Ireland	0.7		0.0003%	
Czech Republic	0.7	0.4	0.0004%	0.0002%
Slovakia	0.1	1.2	0.0001%	0.0016%
Hungary	0.0	0.0	0.0000%	0.0000%
Italy	0.0		0.0000%	
Total EU	282.8	110.9	0.0019%	0.0008%
Other Countries				
Australia	83.7	52.7		
United States	82.6	100.1	0.0005%	0.0006%
Japan	59.2	57.4	0.0015%	0.0013%
Korea	43.6		0.0035%	0.0000%
Switzerland	42.1	42.1	0.0070%	0.0087%
Norway	13.4	14.8	0.0038%	0.0042%
Canada	10.4	15.2	0.0007%	0.0011%
Turkey	4.7	6.8	0.0006%	0.0008%

Source : JRC SETIS, Eurostat, WDI Database

In the field of solar energy, the EU 28 is the largest player in terms of national R&D investment, although the data are not complete for 2016. The U.S, Japan and Korea follow the EU 28. The table 2 displays a growth in national R&D investments in the US, while the figures slightly decrease for Japan. Figures for China as well as some other countries are not available. Within the EU 28, there are three countries with significant public R&D investments, namely Germany, France and the Netherlands. In 2015, Germany, the Netherlands and France are responsible for 72% of the R&D investments of the EU 28 (2015). In Germany, public R&D expenditures are rather constant between 2015 and 2016, with only slight decreases visible. For France and the Netherlands, data for 2016 is not yet available. When looking at the normalization of the R&D figures by GDP, the share of the EU 28 is low, especially compared to Korea (in 2015). However, as data are still incomplete in 2016 a general trend cannot be seen. In 2015, EU 28 reveals still higher figures than the U.S. and Japan. Within the EU, the Netherlands have the largest budget share for solar energy, followed by Denmark, France and Finland. ■

PUBLIC R&D INVESTMENTS
GEOTHERMAL ENERGY

	Public R&D Exp. (in € m)		Share of Public R&D Exp. by GDP	
	2015	2016	2015	2016
EU 28				
Germany	13.4	12.5	0.0004%	0.0004%
France	6.6		0.0003%	
Netherlands	2.0		0.0003%	
Denmark	1.7	2.3	0.0006%	0.0009%
Austria	0.7		0.0002%	
Poland	0.6	0.1	0.0001%	0.0000%
Belgium	0.5		0.0001%	
Slovakia	0.4	0.4	0.0005%	0.0005%
Czech Republic	0.4	0.4	0.0003%	0.0002%
Spain	0.3		0.0000%	
Sweden	0.3	0.0	0.0001%	0.0000%
Portugal	0.2		0.0001%	
Ireland	0.1		0.0000%	
United Kingdom	0.1	0.0	0.0000%	0.0000%
Finland	0.0		0.0000%	
Hungary	0.0	0.0	0.0000%	0.0000%
Total EU	27.3	15.7	0.0002%	0.0001%
Other Countries				
United States	46.2	60.8	0.0003%	0.0004%
Japan	24.8	15.4	0.0006%	0.0003%
Switzerland	12.9	12.9	0.0021%	0.0027%
Korea	5.8		0.0005%	0.0000%
New Zealand	3.9	3.9		
Canada	1.3	1.3	0.0001%	0.0001%
Australia	0.4	0.2		
Turkey	0.0	0.5	0.0000%	0.0001%

Source: JRC SETIS, Eurostat, WDI Database

With regard to geothermal energy, the U.S. can be found to have the largest public R&D investments of € 60.8 million in 2016, followed by the EU 28 with € 15.7 million and Japan with € 15.4 million. Compared to solar energy, the R&D expenditures are rather low. The GDP normalization shows that Switzerland has the largest share of public R&D investment on GDP followed by Denmark (across all countries in our comparison), which has even grown between 2015 and 2016. In comparison, the values are much lower for all other countries. ■

PUBLIC R&D INVESTMENTS
HYDROPOWER

	Public R&D Exp. (in € m)		Share of Public R&D Exp. by GDP	
	2015	2016	2015	2016
EU 28				
France	2.7		0.0001%	n.a.
Denmark	1.9	3.3	0.0007%	0.0013%
Germany	1.7	2.0	0.0001%	0.0001%
Sweden	1.5	1.2	0.0003%	0.0003%
Austria	1.2		0.0004%	
Finland	0.3		0.0001%	
Czech Republic	0.2	0.2	0.0001%	0.0001%
United Kingdom	0.2	0.2	0.0000%	0.0000%
Belgium	0.1		0.0000%	
Poland	0.1	0.0	0.0000%	0.0000%
Netherlands	0.0		0.0000%	
Spain	0.0		0.0000%	
Hungary	0.0	0.0	0.0000%	0.0000%
Ireland	0.0		0.0000%	
Portugal	0.0		0.0000%	
Slovakia	0.0	0.4	0.0000%	0.0005%
Total EU	9.9	7.3	0.0001%	0.0001%
Other Countries				
United States	17.1	22.4	0.0001%	0.0001%
Canada	12.6	13.3	0.0009%	0.0010%
Switzerland	11.5	11.5	0.0019%	0.0024%
Norway	10.3	7.9	0.0030%	0.0022%
Korea	4.3		0.0003%	0.0000%
Japan	2.9	0.0	0.0001%	0.0000%
Turkey	1.2	1.2	0.0002%	0.0001%

Source: JRC SETIS, Eurostat, WDI Database

Hydropower is a small field with regard to public R&D investment when compared to solar energy. In this field, the U.S. has the largest public R&D investment among all countries in Table 4. It is followed by Canada, Switzerland and Norway, which all have significant hydro power resources. In the EU 28, France, Denmark and Germany show the largest values (2015) with € 2.7, 1.9 million and € 1.7 million, respectively. The GDP shares show that the highest (and growing) shares can be found in Switzerland, Norway and Denmark. Within the EU 28, Denmark is followed by Austria and Sweden. Other countries show significantly low investment levels compared to other technologies. ■

PUBLIC R&D INVESTMENTS
BIOFUELS

	Public R&D Exp. (in € m)		Share of Public R&D Exp. by GDP	
	2015	2016	2015	2016
EU 28				
France	83.4		0.0038%	
Germany	34.9	37.3	0.0012%	0.0013%
Finland	27.0		0.0129%	
United Kingdom	26.2	36.0	0.0010%	0.0017%
Netherlands	24.6		0.0036%	
Denmark	23.2	9.6	0.0085%	0.0037%
Sweden	21.2	20.2	0.0047%	0.0048%
Poland	11.3	2.7	0.0026%	0.0006%
Ireland	10.7		0.0042%	
Austria	10.1		0.0030%	
Spain	9.9		0.0009%	
Belgium	5.5		0.0014%	
Portugal	2.0		0.0011%	
Czech Republic	1.9	2.0	0.0011%	0.0011%
Slovakia	0.4	7.2	0.0005%	0.0092%
Hungary	0.0	0.0	0.0000%	0.0000%
Italy	0.0		0.0000%	
Total EU	292.4	115.0	0.0020%	0.0008%
Other Countries				
United States	441.2	485.7	0.0027%	0.0029%
Canada	56.3	50.3	0.0040%	0.0036%
Japan	51.1	34.7	0.0013%	0.0008%
Norway	17.5	13.0	0.0050%	0.0036%
Switzerland	16.3	16.3	0.0027%	0.0034%
Korea	14.1		0.0011%	
Australia	3.9	2.4		
New Zealand	1.6	0.0		
Turkey	0.7	0.8	0.0001%	0.0001%

Source: JRC SETIS, Eurostat, WDI Database

In terms of public R&D investment, biofuels is the largest field within renewables. Here, the U.S. clearly shows a strong commitment, with the largest investment close to € 500 million in 2016. Other countries in this analysis display much lower public R&D investments, all below € 50 million, except for the EU 28 as a whole. The U.S. is followed by the EU 28, Canada and Japan. Within the EU 28, the largest national R&D investments can be observed in France (2015), Germany, the UK and Sweden. Besides these countries, significant public investments in the EU-28 are made in Finland and the Netherlands (above € 25 million in 2015). With regard to the GDP shares, Slovakia is leading in 2016, followed by Sweden and Denmark. In 2015, Finland's shares were high as well (no data in 2016). Albeit large absolute investments in biofuels, the U.S. display relatively low shares, yet with an increasing tendency between 2015 and 2016. ■

PUBLIC R&D INVESTMENTS
OCEAN ENERGY

	Public R&D Exp. (in € m)		Share of Public R&D Exp. by GDP	
	2015	2016	2015	2016
EU 28				
United Kingdom	18.6	17.5	0.0007%	0.0008%
Ireland	15.0		0.0059%	
France	7.6		0.0003%	
Denmark	6.0	0.0	0.0022%	0.0000%
Sweden	3.7	4.4	0.0008%	0.0010%
Netherlands	3.3		0.0005%	
Spain	2.9		0.0003%	
Belgium	0.6		0.0001%	
Portugal	0.0		0.0000%	
Austria	0.0		0.0000%	
Czech Republic	0.0	0.0	0.0000%	0.0000%
Germany	0.0	0.0	0.0000%	0.0000%
Finland	0.0		0.0000%	
Hungary	0.0	0.0	0.0000%	0.0000%
Italy	0.0		0.0000%	
Poland	0.0		0.0000%	
Slovakia	0.0	0.0	0.0000%	0.0000%
Total EU	57.7	21.9	0.0004%	0.0002%
Other Countries				
United States	38.1	40.9	0.0002%	0.0002%
Japan	12.5	8.3	0.0003%	0.0002%
Canada	7.1	2.2	0.0005%	0.0002%
Australia	4.8	0.4		
Korea	4.5		0.0004%	0.0000%
Norway	2.2	2.1	0.0006%	0.0006%
New Zealand	0.3	0.3		
Switzerland	0.0	0.0	0.0000%	0.0000%
Turkey	0.0	0.0	0.0000%	0.0000%

Source: JRC SETIS, Eurostat, WDI Database

Ocean energy is a comparably small field when interpreted alongside public R&D investment. Here, the EU 28 shows the largest values (2015), although many data points are missing. In 2016, however, the EU 28 expenditures have decreased, so the EU 28 and the U.S. swap ranks. This is also due to increasing investments of the U.S. Besides the U.S., it rather seems that the investments have decreased between 2015 and 2016. Interestingly, the GDP shares show the largest values for Ireland (2015), followed by Denmark and Sweden. ■

PUBLIC R&D INVESTMENTS

RENEWABLE ENERGY TECHNOLOGIES IN TOTAL

	Public R&D Exp. (in € m)		Share of Public R&D Exp. by GDP	
	2015	2016	2015	2016
EU 28				
Germany	185.0	180.1	0.0061%	0.0063%
France	181.1		0.0083%	
Netherlands	97.8		0.0145%	
Denmark	70.3	46.5	0.0259%	0.0178%
United Kingdom	69.3	79.0	0.0027%	0.0038%
Spain	51.0		0.0047%	
Sweden	36.9	34.2	0.0083%	0.0081%
Finland	36.7		0.0175%	
Ireland	26.7		0.0105%	
Austria	21.7		0.0064%	
Belgium	17.6		0.0043%	
Poland	17.4		0.0041%	
Portugal	4.4		0.0025%	
Czech Republic	3.3	3.0	0.0020%	0.0017%
Slovakia	0.9	9.2	0.0011%	0.0117%
Hungary	0.0	0.0	0.0000%	0.0000%
Total EU	820.2	355.8	0.0056%	0.0026%
Other Countries				
United States	702.5	777.6	0.0043%	0.0046%
Japan	366.2	315.6	0.0093%	0.0071%
Korea	103.8		0.0083%	
Australia	93.1	56.0		
Canada	92.2	89.2	0.0066%	0.0065%
Switzerland	84.5	84.5	0.0140%	0.0174%
Norway	61.3	54.9	0.0176%	0.0154%
Turkey	7.3	10.7	0.0009%	0.0013%
New Zealand	5.8	4.2		

Source: JRC SETIS, Eurostat, WDI Database ; Note : the sum across technologies is only given, if data of all RET in one country are available, i.e. as soon as one RET is missing, the data are indicated as n.a.

Finally, a closer look at the public R&D investment in all renewable energies technologies reveals a strong position of the US in 2015, which could even be strengthened in 2016 while the EU 28 seems to lose ground. Yet, due to many missing values in the 2016 data, this table has to be interpreted with caution, since it compares only the countries for which data was available for each RET. The GDP shares display a very strong position of Norway, Switzerland, Japan and Korea (2015) when compared to the EU 28 and the U.S. Within the EU, the largest shares can be found in Denmark, Finland, the Netherlands and Ireland (2015). However, only a few countries display data in 2016, which makes comparisons difficult. ■

PRIVATE R&D INVESTMENTS

WIND ENERGY

	Private R&D Exp. (in € m)		Share of Private R&D Exp. by GDP	
	2012	2013	2012	2013
EU 28				
Germany	805.2	512.1	0.0300%	0.0190%
Denmark	214.6	215.9	0.0869%	0.0866%
Spain	152.5	120.0	0.0147%	0.0117%
United Kingdom	74.2	60.1	0.0039%	0.0031%
Netherlands	65.1	60.1	0.0102%	0.0095%
Sweden	41.2	49.9	0.0109%	0.0130%
France	76.4	47.4	0.0037%	0.0023%
Italy	54.0	44.7	0.0034%	0.0029%
Austria	15.7	15.0	0.0051%	0.0049%
Poland	13.4	14.6	0.0035%	0.0037%
Belgium	15.1	8.6	0.0041%	0.0023%
Ireland	7.1	7.1	0.0041%	0.0040%
Romania	2.5	7.0	0.0019%	0.0052%
Luxembourg	14.4	4.6	0.0351%	0.0108%
Finland	9.4	4.2	0.0050%	0.0022%
Hungary	2.9	2.2	0.0029%	0.0022%
Slovakia		0.5		0.0007%
Greece		0.4		0.0002%
Latvia		0.4		0.0022%
Portugal	6.3		0.0037%	
Czech Republic	3.8		0.0024%	
Bulgaria	2.5		0.0064%	
Total EU	1576.3	1174.7	0.0121%	0.0090%

Source : JRC SETIS, Eurostat, WDI Database

In wind energy, on a European level, private investments in R&D have decreased by more than 25% between 2012 and 2013 in value, as well as relatively to the European GDP. The sector however ranks second in terms of attractivity for private R&D investment in 2012 and 2013. Germany scores first with regard to private R&D spending. With investments of about € 512 million in 2016, it has more than twice as much investment as Denmark, which scores second on this indicator. Yet, Germany's investments have dropped between 2012 and 2013, while the investments of Denmark have remained at a rather constant level. Spain ranks third, however, with only half of the budget of Denmark. In terms of GDP shares, the values are by far largest for Denmark, followed by Germany, Sweden and Spain. In sum, this pattern is very similar to the public R&D investment in wind energy. This is also true for the other RET fields. ■

PRIVATE R&D INVESTMENTS
SOLAR ENERGY

	Private R&D Exp. (in € m)		Share of Private R&D Exp. by GDP	
	2012	2013	2012	2013
EU 28				
Germany	1170.5	851.2	0.0436%	0.0315%
France	219.3	252.0	0.0107%	0.0123%
Italy	264.8	153.8	0.0169%	0.0100%
United Kingdom	87.5	108.7	0.0046%	0.0056%
Spain	86.8	88.1	0.0084%	0.0086%
Netherlands	65.1	67.3	0.0103%	0.0106%
Finland	44.8	38.9	0.0237%	0.0207%
Austria	74.5	36.1	0.0243%	0.0118%
Belgium	42.2	28.4	0.0113%	0.0076%
Poland	18.9	26.3	0.0049%	0.0067%
Sweden	24.4	18.2	0.0065%	0.0048%
Denmark	9.1	14.2	0.0037%	0.0057%
Czech Republic	5.3	5.8	0.0033%	0.0037%
Portugal	5.1	5.6	0.0030%	0.0033%
Ireland	9.8	4.1	0.0057%	0.0023%
Greece	4.2	4.1	0.0022%	0.0022%
Hungary	2.7	3.0	0.0027%	0.0030%
Luxembourg	10.4	1.5	0.0253%	0.0035%
Romania	9.8	1.4	0.0076%	0.0011%
Hungary	1.6	0.6	0.0037%	0.0014%
Latvia		0.5		0.0025%
Bulgaria	5.5		0.0141%	
Slovenia	3.4		0.0095%	
Cyprus	2.2		0.0119%	
Total EU	2167.8	1709.7	0.0167%	0.0131%

Source : JRC SETIS, Eurostat, WDI Database

The solar energy is the most attractive RET for private R&D investments before wind. Within the EU 28, private R&D investments have decreased by more than 20% between 2012 and 2013 in absolute and relative terms. Yet this is less uniform a tendency as in wind power, since for some countries (FR, UK, PL) it has increased. Germany is the largest player in terms of national R&D investment. Although the figures have decreased between 2012 and 2013, they still are at a very high level compared to the other EU 28 countries. Germany is followed by France, where the private R&D expenditures for solar energy technologies have risen between 2012 and 2013. Italy and the UK score at ranks three and four within this comparison.

When looking at the normalization of the R&D figures by GDP, Germany has the largest share though it has decreased in 2013 due to decreases in absolute figures. Germany is followed by Finland, France, Austria, the Netherlands and Italy. In all these countries, the shares of public R&D in GDP are above 0.01% for solar energy technologies. ■

PRIVATE R&D INVESTMENTS
HYDROPOWER

	Private R&D Exp. (in € m)		Share of Private R&D Exp. by GDP	
	2012	2013	2012	2013
EU 28				
France	12.7	30.9	0.0006%	0.0015%
Germany	39.9	28.9	0.0015%	0.0011%
Italy	6.2	17.6	0.0004%	0.0011%
Austria	6.3	8.7	0.0021%	0.0028%
United Kingdom	8.0	6.8	0.0004%	0.0004%
Netherlands	1.0	4.6	0.0002%	0.0007%
Poland	2.1	4.2	0.0005%	0.0011%
Slovakia		4.2		0.0059%
Spain	2.1	3.2	0.0002%	0.0003%
Romania		2.8		0.0021%
Finland		2.5		0.0013%
Hungary		2.1		0.0049%
Belgium		2.1		0.0006%
Ireland		1.6		0.0009%
Denmark	0.0	1.4	0.0000%	0.0006%
Greece		0.7		0.0004%
Czech Republic	9.7		0.0061%	
Total EU	88.0	122.4	0.0007%	0.0009%

Source: JRC SETIS, Eurostat, WDI Database

Compared to solar energy, hydropower is a rather small field with regard to private R&D investment. But private R&D investments in 2012/13 are larger than public investments in 2015/16. Contrary to wind and solar energy, private investments have increased in average in the hydropower sector in Europe. France has the largest private R&D investment among the countries in our comparison in 2013 after investments in Germany have dropped. These two countries are followed by Italy, which also has significant private R&D investments in hydropower. These three countries are followed by Austria and the UK, where private R&D expenditures exceeds € 5 million. In addition, the Czech Republic displays significant private R&D spending in this field (2015). The GDP shares, however, show a different ranking: the highest shares can be found in Slovakia and Croatia. Furthermore, Austria shows comparably high (and growing) shares. The countries that have shown large absolute values, i.e. France, Germany and Italy, score in the midfield together with Finland and Poland. Yet, especially in France and Italy a comparably large growth in private R&D investments in hydro energy can be found between 2012 and 2013. ■

PRIVATE R&D INVESTMENTS

GEOTHERMAL ENERGY

	Private R&D Exp. (in € m)		Share of Private R&D Exp. by GDP	
	2012	2013	2012	2013
EU 28				
Germany	25.9	33.7	0.0010%	0.0012%
United Kingdom	3.7	9.3	0.0002%	0.0005%
Poland	4.0	8.7	0.0010%	0.0022%
Sweden	8.5	8.2	0.0022%	0.0022%
Netherlands	0.9	4.4	0.0001%	0.0007%
Spain		4.1		0.0004%
France	4.8	2.7	0.0002%	0.0001%
Italy	3.5	0.7	0.0002%	0.0000%
Austria	1.7		0.0006%	
Finland	5.5		0.0029%	
Total EU	58.4	71.8	0.0004%	0.0006%

Source: JRC SETIS, Eurostat, WDI Database

In geothermal energy, the private (as well as the public) R&D expenditures are lower than within hydropower, but as well as for hydropower, available figure show a two-digit increase between 2012 and 2013. Once again, Germany can be found to have the largest private R&D investments of € 33.7 million in 2013 and the expenditures have increased since 2012. It is followed by the UK, Poland and Sweden, all with less than € 10 million of private R&D expenditures in 2013, though especially the UK and Poland have increased their expenditures. The GDP normalization shows that Poland has the largest share of private R&D investment on GDP (across all countries in our comparison), which has even grown quite significantly between 2012 and 2013. Similar levels are reached by Sweden, although the shares have remained rather constant here between 2012 and 2013. However, it has to be kept in mind that many data points are missing in the table, which might blur the ranking. ■

PRIVATE R&D INVESTMENTS

BIOFUELS

	Private R&D Exp. (in € m)		Share of Private R&D Exp. by GDP	
	2012	2013	2012	2013
EU 28				
Germany	269.8	123.4	0.0100%	0.0046%
Denmark	74.2	74.1	0.0301%	0.0297%
Netherlands	112.9	69.9	0.0178%	0.0110%
France	116.4	56.4	0.0057%	0.0027%
Spain	22.6	44.6	0.0022%	0.0044%
United Kingdom	79.1	35.8	0.0042%	0.0019%
Poland	46.4	35.1	0.0120%	0.0090%
Italy	58.0	32.4	0.0037%	0.0021%
Sweden	41.9	30.0	0.0111%	0.0078%
Finland	59.1	22.5	0.0312%	0.0120%
Austria	7.7	14.7	0.0025%	0.0048%
Belgium	8.3	12.6	0.0022%	0.0034%
Czech Republic	11.3	10.4	0.0072%	0.0066%
Hungary	10.6	10.4	0.0107%	0.0103%
Romania		5.5		0.0041%
Ireland	0.8	2.9	0.0004%	0.0017%
Estonia	4.5	2.8	0.0274%	0.0163%
Luxembourg	0.6	1.8	0.0014%	0.0043%
Slovakia		1.8		0.0026%
Portugal	1.5	1.2	0.0009%	0.0007%
Lithuania	2.3		0.0073%	
Total EU	928.1	588.4	0.0072%	0.0045%

Source: JRC SETIS, Eurostat, WDI Database

Biofuels is the third largest field in terms of private R&D investments. Here, Germany clearly shows the largest investment with nearly € 123 million in 2013. Other countries in this comparison have values below € 100 million. Denmark scores second with €74 million, followed by the Netherlands and France with € 69 million and € 56 million, respectively. All other countries have private R&D investments below € 50 million. In sum it can be found that the private R&D expenditures within biofuels have decreased between 2012 and 2013 by more than 35% for EU as a whole. With regard to the GDP shares, Denmark is leading in 2013, followed by Finland and the Netherlands. ■

PRIVATE R&D INVESTMENTS
OCEAN ENERGY

	Private R&D Exp. (in € m)		Share of Private R&D Exp. by GDP	
	2012	2013	2012	2013
EU 28				
United Kingdom	63.2	45.0	0.0033%	0.0023%
Germany	37.6	38.4	0.0014%	0.0014%
France	20.7	36.0	0.0010%	0.0018%
Sweden	12.3	19.1	0.0033%	0.0050%
Finland	5.3	17.7	0.0028%	0.0094%
Netherlands	7.9	16.5	0.0012%	0.0026%
Spain	8.2	12.2	0.0008%	0.0012%
Italy	9.9	9.7	0.0006%	0.0006%
Ireland	14.1	6.5	0.0082%	0.0037%
Belgium		3.2		0.0008%
Denmark	8.0	2.8	0.0032%	0.0011%
Greece		1.2		0.0006%
Luxembourg	5.3		0.0128%	
Portugal	2.6		0.0016%	
Slovenia	1.3		0.0037%	
Czech Republic	1.3		0.0008%	
Austria	1.1		0.0004%	
Total EU	198.7	208.3	0.0015%	0.0016%

Source: JRC SETIS, Eurostat, WDI Database

Ocean energy is also a comparably small field in terms of private R&D investment. Here, the UK shows the largest values in 2013 followed by Germany and France. Sweden and Finland score at ranks four and five, respectively. However, also in this field many data points are missing. In 2013, the investments for ocean energy have increased for the EU 28 as a whole, although the UK shows declining figures. The growth can mostly be attributed to increasing investments in France as well as in Sweden, Finland and the Netherlands. Sweden and Finland also show the largest GDP shares in comparison, followed by Ireland, the Netherlands and the UK. ■

PRIVATE R&D INVESTMENTS
RENEWABLE ENERGY TECHNOLOGIES IN TOTAL

	Private R&D Exp. (in € m)		Share of Private R&D Exp. by GDP	
	2012	2013	2012	2013
EU 28				
Germany	2348.9	1587.7	0.0874%	0.0588%
France	450.2	425.4	0.0220%	0.0207%
Spain		272.1		0.0267%
United Kingdom	315.7	265.7	0.0166%	0.0137%
Italy	396.5	259.0	0.0253%	0.0168%
Netherlands	252.9	222.8	0.0398%	0.0351%
Total EU	5017.2	3875.4	0.0387%	0.0298%

Source: JRC SETIS, Eurostat, WDI Database ; Note : the sum across technologies is only given, if data of all RET in one country are available, i.e. as soon as one RET is missing, the data are indicated as n.a.

A final look at the private R&D investment in all renewable energy technologies shows a strong position of Germany in 2012 and 2013. Although the German private R&D investments in RET technologies have decreased in 2013, it still is in the top position. Large private R&D investments in RET can also be found in France, which scores second on this indicator. The other countries, for which data is available, i.e. the UK, Spain, Italy and the Netherlands have similar investments in 2013. The GDP shares also display a quite strong position of Germany, although the decreasing trends in absolute investments are also reflected in the share. The Netherland also strike as devoting and important share of private R&D investment in RET. For the public R&D investments, this table has to be interpreted with caution due to many missing values in the data. ■

PUBLIC AND PRIVATE R&D CONCLUSIONS

Due to missing data, especially for China, it is difficult to draw conclusions. China is currently the largest investor in RET installations (wind and solar power), followed by the US. Thus, it is expected to show also significant financial allocations for R&D. Furthermore, China is the main exporter in PV as well as in hydropower. Based on the assumption of strengthening competitiveness through innovation, China is supposed to allocate significant financial resources for R&D to these technologies as well.
Nevertheless, it can be stated that many countries have specialized in certain technology fields within RET technologies. This can be found for public as well as for private R&D investments:

- So far, the EU-28 (2015/16) scores first in public solar energy R&D spending, above the U.S., Japan and Korea, while data for China is not available. Within Europe, especially Germany, France and the Netherlands have the largest public R&D investments. For private R&D investments, only data for the EU-28 countries are available (2012/2013). The solar sector is by far the one which attracts the more private investments in R&D. Here, it can be shown that Germany scores first in terms of national R&D investment, followed by France, Italy and the UK.

- In wind energy, Japan scores first with regard to public R&D spending, followed by the EU-28 (although data for many countries is not available here in 2016). With regard to private R&D spending in the EU, wind power is the second largest sector after solar in 2013. Germany scores first followed by Denmark, which scores second on this indicator.

- In hydro energy, which is a comparably small field with regard to public R&D investment, the U.S. ranks first, which can be explained by its geographical position, i.e. large hydropower resources. It is followed by Canada, Switzerland and Norway. Within the EU-28, France, Denmark and Germany show the largest public investments. As for the private R&D investments, France shows the largest values among the countries in our comparison (EU-28 only). It is followed by Germany and Italy, which both have significant private R&D investments in hydropower.

- With regard to geothermal energy, the U.S. ranks first, although many countries have been found to be active here. When looking at the share of public R&D investments on GDP, especially Switzerland and Denmark stick out. The figures for private R&D expenditures show that Germany seems to have the largest private R&D investments of € 33.7 million in 2013 and the expenditures have increased since 2012. It is followed by the UK, Poland and Sweden.

- Within biofuels, the U.S. clearly shows the largest investment with nearly € 500 million in 2016. The other countries in our comparison have much lower public R&D investments. As for the private investment, Germany scores first with nearly € 123 million in 2016. All other (EU 28) countries in our comparison have values below € 100 million. However, biofuel is the largest field in renewables in terms of public R&D spending and the third in terms of private investments in 2013.

- In ocean energy – also a rather small field in terms of public R&D – the EU 28 sticks out. In 2016, however, the EU 28 expenditures have decreased (based on the available data), so the EU 28 and the U.S. swap ranks. This is also due to increasing public R&D investments of the U.S. Concerning private R&D investments, the UK shows the largest values in 2013 followed by Germany, France, Sweden and Finland.

- Regarding all renewables, Germany, France, the UK and especially the Netherlands and Denmark should be mentioned. These are countries that have significant public R&D investment in nearly all RET fields, as is shown by a share of GDP that surpasses between two or three times that of the first two countries.

- Overall, this analysis shows that private R&D financing by far exceeds public R&D financing, in the monitored years. ■

Patent Filings

The technological performance of countries or innovation systems in general is commonly measured by patent filings as well as patent grants, which can be viewed as the major output indicators for R&D processes. Countries with a high output of patents are assumed to have a strong technological competitiveness, which might be translated into an overall macroeconomic competitiveness. Patents can be analyzed from different angles and with different aims, and the methods and definitions applied for these analyses do differ. Here, we focus on a domestic, macro-economic perspective by providing information on the technological capabilities of economies within renewable energies technologies. The number of patent applications - domestic or international -, the patent specialization as well as patent per GDP are depicted by RE technologies for 2012 and 2013.

Methodological approach

The patent data for this report were provided by JRC SETIS. The data originate from the EPO Worldwide Patent Statistical Database (PATSTAT)[1]. A full dataset for a given year is completed with a 3.5 year delay. Thus, data used for the assessment of indicators have a 4 year delay. Estimates with a 2 year lag are provided at EU level only. The data specifically address advances in the area of low carbon energy and climate mitigation technologies (Y-code of the Cooperative Patent Classification (CPC)[2]). Datasets are processed by JRC SETIS to eliminate errors and inconsistencies. Patent statistics are based on the priority date, simple patent families[3] and fractional counts of submissions made both to national and international authorities to avoid multiple counting of patents. Within the count of patent families, filings at single offices, also known as "singletons" are included. This implies that the results regarding the global technological competitiveness could be biased towards countries with large domestic markets and specialties in their patent systems, e.g. Japan and Korea. Thus, these results might wrongly signal a strong international competitiveness.

1. *EPO. Worldwide Patent Statistical Database (PATSTAT), European Patent Office. Available from: https://www.epo.org/searching-for-patents/business/patstat.html#tab1*
2. *EPO and USPTO. Cooperative Patent Classification (CPC), European Patent Office & United States Trademark and Patent Office. Available from http://www.cooperativepatentclassification.org/index.html*
3. *Patents allow companies to protect their research and innovations efforts. Patents covering the domestic market only (single patent families), provide only a protection at the domestic level, while patents filed at the WIPO or the EPO provide a protection outside the domestic market (i.e. they are forwarded to other national offices), and hence signal an international competitiveness of the company.*

For the analyses of patents in different renewable energy technologies, not only the number of filings but also a specialization indicator is provided. For this purpose, the Revealed Patent Advantage (RPA) is estimated, which builds on the works by Balassa (Balassa 1965), who has created this indicator to analyse international trade. Here the RPA indicates in which RET fields a country is strongly or weakly represented compared to the total patent applications in the field of energy technologies. Thus, the RPA for country i in field RET measures the share of RET patents of country i in all energy technologies compared to the RET world share of patents in all energy technologies. If a country i's share is larger than the world share, country i is said to be specialised in renewable energies within its energy field. The data were transformed, so values between 0 and 1 imply a below average interest or focus on this renewable technology, while values above 1 indicate a positive specialization, i.e. a strong focus on this RET compared to all energy technologies. It should be noted that the specialization indicator refers to energy technologies, and not to all technologies. This makes the indicator more sensitive to small changes in RET patent filings, i.e. it displays more ups and downs, and depicts small numbers in renewable patents as large specialisation effects if the patent portfolio in energy technologies is small, i.e. the country is small. To account for this size effect of the country or economy and to make patent data more comparable between countries, patent filings per GDP (in trillion €) are depicted as well[4].
Figures in 2012 differ from the previous version due to an update of the patent database.

4. *The methodology is described in more detail in the JRC Science for Policy Report "Monitoring R&D in Low Carbon Energy Technologies: Methodology for the R&D indicators in the State of the Energy Union Report, - 2016 Edition" A. Fiorini, A. Georgakaki, F. Pasimeni, E. Tzimas, "Monitoring R&D in Low-Carbon Energy Technologies", EUR 28446 EN (2017). Available from: https://setis.ec.europa.eu/related-jrc-activities/jrc-setis-reports/monitoring-ri-low-carbon-energy-technologies*

WIND ENERGY

	Number of patent families		Patent specialization		Patents per trillion GDP	
	2012	2013	2012	2013	2012	2013
EU 28						
Germany	333	264	2.2	2.0	123.9	97.8
Denmark	94	95	12.6	12.4	379.8	383.1
Spain	67	52	7.8	6.1	64.9	51.2
United Kingdom	28	27	1.4	1.3	14.8	14.2
Netherlands	29	23	2.6	2.2	44.9	36.4
France	35	22	0.7	0.5	17.3	10.8
Italy	23	21	1.6	2.0	14.5	13.8
Sweden	16	21	1.8	2.1	42.6	54.9
Poland	10	11	1.3	1.9	25.5	28.4
Austria	7	6	0.9	1.0	21.6	20.4
Romania	2	5	1.8	4.7	18.1	35.0
Belgium	6	5	1.3	1.3	16.3	12.5
Ireland	3	3	2.4	2.9	16.4	14.2
Finland	10	2	1.5	0.4	51.5	12.9
Luxembourg	6	2	4.9	2.3	140.1	49.0
Latvia	2	2	8.7	2.9	101.6	84.3
Slovakia	0	1		2.8		17.0
Hungary	1	1	2.8	2.5	11.6	9.9
Greece	0	0		0.9		1.1
Portugal	3	0	4.3		14.7	
Czech Republic	2	0	0.9		9.5	
Bulgaria	1	0	4.9		25.7	
Cyprus	0	0				
Estonia	0	0				
Croatia	0	0				
Lithuania	0	0				
Malta	0	0				
Slovenia	0	0				
Total EU	676	564	2.2	2.0	52.1	43.4
Other Countries						
China	574	671	0.8	0.9	86.2	92.7
Korea	393	266	1.4	1.3	413.1	270.0
Japan	230	222	0.4	0.5	47.7	57.2
United States	145	219	0.7	1.0	11.5	17.4
Rest of the world	133	107				

Source: JRC SETIS, Eurostat, WDI Database. Note: single patent families (singletons) have been included.

In wind energy the EU 28 as a group has filed nearly as many patents as China. Korea scores third, followed by Japan and the U.S. This strong position of Europe is mostly borne out of the strong position of two European countries, namely Germany and Denmark, which together are responsible for nearly 64% of all European patents within wind energy. Yet, also Spain, the UK, the Netherlands and France have filed a significant number of patents within this field in 2013.

In wind energy, Denmark is leading in patent applications per GDP followed by Korea, Germany and China. Spain is above the EU 28 average but behind China. Thus, its domestic competitiveness seems lower than that of China.

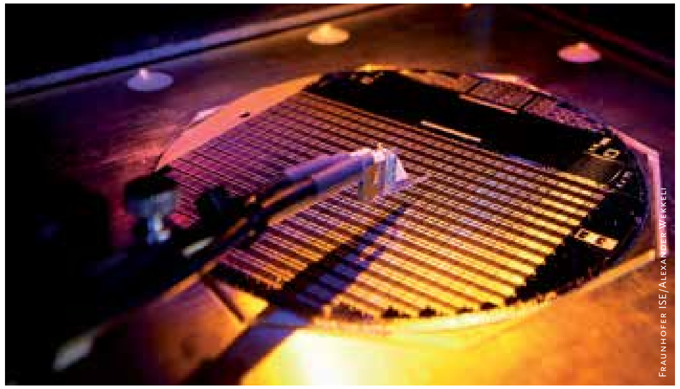
With regard to the patent specialization, especially Spain and Denmark show the largest values, implying that wind energy can be seen as an important factor within their domestic energy technology portfolio. Germany also shows an above average specialization (as is the EU 28 in general), yet it is not as strongly pronounced as in the case of Denmark and Sweden. This is due to the fact that Germany in general files relatively large number of patents in energy technologies so the effect of wind energy patents on its portfolio is not that strong. ■

SOLAR ENERGY

	Number of patent families		Patent specialization		Patents per trillion GDP	
	2012	2013	2012	2013	2012	2013
EU 28						
Germany	448	351	0.8	0.8	166.7	130.1
France	123	128	0.6	0.7	60.2	62.2
United Kingdom	46	51	0.6	0.7	24.3	26.1
Spain	52	48	1.6	1.6	50.0	46.5
Italy	94	47	1.7	1.3	59.7	30.7
Netherlands	32	36	0.8	1.0	50.4	56.4
Belgium	25	19	1.4	1.5	66.2	51.9
Poland	26	17	0.9	0.8	68.2	42.5
Finland	15	14	0.6	0.6	80.4	75.9
Austria	24	12	0.8	0.5	79.3	39.5
Sweden	8	7	0.2	0.2	21.1	17.7
Denmark	6	6	0.2	0.2	23.3	25.4
Romania	16	4	3.2	1.2	122.8	31.2
Ireland	4	4	0.9	1.1	24.6	19.9
Portugal	3	3	1.4	2.2	18.2	17.9
Latvia	1	2	1.2	1.1	50.8	115.7
Czech Republic	4	2	0.5	0.5	22.1	12.7
Greece	2	2	4.5	1.8	11.8	8.1
Slovakia	1	1	1.1	0.7	14.2	13.9
Hungary	1	1	0.7	0.7	11.6	9.9
Luxembourg	4	1	0.9	0.2	101.5	11.8
Croatia	1	0	1.6	0.9	11.4	4.6
Slovenia	3	0	3.4		76.0	
Bulgaria	2	0	2.6		51.3	
Cyprus	1	0	2.0		53.3	
Lithuania	0	0	0.5		8.1	
Malta	0	0				
Estonia	0	0				
Total EU	942	755	0.8	0.8	72.6	58.0
Other Countries						
China	2041	2343	0.8	0.9	306.4	323.7
Japan	2740	2043	1.3	1.2	567.7	526.0
Korea	1249	1075	1.2	1.5	1312.4	1093.3
United States	621	546	0.8	0.7	49.4	43.4
Rest of the world	566	495				

Source: JRC SETIS, Eurostat, WDI Database. Note: single patent families (singletons) have been included.

In the field of solar energy, China has the highest number of patents filed domestically or internationally and ranks third based on patents per GDP. Yet, it is rather closely followed by Japan, where the patenting activity between 2012 and 2013 has decreased (as opposed to China). Korea scores third with regard to patent counting, but first when related to GDP. The EU 28 as a total ranges behind Korea and ahead of the US, although the figures have been decreasing in 2013. Within Europe, Germany has filed the largest number of patents. Within the EU, Germany also ranks first regarding patents per GDP, followed by Latvia and Finland. These differences in patent filings between the countries partly reflect different domestic patenting preconditions or behaviour.



For example, China has a large number of patent filings for the domestic market, while its number of patent applications for the international market is lower. When taking a closer look at the specialization indices of the respective countries, it can be seen that European countries are generally more specialized in solar energy compared to other energy technology fields than the remaining countries in the analysis. The countries with the largest specialization values are Portugal, Greece, Spain and Belgium. However, it has to be kept in mind that these countries have comparably low numbers of filings in general. Thus, a small number of filings in PV and a low number in filings for other energy technologies could lead to a relative high specialisation value. Consequently, minor changes in their patenting activity in a given year can have large influences on the patent specializations. ■

HYDROPOWER

	Number of patent families		Patent specialization		Patents per trillion GDP	
	2012	2013	2012	2013	2012	2013
EU 28						
Germany	21	15	0.8	0.6	7.9	5.7
France	5	13	0.6	1.5	2.6	6.5
Italy	3	9	1.2	4.3	1.9	5.5
Poland	2	6	1.1	5.3	3.9	15.3
Austria	3	4	2.3	3.3	9.8	12.5
United Kingdom	4	3	1.2	0.8	2.3	1.6
Spain	2	3	1.3	1.5	1.9	2.4
Romania	1	2	4.4	12.4	7.8	17.5
Netherlands	1	2	0.3	1.1	0.8	3.4
Slovakia	0	2		24.6		27.9
Finland	0	1		1.0		6.2
Croatia	0	1		85.0		23.0
Belgium	0	1	1.0	1.4		2.7
Denmark	0	1		0.5		2.7
Ireland	0	1		3.0		2.8
Greece	0	0		7.6		1.8
Bulgaria	0	0				
Cyprus	0	0				
Estonia	0	0				
Lithuania	0	0				
Luxembourg	0	0				
Latvia	0	0				
Malta	0	0				
Slovenia	0	0				
Sweden	0	0				
Czech Republic	5	0	16.6		31.1	
Hungary	0	0				
Portugal	1	0	9.8		5.9	
Total EU	48	64	0.9	1.2	3.7	4.9
Other Countries						
China	157	185	1.3	1.3	23.5	25.6
Japan	83	69	0.8	0.8	17.2	17.7
Korea	50	35	1.1	0.9	53.0	35.9
United States	7	10	0.2	0.2	0.5	0.8
Rest of the world	32	24				

Source: JRC SETIS, Eurostat, WDI Database. Note: single patent families (singletons) have been included.

In hydro energy, China displays the largest number of patents, followed by Japan, the EU 28 and Korea. Within Europe, Germany is responsible for nearly 25% of all patent filings within this field. France, Italy, Poland, Austria and the UK also show a certain activity level.
In relation to its economic size, Korea and Slovakia reveal the highest patent filing per GDP, followed by China and Japan. However, as these patents also include single domestic patent applications, an interpretation regarding the international competitiveness is difficult. The US scores surprisingly low. The RPA indicator shows a high specialization for Croatia and Slovakia. However, this is based on very low absolute filing figures. ■

EUROBSERV'ER – THE STATE OF RENEWABLE ENERGIES IN EUROPE – 2017 EDITION

GEOTHERMAL ENERGY

	Number of patent families		Patent specialization		Patents per trillion GDP	
	2012	2013	2012	2013	2012	2013
EU 28						
Germany	11	9	0.8	0.9	4.0	3.4
Poland	2	4	2.4	9.1	3.9	10.5
United Kingdom	1	2	0.8	1.5	0.7	1.2
Sweden	3	2	4.0	2.6	7.9	5.2
Netherlands	0	1	0.4	1.3	0.5	1.7
Spain	0	1	0.0	1.5	0.0	1.0
France	2	1	0.4	0.2	0.8	0.3
Italy	2	0	2.0	0.2	1.5	0.1
Finland	2	0	3.7		10.6	
Austria	1	0	1.6		3.3	
Czech Republic	1	0	7.2		6.3	
Cyprus	0	0				
Estonia	0	0				
Greece	0	0				
Croatia	0	0				
Lithuania	0	0				
Luxembourg	0	0				
Latvia	0	0				
Malta	0	0				
Romania	0	0				
Slovenia	0	0				
Denmark	0	0				
Belgium	0	0				
Slovakia	0	0				
Portugal	0	0				
Ireland	0	0				
Bulgaria	0	0				
Hungary	0	0				
Total EU	25	20	1.0	1.0	1.9	1.6
Other Countries						
Japan	71	57	1.5	1.6	14.8	14.6
China	22	28	0.4	0.5	3.3	3.8
Korea	31	27	1.4	1.7	32.9	27.6
United States	16	12	0.9	0.7	1.2	0.9
Rest of the world	11	11				

Source: JRC SETIS, Eurostat, WDI Database. Note: single patent families (singletons) have been included.

In geothermal energy, the patenting figures are slightly lower than in hydropower. In terms of patent filings, geothermal energy is less significant a field than solar energy. The filing figures are below 100 for each of the countries in our comparison. The EU 28 countries in total filed 20 patents in geothermal energy in 2013, with 9 patents originating from Germany. The other European countries that have actively patented inventions in geothermal energy are Poland, the UK and Sweden. The largest patenting country in geothermal energy worldwide is Japan with 57 patents in 2013, followed by China, Korea and the EU 28. The U.S. has only filed 12 patents within this field in 2013. With respect to patents per GDP, Korea and Japan are leading, i.e. they show the highest level of patent filings. In the EU 28, Poland, Sweden and Germany rank top at a low level in 2013.

As mentioned before, there is a size problem with the specialisation indicator if countries are small. For example, in Poland or Sweden the indicator is high, but it is based on only minor changes in the patenting of renewables. This is because the countries' energy technology portfolio is small, and small changes in renewables patent become a large weight. Overall, Japan and Korea show a relatively high specialization of their domestic markets with a large number of patents, while some EU countries reveal a much stronger specialisation, which is, however, based on a lower number of patents. ■

BIOFUELS

	Number of patent families		Patent specialization		Patents per trillion GDP	
	2012	2013	2012	2013	2012	2013
EU 28						
Germany	70	48	0.6	0.5	25.9	17.8
France	32	22	0.8	0.6	15.8	10.7
Poland	17	18	2.7	4.1	43.2	46.1
Netherlands	24	18	2.8	2.3	37.6	27.7
Spain	9	17	1.4	2.6	8.8	16.4
Denmark	14	16	2.5	2.8	58.4	64.9
United Kingdom	21	12	1.3	0.8	11.0	6.2
Italy	13	10	1.1	1.3	8.1	6.4
Finland	17	9	3.3	2.0	90.0	50.4
Sweden	11	8	1.5	1.1	28.5	21.3
Latvia	0	6	1.8	14.0	16.9	297.5
Belgium	5	5	1.4	1.8	13.4	13.3
Romania	0	4		5.4		30.0
Austria	3	4	0.5	0.9	10.1	13.0
Czech Republic	5	3	3.7	3.2	31.6	18.0
Hungary	2	3	7.3	9.5	23.6	28.1
Ireland	0	2	0.2	2.8	1.0	10.3
Estonia	1	0.75	25.3	12.0	60.5	44.5
Luxembourg	0	1	0.1	0.8	3.0	11.8
Slovakia	0	1		1.6		7.0
Portugal	0	0	0.7	1.2	2.0	2.0
Lithuania	1	0	4.7		16.2	
Total EU	**245**	**207**	**1.0**	**1.0**	**18.9**	**15.9**
Other Countries						
China	754	686	1.4	1.2	113.2	94.8
United States	241	229	1.5	1.3	19.2	18.2
Japan	207	174	0.5	0.5	42.8	44.9
Korea	134	113	0.6	0.7	140.6	115.2
Rest of the world	116	115				

Source: JRC SETIS, Eurostat, WDI Database. Note: single patent families (singletons) have been included.

In biofuels, it is again China that has filed the largest number of patents in 2013. With 686 patent families, China clearly has a dominant position in this respect. Following China the U.S. scores second with 229 patent families. The EU 28 is ranked third with 207 simple patent families in 2013. Biofuels thus is the only technology field where the U.S., in relation to its size, has a significant number of patent filings. Within Europe, the picture is a little more balanced than in the other technology fields, with most of the countries being active in patenting. Germany scores first within the intra-EU comparison, followed by France, Poland and the Netherlands. Korea and China display a strong position in biofuels patent filings per GDP. With regard to the specialization (RPA). Latvia, Estonia and Hungary have the largest value. Yet, this only relates to a very low number of filings in 2013. Still, many European countries show positive (above 1) values here, while the non-European countries are less specialized within this technology field. ■

OCEAN ENERGY

	Number of patent families		Patent specialization		Patents per trillion GDP	
	2012	2013	2012	2013	2012	2013
EU 28						
United Kingdom	26	19	7,6	4,4	13,7	10,0
Germany	16	18	0,6	0,6	6,0	6,5
France	11	16	1,2	1,5	5,2	7,6
Spain	7	9	4,8	4,7	6,7	8,3
Sweden	5	8	3,1	3,8	12,8	21,1
Finland	3	8	2,7	5,6	15,9	39,9
Netherland	4	7	2,1	3,3	6,3	11,6
Italy	4	4	1,5	1,9	2,4	2,7
Portugal	2	3	20,0	36,7	11,8	17,9
Ireland	5	2	24,8	10,7	29,0	11,4
Belgium	0	2	0,0	2,3	0,0	4,9
Denmark	3	1	2,4	0,7	12,1	4,7
Poland	2	1	1,1	0,8	3,9	2,6
Greece	0	1		10,1		2,7
Luxembourg	2	0	10,0		48,7	
Slovenia	1	0	14,1		14,1	
Austria	1	0	0,4		1,6	
Czech republic	1	0	2,6		4,7	
Latvia	0	0				
Malta	0	0				
Romania	0	0				
Bulgaria	0	0				
Cyprus	0	0				
Estonia	0	0				
Croatia	0	0				
Lithuania	0	0				
Hungary	0	0				
Slovakia	0	0				
Total EU	90	97	1,7	1,7	7,0	7,5
Other Countries						
China	102	166	0,9	1,0	15,4	23,0
Japan	62	51	0,6	0,5	12,8	13,1
Korea	51	49	1,1	1,1	53,7	49,6
United States	26	32	0,8	0,6	2,1	2,5
Rest of the world	36	41				

Source: JRC SETIS, Eurostat, WDI Database. Note: single patent families (singletons) have been included.

Ocean energy is also a comparably small field in terms of the number of patent families, but the general trends are also mirrored by these figures here, i.e. China scores first, followed by Europe, Japan, Korea and the U.S. Similar to R&D spending, the UK is the largest applicant within this technology field within Europe. Germany scores second, France third.
Korea is strong in patent filings per GDP. Due to their small size, Finland, Sweden and Portugal range before Japan while countries with a high number of filings (China, Japan, United Kingdom or Germany) show a lower ranking due to their economic size.
The UK also shows a large specialization within this field but due to the size factor some smaller countries score higher. However, there are many countries in Europe where positive specializations with regard to ocean energy can be found. ■

RENEWABLE ENERGY TECHNOLOGIES IN TOTAL

	Number of patent families		Patents per trillion GDP	
	2012	2013	2012	2013
EU 28				
Germany	899	706	334.3	261.3
France	208	202	102.0	98.1
Spain	138	128	132.4	125.8
Denmark	117	120	473.6	480.7
United Kingdom	127	115	66.9	59.2
Italy	138	91	88.1	59.2
Netherlands	89	87	140.5	137.1
Poland	57	57	148.5	145.4
Sweden	43	46	112.9	120.3
Finland	47	35	248.4	185.3
Belgium	36	32	96.0	85.3
Austria	39	26	125.7	85.5
Romania	19	15	148.7	113.6
Ireland	12	10	71.0	58.7
Latvia	3	10	169.3	497.5
Portugal	9	6	52.6	37.8
Czech Republic	17	5	105.3	30.7
Hungary	5	5	46.7	47.9
Slovakia	1	5	14.2	65.9
Luxembourg	12	3	293.3	72.5
Greece	2	3	11.8	13.8
Croatia	1	1	11.4	27.6
Estonia	1	1	60.5	44.5
Bulgaria	3	0	77.0	0.0
Cyprus	1	0	53.3	0.0
Lithuania	1	0	24.3	0.0
Malta	0	0		0.0
Slovenia	3	0	90.1	0.0
Total EU	**2027**	**1708**	**156.2**	**131.3**
Other Countries				
China	3650	4079	548.0	563.6
Japan	3393	2616	703.0	673.6
Korea	1908	1565	2005.7	1591.7
United States	1055	1047	84.0	83.3
Rest of the world	894	793		

Source: JRC SETIS, Eurostat, WDI Database. Note: single patent families (singletons) have been included.

A final look at the patenting figures in all renewable energytechnologies shows that China has filed the largest number of patents in 2013, followed by Japan, the EU 28, Korea and the U.S.. Within the EU 28, a strong position of Germany can be observed, which has also been found at the input side, i.e. in terms of R&D investments. Comparably large numbers of patents in RET can also be found in France, Spain, Denmark and the UK. In terms of patents per GDP, Korea has the top position, followed by Japan and China. The EU 28 is in the (upper) midfield as well as the U.S. Within Europe, Denmark, Latvia (due to the size factor), Germany and Finland reach the largest number of patents per GDP.■

Stiftung Offshore/Windenergie

CONCLUSIONS

Across nearly all fields in renewable energies technologies, the Asian countries display the highest patenting activities in absolute and relative (GDP) numbers when including patent filings that refer only to the domestic market (singletons). It is mostly China who scores first in the number of patent families within the sample. Europe takes a middle position between the Asian countries and the U.S. Besides the technology field biofuels, the U.S. is not very active in patenting RET technologies relative to other countries. It is the only field where the U.S. can score a rank among the top 3 in terms of patent counts. Within the EU 28, it is mostly Germany that files the largest number of patents. But this is due to its size - in terms of patenting Germany ranks first in Europe.
Germany is also one of the few countries that show a certain activity level across all renewable energy technology fields, while most other countries are specialized in only one or two RET technologies. Denmark and Spain, for example, show remarkable filing figures in wind energy, while the UK is most patent active in ocean energy.

Regarding RE technologies, solar energy has the largest number of patent filings in the EU and worldwide, followed by wind energy. In contrast to the large R&D investments into biofuels, the patent statistics show relatively modest results for biofuels. Regarding ocean energy, in terms of patents and R&D spending it is less significant, despite its resource and technological development potentials. ■


Solarstromforschung

International Trade

The analysis of trade and trade-flows has become an important topic in trade economics because it is understood that an increase in trade generally benefits all trading partners. According to the mainstream in international trade theories, the international trade of goods occurs because of comparative advantages. The different advantages in manufacturing goods between two countries lead to trade. However, empirical data revealed that not only factor endowment but also the technological capabilities of a country affect its export performance. Consequently, firms that develop new products or integrate superior technology, will dominate the export markets of these products. In sum, it can be stated that innovation is positively correlated with export performance. This is why a closer look is taken at the export performance. It is considered as an important output indicator of innovative performance within renewable energies technologies.

Methodological approach

To depict trade, not only the absolute (export) advantage in terms of global export shares is analysed but also net exports, i.e. exports minus imports of a given country. It reveals whether there is a surplus generated by exporting goods and services. Moreover, a closer look is taken at the comparative advantage, which refers to the relative costs of one product in terms of a country vis-à-vis another country. While early economists believed that absolute advantage in a certain product category would be a necessary condition for trade, it has been shown that international trade is mutually beneficial under the weaker condition of comparative advantage (meaning that productivity of one good relative to another differs between countries). The analysis of trade-flows has thus become an important topic in trade economics where the most widely used indicator was the Revealed Comparative Advantage (RCA) developed by (Balassa 1965) because an increase in trade benefits all trading partners under very general conditions. Thus, the RCA is a very valuable indicator to analyse and describe specialisation in certain products or sectors.
The share of a country i's RET exports is compared to the world's (sum of all other countries) RET export share. The RET shares itself show RET exports in relation to all exports. Therefore, the RCA for country i measures the share of e.g. wind power technology exports of country i compared to the world's share of wind power technology exports. If a country i's share is larger than the world share, country i is said to be specialised in this field. Further, the RCA refers to all product groups traded, while the RPA indicator refers to energy technologies.
The analysis looks at renewable energy exports as a whole, but also at the disaggregated RET fields. These fields comprise photovoltaics (PV), wind energy and hydroelectricity and biofuels for the reporting year 2017. The export data were extracted from the UN Comtrade database. The fields were identified based on a selection of Harmonized System Codes (HS 2017).

ALL RES

	Share on global exports in renewable energies technologies		Net exports in € m		Export specialisation (RCA)	
	2015	2016	2015	2016	2015	2016
EU 28						
Germany	8,08%	8,15%	1 764	1801	-2	-12
Denmark	4,54%	4,79%	2 753	2690	97	96
The Netherlands	2,18%	2,34%	29	-309	-29	-25
Spain	2,34%	2,00%	1 314	971	30	4
France	1,52%	1,61%	171	196	-60	-62
Belgium	0,88%	0,87%	179	139	-78	-82
Italy	0,73%	0,79%	-164	-175	-87	-88
UK	0,54%	0,67%	-2 381	-1255	-93	-89
Hungary	0,40%	0,55%	57	127	-41	-23
Czech Republic	0,38%	0,40%	-14	7	-74	-77
Poland	0,64%	0,30%	-519	-149	-56	-90
Sweden	0,22%	0,24%	-292	-184	-88	-88
Portugal	0,09%	0,21%	-43	7	-88	-52
Slovakia	0,15%	0,14%	36	25	-80	-87
Luxemburg	0,05%	0,08%	-7	1	-42	-9
Bulgaria	0,07%	0,06%	9	0	-69	-77
Croatia	0,04%	0,06%	-34	-28	-63	-41
Ireland	0,05%	0,06%	-34	-61	-99	-99
Romania	0,03%	0,05%	-155	-133	-99	-97
Estonia	0,05%	0,05%	19	12	-45	-61
Lithuania	0,06%	0,04%	3	-9	-72	-87
Greece	0,02%	0,04%	-153	-223	-97	-90
Finland	0,04%	0,02%	-125	-162	-98	-100
Latvia	0,02%	0,00%	-20	-6	-78	-88
Cyprus	0,00%	0,00%	-5	-5	-100	-100
Malta	0,00%	0,00%	-11	-9	-100	-100
Austria	0,57%	n.a.	25	n.a.	-43	n.a.
Slovenia	0,10%	n.a.	23	0	-43	n.a.

Continues overleaf

EU-28 total (incl. Intra-EU trade)	23,81%	23,52%	2 427	3267	-31	-36
Other Countries						
China	29,90%	26,80%	9 905	7343	64	56
USA	6,05%	6,86%	-4 589	-6457	-41	-35
Japan	5,53%	5,97%	-2 581	-1270	34	29
Canada	0,57%	0,59%	-1 151	-777	-90	-91
India	0,47%	0,45%	-1 687	-2772	-85	-88
Russia	0,12%	0,18%	-243	-120	-99	-98
Switzerland	0,12%	0,14%	-362	-270	-99	-99
Turkey	0,03%	0,03%	-882	-3394	-100	-100
Norway	0,01%	0,02%	-83	-77	-100	-100
New Zealand	0,01%	0,01%	-25	-26	-100	-100
Albania	0,00%	0,00%	-6	-10	n.a.	-100
Rest of the World	33,39%	35,44%	3 027	3865	10	28

Note: Due to rounding up the numbers, 0 means a limit going towards zero.
Source: EurObserv'ER 2017 based on data from UN - COMTRADE - exchange rate: OECD/MEI

The RCA has to be interpreted in relation to the remaining portfolio of the country and the world share. For example, if countries only have a minimal (below average) share of renewable energies within their total trade portfolio, all values would be negative. In contrast, some countries e.g. Denmark, Japan, China and Spain have in relation to all exported goods an above average share of RET in their export portfolio.

With regard to the export shares in all four selected renewable energy-technologies, China has the largest values, although a decline between 2015 and 2016 can be observed. While the Chinese export shares in total RET exports lay at 29.9% in 2015, this share fell to 26.8% in 2016. After China, large export shares can be found for the EU 28 in total. Among the single countries, Germany, the U.S., Japan, Denmark and the Netherlands have the largest shares after China. Due to the declining shares of China, most of the countries show an increase in their shares between 2015 and 2016. The countries with the smallest shares in comparison are Malta, Cyprus, Latvia, Norway, Finland, Turkey, Greece, Lithuania and Estonia.

The above mentioned trends, however, can be quantified when looking at the net exports, i.e. the exports of an economy minus its imports. This can be interpreted as a trade balance and aims at answering the question whether a country is exporting more than it is importing and vice versa. This indicator reveals that China has a very positive trade balance, which, once again, slightly decreased between 2015 and 2016. It is followed by the EU 28 and the rest of the world, where a growth could be observed. However, not all EU countries have a positive trade balance in RET: Denmark, Germany and Spain, France, Belgium, Hungary, Slovakia, Estonia, the Czech Republic, Portugal and Luxemburg. These countries are exporting more RET goods than they are importing. The countries with the most negative trade balances are the U.S., Turkey, India, Japan and the UK. Although Japan has positive export shares, it still imports more RET related goods than it exports – in monetary terms.

In a final step, the export specialization (RCA) was analyzed. With regard to this indicator, Denmark shows the largest values, i.e. goods related to RET technologies have a large weight in Denmark's export portfolio. Positive specialization values can also be found for China and Japan and Spain, while all other countries show a negative specialization with regard to goods related to RET technologies. ■

WIND ENERGY

	Share on global exports in renewable energies technologies		Net exports in € m		Export specialisation (RCA)	
	2015	2016	2015	2016	2015	2016
EU 28						
Denmark	41,71%	41,91%	2 976	2808	100	100
Germany	30,23%	29,39%	1 755	1782	86	82
Spain	18,54%	15,28%	1 305	1006	98	97
Portugal	0,40%	1,53%	24	97	14	88
The Netherlands	0,92%	1,13%	-4	51	-82	-76
Belgium	0,01%	0,69%	1	26	-100	-88
France	0,04%	0,45%	-66	-54	-100	-96
Estonia	0,44%	0,37%	30	25	93	88
Greece	0,16%	0,35%	-123	-195	-9	55
Ireland	0,12%	0,12%	9	-14	-95	-97
UK	0,12%	0,08%	-299	-301	-100	-100
Poland	0,08%	0,06%	-214	-20	-99	-100
Italy	0,06%	0,04%	-44	-52	-100	-100
Czech Republic	0,01%	0,03%	1	2	-100	-100
Lithuania	0,06%	0,02%	3	-5	-73	-97
Romania	0,00%	0,01%	-9	1	-100	-100
Sweden	0,02%	0,01%	-139	-65	-100	-100
Hungary	0,00%	0,00%	-0	0	-100	-100
Malta	0,00%	0,00%	-0	-1	-100	-100
Finland	0,00%	0,00%	-92	-118	-100	-100
Croatia	0,00%	0,00%	-28	-22	-100	-100
Bulgaria	0,11%	0,00%	6	-1	-36	-100
Cyprus	0,00%	0,00%	-0	0	n.a.	-100
Latvia	0,00%	0,00%	-0	0	n.a.	
Luxemburg	0,00%	0,00%	-0	0	n.a.	
Slovakia	0,00%	0,00%	-0	0	-100	
Austria	0,00%		-51	n.a.	-100	
Slovenia	0,00%		-0	n.a.	-100	
EU-28 total (incl. Intra-EU trade)	93,03%	91,49%	5 040	4951	78	75
Other Countries						
China	3,67%	7,89%	260	529	-87	-53
USA	1,88%	0,22%	-77	-98	-92	-100
Canada	0,10%	0,14%	-381	-86	-100	-99
India	0,06%	0,11%	2	1	-100	-99
New Zealand	0,00%	0,02%	-4	-2	n.a.	-98
Turkey	0,00%	0,02%	-376	-797	-100	-100
Switzerland	0,00%	0,01%	-1	-11	-100	-100
Japan	0,03%	0,00%	-77	-67	-100	-100
Russia	0,00%	0,00%	-78	-16	-100	-100
Norway	0,00%	0,00%	-9	-3	n.a.	-100
Rest of the World	1,23%	0,10%	-1 775	-2423	-100	-100

Continues overleaf

Note: Due to rounding up the numbers, 0 means a limit going towards zero.
Source: EurObserv'ER 2017 based on data from UN - COMTRADE - exchange rate: OECD/MEI

In wind power, it is clearly Denmark that has the largest export shares with 42%. It is followed by Germany, with export shares of 29%. This implies that more than 70% of worldwide exports in wind technologies originate from these two countries. When including Spain with a value of 15% this means that nearly 90% of all exported goods related to wind technologies come from these three EU 28 countries. In total, the EU 28 is responsible for a share of 91.5%. The Chinese export shares in 2016 are comparably small with 7.9%, but there has been a large increase since 2015. China is followed by the U.S. with a value of 0.22%.

This pattern can also be found in the trade balance. Here, the largest values can also be found for Denmark, Germany, Spain and China, although the value for China is comparably smaller than for the other three countries.

With regard to the RCA, it can be observed that Denmark, Spain, Portugal, Estonia and Germany are highly specialized in trade with wind technology related goods. Especially for Portugal we see a rising trend since 2015. China, on the other hand, has a negative export specialization in wind technology related goods; its focus seems to be more clearly on PV technologies. ■

PHOTOVOLTAICS

	Share on global exports in renewable energies technologies		Net exports in € m		Export specialisation (RCA)	
	2015	2016	2015	2016	2015	2016
EU 28						
Germany	5,55%	5,51%	360	273	-37	-47
The Netherlands	1,33%	1,61%	-103	-212	-66	-56
France	0,57%	0,75%	-314	-194	-93	-90
Italy	0,62%	0,71%	-143	-118	-91	-90
UK	0,28%	0,33%	-1 828	-809	-98	-97
Belgium	0,44%	0,31%	-77	-100	-94	-97
Czech Republic	0,33%	0,31%	-52	-51	-80	-85
Poland	0,74%	0,25%	-255	-89	-46	-93
Spain	0,09%	0,13%	-79	-56	-99	-99
Luxemburg	0,06%	0,10%	-4	3	-20	17
Hungary	0,06%	0,08%	-148	-143	-98	-98
Croatia	0,04%	0,07%	1	-2	-52	-25
Sweden	0,07%	0,07%	-38	-39	-99	-99
Slovakia	0,08%	0,06%	-14	-17	-94	-97
Denmark	0,05%	0,06%	-129	-48	-99	-98
Lithuania	0,07%	0,05%	10	-1	-70	-87
Ireland	0,04%	0,04%	-4	-4	-100	-100
Portugal	0,03%	0,03%	-57	-66	-98	-98
Finland	0,05%	0,02%	-33	-41	-97	-99
Romania	0,01%	0,01%	-104	-97	-100	-100
Bulgaria	0,00%	0,01%	-19	-24	-100	-100
Estonia	0,01%	0,00%	-8	-10	-99	-100
Greece	0,01%	0,00%	-9	-10	-100	-100
Cyprus	0,00%	0,00%	-4	-4	-100	-100
Malta	0,00%	0,00%	-10	-8	-100	-100
Austria	0,31%	n.a.	-86	n.a.	-79	n.a.
Latvia	0,02%	n.a.	-6	n.a.	-79	
Slovenia	0,08%	n.a.	4	n.a.	-63	
EU-28 total (incl. Intra-EU trade)	10,94%	10,54%	-3 152	-1867	-80	-83
Other Countries			-			
China	37,39%	33,12%	9 648	6849	75	68
Japan	7,08%	7,77%	-2 135	-816	54	51
USA	4,26%	4,59%	-5 564	-7810	-65	-65
Canada	0,56%	0,57%	-215	-155	-91	-91
India	0,26%	0,25%	-1 721	-2740	-95	-96
Switzerland	0,10%	0,13%	-231	-175	-99	-99
Russia	0,04%	0,04%	-149	-132	-100	-100
Turkey	0,02%	0,02%	-371	-2488	-100	-100
Norway	0,00%	0,01%	-15	-17	-100	-100
New Zealand	0,01%	0,00%	-17	-20	-100	-100
Albania	0,00%	0,00%	-0	0		
Rest of the World	39,34%	42,95%	5 226	6552	26	44

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Note: Due to rounding up the numbers, 0 means a limit going towards zero.
***Source:** EurObserv'ER 2017 based on data from UN - COMTRADE - exchange rate: OECD/MEI*

Export shares in photovoltaics (PV) show that again the top position of China can be confirmed. In 2016, more than 33% of worldwide exports in PV originate from China. Yet, also here a decline since 2015 becomes obvious. The next largest countries in this respect are Japan (7.8%), Germany (5.5%) and the U.S. (4.5%).
In sum, the EU 28 countries reach a share of 10.5%. Since the values of Germany lies at 5.5%, Germany is responsible for half of the worldwide exports of the EU 28 countries.

With regard to net exports in PV, positive values can only be found for China, Germany and Luxemburg. All other countries in this comparison are importing more PV technologies than they export. The most negative trade balance can be found for the U.S., followed by India and Turkey. These countries are thus highly dependent on imports from other countries with regard to PV technologies. These trends are also reflected in the RCA values. China is the country that is most highly specialized in goods related to PV, followed by Japan, Luxemburg, Croatia and Germany, although the specialization values are negative for the latter two countries. ■

HYDROELECTRICITY

	Share on global exports in renewable energies technologies		Net exports in € m		Export specialisation (RCA)	
	2015	2016	2015	2016	2015	2016
EU 28						
Germany	9,31%	10,94%	90	89	12	18
Italy	7,80%	8,99%	85	80	77	78
France	6,63%	6,65%	55	41	65	60
Czech Republic	3,35%	4,62%	42	42	84	89
Spain	4,01%	3,91%	41	34	69	61
UK	1,07%	1,62%	5	9	-76	-50
Romania	0,54%	1,45%	2	10	35	83
Portugal	0,88%	0,63%	9	2	73	47
Belgium	2,32%	0,48%	23	4	-6	-94
Bulgaria	0,40%	0,43%	4	4	72	71
The Netherlands	0,11%	0,42%	1	4	-100	-96
Hungary	0,08%	0,29%	1	3	-97	-70
Slovakia	0,19%	0,29%	3	0	-71	-53
Sweden	0,52%	0,26%	-0	-13	-47	-86
Croatia	0,10%	0,24%	-3	1	23	74
Poland	0,15%	0,14%	2	1	-97	-98
Finland	0,09%	0,05%	0	-3	-88	-97
Denmark	0,03%	0,04%	-4	-1	-100	-99
Lithuania	0,00%	0,02%	-0	0	-100	-97
Ireland	0,00%	0,00%	-1	-1	-100	-100
Luxemburg	0,00%	0,00%	-2	-1	-100	-100
Greece	0,00%	0,00%	-1	0	-100	-100
Estonia	0,00%	0,00%	-0	0	-100	-100
Cyprus	0,00%	0,00%	0	0	-99	-100
Malta	0,00%	0,00%	-0	0	n.a.	n.a.
Latvia	0,00%	0,00%	-4	-5	-100	n.a.
Austria	9,59%	n.a.	103	n.a.	98	n.a.
Slovenia	2,02%	n.a.	23	0	99	n.a.
EU-28 total (incl. Intra-EU trade)	49,20%	41,48%	475	300	39	19
Other Countries						
China	18,55%	29,41%	302	311	43	62
USA	3,49%	5,64%	-4	13	-68	-51
India	3,64%	5,48%	55	54	76	81
Russia	1,26%	4,07%	-53	-13	-18	63
Canada	1,71%	1,76%	-43	-51	-50	-39
Switzerland	2,00%	1,72%	-82	-20	9	-19
Japan	3,02%	1,05%	4	0	-79	-89
Turkey	0,20%	0,73%	-79	-56	-75	-28
Norway	0,40%	0,49%	-35	-16	-65	-22
New Zealand	0,05%	0,07%	-1	-3	-100	-84
Albania	0,00%	0,00%	-6	-8	n.a.	n.a.
Rest of the World	12,56%	8,11%	-697	-383	-70	-83

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Note: Due to rounding up the numbers, 0 means a limit going towards zero.
***Source:** EurObserv'ER 2017 based on data from UN - COMTRADE - exchange rate: OECD/MEI*

In hydropower the picture is more balanced than in the case of PV and wind energy. The largest export shares within the EU 28 can be observed for Germany (10.9%), Italy (9%), France (6.6%), the Czech Republic (4.6%) and Spain (3.9%). In sum, the EU 28 is responsible for nearly 41.5% of worldwide exports within the field. This share has decreased since 2015, which is most probably due to missing values for Austria where nearly 10% of export shares in hydroelectricity could be found in 2015.

As a single country, China shows a dominant position, although it is less pronounced than in PV. In addition, India and to a certain extent also the U.S. show comparably large values with 5.5% and 5.6% shares in global trade, respectively. The largest positive net export values within the EU 28 are displayed for Germany, Italy, the Czech Republic, France and Spain. Yet, the largest value can be found for China. India as well as the U.S. also shows a positive trade balance.

The specialization values in hydroelectricity depict a quite positive picture for Europe, where nine EU 28 members have a positive RCA value. China also shows a positive value, but its specialization in PV is still higher. However, regarding the non European countries it is India that is most specialized. ■

BIOFUELS

	Share on global exports in renewable energies technologies		Net exports in € m		Export specialisation (RCA)	
	2015	2016	2015	2016	2015	2016
EU 28						
The Netherlands	10,99%	9,41%	136	-153	87	81
France	9,80%	8,26%	496	402	82	72
Belgium	5,11%	5,21%	231	209	62	57
Hungary	3,69%	4,72%	204	266	94	96
Germany	3,27%	3,89%	-440	-343	-73	-69
UK	3,03%	3,63%	-260	-153	5	25
Sweden	1,62%	1,74%	-114	-67	55	54
Spain	1,92%	1,00%	48	-13	11	-58
Poland	0,61%	0,97%	-52	-42	-59	-31
Slovakia	0,89%	0,85%	47	43	57	44
Italy	0,88%	0,73%	-61	-85	-82	-90
Czech Republic	0,55%	0,72%	-4	14	-52	-40
Bulgaria	0,46%	0,51%	18	22	78	78
Ireland	0,09%	0,11%	-36	-43	-97	-97
Romania	0,16%	0,10%	-44	-48	-69	-90
Lithuania	0,06%	0,06%	-10	-3	-73	-76
Portugal	0,02%	0,03%	-19	-26	-99	-99
Latvia	0,06%	0,02%	-10	-1	-17	70
Estonia	0,01%	0,02%	-2	-3	-94	-94
Denmark	0,02%	0,01%	-90	-70	-100	-100
Croatia	0,01%	0,01%	-4	-5	-98	-99
Greece	0,00%	0,01%	-19	-17	-100	-100
Luxemburg	0,00%	0,00%	-1	-1	-100	-100
Malta	0,00%	0,00%	-0	-1	-100	-100
Cyprus	0,00%	0,00%	-1	-1	n.a.	-100
Finland	0,00%	0,00%	-0	-1	n.a.	n.a.
Austria	1,36%	n.a.	59	n.a.	39	n.a.
Slovenia	0,01%	n.a.	-4	n.a.	-100	n.a.
EU-28 total (incl. Intra-EU trade)	**44,65%**	**42,00%**	**65**	**-118**	**30**	**20**
Other Countries			-			
USA	25,76%	31,05%	1 056	1439	77	82
India	1,77%	1,41%	-23	-87	7	-23
Canada	0,97%	1,00%	-513	-485	-75	-75
Russia	0,59%	0,69%	37	41	-86	-78
China	0,31%	0,37%	-306	-346	-100	-100
Switzerland	0,04%	0,04%	-49	-63	-100	-100
Japan	0,02%	0,02%	-373	-387	-100	-100
Turkey	0,01%	0,01%	-56	-53	-100	-100
New Zealand	0,00%	0,00%	-3	-2	-100	-100
Albania	0,00%	0,00%	-0	-2	n.a.	-99
Norway	0,00%	0,00%	-24	-41	-100	-100
Rest of the World	25,90%	23,42%	273	119	-15	-13

Note: Due to rounding up the numbers, 0 means a limit going towards zero.
Source: EurObserv'ER 2017 based on data from UN - COMTRADE - exchange rate: OECD/MEI

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In biofuels, a different picture emerges. Here, the EU 28 followed by the U.S. scores the top position. In 2016, more than 73% of worldwide exports in biofuels originate from these two regions. Yet, also here a decline since 2015 becomes obvious for the EU. The next largest countries in this respect are the Netherlands, France and Belgium. Regarding net exports in biofuels, the large positive value for the U.S.imply that the U.S. is exporting far more biofuel related technologies than they import. The next largest trade balance can be found for France, Hungary and Belgium, while the most negative trade balance can be found for Canada, Japan, China and Germany. These countries are thus highly dependent on imports from other countries with regard to biofuels. These trends are also reflected in the RCA values. Hungary is the country that is most highly specialized in goods related to biofuels, followed by the USA, the Netherlands, Bulgaria and France. ■

CONCLUSIONS

The analyses of export data in RET technologies have shown that China indeed has achieved quite strong a position in the last years and is continuing with its growth. The Chinese strength in RET exports mostly originates from a strong position in photovoltaics, although the shares in this field have slightly decreased between 2015 and 2016. As the PV technology is rather easy to assemble (compared to wind turbines) China has started building up PV cell and module manufacturing from scratch and employed most up-to-date automatization technologies making Chinas production very competitive. This is different for wind technologies. Nevertheless, the Chinese shares in wind and hydro power have slightly increased. Only in biofuels, China's trade position is far behind the EU.

This picture changes when looking at the other RET subfields, i.e. wind energy and hydroelectricity. In wind energy, especially Denmark, Germany and Spain can be seen as strong competitive countries, dominating the worldwide export markets. These three countries in sum generate a worldwide export share of nearly 90%, while China only plays a minor role. However, not only with respect to patenting activities but also with respect to trade shares China is catching up, while the EU as a whole is slightly loosing shares in wind power in 2016 compared to 2015.

In hydroelectricity, the picture is very balanced. Here, several European countries are active on worldwide export markets, while also China is responsible for comparably large shares. At a low level and pace, China is catching up in patent applications – at least in the domestic market – as well as in exports and might become a more competitive player in the future. In contrast, the EU is slightly loosing shares.

Overall, the EU displays a strong competitiveness in all RET fields, but is loosing trade shares and competitiveness in all RET fields, while China is gaining. The US is only strong in biofuels, and is enforcing its position there, while in other RET its contribution is far below that of the EU. ■

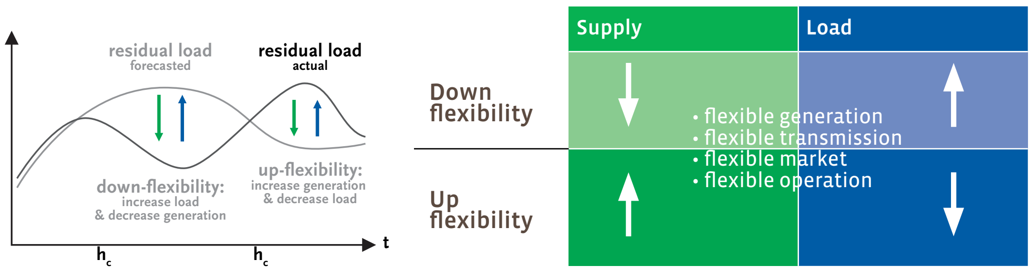
Hapag-Lloyd

INDICATORS ON THE FLEXIBILITY OF THE ELECTRICITY SYSTEM

Balancing of electricity supply and load is nothing new as conventional resources may fail unexpectedly and demand cannot be perfectly forecasted. However, increasing volatile renewable energy shares e.g. wind and solar power make successful balancing more difficult. For example, a decrease in load while at the same time wind power increases requires a large reduction of conventional generation, which is particularly challenging if the residual demand is low and conventional must-run capacity is high. Or a simultaneous increase in demand and decrease in wind power leads to a steep positive ramp. On the other hand, an increase in wind or solar power during peak times might reduce conventionally generated power. The mechanisms work as follows: based on forecasts of load and variable renewable energy (vRE) generation from wind power and PV plants, the remaining generation capacity is scheduled at the day-ahead market. However sudden changes in the supply-demand-balance, be it an unexpected decline or increase in vRE generation, or changes in load, challenge a system's flexibility. To adjust the system to

1

Flexibility needs of the power system



Note: residual load is the difference between load and vRE electricity generation. ***Source: EurObserv'ER 2017***

changes in vRE supply and demand, different mechanisms are applicable. A mismatch could indeed be adjusted by increasing demand or decreasing generation (down-flexibility), or vice versa, by decreasing demand and increasing generation (up-flexibility). Also, unexpected changes within one country could be compensated by cross-border transfers, short-term market or demand side adjustments. Thus, not only the supply side but also the demand side, the transmission infrastructure between countries and the markets provide flexibility in the power system. All these options become increasingly important for successfully integrating RE in the power system. To depict how flexible a system is, a set of indicators is applied: the capacity and transmission flexibility, the operational and market flexibility (see Figure 1). Based on these mechanisms, flexibility indicators are derived and explained in the following.

Methodological note

In a first step, situations are identified in which high flexibility in the system is required. These situations are called critical hours (hc) and are defined as hours in which the difference between forecasted and actual load and vRE generation is the largest. Thus, critical hours are those hours in which either forecasted vRE generation is larger and forecasted load is smaller than actual, or forecasted vRE generation is smaller and forecasted load is larger than actual. In the first case (up-flexibility), additional power is needed either through ramping-up, transmission, intraday market adjustments or reserves, or a reduction of load. The second case, called down-flexibility, entails curtailing especially of renewable power. The latter might reduce sustainability and cost efficiency of generation, but it is feasible in most of the situations. In contrast, ramping up within a short time is more critical due to technical requirements. Thus, up-flexibility is of particular interest. In the following, the up-flexibility in the power system is analysed based on generation, transmission and balancing.

To depict the flexibility of a system in critical hours four indicators are employed that cover generation, transmission, market and operation of a system. A detailed description of the methodological approach can be found under: www.eurobserv-er.org

- *Generation flexibility: actual used generation in the critical hours is compared to the available flexible capacity of the respective countries. The available flexible capacity is defined as availability of capacities within 15 min, i.e. all capacities that could be made available for generation adjustments within 15 min are included (up-flexibility). Thus, it depicts the technically available flexibility of the system to adjust to a situation where generation and demand are in imbalance.*
- *Transmission flexibility: actual exports or imports in the critical hours are compared to the available transmission capacity. Ideally, available transmission capacity is a benchmarked transfer capacity at the borders. But due to data restrictions, the available transmission capacity is defined as the maximum import capacity of a country in the respective year.*
- *Market flexibility: actual intraday trade volumes in the critical hours are compared to the available maximum traded volume in the respective year. The indicator shows how far or close the intraday market in a critical situation is to the maximum traded volume, thus it shows how severe the situation is.*
- *Operational flexibility: actual used secondary and tertiary reserve volumes in the critical hours are compared to the maximum reserve in the respective year. It is employed as a proxy for the available/contracted reserve volume.*

RESULTS AND INTERPRETATION

In the following, the results depicted in this overview illustrate those situations in which up-flexibility is needed, because it is more constraining. Information and results on down-flexibility mechanisms are depicted in the methodological paper (www.eurobserv-er.org)[1].

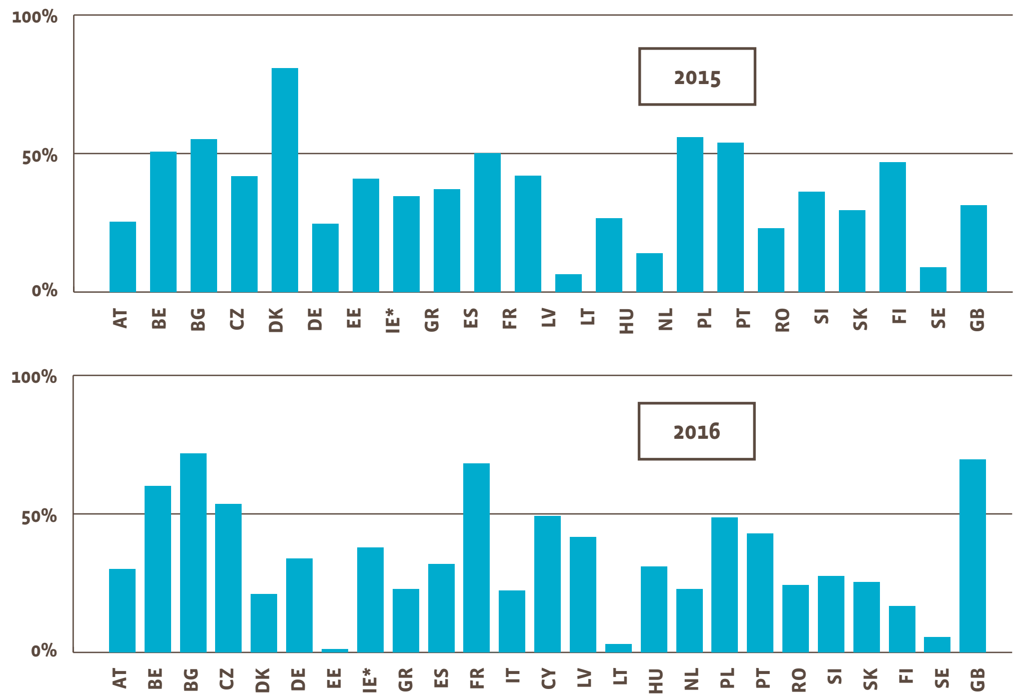
GENERATION FLEXIBILITY

To measure up-flexibility, we calculate the share of the used generation in critical hours to technical available flexible generation. Thus, for every EU member, conventional energy generation technologies are taken into account and the up-flexibility based on the ramp-up time is assessed and compared to the actual running capacities in the critical hours. The results are depicted in Figure 2. The blue bars show the relation of running capa-

1. *Due to restriction in data availability, no critical hours are defined for Malta, Cyprus and Luxemburg, while for the Czech Republic, Italy and Croatia, critical hours are defined on the basis of incomplete data sets and deviations in load. In addition, data on actual generation, transmission, intraday and reserve market are limited from case to case for several EU countries. These limitations are indicated at the respective chapter or figure.*

2

Generation flexibility in critical hours 2015 and 2016



Note: no data for HR, CY, LU, MT. ***Source: own assessment based on ENTSO-E data downloaded 9/2017.***

city to available flexible capacity, i.e. the percentage of used capacity. The closer the bar is to the 100% line (orange line) the smaller the remaining flexibility potential for the system is.

Overall, all EU Member States have sufficient flexibility in their generation. In 2015 Denmark used up to 80% of the available flexible generation while it went down to about 20% in 2016. Great-Britain used about 70% of the available flexible generation in 2016, which was mainly based on gas fuelled generation. Similarly France, Bulgaria and Poland display high shares. In France, the high share of nuclear power does not support the flexibility of the system while in Bulgaria and Poland the use of lignite or coal limits flexibility in power generation. In the lower bound are Estonia, Lithuania and Sweden, which used between 0% to 5% (2016) of their available capacities. This low share is explained by the fact that in Estonia and Lithuania supply relies on gas or oil and both are very flexible but hardly used in critical hours.

TRANSMISSION FLEXIBILITY

To illustrate the flexibility that is available through cross-border exchanges, the import flows in critical hours are compared to the maximum import flows on an hourly basis within the respective year. Figure 3 shows the up-flexibility (imports) needed in critical hours during 2015 and 2016. The closer the bars to the 100% line (orange line), the more available flexibility has been used in the critical hours, i.e. the more severe the situation was.

In 2015 and 2016, the flexibility of the power system with respect to transmission has been underemployed in the EU, except for Great Britain where the import flows reached the maximum value in the critical hour. EU-wide, on average between 40%- 45% of the yearly maximum values were used for up-flexibility in extreme situations. Large countries such as Germany, France and Italy display high cross border flows. However, during their critical hours, their cross border flows were far below the maximum values. Thus, they have still a large potential for up-flexibility. Smaller countries operate at a lower import level but display similar flexibility reserves. Romania and Portugal used almost zero transfer capacities during the analyzed critical hours.

MARKET FLEXIBILITY

Market flexibility is based on the traded intraday volumes as

3

Transmission up-flexibility in critical hours 2015 and 2016

Note: no data for HR,CY, LU, MT. ***Source: own assessment based on ENTSO-E data downloaded 9/2017.***

depicted in Figure 4. The bars show the traded intraday volume in the critical hours compared to the maximum of hourly traded volumes within a year. The closer the blue bar to the orange line (100% line) the more the intraday market served as a mechanism for adjustments. Data is not available for all EU Member states. But for those countries, of which data is available, it becomes clear that in some countries the intraday market seems to play a significant role. For example, in Germany and Spain, the traded volume in critical hours was close to the maximum values (2016) while in other countries such as Latvia, Lithuania, or Poland the intraday market seems to be less needed to compensate unexpected changes in load or generation.

OPERATIONAL FLEXIBILITY

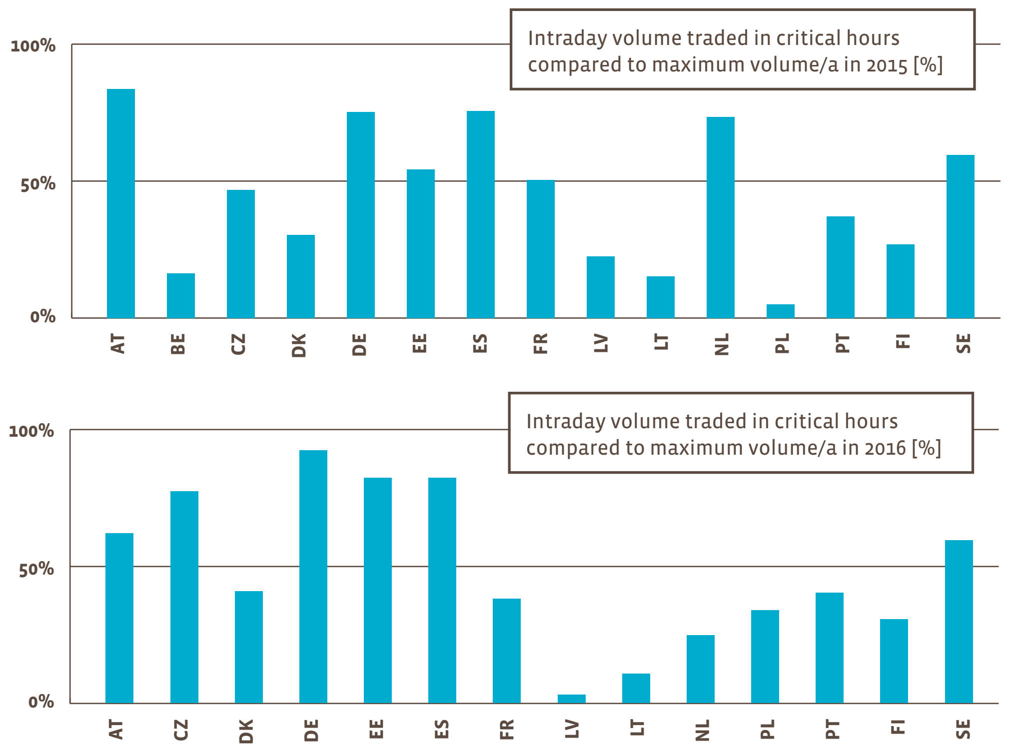
Operational flexibility is represented by the reserve market. Here the activated reserves of power are compared to the yearly maximum in the critical hours per country, which is considered as a proxy for the available volume. The bars in Figure 5 depict the share of actual activated reserves in the critical hours to the available volume. The closer the bars to the orange line (100% line) the more the system relies on the operational flexibility potential in critical situations.

In general, the reserve market provides only a small share of the generation capacity as reserves, because the costs of holding reserve power are mostly higher than the average spot market electricity prices. Thus, there is a strong incentive to keep the use of reserves at minimum.

For 2015, on average almost 30% of the maximum possible reserve power was used during critical hours, but it varies strongly among countries. For example, Germany relied on about 5% (2015) of the operational reserves in the critical hour. But it cannot be concluded

4

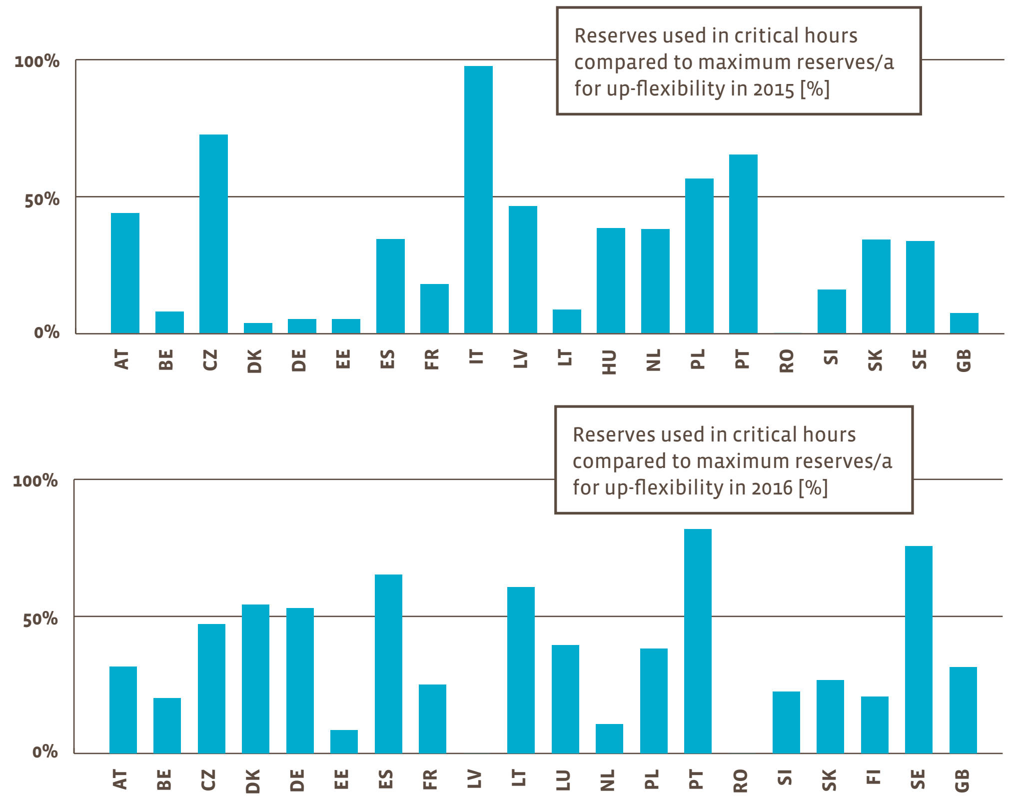
Market flexibility in critical hours in 2015 and 2016



Note: no data for IE, MT, LU, CY, BG, GR, HR, IT, HU, RO, SI, SK, GB; AT and DE have a common market, but different critical hours. In ES and PT maximum values are based on the analysed critical hours. ***Source: own assessment based on data of power exchanges downloaded 11/2017.***

5

Operational flexibility in critical hours 2015 and 2016



Note: no data for BG, GR, IE, HR, MT and CY, no data for IT in 2016. Luxembourg is included in Germany reserves.
Source: own assessment based on ENTSO-E data downloaded 10/2017

that the contracted reserve volume could be cut down, because unexpected outages of conventional generation capacities or network problems (in addition to critical hours defined by this report) are still potential challenges to the power system.

Spain, Sweden and the UK have the highest reserve volumes but at the same time, these countries do not activate even half of their potential in the analyzed critical hour. Italy is close to its maximum annual capacity in its critical hour. Romania is displaying a contrary picture, as the actual used reserve capacity is negative while still having positive potential. One explanation would be that with traded volumes at a kind of intraday market Romania overbalanced the forecast error and therefore has to rebalance with the reserve power.

In 2016, Portugal, Sweden, Spain and Lithuania display high shares. In contrast, Latvia, Estonia and the Netherlands reveal a very low use of their reserve potentials ranging between 0% and 10%. For Romania, the same situation applies as the year before. Even with a demand for up regulation, the actual used reserve power is negative. This analysis is limited to 20 EU Member States due to missing data. ■

Pixabay

CONCLUSIONS

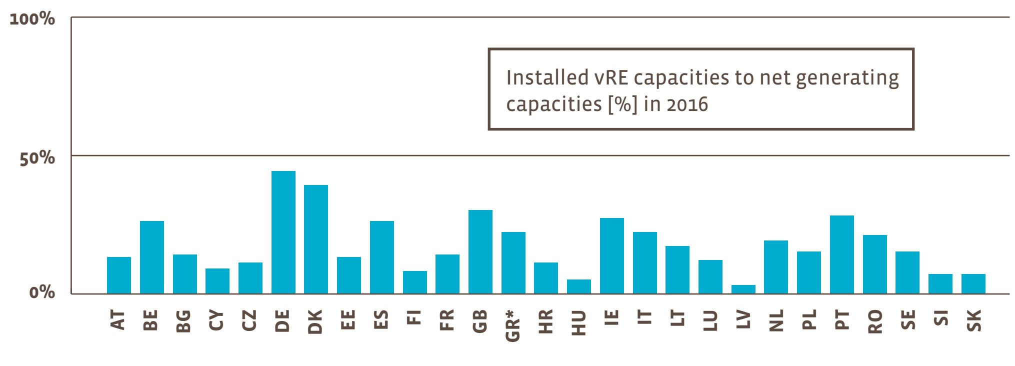
Following the starting point of this chapter, stating that increasing vRE shares of wind and solar power make successful balancing of power supply and load more difficult, countries with a high share of vRE might face higher challenges integrating vRE. Subsequently, the power system of those countries, in which the share of installed vRE capacities to total generation capacities is the highest, are of special interest of this analysis. Germany, Denmark, Great Britain, Portugal display high vRE shares in decreasing order (see Figure 6). In contrast, countries with a low share of vRE such as Latvia and Hungary are supposed to display a small use of flexibility mechanisms.

Regarding the flexibility mechanisms of countries with high vRE shares, Germany but also Spain strongly rely on the intraday market while Great Britain mainly uses transmission and flexible generation capacities in various markets to compensate unexpected changes. Denmark displays a balanced mix of all mechanisms. Countries with lower shares of vRE such as Latvia, Finland or Hungary neither display a homogenous picture: the intraday market represents an important flexibility mechanism for the Czech Republic and Estonia, while Finland relies on transmission; Latvia as well as the Czech Republic use flexible generation capacities for adjustments to changing supply and load.

Overall, in critical hours all countries dispose of sufficient flexibility in the system. Countries with low or high vRE shares do not display a pattern regarding the use of flexibility mechanism, rather the use of mechanisms depends on a combination of various country specific characteristics. For example, France has only

6

Share of volatile renewable energies (installed capacities) in 2016

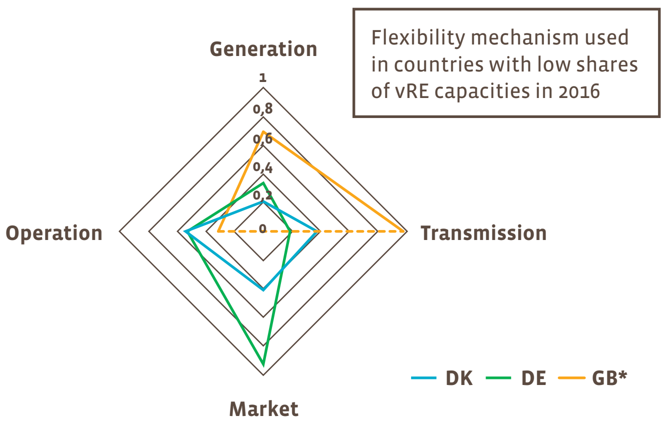


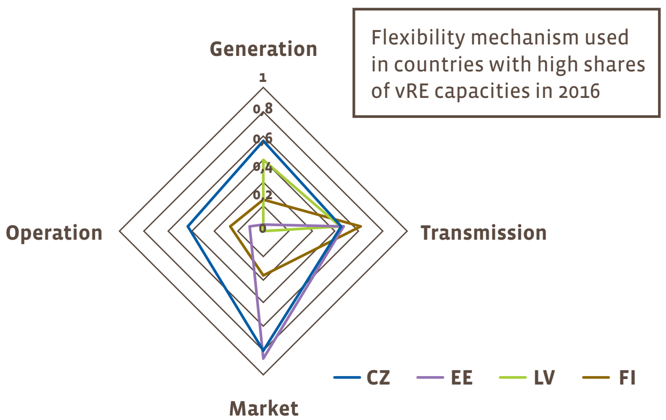
** data from 2015.* ***Source: own assessment based on ENTSO-E data (download 1/2018)***

15% of renewable energies but over 60% of nuclear power; Sweden dispose of a high amount of water reservoirs and therefore of a good source to balance forecast differences; albeit its high share of flexible generation capacities, UK uses mainly the transmission mechanism as prices in France or the Netherlands are lower. ■

7

Pattern of flexibility in critical situations per country





Note: for UK no market data.
Source: own assessment based on ENTSO-E and power stock exchange data (download 2017).

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GREECE

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ITALY

- AIEL – Associazione Italiana Energie Agroforestali *(www.aiel.cia.it)*
- ANEV – Associazione Nazionale Energia del Vento *(www.anev.org)*
- APER – Associazione Produttori Energia da Fonti Rinnovabili *(www.aper.it)*
- Assocostieri – Unione Produttorri Biocarburanti *(www.assocostieribiodiesel.com)*
- Assosolare – Associazione Nazionale dell'Industria Solar Fotovoltaica *(www.assosolare.org)*
- Assotermica *(www.anima.it/ass/assotermica)*
- CDP – Cassa Depositi e Prestiti *(www.cassaddpp.it)*
- COAER ANIMA Associazione Costruttori di Apparecchiature ed Impianti Aeraulici *(www.coaer.it)*
- Consorzio Italiano Biogas – Italian Biogas Association *(www.consorziobiogas.it)*
- Energy & Strategy Group – Dipartimento diIngegneria Gestionale, Politecnico di Milano *(www.energystrategy.it)*
- ENEA – Italian National Agency for New Technologies *(www.enea.it)*
- Fiper – Italian Producer of Renewable Energy Federation *(www.fiper.it)*
- GIFI – Gruppo Imprese Fotovoltaiche Italiane *(www.gifi-fv.it/cms)*
- GSE – Gestore Servizi Energetici *(www.gse.it)*
- ISSI – Instituto Sviluppo Sostenible Italia
- ITABIA – Italian Biomass Association *(www.itabia.it)*
- MSE – Ministry of Economic Development *(www.sviluppoeconomico.gov.it)*
- Ricerca sul Sistema Energetico *(www.rse-web.it)*
- Terna – Electricity Transmission Grid Operator *(www.terna.it)*
- UGI Unione Geotermica Italiana *(www.unionegeotermica.it)*

LATVIA

- CSB –Central Statistical Bureau of Latvia *(www.csb.gov.lv)*
- IPE – Institute of Physical Energetics *(www.innovation.lv/fei)*
- LATbioNRG – Latvian Biomass Association *(www.latbionrg.lv)*
- LBA – Latvijas Biogazes Asociacija *(www.latvijasbiogaze.lv)*
- LIIA – Investment and Development Agency of Latvia *(www.liaa.gov.lv)*
- Ministry of Economics *(www.em.gov.lv)*

LITHUANIA

- EA – State Enterprise Energy Agency *(www.ena.lt/en)*
- LAIEA – Lithuanian Renewable Resources Energy Association *(www.laiea.lt)*
- LBDA – Lietuvos Bioduju Asociacija *(www.lbda.lt/lt/titulinis)*
- LEEA – Lithuanian Electricity Association *(www.leea.lt)*
- LEI – Lithuanian Energy Institute *(www.lei.lt)*
- LHA – Lithuanian Hydropower Association *(www.hidro.lt)*
- Lietssa *(www.lietssa.lt)*
- LITBIOMA – Lithuanian Biomass Energy Association *(www.biokuras.lt)*
- LIGRID AB, Lithuanian electricity transmission system operator *(www.litgrid.eu)*
- LS – Statistics Lithuania *(www.stat.gov.lt)*
- LWEA – Lithuanian Wind Energy Association *(www.lwea.lt/portal)*

LUXEMBOURG

- Biogasvereenegung – Luxembourg Biogas Association *(www.biogasvereenegung.lu)*
- Enovos *(www.enovos.eu)*
- NSI Luxembourg – Service Central de la Statistique et des Études Économiques
- Solarinfo *(www.solarinfo.lu)*
- STATEC – Institut National de la Statistique et des Études Économiques *(www.statec.public.lu)*

MALTA

- WSC - The Energy and Water Agency *(https://energywateragency.gov.mt)*

- MEEREA – Malta Energy Efficiency & Renewable Energies Association *(www.meerea.org)*
- MIEMA – Malta Intelligent Energy Management Agency *(www.miema.org)*
- Ministry for Energy and Health *(energy.gov.mt)*
- MRA – Malta Resources Authority *(www.mra.org.mt)*
- NSO – National Statistics Office *(www.nso.gov.mt)*
- University of Malta – Institute for Sustainable Energy *(www.um.edu.mt/iet)*

NETHERLANDS

- Netherlands Enterprise Agency *(RVO) (www.rvo.nl)*
- CBS – Statistics Netherlands *(www.cbs.nl)*
- CertiQ – Certification of Electricity *(www.certiq.nl)*
- ECN – Energy research Centre of the Netherlands *(www.ecn.nl)*
- Holland Solar – Solar Energy Association *(www.hollandsolar.nl)*
- NWEA – Nederlandse Wind Energie Associatie *(www.nwea.nl)*
- Platform Bio-Energie – Stichting Platform Bio-Energie *(www.platformbioenergie.nl)*
- Stichting Duurzame Energie Koepel *(www.dekoepel.org)*
- Vereniging Afvalbedrijven – Dutch Waste Management Association *(www.verenigingafvalbedrijven.nl)*
- Bosch & Van Rijn *(www.windstats.nl)*
- Stichting Monitoring Zonnestroom *(www.zonnestroomnl.nl)*

POLAND

- CPV – Centre for Photovoltaicsat Warsaw University of Technology *(www.pv.pl)*
- Energy Regulatory Office *(www.ure.gov.pl)*
- Federation of employers renewable energy forum *(www.zpfeo.org.pl)*
- GUS – Central Statistical Office *(www.stat.gov.pl)*
- IEO EC BREC – Institute for Renewable Energy *(www.ieo.pl)*
- National Fund for Environmental Protection and Water Management *(www.nfosigw.gov.pl)*
- SPIUG Polish heating organisation *(www.spiug.pl/)*
- PBA – Polish Biogas Association *(www.pba.org.pl)*
- PGA – Polish Geothermal Association *(www.pga.org.pl)*
- PIGEO – Polish Economic Chamber of Renewable Energy *(www.pigeo.org.pl)*
- POLBIOM – Polish Biomass Association *(www.polbiom.pl)*
- Polska Organizacja Rozwoju Technologii Pomp Ciepła PORT PC *(www.portpc.pl)*
- POPiHN - Polish Oil Industry and Trade Organisation – *(www.popihn.pl/)*
- PSG – Polish Geothermal Society *(www.energia-geotermalna.org.pl)*
- PSEW – Polish Wind Energy Association *(www.psew.pl)*
- TRMEW – Society for the Development of Small Hydropower *(www.trmew.pl)*
- THE - Polish Hydropower Association (PHA) *(www.tew.pl)*

PORTUGAL

- ADENE – Agência para a Energia *(www.adene.pt)*
- APESF – Associação Portuguesa de Empresas de Solar Fotovoltaico *(www.apesf.pt)*
- Apisolar – Associação Portuguesa da Indústria Solar *(www.apisolar.pt)*
- Apren – Associação de energies renováveis *(www.apren.pt)*
- CEBio – Association for the Promotion of Bioenergy *(www.cebio.net)*
- DGEG – Direcção Geral de Energia e Geologia *(www.dgeg.pt)*
- EDP – Microprodução *(www.edp.pt)*
- SPES – Sociedade Portuguesa de Energia Solar *(www.spes.pt)*

ROMANIA

- Association Biofuels Romania *(www.asociatia-biocombustibili.ro)*
- CNR-CME – World Energy Council Romanian National Committee *(www.cnr-cme.ro)*
- ECONET Romania *(www.econet-romania.com/)*
- ENERO – Centre for Promotion of Clean and Efficient Energy *(www.enero.ro)*
- ICEMENERG – Energy Research and Modernising Institute *(www.icemenerg.ro)*
- ICPE – Research Institute for Electrical Engineering *(www.icpe.ro)*
- INS – National Institute of Statistics *(www.insse.ro)*
- Romanian Wind Energy Association *(www.rwea.ro)*
- RPIA -Romanian Photovoltaic Industry Association *(rpia.ro)*
- University of Oradea *(www.uoradea.ro)*
- Transelectrica *(www.transelectrica.ro)*

SPAIN

- AEE – Spanish Wind Energy Association *(www.aeeolica.es)*
- ADABE – Asociación para la Difusión delAprovechamiento de la Biomasa en España *(www.adabe.net)*
- AEBIG – Asociación Española de Biogás *(www.aebig.org)*
- AIGUASOL – Energy consultant *(www.aiguasol.coop)*
- APPA – Asociación de Productores de Energías Renovables *(www.appa.es)*
- ASIF – Asociación de la Industria Fotovoltaica *(www.asif.org)*
- ASIT – Asociación Solar de la Industria Térmica *(www.asit-solar.com)*
- ANPIER – Asociación Nacional de Productores-Inversores de Energías Renovables *(www.anpier.org)*
- AVEBIOM – Asociación Española de Valorización Energética de la Biomasa *(www.avebiom.org/es/)*
- CNMC – Comissiòn Nacional de los Mercados y la Competencia *(www.cnmc.es)*
- FB – Fundación Biodiversidad *(www.fundacion-biodiversidad.es)*
- ICO – Instituto de Crédito Oficial *(www.ico.es)*
- IDAE – Institute for Diversification and Saving of Energy *(www.idae.es)*
- INE – Instituto Nacional de Estadística *(www.ine.es)*
- MITYC – Ministry of Industry, Tourism and Trade *(www.mityc.es)*
- OSE – Observatorio de la Sostenibilidad en España *(www.forumambiental.org)*
- Protermosolar – Asociación Española de la Industria Solar Termoeléctrica *(www.protermosolar.com)*
- Red Eléctrica de Espana *(www.ree.es)*

UNITED KINGDOM

- ADBA – Anaerobic Digestion and Biogas Association – Biogas Group (UK) *(www.adbiogas.co.uk)*
- BHA – British Hydropower Association *(www.british-hydro.org)*
- BSRIA – The Building Services Research and Information Association *(www.bsria.co.uk/)*
- BEIS - Department for Business, Energy & Industrial Strategy *(https://www.gov.uk/government/statistics/energy-trends-section-6-renewables)*
- DUKES – Digest of United Kingdom Energy Statistics *(www.gov.uk/government)*
- GSHPA – UK Ground Source Heat Pump Association *(www.gshp.org.uk)*
- HM Revenue & Customs *(www.hmrc.gov.uk)*
- National Non-Food Crops Centre *(www.nnfcc.co.uk)*
- MCS - Microgeneration Certification Scheme *(www.microgenerationcertification.org)*
- Renewable UK – Wind and Marine Energy Association *(www.renewableuk.com)*
- Renewable Energy Centre *(www.TheRenewableEnergyCentre.co.uk)*
- REA – Renewable Energy Association *(www.r-e-a.net)*
- RFA – Renewable Fuels Agency *(www.data.gov.uk/publisher/renewable-fuels-agency)*
- Ricardo AEA *(www.ricardo-aea.com)*
- Solar Trade Association *(www.solar-trade.org.uk)*
- UKERC – UK Energy Research Centre *(www.ukerc.ac.uk)*

SLOVAKIA

- ECB – Energy Centre Bratislava Slovakia *(www.ecb2.sk)*
- Ministry of Economy of the Slovak Republic *(www.economy.gov.sk)*
- SAPI – Slovakian PV Association *(www.sapi.sk)*
- Slovak Association for Cooling and Air Conditioning Technology *(www.szchkt.org)*
- SK-BIOM – Slovak Biomass Association *(www.4biomass.eu/en/partners/sk-biom)*
- SKREA – Slovak Renewable Energy Agency, n.o. *(www.skrea.sk)*
- SIEA – Slovak Energy and Innovation Agency *(www.siea.sk)*
- Statistical Office of the Slovak Republic *(portal.statistics.sk)*
- The State Material Reserves of Slovak Republic *(www.reserves.gov.sk/en)*
- Thermosolar Ziar ltd *(www.thermosolar.sk)*
- URSO Regulatory Office for Network Industries *(www.urso.gov.sk)*

SLOVENIA

- SURS – Statistical Office of the Republic of Slovenia *(www.stat.si)*
- Eko sklad – Eco-Fund-Slovenian Environmental Public Fund *(www.ekosklad.si)*
- ARSO - Slovenian Environment Agency *(www.arso.gov.si/en/)*
- JSI/EEC - The Jozef Stefan Institute – Energy Efficiency Centre *(www.ijs.si/ijsw)*
- Tehnološka platforma za fotovoltaiko – Photovoltaic Technology Platform *(www.pv-platforma.si)*
- ZDMHE – Slovenian Small Hydropower Association *(www.zdmhe.si)*

SWEDEN

- Avfall Sverige – Swedish Waste Management *(www.avfallsverige.se)*
- ÅSC – Angstrom Solar Center *(www.asc.angstrom.uu.se)*
- Energimyndigheten – Swedish Energy Agency *(www.energimyndigheten.se)*
- SCB – Statistics Sweden *(www.scb.se)*
- SERO – Sveriges Energiföreningars Riks Organisation *(www.sero.se)*
- SPIA – Scandinavian Photovoltaic Industry Association *(www.solcell.nu)*
- Energigas Sverige – *(www.energigas.se)*
- Uppsala University *(www.uu.se/en/)*
- Svensk Solenergi – Swedish Solar Energy Industry Association *(www.svensksolenergi.se)*
- Svensk Vattenkraft – Swedish Hydropower Association – *(www.svenskvattenkraft.se)*
- Svensk Vindenergi – Swedish Wind Energy *(www.svenskvindenergi.org)*
- Swentec – Sveriges Miljöteknikråd *(www.swentec.se)*
- SVEBIO – Svenska Bioenergiföreningen/Swedish Bioenergy Association *(www.svebio.se)*
- SKVP - Svenska Kyl & Värmepumpföreningen *(skvp.se/)* (formely SVEP)

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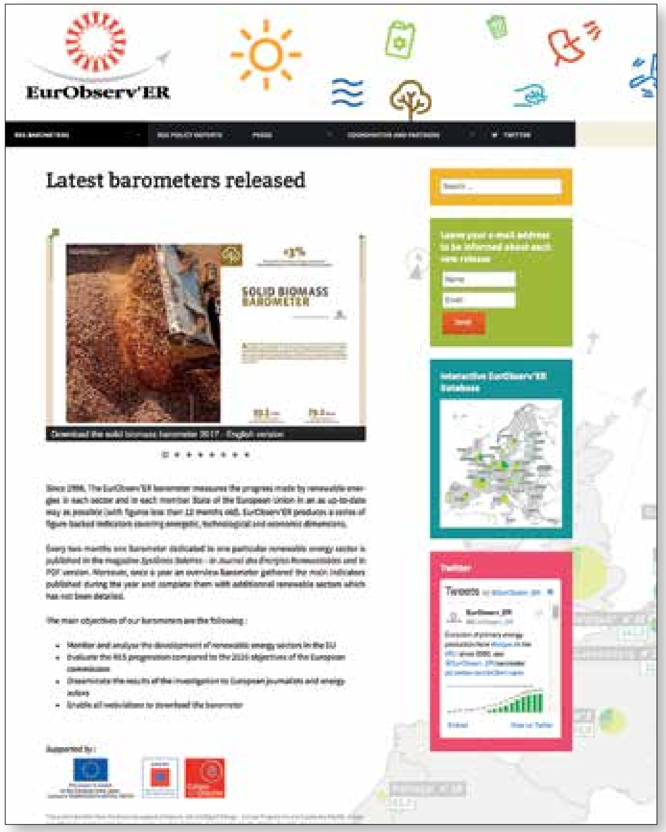

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Photovoltaic	**›› April 2018**
Solar thermal	**›› June 2018**
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Heat Pumps	**›› November 2018**
Solid biomass	**›› December 2018**

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