THE STATE OF RENEWABLE ENERGIES IN EUROPE

EDITION 2016

16th EurObserv'ER Report

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SETTING THE RECORD STRAIGHT

Vincent Jacques le Seigneur, President of Observ'ER

Once the European renewable energy data has been digested, it is clear that a number of preconceived notions are effectively riddled with holes and that the data sets the record straight on wishful thinking about the economics of the various sectors. So looking at the European renewable energy sales figures for 2015, which topped 150 billion euros, wind energy accounted for more than 30% of these figures compared to only 10% produced by photovoltaic. This ranking is almost mirrored by the sectors' job figures, for more than a million people work in renewable energies in Europe. In these times of mass unemployment, that is no mean feat. However half of these workers live in Germany, France and the United Kingdom, namely only three of the twenty-eight Member States that currently form the European Union.

Another home truth worth recalling even if it is not exactly hot off the press is that the renewable energy upswing is more the outcome of bold public policies than fickle weather. If proof of this were needed, we can take a look at the UK which is hardly a sunshine destination. Nevertheless it consolidated its leadership of the annual PV capacity installation stakes in 2015. The opposite applies to small hydropower, where the weather has to take the blame for its dismal results. European output, whose potential is capped by the total take-up of possible hydropower sites, dropped by 10% in 2015 because of the lack of rainfall. The future may be not so rosy for the two main sectors – wind energy and photovoltaic – both for the British who have introduced ceilings to hem in PV power's annual growth rate and for the rest of Europe because of industrial manufacturing overcapacity and the replacement of the Feed-in Tariff system by tendering. Renewables are not only electric, far from it. The figures for 2015 presented in this barometer report a troubling situation for solar thermal that is on a relentless downward spiral abetted by the lack of public authority ambition and the low price of fossil energies. The same applies to biogas, which remains a niche market, and to deep geothermal energy that produces heat and electricity in large installations but cannot compete with crude oil at such low prices. The contrast could not be more flagrant with the air source and ground source heat pump markets, which increased by 20% for sales worth 21.4 billion euros and generated just as many jobs as photovoltaic.

Lastly we should mention biomass, whose importance is too often overlooked. With sales of 36 billion euros in 2015, the sector employs almost as many individuals as the renewable sector with the highest profile, wind energy. Far too often it is forgotten that biomass is not only a source of heat. In 2015 biomass electricity output exceeded 90 TWh, meaning that it can stand its ground with photovoltaic, which generated more than 100 TWh for the first time. What is more, biomass provides a useful complement as its output is not prone to any kind of variability.

The 2016 edition of this report has additional sections broaden understanding of how renewable energies are developing in the European energy, economic and environmental context. The state of renewable energies report has been expanded to include the following new subjects in addition to the traditional sections devoted to energy indicators, socioeconomic aspects and investments made in the European Union's renewable sectors:

- an appraisal of the penetration rates of renewable energy equipment for heating and cooling and urban infrastructures;
- an overview of the main renewable sector costs and their levels of competitiveness in comparison with the fossil fuel sectors;
- an assessment of the impact of the development of renewables on reducing fossil energy consumption within the European Union and the expenses thereby averted;
- a full section on innovation and competitiveness indicators arising from R&D efforts in renewable technologies. This covers public-sector R&D investments, the result in terms of filed patents and a comparison of the significance of the renewable sectors by country for international trade;
- indicators on how flexible European electricity systems are to integrating renewable capacities.

Henceforth EurObserv'ER will cover all these new aspects in the forthcoming editions of its State of Renewable Energies in Europe report.

ENERGY INDICATORS

EurObserv'ER has been gathering data on the European Union's renewable energy sources for seventeen years for its theme-based barometer reports on the state of the sectors and their momentum. The first part of this work is a summary of the barometers published in 2016 for the wind energy, solar photovoltaic, solar thermal, heat pump, biofuel and solid biomass sectors. The data drawn from these barometers has been updated and supplemented by data on the sectors for which no individual barometers were published – small hydropower, biogas, geothermal energy, concentrated solar power, household refuse incineration and renewable marine energy sources.
Hence this publication offers a comprehensive energy dimension review of the twelve renewable sectors that are now developed in the European Union on an industrial scale.
It also gives for the first time a view of the share of RES heating and cooling in the building stock.

Methodological note

The tables reproduce the most recent figures available for each sector. In publishing this edition, the EurObserv'ER data and Eurostat data published early in February 2016 have been fully reconciled. This reconciliation covers most of the energy indicators presented (electrical capacity, output, consumption, etc.). However, the indicators used are solely those of EurObserv'ER whenever there are no parallel indicators published by Eurostat, such as market data for the various categories of heat pump or solar thermal collectors.
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.*
All data sourced Eurostat are derived from www.ec.europa.eu/Eurostat as accessed mit-February 2017.

WIND POWER

The wind energy sector remains on track despite turmoil in Europe's electricity market.

According to Eurostat, 12 382 MW of wind turbine capacity was installed across the EU, which is its highest installation level since 2012. This effort took the sector's total installed capacity to date to 141 482 MW. Much of the credit for this achievement can be taken by Germany, which added net capacity of 5 477 MW, i.e. almost one gigawatt more than in 2014 (4 533 MW). In so doing, Germany consolidated its EU leadership in the wind turbine capacity ratings, with an installed base of 44 670 MW.

The primary reasons for the German growth are that higher yield turbines are being used, lower installation costs and also plummeting interest rates. All these points explaining why despite the lower remuneration for wind power, the German onshore wind energy market remained active. Downgrading of the rates paid for wind power must be viewed in the new context established by the 2014 EEG act, which also made it mandatory to adopt the direct market sales system for any new >500-MW installation from 1 August 2014. In Germany, it is the operator (or aggregator whose profession it is) to sell its electricity output on to the market, receiving an additional "sliding" market premium (Marktprämie). At the end of every month, this premium makes up the difference between the average market electricity price and the reference Feed-in Tariff for onshore wind power. From 2017 onwards, the regulations will change again. The German government plans to modify the renewable energy funding support system, by abandoning the top-up remuneration system under mandatory direct electricity sales and replacing it with a tendering system.

In 2015, Germany made up for the UK's lacklustre performance in new capacity installation. The latter added only 1 254 MW, amounting to a 31.3% fall in its offshore segment business compared to 2014. The administrative

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simplification measures adopted under the energy transition law gave France greater momentum (it added 1 149 MW, a 32.7% rise), while Poland capitalized on its green certificate incentive system (by adding 1 050 MW, a 158% rise) prior to 1 January 2016 and the enactment of its new Contracts for Difference (CfD) scheme. The newly-installed capacity figures for 2015 increased sharply in the Netherlands (526 MW), Italy (454 MW), Finland (378 MW), Denmark (189 MW), Belgium (232 MW) and Lithuania (148 MW).

Momentum in many EU countries in 2015 faltered, primarily in Portugal (which added only 81 MW) and most of Eastern Europe (apart from Poland and Lithuania). Spain's January 2012 moratorium (because of overcapacity of its electricity generating system) continued to block any new capacity installation. The Spanish wind turbine base actually lost a little capacity (32 MW) through the decommissioning of some of its oldest sites. Nonetheless, with 22 943 MW Spain has the second largest installed capacity in the European Union.

OFFSHORE WIND SECTOR KEEPS ON GROWING

In Northern Europe offshore waters, there was a flurry of wind turbine connections in 2015, with more than double the number of grid connections than in the previous year. Three countries increased their offshore capacity, namely Germany, the UK and the Netherlands, which connected a combined total of 3 011.2 MW to the grid, and took the European

1

Installed wind power capacity in the European Union at the end of 2015 (MW)

	2014	2015
Germany	39 193	44 670
Spain	22 975	22 943
United Kingdom	13 037	14 291
France*	9 068	10 217
Italy	8 683	9 137
Sweden	5 097	5 840
Denmark	4 886	5 075
Portugal	4 856	4 937
Poland	3 836	4 886
Netherlands	2 865	3 391
Romania	3 244	3 130
Austria	2 110	2 489
Ireland	2 211	2 440
Belgium	1 944	2 176
Greece	1 978	2 091
Finland	627	1 005
Bulgaria	700	700
Lithuania	288	436
Croatia	339	418
Hungary	329	329
Estonia	275	300
Czech Republic	278	281
Cyprus	147	158
Latvia	69	69
Luxembourg	58	64
Slovenia	4	5
Slovakia	3	4
Malta	0	0
Total EU	129 100	141 482

** Overseas departments not included.* ***Source: EurObserv'ER based on Eurostat data***

Union breezing through the 11 GW threshold at the end of 2015.

Between them, they managed to connect 14 new offshore wind farms to the grid (9 in Germany, 4 in the UK and 1 in the Netherlands), 12 of them are in the North Sea, and one each in the Baltic and Irish Seas.

MORE THAN 300 TWH GENERATED IN 2015

In 2015, many countries in Northern Europe, the UK and Germany enjoyed particularly good wind power-generating climate conditions, which combined with the newly-installed capacity explains the high increase in European Union output. This is contrasted by Southern Europe's poor climate conditions. Output in Spain, Italy and Portugal, for example, declined. All in all, the production trend across the European Union was positive and according Eurostat, increased by 19.3% to reach 301.9 TWh.

AROUND 190 GW CAPACITY IN 2020

The 2020 targets being pursued by the Member States under the Renewable Energy Directive provide for a minimum of opportunities for the wind energy industry. Since 2009, European Union wind energy capacity has increased fairly steadily, rarely dropping below 10 GW per year and has been pitched more often than not around 11–12 GW, at least since 2012. In the medium term, wind energy market expansion should be a little slower as it still rolling out in the very strained context of the electricity market fraught

2

Installed offshore wind power capacities in European Union at the end of 2015 (MW)

	2014	2015
United Kingdom	4 501.3	5 103.5
Germany	994.0	3 284.0
Denmark	1 271.1	1 271.1
Belgium	712.2	712.2
Netherlands	228.0	357.0
Sweden	211.7	201.7
Finland	32.0	32.0
Ireland	25.2	25.2
Spain	5.0	5.0
Portugal	2.0	2.0
Total EU	7 982.5	10 993.7

Source: EurObserv'ER 2016

with increasingly sensitive public reactions to electricity price hikes. No doubt some of the surcharges generated on the bill come from the production subsidies awarded to renewables, but the major operators' financial woes also have a hand in this as they struggle to make a return on their past investments. They have suffered in particular from overcapacity problems which affect the profitability of their production facilities (unamortized fixed costs) and furthermore suffer the significant and continuous decline in electricity's wholesale market price.

Accordingly, they are opposed to rapid new growth of installed renewable energy capacity, and are putting pressure on the decision makers to ensure that new capacity is integrated more gradually. There are several other reasons for the European market's overcapacity crisis. It is also down to the recession, which since 2009 has led to a sustained drop in the industrial demand for electricity. The EU's electricity output has dropped since 2009, from about 3 378 to 3 175 TWh in 2014. The third explanatory factor is better and ongoing interconnection between the European grids. Pooling production infrastructures curbs the need for individual country overcapacity.

Not all of Europe's countries react in the same way to this situation, but the installation level variations witnessed in 2015 compared to those of 2014 and 2013 show that some countries have obviously altered course. As a result, it is likely that the European Union market will slow down a little in the next few years with thresholds

3

Electricity production from wind power in European Union in 2014 and 2015 (TWh)

	2014	2015
Germany	57.357	79.206
Spain	52.013	49.325
United Kingdom	31.966	40.310
France*	17.249	21.249
Sweden	11.234	16.268
Italy	15.178	14.844
Denmark	13.079	14.133
Portugal	12.111	11.608
Poland	7.676	10.858
Netherlands	5.797	7.550
Romania	6.201	7.063
Ireland	5.140	6.573
Belgium	4.615	5.574
Austria	3.846	4.840
Greece	3.689	4.621
Finland	1.107	2.327
Bulgaria	1.331	1.452
Lithuania	0.639	0.810
Croatia	0.730	0.796
Estonia	0.604	0.715
Hungary	0.657	0.693
Czech Republic	0.477	0.573
Cyprus	0.182	0.221
Latvia	0.141	0.147
Luxembourg	0.080	0.102
Slovakia	0.006	0.006
Slovenia	0.004	0.006
Malta	0.000	0.000
Total EU	**253.109**	**301.870**

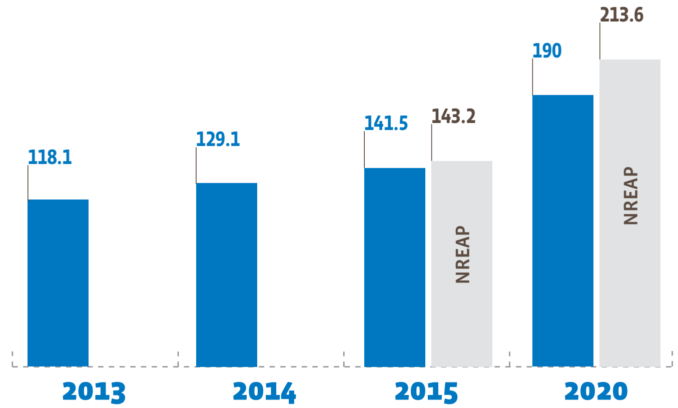
** Overseas departments not included.* ***Source: EurObserv'ER based on Eurostat data***

closer to 10 GW, or even less, which EurObserv'ER feels would at best result in European wind energy capacity in 2020 being at around 190 GW.

Looking at the longer term, current changes to the production system can only increase and wind energy will certainly have a major role to play. The framework has already been set for 2030, as in October 2014, the European Union heads of state and Parliament agreed that the renewable energy share of final consumption would increase to 27%, which in the European Commission's reference scenario could take the form of a 46% share of renewable electricity. ■

4

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



Source: EurObserv'ER 2016

PHOTOVOLTAIC

The European Union market picked up in 2015 putting an end to a three-year slump by increasing its connection rate slightly. However, this will provide only short relief because a new connection decrease is expected in 2016.

According to Eurostat, more than 8 GW (8 042 MW) of net capacity was installed in 2015, which equates to 9.3% growth compared to 2014. However the installation is a far cry from the levels of 21.9 GW and 17.5 GW witnessed in 2011 and 2012 respectively. Notwithstanding, with cumulative capacity standing at 94.9 GW, the European Union's installed base is still more than twice that of China thanks to past investment (43.5 GW at the end of 2015 according to IEA PVPS). However, according to market forecasts, China's capacity should soon overtake that of the European Union. Solar Power Europe claims that China connected 34.2 GW in 2016 (a 115% increase on 2015).

The European market suffers from over-concentration as three countries – the UK, Germany and France – accounted for 79.8% of the connections made in 2015. For the second year running, the UK was the European market leader with 3 763.8 MW... more twice the size of the German market (1 552 MW) and 3 and a half times that of the French market (1 101 MW). Solar PV development was particularly impressive in both the Netherlands (it added 467 MW) and in Denmark (which added 175 MW) given their size. On the downside, growth was lower if not negative in the other countries that have included solar PV in their electricity mix... Austria added 152 MW in 2015 (159 MW in 2014) and Belgium, added 95 MW (105 MW in 2014), while the most spectacular decreases came from Romania (which added 33 MW in 2015 compared to 532 MW in 2014) and Portugal (which added 32 MW in 2015 compared to 119 MW in 2014).

Logically, electricity generated from PV is the highest performer in terms of output. According to Eurostat, it passed the 100-TWh mark, namely 102.3 TWh in 2015.

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1

Installed solar photovoltaic capacity in the European Union at the end of 2014 and 2015 (MW)

	2014	2015
Germany	38 234	39 786
Italy	18 594	18 892
United Kingdom	5 424	9 187
France*	5 654	6 755
Spain	4 787	4 856
Belgium	3 027	3 122
Greece	2 596	2 604
Czech Republic	2 068	2 075
Netherlands	1 048	1 515
Romania	1 293	1 326
Bulgaria	1 026	1 029
Austria	785	937
Denmark	607	782
Slovakia	533	533
Portugal	415	447
Slovenia	223	238
Hungary	77	168
Luxembourg	110	116
Poland	27	108
Sweden	60	104
Cyprus	64	76
Malta	55	74
Lithuania	69	69
Croatia	33	48
Finland	11	15
Ireland	2	2
Estonia	0	0
Latvia	0	0
Total EU	**86 822**	**94 864**

** Overseas departments not included.* ***Source: EurObserv'ER based on Eurostat data***

It has come a long way from 2008 when sector output was only 7.4 TWh. Today, photovoltaic electricity produced in the European Union equals the national electricity output of the Netherlands.

THE UK PLANS TO RESTRAIN ITS MARKET

The UK was the European Union photovoltaic market leader for the second year running. According to Eurostat, 3 763 MWp of photovoltaic capacity was connected in 2015 (2 551 MWp in 2014), taking the UK's cumulative capacity to 9 187 MWp. The highest increase came in March 2015, before the RO (Renewables Obligation) system closed to high-capacity plants (on 1 April 2015). The sectors' players considered closure of the RO scheme to be harmful because the remaining Contracts for Difference (CfD) system only applies to >5-MWp plants. Consequently, the Feed-in Tariff system is intended to apply to <5-MWp plants for 20 years. However, the paltry FiT rates make the scheme unviable. Furthermore, as previously announced, DECC made drastic cuts to its Feed-in Tariffs from 8 February 2016 onwards. For the residential sector the tariff dropped from 12 p to 4.39 p/kWh (€ 0.058/kWh), while the rate for small-scale commercial projects was cut to 4.59 p from 10.9 p/kWh and the <5-MW ground-mounted power plant FiT tariff was slashed to a token 0.87 p/kWh (€ 0.011/kWh) from 4.44 p.

Under the new mechanism, new PV capacity will also be capped with ceilings of 205 MW per quarter for the residential sector and 70 MW for the commercial sector. The UK government justifies its

1

Electricity production from solar photovoltaic in the European Union countries in 2014 and 2015 (in GWh)

	2014	2015
Germany	36 056	38 726
Italy	22 306	22 942
Spain	8 218	8 266
United Kingdom	4 040	7 561
France*	5 913	7 259
Greece	3 792	3 900
Belgium	2 883	3 065
Czech Republic	2 123	2 264
Romania	1 616	1 982
Bulgaria	1 252	1 383
Netherlands	785	1 122
Austria	785	937
Portugal	627	796
Denmark	596	604
Slovakia	597	506
Slovenia	257	274
Cyprus	84	126
Hungary	56	123
Luxembourg	95	104
Sweden	47	97
Malta	68	93
Lithuania	73	73
Croatia	35	57
Poland	7	57
Finland	8	9
Ireland	1	2
Estonia	0	0
Latvia	0	0
Total EU	**92 320**	**102 328**

** Overseas departments not included.* ***Source: EurObserv'ER based on Eurostat data***

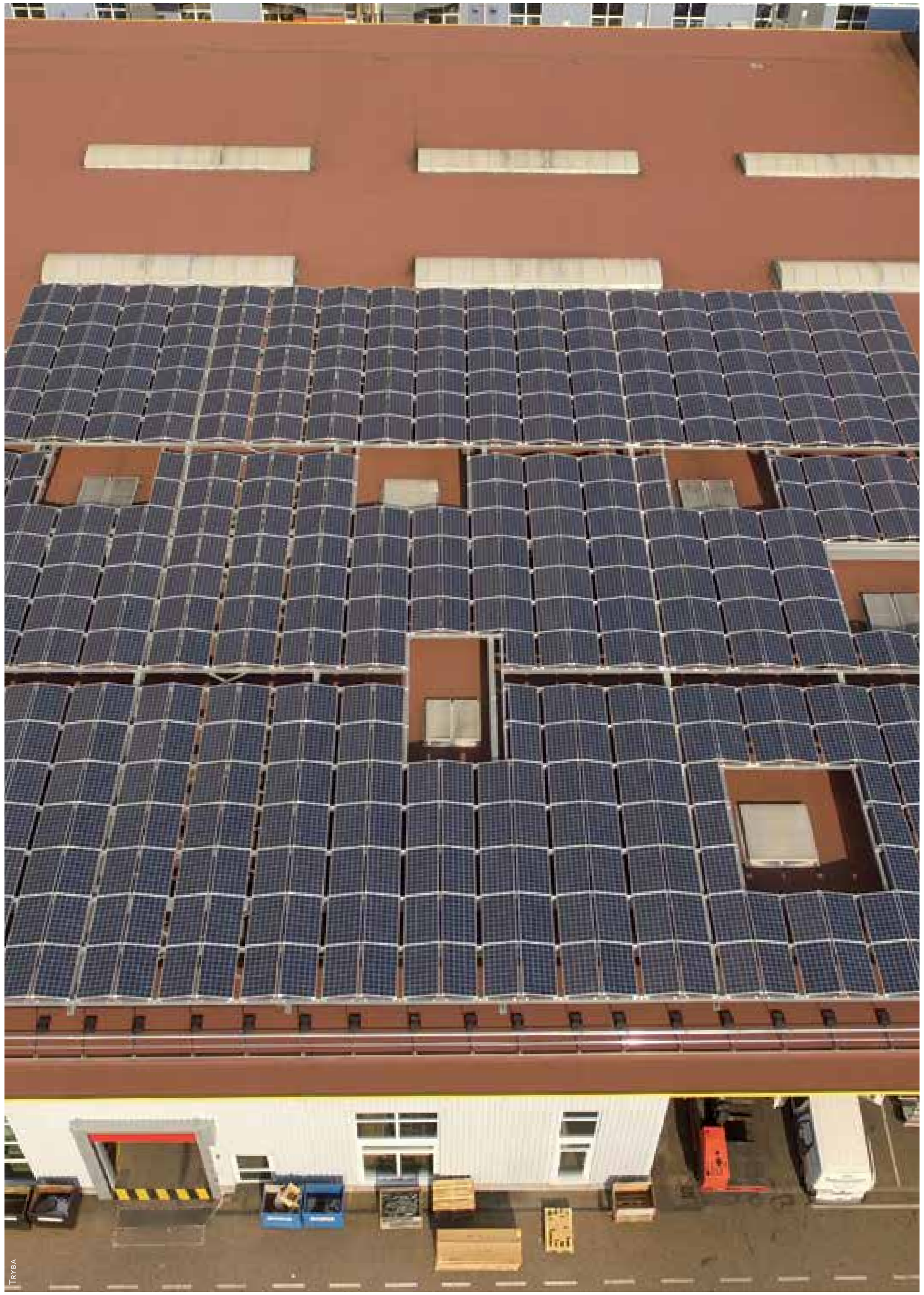
new tariff policy on the basis that renewable energy achievements have greatly outstripped expectations and refuses to allow the cost that it passes on to tax payers via their electricity bill to exceed its set acceptability limits.

THE GERMAN MARKET SLIPS AGAIN

Data released by Eurostat shows that amount of newly installed capacity decreased again. This is the third successive annual drop. Newly connected capacity slipped from 1 899 MWp in 2014 to 1 552 MWp in 2015. Now 39 786 MWp of Germany's installed photovoltaic capacity benefits from production incentives. Accordingly, Germany has once again dipped below its annual target of 2.4–2.6 GW.

Since 1 January 2016, the Feed-in Tariff has only applied to ≤100-kWp capacity systems instead of the previous 500 kWp. German Feed-in Tariffs range from € 0.1231/kWh (<10-kWp roof-mounted systems), to € 0.0853/kWh for ≤100-kWp ground-based power plants. Larger PV systems, i.e. ≥100-kWp capacity systems must sell their electricity on the electricity market (the threshold was 500 kWp in 2015) via the market price plus "premium" system, which is optional for 100-kWp installations. Under this model, the (target) remuneration level is € 0.127/kWh for <10-kWp systems, € 0.1236/kWh for <40-kWp systems, € 0.1109/kWh for<1-MWp systems and € 0.0891/kWh for>1-MWp which applies to <10-MWp systems.

Under the terms of the Renewable Energies Law (EEG 2014), which



came into force on 1 August 2014, the Federal government has amended the renewable electricity support mechanisms to bring the EEG Law in line with the European Commission's guidelines on ≥1-MW capacity installations. The reference value (the Feed-in Tariff or "target value" in the case of direct sales into the market) defined for paying for electricity produced by renewable energy facilities will change to a tender-based system by 2017. The completion times of projects filed before 1 January 2017 should result in a slight increase in the number of connections in 2016 and 2017, yet they will remain below the 2-GW mark.

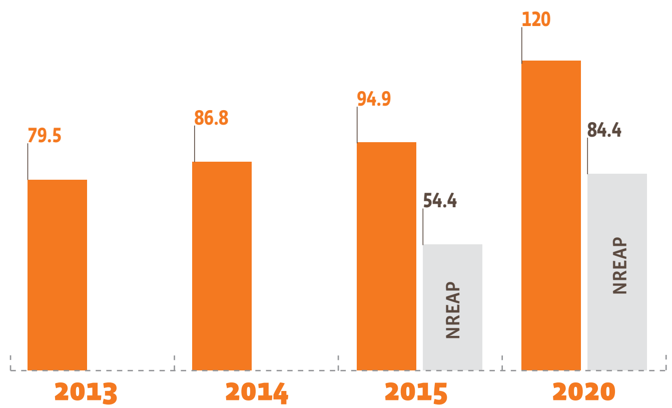
EUROPEAN GROWTH PROSPECTS DASH EXPECTATIONS

While the global market continues on its expansion course, the European Union market is stuck in the downward spiral started in 2012. The British government's decision to slam the brakes on the deployment of solar even though it accounted for almost half of the European Union market in 2015 will put it under downward pressure. The German government also appears to have scaled down its ambitions. The country did not meet the targets it set for 2014 and 2015 under the terms of its Renewable Energies Law, and the situation is unlikely to improve for 2016 and 2017.

The lack of national public policy cohesion on the development of solar power makes projection work very hard. Solar Power Europe presented its growth forecasts for the next five years (up to 2019) in its publication Global Market Outlook 2015-2019 published in June 2015. At the time, the professional body's forecast for the 2015 market level (i.e. the publication year) pitched somewhere between a low scenario of 6 GW and a high scenario of 11 GW (almost double!). Then it predicted a return to growth for the following years, but at a much slower pace – with a market level of 7–17 GW in 2019. So at the end of 2019, the cumulative capacity of Europe's base could be 121–158 GW according to Solar Power Europe. The low scenario is more realistic in the current context. The 2016 installation level could even be at an all-time low, below or close to that of 2008 (5.1 GW according to Eurostat). Taking all these elements into consideration, EurObserv'ER has once again revised its 2020 forecasts downward from 130 to 120 GWp. While the openings for solar power plants solely intended to supply the grid have been restricted, the photovoltaic market should continue to take advantage of its price advantage on the self-consumption market. In Germany, self-consumption carries a large share of the roof-mounted installation market. It also plays a lead role on the Danish and Dutch markets, and similarly on Belgian and Italian markets. But once again, its growth rate is uncertain, because the public authorities have found it very difficult to establish the balance between the interests of the grid users and the prosumers. The absence of Europe-wide regulatory uniformity and common vision on this issue does nothing to promote the deployment of this 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 2016

SOLAR THERMAL

In 2015, the European Union saw its solar thermal market contract for the seventh year in a row. EurObserv'ER puts sales of solar thermal capacity installed for the heating market (hot water and space heating) at 1 861 MWth, equivalent to a 2.7 million m² of collectors … a further 8.6% decrease on the previous year's poor performance. Since 2009, the european solar thermal market shows a 7.6% average annual decrease of its sales.

Total installed area in the EU stood at about 49 million m² (34 332 MWth) – a 4.5% year-on-year increase. This estimate includes the three main solar thermal technologies (flat plate, vacuum and unglazed collectors) and factors in the decommissioning assumptions given by the experts contacted for the purposes of the survey. When no figures are available, EurObserv'ER applies a decommissioning factor of 20 years for flat plate glazed collectors and 12 years for unglazed collectors.

The main European Union markets made few positive signals during 2015. The Polish market bucked the trend by actually registering some growth. It took advantage of its less binding incentive system managed by the National Fund for Environmental Protection and Water Management (NFOSiGW) (see further on). Denmark, whose market is particular in that 95% of the installed collector area supplies heating networks, was also upbeat. Preliminary figures released by Jan Erik Nielsen of the Plan Energi consultancy suggest that at least 175 000 m² of connectors were connected to Denmark's heating networks in 2015, while its individual home market stood at only 10 000 m². Jan-Olof Dalenbäck, a solar heating network specialist of Sweden's University of Technology, says that in 2015, 23 solar heating networks were installed or had additional capacity installed in Europe – 20 in Denmark, one in Italy (Varese Risorse, 990 m²), one in Sweden (Lerum, 850 m²), and one in Austria (Vienna, 1 500 m²). The average size of the new Danish heating networks is much bigger – 10 277 m².

The Greek market, which benefits from tourism investments, is also bearing up well. The market is much less vulnerable to variations because it is dominated by the replacement segment, with relatively high per capita collector areas, and is ranked third in Europe behind Cyprus and Austria.

Apart from these few exceptions, the other key EU solar thermal markets are in the doldrums and contracted by almost 10% in Germany, 11% in Austria and 14% in Italy. The French market (including its overseas territories) is a critical case, as its new capacity collapsed by about 23.3%. The UK market – already on its last legs – slumped by a further 33.5%. Its government could deal the final blow, as in March 2016 it announced a consultation exercise on its plan to exclude solar thermal from the RHI (Renewable Heat Incentive) list of eligible technologies for the residential and collective sectors. Spain's situation gives less cause for concern, although its construction market-driven ST market registered a slight drop (5.5% in 2015).

These poor performance levels can be ascribed to several fac-

tors, some of which are cyclical, such as rock-bottom gas and heating oil prices and sluggish construction activity. The key factor is competition from other technologies, which has increased considerably since new technical solutions emerged in what could be called the high-performance heating category, namely condensing gas- or oil-fired boilers, thermodynamic hot-water heaters and air-to-air heat pumps. Solar thermal is also in a face-off with PV solar systems, whose prices have dropped sharply. Moreover PV is entering the self-consumption segment. While solar thermal solutions are undeniably the most environmentally-friendly in terms of GHG emissions, they are plagued by high investment costs and relatively long ROI periods. Southern Europe, where the winter climate is milder (less prone to frost) operates on another level which means that simpler, less expensive systems, primarily of the thermosiphon type (no controller, probe or need for electricity), can be installed.

1

Annual installed surfaces in 2014 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	814 600	85 400	20 000	920 000	644.0
Greece	270 000	600	0	270 600	189.4
Italy	236 280	32 220	0	268 500	188.0
Poland	208 000	52 000	0	260 000	182.0
Spain	235 355	15 900	3 839	255 094	178.6
France*	189 239	0	6 000	195 239	136.7
Denmark	179 186	0	0	179 186	125.4
Austria	150 530	2 910	1 340	154 780	108.3
Czech Republic	27 095	11 148	35 000	73 243	51.3
Netherlands	27 000	3 000	27 396	57 396	40.2
Belgium	42 500	9 500	0	52 000	36.4
Portugal	50 064	903	0	50 967	35.7
United Kingdom	24 590	5 870	0	30 460	21.3
Ireland	14 691	10 644	0	25 335	17.7
Croatia	18 952	2 575	0	21 527	15.1
Cyprus	18 834	633	0	19 467	13.6
Romania	6 200	12 300	170	18 670	13.1
Hungary	10 580	6 170	1 250	18 000	12.6
Slovakia	5 500	1 000	500	7 000	4.9
Sweden	5 024	1 649	0	6 673	4.7
Bulgaria	5 600	0	0	5 600	3.9
Finland	3 000	1 000	0	4 000	2.8
Slovenia	2 925	700	0	3 625	2.5
Latvia	1 940	420	0	2 360	1.7
Lithuania	800	1 400	0	2 200	1.5
Estonia	1 000	1 000	0	2 000	1.4
Luxembourg	1 985	0	0	1 985	1.4
Malta	1 164	291	0	1 455	1.0
Total EU	**2 552 634**	**259 233**	**95 495**	**2 907 362**	**2 035**

** Including 38 739 m² in overseas departments. **Source: EurObserv'ER 2016***

2

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	733 500	72 500	25 000	831 000	581.7
Poland	230 000	47 000	0	277 000	193.9
Greece	271 000	600	0	271 600	190.1
Spain	226 669	11 121	3 375	241 165	168.8
Italy	203 201	27 387	0	230 588	161.4
Denmark	185 000	0	0	185 000	129.5
France**	143 800	0	6 000	149 800	104.9
Austria	134 260	2 320	890	137 470	96.2
Czech Republic	22 000	9 000	30 000	61 000	42.7
Belgium	39 000	7 500	0	46 500	32.6
Portugal	46 134	0	0	46 134	32.3
Netherlands	17 548	3 971	2 621	24 140	16.9
Ireland	13 297	10 200	0	23 497	16.4
Croatia	18 952	2 575	0	21 527	15.1
United Kingdom	16 935	3 306	0	20 241	14.2
Romania	6 200	12 300	170	18 670	13.1
Cyprus	18 000	600	0	18 600	13.0
Hungary	10 080	5 570	1 250	16 900	11.8
Slovakia	5 500	1 000	500	7 000	4.9
Sweden	5 024	1 649	0	6 673	4.7
Bulgaria	5 600	0	0	5 600	3.9
Finland	3 000	1 000	0	4 000	2.8
Slovenia	2 925	700	0	3 625	2.5
Luxembourg	3 537	0	0	3 537	2.5
Latvia	1 940	420	0	2 360	1.7
Lithuania	800	1 400	0	2 200	1.5
Estonia	1 000	1 000	0	2 000	1.4
Malta	742	186	0	928	0.6
Total EU	**2 365 644**	**223 305**	**69 806**	**2 658 755**	**1 861**

** Estimate. ** Including 39 220 m² in overseas departments. **Source: EurObserv'ER 2016***

3

Cumulated capacity of thermal solar collectors installed in the European Union in 2014 and 2015*** *(in m² and in MWth)*

	2014		2015	
	m²	MWth	m²	MWth
Germany	17 987 000	12 591	18 625 000	13 038
Austria	5 165 107	3 616	5 221 342	3 655
Greece	4 287 775	3 001	4 390 375	3 073
Italy	3 781 739	2 647	4 012 327	2 809
Spain	3 452 473	2 417	3 693 638	2 586
France***	2 820 000	1 974	2 942 000	2 059
Poland	1 741 497	1 219	2 018 497	1 413
Portugal	1 133 965	794	1 180 099	826
Danemark	943 761	661	1 128 761	790
Czech Republic	1 045 542	732	1 106 542	775
United Kingdom	683 101	478	703 342	492
Cyprus	670 624	469	659 224	461
Netherlands	643 832	451	647 397	453
Belgium	585 128	410	630 628	441
Sweden	470 022	329	467 333	327
Ireland	299 141	209	322 638	226
Hungary	213 723	150	230 089	161
Slovenia	215 199	151	218 824	153
Romania	176 055	123	194 725	136
Croatia	167 092	117	188 619	132
Slovakia	164 420	115	171 420	120
Bulgaria	84 200	59	84 800	59
Luxembourg	51 072	36	54 609	38
Finland	50 013	35	53 513	37
Malta	49 976	35	50 904	36
Latvia	19 010	13	21 370	15
Lithuania	13 550	9	15 750	11
Estonia	10 120	7	12 120	8
Total EU	**46 925 137**	**32 848**	**49 045 885**	**34 332**

** All technologies included unglazed collectors. ** Estimate. *** Overseas departments included.* ***Source: EurObserv'ER 2016***

Solar thermal system subsidy reductions caused by recession-inspired budgetary discipline policies are another reason for Europe's shrinking ST market. The new incentive systems also penalize solar thermal. Some countries award incentives to a wide range of technologies (condensing boilers, thermodynamic hot-water heaters, air-source heat pumps, and so on) without necessarily considering energy performance levels and investment costs. In the absence of any obvious differentiation in the aid given, consumers tend to opt for the cheapest systems to purchase. Image and communication are a make-or-break issue for the solar thermal sector, for the ST option simply does not occur to the general public for conventional heating system replacement as there are no sector-specific information campaigns.

2020: NEW PUBLIC COMMITMENT?

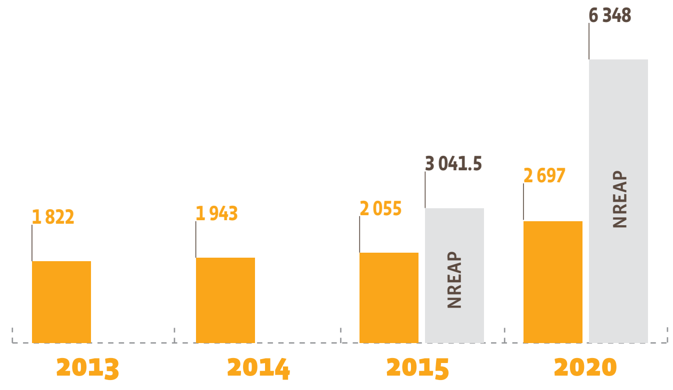
With the passing of every year Europe's solar thermal sector faces a tougher situation and simply cannot stabilize the market. This market downswing observed since 2009 naturally opens up an ever-widening gap with the National Renewable Energy Action Plans (NREAPs). The midway trajectory for the plans was set at 3 Mtoe in 2015, but at the end of the day production finally reached only 2.1 Mtoe. EurObserv'ER believes that the target could be missed by in excess of 50% if nothing is done quickly to reverse the trend.

That is also the conclusion reached by the European Commission in its latest Progress Report on renewable energies published in June 2015 (Cf. p. 10, table 1. Projected Deployment and Deviation from Planned EU Technology Deployment 2014 and 2020). If we take up the Vienna University of Technology (TU Wien) calculation model results, final energy from the solar thermal installations will at most only reach 3.7 million toe (Mtoe) in 2020.

In its report, the Commission identifies the pressing need to implement additional initiatives so that this technology (along with geothermal energy and biogas) can meet the 2020 renewable targets. Many of the solutions for relaunching the sector are in the hands of the public authorities. Estif (the European Solar Thermal Industry Federation) particularly singles out the Member States' lack of enthusiasm to transpose certain key points of the renewable energy directive (2009/28/EC), primarily regarding the "Administrative procedures, regulations and codes" (article 13) and "Information and training" (article 14). Point 6 of article 13, which targets the thermal regulations in construction and point 6 of article 14 which targets informing and promoting the use of renewable energies by the general public are in the firing line. In the sector's current state, market revival can only succeed if national communication campaigns are run to promote solar heating combined with national implementation of much more binding regulatory frameworks on energy efficiency. ■

4

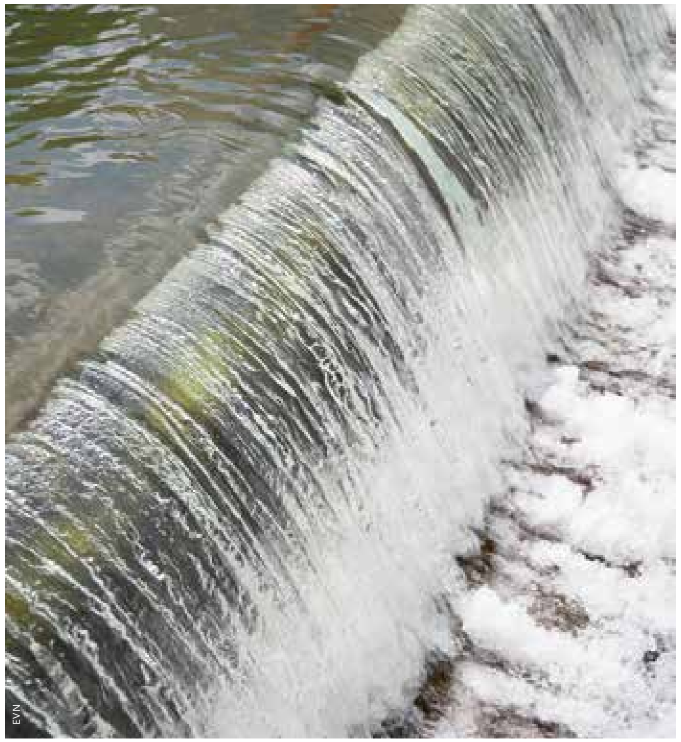
Comparison of the current trend against the NREAP (National Renewable Energy Action Plans) roadmap (in ktoe)



Source: EurObserv'ER 2016

SMALL HYDROPOWER

The European Water Framework Directive and the designation of listed areas with Natura 2000 protection, have put pressure on the development potential of small hydropower, which includes facilities with capacities up to 10 MW, for about a decade. What the European Commission and the public powers need to do is reconcile the renewable electricity production issues with proper stewardship of the water courses. Hydropower installation regulations therefore focus on maximizing energy optimisation combined with maximizing reduction of its impact on biodiversity However, managing this twofold aim is very difficult to put into practice and has prompted many countries to reduce their hydropower production in recent years.


EVN

Small hydropower plants cannot be considered as scaled-down versions of large hydropower plants. They produce electricity by converting the capacity available in water courses, rivers, streams and canals into electrical energy at the lower end of the grid, as plant capacity is proportional to the flow rate and fall height. Not only is small hydropower a renewable energy, but it is an economically competitive one that contributes to grid stability.

The most up-to-date official figures for EU point out that small hydropower sector has reached a 13 994 MW net capacity total at the end of 2015, 244 MW added capacity compared to 2014. This total can be broken down between 3 452 MW for plants under 1 MW capacity and 10 542 for plants between 1 and 10 MW. Small and large hydropower plants reached in the EU a 104 957 installed capacity at the end of 2015 (104 038 TWh in 2014).

The top three countries for net installed capacity are Italy (3 208 MW), France (2 065 MW) and Spain (1 953 MW). Following the upward reclassification of several hydropower plants to the large-scale hydropower class in 2014, Germany dropped to fourth place (1 327 MW).

If we look at the main variations, the countries that contributed the most to the increase in European capacity in 2015 were Italy (adding 122 MW), Germany (adding 44 MW), France (adding 36 MW), the UK (adding 31 MW) and Sweden (adding 28 MW). Austria and Bulgaria suffered the sharpest drop with net capacity falling by 30 MW. Yet it is important to bear in mind that in hydropower, capacity and output are quite distinct notions. A hydropower plant of a particular installed capacity will

1

Small hydraulic capacity (≤10 MW) in running in the European Union countries in 2014 and in 2015 (in MW)

	2014	2015
Italy	3 086	3 208
France	2 029	2 065
Spain	1 948	1 953
Germany	1 283	1 327
Austria	1 310	1 280
Sweden	933	961
Romania	509	518
Portugal	388	394
United Kingdom	319	350
Czech Republic	327	335
Finland	306	306
Bulgaria	331	301
Poland	274	279
Greece	220	223
Slovenia	157	157
Slovakia	72	75
Belgium	66	66
Ireland	41	41
Croatia	30	36
Luxembourg	34	34
Latvia	30	29
Lithuania	27	27
Hungary	16	16
Denmark	9	7
Estonia	5	6
Cyprus	0	0
Malta	0	0
Netherlands	0	0
Total EU	**13 750**	**13 994**

Source: EurObserv'ER based on Eurostat data not produce a single MWh of electricity in low-water periods (when the water course flow is at its minimum). Therefore any prolonged drought-induced low-water period has a major effect on the output level. In 2015, this shortfall was particularly marked in Southern Europe and also in France. Power plant operators are obliged to leave a minimum (instream) flow to guarantee proper water circulation and the reproduction of aquatic species. This has forced them to reduce their recourse to using turbines on stream water. According to Eurostat, European Union small hydropower output totalled 45.2 TWh in 2015, dropping by 6.8 TWh on the previous year's level. Declines were particularly sharp in Italy (3.3 TWh), France (1.1 TWh), Spain 1.1 TWh), Austria (0.8 TWh) and Portugal (0.6 TWh). Trend is similar for large hydropower plants. According to Eurostat, energy produced dropped from 392.9 TWh in 2014 to 295,8 TWh in 2015. The total electricity generated by small and large hydropower plants in the European Union in 2015 reached 341.1 TWh in 2015, a 9% decreased compare to 2014 level (375 TWh).

THE POTENTIAL IS RIPE FOR HARNESSING

Small hydropower is a sector difficult to watch because it can be subject to statistical variations and reclassifications of those plants close to the 10-MW threshold to the large-scale hydropower class. Yet despite the reclassifications of a number of plants, the current trend is not in line with the intermediate capacity targets for 2015 defined in the National Renewable Energy Action Plans. Development

2

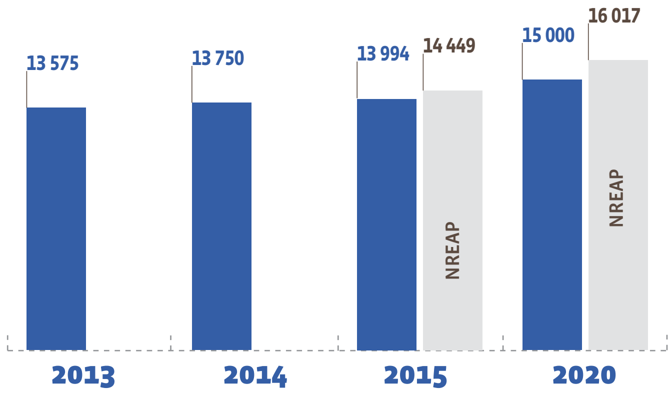
Small hydraulic gross electricity production (≤10 MW) in the European Union (in GWh) in 2014 and 2015

	2014	2015
Italy	14 141	10 864
France	6 807	5 735
Austria	6 226	5 434
Spain	6 081	5 015
Germany	4 821	4 672
Sweden	3 769	4 087
United Kingdom	1 129	1 289
Finland	995	1 288
Romania	1 282	1 261
Bulgaria	1 342	1 062
Czech Republic	1 012	1 002
Poland	887	822
Portugal	1 422	795
Greece	701	707
Slovenia	495	327
Belgium	192	186
Ireland	105	123
Slovakia	149	117
Croatia	131	101
Luxembourg	108	99
Latvia	68	74
Lithuania	71	69
Hungary	81	59
Estonia	27	27
Denmark	16	18
Cyprus	0	0
Malta	0	0
Netherlands	0	0
Total EU	52 058	45 233

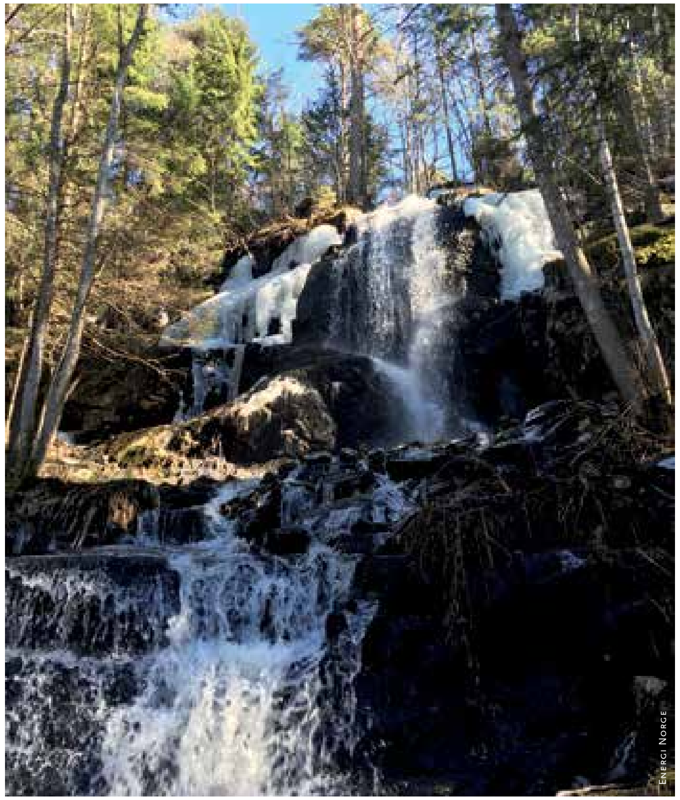
Source: EurObserv'ER based on Eurostat data

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 2016



over the next five years hangs in the balance because it is increasingly running up against Water Quality Framework Directive implementation and lack of political support.

Yet the sector players believe that considerable development potential could still be reaped. A very comprehensive roadmap has been drawn up that factors in the sector's potential as part of the European Stream Map project 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, which is higher than the NREAP forecasts. The most promising countries are Italy, France, Spain, Austria, Portugal, Romania and Greece. However it points out that the sector's growth by this timeline will be heavily dependent on the ability of industry, public authorities and the decision makers to take appropriate steps to deal with current and future challenges. The public authorities should set up financial or administrative arrangements for new incentive mechanisms. The industry must also persevere with investing in technologies that preserve the ecological continuity of watercourses and protect fish populations and should also continue its standardisation efforts across the European Union. Thus much progress remains to be made if the sector is to continue to develop smoothly. ■

GEOTHERMAL ENERGY

This form of energy is hot water or steam drawn from the subsoil. It is used for producing heat, electricity or to deal with cooling needs. Geothermal techniques and uses vary in line with the aquifer temperature (groundwater) from which the water is drawn. When it is in the range 30–150° 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 dwellings. The use of one or more very high capacity heat pumps (HP) may be envisaged to improve the performance of a geothermal heating network. Heat pumps increase the temperature range that can be harnessed by the network and thus make optimum 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 sol, 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, and is found in volcanic regions. 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.

THE PRODUCTION OF ELECTRICITY

According to EurObserv'ER, European Union-wide installed geothermal electrical capacity has risen slightly (by 4 MW) to 993.6 MW. Net capacity, the maximum capacity presumed to be exploitable, is put at 837.1 MW (2 MW more). Gross electricity output production

1

Capacity installed and net capacity usable of geothermal electricity plants in the EU in 2014 and 2015 (in MWe)

	2014		2015	
	Capacity installed	Net capacity	Capacity installed	Net capacity
Italy	915.5	768.0	915.5	768.0
Portugal	29.0	25.0	29.0	25.0
Germany	27.0	24.0	31.0	26.0
France*	17.1	17.1	17.1	17.1
Austria	1.0	1.0	1.0	1.0
Total EU	989.6	835.1	993.6	837.1

** Overseas departments included (15 MW in Guadeloupe).* ***Source: EurObserv'ER 2016***

2

Gross electricity generation from geothermal energy in the European Union countries in 2014 and 2015 (in GWh)

	2014	2015
Italy	5 916.3	6 185.0
Portugal	205.0	204.0
Germany	98.0	134.0
France*	83.0	92.0
Austria	0.4	0.1
Total EU	**6 302.7**	**6 615.1**

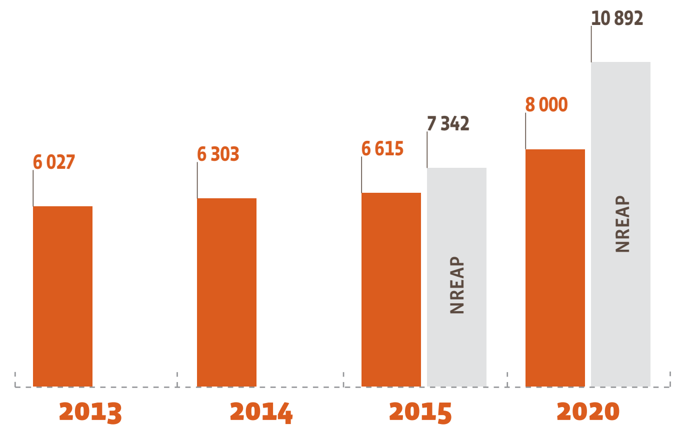
** Overseas departments included.* ***Source: EurObserv'ER 2016***

increased in 2015 to 6 615 GWh, compared to 6 303 GWh in 2014. EurObserv'ER notes that Germany is the only country to have increased its geothermal capacity when the Grünwald/Laufzorn geothermal plant came on stream (adding 4.3 MW). The country's installed geothermal capacity rose to 31 MW at the end of 2015 (net capacity of 26 MW), according to AGEEstat.

Even though its installed capacity figure was stable between 2014 and 2015, Italy remains the clear-cut European geothermal leader with 915.5 MW. According to the country's Ministry of economic Development, its net exploitable capacity also remained stable at 768 MW. This data indicates that the Cornia 2 geothermal plant, commissioned at the very end of 2015, will only be included in the calculations from 2016 onwards.

3

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



Source: EurObserv'ER 2016

SMALLER CAPACITY INCREASES THAN EXPECTED

According to the EGC 2016 report data, the European Union's geothermal capacity is set to rise in the next few years and could be as much as 1 185 MW by 2020. In the interim, new countries in the European Union should be in a position to set up production sectors. Examples are Croatia (26 MW), Greece (23 MW), Hungary (22 MW) and the Czech Republic (10 MW). However, this projection for 2020 is far below the intended NREAP targets of a combined capacity of 1 627.9 MW in 2020. Under the prevailing conditions, output is unlikely to outstrip 8 TWh compared to a planned trajectory of 10.9 TWh in 2020

HEAT PRODUCTION

The main use of geothermal energy thermal applications is for heating dwellings and commercial premises. Other uses are possible, primarily in agriculture (heating greenhouses, drying crops, etc.), fish-farming, industrial processes, thermalism 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.

EurObserv'ER bases its assessment of the thermal capacity of the sector on the data published during the European Geothermal Congress held in Strasbourg in September 2016 "Summary of EGC 2016 Country Update Reports on Geothermal Energy in Europe" in addition to a collection of data from national statistical experts (ministries, statistical offices).

4

Direct uses of geothermal energy in 2014 and 2015 (HP excluded) in the European Union countries (capacity, in MWth)*

	2014	2015
Italy	757.0	841.0
Hungary	863.6	752.4
France	336.9	499.6
Germany	276.0	285.0
Romania	205.1	176.0
Slovakia	147.8	147.8
Netherlands	100.0	115.0
Bulgaria	83.1	105.6
Poland	98.8	105.3
Austria	63.4	76.9
Slovenia	67.1	65.7
Greece	88.0	62.7
Croatia	75.5	62.0
Sweden	48.0	48.0
Denmark	33.0	33.0
Spain	21.0	21.0
Portugal	20.2	20.2
Lithuania	18.0	13.6
Belgium	8.1	7.0
Czech Republic	4.5	6.5
United Kingdom	3.8	2.6
Latvia	1.3	1.3
Total EU	**3 320.2**	**3 448.2**

** The capacity of ground source heat pumps for residential, tertiary or industrial uses is excluded from the figures. However, the total geothermal heat installation capacity of high-capacity pumps is included provided that the heat is distributed via district heating networks.* ***Source: EurObserv'ER 2016***

The capacity of direct uses of geothermal energy for heating purposes in the EU for 2015 is put at 3 448.2 MWth. The reasons for the main difference with the previous year's figure are the commissioning of new capacities supplying heating networks and more accurate figures for thermal capacities for balneology.

The EGEC (European Geothermal Energy Council) annual market report records the capacity of geothermal heat networks in more detail. EGEC's methodology differs slightly from that used by the congress because it factors in the direct uses arising from urban heating networks and includes those supplying greenhouses with heat.

According to the European association, the combined thermal capacity of the 177 geothermal heating networks identified in the European Union was 1 552 MWth at the end of 2015. The main countries operating geothermal heating networks are France (389 MWth), Hungary (271 MWth), Germany (262.6 MWth) and Italy (137.6 MWth). The association also points out that 150 MWth of capacity was commissioned in 2015. France was particularly active as it connected 80 MWth in the Greater Paris region to supply the Arcueil (10 MW, geothermal energy + HP), Bagneux (10 MW), Paris-Batignoles (5 MW) Rosny-sous-Bois (10 MW) heating networks, the extension of the Tremblay network (10 MW), Villejuif (10 MW), Villepinte (10 MW) and Val d'Europe (15 MW) which supplies the two Euro Disney theme parks. In November 2015, Hungary inaugurated the Györ (52 MW) geothermal project that supplies heat to 24 266 dwellings, 1 046 other private consumers in addition to providing 60% of the heating requirements of a car plant. In the Netherlands, the Vierpolders

5

Heat consumption from geothermal energy in the countries of the European Union in 2014 and 2015

	2014			2015		
	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	129.5	111.3	18.2	132.7	114.1	18.6
France	120.1	30.6	89.5	121.3	29.5	91.8
Hungary	86.8	58.9	27.9	95.6	53.3	42.3
Germany	90.6	83.3	7.3	83.4	68.4	15.0
Netherlands	35.9	35.9	0.0	58.5	58.5	0.0
Slovenia	36.0	35.5	0.5	42.3	41.8	0.5
Bulgaria	33.4	33.4	0.0	33.4	33.4	0.0
Romania	25.1	19.9	5.2	25.7	19.7	6.0
Poland	20.2	20.2	0.0	21.7	21.7	0.0
Austria	18.8	6.4	12.4	21.0	7.2	13.8
Spain	18.8	18.8	0.0	18.8	18.8	0.0
Croatia	10.7	10.7	0.0	10.7	10.7	0.0
Greece	11.7	11.7	0.0	9.8	9.8	0.0
Slovakia	4.2	1.3	2.9	4.2	1.3	2.9
Denmark	2.0	0.0	2.0	1.7	0.0	1.7
Cyprus	1.6	1.6	0.0	1.6	1.6	0.0
Belgium	1.4	0.0	1.4	1.5	0.0	1.5
Portugal	1.3	1.3	0.0	1.5	1.5	0.0
Lithuania	0.9	0.0	0.9	0.8	0.0	0.8
United Kingdom	0.8	0.8	0.0	0.8	0.8	0.0
Total EU	**649.8**	**481.6**	**168.2**	**687.0**	**492.1**	**194.9**

Source: EurObserv'ER based on Eurostat data

(17 MWth) heating network went on stream. it supplies heat to several horticultural hot houses growing tomatoes, aubergines and other vegetables. Finally, Enel inaugurated the Cornia 2 cogeneration plant in Castelnuovo Val di Cecina, Central Italy, which is the first to combine biomass energy and geothermal energy. The temperature of the water vapour from the geothermal well is raised from 150-160° C to 370-380° C by burning the biomass. The plant has 5 MW of electrical capacity and supplies about 1 MW of geothermally-sourced heating capacity.

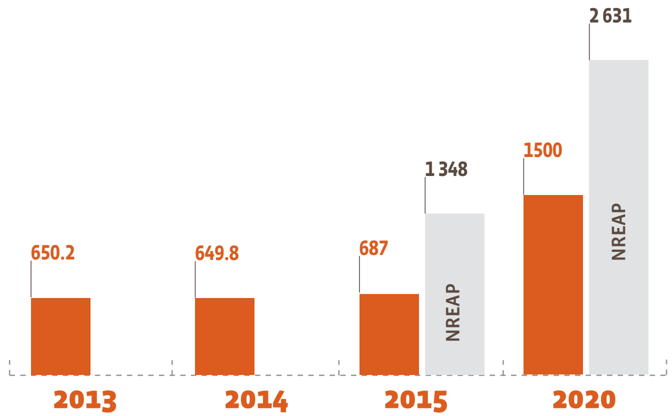
In contrast with the thermal capacity data, the geothermal heat production data is regularly monitored by the national statistics bodies. The official data covers the geothermal heat distributed by the heating networks and the direct heat sold to final users. It attests to 687 ktoe of output in 2015, which is an increase of 5.7% over 2014.

GEOTHERMAL HEAT IS OFF THE TRAJECTORY

There is a growing trend in many European countries to let their NREAP targets slip despite their commitment to developing geothermal heating networks. Geothermal heat output across the European Union only mustered 700 ktoe in 2015. This needs to be compared with the year's intermediate NREAP target of 1 359.5 ktoe 2015. If the current trajectories are to be put back on course, suitable measures and much more commitment on the part of the political decision-makers will be required. ■

6

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



Source: EurObserv'ER 2016

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.


Nibe

AIR-SOURCE TECHNOLOGIES DOMINATE THE MARKET

If we consider the market as a whole, 2015 was a very good year for the heat pump sector. According to EurObserv'ER, an impressive 2 655 331 units were sold taking all technologies into account – which amounts to 20% growth. In 2015, air-to-air HPs led sales in the European market with 2 325 625 units or a 21.6% increase. Lower installation costs and easier installation make them more suitable for the renovation segment and form the basis for this major market share.

Nowadays most of the air-to-air HPs sold in the European market are reversible and cooling needs also have a hand in the strong demand for them. Market sales were boosted by high summer temperatures in Italy, in France, Spain and Portugal. The air-to-air HP market was also very buoyant in parts of Northern Europe, such as Sweden and Denmark by offering products perfectly suited to cold climates. Sales of HPs drawing on exhaust air, whose market is limited to a few countries – essentially Finland, Sweden and Germany – increased by 4.1% with 28 123 units sold.

The HP market for hydronic systems (i.e. GSHP and air-water heat pumps) has also increased sharply. It has taken advantage of the revival of the new build home construction sector in a number of countries, where most of the sales are concentrated and where new energy efficiency promotion policies are in force such as Germany. This market picked up 10% in 2015, with almost 300 000 units sold in Europe. The air-to-water HP market segment has the biggest share with 219 090 units sold in 2015 equating to 14.5% growth. The ground-source HP market at last appears to be stabilizing after several years of declining sales. It fell by only 0.3% in 2015 with 82 493 units sold (a 7.3% fall in 2014 with 82 744 units sold). The air-to-water HP market's increased share of 72.6% in 2015 compared to 69.8% in 2014 marks a strong trend in the market for water-borne systems.

THE EUROPEAN HEAT PUMPS BASE STOOD AT ALMOST 30 MILLION UNITS IN 2015

It is hard to estimate the HP base in service because of the variety of assumptions used and the availability of statistics supplied by the Member States and HP industry associations. The statistics are strongly affected by the practice of a number of Member States of including small reversible single-split[1] HP systems, such as Italy and France. According to EurObserv'ER, the cumulative European Union HP base to date is around 29.5 million units (28.1 ASHPs and 1.4 million GSHPs).

As for renewable energy output, the SHARES tool puts input by HPs at the end of 2015 at 8.6 Mtoe (8 607 ktoe), a 5.3% increase compared to 2014 data (8 175 ktoe).

1. A system is single-split when an outdoor unit pumps heat to a single indoor unit as opposed to a multi-split system whose outdoor unit pumps heat to several indoor units.

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ENCOURAGING POLITICAL SIGNS

In 2015, after several years of relative stagnation, the HP market, and particularly the air-source segment, posted very good performance levels. This performance goes right across the board, for apart from the Finnish market; all the countries where this technology has been developed posted strong growth rates. The lights are set to green for the next few years, with firstly the confirmation of a recovery in the construction market, albeit modest as yet, and the sector's capacity to take market shares in the renovation sector through suitable products. Another encouraging sign is that political and regulatory constraints should finally intensify in the renovation market. On 16 February 2015, the European Commission presented its Strategy for heating and cooling, in the form of a com-

1

Market of aerothermal heat pumps in 2014 and 2015 (number of units sold)*

	2014				2015			
	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	863 000	845 000	18 000	0	997 200	972 000	25 200	0
Spain	506 618	500 129	6 489	0	742 999	734 199	8 800	0
France	353 250	287 100	66 150	0	405 680	332 110	73 570	0
Portugal	56 840	56 379	461	0	77 591	77 132	459	0
Sweden	60 213	43 000	6 355	10 858	73 608	52 000	8 040	13 568
Germany	52 903	0	39 503	13 400	52 331	0	39 831	12 500
Finland	56 069	52 822	1 480	1 767	49 515	45 027	2 704	1 784
Netherlands	44 028	39 529	4 499	0	49 176	43 541	5 635	0
Belgium	34 638	31 906	2 732	0	33 099	27 542	5 557	0
Denmark	19 666	16 743	2 822	101	26 674	23 442	3 163	69
United Kingdom	16 360	0	16 360	0	17 013	0	17 013	0
Estonia	14 340	13 300	1 000	40	15 010	13 700	1 280	30
Austria	10 064	0	10 004	60	11 603	0	11 554	49
Poland	6 537	4 230	2 301	6	8 416	4 500	3 819	97
Czech Republic	6 247	0	6 247	0	7 193	0	7 193	0
Ireland	1 816	0	1 804	12	3 489	0	3 465	24
Hungary	611	362	247	2	815	432	381	2
Slovakia	585	0	585	0	721	0	721	0
Lithuania	260	0	15	245	605	0	605	0
Luxembourg	156	0	156	0	100	0	100	0
Bulgaria	20 727	19 173	1 036	518	n.a.	n.a.	n.a.	n.a.
Slovenia	5 226	2 118	3 108	0	n.a.	n.a.	n.a.	n.a.
Total EU	2 130 154	1 911 791	191 354	27 009	2 572 838	2 325 625	219 090	28 123

*Note: Datas from italian, french and portuguese aerothermal heat pump market are not directly comparable to others, because they include the heat pumps whose principal function is cooling. *Estimate.* ***Source: EurObserv'ER 2016***

2

Market of geothermal (ground source) heat pumps in 2014 et 2015 (number of units sold)*

	2014	2015
Sweden	23 356	26 377
Germany	18 500	17 000
Finland	11 125	9 210
Austria	5 885	5 897
Poland	5 275	5 567
France	4 045	3 810
United Kingdom	2 190	2 388
Netherlands	2 510	2 086
Denmark	2 242	1 885
Estonia	1 520	1 750
Czech Republic	1 578	1 586
Belgium	988	1 404
Italy	780	952
Lithuania	815	785
Bulgaria	532	532
Slovenia	390	390
Ireland	508	337
Slovakia	312	234
Luxembourg	55	87
Hungary	80	85
Spain	0	72
Portugal	58	59
Total EU	82 744	82 493

** Hydrothermal heat pumps included.* ***Source: EurObserv'ER 2016***

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3

*Total number of heat pumps in operation in 2014 and 2015**

	2014			2015		
	Aerothermal heat pumps	Ground source heat pump	Total heat pumps	Aerothermal heat pumps	Ground source heat pump	Total heat pumps
Italy	18 218 000	13 200	18 231 200	18 430 000	14 100	18 444 100
France	4 233 228	144 865	4 378 093	4 638 908	148 675	4 787 583
Spain	754 345	1 144	755 489	1 497 344	1 216	1 498 560
Sweden	920 813	474 057	1 394 870	988 191	497 658	1 485 849
germany	527 422	314 503	841 925	567 327	330 244	897 571
Finland	528 293	85 294	613 587	577 808	94 504	672 312
Denmark	225 209	51 638	276 847	245 291	56 023	301 314
Netherlands	199 148	45 986	245 134	248 051	47 407	295 458
Portugal	177 353	773	178 126	254 944	832	255 776
Nbulgaria	214 971	4 272	219 243	214 971	4 272	219 243
Austria	55 584	91 157	146 741	66 907	95 860	162 767
United Kingdom	97 781	24 875	122 656	114 794	27 263	142 057
Estonia	86 697	8 875	95 572	101 707	10 625	112 332
Belgium	51 400	6 370	57 770	84 499	7 774	92 273
Czech Republic	36 819	19 908	56 727	44 012	21 494	65 506
Poland	13 566	31 038	44 604	21 982	36 605	58 587
Slovenia	22 231	5 500	27 731	22 231	5 500	27 731
Ireland	5 538	3 116	8 654	9 027	3 453	12 480
Slovakia	5 886	2 839	8 725	6 607	3 073	9 680
Hungary	4 400	463	4 863	5 200	510	5 710
Lithuania	1 265	2 908	4 173	1 870	3 693	5 563
Luxembourg	1 095	333	1 428	1 195	420	1 615
Total EU	26 381 044	1 333 114	27 714 158	28 142 866	1 411 201	29 554 067

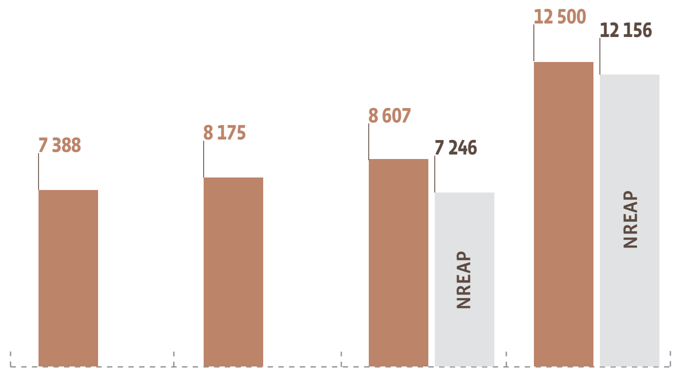
*Note: Datas from italian, french and portuguese aerothermal heat pump market are not directly comparable to others, because they include the heat pumps whose principal function is cooling. * Estimate.* ***Source: EurObserv'ER 2016***

munication (COM 2016, 51 final), that aims to optimize heating and cooling production systems in two sectors, residential/tertiary and industry. This strategy is one of the flagship policies of the strategy framework for an Energy Union. It should contribute to improving the EU's energy security and the implementation of the post COP21 Climate Action programme.

The EU's heating and cooling strategy primarily plans to implement a set of measures to encourage the renovation of multi-occupied apartment blocks, such as by installing modern heating and cooling appliances and especially HPs, to end energy losses from buildings, maximize efficiency and increase the renewable energy share. ■

4

Actual trend of renewable energy from heat pumps compared with the NREAP (National Renewable Energy Action plans) roadmap (in ktoe)



Source: EurObserv'ER 2016

Thermia/Danfoss

BIOGAS

Anaerobic digesters specially designed to recover energy produce most of the biogas across the European Union. The plants come in different types and sizes ranging from small anaerobic digesters on farms, larger co-digestion (or multi-product) plants and household waste methane production plants. Their feedstock (raw materials) is typically slurry, farming waste, green waste, food-processing waste and domestic refuse but the facilities can also use cultivated farm crops such as intermediate crops (crucifers, grasses, etc.), and other energy crops (maize, etc.), to optimize the methanization reaction by introducing carbon. The umbrella term "other biogas" covers the output of these installations for the sake of convenience, to distinguish it from the biogas produced by wastewater treatment plants that produce methane from sewage sludge only and from landfill biogas whose output is directly captured inside the landfills rather than being produced by an industrial plant. Biogas can also be produced using thermal processes, pyrolysis or gasification of solid biomass (including fermentable waste). The processes result in the production of hydrogen (H2) and carbon monoxide (CO), which when recombined produce a synthetic biogas that can substitute natural gas (CH4). These processes have been identified in Finland and Italy and in the interest of expedience.

16 MTOE PRODUCED IN THE EUROPEAN UNION

According Eursostat, European Union produced 15.6 Mtoe of biogas energy in 2015, i.e. 630 koe more than in 2014 and at 4.2 % of a similar growth rate to the previous twelve-month period. While all the EU countries produced biogas output figures, almost 77% of Europe's output is concentrated in the hands of three countries – Germany (7.9 Mtoe), the UK (2.3 Mtoe) and Italy (1,9 Mtoe).
For a number of years, most of the EU's primary biogas energy production spread has been taken up by the "other biogas" category, whose share has constantly risen against the landfill and sewage plant biogas categories. According to EurObserv'ER, the "other biogas" category accounts for about 72.7% of this output in 2015 (72.1% in 2014), which is a long way ahead of landfill biogas at 18.1% (18.4% in 2014) and 8.9% for sewage plant biogas (9.2% in 2014). For the time being the identified output of synthetic biogas (by thermal processes) is negligible, amounting to 0.3% of European biogas output.
The spread differs in individual Member states and is not always dominated by the "other biogas" category" which applies to those countries that have developed an industrial methane recovery sector for farm biogas and co-digestion. Prime examples are Germany, Italy, Austria, the Netherlands, Belgium and the Czech Republic. Landfill biogas retains the lead in those countries where the emergence of anaerobic digestion on farms and in industry is more recent or run on a small-scale. Prime examples are the UK, France, Spain, Portugal, Finland, Greece, Ireland and Estonia.

Biogas electricity production, regardless of whether or not it is produced in cogeneration plants, is still the main outlet for biogas energy recovery. It accounted for 60.9 TWh of output in 2015, which equates to 5.3% growth over 2014. Heat sales to district heating networks amounted to 636.1 ktoe in 2015, i.e. 11.1% growth. Self-consumed heat (used directly on production sites), is put at about 2 630 ktoe in 2015 (6.9% more than in 2014). Biogas can be fully harnessed with maximum energy efficiency to produce heat where there are outlets close to the methanization plant. It can also be refined into biomethane so that it can be put to use in the same way as natural gas, in the form of electricity in cogeneration plants, but also as biofuel for natural gas-powered vehicles (NGVs) or even injected into the natural gas grid.

GERMANY LIMITS THE DEVELOPMENT OF ITS BIOGAS PRODUCTION

Germany's new renewable energy law (EEG 2014) that came into force on 1 August 2014 marked a new strategy for biogas, whose future production will be much less reliant on the use of energy crops. One of the new law's aims is to reduce the financial cost of energy transition by slowing down the growth of the more costly electricity generating sectors, singling out solid biomass and biogas. According to the Germany biogas industry association (Fachverband Biogas e.V.), the number of new digester installations installed per annum has dropped sharply, falling from 1 476 in 2011 to 439 in 2012, 345 in 2013 and 163 in 2014 and 130 in 2015. The number should rise slightly 2016 with 148 new installations.

It put the number of biogas plants in 2015 at 8 856 (8 726 in 2014) for an equivalent 4 018 MW of electrical capacity. In 2015, 183 of these plants (167 in 2014) injected biomethane directly into the natural gas grid. The total number of biogas installations for 2016 should exceed 9 000 with 4 166 MW of combined electrical capacity.
According Eurostat, 33.1 TWh of biogas electricity was produced in 2015, i.e. 2 TWh more than in 2014 (6.3%). Most of this output (73.3% of the total) was generated by CHP plants. Biogas heat sold on to district heating networks increased much more by rising 41.1% above its 2014 performance to 221.8 ktoe.

In the UK, primary biogas energy output reached 2 252.4 ktoe in 2015 according to the Department for Business, Energy & Industrial Strategy (BEIS), which is an increase of 5.8%. While the main source is landfill biogas which accounts for 64.4% of the total, it has tended to contract since 2014 (1 535.8 ktoe in 2013, 1 501.8 ktoe in 2014 and 1 450.8 ktoe in 2015). The UK's output growth is due to the momentum of anaerobic digestion biogas ("Other biogas" category) whose output has more than doubled since 2013 (215.7 ktoe in 2013, 316.8 ktoe in 2014 and 473.8 ktoe in 2015). The BEIS claims that the country had 351 anaerobic digestion plants in 2015 of which 67 (72.1 MW) operate in cogeneration. The UK has 20 additional units that are dedicated to heat production and 23 that produce biomethane for injection into the grid.

THE FRENCH MARKET ENJOYS MODEST GROWTH

The Monitoring and Statistics Directorate trend chart data for the third quarter of 2016 shows that France (mainland and overseas territories) had 425 biogas plants by the end of 2015. They generated 1.7 TWh of electricity, which is 15.2% more year-on-year with their combined installed electrical capacity of 368 MW (42 MW more than in 2014). In France (overseas departments excluded), French statistics office (SOeS) has counted 1.8 TWh of electricity production from biogas in 2015 (+ 9.3% compared to 2014). Over the first three quarters of 2016, 24 MW of capacity was hooked up to the grid; taking the combined capacity to 385 MW... all spread over 478 facilities. Most of these installations were anaerobic digesters – 306 – but at 0.3 MW, their mean capacity was relatively low (compared to the total capacity of 104 MW). There were fewer plants recovering biogas from non-hazardous waste

1

Primary energy production from biogas in the European Union in 2014 and 2015 (in ktoe)

	2014	2015
Germany	7 434	7 854
United Kingdom	2 129	2 252
Italy	1 961	1 872
Czech Republic	608	613
France	473	539
Netherlands	313	327
Austria	297	300
Spain	353	262
Poland	207	229
Belgium	207	227
Sweden	153	167
Denmark	132	152
Slovakia	96	149
Finland	100	103
Greece	87	91
Latvia	75	88
Portugal	82	83
Hungary	76	80
Ireland	52	55
Croatia	26	36
Slovenia	31	30
Lithuania	21	23
Bulgaria	10	20
Romania	19	18
Luxembourg	17	18
Estonia	10	13
Cyprus	11	11
Malta	2	2
Total EU	**14 982**	**15 612**

Source: EurObserv'ER based on Eurostat data

storage facilities (146 sites equipped) but their average individual capacity is much higher (1.8 MW) giving a total of 259 MW. France also has 26 wastewater treatment plants that recover biogas as electricity with combined capacity of 23 MW (average individual capacity of 0.9 MW). At the end of 2015, France also had 17 biomethane grid injection sites. Biomethane injection into the natural gas grids increased sharply in 2015, to 82 GWh, compared to 33 GWh in 2014. In the third quarter of 2016, the amount injected was as much as 133 GWh, which is two and a half times as much as the total for the first three quarters of 2015.

WHAT WILL THE BIOGAS INPUT BE IN 2030?

Given the headway made by a few countries, European Union-wide biogas electricity and heat output has transcended the National Renewable Energy Action Plan target roadmap. The 2020 electricity output target is already well on the way to achievement. The German biogas incentive policy is largely responsible for this impetus. The country has beaten its 2020 biogas power output targets, set at 23.4 TWh with 2015 output standing at 32.9 TWh. Italy and the UK are in the same position; the former having set a 2020 target of 6 TWh with 2015 output standing at 8.2 TWh, and the latter having set a 2020 target of 5.6 TWh with output at 7.2 TWh. These success stories mask the time lost by countries such as France, the Netherlands and Spain. EU-wide progress on heat production from biogas is less spectacular at 3.3 Mtoe

2

Gross electricity production from biogas in the European Union in 2014 and 2015 (in GWh)

	2014			2015*		
	Electricity-only plants	CHP plants	Total	Electricity-only plants	CHP plants	Total
Germany	8 745	22 368	31 113	8 845	24 228	33 073
Italy	3 537	4 661	8 198	3 139	5 073	8 212
United Kingdom	6 239	672	6 911	6 429	760	7 189
Czech Republic	56	2 527	2 583	51	2 560	2 611
France	709	923	1 632	713	1 070	1 783
Netherlands	46	959	1 005	43	993	1 036
Spain	738	169	907	743	239	982
Belgium	130	741	871	88	867	955
Poland	0	816	816	0	906	906
Austria	564	54	618	580	44	624
Slovakia	171	308	479	117	424	541
Denmark	1	456	457	1	484	485
Latvia	0	350	350	0	391	391
Finland	232	118	350	204	154	358
Portugal	264	14	278	279	15	294
Hungary	65	222	287	72	221	293
Greece	36	184	220	34	196	230
Ireland	167	36	203	172	30	202
Croatia	47	68	115	25	152	177
Slovenia	4	125	129	3	129	132
Bulgaria	8	54	62	34	86	120
Lithuania	0	78	78	0	86	86
Luxembourg	0	61	61	0	62	62
Romania	22	29	51	29	32	61
Cyprus	0	51	51	0	51	51
Estonia	0	27	27	0	50	50
Sweden	0	14	14	0	11	11
Malta	0	7	7	0	7	7
Total EU	21 781	36 092	57 873	21 601	39 321	60 922

Source: EurObserv'ER based on Eurostat data

3

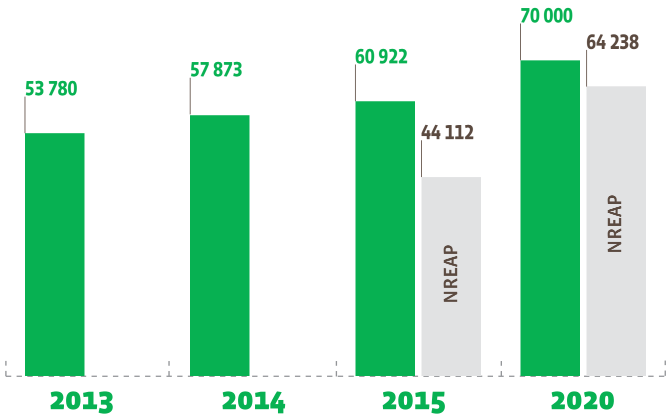
*Gross heat production from biogas in the European Union in 2014 and in 2015 (in ktoe) in the transformation sector**

	2014			2015*		
	Heat only plants	CHP plants	Total	Heat only plants	CHP plants	Total
Germany	54.4	102.8	157.2	71.8	150.0	221.8
Italy	0.3	238.5	238.8	0.3	205.3	205.6
Denmark	7.1	36.1	43.2	11.2	39.0	50.2
France	2.4	20.9	23.3	2.7	31.6	34.3
Latvia	0.0	18.2	18.2	0.0	21.3	21.3
Finland	7.6	8.1	15.7	6.8	11.4	18.2
Czech Republic	0.0	13.5	13.5	0.0	14.8	14.8
Slovakia	0.0	7.8	7.8	0.0	11.3	11.3
Poland	0.2	6.9	7.1	0.3	10.1	10.4
Belgium	0.0	7.6	7.6	0.0	9.3	9.3
Slovenia	0.0	8.4	8.4	0.0	7.3	7.3
Sweden	4.0	4.8	8.8	3.0	3.6	6.6
Croatia	0.0	3.2	3.2	0.0	5.2	5.2
Romania	0.0	3.9	3.9	0.1	3.7	3.8
Austria	1.7	3.3	5.0	1.6	1.8	3.4
Hungary	0.0	1.8	1.8	1.3	1.9	3.2
Estonia	0.0	1.3	1.3	0.0	2.7	2.7
Lithuania	0.0	2.2	2.2	0.0	2.2	2.2
Luxembourg	0.0	1.8	1.8	0.0	1.9	1.9
Cyprus	0.0	1.1	1.1	0.0	1.2	1.2
Netherlands	0.0	1.1	1.1	0.0	1.1	1.1
Bulgaria	0.0	1.3	1.3	0.0	0.6	0.6
Malta	0.0	0.0	0.0	0.0	0.1	0.1
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	77.8	494.6	572.4	98.9	537.2	636.1

** Correspond to "Derived heat" (see Eurostat definition).* ***Source: Eurostat 2016***

4

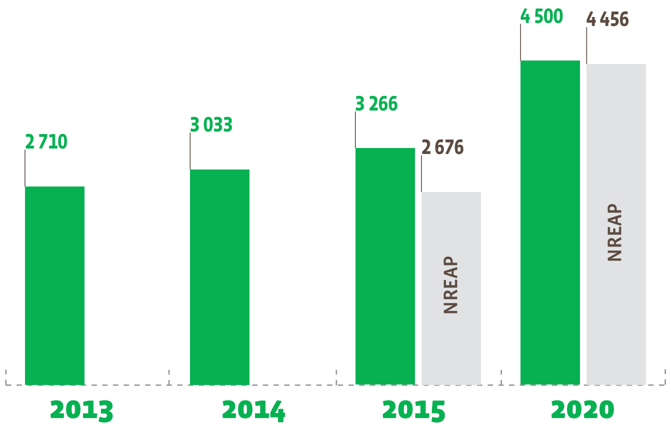
Comparison of the current trend of electricity biogas generation against the NREAP (National Renewable Energy Action Plans) roadmap (in GWh)



Source: EurObserv'ER 2016

5

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

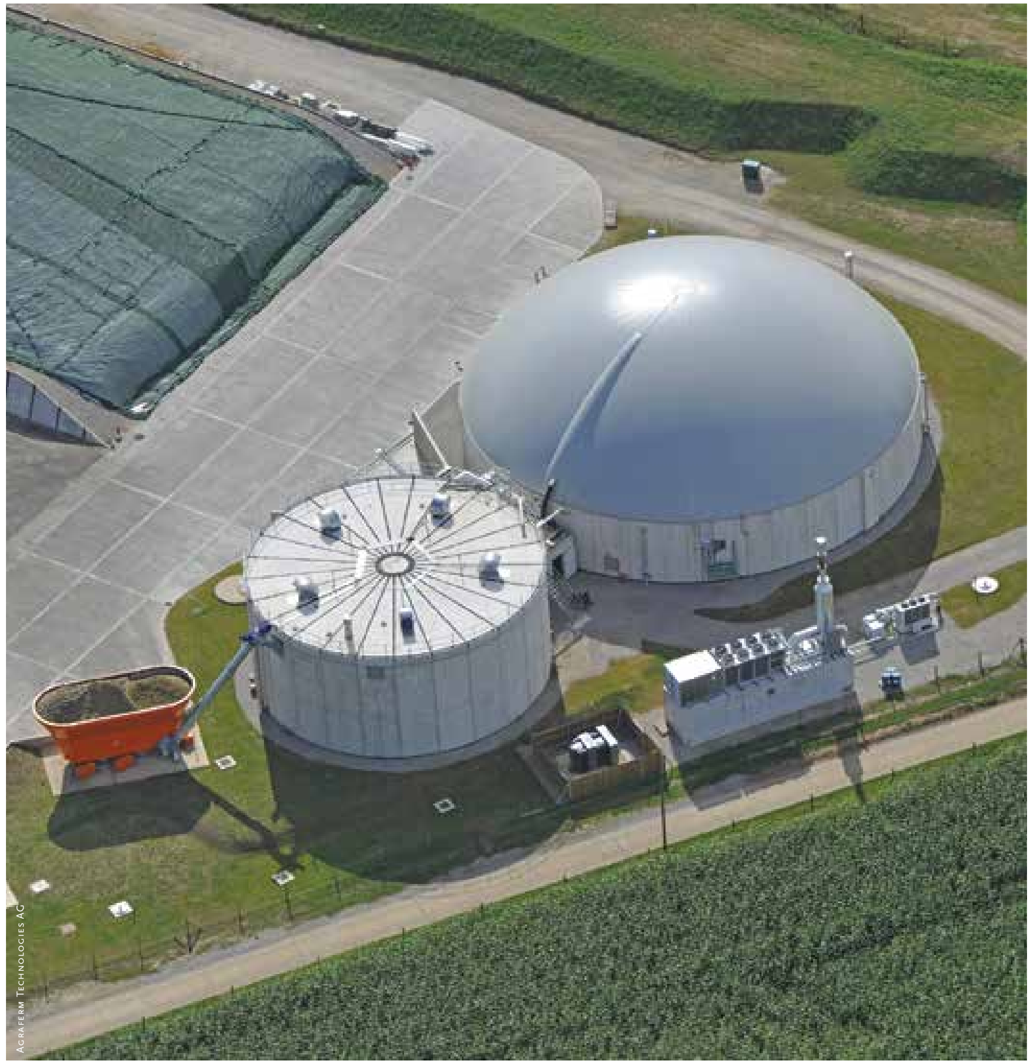


Source: EurObserv'ER 2016

against the intermediate target of 2.7 Mtoe. Recovering heat from biogas, which is more complex, still presents a number of European countries with a challenge, as they call for considerable efforts to be made on supplying district heating networks and heat recovery on the production sites. Many of them are lagging behind on their NREAP trajectory and will need to apply special policies if they are to achieve their 2020 targets.

After 2020, fermentation biogas and synthetic biogas could play a much bigger role in the future European electricity market. Given the increase in the variable electricity production sources' share – i.e. wind and solar power – biogas is one renewable energy that could bring flexibility to the electricity generating system, either through storage possibilities at the production sites or, when injection is possible, by using the storage capacities of the natural gas grid. This would call for setting up new mechanisms for the future European electricity market, such as flexible remuneration systems that extend to low-capacity facilities. This development would limit the capacity requirement of the market, whose function is to smooth the adjustments to be made between production capacities and electricity requirements when demand peaks.

Biogas production also has a major role to play in its use as fuel, for while electric vehicles have a hand to play in the urban environment; gas-driven engines have major potential in the rural environment, because of the availability of the resource and great driving range



requirements. Biogas fuel is also highly suitable for bus and road transport fleets, offering significant gains in GHG emission reduction.

The new European Commission renewable energy directive proposal presented in November 2016 could pave the way to increasing biogas fuel use. The European Commission will make it binding on transport fuel suppliers to include a bigger share of renewable and low carbon content fuels (hydrogen and electricity), including advanced biofuels and also biofuels produced from waste feedstock from 2021 onwards. The 1.5% obligation of 2021 will gradually rise to 6.8% in 2030, including at least 3.6% of advanced biofuel.

According to the EBA (European Biogas Association), potential output of biomethane (including anaerobic digester biogas and biomass gasification) could be up to 48 billion standardized m3 by 2030 (equivalent of 40.6 Mtoe). Harnessing this potential while adopting suitable policies would enable the industry to produce the equivalent of 10% of the European Union's current natural gas consumption. Thus the issue of the future of biogas sector development is largely political. ■

BIOFUELS

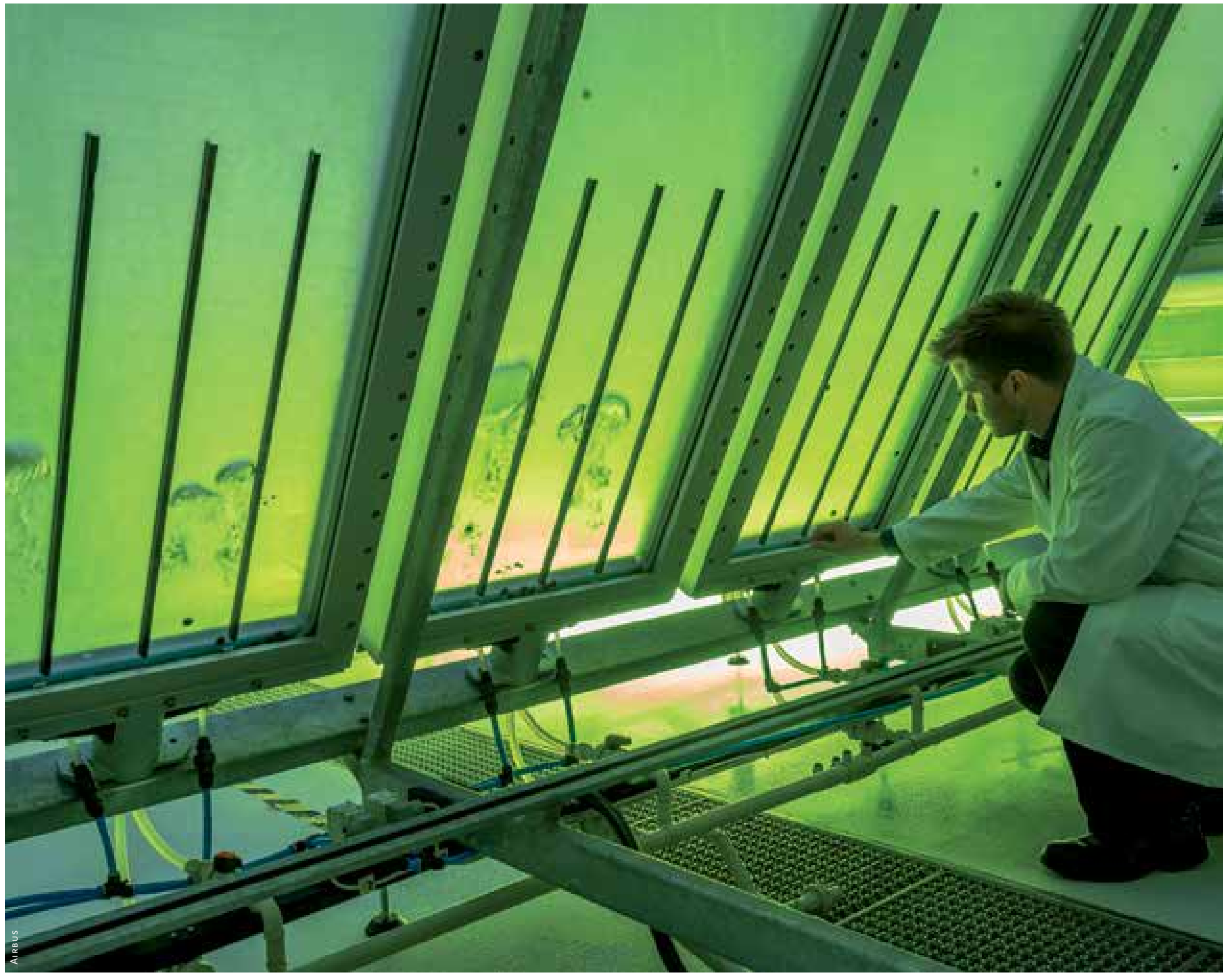
The European biofuel market is now regulated by the directive, known as ILUC, whose wording focuses on the environmental impact of first-generation biofuel development. The main effect of this directive is to limit the energy share of biofuel produced from cereal, sugar and oilseed crops on farming land to 7% by 2017 in Member States' renewable energy consumption for transport. The overall 10% renewable energy target in transport is retained, while the remaining 3% can be obtained through electric mobility or by using biofuel produced from specific feedstocks that benefit from double accounting.

CONSUMPTION STABILIZED IN 2015

The controversy surrounding the sustainability of certain types of biofuel and the long wait for amendments to be made to the relevant legislation have prompted the Member States to redefine their biofuel promotion policies and reduce the expansion pace of their sectors based on feedstock from food crops. As a result, biofuel consumption in transport levelled off in 2013 (at 13.1 Mtoe) after increasing sharply and regularly until 2012 (from 1.1 Mtoe in 2002 to 14.4 Mtoe in 2012), and then stabilized at 14.2 Mtoe in 2014 and 2015 (Eurostat[1] data). If we break down this consumption by type (expressed as energy content as opposed to metric volume), biodiesel remained the main biofuel used in transport (80.2% in 2015, i.e. 11 358 ktoe), which reflects the number of European vehicles running on diesel. Bioethanol, either directly blended with petrol or converted into ETBE) holds an 18.9% share (2 680 ktoe), compared to biogas fuel consumption which stands at 0.9% (128 ktoe).

EurObserv'ER took into account the statistical work provided by each Member State under the Eurostat SHARES project (SHort Assessment of Renewable Energy Sources), published in the middle of March 2017, to determine the share of consumption that upholds the sustainability criteria set by the European Directive. This share was 92.3% in 2015 compared to 91.2% in 2014. The main reason for this difference is that in 2015, Spain had not set up the legal framework for officially certifying its biofuel consumption. However as a Royal Decree has been passed enforcing compliance with the sustainability criteria of the "Renewable Energies" Directive for biofuel consumption, this should no longer happen in 2016. Likewise only 22% of biofuel consumption in Greece complies with the directive. In most of the other countries the biofuel share is now almost or 100% compliant.

1. Final transport energy consumption indicator



Airbus

If we now consider the directive's target transport indicator (that only factors in compliant biofuel, including biofuel produced from waste and renewable electricity consumption in road transport), then according to SHARES, the renewable energy share in transport reached 6.7% in the EU compared to 6.5% in 2014. If Spanish biofuel consumption had been

1

Biofuels consumption for transport in the European Union in 2014 (in toe)

	Bioethanol	Biodiesel	Biogas fuel	Other biofuels*	Total consumption	% compliant**
France	407	2 500	0	0	2 906	100%
Germany	779	1 957	50	4	2 790	100%
United Kingdom	414	754	0	0	1 168	100%
Italy	10	1 055	0	0	1 065	100%
Spain	186	765	0	0	951	0%
Sweden	165	623	84	0	872	99%
Poland	133	573	0	0	705	100%
Austria	63	524	1	0	588	90%
Finland	70	428	0	0	498	100%
Belgium	39	380	0	0	419	100%
Netherlands	137	221	0	0	358	96%
Czech Republic	66	251	0	0	317	100%
Portugal	2	255	0	5	261	58%
Denmark	0	231	0	0	231	100%
Hungary	60	128	0	0	189	100%
Romania	42	125	0	0	167	100%
Greece	0	135	0	0	135	22%
Slovakia	25	109	0	0	134	98%
Bulgaria	15	96	0	0	111	100%
Ireland	25	65	0	0	90	100%
Luxembourg	3	68	0	0	72	100%
Lithuania	6	57	0	0	63	94%
Slovenia	8	36	0	0	44	100%
Croatia	0	30	0	0	30	100%
Latvia	6	18	0	0	24	100%
Cyprus	0	10	0	0	10	100%
Estonia	6	0	0	0	6	0%
Malta	0	5	0	0	5	93%
Total EU	2 665	11 397	134	8	14 205	91%

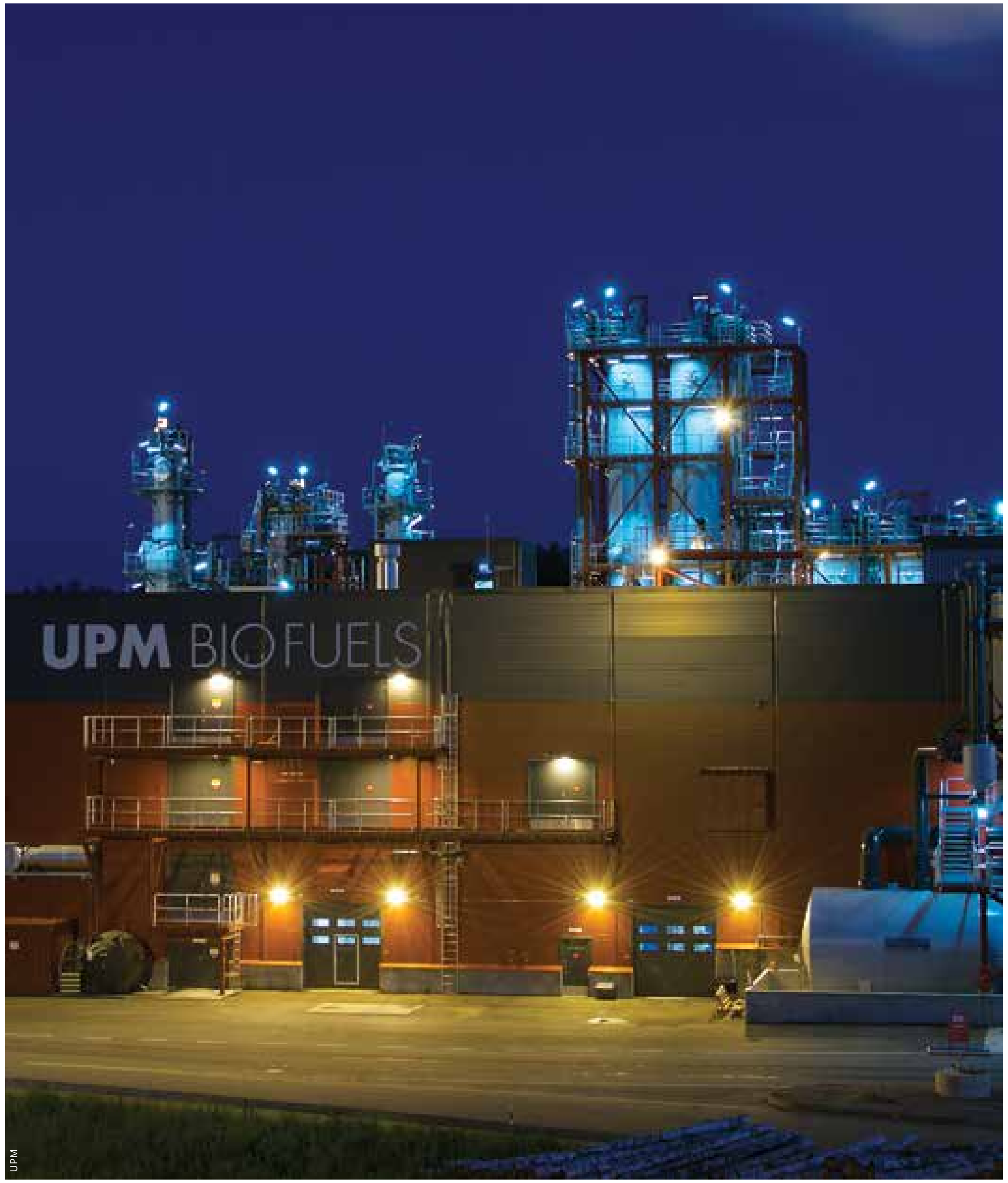
** Pure used vegetable oil and unspecified biofuel. ** Compliant with Articles 17 and 18 of Directive 2009/28/EC.*
Source: EurObserv'ER based on Eurostat data and Shares data for % compliant

2

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

	Bioethanol	Biodiesel	Biogas fuel	Other biofuels*	Total consumption	% compliant**
France	421	2 528	0	0	2 949	100%
Germany	744	1 792	30	1	2 567	100%
Italy	25	1 142	0	0	1 167	100%
Sweden	133	872	97	0	1 102	100%
Spain	189	769	0	0	958	0%
United Kingdom	404	529	0	0	933	100%
Poland	154	627	0	0	780	100%
Austria	60	585	1	0	646	97%
Finland	65	432	0	0	497	100%
Portugal	22	302	0	3	328	100%
Netherlands	142	156	0	0	297	99%
Czech Republic	63	233	0	0	297	100%
Belgium	41	221	0	0	261	100%
Denmark	0	232	0	0	232	100%
Romania	62	141	0	0	203	100%
Hungary	43	133	0	0	175	100%
Bulgaria	32	114	0	0	146	99%
Slovakia	23	121	0	0	144	100%
Greece	0	142	0	0	142	22%
Ireland	24	64	0	0	88	100%
Luxembourg	7	76	0	0	83	100%
Lithuania	10	58	0	0	68	100%
Latvia	8	29	0	0	37	100%
Slovenia	7	23	0	0	29	100%
Croatia	0	24	0	0	24	100%
Cyprus	0	10	0	0	10	97%
Malta	0	5	0	0	5	100%
Estonia	3	0	0	0	3	0%
Total EU	2 680	11 358	128	5	14 170	92%

** Pure used vegetable oil and unspecified biofuel. ** compliant with Articles 17 and 18 of Directive 2009/28/EC.*
Source: EurObserv'ER based on Eurostat data and Shares data for % compliant



certified as compliant, this share would have risen to 7%, and if we take the UK out of the equation through Brexit, the share would rise to 7.4%, because although the UK uses a lot of fuel, not much of it is renewable.

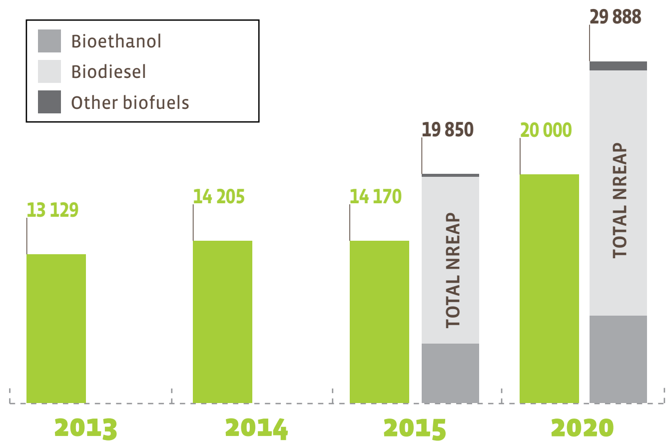
THE FUTURE DRIVEN BY ADVANCED BIOFUELS

The European Council has clarified European biofuel policy for 2020, by penning a new directive in September 2015. Many of the key Member States have clarified their roadmaps to 2020 and are set to achieve their 10% renewable energy target for transport.

However the United Kingdom's departure from the European Union will affect EurObserv'ER's

3

Comparison of the current biofuel consumption for transport trend against the NREAP (National Renewable Energy Action Plan) roadmaps (in ktoe)*



** Consumption of certified sustainable and unsustainable biofuel.*
Source: EurObserv'ER 2016

biofuel consumption forecasts that are based on an effective biofuel incorporation rate of about 7,5%, i.e. biofuel consumption of about 20 Mtoe. The UK actually accounts for about 13% of fuel consumption in European Union transport (40 Mtoe of the 302.1 Mtoe in 2015). Nonetheless this forecast is contingent on the political determination of the Member States to meet their obligations.

The forthcoming renewable energy directive that will regulate sector development after 2020 through to the 2030 timeline should mark a complete shift in European biofuel and sustainable mobility policy. This is because the new European strategy acknowledges that biofuels produced from food crops play a much lower than expected role in decarbonizing the transport sector and that their use should gradually be phased out in favour of advanced biofuels. Thus the new draft directive that was made public in November 2016 has chosen to further curb the quantities of these food-crop sourced biofuels that can be included in the EU target calculations. To minimize the impact of the ILUC effect, the draft has introduced a ceiling for the input of these biofuels, starting at 7% in 2021 and gradually reducing the share to 3.8% in 2030, along the lines of a trajectory set out in Annexe X (part A) of the draft directive. The Member States can even set a lower limit and make a distinction between different types of biofuel, for instance by setting a lower limit for the input of biofuel produced from oilseed crops.

Another important point raised by the draft directive is that Member States are obliged to ask fuel suppliers to include a minimal share of renewable energy and low-carbon fuels in the total quantity of fuel used for transport. These include advanced biofuels, fuels of non-biological origin (e.g.: hydrogen), fuels produced from waste or from renewably-sourced electricity. The minimum content threshold is at least 1.5% in 2021 and should rise to at least 6.8% in 2030, along the lines of a trajectory set out in Annexe X part B. The text points out that in the total share, the input of advanced biofuel and biogas produced from the feedstocks listed in Annexe IX, part A[1] must account for as much as 0.5% of the fuels for the transport sector to be used in the market starting on 1 January 2021 and at least 3.6% by 2030, along the lines of a trajectory set out in Annexe X, part C. The draft directive also states that the GHG emission reductions achieved by using the above advanced biofuels and biogas must be at least 70% from 1 January 2021. This draft Directive will call for the implementation of a suitably attractive and sustainable green taxation scheme to enable the advanced biofuel industry to build up steam. ■

1. Such as algae, biowaste, straw, manure, wood waste, non-food grade cellulose matter etc.

RENEWABLE URBAN WASTE

Primary renewable energy output recovered by household refuse incineration plants (Energy from Waste plants) across the European Union reached the 9.5 Mtoe mark in 2015, which equates to a 452 ktoe increase over 2014 (5% growth). Note that these figures do not factor in all the energy recovered by these plants, as we only include the biodegradable part of household refuse. Thus about 9 Mtoe of the energy recovered from non-renewable municipal waste (plastic packaging, etc.) is excluded. According to CEWEP, as much as 88 million tonnes of waste are recovered in Europe's 480 energy–from-waste incineration plants.

The data collected suggests that growth in electricity and final heat output was greater than that of primary energy output, which suggests more efficient energy recovery from incineration plants. Electricity output qualified as sourced from renewable municipal waste increased by 5.8% between 2014 and 2015 and for the first time exceeded 20 TWh (20.7 TWh in 2015). As for heat sales to district heating networks – this increased by 8.2% and reached 2.7 Mtoe.

The amount of energy recovered by incineration from municipal waste across the EU differs widely. If we take a per capita primary energy production indicator, the Nordic countries (with 93.2 toe per 1000 inhab. for Sweden, 82.5 toe per 1000 inhab for Denmark, and 49.9 toe per 1000 inhab. for Finland) and the Netherlands (with 49.8 toe per 1000 inhab.) are clearly the most deeply committed. Countries like France (18.3 toe per 1000 inhab), where many of the older design plants were not purposely devised to produce energy but simply to incinerate waste, have been slow on the uptake, while other Central and Southern European countries have so far invested very little in energy recovery from their household waste.

The UK currently has the most active waste-to-energy plant construction programme. Spain, Finland and Portugal are other Member States that significantly

1

Primary energy production from renewable urban waste in the European Union in 2014 and 2015 (in ktoe)

	2014	2015
Germany	3 037	2 994
France	1 171	1 212
Sweden	858	908
Italy	858	846
Netherlands	794	841
United Kingdom	522	749
Denmark	463	467
Belgium	364	373
Finland	247	273
Spain	204	252
Austria	175	182
Portugal	82	97
Czech Republic	83	80
Hungary	44	66
Ireland	52	53
Poland	37	40
Lithuania	11	16
Slovakia	12	15
Luxembourg	11	12
Bulgaria	7	8
Romania	2	1
Cyprus	1	0
Total EU	**9 033**	**9 485**

EurObserv'ER based on Eurostat data

increased their energy production through this sector in 2015.

EUROPEAN OVERVIEW

The construction of energy-from-waste (EfW) plants is burgeoning in the UK. The Department for Business, Energy & Industrial Strategy (BEIS) states that energy production from renewable household waste increased by 43.5% in 2015 to achieve 748.9 ktoe. Most of this energy was used to produce electricity – output increased by 44.7% to 2.8 TWh in 2015 (1.9 TWh in 2014). This momentum should be pursued for several years. According to data released by the German environmental market consultancy Ecoprog in its "Waste to energy 2016-2017" market survey, seven new plants were commissioned in 2015 and over the first half of 2016. Their combined waste treatment volume is 1 million tonnes. Another 17 plants are under construction, and will add

2

Gross electricity production from renewable urban waste in the European Union in 2014 and 2015 (in GWh)

	2014			2015		
	Electricity-only plants	CHP plants	Total	Electricity-only plants	CHP plants	Total
Germany	3 684	2 386	6 070	3 530	2 238	5 768
United Kingdom	1 209	714	1 923	2 174	608	2 782
Italy	1 257	1 114	2 371	1 208	1 136	2 344
France	1 113	858	1 971	1 142	857	1 999
Netherlands	0	1 909	1 909	0	1 997	1 997
Sweden	0	1 626	1 626	0	1 749	1 749
Denmark	0	886	886	0	919	919
Belgium	368	465	833	396	473	869
Spain	686	0	686	672	96	768
Finland	57	384	441	35	436	471
Portugal	240	0	240	292	0	292
Austria	199	45	244	239	50	289
Hungary	57	80	137	131	77	208
Czech Republic	0	88	88	0	87	87
Ireland	72	0	72	77	0	77
Lithuania	0	29	29	0	42	42
Luxembourg	34	0	34	40	0	40
Slovakia	0	22	22	0	22	22
Total EU	**8 976**	**10 606**	**19 582**	**9 936**	**10 787**	**20 723**

EurObserv'ER based on Eurostat data

3.6 million tonnes of treatment capacity. Most of these projects will be up and running between 2016 and 2018. One of the biggest plants to be commissioned in 2016 is the MVV Devonport EfW CHP facility in Devon. It has 245 000 tonnes of treatment capacity and installed electrical capacity of 25 MW, designed to produce 190 GWh of electricity and 60 GWh of heat annually. There is also the Greatmoor EfW plant in Buckinghamshire, with 300 000 tonnes of treatment capacity and installed electrical capacity of 27.7 MW. Another 65 plants are in various stages of development, which will add around 10 million tonnes of treatment capacity in time. British legislation enacted in 1996 is driving this trend, as taxation on landfills rises annually. In 2016, landfill tax rose to £ 84.40 (€ 99.10) per tonne. Ecoprog confirms that one outcome of this incentive policy is that 60% of the country's waste treatment capacity is less than 10 years old.

Statistics Finland claims that the country's primary energy production from renewable waste increased by 10.6% to 272.8 ktoe. In terms of final energy this translates into a 7.2% increase in electricity output to 471 GWh and a 20.4% increase in heat sold to district heating networks, i.e. 144.5 ktoe. Most of this growth can be attributed to the September 2015 commissioning of a new energy-from-waste plant in the city of Vantaa. This new facility has been designed to produce 600 GWh of electricity and 920 GWh of heat... enough to cover half the city's district heating requirements and 30% of its electricity needs. It

3

*Gross heat production from renewable urban waste in the European Union in 2014 and in 2015 (in ktoe) in the transformation sector**

	2014			2015		
	Heat only plants	CHP plants	Total	Heat only plants	CHP plants	Total
Germany	244.4	462.8	707.2	280.9	442.4	723.3
Sweden	42.2	534.1	576.3	57.8	575.1	632.9
Denmark	32.7	299.9	332.6	39.0	318.6	357.6
France	51.9	225.0	276.9	51.9	239.8	291.7
Netherlands	0.0	232.8	232.8	0.0	279.2	279.2
Finland	14.9	105.1	120.0	19.2	125.3	144.5
Italy	0.0	85.2	85.2	0.0	107.9	107.9
Austria	14.5	46.5	61.0	13.6	43.3	56.9
Czech Republic	0.0	37.5	37.5	0.0	37.3	37.3
Belgium	3.3	29.3	32.6	0.0	29.1	29.1
United Kingdom	11.8	0.0	11.8	15.0	0.0	15.0
Hungary	0.0	8.8	8.8	0.0	11.5	11.5
Lithuania	0.0	7.1	7.1	0.0	9.1	9.1
Poland	0.3	0.0	0.3	0.2	0.0	0.2
Romania	0.8	0.0	0.8	0.1	0.0	0.1
Total EU	**416.8**	**2 074.1**	**2 490.9**	**477.7**	**2 218.6**	**2 696.3**

** Correspond to "Derived heat" (see Eurostat definition).* ***EurObserv'ER based on Eurostat data***

has been designed to treat 320 000 tonnes of waste per annum.

In Portugal, according to the Energy and Geology Department (DGEG) primary energy production increased by 19.1% to reach 97.4 ktoe essentially in the form of electricity whose output was 52 GWh higher and reached 292 GWh. This figure is bound to increase further as in October 2015 the CVE Ilha Terceira EfW plant went on stream in the Azores. The waste treatment design capacity of this small plant is 40 000 tonnes per annum and it has 1.9 MW of electrical capacity.

Spain's Institute for Energy Diversification and Saving (IDEA) puts 2015 output at 252.2 ktoe… a 23.4% year-on-year increase. Most of this was channelled into electricity production which increased by 12% in 2015 to achieve 768 GWh. For once the increase can be attributed to higher efficiency of existing plants rather than the addition of a new facility.

NEW AMBITIONS FOR 2030

As regards primary energy production, energy recovery is growing at a moderate pace and can be mainly attributed to the construction of the UK's new facilities. Nonetheless, Europe is increasing pressure on its Member States, resulting in investment decision-making primarily in Eastern Europe where the countries are starting from scratch. If they are to comply with the directive, they will obviously have to invest


Hauke Hass

in the sector during the second half of this decade not to say from 2017 onwards. The European Commission's "Circular Economy" package of 2 December 2015, proposed introducing a binding landfill target to reduce the maximum municipal waste content to 10% by 2030. The package also revises the framework directive on waste recycling targets. The household waste recycling and second-life use targets will be raised to 65% by 2025 and 75% by 2030. The total amount of (renewable and non-renewable) energy produced by energy recovery plants could reach 189 TWh by 2030 (54 TWh as electricity and 135 TWh as heat) by applying these measures.

The CEWEP projections to 2020 are that the energy contribution of waste to 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. EurObserv'ER views that total heat consumption (heat from the processing sector and final heat consumption) reached 3.5 Mtoe in 2015 (including 2.7 Mtoe of heat sales to networks), thus CEWEP's 2020 heat target is perfectly feasible and could be considerably bettered. The commissioning of new incineration facilities in the UK, along with enhanced energy efficiency measures made to existing plants should also enable the coveted 25 TWh to be achieved by 2020. ■

SOLID BIOMASS

Solid biomass includes all the solid organic components to be used as fuels… wood, wood waste (wood chips, sawdust, etc.), wood pellets, black liquors from the paper industry, straw, bagasse, animal waste and other materials and solid plant residues.

Solid biomass consumption, primarily wood energy, is still largely governed by heating requirements which are climate-dependent. Leaving aside climatic variations, the use of solid biomass for producing heat or electricity has tended to increase in the European Union, spurred on by European support policies. Although 2015 is one of the warmest years on record, it was not as mild across the European Union as it was in 2014. It stands to reason that solid biomass energy consumption (excluding charcoal) picked up (by 4.7% in comparison with 2014) and reached 95.3 Mtoe in 2015, breaking its previous consumption record in 2013 (93.4 Mtoe).

Solid biomass primary energy production, whose solid biomass is sourced from European Union soil, is rising at a slightly slower pace (4.8%) and achieved 91.4 Mtoe. The difference, made up of nett imports, has tended to increase over the past few years from 2.3 Mtoe in 2012 to 3.8 Mtoe in 2015. It can primarily be put down to higher wood pellet imports from North America.

Solid biomass heat is in turn differentiated by direct use in final consumers' heating appliances (boilers, burners, inserts, etc.), which accounts for most of the consumption or conversion and distribution via heating networks (heat sales). For all European Union Member States, consumption of heat directly used by final consumers rose by 5.8% over 2014 (3.6 Mtoe) to 66.4 Mtoe in 2015. Gross solid biomass heat output sold on to heating networks heat rose by 3.4% (0.3 Mtoe) to meet increased heating demands. It rose to 9.3 Mtoe in 2015 and 62.3% of this figure was produced by CHP plants, i.e. that produce heat and electricity at the same time. If we add these two elements together, total final biomass heat energy consumption increased by 5.7% to 74.8 Mtoe. European Union solid biomass electricity production is less sensitive to climate variations, and is governed more by the policies of a few Member States to develop biomass electricity, either by converting old coal-fired plants or by developing biomass cogeneration. At European Union level, biomass electricity output increased by 6.9% (5.8 TWh) over 2014 to 90.7 TWh in 2015.

THE SIGNIFICANT SHARE OF UNITED KINGDOM IN THE EUROPEAN SOLID BIOMASS SECTOR

The UK's exit from the European Union will shake up the solid biomass energy scene. While the UK only accounts for 6.4% (6.1 Mtoe in 2015) of the total solid biomass consumption of the EU of 28, it has led Europe in solid biomass electricity production since 2014. The Department for Business, Energy & Industrial Strategy claims that solid biomass electricity output rose from 13 852 GWh in 2014 to 19 418 GWh in 2015, which equates to 40.2% growth. The UK now produces 21.4% of the European Union's solid biomass electricity. If the UK is taken out of the equation, then overall European Union solid biomass electricity output has been stable since 2013 and has even contracted slightly (70.8 TWh in 2013, 70.9 TWh in 2014 and 71.3 TWh in 2015).

FORTUM

GERMANY'S WOOD CONSUMPTION BOOSTED BY FALLING TEMPERATURES

Data released by AGEEstat indicates that solid biomass consumption passed the 12 Mtoe mark, with a 5.6% increase over 2014. There are two reasons for this increase – firstly the harsher weather which boosted heating requirements and secondly the larger base of modern wood-burning heating appliances. Renewable energy use in Germany's heating sector is regulated by the renewable heat law (EEWärmeG) which came into force on 1 July 2009. It intends to raise the renewable energy share of final energy consumption for heating and cooling to 14% by 2020. Thus the law has made partial use of

1

Primary energy production and gross inland consumption of solid biomass in the European Union in 2014 and 2015 (in Mtoe)*

	2014		2015	
	Production	Consumption	Production	Consumption
Germany	11.425	11.425	12.062	12.062
France	9.078	9.078	9.661	9.661
Sweden	8.923	8.923	9.129	9.129
Italy	6.539	8.066	7.340	8.578
Finland	8.117	8.137	7.901	7.927
Poland	6.180	6.755	6.268	6.774
United Kingdom	3.165	4.885	3.824	6.097
Spain	5.161	5.276	5.260	5.260
Austria	4.227	4.361	4.474	4.573
Romania	3.646	3.618	3.521	3.514
Czech Republic	2.842	2.763	2.954	2.874
Denmark	1.308	2.351	1.590	2.532
Hungary	2.363	2.350	2.511	2.480
Portugal	2.671	2.350	2.603	2.339
Belgium	1.104	1.689	1.171	1.942
Latvia	2.046	1.338	2.009	1.259
Croatia	1.375	1.093	1.532	1.258
Lithuania	1.117	1.084	1.205	1.204
Netherlands	1.290	1.147	1.364	1.179
Bulgaria	1.087	0.992	1.160	1.035
Greece	0.869	0.930	0.952	1.013
Slovakia	0.760	0.752	0.890	0.879
Estonia	1.122	0.789	1.209	0.825
Slovenia	0.533	0.533	0.590	0.590
Ireland	0.210	0.252	0.202	0.228
Luxembourg	0.066	0.064	0.055	0.064
Cyprus	0.007	0.008	0.007	0.010
Malta	0.000	0.001	0.000	0.001
Total EU	**87.228**	**91.011**	**91.444**	**95.285**

* *Excluding charcoal.* ***Source: Eurobserv'ER 2016***

2

Gross electricity production from solid biomass in the European Union in 2014 and 2015 (in TWh)*

	2014			2015		
	Electricity-only plants	CHP plants	Total	Electricity-only plants	CHP plants	Total
United Kingdom	13.852	0.000	13.852	19.418	0.000	19.418
Germany	5.333	6.535	11.868	4.796	6.238	11.034
Finland	1.074	9.894	10.968	1.217	9.372	10.589
Poland	1.892	7.269	9.161	1.957	7.069	9.026
Sweden	0.000	9.007	9.007	0.000	8.977	8.977
Spain	2.856	0.965	3.821	3.126	0.888	4.014
Italy	2.031	1.792	3.823	2.089	1.858	3.947
Belgium	1.388	1.243	2.631	2.298	1.256	3.554
Austria	1.109	2.332	3.441	1.232	2.265	3.497
Denmark	0.000	2.958	2.958	0.000	2.803	2.803
Portugal	0.765	1.765	2.530	0.795	1.723	2.518
France	0.098	1.633	1.731	0.098	2.042	2.140
Czech Republic	0.054	1.938	1.992	0.049	2.043	2.092
Netherlands	1.437	0.663	2.100	1.725	0.172	1.897
Hungary	1.210	0.492	1.702	1.011	0.649	1.660
Slovakia	0.011	0.905	0.916	0.004	1.095	1.099
Estonia	0.061	0.670	0.731	0.069	0.641	0.710
Romania	0.237	0.217	0.454	0.108	0.355	0.463
Latvia	0.002	0.317	0.319	0.000	0.378	0.378
Lithuania	0.000	0.293	0.293	0.000	0.318	0.318
Ireland	0.251	0.014	0.265	0.184	0.013	0.197
Bulgaria	0.010	0.128	0.138	0.003	0.149	0.152
Slovenia	0.000	0.125	0.125	0.000	0.131	0.131
Croatia	0.000	0.050	0.050	0.000	0.089	0.089
Luxembourg	0.000	0.021	0.021	0.000	0.024	0.024
Greece	0.000	0.000	0.000	0.001	0.000	0.001
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	**33.671**	**51.226**	**84.897**	**40.180**	**50.548**	**90.728**

* *Excluding charcoal.* ***Source: EurObserv'ER based on Eurostat data***

renewable heat compulsory in all new buildings, and in existing public buildings. Owners are free to choose the type of renewable energy they wish to use, but if they choose a system that runs on solid biomass, it must cover at least 50% of the building's heating consumption.

NEW TEMPERATURE RECORDS CURB FINLAND'S WOOD CONSUMPTION

In Finland, solid biomass-sourced energy consumption dropped again according to Statistics Finland, from 8.1 Mtoe in 2014 to 7.9 Mtoe in 2015. The explanation for this drop is another warm year that reduced heating requirements. The Finnish Meteorological Institute points out that the country went through four exceptionally warm years in the first half of the decade... 2011, 2013 and 2014 crowned by a record year in 2015, when home heating consumption dropped by 5% to 41 TWh (3.5 Mtoe). The most popular heat sources in Finland used for heating are electricity, heating networks and wood-fired appliances. It should be noted that the use of solid biomass is widespread for generating electricity (10.6 TWh) and supplying district heating networks (1.6 Mtoe).

2030 – THE "WINTER PACKAGE" IS BLOWING HOT AND COLD

Three years before the 2020 deadline, the European Commission presented its new Clean Energy Package of measures that aims to round off the European Union climate and energy framework to the 2030 timeline. The package includes a number of amendment proposals to directives covering energy efficiency, renewable energy, the design of the electricity market, security of electricity supply and governance rules for the Energy Union.

3

Gross heat production from solid biomass in the European Union in 2014 and in 2015 (in Mtoe) in the transformation sector***

	2014			2015		
	Heat only plants	CHP plants	Total	Heat only plants	CHP plants	Total
Sweden	0.716	1.562	2.278	0.704	1.614	2.318
Finland	0.630	1.055	1.685	0.594	1.012	1.606
Denmark	0.398	0.592	0.990	0.420	0.602	1.022
Austria	0.457	0.333	0.790	0.471	0.356	0.827
France	0.256	0.355	0.611	0.328	0.395	0.723
Germany	0.178	0.359	0.537	0.184	0.399	0.583
Italy	0.065	0.528	0.593	0.070	0.461	0.531
Lithuania	0.261	0.095	0.355	0.346	0.100	0.445
Poland	0.033	0.301	0.334	0.029	0.268	0.297
Estonia	0.049	0.133	0.182	0.075	0.140	0.215
Latvia	0.095	0.090	0.185	0.095	0.106	0.201
Czech Republic	0.022	0.117	0.139	0.030	0.123	0.153
Slovakia	0.041	0.073	0.114	0.043	0.076	0.119
Hungary	0.032	0.050	0.083	0.050	0.055	0.106
Romania	0.029	0.035	0.064	0.034	0.035	0.069
Netherlands	0.009	0.017	0.025	0.018	0.015	0.032
Slovenia	0.006	0.014	0.019	0.009	0.019	0.027
Croatia	0.000	0.006	0.006	0.000	0.015	0.015
Luxembourg	0.003	0.008	0.011	0.004	0.009	0.013
Bulgaria	0.004	0.003	0.007	0.007	0.004	0.011
Belgium	0.000	0.007	0.007	0.000	0.006	0.006
United Kingdom	0.003	0.000	0.003	0.004	0.000	0.004
Cyprus	0.000	0.000	0.000	0.000	0.000	0.000
Greece	0.000	0.000	0.000	0.000	0.000	0.000
Ireland	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
Portugal	0.000	0.000	0.000	0.000	0.000	0.000
Spain	0.000	0.000	0.000	0.000	0.000	0.000
Total EU	3.287	5.731	9.019	3.513	5.809	9.322

** Excluding charcoal. ** Correspond to "Derived heat" (see Eurostat definition).* ***Source: EurObserv'ER based on Eurostat data***

4

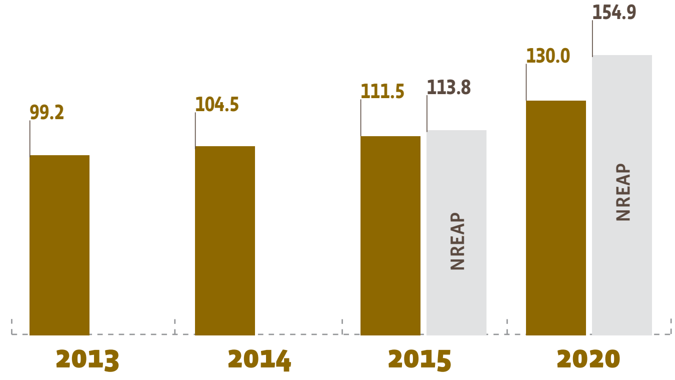
Heat consumption from solid biomass in the countries of the European Union in 2014 and 2015*

	2014	of which final energy consumption	of which derived heat**	2015	of which final energy consumption	of which derived heat**
Germany	8.375	7.837	0.537	9.255	8.671	0.583
France	8.328	7.717	0.611	8.937	8.214	0.723
Sweden	7.464	5.186	2.278	7.689	5.371	2.318
Italy	6.594	6.001	0.593	7.331	6.800	0.531
Finland	6.530	4.846	1.685	6.433	4.826	1.606
Poland	4.771	4.438	0.334	4.786	4.489	0.297
Spain	3.734	3.734	0.000	3.926	3.926	0.000
Austria	3.580	2.790	0.790	3.728	2.902	0.827
Romania	3.495	3.431	0.064	3.375	3.306	0.069
United Kingdom	2.197	2.193	0.003	2.595	2.591	0.004
Czech Republic	2.335	2.196	0.139	2.405	2.251	0.153
Denmark	1.949	0.959	0.990	2.171	1.149	1.022
Hungary	1.880	1.787	0.083	2.024	1.919	0.106
Portugal	1.741	1.741	0.000	1.719	1.719	0.000
Croatia	1.058	1.052	0.006	1.207	1.192	0.015
Belgium	1.135	1.128	0.007	1.190	1.184	0.006
Latvia	1.196	1.010	0.185	1.107	0.906	0.201
Lithuania	0.990	0.635	0.355	1.065	0.620	0.445
Greece	0.927	0.927	0.000	1.010	1.010	0.000
Bulgaria	0.959	0.952	0.007	1.003	0.992	0.011
Estonia	0.654	0.472	0.182	0.692	1.919	0.215
Netherlands	0.645	0.620	0.025	0.685	0.653	0.032
Slovenia	0.510	0.491	0.019	0.565	0.538	0.027
Slovakia	0.481	0.367	0.114	0.564	0.445	0.119
Ireland	0.196	0.196	0.000	0.193	0.193	0.000
Luxembourg	0.059	0.048	0.011	0.058	0.045	0.013
Cyprus	0.007	0.007	0.000	0.008	0.008	0.000
Malta	0.001	0.001	0.000	0.001	0.001	0.000
Total EU	**71.790**	**62.772**	**9.019**	**75.721**	**66.399**	**9.322**

** Excluding charcoal. ** Essentially district heating (see Eurostat definition).* ***Source: EurObserv'ER based on Eurostat data***

5

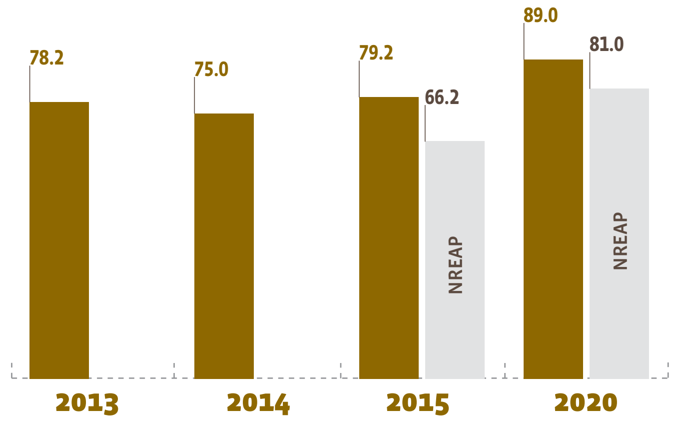
Comparison of the current trend of electricty production from solid biomass against the NREAP (National Renewable Energy Action Plan) roadmaps (in TWh)



This data includes an estimate of renewable heat from municipal waste incineration plants. ***Source: EurObserv'ER 2016***

6

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



This data includes an estimate of renewable electricity from municipal waste incineration plants. ***Source: EurObserv'ER 2016***

The « winter package » introduces major changes to the energy use of solid biomass. The revised renewable energy directive strengthens current European Union criteria that apply to bioenergy sustainability and extends their application to biomass and biogas used to produce heat and electricity. One of the new sustainability criteria in the proposed measures now applies to the forest biomass used for energy purposes, to mitigate the risk of forest overexploitation and guarantee that accounting rules on land use, land use change and forestry (LULUCF) are applied. The sustainability criteria will be extended to large heat-producing and biomass or biogas electricity producing installations (with capacities of ≥20 MW) combined with a binding reduction in GHG of 80% compared to fossil fuels from 2021 onwards and of 85% from 2026 onwards). This is compounded by the demand that the electricity is produced by high-efficiency cogeneration (with a yield of >80%). However there will be no challenge to the acquired rights of existing installations. ■

CONCENTRATED SOLAR POWER

Concentrated solar power covers all the technologies that aim to transform the sun's rays into very high-temperature heat. This thermal energy can be used to produce electricity, via thermodynamic cycles or supply industrial processes that run on very high temperature levels (up to 250°C). Concentrated solar systems harness optical concentration devices that convert direct solar radiation.

The four main technologies are tower plants and dish concentrator plants (Dish Stirling), that concentrate the radiation on a given point, those that use parabolic trough collectors and Compact linear Fresnel reflectors (CLFR), that concentrate the radiation on to a linear receiver (a tube containing heat transfer fluid).

One of the particular advantages of concentrated solar power is that it passes through a heat production stage prior to conversion into electricity, which means it can be combined with other renewable energies such as biomass and waste, and also with conventional sources such as natural gas and coal. The other advantage is that the energy can be stored as heat using various processes such as molten salts – hence the plants can operate outside of sunshine periods and during peak consumption periods at the end of the day.

ANOTHER LOST YEAR FOR CSP IN THE EUROPEAN UNION

Despite its strengths, the sector is making no headway in Europe. According to EurObserv'ER, the EU's CSP capacity meter stuck fast in 2015 at 2 313.7 MW (including prototype projects). Eurostat claims that officially listed 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 country to have developed a commercial CSP electricity-generating sector. However no additional capacity has been added since 2013 and no new projects have been announced. Yet a window of opportunity for new plants before 2020 was opened at the end of December 2016, when the Spanish government announced that it was working on a tender for a 3 000 MW package of all types of renewable energy to meet its 2020 European target of 20% of final renewable energy consumption (compared to 16.8% in 2015). Spain's CSP plants kept their technology promise by posting a new production record of 5 593 GWh in 2015 compared to 5 455 GWh in 2014 (a 2.5% rise), which covers a little over 2% of its domestic electricity needs.

Schott AG

Likewise Italy connected no new CSP power plants in 2015. New project launches have been delayed primarily because the developers are dissuaded by the paltry remuneration terms. 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 PV), 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

EUROBSERV'ER – THE STATE OF RENEWABLE ENERGIES IN EUROPE – 2016 EDITION

1

Concentrated solar power plants in operation at the end of 2015

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		**2313.7**	

Parabolic trough plants, Central receiver plants, Dish Stirling systems, Linear Fresnel systems, HB (Hybrid Biomass)
Source: EurObserv'ER 2016

Continues overleaf

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 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), CSP San Quirico (10.8 MW, hybrid parabolic trough) and San Severo (10 MW, tower plant).

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 (Multiannual energy programming plan) of October 2016 although the previous targets for the end of 2020 were set at 540 MW.

A single project in Cyprus, financed through the NER 300 European Fund is still under construction. It is the Eos small tower plant project (25 MW), with a graphite storage system. Greece has two projects approved that draw on the same fund… the Minos tower plant on Crete and the Maximus parabolic trough project (75 MW) on the mainland. As it stands only the Minos project (50 MW tower plant) is being promoted.

THE LONG-TERM STORAGE ADVANTAGE OF CSP

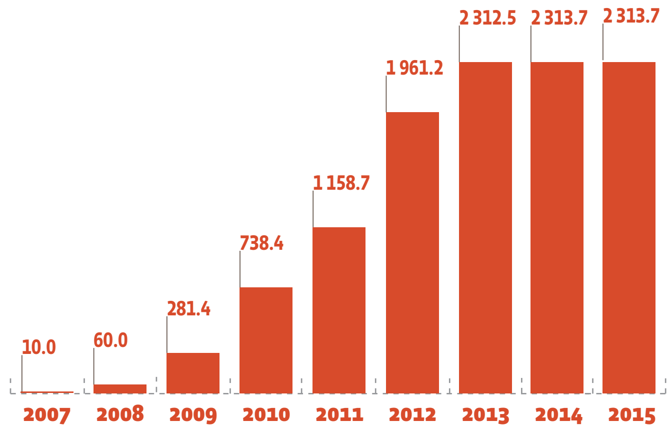
The National Renewable Energy Action Plans set under the terms of the European directive planned for installed capacity of 6 765 MW (4 800 in Spain, 600 in Italy, 540 in France, 500 in Portugal, 250 in Greece and 75 in Cyprus) equating to 20 TWh of output by the 2020 timeline. It is now clear that these 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. Estela feels that the grids have been able to manage variable electricity production in Europe (solar PV and wind power) so far because the interconnections enable excess output to be exported to neighbouring systems. However the association insists that management problems will start to arise once the variable renewable energy supply passes the 30% mark, when new problems will affect the development of those sectors, such as losses or storage of the excess electricity and their associated costs. Estela also believes that this massive integration will eventually lead to profitability issues for renewable investments when the demand for consumption over certain periods is lower than output.

So 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

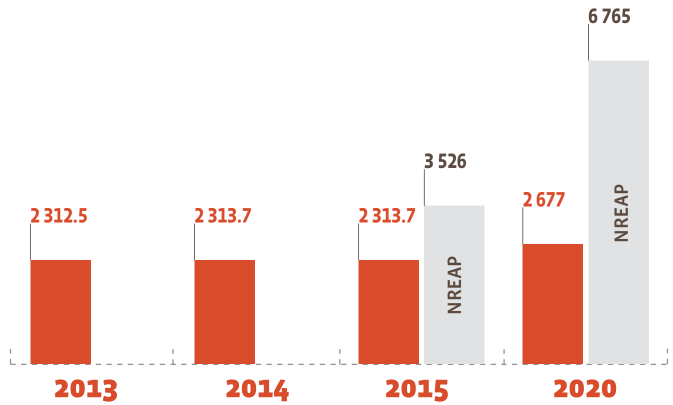
CSP plant capacity trend in the European Union (MW)



Source: EurObserv'ER 2016

3

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



Source: EurObserv'ER 2016

OCEAN ENERGY

Tidal energy, currents (underwater turbines) and waves (wave energy converters), energy recovered from temperature (thermal) or salt content differences between two bodies of water... Europe knows more than a thing or two about the endless bounty offered by the seas and oceans for with its kilometres of continental and outlying coasts it leads the world in harnessing ocean energy. The sector is still in its infancy but has started to get organized and reap the rewards for its efforts.

The November publication of two major reports on the sector turned 2016 into a landmark year. The first was published by the European Technology and Innovation Platform for Ocean Energy (TP Ocean), an advisory body to the European Commission. The "Strategic Research Agenda" for ocean energy prioritizes the research topics as the industry's main input into European and national research programmes. For its part, the Ocean Energy Forum presented its roadmap for harnessing ocean energies to the European Commission. It is the result of two years' work by about a hundred experts and draws up an ambitious plan for developing ocean energy in Europe, from the initial research and development phase to final industrial deployment.

At the same time, funding programmes have been based on the report recommendations. We should mention the launch of a second MaRINET programme from 2017–2021 as part of the European Commission's Horizon 2020 programme, which gives research firms and consortia free access to 57 test sites in 13 European countries. Wave energy also gets into the limelight through the OPERA experimental wave energy converter programme, which has received 5.7 million euros from Horizon 2020 to slash costs by 50%. The year was also marked by the number of sea-based projects that got off the ground. Nonetheless, tidal energy is still the only form to be commercially exploited through France's la Rance (Ille-et-Vilaine) tidal barrage installed in the Rance river estuary in 1966. The 240 MW power plant is the only one in Europe because development of these systems runs up against social and environmental acceptance issues. Notwithstanding, research is going on into other technologies that exploit tides, which essentially involve installing artificial lagoons away from the estuaries. Construction work on a 320 MW prototype tidal power plant operated by Tidal Lagoon Power should have started in 2016 in Swansea Bay, but has been postponed until 2018 at the earliest.

Work is underway on the other ocean energies through small-scale pilot projects in R&D phase and testing out at sea. Many commercial-scale underwater turbine and wave converter fleets are starting to materialize. The UK, which has at its disposal 50% of the wave energy resources and 35% of the current resources of the European continent, has made the most progress on these two energies, primarily through the experiments that have been conducted for over a decade at the European Marine Energy Centre (EMEC)


DCNS

in Scotland. In 2016, Australia's Atlantis Resources Corporation installed the first tidal turbines of its enormous 398 MW MeyGen project in the waters off the Island of Stroma. The first 6 MW phase was completed early in 2017, while the second phase, of the same capacity (6 MW) should be operated commercially and has been awarded a 20.3 million euro grant by the European Commission.

France is committed to developing ocean energies, but the projects started off its coasts have suffered setbacks. Sabella's 1 MW tidal turbine in the Fromveur passage off Ouessant Island that was connected to the grid in June 2015 is currently in maintenance. It should be put back into the water in spring 2017. Engie pulled out of the Fromveur project to concentrate on the 5.6 MW Raz Blanchard tidal project but in the meantime General Electric has stopped development work on its turbine for Raz Blanchard.

On EDF Energies nouvelles' experimental site at Paimpol-Bréhat, the two 2 MW prototypes installed by the DCNS subsidiary Openhydro in 2016, have run into technical problems and been taken out of the water. Commissioning has been postponed until the end of 2017. At the same time the site should see the installation of a 1 MW tidal turbine by HydroQuest and CMN (Constructions Mécaniques de Normandie) as part of an agreement with EDF. The project made a successful bid in the State-financed "Marine renewable energies and pilot river turbine farms" call for projects under the Investments for the Future programme. River turbine technology is making headway through the installation of several prototypes and current development of larger turbine farms.

Portugal also has useful sites for harnessing the seas. It is one of the first countries to have accommodated a wave harnessing system in its waters, Pico OWC. In 2007 Finland's AW-Energy also chose to test its WaveRoller wave converter off the Portuguese coasts. A 350-kW prototype should shortly be installed off the coast of Peniche.

Ireland also has ample resources and opened three ocean energy test centres. The first wave converter system, Oceantec's MARMOK-A-5 has been installed off the Basque coast and connected to the grid via the Bay of Biscay (BiMEP) open sea research platform. Tocardo Tidal Turbines deploys its turbines off the Dutch coast. The Netherlands has a long history of backing osmotic technologies. The European Commission has granted Sweden's CorPower Ocean 4 million euros to finance its WaveBoost project, a three-year innovation programme that aims to improve wave energy converters.

Many European countries have now included ocean energy in their National Renewable Energy Action Plans which reassures manufacturers that there will be a market in the future. Currently 45% of the companies working in wave converters and 50% of those working on tidal turbines are European. According to the Ocean Energy Forum roadmap, ocean energy could cover up to 10% of the European Union's electricity demand by 2050, which would equate to a 276 million tonne reduction in CO_2 emissions per annum.

These figures make good news for both the environment and the economy, as in the long term, the global ocean energy market could be worth 50 billion euros per annum. The activity would generate new jobs in the energy industry and all the related service sectors. While the sector seems to be making slow headway, the experience acquired in offshore wind energy has proven the importance of the pre-commercial phase prior to rapid sector development. ■

1

List of European Union plants harnessing ocean energy at the end of 2016

Projects	Capacity (MW)	Commissioning date	Current state
United Kingdom			
Limpet	0.5MW	2000	Connected
Open Center Turbine	0.25 MW	2006	Connected
SeaGen	1.2 MW	2008	Connected
Wello Oy-Penguin	0.6 MW	2012	Connected
Nova 30	0.03 MW	2014	Connected
Minesto-Deep GreenOcean	0.3 MW	2013	Connected
WaveNET Series-6	0.022 MW	2014	Being tested
Scotrenewables Tidal Power	2 MW	2016	Connected
Nova 100	0.3 MW	2016	Connected
Andritz TTG#1-Meygen	1.5 MW	2016	Connected
Total UK	**6.7 MW**		
Portugal			
OWC Pico	0.4 MW	2004	Connected
Total Portugal	**0.4 MW**		
France			
Barrage de La Rance	240 MW	1966	Connected
Hydro Gen 2	0.02 MW	2010	Being tested
HydroQuest River 1.40	0.04 MW	2014	Connected
Hydrotube Énergie H3	0.02 MW	2015	Being tested
Bertin Technologies	0.018 MW	2016	Connected
Total France	**240.1 MW**		
Spain			
Mutriku OWC – Voith Wavegen	0.3 MW	2011	Connected
Oceantec WEK MARMOK-A-5	0.03 MW	2016	Connected
Total Spain	**0.3 MW**		
Italy			
R115	0.1 MW	2015	Connected
H24	0.05 MW	2015	Connected
Total Italy	**0.15 MW**		
Netherlands			
Friesland/Afsluitdijk	0.05 MW	2015	Connected
Afsluitdijk tidal barrage Tocardo T1	0.3 MW	2015	Connected
Easten Scheldt Tocardo T2	1.25 MW	2015	Connected
Texel Island Torcado T2	0.25 MW	2016	Connected
Total Netherlands	**1.85 MW**		
Sweden			
Lysekil	0.018 MW	2005	Being tested
Seabased	1 MW	2016	Connected
Total Sweden	**1 MW**		
Total EU	**250.5 MW**		

Source: EurObserv'ER 2016

INTEGRATION OF RES IN THE BUILDING STOCK AND URBAN INFRASTRUCTURE

The use of heating and cooling is currently 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 networks will gain more importance. The indicators on RES integration in the building stock and urban structure are designed to show the status and the dynamics of RES deployment in this respect. The consumption share of RES in the building stock shows the status quo of RES use. EurObserv'ER's goal is to provide separate indicators for RES in buildings and in district heating in the next editions of this report; in the current issue they are aggregated.

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, innovative applications such as solar thermal collector fields and large heat pumps as well as waste heat from sewage treatment plants.

Methodological note

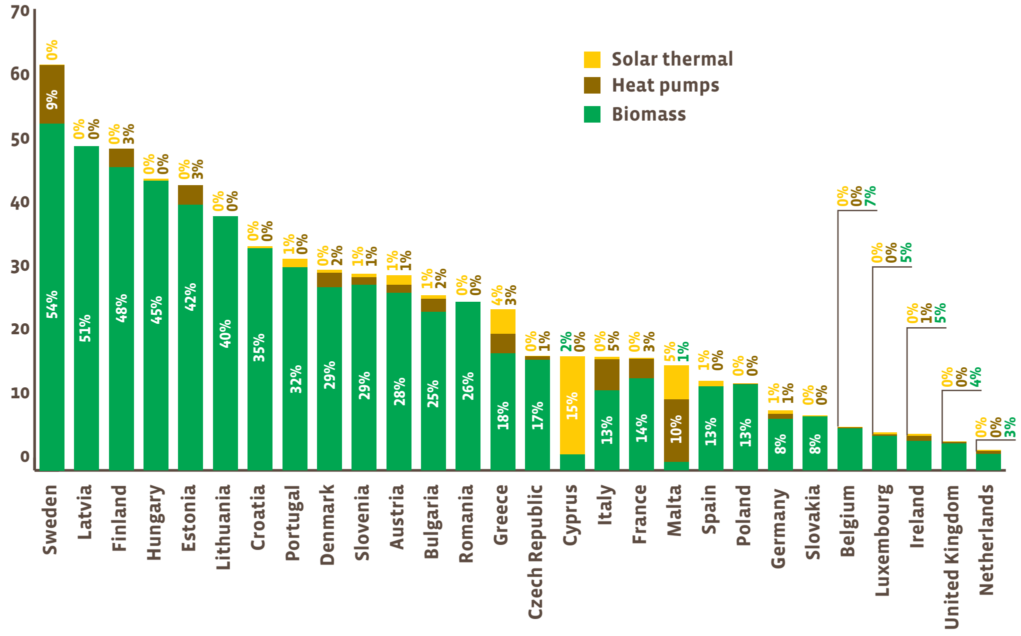
The consumption shares of RES in the building stock shows the significance of the respective RES in the building sector. It is the quotient of final renewable energy demand for heating and cooling in building and total final energy demand in buildings without electricity. Electricity is not included in final energy demand because in Eurostat RES demand for heating and cooling excludes electricity as well.

A more detailed description on the methodological approach of Eurostat can be found under: http://ec.europa.eu/eurostat/web/energy/data/shares, and of this indicator can be found under www.eurobserv-er.org

RESULTS AND INTERPRETATION

1

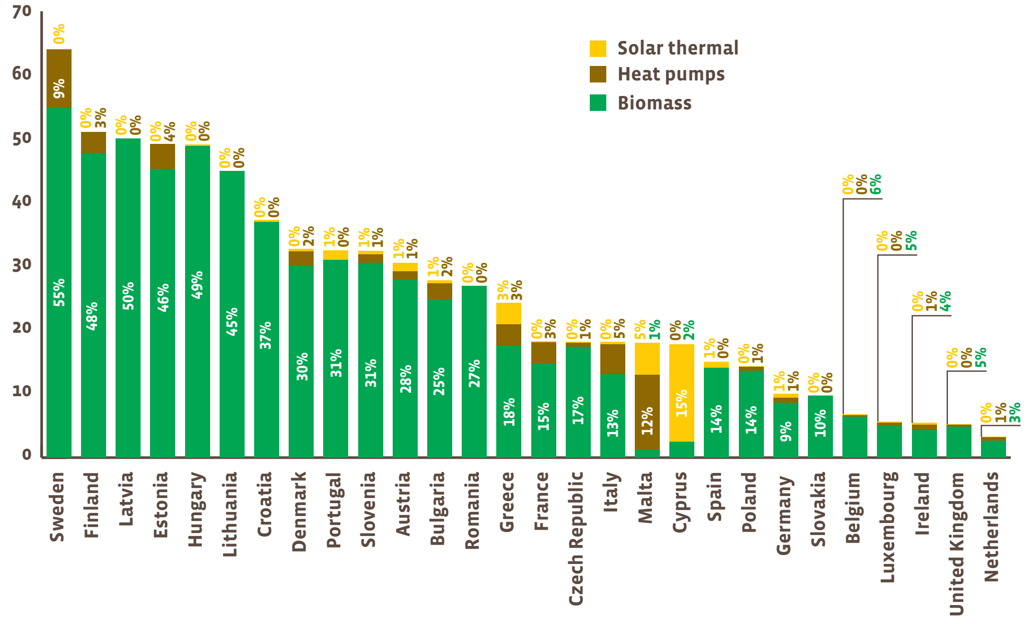
RES-H/C shares in 2014



Source: EurObserv'ER 2016 partly based on Eurostat

2

RES-H/C shares in 2015



Source: EurObserv'ER 2016 partly based on Eurostat

Figure 1 presents the shares of heating and cooling with renewable energies. This share is basically the 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. Electricity consumption for heating and cooling is excluded here (accounted for under electricity).

In most countries, biomass is the dominant renewable energy source for heating and cooling. Countries with an overall high renewable energy share in heating and cooling have a long tradition of biomass use, for example the Scandinavian and Baltic States. Thereby, biomass is mainly used for stoves or boilers in buildings. During cold winters or cold spells, the use of biomass might increase disproportionately, as biomass serves as additional or secondary heating source and is mainly applied in boilers or stoves that are less efficient than fossil fuel boilers. But Denmark, Sweden, Estonia and Lithuania deploy already comparably high shares of biomass in district heating. It accounts between 12% and 18 % of final energy demand in heating and cooling.

South and Southeast European countries have favourable solar preconditions for solar thermal heating and cooling. Thus, the shares of solar thermal heating and cooling reflect the solar irradiation conditions. The shares are below 1 % in most countries.

Not surprisingly, some South/Southeast European countries display high shares. The highest share is observed in Cyprus with approximately 15%, in Malta with 5 %, followed by Greece with 3%, and Austria and Portugal, both exhibiting a share of 1.4 %.

Heat pumps have slightly higher shares than solar thermal heating and cooling: approximately 12% in Malta, 3 – 5 % in Italy, France and Estonia. However, it is important to note that some statistical offices base their calculations of ambient heat use on a large share of the installed reversible aerothermal heat pumps with a low performance factor, which are usually not included by other Member States. For example, some heat pumps used for cooling display such a low seasonal performance factor, that they are not considered as a renewable energy source according to the RE Directive (2009/28/EC). But some countries don't differentiate heat pumps by their performance factor and, hence, count them still all as renewable energy source. This explains to some extent the high geothermal shares e.g. in Malta, France or Italy. ■

THE EUROPEAN UNION IS ON THE RIGHT TRACK

In 2014, unusual climate conditions in the European Union led to plummeting energy consumption. Unseasonably warm winter temperatures slashed heating requirements for much of Europe. As a result there was a slight rebound in heating consumption that pushed up total energy consumption followed by a generally very warm year in 2015, with some countries experiencing harsher winters (primarily Germany and France).

Accordingly, gross final energy consumption, as calculated for the 2020 European Union targets, increased by 2.2% between 2014 and 2015 (from 1 097.7 to 1 121.4 Mtoe), after suffering an exceptional 4.2% drop over the previous twelve-month period. Another reason for the increased energy use is the slight pick-up in economic activity in the EU of 28. According to Eurostat, actual GDP growth was 2.2%, i.e. an increase of 0.6 of a percentage point [PP] over 2014. However energy use in 2015 remained low... at its second lowest level for twelve years... and >100 Mtoe less than the pre-recession levels observed between 2004 and 2008.

CLIMATE CONDITIONS MADE A STRONG IMPACT ON RENEWABLE ELECTRICITY PRODUCTION

While the particularly mild climate conditions stifled the expansion of energy consumption yet again, they had a high impact on hydropower and wind energy production albeit with opposite effects in the different regions. Eurostat's most recent data on actual renewable electricity output (updated in February), namely non-normalised for wind energy and hydropower, indicates a 4% increase between 2014 and 2015, which puts total electricity output at 935.8 TWh (graph 1). This growth is a little less than the figure for the previous twelve months (5%, with 899.8 TWh in 2014), but is nonetheless significant as it represents an EU-wide rise of 36 TWh.

The increase in output would have been much higher had it not been for the rainfall shortage in a few Southern European countries (Italy, Spain and Portugal), and also France and Austria. The phenomenon was partly offset by equal gains in Northern Europe (Sweden and Finland) as well as Greece and Bulgaria. However across the European Union, the hydropower deficit hit the sector with a 9% fall in output (33.9 TWh less than in 2014), i.e. a total of 341.1 TWh in 2015. This decline affected hydropower's share in total renewable electricity output, contracting to 36.4% in 2015 compared to 41.7% in 2014.

Weather conditions also hit wind energy production with extremely good conditions in most of Europe's regions (Northern Europe, the British Isles, France, Germany and Central Europe), excluding the zone comprising the Iberian Peninsula (Spain, Portugal) and Italy. Across the EU, the balance is clearly positive with 19.3% growth (48.8 TWh), i.e. output of 301.9 TWh. As a result the sector's share in the renewable mix was consolidated at 32.3% in 2015 compared to 28.1% in 2014. While this major growth was helped by the weather conditions, it can also be put down to the continued increase in the number of both new onshore wind farm connections (12 382 MW in the EU in 2015) and offshore connections with 3 012 MW of additional capacity connected in the North Sea, Baltic Sea and Irish Sea.

However first estimates of 2016 production levels look much lower for Northern Europe – the UK, Ireland, along with Germany and France – which could result in a European Union-wide drop in output.

Solar PV's contribution, which is less vulnerable to climatic variations, remained significant as a result of a sharp increase in installed photovoltaic capacity (8 042 MW added in 2015 giving a European base of 94 864 MW). This contrasts with CSP capacity, which did not change in 2015 and is still concentrated in Spain (2 302 MW). Solar power output, all technologies taken together, increased by 10.4% between 2014 and 2015 (or 10.1 TWh) giving 107.9 TWh of output, which raised solar power's share of renewable electricity production to 11.5% (10.9% in 2014).

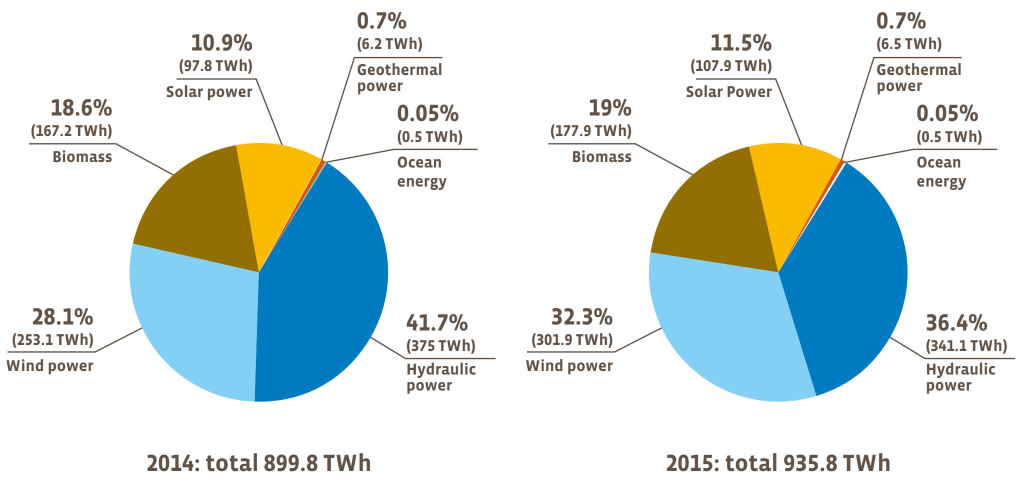
The 2015 electricity output figure of all types of biomass energy was 177.9 TWh. If we compare it with that of solar power, we see that its annual growth rate was lower (6.4% compared to 10.4%) despite the fact that its increase in output (10.7 TWh) was slightly higher due to greater biomass development. If we break down the results of the various biomass sectors, we find in order of importance: solid biomass electricity driven by the conversion of British coal-fired power plants, which gained 5.8 TWh (6.9%), biogas which improved by 3 TWh (5.3%), renewable municipal waste which improved by 1.1 TWh (5.8%) and liquid biomass whose output increased by 664 GWh (13.7%). Biomass taken together now accounts for 19% of total renewable electricity output, i.e. slightly more than in 2014 (18.6%). Geothermal energy added another 304 GWh (4.9%) and renewable marine energy, essentially represented by the output from the La Rance Tidal Power Plant in France, improved by a few GWh in 2015 (adding 6 GWh).

The actual share of renewable energies in EU's total electricity output (NB: non-normalised for wind energy and hydropower) rose from 28.2% in 2014 to 28.9% in 2015 (0.7 PP) while overall output rose (from 3 190.8 TWh in 2014 to 3 234.3 TWh in 2015), thereby ending the unbroken fall in production since 2011 (3 666.1 TWh in 2010).

The electricity production monitoring indicator used for calculating the Renewable Energy Directive (2009/28/ CE) target differs in that it uses normalised production for hydropower and wind energy (the normalisation formula is set out in Annex II), to play down the climatic variations and present a more represen-

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 2016***

tative indicator of the efforts made by each Member State. Thus the figure used for normalised hydropower output was 349.5 TWh in 2015 (348.6 TWh in 2014) and that of wind power was 284.8 TWh (251.6 TWh in 2014). The total renewable electricity production taken into account thus reaches 927.2 TWh in 2015 (871.9 TWh in 2014). Total electricity output (conventional and renewable), including updated normalised wind power and hydropower output, came to 3 218.5 TWh in 2015 as against 3 174.8 TWh in 2014. On this basis, increase in the renewable energy share of total electricity output was more marked, rising from 27.5% in 2014 to 28.8% in 2015 (by 1.3 PP). If we take 2004 as the reference year (14.3%), the (normalised) renewable electricity share doubled. A number of countries recorded outstanding changes in their renewable electricity shares from 2004–2015: 27.6 PP for Denmark, 21.3 PP for Germany, 19.2 PP for Ireland, 18.8 PP for the UK and 18.2 PP for Romania. The lowest inputs came from Hungary (5.1 PP), France (5 PP), Slovenia (3.5 PP), Luxembourg (3.4 PP) and Malta (4.2 PP).

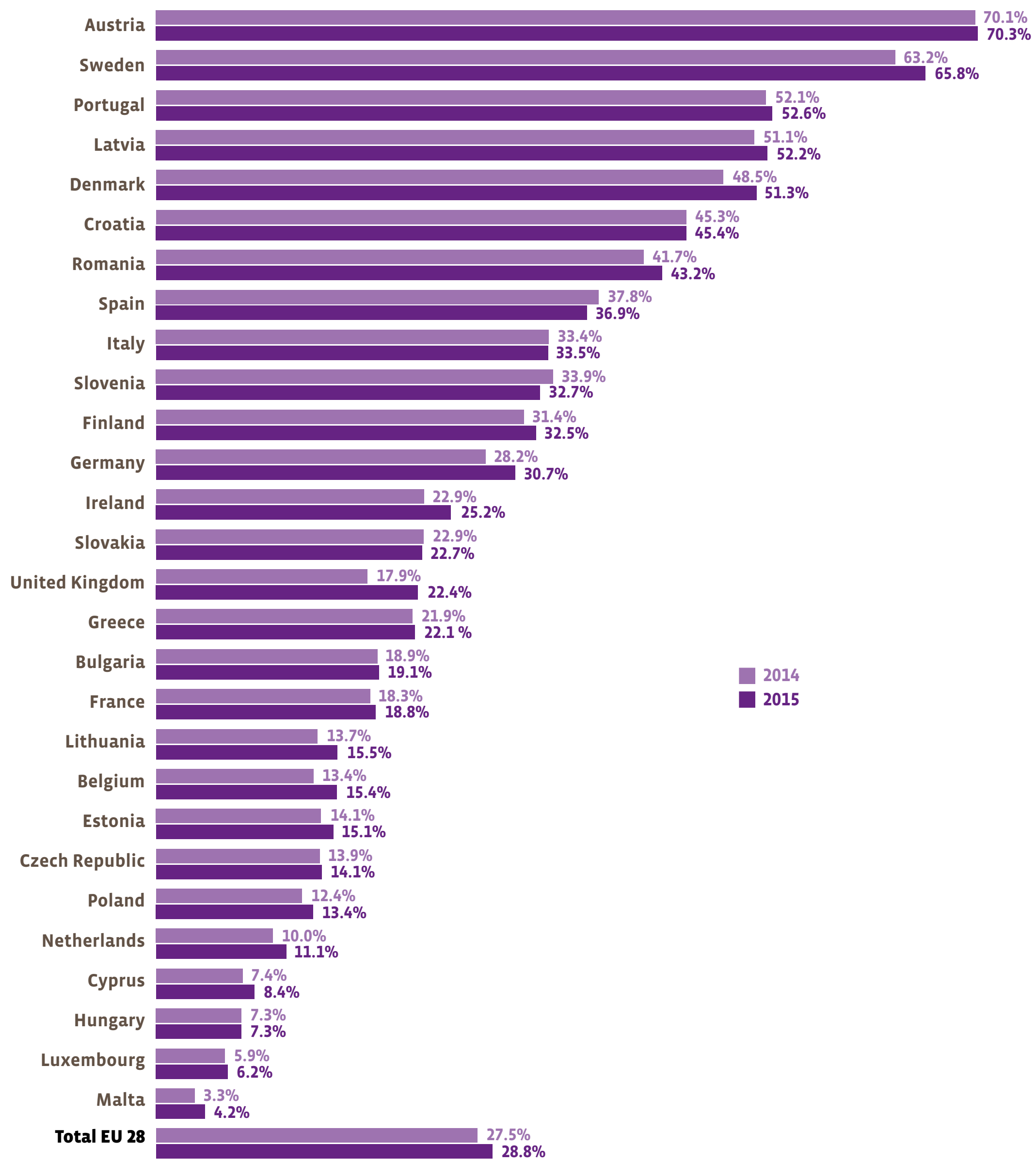
Graph 2 shows that the renewable electricity share can vary wildly as it depends on the potential and renewable energy policies of the Member States. Renewable production dominates in the five top-ranking countries: Austria (70.3% in 2015), Sweden (65.8%), Portugal (52.6%), Latvia (52.2%) and Denmark (51.3%), but stands at less than 10% in four other countries: Cyprus, Hungary, Luxembourg and Malta.

RENEWABLE HEAT RETURNS TO GROWTH

Heat and electricity develop in fairly similar contexts. Renewable heat consumption is driven by the investments made in renewable energy production facilities geared to replacing fossil fuels directly and also by heating needs. Climate variations also affect renewable heat consumption because space heating needs are largely met by wood energy consumption. According to the Eurostat Shares tool data (2015 version) released in the middle of March 2017, heat (and cooling) consumption returned to growth in 2015 (5.6% higher than in 2014) with a 5 Mtoe increase following an "unusual" drop in consumption of about 2 Mtoe in 2014. Most of the credit for the increase can be ascribed to additional input by solid biomass (3.9 Mtoe) and to a lesser extent by the heat pump (0.4 Mtoe),

2

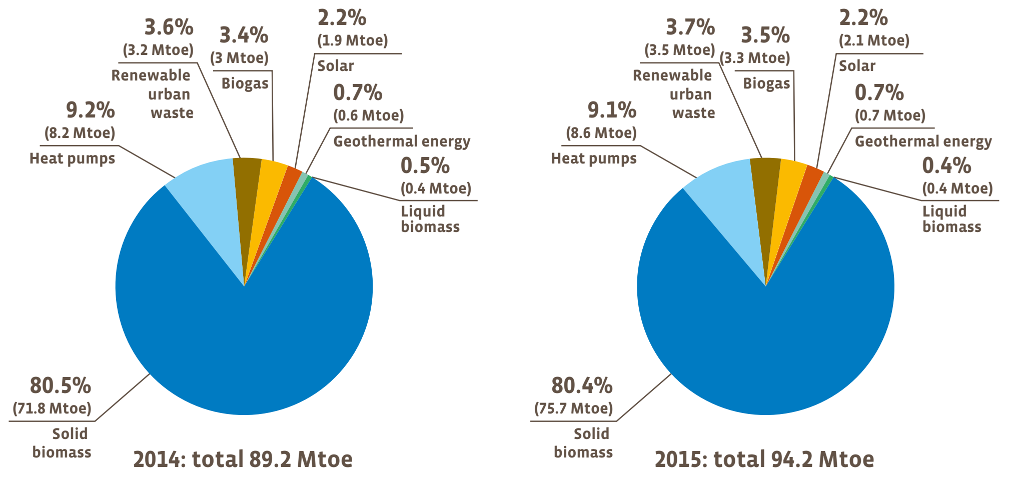
Share of renewable energy in the electricity generation of EU countries in 2014 and 2015 (in %)



Notes for calculation: *Hydro is normalised and excluding pumping. Wind is normalised. Solar includes solar photovoltaic and solar thermal generation. All other renewables include electricity generation from gaseous and liquid biofuels, renewable municipal waste, geothermal, and tide, wave & ocean.* ***Sources: EurObserv'ER based on SHARES 2015 data***

3

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



Source: EurObserv'ER 2016

renewable urban waste (0.2 Mtoe), biogas (0.2 Mtoe) and solar (0.1 Mtoe) sectors. In 2015 total renewable heat consumption rose to 94.2 Mtoe compared to 89.2 Mtoe in 2014. Leaving aside annual variations caused by mild or harsh winters, the renewable heat contribution of the EU of 28 has seen a sharp increase since 2004. It has risen by 32.9 Mtoe, which equates to 53.7% growth.

According to our calculations, distribution between the various renewable heat sectors hardly changed over the twelve-month period (graph 3). Solid biomass remains the main renewable heat source (80.4% of the 2015 total) with consumption at 75.7 Mtoe. If we add the three other biomass heat sources (biogas, renewable municipal waste and liquid biomass), the total biomass share came to 88% with consumption at 82.9 Mtoe. Biomass is followed by heat pumps, be they ASHPs or GSHPs (which also generate cooling), with a 9.1% share and 8.6 Mtoe of consumption. These are followed by renewable municipal waste (3.7% share of consumption at 3.5 Mtoe), biogas (3.5%, 3.3 Mtoe), solar (2.2%, 2.1 Mtoe), geothermal energy (0.7%, 0.7 Mtoe) and liquid biomass (0.4%, 0.4 Mtoe).

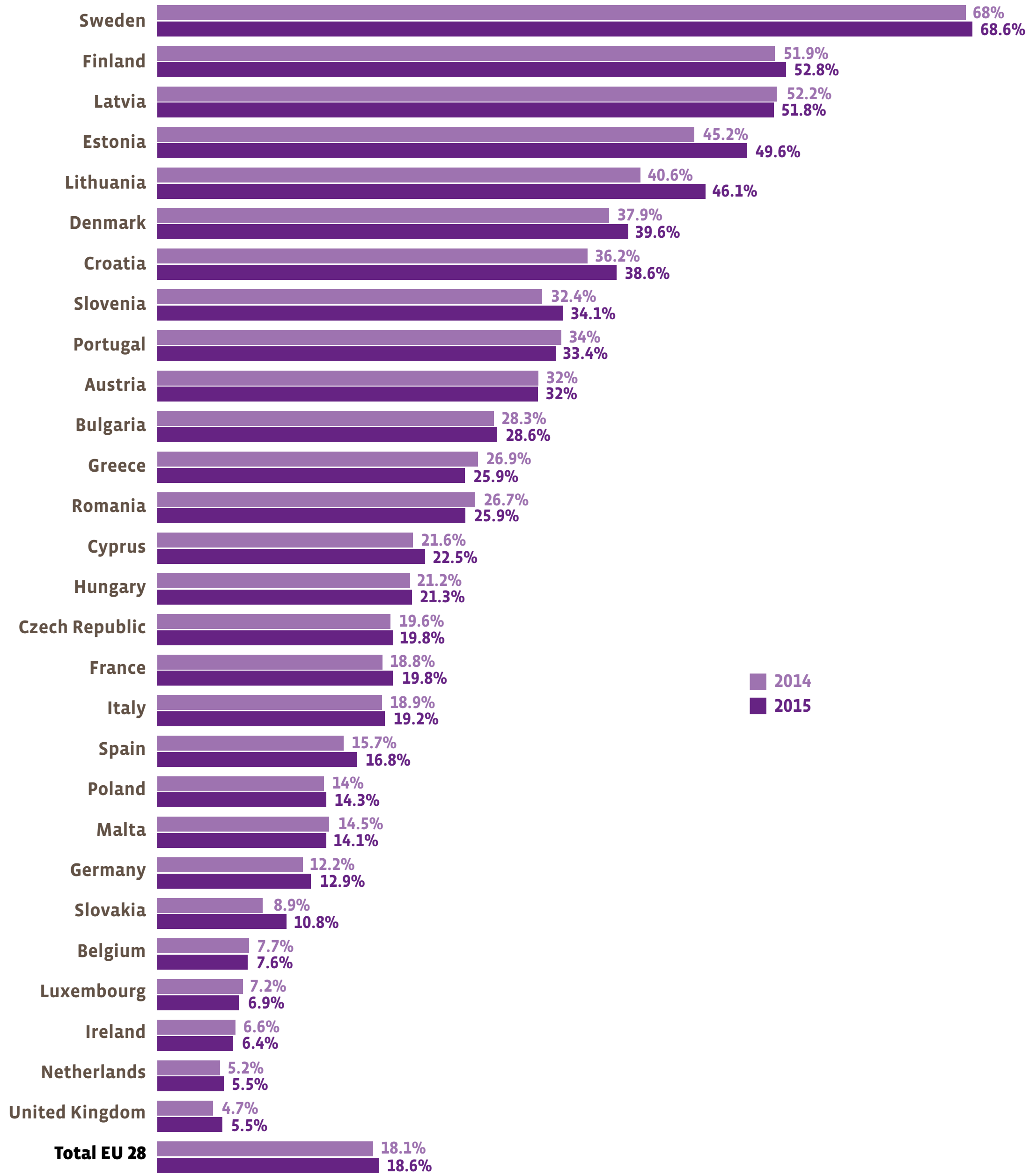
The total increase in heat consumption rose by 2.7% from 493.3 Mtoe in 2014 to 506.6 Mtoe in 2015, while the renewable heat share rose to 18.6%, i.e. a year-on-year gain of 0.5 PP (18.1% in 2014). If we take 2004 as the reference year (10.2%), the gain is as much as 8.4 PP.

As biomass is far and away the main renewable heat source, the renewable heat share of total consumption is naturally highest in the EU's forest countries. So while in Northern Europe its consumption sometimes predominates (68.6% in Sweden, 52.8% in Finland) and the Baltic States (51.8% in Latvia, 49.6% in Estonia and 46.1% in Lithuania), it is negligible in the Benelux (7.6% in Belgium, 6.9% in Luxembourg and 5.5% in the Netherlands) and in the British Isles (6.4% in Ireland and 5.5% in the UK).

From 2004 to 2015, the biggest increases in renewable heat shares were made in Sweden (21.9 PP), Denmark (19 PP), Estonia (16.4 PP), Slovenia (15.7 PP) and Lithuania (15.6 PP). This contrasts with the lowest increases

4

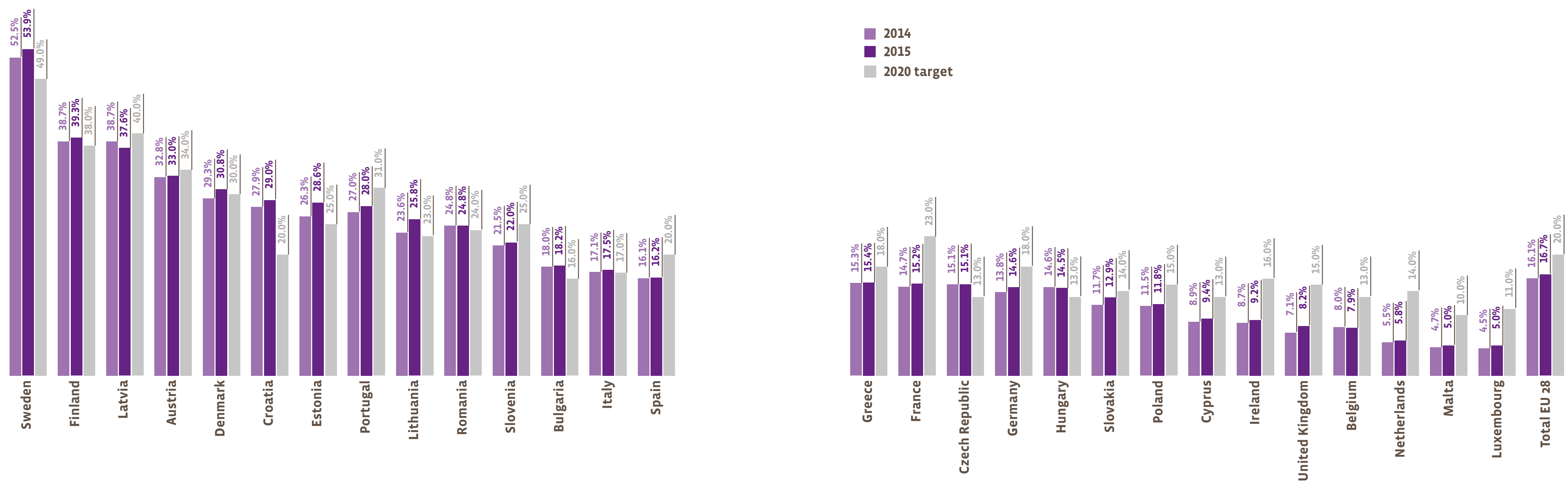
Share of renewable energy in heating and cooling of EU countries in 2014 and 2015 (in %)



Source: SHARES 2015

5

Share of energy from renewable sources in gross final energy consumption in 2014 and 2015 and 2020 targets (in %)



__Note:__ SHARES tool version 2015 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. ***Sources: EurObserv'ER based on SHARES 2015 data***

seen in the UK (4.8 PP), Belgium (4.8 PP), Poland (4.1 PP), Ireland (3.5 PP), the Netherlands (3.3 PP) and Portugal (0.9 PP), all of which have directed more of their efforts into renewable electricity-generating capacities.

ELEVEN COUNTRIES HAVE ALREADY MET THEIR EUROPEAN TARGET FOR 2020

The key indicator of the European Union's energy strategy, whose agreed 2020 target has been set at 20% and will rise to 27% for 2030, is the renewable energy share of gross finale energy consumption.
According to data released on 14 March 2017 produced by the Eurostat monitoring tool, SHARES, the European Union has again succeeded in increasing this renewable energy share. In 2015 it rose to 16.7% compared to 16.1% in 2014 (adding 0.6 PP), and now stands at about double the level in 2004 (8.5%), the first year for which data is available. Yet this increase is a little lower than the three previous years' performance levels (1.2 PP between 2011 and 2012, 0.7 PP between 2012 and 2013 and 1 PP between 2013 and 2014).

Admittedly, each Member State has its own target that factors in the differences in initial situation, renewable energy potentials and economic performance. A progress report on the year 2015 shows that most of the countries are on track to meet target, which means, either they have met their target or they are on course as per the indicative trajectory defined in the Renewable Energy Directive. In 2015, only three countries were behind their trajectory – France (by 0.8 PP), the Netherlands (by 1.8 PP) and Luxembourg (by 0.5 PP). The shortfall observed in France applies to both renewable electricity and heat, and was exacerbated by the unusual weather conditions in 2014 and 2015 that took their toll on wood fuel consumption. The same applies to the shortfall observed in Luxembourg. In the Netherlands, part of the delay should be remedied next year when the Gemini offshore Wind Farm (600 MW), the second biggest in Europe, as well as the Westermeerwind near-shore Wind Farm (144 MW), come on stream and will revitalize its wind energy sector.

Eleven of the European Union's 28 Member States have already met their 2020 target, namely Sweden, Finland, Denmark, Croatia, Estonia, Lithuania, Romania, Bulgaria, Italy, the Czech Republic and Hungary. In the case of Hungary, a new household consumption survey has led to the assessment of its wood energy consumption being dramatically upgraded. We note that prior to Hungary, other countries' successful target achievements were aided by more thorough surveys of household wood energy consumption. This applies to Italy, while Austria and Slovakia are very close to reaching target, of about 1 PP, which could be met quite simply if weather conditions revert to normal for a year.

In the next few years, the following countries will have to invest much more effort if they are to make their national targets – the Netherlands (8.2 PP to make up), France (7.8 PP), Ireland and the UK (6.8 PP for both of them) and Luxembourg (6 PP) – all of which had initially set high ambitions when the directive was being drafted.

While these countries may find it hard to meet their national targets, achievement of the common 20% target is very much on the cards, boosted by the fact that the energy policies of a number of countries,

6

Share of energy from renewable sources in gross final energy consumption in 2014 and 2015 and indicative trajectory (in %)

Country	2014	2015	*Indicative trajectory 2015-2016*
Sweden	52.5%	53.9%	43.9%
Finland	38.7%	39.3%	32.8%
Latvia	38.7%	37.6%	35.9%
Austria	32.8%	33.0%	28.1%
Denmark	29.3%	30.8%	22.9%
Croatia	27.9%	29.0%	15.9%
Estonia	26.3%	28.6%	21.2%
Portugal	27.0%	28.0%	25.2%
Lithuania	23.6%	25.8%	18.6%
Romania	24.8%	24.8%	20.6%
Slovenia	21.5%	22.0%	20.1%
Bulgaria	18.0%	18.2%	12.4%
Italy	17.1%	17.5%	10.5%
Spain	16.1%	16.2%	13.8%
Greece	15.3%	15.4%	11.9%
France	14.7%	15.2%	16.0%
Czech Republic	15.1%	15.1%	9.2%
Germany	13.8%	14.6%	11.3%
Hungary	14.6%	14.5%	8.2%
Slovakia	11.7%	12.9%	10.0%
Poland	11.5%	11.8%	10.7%
Cyprus	8.9%	9.4%	7.4%
Ireland	8.7%	9.2%	8.9%
United Kingdom	7.1%	8.2%	7.5%
Belgium	8.0%	7.9%	7.1%
Netherlands	5.5%	5.8%	7.6%
Malta	4.7%	5.0%	4.5%
Luxembourg	4.5%	5.0%	5.4%
EU 28	16.1%	16.7%	-

__Note:__ SHARES tool version 2015 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 2015__

especially in Northern Europe, should easily take them well over target. Another point which was not in the original picture should also affect the results –Brexit. The British Government activated article 50 of the Lisbon Treaty on 29 March 2017, formally starting divorce proceedings with the European Union. Now it is more than likely that the final 2020 target assessment will be made without the UK. Brexit should make meeting the target easier in accounting terms, as the renewable share of the European Union of 27 will automatically drop to 17.8% in 2015. But that is almost a detail. In these uncertain times for European construction, formation of the Energy Union, the major European Union programme that aims to relaunch integration of European energy sector to ensure Europe's energy independence and combat climate change, will certainly be at the heart of the re-founding of the European Union. The programme has set its sights on making the EU the "world number one in renewable energy and lead the fight against global warming", by reducing its energy use by at least 27% and its GHG emissions by at least 40% by 2030. ■

SOCIO-ECONOMIC INDICATORS

Also in this year, the following chapter sheds a light on the European renewable energy sector in terms of socio economic impacts. It updates (and partially retroactively revises) or adds new data reported by numerous institutions concerning turnover and gross employment in 10 renewable energy sectors. All 28 Member States composing the European Union in 2014 and 2015 are covered. The aggregates refer to the employment figures and turnover sales generated in the two preceding years 2014 and 2015.

Methodological note

The socio economic indicators published in the subsequent section were derived from a large variety of sources. National statistical offices and national energy agencies provided the bulk of the energy data. Complete national socio economic statistics for turnover and employment for all sectors annually updated and published in France (Ademe), Germany (AGEE-Stat, BMWi, DLR/GWS), Austria (BMLFUV, BMVIT/EEG), and the United Kingdom (REA/PwC). Further national accounts on socioeconomic impacts for some RES sectors with different methodological approaches are available for the Netherlands (ECN, CBS) and Sweden (SCB).
When no national data was officially available, estimations based on energy data (installed capacities or energy output), or on regularly updated and improved employment and investment ratios have been conducted. Job factors and turnover ratios were derived from the Energy [r]evolution report published by Greenpeace / GWEC and SPE (September 2015). For the employment section this report contained an updated methodology part prepared by the Institute for Sustainable Futures (ISF).
Further valuable and inspiring sources for the investigation and for cross-check validation are renewable energy industry associations on EU level (such as WindEurope (formerly EWEA), SPE (SolarPowerEurope - formerly EPIA), AEBIOM (biomass), Estif (solar thermal), EHPA (heat pumps), ePure (biofuels), ESHA (small hydro), or CEWEP (waste), as well as on national level (iG Windkraft, Wind in Austria), BWE (wind in Germany), ANEV (wind in Italy), AEE

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(wind in Spain), Svensk Vindenergi (wind in Sweden), PWEA (wind in Poland), BSW-Solar (PV in Germany), SVEBIO (biomass in Sweden), Finbio (biomass in Finland), Sulpu (heat pumps in Finland), SVEP (heat pumps in Sweden), APPA (all RES in Spain), BEE (all RES in Germany), SOES (all RES in France).
Beyond, dedicated reports from the European Union (Eurostat-SHARES Joint Research Centre - JRC), and the international sphere such as the REN21 Global status report, IRENA capacity statistics (2015+2016), the IEA-Photovoltaic Power Systems (PVPS) national status reports, the IEA-Renewable Energy Technology Deployment (IEA-RETD) employment statistics as well as GWEC/Greenpeace Sustainable Energy Outlook proved to be more than helpful.

*Once more this year, some data consolidation and retroactive revisions have been done in some Member States. The socio economic indicators given in this chapter **cannot be directly compared to the figures published last years' edition of "State of renewable energy in Europe 2015"**. The published figures though accurately represent the trends observed during the past two years.*

EurObserv'ER endeavoured to apply a consistent definition and scope of the presented indicators:

- *In order to represent the tentative nature of EurObserv'ER estimations, job figures are **rounded** to 50 jobs and turnover indicators to €5 million.*

- *Employment data refers to **gross employment**, i.e. not taking into account job losses in other industrial sectors or due to reduced investment in other sectors. Net employment effects will be estimated in the course of later EurObserv'ER publications.*

- *Turnover figures are expressed **in current million euros (M€)**. Turnover data found in non-Euro currency countries (Denmark, Sweden, United Kingdom) were converted into EURO, based on **averaged annual conversion rates** for 2015 as published by Eurostat.*

- *Employment and turnover refer to the main economic investment activities in the renewable energy technology supply chains, namely **manufacturing, distribution and installation of equipment, plant operation and maintenance**.*

- *Turnover and employment arising from electricity or **heat sale, training activities, or publicly funded research, etc. are excluded**. Turnover figures for France, published by Ademe include sales of energy.*

- *Socio economic indicators for the bioenergy sectors (biofuels, biomass and biogas) include the upstream part, namely **fuel supply in the agricultural, farming and forestry sectors**.*

Federal Ministry
for Economic Affairs
and Energy

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WIND POWER

The year 2015 once more confirmed the strong trend and leading role of wind power in the European renewable energy sector. With 12.5 GW of newly installed capacity the sector grew slightly against 2014. EurObserv'ER estimates a sector ***turnover of over € 49.1 billion for 2015***. Employment level should have been risen slightly to around 332 250 jobs in the EU-28. WindEurope – the European Wind Energy Association formerly known as EWEA - projected in a high-scenario, that implementing ambitious post-2020 renewables policies could boost the job count to 366 000 by 2030. Considering the enormous shifts in global investment towards renewables - meanwhile also widely acknowledged by IEA - this number does not seem to be too far away and might be achieved by 2020 already if the current momentum continues.

Germany remains the wind primus in terms of employment in Europe. Data released with the Fifth Annual Monitoring report on the Energiewende reveal a ***sector turnover of € 11 600 million*** and a work force of ***142 900 jobs*** in the country with a slightly grown share of 20 500 jobs thereof in the offshore segment. Despite a record year in terms of installation (over 6 GW in total) the number declined by around 7 000 employees in the industry against 2014. In early 2017 Germany also confirmed the upward trend of offshore installations in the North and the Baltic Sea, with Deutsche Wind Guard quantifying them at 9 695 MW of new installed and connected capacity.

The ***United Kingdom*** is the nearly unrivalled offshore leader and is the second largest wind market in the EU in terms of socioeconomic impacts: ***€ 8 billion in turnover and more than 41 000 jobs*** are reported in the annually updated renewable sector report by REA (Renewable Energy Agency) and PriceWaterhouseCooper (PwC).

Denmark in many ways was pioneering of wind power in the EU and globally. The Danish wind industry association also annually published data on its wind industry. 2014 and 2015 saw further advancements and continued growth with ***€ 11 425 million and 31 250 persons*** working in the countries numerous turbine manufacturing and component supply. The increase also reflects the rise in new installations domestically from 68 MW in 2014 to 168 in 2015.

Lagerwey Wind – Finlande

The situation in ***Spain*** is paradox in that the country generates a significant turnover and is home to some ***22 500 employees*** in the wind industry, despite zero MW of new installations in 2015. This can be explained by the fact that the Spanish wind industry – and specifically the wind industry giant Gamesa – is the world's third largest exporter of wind turbines. So Spain is producing wind technology exclusively for exports. The country's industry body AEE states that Spain has 195 wind related factories, and is the world's fifth largest wind turbine manufacturing capacity[1].

1. Source: AEE 2015: The Government launches a Plan to support the Spanish wind energy industry.

Employment and turnover

	Employment (direct and indirect jobs)		Turnover (in M€)	
	2014	2015	2014	2015
Germany	149 200	142 900	13 700	11 600
United Kingdom	38 300	41 100	7 300	7 925
Denmark	30 000	31 250	11 330	11 425
Italy	30 000	26 000	1 000	2 000
Spain	18 000	22 500	3 800	4 500
France	20 000	22 000	3 080	3 170
Poland	8 400	11 500	1 000	2 000
Sweden	9 900	6 500	1 700	1 100
Netherlands	2 000	6 300	800	1 500
Austria	6 000	5 500	980	1 070
Finland	1 700	3 300	300	570
Belgium	3 700	2 800	1 025	565
Ireland	2 500	2 500	400	410
Portugal	3 000	2 500	430	370
Greece	2 000	2 000	310	315
Romania	2 200	1 100	750	150
Lithuania	100	1 000	15	200
Croatia	750	750	130	125
Bulgaria	300	200	45	25
Cyprus	<50	150	<5	20
Czech Republic	200	100	35	15
Estonia	500	100	90	15
Hungary	100	100	15	15
Latvia	<50	<50	<5	<5
Luxembourg	<50	<50	<5	10
Slovakia	<50	<50	<5	0
Slovenia	<50	<50	<5	<5
Malta	0	0	<5	0
Total EU	**329 100**	**332 350**	**48 265**	**49 105**

Source: EurObserv'ER 2016

In 2016, the Polish wind Industry association claimed that 8 400 persons were directly and indirectly employed in ***Poland*** in 2014. EurObserv'ER in its last edition has thus underrated the sector. Considering market development in 2015 (+1 260 MW new installed) EurObserv'ER confidently assumes ***11 500 jobs and a sector volume of € 2 000 millions*** for 2015.

Wind energy sector has once more confirmed its leading role in terms of socio economic impacts in the European Union's renewable energy sector. The revived strengths of new installations is an indication of the sectors prosperity although depending strongly on the market development in Germany. In the light of changes from feed-in tariffs to tenders in Germany from 2017 onwards, observers warn of a potential installation rush and of a possible downward trend from 2018 on. Be it as it is. The growth of renewables over the past decades have surprised and exceeded analysts and the general public's expectations again and again. ■

EUROBSERV'ER – THE STATE OF RENEWABLE ENERGIES IN EUROPE – 2016 EDITION

PHOTOVOLTAIC

After three years of consecutive market decline, 2015 saw a slight increase in installation activity in the EU again (+7.8 GWp), after 6.9 GWp in 2014. But this has to be put into perspective: once the global leader in PV deployment, the continent is meanwhile dwarfed by China that has installed more than 15 GWp in 2015 and an all-time-record-breaking 34 GWp in 2016.[1] Ironically, Europe has installed the vast part of its PV plant fleet at times when costs were still relatively high and retreat from the market, just when the costs have reached levels competitive with conventional power plants. Still the fame for historically bringing down PV costs by economies of scale and deploying innovative financing schemes can be attributed to the European Union. Overall the European PV industry in 2015 still created turnover of roughly **€ 16 billion** and employment of an nearly **111 000 persons** (down from over 115 000 the year before). The installation costs went down further although not at the speed witnessed during the years before.

The **United Kingdom** has confirmed its top spot in terms of installation for a second year, and even expanded its annual addition to over 3.5 GW. REA and PwC in their annual account of the British renewable energy scene reported a PV job force of **16 900 persons and a sector turnover of over € 3.4 billion** (at averaged 2015 exchange rates). This represents the highest economic impact of PV of all EU countries.

Once leader in EU and global PV installations, **Germany** once more remained far below the target corridor of 2.4-2.6 GWp with "only" 1 355 MWp. Accordingly the job losses in the German PV industry continued further. The country's working group on renewable energy statistics (AGEE-STAT) claims a sector turnover of

1. PVMA estimates global PV installations at 75 GW in 2016, expects stable market in 2017, Solarserver, 19 January 2017.

Employment and turnover

	Employment (direct and indirect jobs)		Turnover (in M€)	
	2014	2015	2014	2015
Germany	38 300	31 600	3 700	3 000
United Kingdom	16 100	16 900	3 180	3 410
France	17 000	16 150	3 920	4 440
Italy	10 000	12 500	2 340	2 500
Netherlands	5 500	7 000	500	660
Spain	6 500	6 500	300	350
Austria	3 600	3 400	580	615
Belgium	3 400	3 400	250	180
Denmark	850	2 500	70	250
Greece	2 000	1 900	75	65
Czech Republic	1 500	1 700	40	60
Romania	4 000	1 300	450	70
Poland	350	1 100	40	80
Hungary	500	900	70	85
Portugal	1 800	750	200	60
Sweden	700	750	80	90
Bulgaria	750	700	25	20
Slovakia	400	400	15	15
Malta	400	300	40	25
Slovenia	500	300	20	10
Croatia	200	150	25	15
Luxembourg	250	150	25	25
Cyprus	200	100	50	10
Lithuania	<50	100	<5	10
Estonia	0	<50	<5	<5
Finland	100	<50	<5	<5
Ireland	<50	<50	<5	<5
Latvia	<50	<50	0	0
Total EU	**115 050**	**110 750**	**16 015**	**16 060**

Source: EurObserv'ER 2016

€ 3 billion (down from € 3.7 billion) and 31 600 jobs. These are again 7 000 jobs less than in 2014.

There is still room for PV market expansion in ***France***. The tendering schedule in the country foresee volumes of 4 350 MWp of PV until 2019, which, if realized will bring the French market below the 10 GWp threshold. The evaluation of the work force is about ***16 150 jobs*** and a ***€ 4.4 billion sector turnover***.

Better progress was evident in the ***Netherlands*** (EurObserv'ER estimates over ***€ 660 million in turnover and 7 000 jobs***) where installation activity increased substantially to 350 MW or a slightly growing ***Italian*** market with a regained workforce of ***12 500 employees € 2.5 billion*** in industry sector turnover.

However, most EU Member States display decreases, further evidence that the major market momentum and production capacity has shifted to other world regions. The good news is that for the first time PV electricity generation has passed the ***100 TWh*** threshold. And in 2016 Germany has exceeded the 40 GWp mark for cumulated installations.

The photovoltaic development context has deteriorated politically in contrast to most of the world's major markets. Europe's electricity market is still characterized by power overcapacities. And in the face of dwindling political support for PV the socioeconomic outlook for the next years is rather bleak. Hence, the leading UK market has stepped on the brakes by introducing ceilings to frame the annual PV growth while Germany is introducing tenders and will remain below its self-set targets. In this context, more or less maintaining even the current employment and sector turnover levels might be judged as a success. ■

SOLAR THERMAL

Once more the solar thermal market declined between 2014 and 2015. Italy, Spain, France, Austria, Germany, Poland and Greece are the EU frontrunners in terms of cumulated solar thermal collector area. Overall, EurObserv'ER observes a sector turnover of roughly ***€ 3.47 billion*** and jobs in the area of manufacturing, installation and O&M ***of 37 300***. In its 2016 Trends and market statistic report, Estif, the European Solar Thermal Industry Federation, assumes an economic volume of the solar thermal activity with a combined turnover of € 1.9 billion in 2015, employing approximately 23 700 people directly involved in the sector.[1]

One of the few exceptions is ***Poland*** that saw a growing solar thermal market. Accordingly, EurObserv'ER estimates the Polish sector at over ***2 750 jobs*** and ***€ 235 million*** in turnover.

Greece represents the third largest EU market in terms of new solar collector installations. The country benefits from replacements and tourisms based investments. We value the country's labour force at a stable ***2 700 persons*** and ***€ 230 million***, around the size of the UK industry. Also installation activity in the ***United Kingdom*** collapsed after the exclusion of solar thermal from the RHI (Renewable Heat Incentive) list of eligible technologies. Socioeconomic figures reported by REA/PwC do thus not seem plausible which is why EurObserv'ER rates the sector at ***€ 250 million and 750 jobs***.
The solar thermal market contracted by almost another 10%

in ***Germany***. The annual gross employment statistics prepared by DLR/DIW/GWS report no major changes in the CSP technologies, but monitored a further decline in both turnover (***€ 1 billion*** against € 1,1 billion in 2014), and employment (***10 600*** against 11 000 in 2014) concerning the solar thermal sector.

1. http://www.estif.org/fileadmin/estif/content/publications/downloads/Online_version_-_Solar_Thermal_Markets_in_Europe_-_Summary_-_Final_version.pdf

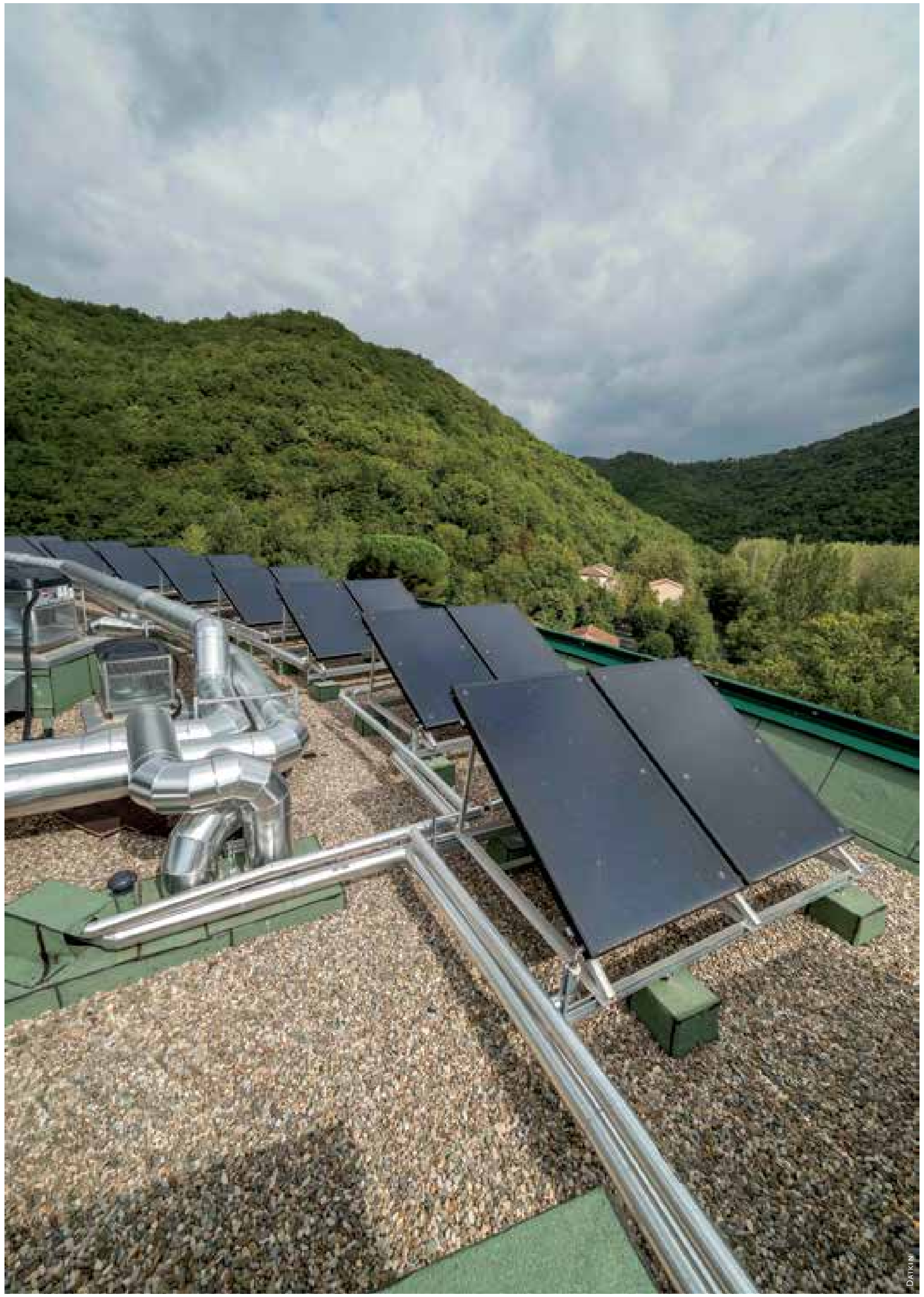
Also ***Austria*** (still the second largest EU turnover with ***€ 440 million and 2 800 jobs*** due to is broad manufacturer and installation base) saw declines by 11% compared to 2014. For ***France***, 2015 was once again a difficult year. The solar thermal collapsed both, housing and collective applications despite a support mechanism implemented during the last years. However the industry - ***€ 380 million and roughly 5 500 workers*** – still belongs to the largest in the European Union.

A reversal of the downward trend a projected in last year's annual report did not materialize. Solar thermal faces several market barriers for further penetration of RES heat such as continuously low fossil fuel prices, stagnating construction activity in the housing market, and the competition with technical solutions such as PV and heat pumps. ■

Employment and turnover

	Employment (direct and indirect jobs)		Turnover (in M€)	
	2014	2015	2014	2015
Germany	11 000	10 600	1 100	1 000
France	5 900	5 500	390	380
Spain	5 000	4 000	250	230
Italy	3 500	3 000	300	250
Austria	3 000	2 800	465	440
Poland	2 600	2 750	220	235
Greece	2 700	2 700	225	230
Denmark	1 800	1 850	150	155
United Kingdom	800	750	300	250
Czech Republic	750	600	60	50
Belgium	500	450	45	40
Portugal	500	450	45	40
Ireland	250	250	20	20
Netherlands	550	250	50	25
Croatia	200	200	20	20
Cyprus	200	200	15	15
Romania	200	200	15	15
Hungary	200	150	15	15
Slovakia	100	100	10	10
Sweden	100	100	10	10
Bulgaria	<50	<50	<5	<5
Estonia	<50	<50	<5	<5
Finland	<50	<50	<5	<5
Latvia	<50	<50	<5	<5
Lithuania	<50	<50	<5	<5
Luxembourg	<50	<50	<5	<5
Malta	<50	<50	<5	<5
Slovenia	<50	<50	<5	<5
Total EU	**40 250**	**37 300**	**3 745**	**3 470**

Source: EurObserv'ER 2016



SMALL HYDROPOWER

Small hydro power (up to installed capacities of up to 10 MW) is the less dynamic renewable energy sector. The reason for this being that most suitable sites are already utilized and new constructions being hindered by numerous legislative or environmental obstacles and regulations. EurObserv'ER monitors an increase of around 270 MW of new generating capacity in the European Union between 2014 and 2015. However, the electricity output is strongly depends on the annual precipitation amounts and on this point 2015, wasn't a good year. Indeed, gross electricity production declined to 44.6 TWh (down from 51.1 TWh in 2014).

There is only little literature on turnover and employment for the small hydro sector and it has to be noted that figures published for Austria, Germany, and the United Kingdom include the entire industry sector, i.e. large hydropower as well. Based on these statistics and published employment and turnover ratios, and taking into account strongly varying investment costs in the EU Member States, EurObserv'ER arrives at a slightly diminished head count of over ***46 150 jobs*** (slightly down from 49 200 in 2014) and a stable EU wide industry turnover of over ***€ 5.3 billion*** for small hydro. The countries with the largest small hydropower fleets are Italy (3 208 MW), France (2 065 MW), Spain (1 953 MW), Germany (1 327 MW) and Austria (1 280 MW).

Based on the Ademe data the sector turnover for small hydro plants is estimated around ***€ 450 million and 3 900 persons for France***. ***Austria***, one of the leading small hydro users published an annual sector turnover of ***€ 1.63 billion*** (down from € 1.69 in 2014). For ***Italy*** EurObserv'ER estimates around ***€ 1 billion*** in turnover considering the country's large number of small hydro plants and many technology and component suppliers. ***Germany*** saw a decline in new investment in small hydro power compared to the year before which is partly due to some methodological consolidations. The downward trend gross employment to ***6 700*** jobs (down from 11 800 in 2014) and ***€ 320 million*** may be reversed in the years ahead.

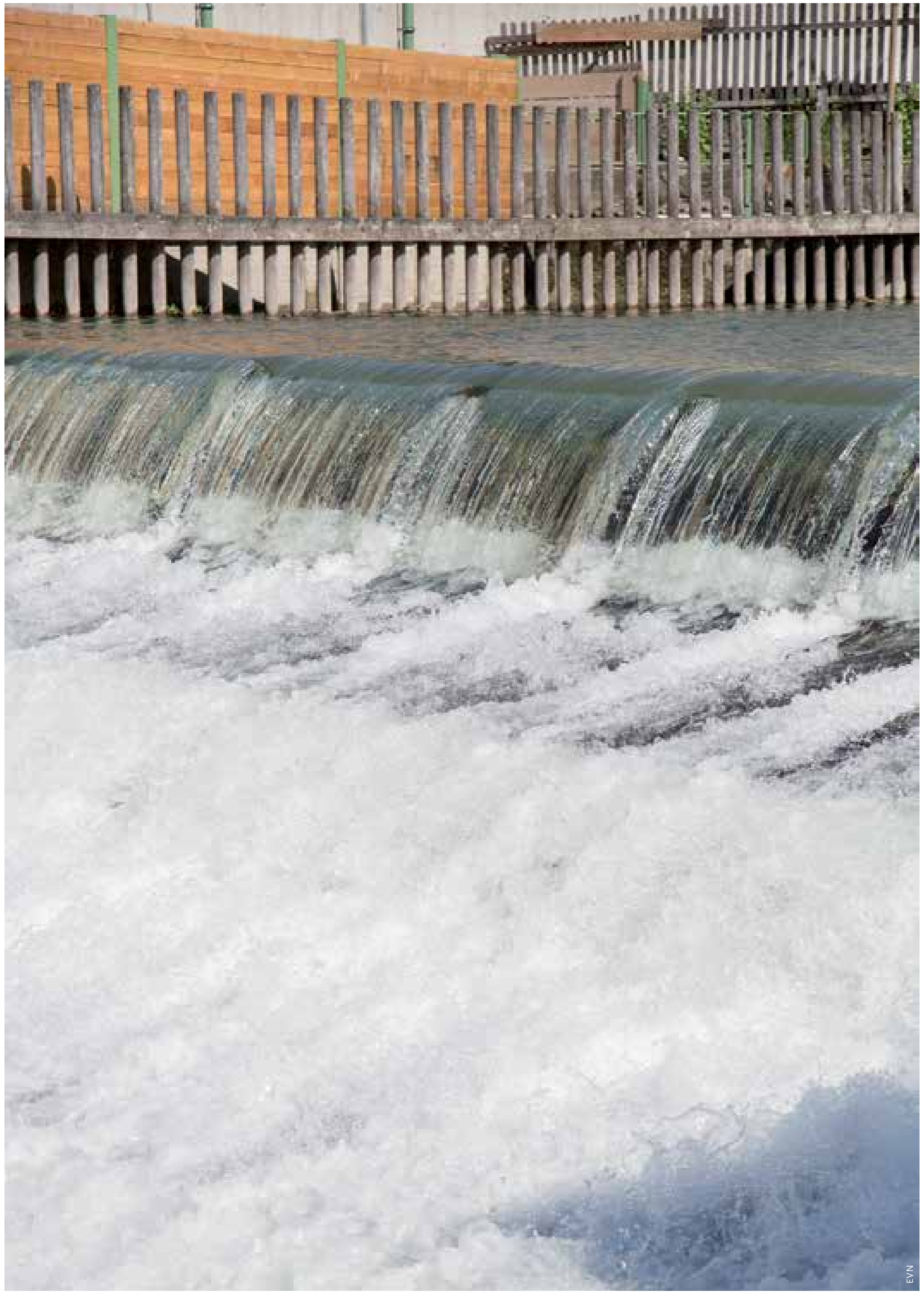
A small growth in both turnover and employment is monitored for the ***United Kingdom*** where the annual market report of the Renewable Energy Association (REA) published ***5 500 jobs and € 850 million turnover*** for 2015.

The growth of small hydro capacity is currently in phase with the intermediate power 2015 objectives defined by National Renewable Energy Action Plans. Its 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. The sector believes however that a significant development potential can still be realized. As part of the European project coordinated by Stream Map ESHA (European Small Hydropower Association), a road map (roadmap) was conducted taking into account the potential of the sector. The report estimates that small hydro plants could reach an installed capacity of 17.3 GW in 2020 to 59.7 TWh of a producible, more than what is provided under the action Plans. ■

Employment and turnover

	Employment (direct and indirect jobs)		Turnover (in M€)	
	2014	2015	2014	2015
Germany*	11 800	6 700	330	320
Austria*	6 250	5 850	1 690	1 635
United Kingdom*	5 400	5 500	820	850
Italy	4 500	5 000	880	1 000
Sweden	3 000	4 000	200	250
France	3 850	3 900	430	450
Romania	2 600	2 600	30	30
Greece	2 200	2 500	15	20
Portugal	2 100	2 000	60	40
Czech Republic	1 600	1 750	30	70
Spain	1 500	1 600	350	380
Poland	1 300	1 450	100	100
Slovenia	700	750	<5	10
Bulgaria	400	400	20	20
Finland	400	400	40	75
Slovakia	350	400	<5	20
Belgium	300	350	<5	15
Croatia	200	250	10	25
Ireland	200	200	<5	<5
Latvia	150	150	<5	<5
Luxembourg	150	150	<5	<5
Hungary	100	100	<5	<5
Denmark	<50	<50	<5	<5
Estonia	<50	<50	<5	<5
Lithuania	<50	<50	<5	<5
Cyprus	0	0	0	0
Malta	0	0	0	0
Netherlands	0	0	0	0
Total EU	49 200	46 150	5 055	5 345

** Figures for large and small hydro plants. Source: EurObserv'ER 2016*



EVN

GEOTHERMAL ENERGY

Nuon-Jorrit Lousberg

Not much activity could be witnessed in 2015 in the deep geothermal sector, that generates heat and electricity in larger plants and installations Cumulated net capacity of deep geothermal remained stable at 837 MW. Slight growth is monitored by national statistical offices in the direct use of geothermal energy. Installed heat capacity grew slightly to 3 448 MWth in 2015 compared to 3 320 MWth the year before. EurObserv'ER assesses the EU geothermal sector at an annual turnover of ***€ 1.56 billion and 12 600 jobs***. The largest shares of economic activity and employment are based on the operation and maintenance (O&M) part of existing power and/or heat generating facilities, in component manufacturing and geological engineering.

Italy is the unchallenged leader in terms of installed deep geothermal electricity capacity and production. The 768 MW operational in the country represent over 90% of the EU total capacity. The socioeconomic impacts associated with this amounts to ***6 000 employed persons*** in the Italian sector generating turnover of ***€ 700 million***. With a reasonable good underground potential for exploiting geothermal heat, primarily in the Ile-de-France region and in the east of the country, ***France*** is the next biggest player. Ademe quantifies the sector at ***€ 220 million and around 2 900 jobs***.

Officially published figures for other countries could only be found in the literature for ***Germany*** (1 200 jobs and around € 200 million turnover), and ***Austria*** (around 50 jobs and a turnover of € 20 million).

Geothermal remains the smallest sector observed in terms of socio economic impacts for the European Union. As mentioned in previous years: a lot of the near and mid-term future perspectives of the European geothermal sector will depend on the cost level of fossil fuels, which will affect investment decisions on renewable heat installations. Looking at the massive drop in oil and gas prices witnessed in 2015 this background trend was a very uncomfortable fact for the geothermal industry. Although being a mature technology the inherent limitations of geothermal resources and a low fossil fuel prices context prevent a larger market uptake, or to put it positively: there is room for further market development. ■

Employment and turnover

	Employment (direct and indirect jobs)		Turnover (in M€)	
	2014	2015	2014	2015
Italy	5 500	6 000	600	700
France	2 600	2 850	180	220
Germany	1 100	1 200	190	200
Hungary	1 000	1 000	180	75
Romania	200	200	40	20
Netherlands	150	150	100	150
Slovakia	150	150	25	25
Bulgaria	<50	100	15	40
Croatia	100	100	10	<5
Denmark	100	100	<5	<5
Greece	100	100	<5	<5
Lithuania	100	100	<5	<5
Poland	<50	100	20	25
Portugal	100	100	30	10
Austria	100	<50	25	20
Belgium	<50	<50	<5	<5
Czech Republic	0	<50	<5	<5
Slovenia	<50	<50	15	15
Spain	<50	<50	<5	<5
United Kingdom	<50	<50	15	15
Sweden	<50	<50	10	10
Estonia	0	0	0	0
Finland	0	0	0	0
Ireland	0	0	0	0
Latvia	0	0	0	0
Luxembourg	0	0	0	0
Malta	0	0	0	0
Cyprus	0	0	0	0
Total EU	**11 650**	**12 600**	**1 485**	**1 560**

Source: EurObserv'ER 2016

HEAT PUMPS

Thermia/Danfoss

The European heat pump sector increased by 20% in 2015 with air source heat pumps gaining substantial market shares. Over 2.6 million heat pumps of all types were sold in the EU market. The socio economic impact of the European heat pump sector covers the aerothermal and geothermal heat pump segment and explicitly excludes the deep geothermal energy sector.

Taken together the positive market development of the aerothermal segment has increased the European sector turnover to around ***€ 21.4 billion*** in 2015 (up from € 18 billion in 2014), representing one of the largest turnover leaps of all RES technologies covered. Also the head count is positive with an additional 12 000 jobs now totaling ***111 000 persons*** throughout the European Union.

France is still the top European market concerning job creation with a job force totaling around ***34 700*** and with a sector turnover of ***€ 2.6 billion for 2015***. This figure is largely due to the ease to install air heat pumps in new buildings, thanks to the French RT 2012. However, the French market is mainly driven by aerothermal equipment while geothermal heat pumps market is constantly shrinking since the last 5 years.

Italy (€ 6.5 billion) and Spain (€ 5.5 billion) rank first in terms of national heat pump turnover. The reason for this being the high installation rate and share of aerothermal heat pump applications. Accordingly the head count, according to EurObserv'ER estimations, also moved upwards: ***10 000 in Italy and 7 500 in Spain***. For ***Austria*** the annual market statistics of BMVIT monitored a rise in sales of heat pumps and export activity. The Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) published a figure of ***2 200 jobs*** in the ambient heat sector and a turnover of ***€ 515 million***.

For ***Germany*** AGEE-Stat monitored a reduced investment activity in heat pumps and the deep geothermal sector. The heat pump

Employment and turnover

	Employment (direct and indirect jobs)		Turnover (in M€)	
	2014	2015	2014	2015
France	31 400	34 700	2 350	2 600
Germany	16 100	16 100	1 710	1 700
Italy	8 500	10 000	5 300	6 500
United Kingdom	8 300	8 600	1 510	1 600
Sweden	6 400	7 800	590	700
Spain	4 900	7 500	4 050	5 500
Portugal	5 100	7 000	450	620
Netherlands	4 000	4 400	350	390
Belgium	3 100	3 000	275	260
Denmark	1 800	2 400	160	215
Austria	1 900	2 200	440	515
Bulgaria	1 900	1 900	175	175
Finland	2 000	1 600	400	350
Estonia	1 300	1 350	115	120
Poland	600	750	50	65
Czech Republic	550	650	45	55
Slovenia	500	400	40	n.a.
Ireland	200	300	15	30
Hungary	<50	100	<5	<5
Lithuania	<50	<50	<5	<5
Luxembourg	<50	<50	0	0
Slovakia	<50	<50	<5	<5
Croatia	0	0	0	0
Cyprus	0	0	0	0
Greece	0	0	0	0
Latvia	0	0	0	0
Malta	0	0	0	0
Romania	0	0	0	0
Total EU	**98 750**	**110 900**	**18 040**	**21 450**

Source: EurObserv'ER 2016

work force remained stable at ***16 100 employees*** and so did the turnover stabilize at ***€ 1.7 billion***. The annual market account of the Renewable Energy Agency for the ***United Kingdom*** claims ***8.600 jobs*** in the British Air and Ground Source Heat Pump market. The rising number of heat pump sales in all segment in the UK translate in a higher turnover by UK companies totaling ***€ 1.6 billion for 2015***. In Sweden the national heating and cooling association SKVP has announced a successful year 2015 with over 100 000 heat pumps sold and states annual turnover of around ***€ 700 million*** (2015 Euro exchange rate to the Kronor, up from € 590 million in 2014). We estimate around ***7 800 jobs*** in the sector for ***Sweden*** that is a major user of heat pumps. Also here the share of air sourced heat pumps grew. In Finland, the Heat Pump Association Sulpu quantifies investment of private end users at ***€ 350 million*** for the ***Finnish heat pump sector*** for 2015. The market – except for air/water heat pumps contracted by 12% between 2014 and 2015 but still Finland belongs to the technology leaders in the EU in terms of socioeconomic impacts.

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

Mitsubishi Electric

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BIOGAS

The Growth of primary production of all types of biogas slowed down in 2015 compared to the trend observed over the first years of the decade. EurObserv'ER estimates a total turnover of ***€ 6.9 billion*** in all EU Member States. Employment should even have decreased from around 68 200 in 2014 to roughly ***63 950 jobs in 2015***. The EU market is dominated by the three major biogas producing countries Germany, the United Kingdom and Italy, which have a thriving manufacturing scene.

The largest share stems from the EU leader Germany (45 000) but following the reform of the EEG regulation and a de facto market cap of 100 MW for biomass installations, there is no foreseeable revival. According to information by AGEE-Stat,the working group on renewable energy statistics in ***Germany*** the biogas sector witnessed a decline in sector employment to ***45 000*** in 2015 (down from 48 500 in 2014). Whereas the equipment exports of German manufacturers were stable, domestic investments in new installations though dropped

VIESSMANN

by 58%. EurObserv'ER estimates a ***turnover of € 2.350 million***. The 2014 and 2016 amendments to the renewable energy sources act (EEG) have led to factual standstill in the biogas market that is even below the target threshold of 100 MW capacity annually.

The ***United Kingdom*** is one of the few countries were published job and turnover figures are available. The renewable energy agency and PwC market statistics announce a sector turnover of £ 347 million, which is equivalent to ***€ 480 million*** at average 2015 exchange rates. The report also identifies ***2 800 jobs*** in the anaerobic digestion sector in the United Kingdom.

Italy is also home to a slightly growing biogas industry and the trends going upwards again. We calculate a sector worth ***€ 2.5 billion and 5 500 employees*** for 2015.

France comes in on fourth place regarding the primary energy

Employment and turnover

	Employment (direct and indirect jobs)		Turnover (in M€)	
	2014	2015	2014	2015
Germany	48 300	45 000	2 500	2 325
Italy	5 000	5 500	2 700	2 500
France	4 200	4 400	540	610
United Kingdom	2 850	2 800	470	480
Czech Republic	1 200	900	150	150
Poland	900	800	50	60
Austria	650	650	195	185
Belgium	700	550	50	65
Netherlands	600	500	150	170
Spain	600	500	90	65
Denmark	350	250	35	40
Finland	250	250	25	25
Greece	150	200	20	25
Ireland	300	200	15	15
Slovakia	750	200	25	40
Croatia	<50	150	<5	10
Hungary	150	150	20	20
Latvia	200	150	20	20
Lithuania	150	150	<5	<5
Portugal	300	150	<5	20
Bulgaria	<50	100	<5	<5
Slovenia	200	100	10	10
Sweden	100	100	40	45
Cyprus	<50	<50	<5	<5
Estonia	<50	<50	<5	<5
Luxembourg	<50	<50	<5	<5
Romania	100	<50	<5	<5
Malta	0	0	0	0
Total EU	**68 250**	**63 950**	**7 145**	**6 910**

Source: EurObserv'ER 2016

production. Based on the Ademe analysis of the French renewable energy sector, Observ'ER states a turnover of ***€ 610 million*** and estimates a French labor work force of ***4 400 persons***.

In total, biogas remains a rather small niche sector of renewable energy deployment throughout the EU, despite the unchallenged inherent advantages of biogas energy production that is independent of climatic conditions that can provide electricity and heat and might even play a more crucial role in leveling grid fluctuations or even provide transport fuels in the form of biomethane. So far these potential are not yet fully tapped on a wide scale in the European Union. Possibly the EU energy package might stimulate the sector so that these evident factors might materialize in the medium or longer term. ■

BIOFUELS

The year 2015 was tough for Europe's biofuel industry players. The European Union-wide drop in fuel consumption was compounded by a number of countries' refusals to increase their incorporation targets that has limited market opportunities for the sector. EurObserv'ER estimates a drop in European biofuel consumption of -0.9% between 2014 and 2015 now standing at 14.1 MTOE. Biodiesel still accounts for roughly 80% of overall biofuel consumption.

In this context, the quite stable socioeconomic indicators may thus be seen as a success already. The biofuel sector estimations (a stable ***95 900 persons employed*** and a sector turnover of ***€ 13.1 billion in 2015***) take the supply side activities in the agricultural sector and biofuel imports from non-EU countries into account. The range of jobs profiles in the biofuel sector and industry is wide, including farmer sector, engineering activities or tanker drivers in the process of feed-stock production. Beyond, jobs are visible in the design and development construction of biofuel plants and the operation and maintenance besides the entire fuel logistics.

Along with the observed trends throughout Europe, the market in ***Germany*** witnessed a decrease of 14% in biodiesel production and a slight increase of 2% in bioethanol. The working group on renewable energy statistics (AGEE-Stat) states a reduced biofuel turnover of ***€ 2.5 billion*** for 2015 and a slightly diminished number of ***22 800 jobs*** for the German biofuel industry.

France remains one of the leading biofuel users in the EU-28. The industry creates turnover of over ***€ 3 billion and with 22 000 jobs*** employs a significant share of the total EU biofuel work force.

Other leading users include the United Kingdom, Italy, Poland, Spain and Sweden. ***Spain*** saw a rise in biodiesel consumption but a drop in bioethanol. The overall increase in total consumption is reflected in some higher sector turnover of ***€ 920 million*** but due to the financial troubles of some leading biofuel industry leader should have dropped to around ***7 500 jobs***.

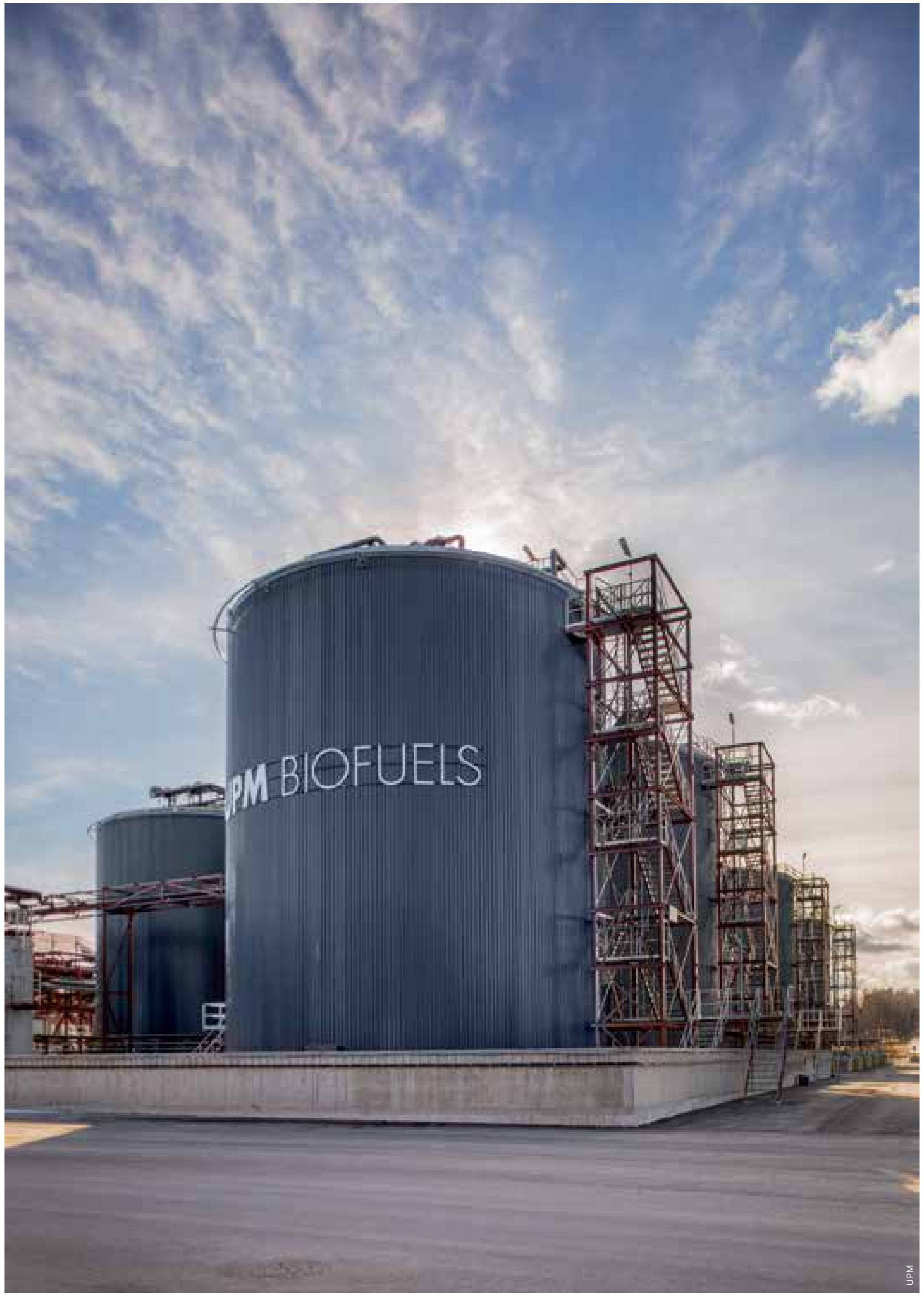
For the ***United Kingdom***, the annual renewable energy market review of REA and PwC, the UK biofuel sector is estimated at a volume of ***€ 740 million*** turnover and an industry totaling ***3 900 jobs***.

The European Council has clarified European biofuel policy for 2020, by penning a new directive in September 2015. Many of the key Member States have clarified their roadmaps to 2020 and are set to achieve their 10% renewable energy target for transport. While, from a regulatory stance, the issue of biofuel use in transport is regulated through to 2020, uncertainties remain for the post-2020 period and their significance through to 2030. The European Commission intends to present a new renewable energy directive for 2020–2030 to address this with a new common invariable European renewable energy target of 27% right across the Member States. ■

Employment and turnover

	Employment (direct and indirect jobs)		Turnover (in M€)	
	2014	2015	2014	2015
Germany	23 100	22 800	2 700	2 500
France	22 000	22 000	3 250	3 030
Belgium	8 300	7 500	350	250
Spain	10 000	7 500	930	920
Italy	5 500	6 000	1 000	1 100
Poland	5 900	6 000	700	710
Sweden	3 300	4 500	900	1 000
United Kingdom	3 800	3 900	720	740
Netherlands	3 000	2 800	330	300
Finland	1 900	1 800	200	200
Portugal	1 500	1 600	280	330
Czech Republic	1 400	1 400	320	330
Luxembourg	1 300	1 400	65	80
Austria	1 100	1 200	365	400
Denmark	1 200	1 100	250	200
Greece	700	750	130	140
Hungary	600	650	145	200
Romania	900	650	200	200
Slovakia	400	550	130	130
Bulgaria	300	500	50	50
Ireland	350	400	110	120
Lithuania	300	300	60	65
Slovenia	150	200	30	30
Croatia	150	150	30	30
Latvia	100	100	20	25
Cyprus	<50	<50	15	10
Estonia	<50	<50	<5	<5
Malta	<50	<50	<5	<5
Total EU	**97 400**	**95 900**	**13 290**	**13 100**

Source: EurObserv'ER 2016



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RENEWABLE URBAN WASTE

The renewable biomass share contained in municipal waste that is incinerated in Waste-to-Energy (WtE) plants is considered by the Renewable Energy directive to contribute to the renewable energy statistics. The total amount total primary energy production in the EU (electricity and heat) from renewable municipal waste (RMW) increased from 9 032 ktoe in 2014 to 9 394 ktoe in 2015. France, Germany, Italy, Sweden, and the Netherlands remain the major energy producing countries using renewable municipal waste. The job impacts by RMW stem from the collection and transport of waste, the construction of WtE facilities, but most notably from the operation of waste incineration plants. The figure is also dependent on the volume of thermally treated waste in a country.

The Confederation of European Waste-to-Energy Plants (CEWEP) monitors the EU development in dedicated and regularly updated country reports. Some country market reports were updated for 2016 for some EU Member States

but there is only few information on employment numbers. However, the CEWEP country reports hint at some employment levels in single Member States, for example around ***200 jobs for Ireland***, around ***250*** in the operation of plants in the ***Czech Republic***, or close to ***300 persons*** employed in the sector in ***Portugal***. One ratio published estimates that 180 jobs can be maintained per 1 million tons of treated waste. Based on these assumptions EurObserv'ER estimates a revised total workforce of around ***14 450 jobs*** for the entire European Union.

A major deviation to data published in last year's Overview report is the inclusion of the REA/PwC data for the ***United Kingdom***'s waste sector. The report states ***7 300 jobs*** and an industry turnover of ***£ 895 million*** (around € 1 230 million). For France Ademe estimates ***around 600 jobs***. The national job and turnover statistics for Germany and Austria do not cover waste.

The annually updated IRENA capacity statistics reveal a continual increase for installed capacities for renewable municipal waste increased from 6 277 MW to 6.436 MW in 2015. Given this trend, job impacts might continue to slightly increase over the coming years, although not being a fundamental part of the account of socioeconomic impacts from renewable energy. ■

Employment and turnover

	Employment (direct and indirect jobs)		Renewable municipal waste** Installed capacities in MW	
	2014	2015	2014	2015
United Kingdom	7 100	7 300	696	781
Netherlands	1 200	1 350	649	649
Italy	1 000	1 100	n.a	n.a
Sweden	900	1 000	459	459
Belgium	500	600	247	247
Denmark	600	600	325	325
France	600	600	830	872
Spain	450	450	234	251
Portugal	250	300	77	77
Czech Republic	250	250	45	45
Finland	<50	200	n.a	n.a
Ireland	200	200	17	17
Hungary	150	150	38	38
Bulgaria	<50	<50	n.a	n.a
Latvia	<50	<50	n.a	n.a
Lithuania	<50	<50	10	10
Luxembourg	<50	<50	17	17
Poland	<50	<50	n.a	n.a
Slovakia	<50	<50	11	11
Slovenia	<50	<50	n.a	n.a
Austria*	n.a	n.a	524	539
Croatia	n.a	n.a	n.a	n.a
Cyprus	n.a	n.a	n.a	n.a
Estonia	n.a	n.a	210	210
Germany*	n.a	n.a	1 888	1 888
Greece	n.a	n.a	n.a	n.a
Malta	n.a	n.a	n.a	n.a
Romania	n.a	n.a	n.a	n.a
Total EU	**13 600**	**14 450**	**6 277**	**6 436**

**Jobs not sperately monitored in official statistics. ** Source : IRENA 2016 - Renewable Capacity Statistics 2016. n.a.: not available.*
Source: EurObserv'ER 2016

SOLID BIOMASS

According to IRENA the installed capacity in solid biomass generation (including waste sector) increased from 24.6 GW in 2014 to 26.2 GW in 2015 in the European Union. Also solid biomass based gross electricity production rose from 84.6 TWh in 2014 to over 90.3 TWh in 2015. Consequentially, biomass remains one of the top sectors in terms of employment creation and turnover amongst

the 10 covered renewable energy technologies. EurObserv'ER, based on latest power and heat generation data arrives at an economic turnover volume of ***€ 36 billion*** and nearly ***315 000 persons*** employed in the European Union Member States. This turns the sector into the second largest after wind power.

The major contributors to these largely stable indicators are France, Germany, Sweden, the United Kingdom, Finland, Italy and Austria. But also many of the smaller EU Member States generate a relatively large share of their overall employment in the biomass sector that includes the job impacts on the forestry and agricultural part of the bioenergy value chain. As indicated in the previously released Solid Biomass Barometer (December 2016), the Brexit will have a significant impact on Europe's Bioenergy landscape, both in terms of biomass energy production as well as for the socioeconomic impact of the British sector for the European Union will shake up the solid biomass energy scene.

In 2015, the ***United Kingdom*** produced 21.5% of the European Union's solid biomass electricity. REA/PwC count over ***22 300 jobs*** and claim an annual market turnover of over ***€ 4.2 billion*** for the British biomass industry. In November 2016, the UK government presented its plan to phase out coal by 2025, which would give the biomass sector another boost. Biomass turnover in ***Germany*** declined from over € 7.5 billion in 2014 to around ***€ 7 billion*** in 2015. AGEE-Stat explains this drop by clearly dropped investments in large biomass heating plants (-71%). This could by far not be offset by small increases in small biomass installations. The German biomass job sector though (with ***45 000 persons***) is still Europe second largest. It is beaten by ***France*** that is home to the largest biomass sector in terms of employment, with around ***50 000 places*** and an annual turnover of ***€ 5.1 billion*** according to market estimations by Ademe. The country has developed an efficient green heat support scheme (Fonds Chaleur) which has lead to a strong increase of wood heat plants during the last 5 years. According to the annual market statistics of BMVIT, ***Austria*** is home to 27 pellet manufacturers and with an additional vibrant solid biomass boiler and stove industry the overall positive socioeconomic impacts. Accounts for ***13 600 jobs*** and sector turnover over the ***€ 2 billion*** mark.

Finally a solid rock in the European biomass sector are ***Sweden and Finland***. The Swedish industry association SVEBIO monitors over 4 500 MW of installed capacity. EurObserv'ER observed that these countries also European leaders in terms of gross heat production from solid biomass and estimates over ***27 400 workers and € 2.65 billion for Sweden*** and ***23 700 job and € 2.3 billion for Finland*** which are by far the largest socioeconomic impacts for the countries of all monitored renewable energy technologies.

As it stands, solid biomass in heat consumption is ahead of the planned NREAP trajectory with

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Employment and turnover

	Employment (direct and indirect jobs)		Turnover (M€)	
	2014	2015	2014	2015
France	48 000	50 000	4 600	5 130
Germany	48 500	45 400	7 500	6 975
Sweden	26 800	27 400	2 600	2 650
Finland	24 300	23 700	2 400	2 300
United Kingdom	21 500	22 300	4 000	4 240
Italy	19 600	22 000	1 900	2 150
Poland	18 500	18 800	1 800	1 825
Spain	15 500	15 800	1 500	1 530
Austria	13 650	15 450	1 975	2 045
Romania	10 900	11 100	1 050	1 080
Czech Republic	8 500	8 900	820	860
Portugal	8 000	7 800	780	760
Latvia	6 100	6 000	595	580
Denmark	3 900	4 800	380	460
Croatia	4 100	4 600	400	440
Hungary	4 200	4 250	410	410
Netherlands	3 900	4 100	375	400
Estonia	3 350	3 600	320	350
Lithuania	3 350	3 600	325	350
Belgium	3 300	3 500	320	340
Bulgaria	3 200	3 500	315	340
Greece	2 600	2 800	250	275
Slovakia	2 300	2 700	220	260
Slovenia	1 600	1 800	150	170
Ireland	650	600	60	60
Luxembourg	200	150	20	15
Cyprus	<50	<50	<5	<5
Malta	0	0	0	0
Total EU	306 550	314 700	35 070	36 000

Source: EurObserv'ER 2016

77.6 Mtoe (including 3.4 Mtoe from the incineration of renewable urban waste) compared to the projection of 66.2 Mtoe in 2015 but possibly behind the plan in terms of solid biomass electricity. Industry bodies welcomed parts of the European Commission energy, released in November 2016. But associations such as AEBIOM also stated that it ignores the potential role that could be played by "biopower" in backing up variable renewable electricity such as wind and solar. And the continuing low price of the ton of coal and the per ton price of carbon being is not stimulating renewable electricity use either. Our projection of more or less flat market development in terms of socioeconomic impacts stemming from solid biomass use, is confirmed by this year's analysis. ■


Deromegruppen

From today's perspective on socioeconomic impacts, the two preceding years are characterized by stagnation on a high level. After some statistical consolidations and corrections, five out of ten renewable energy sectors (wind, biomass, heat pumps, geothermal and waste) showed slight increases in employment in 2015 over 2014 and four out of ten in turnover (wind energy, heat pumps, geothermal and waste).

EMPLOYMENT

The EurObserv'ER job head count for 2015 for the EU 28 also indicates a consolidation on a high level and even small growth – a noteworthy finding as it reverses the trend of recent years. According to the conducted estimations and in contrast to the two editions before, EurObserv'ER assumes a growing renewable energy work force of ***1.139 million*** persons employed throughout the EU for the ten monitored RES technologies, a growth of 10 000 jobs. Looking at this amount by country, also here ***Germany*** defended its top slot with ***322 300 jobs***, although it also was the country with the highest absolute job losses (-25 000 jobs against 2014). In absolute numbers, the next big countries are ***France (162 100 jobs)***, the ***United Kingdom (109 200 jobs)***, ***Italy (97 100 jobs)***. According to EurObserv'ER estimations ***20 out of 28 Member states maintained or slightly increased their renewable energy related work force***, which is more than an encouraging sign, even more so considering that these growth also occurred in crisis affected countries such as Spain (+3 900 jobs), Greece (+500 jobs), and Portugal and Ireland as well as notable increases for new Member states Poland (+4 650 jobs), Croatia (+600 jobs) or Lithuania (+1 200 jobs). Analyzed by technology, the heat pump sector displayed the largest growth (+12 000 new jobs out of a total of over nearly 111 000), followed by solid biomass (+8 000 jobs), and wind energy (332 350 jobs) with 3 000 new persons employed.

The overall flat development in employment and turnover - from a rather pessimist point of view - may be interpreted as such that the EU renewable energy markets are approaching a point of market saturation and political framework conditions are not clear enough for investors to sustain more positive market dynamics. Global political and economic uncertainties (fossil fuel prices, emission trading, and the aftermath of the financial crisis) are further barriers.

However, this view may be opposed by a much more positive interpretation: The EU and its Member states' renewable energy industries are starting to re-emerge after years of market contraction. The results of the Paris climate conference, more ambitious climate and energy policies in China or India open up room for market expansions, for the European Union on international markets. Having developed ever more mature technological and competitive solutions, renewable energy industry players can increasingly stretch out to non-EU markets to compensate declining shares in domestic markets. The EU renewable energy industry is competitive on an international scale and the know-how and quality levels developed in the EU over the past decades are an internationally acknowledged asset that can be built upon. Viewed from this perspective, the huge investments in technology development and know-how over the past decade will now start to pay off for the European Union Member states that – if the commitment to fight global warming and reduce greenhouse gas emissions continues - may consolidate their role as global driver of clean energy solutions and an effective climate and renewable energy policy. Considering the current global political and energetic landscape, possibly more than ever before, an old Chinese proverb gains substantial relevance: "When the winds of change blow, some build walls. Other build windmills." ■

TURNOVER

The combined turnover of 10 renewable energy sectors in all 28 EU Member States reached ***€ 153 billion in 2015*** and thus slightly grew compared to 2014 (€ 148.7 billion). Sorted by technology, ***wind energy*** maintained its leading role in generating turnover (€ 49.1 billion, equivalent to over ***31% of total EU industry turnover***), followed by ***solid biomass (€ 36 billion)***, and the ***pumps sector (€ 21.4 billion against € 18 billion in 2014)*** of which positive market dynamics was a noteworthy exception in the quite flat European development.

Looking at the turnover estimations by country, ***17 out of 28 EU Member states should have increased or maintained their industrial turnover***. Germany, despite some substantial declines, maintained its top slot for industry turnover at € 29.6 billion. France (€ 20 billion) is catching up, as well as the third ranked United Kingdom (€ 19.5 billion), Italy on fourth place (€ 18.7 billion), and Spain (€ 13.5 billion) overtaking Denmark that still stand at a remarkable € 12.7 billion. In relative terms noteworthy turnover growth is observed for Lithuania (€ 650 million against € 430 million in 2014), the Netherlands, Slovakia or Poland, the latter one primarily by advancements in wind and solar thermal energy. Represented in these figures is an exceptionally good year for wind power and heat pumps on the positive side. Photovoltaic energy despite less installation activity maintained its turnover level. ■

EMPLOYMENT

2015 employment distribution by sector

	Country total	Wind	Biomass	Heat pumps	Photovoltaic	Biofuels	Biogas	Hydro	Solar thermal	Waste*	Geothermal
Germany	322 300	142 900	45 400	16 100	31 600	22 800	45 000	6700 **	10 600	n.a	1 200
France	162 100	22 000	50 000	34 700	16 150	22 000	4 400	3 900	5 500	600	2 850
United Kingdom	109 200	41 100	22 300	8 600	16 900	3 900	2 800	5500 **	750	7 300	<50
Italy	97 100	26 000	22 000	10 000	12 500	6 000	5 500	5 000	3 000	1 100	6 000
Spain	66 400	22 500	15 800	7 500	6 500	7 500	500	1 600	4 000	450	<50
Sweden	52 200	6 500	27 400	7 800	750	4 500	100	4 000	100	1 000	<50
Denmark	44 900	31 250	4 800	2 400	2 500	1 100	250	<50	1 850	600	100
Poland	43 300	11 500	18 800	750	1 100	6 000	800	1 450	2 750	<50	100
Austria	37 100	5 500	15 450	2 200	3 400	1 200	650	5850 **	2 800	n.a	<50
Finland	31 350	3 300	23 700	1 600	<50	1 800	250	400	<50	200	0
Netherlands	26 850	6 300	4 100	4 400	7 000	2 800	500	0	250	1 350	150
Portugal	22 650	2 500	7 800	7 000	750	1 600	150	2 000	450	300	100
Belgium	22 200	2 800	3 500	3 000	3 400	7 500	550	350	450	600	<50
Romania	17 200	1 100	11 100	0	1 300	650	50	2 600	200	n.a	200
Czech Republic	16 300	100	8 900	650	1 700	1 400	900	1 750	600	250	<50
Greece	12 950	2 000	2 800	0	1 900	750	200	2 500	2 700	n.a	100
Hungary	7 550	100	4 250	100	900	650	150	100	150	150	1 000
Bulgaria	7 500	200	3 500	1 900	700	500	100	400	<50	<50	100
Latvia	6 600	<50	6 000	0	<50	100	150	150	<50	<50	0
Croatia	6 350	750	4 600	0	150	150	150	250	200	n.a	100
Lithuania	5 450	1 000	3 600	<50	100	300	150	<50	<50	<50	100
Estonia	5 300	100	3 600	1 350	<50	<50	50	<50	<50	n.a	0
Ireland	4 700	2 500	600	300	<50	400	200	200	250	200	0
Slovakia	4 650	<50	2 700	<50	400	550	200	400	100	<50	150
Slovenia	3 750	<50	1 800	400	300	200	100	750	<50	<50	<50
Luxembourg	2 100	<50	150	<50	150	1 400	50	150	<50	<50	0
Cyprus	600	150	<50	0	100	<50	50	0	200	n.a	0
Malta	400	0	0	0	300	<50	0	0	<50	n.a	0
Total EU	1 139 050	332 350	314 700	110 900	110 750	95 900	63 950	46 150	37 300	14 450	12 600

** Only direct jobs. ** Figures for large and small hydro plants. n.a.: non available.* ***Source: EurObserv'ER 2016***

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TURNOVER

2015 turnover by sector (€M)

	Country total	Wind	Biomass	Heat pumps	Photovoltaic	Biofuels	Biogas	Hydro	Solar thermal	Geothermal energy
Germany	29 620	11 600	6 975	1 700	3 000	2 500	2 325	320	1 000	200
France	20 030	3 170	5 130	2 600	4 440	3 030	610	450	380	220
United Kingdom	19 510	7 925	4 240	1 600	3 410	740	480	850	250	15
Italy	18 700	2 000	2 150	6 500	2 500	1 100	2 500	1 000	250	700
Spain	13 480	4 500	1 530	5 500	350	920	65	380	230	<5
Denmark	12 755	11 425	460	215	250	200	40	<5	155	<5
Austria	6 925	1 070	2 045	515	615	400	185	1 635	440	20
Sweden	5 855	1 100	2 650	700	90	1 000	45	250	10	10
Poland	5 100	2 000	1 825	65	80	710	60	100	235	25
Netherlands	3 595	1 500	400	390	660	300	170	0	25	150
Finland	3 530	570	2 300	350	<5	200	25	75	<5	0
Portugal	2 250	370	760	620	60	330	20	40	40	10
Belgium	1 720	565	340	260	180	250	65	15	40	<5
Czech Republic	1 595	15	860	55	60	330	150	70	50	<5
Romania	1 570	150	1 080	0	70	200	<5	30	15	20
Greece	1 075	315	275	0	65	140	25	20	230	<5
Hungary	830	15	410	<5	85	200	20	<5	15	75
Bulgaria	680	25	340	175	20	50	<5	20	<5	40
Croatia	670	125	440	0	15	30	10	25	20	<5
Ireland	665	410	60	30	<5	120	15	<5	20	0
Lithuania	650	200	350	<5	10	65	<5	<5	<5	<5
Latvia	640	<5	580	0	0	25	20	<5	<5	0
Estonia	510	15	350	120	<5	<5	<5	<5	<5	0
Slovakia	505	0	260	<5	15	130	40	20	10	25
Slovenia	295	<5	170	40	10	30	10	10	<5	15
Luxembourg	145	10	15	0	25	80	<5	<5	<5	0
Cyprus	65	20	<5	0	10	10	<5	0	15	0
Malta	35	0	0	0	25	<5	0	0	<5	0
Total EU	153 000	49 105	36 000	21 450	16 060	13 100	6 910	5 345	3 470	1 560

Source: EurObserv'ER 2016

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) database and covers utility-scale investments in renewable energy, i.e. investment in power plants. In order to capture the involvement of the public sector in RES financing, information on national and EU-wide financing or promotion programmes for RES will be presented.

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 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.

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 edition of "The state of renewable energies in Europe". 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 2014 presented in last year's edition and this edition naturally differ.

Investment in Renewable Energy Capacity

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 2014 and 2015 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.

Methodological note

Asset finance is differentiated by three types: balance-sheet finance, non-recourse project finance, and bonds and other approaches. 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

While a slowdown of investments can be observed for some RES sectors in the European Union in 2015, it was another very impressive year for investments in the wind sector. Investments grew from already impressive € 23 billion in 2014 to almost € 31 billion in 2015. This is an increase by almost 34% between both years. The number of wind power projects that reached financial close increased from 701 to 771. Similarly, also the capacity added associated with asset finance went up from 13.5 GW in 2014 to 14.5 GW in 2015. This growth in capacity added of more than 10%, however, is notably smaller than the increase in investments. This indicates an increase in investment expenditure per MW of wind capacity. On average, € 1.71 million were spent per MW of wind capacity in 2014 compared to € 2.07 million in 2015. One reason for this development could be the relatively weak Euro in 2015. In the case of offshore wind, an almost identical upsurge of investments by around 34% could be observed. In 2015, offshore wind investments in the EU totalled € 13.9 billion compared to € 10.4 billion in 2014.

With respect to the financing sources of investments for wind, some minor differences can be observed between 2014 and 2015. In both years, on-balance-sheet funding is the dominating source for new investments in wind capacity. Its share, however, marginally decreased from 66% in 2014 to around 60% in 2015. A similar trend can be observed for non-recourse project finance. Its share dropped slightly from 34% in 2014 to 30% in 2015. In contrast, the importance of other financing instruments, as e.g. bonds or guarantees, seems to have increased notably to more than 10% in 2015. The shares 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 traditional corporate financing, i.e. balance sheet finance. Although project finance is associated with around a third of financing volume in both years, only 8% (2014) and 10% (2015) of all projects are covered by project financing.

OFFSHORE PLAYS A KEY ROLE IN WIND INVESTMENTS

In terms of aggregate EU-wide investments, offshore wind shows the same positive trend as onshore. Overall, offshore investments increased from € 10.4 billion in 2014 to € 13.9 billion in 2015. Both in 2014 and 2015, offshore played a significant role in overall wind investments with a share of around 45%, respectively. The relatively low numbers of offshore wind projects, namely 9 in 2014 and 11 in 2015, indicate the substantially larger size of these investments compared to the average onshore wind project. In 2014, an average offshore wind investment in the EU was € 1.16 billion and € 1.26 billion in 2015. In comparison, the average project sizes of onshore wind projects were € 33 million in 2014 and € 40 million 2015, respectively. The significantly larger size of offshore wind projects is a main explanation, why non-recourse project financing is used notably more often compared to smaller onshore wind projects.

Similar to overall investments, the associated capacity of offshore wind added increased between both years, however, at a slower pace. Capacity added rose from 2.45 GW in 2014 to 3.01 GW in 2015, which corresponds to an increase by 23%. This lower growth in capacity added is reflected in the investment costs per MW. In 2014, investment expenditures per MW of offshore capacity were € 4.24 million. This value increased to € 4.61 million in 2015. As expected, the investment costs for onshore capacity are substantially lower, namely € 2.07 million per MW in 2015 and only € 1.71 million in 2014. A reason for this increase in investment expenditure could be the devaluation of the Euro between 2014 and 2015 that possibly increased the costs for imported components used for constructing the wind power plants.

1

Overview of asset finance in the wind power sector (onshore + offshore) in the EU Member States in 2014 and 2015

	2014			2015		
	Asset Finance - New Built (mln. €)	Number of Projects	Capacity (MW)	Asset Finance - New Built (mln. €)	Number of Projects	Capacity (MW)
United Kingdom	4 455.30	52	1 654.4	12 913.97	69	4 050.9
Germany	8 832.10	417	5 571.4	10 800.99	439	5 786.9
France	1 539.80	80	1 388.3	1 244.18	51	956.6
Poland	614.34	14	517.4	1 011.28	46	798.2
Belgium	431.46	24	399.1	850.54	21	315.6
Finland	503.87	17	433.5	777.81	19	578.9
Ireland	211.96	10	193.1	765.21	14	511.9
Sweden	368.89	14	350.1	525.68	23	416.6
Italy	154.90	8	131.6	491.59	17	374.3
Austria	576.54	14	505.3	395.60	18	298.32
Denmark	206.39	13	195.3	345.99	19	274.2
Greece	74.51	3	70.7	300.01	5	215.9
Netherlands	4 010.39	15	1 177.6	250.07	23	196.5
Portugal	486.43	12	408.2	103.17	4	89.7
Luxembourg	0.00	0	0	26.50	1	21,0
Cyprus	0.00	0	0	12.62	1	10,0
Lithuania	288.31	4	202.5	1.89	1	1.5
Romania	284.16	6	263.8	0	0	0
Estonia	22.45	2	21.3	0	0	0
Czech Republic	17.68	5	12.0	0	0	0
Total EU	23 079.47	710	13 496.7	30 817.10	771	14 897.0

Source: EurObserv'ER 2016


MHI Vestas Offshore Wind

HIGHEST INVESTMENTS IN THE UK, THE MOST PROJECTS IN GERMANY

With respect to wind investments by Member State, the UK took over the lead from Germany in 2015. In spite of an increase in investments from € 8.83 billion in 2014 to € 10.8 billion in 2015, Germany was overtaken by the UK, where wind investments totalled almost € 13 billion in 2015. Both countries did not just kept the first two ranks among each other, but also increased the distance to the other EU Member States. In 2014, 58% of all wind investments in the EU were conducted in either the UK or Germany. This already high share even increased in 2015 to 77%. A main difference between both countries is that UK investments are largely driven by offshore. In both years, around 75% of investments in wind capacity in the UK were offshore. This share was notably smaller in Germany, namely 41% in 2014 and only 33% in 2105. This difference in the relative importance of offshore explains two other observations. First, the number of projects in the UK in both years is notably lower than in Germany. In 2015, e.g., a total of 439 wind projects were recorded in Germany, which corresponds to about 57% of all projects in the EU. Second, in spite of higher investments, the associated capacity added in 2015 is lower in the UK (4 GW) than in Germany (5.8 GW), which is due to the higher investment costs of offshore wind.

INCREASE OF INVESTMENT IN SEVERAL COUNTRIES, FRANCE KEEPS THIRD POSITION

In 2014, France was ranked third with respect to investments in utility-scale wind power. Although asset finance dropped from € 1.54 billion in 2014 to € 1.24 billion in 2015, France still kept its position behind the UK and Germany. The number of projects that reached financial close declined even stronger from 80 in 2014 to 51 in 2015. Apart from the top three, there have been several success stories in the wind sector in 2015. Eight Member States experienced partially high increases in investments in wind power plants.

Poland showed a very positive trend between both years. Investments increased from € 614 million in 2014 to € 1.01 billion in 2015 and hence Poland reached wind investments over one billion for the first time since 2012. It is particularly striking that the number of projects that reached financial close in Poland increased from 14 to 46 between 2014 and 2015. Three Member States with particularly high upsurges in asset financing were Belgium, Finland, and Ireland. Between 2014 and 2015, wind investments almost doubled from € 431 million to € 851 in Belgium, and increased from € 504 million to € 778 million in Finland. In Ireland, wind investments almost quadrupled from € 222 million to € 765 million. A similarity among these three

2

Share of different types of asset finance in the wind power sector (onshore + offshore) in the EU in 2014 and 2015

	2014		2015	
	Asset Finance - New Built (%)	Number of Projects	Asset Finance - New Built (%)	Number of Projects
Balance Sheet	65.8%	91.5%	59.52%	89.4%
Project Finance	33.8%	7.9%	30.2%	9.6%
Bond/Other	0.4%	0.6%	10.3%	1.0%
Total EU	100.0%	100.0%	100.0%	100.0%

Source: EurObserv'ER 2016


Lagerwey Wind

3

Overview of asset finance in the wind power sector offshore in the EU Member States in 2014 and 2015

	2014			2015		
	Asset Finance - New Built (mln. €)	Number of Projects	Capacity (MW)	Asset Finance - New Built (mln. €)	Number of Projects	Capacity (MW)
United Kingdom	3 407.96	2	790.8	9 700.00	6	1 999.2
Germany	3 646.81	3	915.2	3 526.60	4	847,0
Belgium	8.57	1	2.3	655.81	1	165,0
Netherlands	3 326.04	2	744,0	0	0	0
France	7.45	1	2,0	0	0	0
Total EU	10 396.85	9	2454.3	13 882.41	11	3 011.2

Source: EurObserv'ER 2016

and a major difference compared to ,e.g., Poland, is that the rise in investments was mainly driven by larger project sizes rather than more projects. In Belgium, the number of wind projects reaching financial close even declined from 24 in 2014 to 21 in 2015.

Sweden, Italy, Denmark, and Greece experienced increases in wind investments as well. In Italy, asset finance for wind projects more than tripled from € 155 million in 2014 to € 492 million in 2015. The associated capacity added almost tripled from 132 MW to 374 MW. Investments in wind power plants even quadrupled in Greece. In 2015, € 300 million were invested compared to only € 75 million in the previous year. Swedish investments grew by almost 43% from € 369 million to € 526 million between 2014 and 2015. These investments, however, are still substantially lower that the investments sums Sweden experienced in some previous years. Investments in Denmark increased by 68% from € 206 million in 2014 to € 346 million in 2015. Finally, minor investments were recorded in two Member States in 2015, which did not experience any wind investments in 2014. Both in Luxembourg and Cyprus, one wind project reached financial close, respectively, worth almost € 26.5 million (Luxembourg) and € 12.6 million (Cyprus).

REDUCTIONS IN INVESTMENTS IN SEVERAL MEMBER STATES

The most dramatic decline in asset finance can be observed in the Netherlands. While the Netherlands were the Member State with the fourth highest wind investment in 2014, totalling more than € 4 billion, investments in 2015 only amounted to € 250 million.

4

Share of different types of asset finance in the wind power sector offshore in the EU in 2014 and 2015

	2014		2015	
	Asset Finance - New Built (%)	Number of Projects	Asset Finance - New Built (%)	Number of Projects
Balance Sheet	52.5%	66.7%	41.2%	36.4%
Project Finance	47.5%	33.3%	44.9%	45.4%
Bond/Other	0.0%	0.0%	13.9%	18.2%
Total EU	100.0%	100.0%	100.0%	100.0%

Source: EurObserv'ER 2016

The largest share of this slump in investments is due to offshore. In 2014, two very large offshore projects reached financial close and amounted to € 3.33 billion. But even when only considering onshore wind, investments dropped by more than 60%.

Further Member States with declines in asset finance for wind power are Austria, Portugal, and Lithuania. In Austria, overall investments fell from € 577 million in 2014 to € 396 million 2015, while the number of projects even increased from 14 to 18. Reductions in investments are more severe in Portugal and in particular Lithuania. In the former, investments dropped from € 486 million in 2014 to only € 103 million in 2015, while in the latter, total investments in wind power totalled less than € 2 million in 2015 compared to a € 288 million in the previous year.

In three Member States, financial deals for wind projects were only closed in 2014. In both Estonia and the Czech Republic no investments in wind capacity was recorded in 2015 after having experienced moderate investments in 2014. These totalled € 22.5 million in Estonia (2 projects) and € 17.7 million in the Czech Republic (5 projects). The difference between the two years is particularly striking in the case of Romania, where 6 wind projects secured financing in 2014 totalling € 284 million, while no investments were recorded in 2015. ■

PHOTOVOLTAIC

When analysing investments in solar PV, 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, in addition to investments in utility-scale PV, overall EU investments in commercial and residential PV installations. This data provides estimates on financing for small-scale PV installations with capacities below 1 MW. Thus, it is complementary to the asset finance data that captures all PV power plants with capacities above 1 MW.

PV INVESTMENTS FALL IN THE EU

Between 2014 and 2015, investments in solar PV power plants (>1 MW) fell considerably by almost 31%. Asset finance for utility-scale PV totalled € 4.24 billion in 2015 compared to € 6.13 billion in 2014. In contrast to overall investments, the number of PV projects that reached financial close remained relatively constant. In 2014, 366 new PV projects were recorded, while in 2015 the number of projects totalled 343, which corresponds to a decrease by around 6%. Those two observations combined imply a decline of the average size of a PV project. In 2014, on average € 16.7 million were invested per solar PV plant. This value decreased to € 12.4 million per project in 2015. In the last editions, a continuous decline of investment cost for PV could be observed. This trend, however, seems to have stopped or at least slowed down for the time being. Investment expenditures per MW of utility-scale PV totalled € 1.43 million in 2015 compared to only € 1.22 million in 2014. This corresponds to an increase in investment costs by 17%. An explanation might be the rather weak Euro in 2015, which increased the cost of all imported PV components from non-Euro countries. Similar to overall asset finance for PV power plants, also the capacity added of these investments declined. While capacity added totalled 5.04 GW in 2014, it only reached 2.97 GW in 2015, which is a decline in capacity added by 35%.

With respect to the sources of finance for PV power plants, there is no substantial change observable between 2014 and 2015. In both years, the majority of PV power plants were financed through traditional corporate financing, i.e. on-balance-sheet financing. The share of balance sheet financed PV investments increased only marginally from 67% in 2014 to 72% in 2015. In contrast, the share of non-recourse project financing dropped marginally. In 2014, 33% of all PV power plants in the EU were project financed compared to 28% in 2015. The main difference between the two years related to the number of projects financed. In 2014, the number of projects that were financed using non-recourse project finance was significantly lower than the share of total investment. Hence, project financed PV power plants were on average larger, which is a typical observation for project finance that is also predominant in the wind sector. In 2015, however, the picture changes. 72% of all projects are classified as on-balance-sheet finance compared to a share of 28% using project finance. Hence, there is no diffe-


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Overview of asset finance in the PV sector in the EU Member States in 2014 and 2015 (PV Plants)

	2014			2015		
	Asset Finance - New Built (mln. €)	Number of Projects	Capacity (MWp)	Asset Finance - New Built (mln. €)	Number of Projects	Capacity (MWp)
United Kingdom	4 105.68	268	3 384.5	3 130.77	264	2 197.3
France	1 647.05	41	1327.8	314.95	15	217.4
Denmark	6.99	2	5.8	290.44	5	201.4
Germany	160.87	24	147.1	265.67	40	203.7
Italy	62.15	9	51.6	135.54	5	79.6
Portugal	71.42	5	59.3	23.18	3	17.3
Hungary	0.00	0	0,0	23.07	1	16,0
Sweden	0.00	0	0,0	21.03	4	14.6
Romania	49.06	10	40.7	18.03	1	12.5
Cyprus	3.61	1	3,0	4.33	1	3,0
Poland	6.74	2	5.6	3.61	2	2.5
Belgium	3.61	1	3,0	2.88	1	2,0
Malta	0.00	0	0,0	2.65	1	1.9
Bulgaria	7.23	2	6,0	0	0	0
Spain	2.41	1	2,0	0	0	0
Total EU	**6 126.82**	**366**	**5 036.4**	**4 236.14**	**343**	**2 969.2**

Source: EurObserv'ER 2016

2

Investment in the PV sector in the EU in 2014 and 2015 (for commercial and residential PV <1MWp)

	2014		2015	
	Investment (mln. €)	Capacity (MWp)	Investment (mln. €)	Capacity (MWp)
Total EU	5 880.18	3 309.63	5 178.64	3 153.95

Source: EurObserv'ER 2016

rence in size of PV investments between the two financing types. In both years, bonds or other financing mechanisms were not used for PV investments.

With a total of € 5.18 billion in 2015, small-scale PV investments dominate asset financing for utility-scale investments in that year. Overall investments in utility-scale PV plants were almost € 1 billion less in total compared to commercial and residential PV. However, the trend within small-scale PV is negative. In 2014, investments were slightly higher than in 2015 totalling € 5.88 billion. Hence, investments in small-scale PV dropped by around 12% between the two years. Similarly, the associated capacity added also decreased from 3.31 GW in 2014 to 3.15 GW in 2015. The fact that the drop in capacity is smaller than the decline in financing indicates that the investment costs of distributed PV capacity, in contrast to utility-scale PV, have dropped. The investment costs per MW of commercial and residential PV decreased marginally from € 1.78 in 2014 to € 1.64 in 2015, which corresponds to a drop by 7.6%.

UK DOMINATES PV INVESTMENTS, DROP IN FRENCH INVESTMENTS

The most striking development in asset financing for utility-scale PV is the strong concentration of investments in the UK. This is a trend in PV investments that could be observed since 2012 and seems to have continued in 2014 and 2015, although asset finance for utility-scale PV dropped notably between the two years. In 2014, € 4.1 billion were invested in PV power plants in the UK. In 2015, the number fell by almost 24% to € 3.1 billion. The number of PV projects, however, remained almost constant with 268 projects in 2014 and 264 projects in 2015. Hence, the decline in overall asset finance is mainly due to on average smaller project sizes. In contrast, the associated capacity added decreased even stronger than asset finance from 3.4 GW in 2014 to 2.2 GW in 2015. In spite of the drop in investments, the UK dominance in the PV sector even increased between the two years. While in 2014 already 67% of all investments in PV power plants were recorded in the UK, this share even increased to 74% in 2015.

Although smaller with respect to absolute values, France is ranked second with respect to investments in PV capacity in both years. However, after the tremendous upsurge in investments from 2013 and 2014, a drastic drop in asset financing for PV plants can be observed between 2014 and 2015. In 2014, PV investments totalled € 1.65 billion in France. In comparison to these exceptionally high investments, asset finance in 2015 only totalled € 315 million. The number of PV projects in France decreased at a similar pace as asset finance from 41 projects in 2014 to 15 projects in 2015. The same pattern is observable for capacity added, which slumped from 1.3 GW to 217 MW between the two years.

HETEROGENEOUS DEVELOPMENTS THROUGHOUT THE EU

In contrast to the negative developments in the top two Member States with respect to PV investments, there are also several success stories in 2015, namely Denmark, Germany, and Italy. The by far largest upsurge in PV investments was recorded in Denmark. Investments in PV power plants increased from a very low 2014

3

Share of different types of asset finance in the PV sector in the EU in 2014 and 2015

	2014		2015	
	Asset Finance - New Built (%)	Number of Projects	Asset Finance - New Built (%)	Number of Projects
Balance Sheet	67.0%	78.7%	72.1%	71.7%
Project Finance	33.0%	21.3%	27.9%	28.3%
Bond/Other	0.0%	0.0%	0.0%	0.0%
Total EU	100.0%	100.0%	100.0%	100.0%

Source: EurObserv'ER 2016

value of € 7 million to € 290 million in 2015, which is the third highest value in the EU in that year. In line with this, the associated capacity added made a leap from 6 MW to 210 MW between the two years years. In Germany and Italy investments grew less drastically. In Italy, asset finance for PV more than doubled from € 62 million in 2014 to almost € 136 million in 2015, while capacity added less than doubled from 52 MW to 80 MW. In Germany, PV investments increased from € 161 million to almost € 266 million between the two years. Furthermore, the number of PV projects grew notably, from 24 to 40, in Germany.

With Hungary, Sweden, and Malta, there are three Member States with PV investments in 2015 totalling € 23 million, € 21 million, and € 2.7 million, respectively, but none in 2014. In contrast, Cyprus, Poland, and Belgium experienced asset finance for utility-scale PV in both years, however, at rather low rates from € 2.9 - 6.7 million. In both Portugal and Romania, PV investments dropped quite similarly between the years; in Portugal from € 71 million to € 23 million and from € 49 million to € 18 million in Romania. In the latter, it is particularly striking that the number of PV projects declined from 10 in 2014 to only 1 in 2015. Finally, both Bulgaria and Spain saw rather small investments in 2014 amounting to € 7.2 million and € 2.4 million, respectively, but no investments in 2015. ■

BIOGAS

When analysing asset financing of biogas, it is essential to characterise the projects that are covered. 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 the 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 (bio methane 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.

BIOGAS INVESTMENTS STABILISE

After the substantial decline in biogas investments after 2013, biogas investments grew again between 2014 and 2015. Asset finance for biogas – including biogas power plants as well as biogas production plants – almost doubled from € 57 million in 2014 to € 102 million in 2015. The 2015 value, however, is still substantially lower than the total investments of around € 330 million that were recorded in 2013. The number of biogas projects increased, however, with less magnitude. In 2014, four biogas projects reached financial close compared to five deals in 2015. Consequently, also the average investment size increased from € 14.2 million per project in 2014 to € 20.4 million in 2015.

Investments in biogas power plants remained relatively stable between the two years with € 56.7 million in 2014 and € 59.1 million in 2015. The associated capacity added of these investments, however, grew notably from 8.7 MW in 2014 to 17 MW in 2015. This corresponds to an increase in capacity added by more than 95%. Hence, investment expenditures per MW of biogas capacity dropped between the two years, namely from € 6.5 million in 2013 to € 3.5 million in 2015. These

1

Overview of asset finance in the biogas sector in the EU Member States in 2014 and 2015 (biogas plants)

	2014			2015		
	Asset Finance - New Built (mln. €)	Number of Projects	Capacity (MW)	Asset Finance - New Built (mln. €)	Number of Projects	Capacity (MW)
United Kingdom	18.92	1	1.2	54.03	2	15,0
Germany	14.38	1	3,0	5.03	1	2,0
France	23.35	1	4.5	0	0	0
Total EU	56.66	3	8.7	59.06	3	17,0

Source: EurObserv'ER 2016

2

Overview of asset finance in the biogas sector in the EU Member States in 2014 and 2015 (biomethane)

	2014			2015		
	Asset Finance - New Built (mln. €)	Number of Projects	Capacity (m³/hr)	Asset Finance - New Built (mln. €)	Number of Projects	Capacity (m³/hr)
United Kingdom	0.06	1	3	43.12	2	450
Total EU	0.06	1	3	43.12	2	450

Source: EurObserv'ER 2016

GASAG

changes, however, should be interpreted only with care due to the few observed biogas projects. In contrast to the stable investments in biogas power plants, investments in biogas production plants increased notably. In 2014, investments were only € 0.06 million and leaped to € 43 million in 2015. Similarly, the number of projects reaching financial close increased from one in 2014 to two in 2015. The capacities of these production plants, however, are not comparable across years, as there is no information about the capacity for one of the 2015 biogas production plants.

In case of biogas power plants, the relative importance of balance sheet and project finance reversed. In 2014, the share of project financed investments (33%) is smaller than the share of investments using on-balance-sheet finance (67%). As the respective shares of projects covered by both financing types have a similar pattern, there is no difference in the average project size between the two financing types. This picture changes drastically in 2015. The majority of investments in biogas power plants, namely 74%, but a significantly smaller share of projects, 33%, were project financed. In the case of balance sheet financing, the situation is reversed. Only 33% of all investments in 2015 are categorised as balance sheet finance, but almost 67% of all projects. Hence, the size of project financed biogas investments was on average significantly larger

3

Share of different types of asset finance in the biogas sector in the EU in 2014 and 2015 (biogas plants)

	2014		2015	
	Asset Finance - New Built (%)	Number of Projects	Asset Finance - New Built (%)	Number of Projects
Balance Sheet	66.6%	66.7%	25.6%	66.7%
Project Finance	33.4%	33.3%	74.4%	33.3%
Bond/Other	0.0%	0.0%	0.0%	0.0%
Total EU	100.0%	100.0%	100.0%	100.0%

Source: EurObserv'ER 2016

than those financed from balance sheet in 2015, which could often be observed for other RES as well. In both years, no biogas power plants were financed using bonds or other financing mechanisms. Biogas production facilities were financed entirely from balance sheets in both years.

SPORADIC INVESTMENTS ACROSS THE EU

With respect to investments in plants producing biogas, all observed investments occurred in the UK in both years, which is similar to the investments in 2013. In 2015, the UK is also the dominant Member State with respect to investments in biogas power plants. € 54 million were invested in the UK, which has a market share of 91% in that year. Compared to its 2014 value of € 19 million, UK investments have almost tripled between both years. The only other Member State with asset finance for biogas power plants in 2015 is Germany with an investment of € 5 million, which is a considerable decline in investments compared to the value of € 14 million in 2014. In 2014, the largest investments in biogas power plants were conducted in France and amounted to € 23 million. In the subsequent year, however, no investments were recorded in France. ■

4

Share of different types of asset finance in the biogas sector in the EU in 2014 and 2015 (biomethane)

	2014		2015	
	Asset Finance - New Built (%)	Number of Projects	Asset Finance - New Built (%)	Number of Projects
Balance Sheet	100.0%	100.0%	100.0%	100.0%
Project Finance	0.0%	0.0%	0.0%	0.0%
Bond/Other	0.0%	0.0%	0.0%	0.0%
Total EU	100.0%	100.0%	100.0%	100.0%

Source: EurObserv'ER 2016

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. In practice, most of the investments in waste-to-energy plants in 2014 and all of those in 2015 are categorised as (i) electricity generation (new). A smaller fraction of the 2014 investments falls in category (iii) CHP. There are no investments in pure thermal plants. The reason for this similarity in the categories among solid biomass, waste-to-energy, and biogas is due to the fact that the underlying data source does not distinguish between the three industries. This disaggregation was done on a project basis. 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.

FALLING WASTE-TO-ENERGY INVESTMENTS IN THE EU

After the positive development of asset finance for waste-to-energy plants between 2013 and 2014, waste-to-energy investments experienced a bad year in 2015. Asset finance for utility-scale waste-to-energy slumped from € 2.19 billion in 2014 to only € 615 million 2015. This corresponds to a decrease of investments by almost 72%. The number of waste-to-energy projects reaching financial close, however, fell with a smaller magnitude compared to investments, namely from 11 projects in 2014 to only 4 new projects in 2015. This indicates that also the average project size decreased between the two years. In 2015, an average waste-to-energy investment was € 154 million compared to € 199 million in 2014. In contrast, the reduction in capacity added associated with the investments is even stronger than the fall in investments. Capacity added slumped by 85% from 332 MW in 2014 to 50 MW in 2015. This implies higher average investment expenditures per MW of waste-to-energy capacity in 2015, namely € 12.3 million per MW, compared to € 6.6 million per MW in the previous year. These changes, however, should be only interpreted with care due to the few observed waste-to-energy projects.

1

Overview of asset finance in the waste sector in the EU Member States in 2014 and 2015

	2014			2015		
	Asset Finance - New Built (mln. €)	Number of Projects	Capacity (MW)	Asset Finance - New Built (mln. €)	Number of Projects	Capacity (MW)
United Kingdom	1 556.43	9	262.8	615.02	4	50.1
Ireland	482.89	1	60,0	0	0	0
Poland	145.90	1	9,0	0	0	0
Total EU	**2 185.22**	**11**	**331.8**	**615.02**	**4**	**50.1**

Source: EurObserv'ER 2016

An investigation of the sources of financing for waste-to-energy plants reveals considerable changes in the financing structure between the two years. In 2014, the typical picture concerning balance sheet and project financing can be observed. Overall, the share of balance sheet finance in waste-to-energy investments, 59%, is higher than the share of non-recourse project finance, 41%. However, almost 82% of all projects are on-balance-sheet financed compared to only 18% using project finance. This implies that, as to be expected, project financed investments are larger, namely on average € 450 million compared to € 143 million for a waste-to-energy plant financed through traditional corporate finance. As in the previous year, the majority of investments in 2015 are on-balance-sheet financed, namely 62% compared to 38% using project finance. The equal shares in the number of projects, however, means that project financed investments were on average smaller, which is a rather untypical observation. In both years, no projects were financed through bond emissions or other financing instruments.

2

Share of different types of asset finance in the waste sector in the EU in 2014 and 2015

	2014		2015	
	Asset Finance - New Built (%)	Number of Projects	Asset Finance - New Built (%)	Number of Projects
Balance Sheet	58.8%	81.8%	62.4%	50.0%
Project Finance	41.2%	18.3%	37.6%	50.0%
Bond/Other	0.00%	0.00%	0.00%	0.0%
Total EU	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Source: EurObserv'ER 2016

THE UK DOMINATES WASTE-TO-ENERGY INVESTMENTS

With respect to the allocation of investments in the EU, the overall picture did not change substantially since 2012, i.e. the UK dominates waste-to-energy investments. The UK is the only country that experienced asset finance for waste-to-energy projects both in 2014 and in 2015. UK investments, however, dropped by more than 60% from € 1.56 billion in 2014 to € 615 million in 2015. However, the number of UK waste projects reaching financial close declined with smaller magnitude from nine projects to four projects between both years. Hence, the average project size in the UK declined from € 173 million per waste-to-energy plant in 2014 to € 154 million in 2015.

While in 2015 the UK was the only Member State where waste-to-energy investments were recorded, two other Member States experienced investments in 2014 as well. The second highest investment in 2014 was conducted in Ireland and amounted to € 483 million. Poland saw asset finance for a waste-to-energy plant totalling € 146 million. In spite of these two non negligible investments, the UK also dominated investments in 2014, as 71% of all EU wide investments for waste-to-energy plants were observed in the UK. ■

SOLID BIOMASS

When analysing asset financing of solid biomass, it is essential to characterise the underlying data before discussing the changes in investments in details. First of all, the asset financing for 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 1MWe 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.

INCREASING BIOMASS INVESTMENTS

Overall, 2015 was a very good year for asset finance for utility-scale biomass. EU-investments increased by almost 58% from € 1.56 billion in 2014 to € 2.53 billion in 2015, which is the highest investment level since 2011. In spite of this massive upsurge in asset finance, the number of biomass projects that reached financial close actually decreased between both years from 18 projects in 2014 to 16 in 2015. Hence, the average project size increased considerably between both years from € 87 million to € 158 million.

In comparison to the upsurge in asset finance, the increase in capacity added seems rather low at first sight. Capacity added associated with investments in biomass power plants increased by 14% from 506 MW in 2014 to almost 578 MW in 2015. This weaker increase in capacity added could be driven by several effects. The data could also include investments in converting existing power plants, e.g. the conversion of coal

1

Overview of asset finance in the solid biomass sector in the EU Member States in 2014 and 2015

	2014			2015		
	Asset Finance - New Built (mln. €)	Number of Projects	Capacity (MW)	Asset Finance - New Built (mln. €)	Number of Projects	Capacity (MW)
United Kingdom	678.28	9	165.6	1 791.42	10	289.2
Finland	0.00	0	0,0	368.98	1	142,0
Ireland	0.00	0	0,0	180.30	1	42.5
Denmark	67.75	1	93.3	88.33	1	70,0
Czech Republic	0.00	0	0,0	49.21	1	15,0
France	138.16	3	57.3	37.47	1	14.9
Netherlands	0.00	0	0,0	9.96	1	3.9
Sweden	611.11	2	165,0	0	0	0
Bulgaria	40.27	1	15,0	0	0	0
Spain	13.40	1	5,0	0	0	0
Italy	10.50	1	5,0	0	0	0
Total EU	1 559.46	18	506.2	2 525.66	16	577.50

Source: EurObserv'ER 2016

into biomass power plants. In these cases, the investment costs per MW are typically significantly smaller. Another reason for this increase in investment expenditure could be the devaluation of the Euro between 2014 and 2015 that possibly increased the costs for imported components used for constructing the biomass power plants. These effects could have also affected the increase in investment expenditures per MW of installed capacity. Investment costs in 2015 were on average € 4.4 million per MW of biomass capacity installed compared to only € 3.1 million per MW in 2014.

With respect to the source of financing for solid biomass plants, there is a notable difference between the two years. In 2015, the share of project financed (57%) and balance sheet financed (43%) investments was relatively balanced. As balance sheet finance captures 56% of all projects compared to 44% for project finance, there is no difference in the average project size between the two financing types. In 2014, the majority of investments, namely 61%, but a significantly smaller share of projects, 33%, were project financed. In the case of balance sheet financing, the situation is reversed. Only 39% of all investments in 2014 were financed from balance sheets, but almost 67% of all projects. Hence, the size of project financed investments was on average significantly larger than those financed from

balance sheet in 2014, which is the typical observation that can often be made across RES. In both 2014 and 2105, no biomass power plants were financed using bonds or other financing mechanisms.

THE UK DOMINATES BIOMASS INVESTMENTS IN 2015, INVESTMENTS FALL IN SWEDEN

While investments in biomass capacity are concentrated in two EU Member States in 2014, namely the UK and Sweden, the UK becomes the sole large player in biomass investments in 2015. Asset finance for biomass plants in the UK leaped from € 678 million in 2014 to astonishing € 1.79 billion in 2015. In 2014, more than 43% of all biomass investments in the EU were recorded in the UK. This already high share even increased to 71% in 2015. In spite of these more than doubled investments, the number of biomass projects only increased marginally from nine to ten. Hence, the average biomass investment in the UK was significantly larger in 2015 compared to the previous year. The capacity added associated with asset finance in the UK grew from 166 MW in 2014 to 289 MW in 2015.

A reversed, but equally considerable trend could be observed in Sweden. In 2014, Sweden saw the second highest investments in biomass plants in the EU that totalled € 611 million, i.e. almost as high as asset finance in the UK. These investments were directed at two biomass plants with an aggregated capacity of 165 MW. With combined investments of € 1.26 billion in 2014, Sweden and the UK were responsible for almost 83% of all investments in biomass in the European Union in that year. In 2015, however, no biomass projects reaching financial close were recorded in Sweden.

DIVERSE DEVELOPMENTS ACROSS THE EU

As in the previous years, new investments in biomass capacity develop very heterogeneously within and across EU Member States, where Member States with investments in both 2014 and 2015 are the exception. And even those Member States experience rather large changes in investment amounts across both years. Furthermore, it is striking that all countries other than the UK, where biomass investments were observed in 2015, experienced one biomass project, respectively.

The second and third highest biomass investments in 2015 could be observed in Finland and Ireland, where € 369 million and € 180 million were invested, respectively. Both countries did not experience any biomass investments in the previous years. Denmark and France are the only Member States, other than the UK, where biomass investments were recorded in both years. While investments increased in Denmark, namely from € 68 million in 2014 to € 88 million in 2015, asset finance for biomass plants dropped considerably in France. In 2014, three French biomass projects reached financial close totalling € 138 million. In the subsequent year, investments only reached € 37 million.

The remaining 2015 biomass investments were conducted in the Czech Republic and the Netherlands. In both Member States, financing was secured for one biomass plant, while the investments amounted to € 49 million and € 10 million, respectively. In both countries no asset finance deals for biomass were recorded in 2014. In contrast, in Bulgaria, Spain, and Italy biomass investments could be observed only in 2014. They totalled € 40 million, € 13 million, and € 10.5 million, respectively. ■

2

Share of different types of asset finance in the solid biomass sector in the EU in 2014 and 2015

	2014		2015	
	Asset Finance - New Built (mln. €)	Number of Projects	Asset Finance - New Built (mln. €)	Number of Projects
Balance Sheet	38.8%	66.7%	57.1%	56.3%
Project Finance	61.2%	33.3%	42.9%	43.7%
Bond/Other	0.00%	0.0%	0.00%	0.0%
Total EU	100.0%	100.0%	100.0%	100.0%

Source: EurObserv'ER 2016

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OTHER RES SECTORS

Some RES sectors saw only very few or no investments in new capacity in 2014 and 2015. Hence, asset financing for these RES is not covered individually. For completeness, however, these RES sectors are jointly analysed in this section. While some biofuel and geothermal projects reached financial close in 2014 and/or 2015, no new investments were recorded in case of concentrated solar power (CSP).

BIOFUEL INVESTMENTS

Biofuels are liquid transportation fuels that include biodiesel and bioethanol. Asset finance for biofuels largely differs from the other renewable energy technologies, where asset financing is almost entirely defined as investment in power plants that produce electricity (or in a few cases also heat). In the case of biofuels, asset financing is defined as investment in plants that produce biofuels. Hence, it excludes producers of biomass that is used as an input for biofuels. The following two types of biofuel utility-scale investments are tracked: (i) Diesel substitutes and (ii) petrol substitutes. Hence, capacity is measured in million litres per year (mLpa)

1

Overview of asset finance in the biofuels sector in the EU Member States in 2014 and 2015

	2014			2015		
	Asset Finance - New Built (mln. €)	Number of Projects	Capacity (MW)	Asset Finance - New Built (mln. €)	Number of Projects	Capacity (MW)
Denmark	39.95	1	73	0	0	0
Netherlands	66.62	1	171	0	0	0
Sweden	34.78	1	167	0	0	0
Total EU	141.35	3	411	0	0	0

Source: EurObserv'ER 2016

In the biofuels sector, investments into new biofuels plants were only recorded in 2014. In Denmark, Netherlands, and Sweden, one biofuel project reached financial close in that year, respectively. The largest investment occurred in the Netherlands with almost € 67 million, followed by Denmark (€ 40 million) and Sweden (€ 35 million). While the Danish investment is aimed at a bioethanol plant, both investments in the Netherlands and in Sweden can be attributed to the biodiesel sector. For all these investments, balance sheet financing was used. The capacity added associated with all investments in 2014 totals 411 mLpa. ■

2

Share of different types of asset finance in the biofuels sector in the EU in 2014 and 2015

	2014		2015	
	Asset Finance - New Built (mln. €)	Number of Projects	Asset Finance - New Built (mln. €)	Number of Projects
Balance Sheet	100.0%	100.0%	0.0%	0.0%
Project Finance	0.0%	0.0%	0.0%	0.0%
Bond/Other	0.0%	0.0%	0.0%	0.0%
Total EU	100.00%	100.00%		

Source: EurObserv'ER 2016

GEOTHERMAL INVESTMENTS

This technology uses geothermal energy to 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 due to the large differences with respect to geothermal potential across Member States. In 2015, investments in new geothermal plants were solely recorded in the Netherlands, while in 2014 one geothermal project reached financial close in Hungary. The 2014 investment in Hungary totalled € 31 million with associated capacity added of 52 MWth.

1

Overview of asset finance in the geothermal sector in the EU Member States in 2014 and 2015

	2014			2015		
	Asset Finance - New Built (mln. €)	Number of Projects	Capacity (MWth)	Asset Finance - New Built (mln. €)	Number of Projects	Capacity (MW)
Netherlands	0	0	0	58.81	3	45.0
Hungary	31.25	1	52.0	0	0	0
Total EU	**31.25**	**1**	**52.0**	**58.81**	**3**	**45.0**

Source: EurObserv'ER 2016

The three projects recorded in the Netherlands in 2015 amount to € 59 million. The associated capacity added totals 45 MWth. While the geothermal investment in Hungary was balance sheet financed, the investments in the Netherlands all used project financing. ■

2

Share of different types of asset finance in the geothermal sector in the EU in 2014 and 2015

	2014		2015	
	Asset Finance - New Built (mln. €)	Number of Projects	Asset Finance - New Built (mln. €)	Number of Projects
Balance Sheet	100.0%	100.0%	0.0%	0.0%
Project Finance	0.0%	0.0%	100.0%	100.0%
Bond/Other	0.0%	0.0%	0.0%	0.0%
Total EU	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Source: EurObserv'ER 2016

INTERNATIONAL COMPARISON OF INVESTMENT COSTS

For the first time, 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 (based on the figures given in the chapter asset financing) 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. Furthermore, for several RES sectors, e.g. biogas or biofuels, investment expenditures are not calculated as no or too few investments in the respective RES sectors were

recorded in the considered non-EU countries.

1

Wind Onshore Investment Expeditures (mln. € per MW)

	2014	2015
Canada	2.34	1.73
China	1.40	1.40
India	1.16	1.12
Japan	1.44	1.40
Norway	–	1.40
Russian Federation	–	1.40
Turkey	1.41	1.40
USA	1.48	1.46
Average EU	1.15	1.42

Source: EurObserv'ER 2016

2

Wind Offshore Investment Expeditures (mln. € per MW)

	2014	2015
China	2.99	3.20
Japan	4.95	27.00
USA	–	10.42
Average EU	4.24	4.61

Source: EurObserv'ER 2016

INVESTMENT EXPENDITURES ACROSS RES SECTORS

In the wind sector, investment costs have been calculated separately for onshore and offshore wind. The rationale behind this approach is that, as it could be seen in the analysis of wind investments in the EU presented in this and the last editions, investment expenditures per MW are notably higher for offshore compared to onshore wind. With respect to onshore wind, it is notable that in almost all of the countries, where onshore wind projects reached financial close in both years, investments costs decreases between the two years. In the EU, in contrast, investment expenditures increased marginally. In 2014, the average EU investment costs of € 1.15 million for one MW of onshore capacity were below the non-EU countries' average of € 1.54 million per MW. In 2015, however, the EU costs of € 1.42 million per MW are almost equal to the average of the other countries of € 1.41 million per MW.

In contrast to onshore, only very few of the analysed countries experienced offshore wind investments, namely the United States in 2015 as well as China and Japan in 2014 and 2015, respectively. Due to the very few underlying offshore wind projects – e.g., Japan and the United States saw one offshore wind investment in 2015, respectively – it is difficult to compare the investment costs. In the case of Japan, e.g., the offshore wind investment in 2015 is a demonstration plant, which explains the very high costs per MW.

With respect to investment costs for Solar PV plants, the same pattern as in the (onshore) wind sector can be observed for the EU, i.e. costs increase between 2014 and 2015 from € 1.22 million per MW to € 1.43 million. Similar to wind power, India had the lowest investment expenditures per MW of capacity in both years. In 2014, the investment costs for Solar PV capacity in the EU was notably below the average of the analysed non-EU countries, which was € 2.15 million per MW. In spite of the increase in investment costs in the EU, the EU investment costs remained below the average costs of the other countries, which amounted to € 1.87 million in 2015.

In the biomass sector, the investment costs for one MW of capacity in the EU amounted to € 3.08 million per MW in 2014. This value was below the average of the considered non-EU countries (€ 3.57 million per MW). The relation reverses in 2015, where investment costs increased notably in the EU. In the other countries, average investment expenditures per MW of biomass capacity dropped notably to only € 2.8 million. Analogue to the case of offshore wind, however, these numbers have to be interpreted with care due to, in some cases, very few observations. In Canada, India, and the United States only one biomass investment was recorded, respectively.

3

Solar PV Investment Expeditures (mln. € per MW)

	2014	2015
Canada	3.39	3.14
China	1.62	1.56
India	1.20	1.10
Japan	2.12	2.00
Russian Federation	3.08	1.89
Turkey	1.60	1.50
United States	2.05	1.87
Average EU	1.22	1.43

Source: EurObserv'ER 2016

4

Biomass Investment Expeditures (mln. € per MW)

	2014	2015
Canada	5.49	–
China	2.08	1.65
India	2.79	–
Japan	3.93	2.75
United States	–	4.00
Average EU	3.08	4.37

Source: EurObserv'ER 2016

Overall, the analysis shows that for the majority of RES technologies, the investment costs per MW of capacity in the EU seem to be below the average of the considered non-EU countries. However, it is striking that investment costs seemed to have increased between 2014 and 2015, while they dropped in the EU trading partner countries. If this trend continues in the subsequent years, the EU could lose its good position with respect to investment expenditures some RES sectors, as solar PV or (onshore) wind. ■

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 2014 and/or 2015 is presented. This overview only contains programmes, where financial instruments, as debt or equity finance or guarantees, are offered[1]. As the overview concentrates on programmes for finance RES or funds, it might omit public finance institutions that provide RES financing without having explicitly set up a programme or dedicated fund. 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.

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) or Cassa Depositi e Prestiti. 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).

FINANCING SCHEMES AND INSTRUMENTS

The presented public finance programmes differ with respect to the financing instruments used as well as the financing amounts and types of final beneficiaries. Most of the programmes and funds offer concessional financing. In some cases, also loan guarantees are offered. An example is the French loan guarantee programme FOGIME. The French Agency for Environment and Management (ADEME) offers guarantees for loans for RES investments of SMEs, which cover 70% of the loan.

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

1. This chapter is therefore complementary to the RES policy reports that the EurObserv'ER project publishes on its website https://www.eurobserv-er.org/eurobserver-policy-files-for-all--member-states/

Pixabay

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). This facility 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.

Overall, a wide variety of financing schemes, used instruments, and targeted final borrowers can be observed in the EU. It will remain to be seen, how the public involvement in financing RES projects will evolve over the next years. On the one hand, the need of public finance might decline as different RES technologies mature over the years. On the other hand, 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
Joint European Support for Sustainable Investment in City Areas (JESSICA)	European Investment Bank (EIB) & the Council of Europe Development Bank (CEB)	2007	EU 28	Multiple RES	Loans and guarantees for RES investments in urban areas
EIB Cohesion Fund	European Investment Bank (EIB)	2014	Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia and Slovenia	Multiple RES (and other non-RES focus areas)	Financial support (guarantees, loans, (quasi-) equity participation and other risk-bearing mechanisms) is provided to Member States whose Gross National Income per inhabitant is less than 90% of the EU average.
Loan guarantees for local initiatives for the construction of wind-energy plants	Energinet.dk	2009	Denmark	Onshore Wind	Provision of loan guarantees
Government Crediting and Loan Guarantee for Energy Efficiency and Renewable Energy Investment - FOGIME	French development bank for SMEs (OSEO / Bpifrance); French Agency for Environment and Energy Management (ADEME)	2001	France	Multiple RES	Guarantees for SME loans for renewable energy investments
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 photovoltaic, Solar Thermal	Loans for RES (with different conditions based on RES technolology)
Market Incentive Programme	Kreditanstalt für Wiederaufbau (KfW), Federal Ministry of Economic Affairs	1999	Germany	Biomass, geothermal, solar PV	Soft loans for larger/commercial RES installations
Environment Innovation Programme	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 projects
The Lithuanian Environmental Investment Fund (LEIF)	The Lithuanian Environmental Investment Fund (LEIF)	1996	Lithuania	Multiple RES	Soft 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
Sustainable Energy Financing Facility (PolSEFF)	European Bank for Reconstruction and Development (EBRD)	2011	Poland	Multiple RES	Provision of credit lines that are available through partner banks
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 projects
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 Startup 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 2016

Investment in Renewable Energy Technology

The EurObserv'ER investment indicators also focus on describing the financing of the development and the production of the RES technologies themselves. To this end, they provide an overview of the investments in venture capital and private equity on the one hand, and on the evolution of RES firms listed on stock markets on the other hand.

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 amount 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 that VC deals. PE-buyouts are in general the largest deals by far 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, for the first time in this edition, 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-only 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 2014, the firms are weighted by their 2013 revenues whereas in 2015, the 2014 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 2014 revenues.

For the first time in this edition, 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.

VENTURE CAPITAL – PRIVATE EQUITY

Compared to 2014, 2015 was not a good year for venture capital (VC) and private equity (PE) investment in renewable energy. VC/PE investments fell substantially from € 3.67 billion in 2014 to € 2.03 billion in 2015. This corresponds to a decrease by more than 44%. The 2015 investments, however, are still above the 2013 VC/PE investments of € 1.89 billion. In spite of the decline in investment sums, the number of deals remained almost constant. In 2014, 30 deals were recorded compared to 31 deals in 2015. Hence, the average investment per deal fell with a similar magnitude as total investments, namely from an average VC/PE deal size of € 122 million in 2014 to € 66 million per deal in 2015. The negative trend in VC/PE investments seems even more drastic, when these developments are compared to the trends of the overall activity in VC/PE investments in the EU (covering all sectors). Data published by the European Private Equity and Venture Capital Association (EVCA) shows an increase of overall VC/PE investments in the EU between 2014 and 2015, which grew by 13% between both years. Hence, the reduction of VC/PE investments in the renewable energy sector seem to be RES specific, as all other sectors, on average, experienced an upsurge in VC/PE investments.

BREAKDOWN OF VC/PE INVESTMENT STAGES

Before analysing the sectorial trends in VC/PE investments, a disaggregation of data in investments stages reveals interesting insights, as it offers insights in the relative importance of investments in the different stages of maturity of RES technology firms. 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 seed 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. In contrast to VC, 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. This breakdown allows for a more detailed analysis of the dynamics in the VC/PE market. However, the trends have to be interpreted with care as the data coverage might not be perfect and due to the rather low amount of observations for VC/PE, potentially missing data might have a dilutive effect on the results.

The data shows that the decrease in VC/PE investments from 2014 to 2015 was mainly driven by a decline of PE investments. The by far highest investment amounts can be observed for PE Expansion Capital. While PE Buy-outs only fell marginally from € 1.97 billion in 2014 to € 1.85 billion in 2015, PE Expansion Capital slumped drastically from € 1.63 billion to only € 113 million.

With respect to venture capital investments, however, the picture changes notably. VC investments in 2014, both early- and late-stage, totalled € 60 million compared to € 74 million in 2015, which is an increase by 24%. Early-stage VC investments, in particular, experienced a significant upsurge between the two years. The number of VC deals remained relatively constant with 12 deals in 2014 and 15 deals in 2015. This indicates that, in spite of the overall decline in VC/PE investments, the investment activities into young RES technology firms seem still to be attractive for venture capital funds.

WIND DOMINATES VC/PE INVESTMENTS

When taking a more detailed look at the respective renewable energy technologies, it is important to keep in mind the types of VC/PE investment discussed above. Hence, when total VC/PE data is dominated by specific large PE buy-out or PE expansion capital deals, this will be addressed in the analysis of the respective sectors. Furthermore, 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 at least two sectors, which makes a disaggregation nearly impossible.

As in the previous years, it can be observed that the by far largest VC/PE investments occur in the wind sector. Particularly in 2014, the wind sector dominated the market with investments worth € 3.31 billion. This means that, in that year, 90% of all VC/PE investments were aimed at project developers or technology firms in the wind sector. The situation changes in 2015, however, where wind investments decreased by 55% to € 1.49 billion. Due to this significant decline, the share of wind in total VC/PE investments also decreased to 73% in 2015. The dominance of the wind sector in overall investments, however, can be mainly explained by very large PE Buy-outs, which amounted to € 1.3 billion in 2015 and even € 1.75 billion in 2014.

1

Venture Capital and Private Equity Investment in Renewable Energy per Technology in the EU in 2014 and 2015

	2014		2015	
	Venture Capital / Private Equity (mln. €)	Number of Projects	Venture Capital / Private Equity (mln. €)	Number of Projects
Wind	3311.97	10	1490.00	7
Solar PV	288.95	14	343.12	13
Biofuels	53.00	2	112.83	3
Geothermal	0	0	57.72	2
Small Hydro	0	0	18.40	1
Biogas, Biomass & Waste	11.22	4	12.71	5
Total EU	3665.13	30	2034.76	31

Source: EurObserv'ER 2016

Analysing the amounts of VC/PE investment without PE buy-outs in the wind sector shows that the latter are driving the dominance of the wind sector in 2015. In contrast, even when subtracting PE buy-outs from overall wind investments in 2014, the sector remains by far largest with around € 1.56 billion. Finally, it should be mentioned that another key driver of the 2014 VC/PE investments in the wind sector is one very large PE Expansion Capital deal in the range of € 1.5 billion.

Compared to investments in the wind sector, which are mainly driven by these large PE Expansion Capital deals and PE Buy-outs, the investments in the other RES sectors are relatively small in absolute amounts. Furthermore, it is noteworthy that wind is the only sector that experienced declining investments. All other sectors, where VC/PE deals were recorded, saw upsurges in investments. VC/PE investments in Solar PV ranked second in both years and increased by almost 19% from € 299 million in 2014 to € 343 million in 2015. The number of deals, however, remained relatively constant between the two years with 14 and 13 deals in 2014 and 2015, respectively.

In the biofuels sector, the largest increase in VC/PE investments could be observed. Investments more than doubled from € 53 million in 2014 to € 113 million in 2015. In both 2014 and 2015, this sector had the third largest VC/PE investments. Furthermore, it is noteworthy that, in both years, there was no venture capital investment in biofuels, but rather PE Expansion Capital – and PE Buy-out deals.

The biogas, biomass, and waste sectors experienced the lowest investments in both years. In 2014, € 11.2 million were invested compared to € 12.71 million VC/PE investments in 2015. Similarly, also the number of VC/PE deals in these sectors remained almost constant at 4 in 2014 and 5 in 2015. In contrast to biofuels, the majority of investments are venture capital investments. Hence, there seem to be more new technology firms in these sectors in both years. This fact also explains the relatively small investment sums for biogas, biomass, and waste.

Finally, there are two sectors that only experienced VC/PE investments in 2015, namely geothermal and small hydro. Investments amounted to € 18.4 million in the small hydro and € 57.7 million in the geothermal sector. The single

2

Venture Capital and Private Equity Investment in Renewable Energy per Investment Stage in the EU in 2014 and 2015

	2014		2015	
	Venture Capital / Private Equity (mln. €)	Number of Projects	Venture Capital / Private Equity (mln. €)	Number of Projects
VC Early Stage	42.18	11	71.74	13
VC Late Stage	17.31	1	2.19	2
PE Expansion Capital	1632.28	11	112.86	5
PE Buy-out	1973.36	7	1847.98	11
Total EU	3665.13	30	2034.76	31

Source: EurObserv'ER 2016

deal recorded for small hydro, however, is a PE Buy-out, while in the case of geothermal we saw one PE Buy-out deal as well as an Early-stage VC investment.

MOST VC/PE DEALS IN THE UK, LARGEST INVESTMENTS IN GERMANY

In general, it is difficult to derive country trends in VC/PE investments as typically very few deals can be observed per country and hence the situation varies largely between years. However, a few noticeable country-specific observations should be pointed out to complete the analysis of VC/PE investments. The four countries with the largest VC/PE investments were Germany, France, Italy, and the United Kingdom. Both Germany and France saw six deals, respectively, compared to three deals in Italy. Although it only experienced the fourth largest VC/PE investments, 11 VC/PE deals were recorded in the UK in 2015 indicating a relatively vibrant market compared to other EU Member States.

In 2014, the largest investments were by far recorded in Denmark and Ireland amounting to € 1.5 billion and € 1.1 billion, respectively. In both cases, however, there was one PE Buy-out deal. With respect to the number of VC/PE deals, France was ranked first in 2014 with 9 deals followed by Germany with 6 deals. Hence, these two Member States accounted for half of all VC/PE deals in the EU in 2014. ■

Pixabay

PERFORMANCE OF RES TECHNOLOGY FIRMS AND RES ASSETS

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. In this edition, four indices are presented, i.e. a Wind, a Solar, a composite Bio-Technology Index, and an aggregate RES Index. The former three indices consist of 10 firms that are (almost) entirely active in the respective RES sector, while the latter is an aggregate index of those three technology indices. These indices are an indicator of current and expected future performance of EU RES companies listed on stock markets.


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As there is a small adjustment in the methodology of these indices, they are normalized to 100 at a new base date, namely the beginning of 2014. The main difference compared to previous editions is a composite Bio-Technology Index, while previous editions reported separate biogas, biomass, and biofuels indices. There are two main reasons for this amendment. First, several of these firms are not listed on stock markets anymore due to, e.g., bankruptcy or acquisition by another company. Hence, there were not enough firms left to construct meaningful separate indices. Second, most of the firms captured in the current Bio-Technology Index are active in more than one RES sector, 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 and hence should not be interpreted too generally. Entities that are owned by parent companies (e.g. Siemens Wind Power owned by Siemens AG) 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 a RES sector. Examples are Abengoa, a Spanish company that is active in CSP and biofuels, but also in other fields as water treatment and conventional generation and hence does not satisfy the criteria of the RES indices as their revenues are not mainly driven by activities in RES sectors.

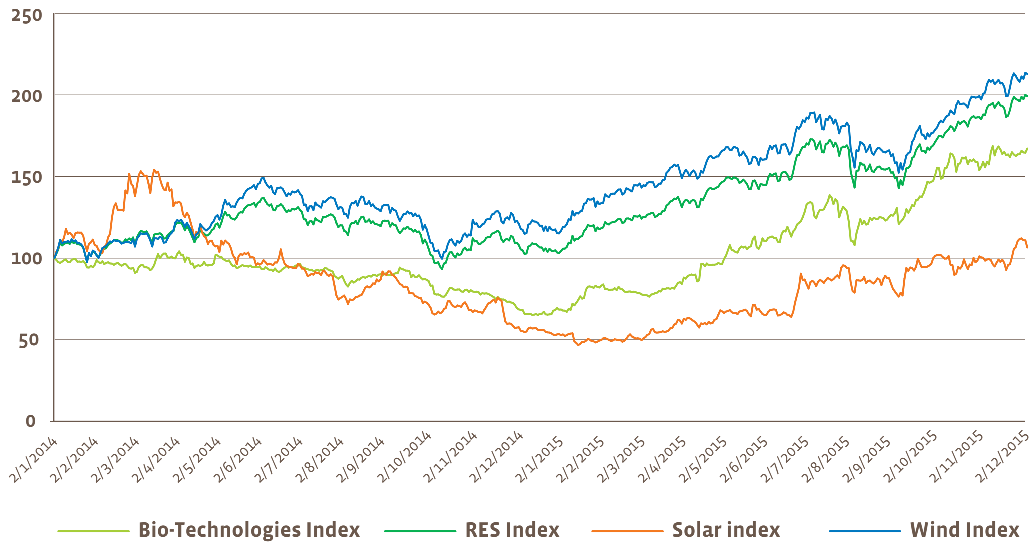
As in the previous editions, a non-RES stock index is captured in order to assess how RES companies perform in comparison to the whole market. Instead of the STOXX Europe 50 index, however, the EURO STOXX 50 is used as a base index from this edition onwards. The main reason is the composition of both indices. The STOXX Europe 50 is an index of the 50 largest companies in Europe, while the regional focus of the EURO STOXX 50 is the Eurozone. The disadvantage of the latter, of course, is that it does not include EU Member States without the Euro. However, the STOXX Europe 50 is not limited to the EU and hence also includes 9 Swiss companies. As the majority of the companies in the RES-Indices are from the Eurozone, the EURO STOXX 50 seems to be a more suitable base index within this analysis. Since the STOXX is using market capitalization weights, it cannot be compared to the RES indices in every detail.

COMPOSITION OF RES INDICES

Compared to the last edition, some firms in the indices were replaced. One reason for removal was a change in methodology. As the focus of the RES Indices is to be on EU companies, and not, as previously, RES companies listed on EU stock exchanges, two firms were replaced in the indices. These are the Indian wind turbine producer Suzlon as well as China New Energy. Due to the exclusion of Suzlon, FUTUREN (ex Theolia SA) was included into the wind power index. As firms are selected based on the revenues, there are also replacements due to changes in revenues.

1

Evolution of the RES indices during 2014 and 2015



Wind Index: *Vestas (DK), Enel Green Power (IT), Gamesa (ES), Nordex (DE), EDP Renovaveis (PT), Falck Renewables (IT), PNE Wind AG (DE), Energiekontor AG (DE), ABO Wind AG (DE), FUTUREN (FR)*

Photovoltaic Index: *SMA Solar Technology AG (DE), Solarworld AG (DE), Centrotherm Photovoltaics AG (DE), Ternienergia (IT), Solar-Fabrik AG (DE), PV Crystalox Solar PLC (UK), Etrion (SE) , Auhua Clean Energy (UK), Solaria Energia (ES), Enertronica SpA (IT)*

Bio-Technologies Index: *Cropenergies AG (DE), Verbio Bioenergie (DE), Albioma (FR), 2G Energy AG (DE), Envitec Biogas (DE), KTG Energie AG (DE), Cogra (FR), BDI-BioEnergy International AG (DE), Active Energy (UK), Global Bioenergies (FR)*

The majority of firms in the Bio-Technologies Index are German companies. Six out of the ten companies in this index are based in Germany. Furthermore, there are two 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. Compared to the previous years, the relative dominance of German firms in the Solar PV index declined. The Solar PV Index comprises four German companies, two from each of Italy and the UK, and one Spanish PV firm. The largest company in the Solar PV Index is by far SMA Solar Technology AG. The Wind Index is marginally more heterogeneous with respect to the regional distribution of the companies. The only Member States represented with more than one firm are Germany with four and Italy with two wind companies. In addition, there is one firm from each of Denmark, France, Portugal, and Spain. The largest company represented in the Wind Power Index is the Danish company Vestas.

GOOD PERFORMANCE OF QUOTED RES FIRMS

A comparison of the three RES indices shows differences both in the trend and the volatility of the indices. Quoted wind firms experienced the best development, particularly in 2015. Between January and June 2014, the Wind Index grew to almost 150 points, but subsequently fell again to the 100 points base mark by November that year. Subsequently, however, a continuous positive trend can be observed until the end of 2015, where the Wind Index closes at almost 213 points. The Bio-Technology Index shows substantially different development in 2014 and 2015. In 2014, the Bio-Technology Index was characterised by a quite stable downward trend. Having started at 100 base points, the Index closes at 66 points at the end of the year. At the transition from 2014 to 2015, the trend reverses. The Bio-Technologies Index shows a positive trend until the end of 2015 and closes at 167 points in December 2015. The Solar PV Index shows a similar pattern, but an overall less positive development. Similar to the Bio-Technology Index, the overall trend of the Solar PV Index in 2014 and early 2015 is negative. Early 2015, the Index even falls below the 50 points mark. From the second quarter in 2015, the Solar PV Index shows a positive development, however, with a smaller magnitude compared to the other two indices and hence closes only marginally above the 100 points mark by the end of 2015. A major difference of the Solar PV Index compared to the other two indices is the short upsurge in the PV index in February and March 2014, where the index crosses the 150 points mark. This increase, however, is only temporary and the Solar PV Index drops to the initial value only two months later.

Due to the positive developments captured by all three RES Technology Indices, it is not surprising that the aggregate RES-Index also shows a positive picture. As can be seen in the figure, the 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 – revenues in the wind sector are responsible for around 75%-80% of the aggregate revenues generated by all RES firms in the indices – the Wind Index dominates the aggregate RES Index. An interesting joined pattern for all RES technology indices and hence for the RES-Index can be observed in the third quarter of 2015, more precisely on 20 August 2015. On this date, all indices experienced a notable drop. A possible explanation might be an article of the Guardian published on that day. The Guardian[1] claimed that several large fossil fuel companies had conducted organised lobbying activities in order to curb EU policy support for renewable energies.

Overall, the RES indices show that the years 2014 and, in particular, 2015 were very prosperous for listed RES companies. In both years,

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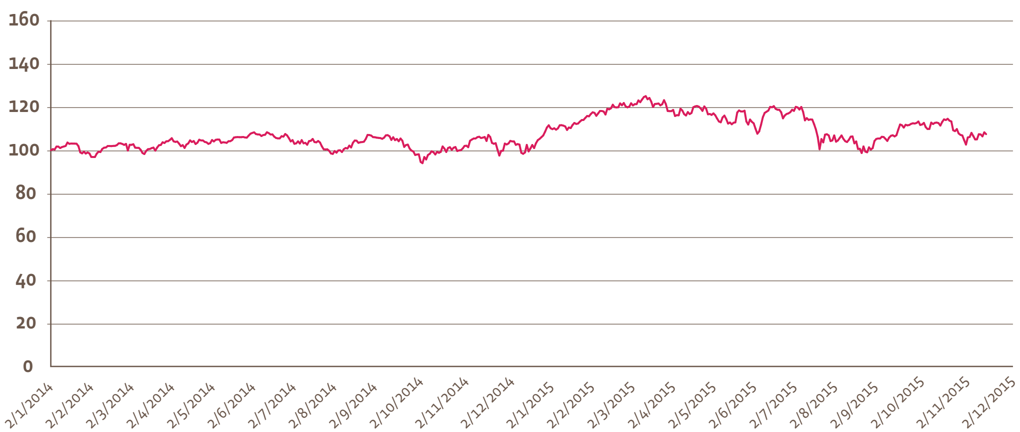
Evolution of the Euro STOXX 50 index during 2014 and 2015



1. theguardian.com/environment/2015/aug/20/bp-lobbied-against-eu-support-clean-energy-favour-gas-documents-reveal the RES sectors also seemed to have performed better than the whole market, approximated by the EURO STOXX 50 Index. 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. The particularly good development of technology firms and developers in the wind sector is in line with the developments in investments in capacity. Between 2014 and 2015, as well as in the previous years, a stable growth in wind investments could be observed. Wind technology firms seem to have profited from these developments. In contrast, Solar PV firms faced a rather tough environment in the last years with unstable or dropping investments in PV capacity and dropping prices.

In spite of these developments, the overall development of quoted firms, however, is relatively stable. One should nevertheless 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

In order to compare profitability of technology firms and the plants actually using those technologies, the analysis of RES technology shares is complemented by so-called YieldCos. YieldCos are 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.

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 to their low risk profile and predictable cash flows.

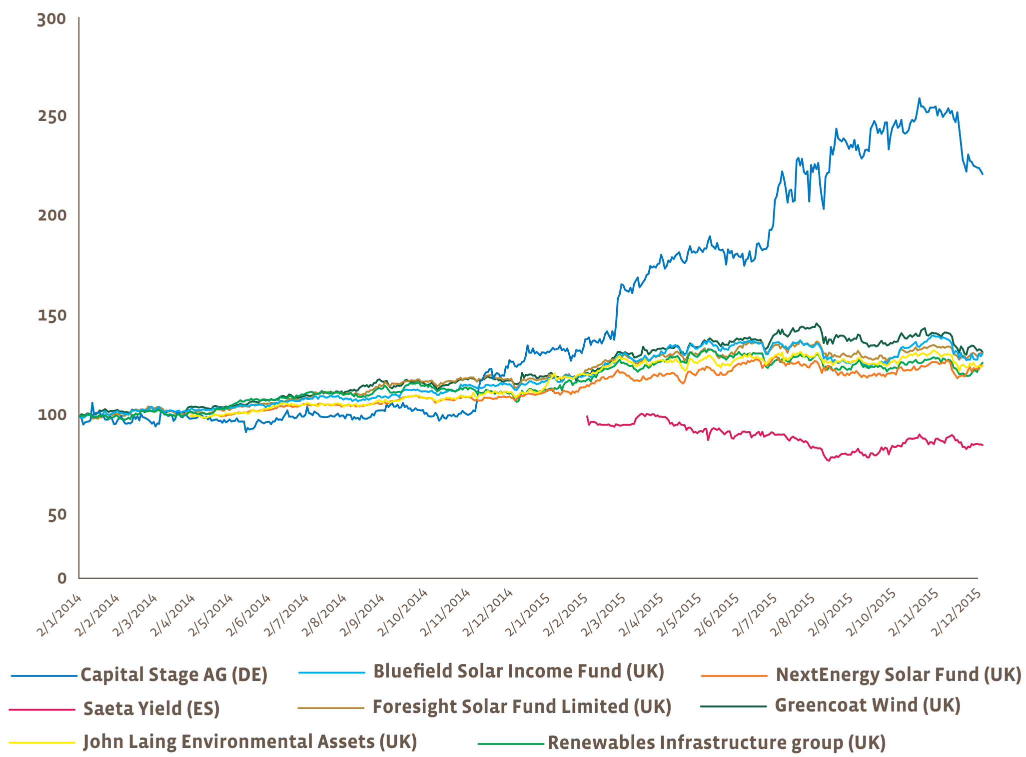
There are only very few YieldCos currently operational in the EU. In the relevant period, 2014 and 2015, eight YieldCos were active in the EU. The majority of these, namely six, are based in the UK, which is, next to the United States, the country were the first YieldCos emerged. The two remaining YieldCos are based in Germany and

Spain, respectively. The figure on YieldCos shows the developments of the stock prices of these eight YieldCos. For comparison, the stock prices of all YieldCos were normalised to 100 at the beginning of the observation period. For all the UK based YieldCos, a slow but steady positive development can be observed until summer 2015. In the second half of 2015, the upward trend seems to have stagnated. The German YieldCo has performed significantly better, in particular in 2015. However, it seems more volatile compared to the UK based YieldCos. In early 2015, a Spanish YieldCo was initially offered on the public market. This YieldCo, however, is the only one that shows a downward trend until the end of 2015.

Overall, the few existing YieldCos in the EU seemed to have performed rather well. However, it remains to be seen whether EU YieldCos also show a stable development in the longer term. Furthermore, it remains to be seen how this YieldCo concept develops in the EU and whether more YieldCos will emerge in the coming years. 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. ■

3

Evolution of European YieldCos during 2014 and 2015



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 renewable energy generation capacity grew notably between 2014 and 2015. EU investments in RES capacity totalled € 33.2 billion in 2014 and € 38.4 billion in 2015, which is an increase by almost 16%. This upsurge in investments is even more astonishing, when considering that RES investments already increased substantially between 2013 and 2014.

However, the individual analysis of all RES sectors has revealed very heterogeneous developments. As in the previous years, investments in onshore and offshore wind dominate aggregate asset finance with respect to investment amounts. In 2014, € 23 billion were invested in wind power plants. In 2015, wind investments grew by more than 33% to almost € 31 billion. Hence, the share of wind in overall RES investments even increased between the two years. Apart from the wind sector, the biomass sector is the only RES sector with a notable positive trend between the two years. In contrast, a substantial drop in investments could be observed for solar PV, the second largest RES sector with respect to asset finance. Investments in utility-size PV capacity dropped from € 6.1 billion in 2014 to € 4.2 billion in 2015, which corresponds to a decrease by almost 31%. In contrast to these utility-size investments, investments in small scale PV installations, namely residential and commercial PV with capacities below 1MW, dropped slightly between 2014 and 2015, namely from € 5.9 billion to € 5.2 billion.

A common trend for most RES sectors is an increase in investment expenditures per MW of capacity between 2014 and 2015. A reason for this increase in investment expenditure might be the devaluation of the Euro between 2014 and 2015 that possibly increased the costs for imported components used for constructing the RES plants. It will remain to be seen whether this trend continues in the coming years. In contrast to utility-size investments, investments costs for small scale PV installations dropped by around 7.5%. For the first time, 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, Russian Federation, Turkey and the United States. Overall, the analysis showed that the investment costs per MW in the EU seem to be below the average of the considered non-EU countries for most RES sectors. However, if the trend of increasing investment expenditures in the EU continues in subsequent years, the EU could lose its good position with respect to investment costs.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VENTURE CAPITAL & PRIVATE EQUITY

Between 2014 and 2015, VC/PE investment in renewable energy fell by more than 44% in the EU. While VC/PE investments totalled € 3.67 billion in 2014, they only amounted to € 2.03 billion in the subsequent year. The decline in VC/PE investments in the RES sectors, however, was mainly driven by slumping PE investment. Venture capital, in particular early-stage VC, increased between both years.

As in the previous years, the largest VC/PE investments by far occurred in the wind sector. Particularly in 2014, the wind sector dominated the market, as 90% of all VC/PE investments were aimed at project developers or technology firms in the wind sector. However, the wind sector also experienced the largest slump in VC/PE investments between the two years. VC/PE investments in solar PV ranked second in both years and increased by almost 19% from € 299 million in 2014 to € 343 million in 2015. In the biofuels sector, an even larger increase in VC/PE investments could be observed. While the biogas, biomass, and waste sectors experienced the lowest investments in both years, there are two sectors that only experienced VC/PE investments in 2015, namely geothermal and small hydro.

The overall reduction in VC/PE investments in RES sectors were compared to the trends in other non-RES sectors. According to the European Private Equity and Venture Capital Association (EVCA), overall VC/PE investments in the EU grew by 13% between 2014 and 2015. This indicates that the reduction of VC/PE investments in the renewable energy sector might be RES specific, as all other sectors, on average, experienced an upsurge in VC/PE investments.

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-Technologies Index, comprise the ten largest quoted RES companies in the respective sector.

The Wind Index shows the most positive development by far, in particular in 2015. The Bio-Technologies Index shows substantially different development in 2014 and 2015. While the trend is overall negative in 2014 and the beginning of 2015, it reverses and shows a positive development in 2015. The Solar PV Index shows a similar pattern, but an overall less positive development. Due to the positive developments captured by all three RES Technology Indices, it is not surprising that the aggregate RES-Index also shows a positive picture.

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 reveal a very positive performance of quoted RES companies in the EU in the years 2014 and, in particular, 2015. In both years, 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, for the first time in this edition, 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 2014 and 2015, there were only eight YieldCos active in the EU, which overall performed rather well. However, it remains to be seen how the YieldCo concept develops in the EU and whether more YieldCos will emerge in subsequent years. ■

RENEWABLE ENERGY COSTS, PRICES AND COST COMPETITIVENESS

Are renewable technologies competitive or not? Renewables certainly have the potential to become mainstream energy sources. But whether or not, and when, this might happen depends, among others, on the reference prices paid for energy. Some renewables are already competitive, and some are not. But a full answer requires more aspects to be taken into account, such as the demand sector to which is being referred to and other non-economic barriers.

In this new section of the State of renewable energies in Europe, 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: ALWAYS 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.

METHODOLOGY

This section 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 are provided in a separate methodology paper, available from the EurObserv'ER website (see reference further below).

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 different 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. In the current approach, WACC is assumed to be country and technology specific. A Monte Carlo analysis is applied in the LCoE calculation approach. Important to note is that the costs presented here have been estimated based on literature sources[1]. 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[2] 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). For household applications (i.e. residential photovoltaics) the reference price includes levies and taxes, while for all other technologies the taxes and levies are excluded from the reference prices.

TECHNOLOGIES CONSIDERED

The technologies addressed are: residential ambient heat from 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). More background to the exact definitions can be found in the methodology paper (available from the EurObserv'ER website: www.eurobserv-er.org).

COST-COMPETITIVENESS OF RENEWABLE ENERGY TECHNOLOGIES

Overall the cost-competitiveness of renewable energy technologies varies per technology per Member State depending on the renewable energy resource characteristics and the cost of capital. Furthermore, cost-competitiveness varies with differences in reference energy prices in Member States. Mature technologies such as hydro, geothermal and solid biomass can provide 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 when compared with the reference heat prices mostly in the northern part of the EU.

LCOE RESULTS AND THE COST-COMPETITIVENESS

Graph 1 provides an overview of the LCoE ranges for the assessed technologies on a European Union level; the ranges derive from the Member State differentiation. The graph also presents the ranges of reference electricity, reference heat and reference transport fuel prices, all excluding taxes and levies. An exception is the reference price for Solar PV (household electricity

1. • *JRC, 2014. Energy Technology Reference Indicator projections for 2010-2050, Luxemburg: Publications Office of the European Union.*
• *Elbersen, B., Staritsky, I., Hengeveld,G., Jeurissen, L., Lesschen, J.P., Panoutsou C. (2016). Outlook of spatial biomass value chains in EU28. Deliverable 2.3 of the Biomass Policies project.*

2. • *Eurostat, http://ec.europa.eu/eurostat.*
• *Renewable energy in Europe 2017 - Recent growth and knock-on effects', EEA, April 2017, http://www.eea.europa.eu//publications/renewable-energy-in-europe-2017*

prices), where taxes and levies are included. The ranges illustrate the different energy prices observed in the EU Member States.

Renewable electricity

Among the technologies producing electricity from bioenergy (via biogas, liquid and solid biomass), the LCoE for technologies based on solid biomass seem the least expensive, and even in the same range as the reference electricity price. The LCoE for electricity from deep geothermal energy and hydropower are comparable. Commercial large scale PV shows a wide LCoE range, mostly as a result of the differences in solar yield across the Member States. Concentrating solar power has only been quantified for Southern Europe and results in a higher LCoE than Commercial solar PV. Wind energy LCoE has not been broken down into onshore versus offshore. The underlying reason for this is the very fast decline of offshore wind bid prices in recent tenders (Denmark, Germany, the Netherlands), which demonstrate that in certain large scale cases offshore wind LCoE is undercutting onshore wind levels. Moreover, the LCoE range observed for onshore wind is already very wide, largely covering offshore wind as well. Solar PV in the residential sector is special in the sense that the reference electricity prices are relatively high, making this technology, albeit at high LCoE levels, competitive in many Member States. One of the technologies not displayed in the figure is ocean energy (including wave and tidal energy), for which the assessment results in LCoE ranges between 400 and 600 EUR/MWh. As this is an outlying range the technology is not presented in the graph.

Renewable heat

For the technologies producing heat, the LCoE for solid biomass is overlapping the reference heat range, indicating it is competitiveness in many countries. The LCoE range for solar water heaters is only partly overlapping the reference heat range, indicating that it is mainly competitive in selected countries (mostly in the Southern part of the European Union). Heat captured from ambient heat via heat pumps shows, according to the analysis, relatively high LCoE levels.

Renewable transport

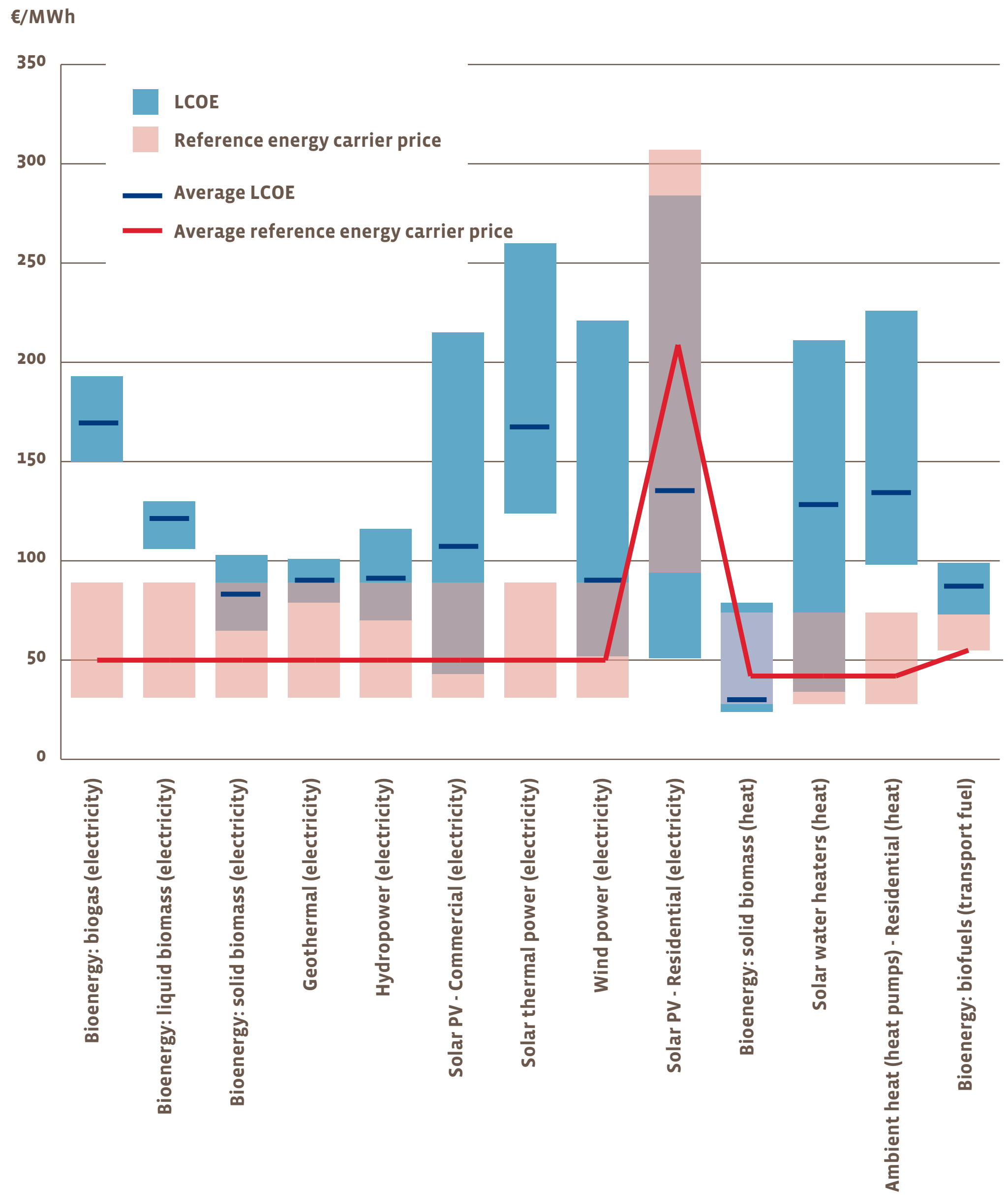
LCoEs for biofuels for transport show quite a narrow range, just above the reference transport fuel price levels.

TRANSPARENCY AND FEEDBACK

In order to improve the evaluation of the renewable energy cost competitiveness in the European Union, the applied methodology, the data and the assumptions have been transparently reported in a separate paper. Feedback on this paper from European and/or national renewables associations is appreciated. ■

1

LCoE and reference energy carrier (€/MWh) EU Overview



Note: Overview of the LCoE assessment on a European Union level; ranges derive from the Member State differentiation. The graph also presents the ranges of reference electricity, reference heat and reference transport fuel prices, all excluding taxes and levies. An exception is the reference price for Solar PV (household electricity prices), where taxes and levies are included. Data refer to 2015

Source: EurObserv'ER 2016

AVOIDED FOSSIL FUEL USE AND RESULTING AVOIDED COSTS

RENEWABLES REDUCE PURCHASING OF CONVENTIONAL ENERGY CARRIERS

This section covers two new indicators; avoided fossil fuels and avoided costs.

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 note

- *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 refers 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 2015 estimates are proxies for which updated statistics are currently available.*

The amount of avoided fossil fuels have been analysed by the European Environment Agency and presented in the report 'Renewable energy in Europe 2017 - Recent growth and knock-on effects', (EEA 2017[1]). 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.

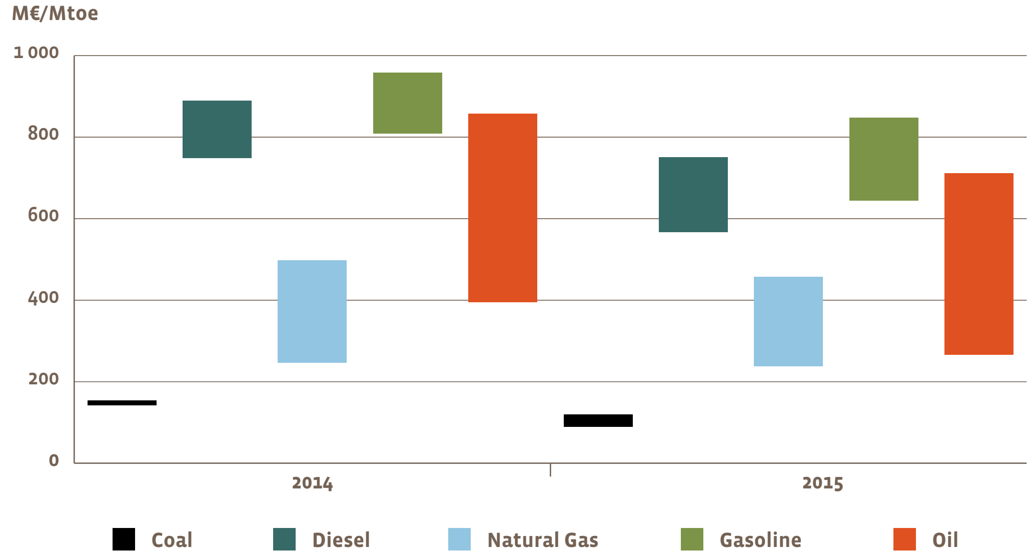
The avoided fossil fuel costs are based on the country specific fuel prices derived from multiple sources (Eurostat, European Commission, BP/Quandl). Figure 1 highlights the fuel price ranges observed in the 28 EU Member States for 2014 and 2015 for five energy carriers: coal, diesel, gasoline, natural 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).

Looking at the individual energy carriers and their ratios, it can be observed that coal is the least expensive fuel. Secondly, natural gas comes into play, followed by (heating) oil. Finally, diesel and gasoline are the most expensive fuels. Compared to 2014, prices in 2015 were lower and the data spread for natural gas and oil smaller.

1. *Renewable energy in Europe 2017 - Recent growth and knock-on effects', EEA, April 2017, http://www.eea.europa.eu//publications/renewable-energy-in-europe-2017*

1

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



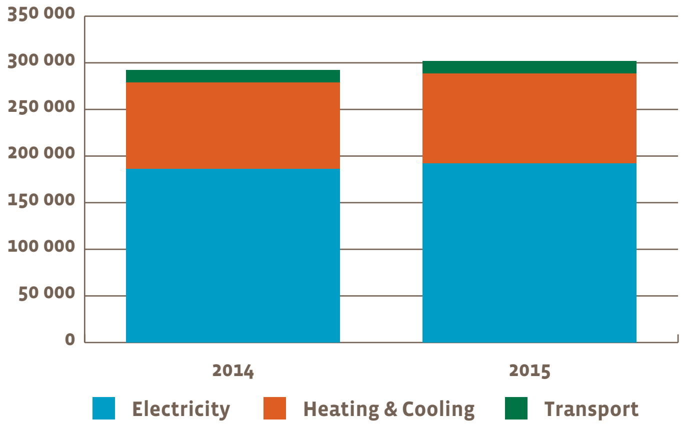
Source: EurObserv'ER based on EEA data

AVOIDED FOSSIL FUEL USE & AVOIDED COSTS PER TECHNOLOGY

The use of renewable electricity contributed to 64% of the total avoided fossil fuels. This is followed by renewables in the heating and cooling sector contributing to approximately 32% of the total avoided fossil fuels and the remaining 4% was substituted through renewable transport fuels (mainly compliant with the Directive 2009/28/EC are included) both in 2014 and 2015. In monetary terms, the avoided costs were € 49.3 billion in 2014 and € 40.5 billion in 2015 in the electricity sector.

2

Avoided fossil fuels per sector (ktoe)



Source: EurObserv'ER based on EEA data

Second, renewable heat contributed to avoided costs reaching to € 44.4 billion in 2014. In 2015 this fell to € 38.6 billion. Third is renewable transport fuels which contributed to avoided costs of € 10.4 billion in 2014 and € 8.3 billion in 2015. For correctly interpreting these results it is important to take note of a number of methodological issues, referred to in the text box page 197.

Although the penetration of renewable energy expanded by approximately 3% in 2015, the cumulative effect of the avoided fossil fuel costs is lower than in 2014. Underlying reason can be found in the decreasing fossil fuel prices in 2015 compared to 2014.

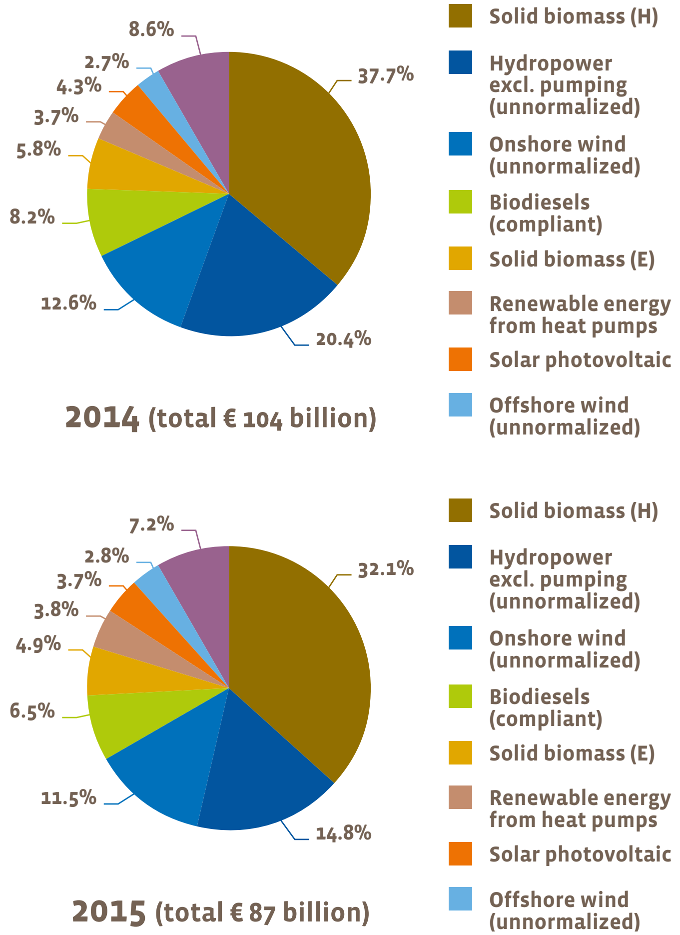
Among the RES technologies, solid biomass avoided the purchase of fossil fuels at an amount of € 32.1 billion in 2015 (€ 37.7 billion in 2014). Next, hydropower has been responsible for € 14.8 billion in 2015 (€ 20.4 billion in 2014). Onshore wind is third in the row with € 11.5 billion in 2015 (€ 12.6 billion in 2014).

In a graphical manner, graph 2 and the pie charts (graph 3) show how each technology contributes to the total avoided costs.

The largest share of avoided fossil fuels comes from solid fuels (mainly coal, 44% for both years 2014 and 2015), followed by natural gas (30% for both years). Next are oil products, with a contribution of 19% in 2014 and 20% in 2015. The remaining fuels (transport fuels and non-renewable waste) cover the remaining 7%.

3

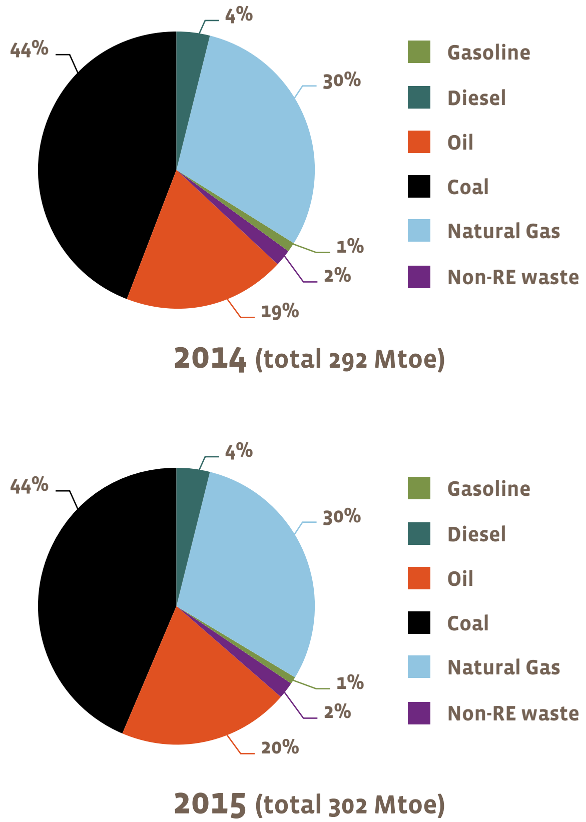
Avoided expenses in EU 28 through renewables in 2014 and 2015



Source: EurObserv'ER based on EEA data

4

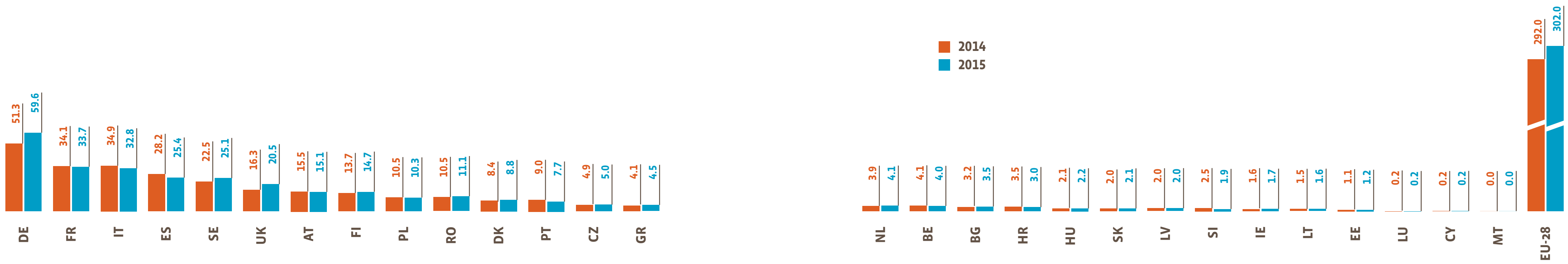
EU substituted fossil fuels during 2014 and 2015



Source: EurObserv'ER based on EEA data

5

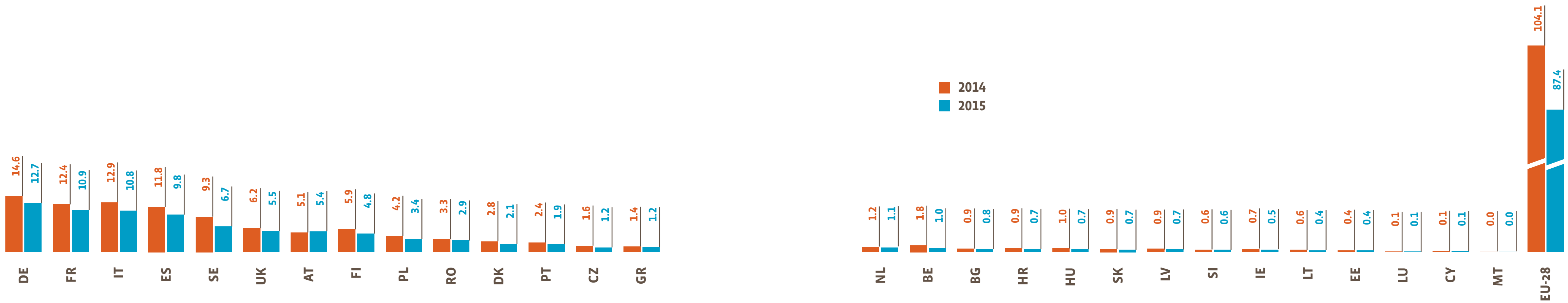
Avoided fossil fuels per country [Mtoe]



Source: EurObserv'ER based on EEA data

6

Avoided expenses per country [billion euro]



Source: EurObserv'ER 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 2015 compared to 2014, all countries show a similar pattern (except the United Kingdom: in relative terms the increase in avoided fossil fuels was highest in the United Kingdom, approximately 26% between 2014 and 2015, resulting in an increase in avoided costs while fuel prices lowered).

Nine Member States, however, experienced a decreasing trend in avoided fossil fuels due to decreased renewable energy deployment in 2015 compared to 2014. These countries are Spain, Italy, Portugal, Croatia, Slovenia, Romania, France, Austria and Belgium. See also the methodological notes on the EurObserv'ER website www.eurobserv-er.org

The data have been displayed graphically in figures 5 and 6.

CONCLUSIONS

In 2014 and 2015 renewable energy substituted around 292 Mtoe and 300 Mtoe of fossil fuels respectively. These figures correspond to an avoided annual cost of € 104 billion for EU 28 collectively (this represents approximately 0.7% of the EU 28 GDP in 2015) in 2014, decreasing to € 87 billion. This decrease was due to lower fossil fuel prices. The largest contributions derive from renewable electricity and renewable heat (at approximately equal contributions together representing about 90% of the avoided expenses). ■

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 new chapters: R&D expenditures 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.

Public R&D Investments

Investments into R&D and innovation in general are commonly seen as an important factor for the economic growth of countries. The analysis of R&D investments from a macro-economic perspective can thereby be viewed as a major input measure to indicate innovative performance of economies or innovation systems. The measure is able to indicate 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 the business, government and higher education sector (see Figure 1). In this section, the focus is on public R&D expenditures of a selected set of countries with regard to renewable energy technologies, i.e. research investments originating from the public sector, are taken into account (see 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.

The data on public R&D investment for this report were provided by JRC SETIS. The IEA statistics[1] are the main source of data for national R&D investments. They address 20 of the EU Member States with varying regularity and granularity of technology detail. There is a 2-year time delay in reporting for most Member States. Data gaps are supplemented by the Member States through the SET Plan Steering Group or through targeted data mining. 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".[2]
Besides providing absolute figures for public R&D expenditures (Euro) of the given countries, the share of public R&D expenditures on the GDP (%) is calculated to get an impression of the relative size of a country's investments in RET technologies. Blanks in the tables mean that no data was available.

1

Sectors by financing and performing of R&D

	Total R&D spending		
Increase	Business	Government	
Decrease	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

WIND ENERGY

	Public R&D Exp. (in Mio. €)		Share of Public R&D Exp. by GDP	
	2014	2015	2014	2015
EU 28				
Slovakia		0.0		0.0000%
Germany	53.1	53.0	0.0018%	0.0017%
United-Kingdom	25.5		0.0011%	
Denmark	25.3	26.0	0.0095%	0.0096%
Spain	16.5		0.0016%	
France	7.0		0.0003%	
Sweden	5.3		0.0012%	
Netherlands	4.8	16.1	0.0007%	0.0024%
Belgium	4.1		0.0010%	
Finland	1.9		0.0009%	
Austria	1.0		0.0003%	
Poland	0.8	0.8	0.0002%	0.0002%
Romania	0.6		0.0004%	
Portugal	0.3	0.3	0.0002%	0.0002%
Estonia	0.2		0.0008%	
Czech Republic	0.0	0.1	0.0000%	0.0001%
Total EU	146.1	96.3	0.0010%	0.0007%
Other Countries				
Japan	49.2	193.4	0.0013%	0.0049%
Korea	36.1	32.2	0.0034%	0.0026%
Norway	30.5	16.2	0.0081%	0.0047%
USA	9.1	77.2	0.0001%	0.0005%
Canada	3.6	3.0	0.0003%	0.0002%
Switzerland	3.4	3.4	0.0006%	0.0006%
Turkey	0.8	0.7	0.0001%	0.0001%

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 here). The U.S. ranks third, however, with less than half of the budget of Japan. Within the EU 28, it is Germany, Denmark (UK and Spain, 2014) and the Netherlands with the largest public R&D budget in 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 largest for Denmark, followed with a large distance by Japan, Norway and the Netherlands in 2015. ■

SOLAR ENERGY

	Public R&D Exp. (in Mio. €)		Share of Public R&D Exp. by GDP	
	2014	2015	2014	2015
EU 28				
France	68.5		0.0032%	
Germany	65.9	82.0	0.0023%	0.0027%
Sweden	19.5		0.0045%	
Netherlands	19.3	51.7	0.0029%	0.0076%
Austria	19.2		0.0058%	
Spain	17.7		0.0017%	
United-Kingdom	14.0		0.0006%	
Denmark	9.4	10.6	0.0035%	0.0039%
Belgium	7.5		0.0019%	
Poland	6.1	4.9	0.0015%	0.0011%
Finland	5.5		0.0027%	
Portugal	2.2	1.9	0.0013%	0.0011%
Romania	1.8		0.0012%	
Estonia	0.6		0.0032%	
Czech Republic	0.6	0.6	0.0004%	0.0004%
Slovakia	0.4	0.1	0.0006%	0.0001%
Lithuania	0.4		0.0011%	
Total EU	258.7	151.8	0.0018%	0.0010%
Other Countries				
Japan	107.3	81.9	0.0008%	0.0005%
Korea	90.8	53.1	0.0025%	0.0013%
Norway	54.0	44.6	0.0051%	0.0036%
USA	41.3	41.3	0.0078%	0.0068%
Canada	15.8	12.7	0.0012%	0.0009%
Switzerland	11.6	13.9	0.0031%	0.0040%
Turkey	8	5	0.0	0.0007%

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. The EU-28 is followed by Australia and the U.S. After a significant decrease between 2013 and 2014, Australia's R&D expenditures show a massive growth between 2014 and 2015. Figures for China are not available.

Within the EU28, there are four countries with significant public R&D investments, namely once again Germany, the Netherlands, France and Denmark. In 2015, Germany, the Netherlands and Denmark are responsible for more than 95% of the R&D investments of the EU28. While in Germany and Denmark public R&D expenditures are rather constant between 2014 and 2015, they significantly increased in the Netherlands in 2015. However, it has to be kept in mind that there are missing values in the data making a conclusion difficult. When looking at the normalization of the R&D figures by GDP, the share of the EU28 is low. Within the EU, the Netherlands have the largest budget for solar energy. At the international level, they are followed by Switzerland, Norway, Denmark (2015). ■

HYDROPOWER

	Public R&D Exp. (in Mio. €)		Share of Public R&D Exp. by GDP	
	2014	2015	2014	2015
EU 28				
Finland	4.4		0.0021%	
France	1.5		0.0001%	
Austria	1.4		0.0004%	
Germany	1.2	1.7	0.0000%	0.0001%
Sweden	1.1		0.0002%	
Spain	1.0		0.0001%	
Romania	0.6		0.0004%	
Poland	0.5	0.1	0.0001%	0.0000%
Czech Republic	0.3	0.2	0.0002%	0.0001%
United-Kingdom	0.1		0.0000%	
Belgium	0.1		0.0000%	
Denmark		1.9		0.0007%
Netherlands		0.1		0.0000%
Total EU	12.2	3.9	0.0001%	0.0000%
Other Countries				
Canada	19.4	20.3	0.0014%	0.0015%
USA	15.3	17.3	0.0001%	0.0001%
Norway	10.1	11.2	0.0027%	0.0032%
Switzerland	9.2	10.6	0.0017%	0.0018%
Japan	6.7	2.6	0.0002%	0.0001%
Korea	6.2	4.4	0.0006%	0.0004%
Turkey		1.4		0.0002%

Source: JRC SETIS, Eurostat, WDI Database

Compared to solar energy, hydropower is a small field with regard to public R&D investment. In this field, Canada has the largest public R&D investment among the countries in our comparison. It is followed by the U.S., Norway and Switzerland. They all have significant hydro power resources. In the EU28, public R&D spending for hydro energy is small, Germany and Denmark show the largest values (2015) with € 1.9 million and € 1.7 million, respectively. In 2014, Finland (no data available in 2015) was the largest investor in R&D, and 2013 Italy (no data in 2014 and 2015). The GDP shares show a different ranking: these are highest (and growing) in Norway. Switzerland ranks second and Canada third. Within the EU28, the GDP shares (2015) are highest in Denmark. ■

GEOTHERMAL ENERGY

	Public R&D Exp. (in Mio. €)		Share of Public R&D Exp. by GDP	
	2014	2015	2014	2015
EU 28				
Germany	15.5	13.4	0.0005%	0.0004%
France	4.1		0.0002%	
Belgium	1.8		0.0004%	
Netherlands	1.2	2.0	0.0002%	0.0003%
Slovakia	1.0	0.4	0.0013%	0.0005%
Austria	0.9		0.0003%	
Poland	0.4	0.6	0.0001%	0.0001%
Sweden	0.3		0.0001%	
Czech Republic	0.2	0.4	0.0001%	0.0003%
Romania	0.1		0.0001%	
United-Kingdom	0.1		0.0000%	
Portugal	0.1	0.2	0.0001%	0.0001%
Denmark		1.7		0.0006%
Total EU	25.6	18.8	0.0002%	0.0001%
Other Countries				
Canada	2.0	1.3	0.0001%	0.0001%
Switzerland	10.7	12.4	0.0020%	0.0021%
Japan	11.5	22.2	0.0003%	0.0006%
Korea	7.3	5.9	0.0007%	0.0005%
Turkey		0.0		0.0000%
USA	38.8	51.8	0.0003%	0.0003%

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 € 51.8 million, followed by Japan with € 22.2 million, Germany (13.4 € million) and Switzerland (€ 12.4 million). Compared to solar energy, the R&D expenditures are low, but all countries, for which data is available, have at least a certain public R&D budget, except for Turkey, where the public spending in geothermal energy are zero. The GDP normalization shows that Switzerland has the largest share of public R&D investment on GDP, which has even grown slightly between 2014 and 2015, while the values are much lower for the other countries in comparison. In the EU, Hungary and Italy have a large share of installed geothermal energy capacities, but R&D data are not available. ■

BIOFUELS

	Public R&D Exp. (in Mio. €)		Share of Public R&D Exp. by GDP	
	2014	2015	2014	2015
EU 28				
France	91.5		0.0043%	
Germany	34.0	34.9	0.0012%	0.0012%
Sweden	31.7		0.0073%	
United Kingdom	24.4		0.0011%	
Netherlands	20.8	24.6	0.0031%	0.0036%
Finland	20.1		0.0098%	
Denmark	18.9	22.9	0.0071%	0.0084%
Belgium	10.3		0.0026%	
Spain	9.9		0.0010%	
Austria	9.4		0.0028%	
Slovakia	8.4	0.4	0.0111%	0.0005%
Poland	6.4	11.8	0.0016%	0.0027%
Portugal	2.4	2.0	0.0014%	0.0011%
Czech Republic	1.8	1.8	0.0011%	0.0011%
Romania	1.3		0.0009%	
Lithuania	0.6		0.0016%	
Total EU	291.8	98.4	0.0021%	0.0007%
Other Countries				
USA	463.5	489.5	0.0035%	0.0030%
Japan	43.3	45.8	0.0012%	0.0012%
Canada	24.6	22.7	0.0018%	0.0016%
Switzerland	15.9	17.2	0.0030%	0.0029%
Korea	13.4	14.4	0.0013%	0.0012%
Norway	10.9	18.1	0.0029%	0.0052%
Turkey	1.1	0.8	0.0002%	0.0001%

Source: JRC SETIS, Eurostat, WDI Database

Biofuels is a much larger field in terms of public R&D investment than geothermal energy. Here, the U.S. clearly shows the largest investment with nearly € 500 million in 2015. The other countries in our comparison have much lower public R&D investments, all below € 50 million. The U.S. is followed by Japan, Germany and the Netherlands. Besides these two EU countries, significant public investments in the EU-28 are made in Denmark and Poland (above € 10 million). With regard to the GDP shares, Denmark is leading in 2015, followed by Norway and the Netherlands. In 2014, Finland's and Sweden's shares were high as well (no data in 2015). Albeit large absolute investments in biofuels, the U.S. display relatively low shares with a decreasing tendency between 2014 and 2015. This is due to an increase in GDP. ■

OCEAN ENERGY

	Public R&D Exp. (in Mio. €)		Share of Public R&D Exp. by GDP	
	2014	2015	2014	2015
EU 28				
United Kingdom	30.1		0.0013%	
Sweden	5.0		0.0012%	
France	4.3		0.0002%	
Belgium	3.1		0.0008%	
Denmark	2.6	5.0	0.0010%	0.0018%
Spain	1.9		0.0002%	
Netherlands	0.2	3.3	0.0000%	0.0005%
Portugal	0.0	0.0	0.0000%	0.0000%
Romania	0.0		0.0000%	
Total EU	47.2	8.3	0.0003%	0.0001%
Other Countries				
USA	37.5	37.7	0.0003%	0.0002%
Canada	13.6	3.3	0.0010%	0.0002%
Korea	6.6	4.6	0.0006%	0.0004%
Norway	1.8	2.2	0.0005%	0.0006%

Source: JRC SETIS, Eurostat, WDI Database

Ocean energy is also a comparably small field when interpreted alongside public R&D investment. Here, the EU28 shows the largest values in 2014, although many data points are missing. It also seems that the investments have decreased between 2014 and 2015. However, this is due to missing data for the UK in 2015, which had the highest absolute public R&D investment among all countries in our comparison in 2014. Behind the UK, the U.S. scores second with € 37.7 million of public R&D investment. All other countries are comparably small when looking at this indicator. This is also reflected in the GDP shares, especially for the UK in 2014, which are highest in comparison. The UK is followed by Denmark, where the absolute public R&D spending for ocean energy is comparably small. Yet, due to the size of the country, this still translates to a significant GDP share. Overall, countries with ocean energy resources invest into R&D, but at a low level. ■

ALL RES

	Public R&D Exp. (in Mio. €)		Share of Public R&D Exp. by GDP	
	2014	2015	2014	2015
EU 28				
France	176.8		0.0083%	
United Kingdom	94.2		0.0042%	
Sweden	62.8		0.0145%	
Belgium	26.8		0.0067%	
Romania	4.4		0.0029%	
Denmark		67.9		0.0250%
Netherlands		97.8		0.0145%
Total EU	781.6	377.5	0.0056%	0.0026%
Other Countries				
USA	671.5	755.4	0.0051%	0.0046%
Korea	123.7	106.2	0.0116%	0.0085%
Canada	79.0	63.3	0.0059%	0.0045%

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, while in 2014 the EU 28 were leading. Yet, due to many missing values in the 2015 data, this table has to be interpreted with caution. The GDP shares display a very strong position of Korea. The US, Canada and the EU seem to have similar shares in 2014. Within the EU, only a few countries display data. In 2015 Denmark and the Netherlands display lower values than the EU28, and in 2014, Sweden, France and Belgium range above the EU28 share. ■

EDF

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.

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]). 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.

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 with regard to 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 energy technologies compared to the RET world share of patents in energy technologies. If a country i's share is larger than the world share, country i is said to be specialised in this 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 instead of to all technologies. This makes the indicator more sensitive to small changes in RET patent filings, i.e. more up and downs. Due to the fractional account, figures might also range between zero and one. In case the figure is smaller than one, the decimal is given, otherwise zero.[4]

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.cooperative-patentclassification.org/index.html
2. 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.

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&I 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	
	2011	2012	2011	2012	2011	2012
EU 28						
Germany	279	338	2.1	2.2	95.5	111.5
Denmark	128	97	12.9	10.6	482.7	357.7
Spain	48	68	6.0	7.0	46.1	63.0
Poland	28	10	4.4	1.5	68.5	24.0
United Kingdom	22	30	1.6	1.5	9.6	11.7
France	21	34	0.6	0.8	9.9	15.5
Italy	21	23	1.6	1.6	12.8	13.8
Netherlands	17	26	1.7	2.2	26.1	38.8
Sweden	10	17	2.3	2.2	23.8	38.3
Romania	10	2	4.4	1.9	65.4	14.5
Luxembourg	8	7	5.4	6.1	162.0	131.8
Austria	7	8	1.5	0.9	22.5	22.8
Belgium	6	6	1.7	1.2	15.6	14.8
Finland	6	9	1.4	1.4	28.0	41.8
Hungary	2	1	7.7	2.9	20.6	10.4
Latvia	2	2	6.3	8.7	84.6	82.1
Ireland	1	3	1.5	2.1	5.5	11.1
Greece	1	0	2.7		5.6	
Czech Republic	1	2	0.5	0.9	3.2	9.0
Portugal	0.1	3	0.3	4.4	0.7	13.9
Bulgaria	0	1		3.1		22.1
Cyprus	0	0				
Estonia	0	0				
Croatia	0	0				
Lithuania	0	0				
Malta	0	0				
Slovenia	0	0				
Slovakia	0	0				
Total EU	619	686	2.4	2.3	44.2	46.6
Other Countries						
China	634	697	1.0	0.9	80.2	70.2
Korea	356	463	1.4	1.5	334.3	372.9
Japan	178	233	0.3	0.3	48.8	59.1
USA	95	139	0.8	0.7	7.3	8.6
Rest of the world	132	133				

Continues overleaf

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

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 65% of all European patents within wind energy. Yet, also Spain, France and the UK have filed a significant number of patents within this field in 2012. In wind energy, Korea is leading in patent applications per GDP followed by Denmark, Luxembourg and Germany. Spain is above the EU 28 average but behind China. Thus, its domestic competitiveness is lower than that of China.

Energie AG / Raimo Rumpler

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, 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 numbers 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	
	2011	2012	2011	2012	2011	2012
EU 28						
Germany	431	452	0.9	0.9	147.5	149.2
France	108	126	0.9	0.8	50.5	57.8
Italy	94	93	2.1	1.9	58.0	56.4
Spain	47	51	1.7	1.5	45.1	47.6
Netherlands	30	32	0.8	0.8	44.7	47.1
United Kingdom	29	46	0.6	0.7	12.7	17.9
Belgium	19	25	1.5	1.4	47.7	60.0
Austria	19	25	1.1	0.9	56.1	73.3
Romania	19	14	2.4	3.2	123.0	85.2
Poland	17	25	0.8	1.0	40.9	58.9
Finland	8	15	0.6	0.7	40.7	70.2
Czech Republic	6	3	1.6	0.5	36.7	18.0
Sweden	5	9	0.3	0.3	12.1	20.1
Latvia	5	1	4.5	1.2	211.6	41.0
Portugal	4	3	2.7	1.4	24.2	15.2
Denmark	3	6	0.1	0.2	12.8	21.2
Greece	3	2	2.2	3.9	16.4	12.8
Luxembourg	2	5	0.5	1.4	47.7	102.5
Ireland	2	5	0.9	1.0	10.8	18.6
Bulgaria	2	2	3.0	1.8	46.8	44.2
Hungary	1	1	1.4	0.8	12.7	10.4
Lithuania	1	0	5.3	0.8	34.2	6.7
Slovenia	1	3	1.8	3.1	33.5	72.6
Croatia	1	1	4.2	3.4	23.3	11.4
Malta	1	0	6.3		118.7	
Slovakia	1	1	0.8	1.4	13.2	12.7
Cyprus	1	1	4.7	2.0	39.8	56.7
Estonia	0	0				
Total EU	860	946	1.0	0.9	61.4	64.3
Other Countries						
China	2396	2754	1.1	1.2	655.7	696.9
Korea	1476	2054	0.7	0.8	186.8	207.0
Japan	1270	1229	1.4	1.2	1193.6	989.4
USA	436	613	1.0	0.9	33.2	37.7
Rest of the world	521	558				

Continues overleaf

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

In the field of solar energy, Japan is the largest patent providing country based on the patent count, and second based on patents per GDP. Yet, it is rather closely followed by China, which has strongly increased its patenting activity between 2011 and 2012. 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. It has managed a growth in patent filings of more than 10% between 2011 and 2012. Within Europe, Germany has filed the largest number of patents. Within the EU, Germany also ranks first regarding patents per GDP, followed by Luxembourg. These differences between the countries can be explained by the different domestic patenting preconditions in these countries. 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 Greece, Croatia, Romania and Slovenia. 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. And consequently, minor changes in their patenting activity in a given year can have large influence on the patent specializations. ■

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HYDROPOWER

	Number of patent families		Patent specialization		Patents per € trillion GDP	
	2011	2012	2011	2012	2011	2012
EU 28						
Germany	19	21	0.9	0.9	6.6	7.0
United Kingdom	6	4	2.7	1.4	2.8	1.7
France	5	5	0.8	0.7	2.2	2.4
Poland	4	2	3.7	1.3	9.7	3.5
Romania	2	1	5.3	5.1	13.3	6.2
Italy	2	4	0.7	1.7	0.9	2.4
Sweden	2	0	2.0		3.5	
Austria	1	3	1.3	2.2	3.4	8.8
Denmark	1	0	0.6		3.8	
Slovenia	1	0	28.9		26.8	
Spain	1	2	0.4	1.5	0.5	2.2
Ireland	0.3		2.1		1.3	
Belgium	0	0				
Bulgaria	0	0				
Cyprus	0	0				
Czech Republic	0	5		18.3		29.4
Estonia	0	0				
Greece	0	0				
Finland	0	0				
Croatia	0	0				
Hungary	0	0				
Lithuania	0	0				
Luxembourg	0	0				
Latvia	0	0				
Malta	0	0				
Netherlands	0	1		0.3		0.7
Portugal	0	1		10.9		5.6
Slovakia	0	0				
Total EU	43	49	1.0	1.0	3.1	3.3
Other Countries						
China	134	157	1.3	1.3	16.9	15.8
Japan	76	83	0.7	0.8	20.8	21.0
Korea	49	50	1.1	1.0	45.8	40.4
USA	7	7	0.3	0.2	0.5	0.4
Rest of the world	32	31				

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

Continues overleaf

In hydro energy, the patenting figures are slightly higher than in geothermal energy. Here, China displays the largest number of patents, followed by Japan and Korea and the EU 28, which are at a very similar level. Within Europe, Germany is responsible for more than 50% of patent filings within this field. The Czech Republic, Italy, France and the UK also show a certain activity level, resulting in 4 to 5 patent filings in 2012.

In relation to their economic sizes, Korea and the Czech Republic reveal the highest patent filing per GDP, followed by Japan and China. However, as these patents also include single domestic patent applications, an interpretation regarding the international competitiveness is difficult.

Similar to geothermal energy patents, the RPA indicator shows a high specialization for the Czech Republic. This implies that although the Czech Republic has a comparably low number of total patent filings in energy technologies, its domestic market is specialized in these renewable energy technologies. Similar results are displayed for Portugal. In Slovenia the specialization is very high in 2011 and zero in 2012 due to the small number of patents in both years. ■

Südtirol Marketing / Max Lautenschläger

GEOTHERMAL ENERGY

	Number of patent families		Patent specialization		Patents per € trillion GDP	
	2011	2012	2011	2012	2011	2012
EU 28						
Germany	9	11	0.8	1.0	2.9	3.5
France	2	2	0.8	0.5	1.1	0.8
Spain	2	0	2.5		1.5	
Finland	2	2	4.6	4.2	7.3	9.5
Poland	2	2	2.9	2.8	3.6	3.5
Netherlands	1	0.3	1.6	0.4	2.0	0.5
Italy	1	2	1.1	2.2	0.7	1.4
United Kingdom	1	1	1.0	0.9	0.5	0.5
Sweden	0	3	0.9	5.1	0.8	6.7
Austria	0	1		1.6		2.9
Belgium	0	0				
Bulgaria	0	0				
Cyprus	0	0				
Czech Republic	0	1		8.0		
Denmark	0	0				
Estonia	0	0				
Greece	0	0				
Croatia	0	0				
Hungary	0	0				
Ireland	0	0				
Lithuania	0	0				
Luxembourg	0	0				
Latvia	0	0				
Malta	0	0				
Portugal	0	0				
Romania	0	0				
Slovenia	0	0				
Slovakia	0	0				
Total EU	19	25	0.9	1.1	1.4	1.7
Other Countries						
Japan	49	73	0.9	1.5	13.4	18.4
Korea	39	30	1.9	1.3	36.7	24.4
China	33	23	0.7	0.4	4.2	2.3
USA	10	14	1.0	1.0	0.8	0.9
Rest of the world	11	10				

Continues overleaf

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

In terms of patent filings, geothermal energy is a less significant 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 25 patents in geothermal energy in 2012, with 11 patents originating from Germany. The other European countries that have actively patented inventions in geothermal energy are Austria, the Czech Republic, Finland, France, Italy, Poland, Sweden and the UK. The largest patenting country in geothermal energy worldwide is Japan with 73 patents in 2012, followed by Korea, the EU 28 and China. The U.S. has only filed 14 patents within this field in 2012. 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, the Czech Republic, Sweden and Finland rank top at a low level.

The size problem is also reflected in the specializations. Although the values are high for some countries, e.g. the Czech Republic, these reflect only minor changes in the patenting portfolios of the countries with small portfolios that heavily influence this indicator. Overall, Japan and Korea show a relatively high specialization of their domestic markets, while some EU countries reveal a much stronger specialisation based on a lower number of patents. ■

BIOFUELS

	Number of patent families		Patent specialization		Patents per € trillion GDP	
	2011	2012	2011	2012	2011	2012
EU-28						
Germany	53	67	0.7	0.6	18.3	22.2
France	24	30	1.2	1.0	11.4	13.8
Poland	14	17	3.8	3.4	34.1	38.8
Netherlands	13	18	2.3	2.2	20.0	26.9
Denmark	12	12	2.1	1.8	45.2	43.0
United Kingdom	11	20	1.4	1.5	5.0	7.9
Sweden	9	10	3.6	1.9	21.8	23.3
Finland	8	16	3.6	3.6	40.7	76.1
Spain	7	10	1.5	1.5	6.5	9.3
Italy	5	13	0.6	1.3	2.8	8.1
Romania	4	0	3.1		26.6	
Austria	3	3	1.1	0.5	9.4	8.8
Czech Republic	3	5	4.9	4.3	19.1	29.9
Luxembourg	2	0	1.8		31.6	
Belgium	2	5	0.7	1.4	3.7	11.7
Slovakia	1	0	4.8		13.2	
Estonia	0.5	1	5.9	30.5	25.3	49.4
Ireland	0	0	0.6		1.3	
Hungary	0	2	1.3	6.1	2.1	15.2
Bulgaria	0	0				
Cyprus	0	0				
Greece	0	0				
Croatia	0	0				
Lithuania	0	0.5		7.9		13.4
Latvia	0	0.3		2.1		13.7
Malta	0	0				
Portugal	0	0.3		0.8		1.9
Slovenia	0	0				
Total EU	173	231	1.2	1.1	12.3	15.7
Other Countries						
China	515	756	1.4	1.4	65.2	76.2
Japan	166	199	0.4	0.4	45.4	50.4
USA	120	206	1.6	1.6	9.2	12.6
Korea	110	138	0.7	0.7	103.0	111.1
Rest of the world	89.8	111.0				

Continues overleaf

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

In the biofuels sector, it is again China that has filed the largest number of patents in 2012. With 756 patent families, China clearly has a dominant position in this respect. Following China, the EU 28 scores second with 231 patent families. The U.S. is ranked third with 206 simple patent families in 2012. 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, the UK, the Netherlands and Poland.

Korea, China and Japan display a strong position in biofuels patent filings per GDP, the EU 28 ranks a bit higher than the US. Within the EU, Finland is strong, followed by Estonia and Denmark.

With regard to the specialization (RPA), Estonia has the largest value. Yet, this only relates to one patent filing in 2012. 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	
	2011	2012	2011	2012	2011	2012
EU 28						
Germany	19	16	1.0	0.7	6.6	5.3
United Kingdom	18	25	9.2	8.4	8.1	9.8
France	8	11	1.6	1.5	3.9	4.9
Ireland	5	5	52.2	23.8	26.9	19.5
Italy	5	3	2.8	1.3	3.2	1.7
Spain	4	7	3.8	4.6	4.1	6.4
Sweden	4	5	5.7	4.0	8.3	10.8
Denmark	3	3	1.9	2.1	10.4	11.0
Finland	1	3	2.3	3.1	6.5	14.3
Luxembourg	1	2	4.7	11.7	20.3	39.1
Poland	1	2	1.1	1.4	2.4	3.5
Portugal	1	2	15.5	22.7	5.8	11.1
Austria	1	1	1.1	0.4	2.4	1.5
Netherlands	1	4	0.4	2.2	0.9	5.9
Romania	0.3	0	1.1		2.2	
Belgium	0	0				
Bulgaria	0	0				
Cyprus	0	0				
Czech Republic	0	0.8		2.9		4.5
Estonia	0	0				
Greece	0	0				
Croatia	0	0				
Hungary	0	0				
Lithuania	0	0				
Latvia	0	0				
Malta	0	0				
Slovenia	0	0.5		12.5		13.0
Slovakia	0	0				
Total EU	73	89	2.0	1.9	5.2	6.0
Other Countries						
China	74	101	0.8	0.9	9.4	10.2
Korea	62	51	1.7	1.1	58.1	41.3
Japan	42	62	0.5	0.6	11.5	15.7
USA	15	23	0.8	0.8	1.2	1.4
Rest of the world	21	36				

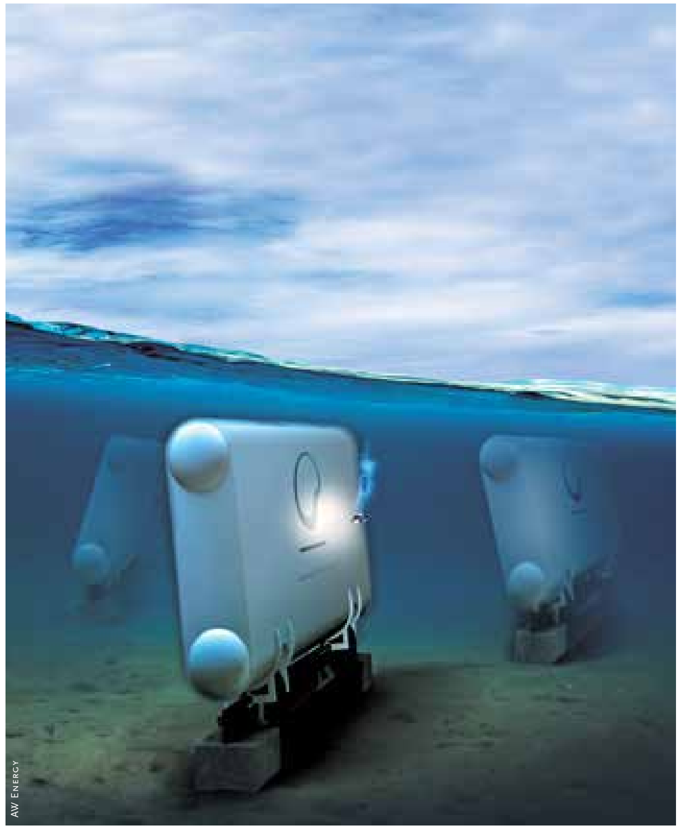
Continues overleaf

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

Ocean energy is a comparably small field in terms of the number of patent families, but the general trends are also mirrored by these figures, 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 its small size, Luxembourg and Ireland 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. ■



AW Energy

CONCLUSIONS

EDF Gilles Huguet

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 which 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 also related to the size of the countries in terms of patenting as Germany is the largest patent providing country 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. The Czech Republic on the other hand, is rather active in geothermal and hydro energy in comparison to any other energy technology field. ■

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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 differences of these 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, which 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, which is why a closer look is taken at the export performance as an 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 to find out 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 measured by the RET exports in relation to all exports of this country i. 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 (used for the patents filings) refers to energy technologies.

The analysis looks at renewable energies exports as a whole, but also at the disaggregated RET fields. These fields comprise wind energy, photovoltaics (PV) and hydroelectricity 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).[1]

1. The HS 2017 codes used for the demarcation are: Photovoltaics (85414090), wind energy (85023100) and hydroelectricity (84101100, 84101200, 84101300, 84109000).

ALL RES

	Share on global exports in renewable energies technologies		Net exports in € Mio.		Export specialisation (RCA)	
	2014	2015	2014	2015	2014	2015
EU 28						
Germany	8.33%	8.20%	1342	2206	3	-3
Denmark	5.69%	4.79%	2772	2845	98	97
Spain	2.58%	2.27%	1140	1267	39	24
Netherlands	1.77%	1.20%	-265	-106	-50	-73
Poland	0.73%	0.62%	-361	-467	-43	-60
France	0.67%	0.62%	-353	-325	-91	-93
Italy	0.56%	0.69%	-191	-102	-92	-89
Belgium	0.50%	0.41%	-289	-52	-92	-95
Austria	0.48%	0.46%	10	-34	-56	-60
Czech Republic	0.48%	0.34%	-2	-9	-59	-79
United Kingdom	0.37%	0.27%	-2101	-2123	-96	-98
Slovenia	0.14%	0.11%	38	27	-17	-41
Portugal	0.10%	0.09%	-50	-19	-84	-89
Greece	0.09%	0.02%	-38	-134	-61	-97
Sweden	0.09%	0.07%	-166	-179	-98	-99
Slovakia	0.09%	0.07%	2	-11	-93	-95
Ireland	0.07%	0.04%	4	3	-98	-99
Lithuania	0.06%	0.06%	0,2	13	-77	-75
Hungary	0.06%	0.05%	-113	-147	-98	-99
Finland	0.06%	0.04%	-126	-124	-96	-98
Estonia	0.05%	0.05%	13	22	-59	-45
Luxemburg	0.04%	0.05%	-6	-6	-65	-41
Croatia	0.03%	0.04%	-15	-30	-72	-63
Romania	0.03%	0.02%	-234	-112	-99	-100
Bulgaria	0.02%	0.03%	-28	-9	-98	-95
Latvia	0.01%	0.02%	-11	-10	-97	-86
Malta	0.00%	0.00%	-11	-10	-100	-100
Cyprus	0.00%	0.00%	-14	-4	-100	-100
Total EU	23.09%	20.64%	946	2368	-32	-45
Other Countries						
China	30.14%	33.76%	7225	10460	70	69
Japan	6.91%	5.83%	-3214	-2209	55	36
USA	4.24%	3.79%	-2961	-5674	-62	-73
India	0.48%	0.32%	-348	-1665	-85	-93
Canada	0.30%	0.51%	-801	-641	-97	-93
Switzerland	0.14%	0.13%	-247	-314	-99	-99
Russian Federation	0.07%	0.07%	-605	-280	-100	-100
Turkey	0.03%	0.03%	-486	-827	-100	-100
Norway	0.01%	0.01%	-67	-59	-100	-100
Rest of the world	34.58%	34.92%	2951	4032	7	2

Continues overleaf

Source: EurObserv'ER 2016 based on data from UN - COMTRADE

The RCA has to be interpreted in relation to the remaining portfolio of the country and the world share. I.e. 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 three selected renewable energies technologies, China has a rather dominant position, which the country even strengthened between 2014 and 2015. While the Chinese export shares in total RET exports lay at 30.1% in 2014, this share rose to 33.8% in 2015. After China, large export shares can be found for Germany, Japan, Denmark, the U.S. and Spain. From these countries, however, only Germany could keep up stable shares between 2014 and 2015. For all other mentioned countries, the export shares for all RET slightly declined, which is at least partly a result of the growing role of China. The countries with the smallest shares in comparison are Cyprus, Malta, Albania, New Zealand, Norway, Turkey, Romania, Latvia, Greece, Bulgaria and Romania.

These trends, however, can be qualified 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, could be increased between 2014 and 2015. The only other countries with a positive trade balance in RET are Denmark, Germany and Spain. These countries are exporting more RET goods than they are importing. The countries with the most negative trade balances are the U.S., the UK, Japan and India. 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 POWER

	Share on global exports in renewable energies technologies		Net exports in € Mio.		Export specialisation (RCA)	
	2014	2015	2014	2015	2014	2015
EU 28						
Denmark	42.54%	41.73%	2821	2978	100	100
Germany	25.08%	30.24%	1251	1755	81	85
Spain	17.74%	18.55%	1168	1305	98	98
Netherlands	0.52%	0.92%	-18	-4	-94	-83
Portugal	0.48%	0.36%	31	21	32	1
Estonia	0.32%	0.44%	21	30	84	92
Greece	0.25%	0.16%	-34	-123	25	-12
Ireland	0.20%	0.12%	13	9	-81	-95
Finland	0.12%	0.00%	-76	-92	-83	-100
Belgium	0.07%	0.01%	-202	1	-100	-100
Poland	0.06%	0.08%	-105	-214	-99	-99
France	0.05%	0.04%	-110	-66	-100	-100
United Kingdom	0.05%	0.12%	-444	-299	-100	-100
Lithuania	0.03%	0.06%	1	3	-95	
Italy	0.03%	0.06%	-27	-44	-100	-100
Czech Republic	0.02%	0.01%	-2	1	-100	-100
Romania	0.02%	0.00%	-86	-9	-100	-100
Austria	0.01%	0.00%	-19	-51	-100	-100
Bulgaria	0.01%	0.11%	-4	6	-100	-38
Slovakia	0.00%	0.00%	0,1	0	-100	-100
Sweden	0.00%	0.02%	-108	-139	-100	-100
Latvia	0.00%	0.00%	0	0	-100	
Croatia	0.00%	0.00%	-9	-28	-100	-100
Slovenia	0.00%	0.00%	0	0,0	-100	-100
Luxemburg	0.00%	0.00%	0	0	-100	
Hungary	0.00%	0.00%	-0,4	0		-100
Malta	0.00%	0.00%	0	0,0		-100
Total EU	**87.59%**	**93.02%**	**4060**	**5040**	**76**	**77**
Other Countries						
USA	6.18%	1.88%	268	-77	-33	-93
China	3.44%	3.68%	221	262	-86	-88
India	0.94%	0.06%	62	2	-53	-100
Canada	0.15%	0.10%	-444	-381	-99	-100
Japan	0.02%	0.03%	-63	-77	-100	-100
Norway	0.00%	0.00%	-35	-9	-100	
Turkey	0.00%	0.00%	-263	-376	-100	-100
Switzerland	0.00%	0.00%	0	-1	-100	-100
Russian Federation	0.00%	0.00%	-404	-78	-100	-100
Rest of the world	1.67%	1.23%	-1575	-1776	-99	-100

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Source: EurObserv'ER 2016 based on data from UN - COMTRADE

In wind power, the picture differs from PV. Here, it is clearly Denmark that has the largest export shares with 41.7%. It is followed by Germany, which increased its exports share between 2014 and 2015 by 5 percentage points to 30.2%. This implies that 70% of worldwide exports in wind technologies originate from these two countries. When including Spain with a value of 18.6% this means that nearly 90% of all exported goods related to wind technologies come from EU 28 countries. The Chinese export shares in 2015 are comparably small with 3.7%, followed by the U.S. with a value of 1.9%.

This pattern can be found in the trade balance. Positive trade balances in goods related to wind energy can only be found for Denmark, Germany, Spain and China, although the value for China is comparably smaller than for the other three countries. Although the U.S. still had a significant export share in wind technology related goods, its trade balance is negative.

With regard to the RCA, it can be observed that Denmark, Spain and Germany are highly specialized in trade with wind technology related goods. Interestingly, also Estonia shows a very positive value here. China, on the other hand, has a negative export specialization in wind technology related goods; its focus seems to be more on PV technologies. ■

PHOTOVOLTAICS

	Share on global exports in renewable energies technologies		Net exports in € Mio.		Export specialisation (RCA)	
	2014	2015	2014	2015	2014	2015
EU 28						
Germany	5.65%	5.26%	2	360	-44	100
Netherlands	2.02%	1.27%	-248	-103	-70	85
Poland	0.85%	0.70%	-257	-255	-52	98
France	0.61%	0.54%	-294	-315	-94	-83
Belgium	0.56%	0.41%	-91	-77	-95	1
Czech Republic	0.45%	0.31%	-42	-52	-82	92
United Kingdom	0.40%	0.27%	-1663	-1829	-98	-12
Italy	0.38%	0.59%	-264	-143	-92	-12
Austria	0.21%	0.29%	-89	-86	-82	-95
Spain	0.11%	0.08%	-86	-79	-100	-100
Sweden	0.10%	0.07%	-35	-40	-99	-100
Slovakia	0.10%	0.08%	2	-14	-95	-99
Greece	0.07%	0.00%	-2	-9	-100	-100
Slovenia	0.07%	0.07%	3	4	-68	-100
Lithuania	0.07%	0.06%	-1	10	-74	
Hungary	0.07%	0.06%	-113	-148	-98	-100
Denmark	0.06%	0.05%	-45	-129	-99	-100
Ireland	0.05%	0.03%	-7	-4	-100	-100
Finland	0.04%	0.04%	-49	-33	-97	-100
Luxemburg	0.04%	0.06%	-5	-4	-28	-38
Portugal	0.04%	0.03%	-58	-49	-98	-100
Croatia	0.03%	0.04%	-3	1	-57	-100
Bulgaria	0.01%	0.00%	-25	-19	-100	
Latvia	0.01%	0.02%	-10	-6	-81	-100
Estonia	0.01%	0.01%	-8	-8	-99	-100
Romania	0.01%	0.01%	-153	-104	-100	
Malta	0.00%	0.00%	-11	-10	-100	-100
Cyprus	0.00%	0.00%	-14	-4	-100	-100
Total EU	**12.02%**	**10.37%**	**-3566**	**-3146**	**-83**	**77**
Other Countries						
China	34.69%	38.01%	6772	9896	74	-93
Japan	8.12%	6.71%	-3182	-2136	48	-88
USA	3.96%	4.03%	-3237	-5592	-70	-100
India	0.31%	0.24%	-452	-1722	-96	-100
Canada	0.28%	0.53%	-319	-217	-92	-100
Switzerland	0.11%	0.10%	-178	-231	-99	
Russian Federation	0.05%	0.04%	-116	-149	-100	-100
Turkey	0.03%	0.02%	-112	-371	-100	-100
Norway	0.00%	0.00%	-15	-15	-100	-100
Rest of the world	40.44%	39.93%	5136	6477	33	-100

Source: EurObserv'ER 2016 based on data from UN - COMTRADE

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Besides this general view on RET export shares in photovoltaics (PV) are analyzed. Again the top position of China can be confirmed. In 2015, more than 38% of worldwide exports in PV originate from China. The next largest countries in this respect are Japan, (6.7%), Germany (5.3%) and the U.S. (4.0%). In sum, the EU 28 countries reach a share of 10.4%, i.e. 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. 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 the UK. Both 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 and Germany, although the specialization values are negative for the latter two countries. ■

HYDROPOWER

	Share on global exports in renewable energies technologies		Net exports in € Mio.		Export specialisation (RCA)	
	2014	2015	2014	2015	2014	2015
EU 28						
Austria	11.98%	9.63%	118	103	99	98
Germany	9.66%	9.34%	89	90	18	10
Italy	9.46%	7.83%	100	85	83	76
France	5.97%	6.65%	51	55	59	63
Spain	5.52%	4.03%	59	41	82	68
Czech Republic	3.60%	3.36%	42	42	87	84
Slovenia	3.06%	2.03%	35	23	99	99
United Kingdom	1.07%	1.08%	7	5	-74	-77
Romania	0.86%	0.54%	5	2	68	33
Belgium	0.73%	2.33%	3	23	-85	-8
Bulgaria	0.33%	0.40%	1	4	63	71
Portugal	0.17%	0.82%	-23	8	-59	69
Poland	0.17%	0.15%	1	2	-96	-97
Sweden	0.15%	0.52%	-23	0,0	-94	-49
Finland	0.12%	0.09%	-1	0	-83	-89
Croatia	0.11%	0.10%	-4	-3	33	20
Netherlands	0.07%	0.11%	1	1	-100	-100
Hungary	0.03%	0.08%	0	1	-100	-97
Denmark	0.02%	0.03%	-3	-4	-100	-100
Lithuania	0.01%	0.00%	0,1	0	-100	-100
Ireland	0.00%	0.00%	-2	-1	-100	-100
Greece	0.00%	0.00%	-1	-1	-100	-100
Slovakia	0.00%	0.19%	0	3	-100	-72
Luxemburg	0.00%	0.00%	-1	-2	-100	-100
Estonia	0.00%	0.00%	0	-0,3	-100	-100
Cyprus	0.00%	0.00%	0	0		-99
Latvia	0.00%	0.00%	-2	-4		-100
Total EU	**53.12%**	**49.32%**	**452**	**474**	**46**	**37**
Other Countries						
China	18.55%	22.32%	232	302	37	40
India	3.64%	4.48%	42	55	64	75
USA	3.49%	3.97%	9	-5	-72	-71
Japan	3.02%	1.32%	31	4	-20	-80
Switzerland	2.00%	1.99%	-69	-82	18	7
Canada	1.71%	1.47%	-38	-43	-38	-51
Russian Federation	1.26%	1.78%	-84	-53	-64	-20
Norway	0.40%	0.30%	-18	-35	-59	-66
Turkey	0.20%	0.34%	-111	-79	-90	-76
Rest of the world	12.56%	12.69%	-610	-669	-74	-66

Source: EurObserv'ER 2016 based on data from UN - COMTRADE

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In hydro-electricity the picture is more balanced than in the case of PV and wind energy. The largest export shares can be observed for Austria (9.6%), Germany (9.4%), Italy (7.8%), France (6.7%), Spain (4.9%) and the Czech Republic (3.5%). In sum, the EU 28 is responsible for nearly 50% of worldwide exports within the field. As a single country, however, 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 4.5% and 4.0% shares in global trade, respectively. Positive net exports values are displayed for Austria, Germany, Italy, France, Spain and the Czech Republic. Yet, the largest value can be found for China. India also shows a positive trade balance, while it is slightly negative for the U.S.

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

CONCLUSIONS

The analyses of export data in RET technologies have shown that China indeed has achieved a quite strong position in the last years. The Chinese strength in RET exports mostly originates from a strong position in photovoltaics, which has even increased between 2014 and 2015. As this technology is, compared to wind turbines, easy to assemble, China has started building up PV cell and module manufacturing from scratch and employed most up-to-date automatization technologies making China's production very competitive. In this field, Europe is challenged by China, as the EU 28 states show a - decreasing - export share of about 20.6% and China's patent applications -as indicator for technological innovations- are growing exorbitantly, pointing to further growing market position.

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, with respect to patenting activities China is catching up, but with a significantly lower pace than in PV.

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 – and might become a more competitive player in the future. ■

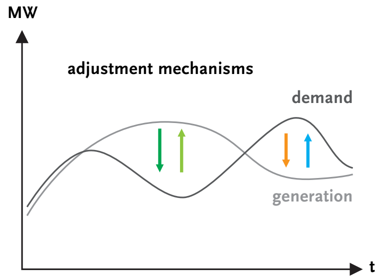
London Gateway

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 and especially solar power might reduce peak times of conventional generation. Unexpected changes within one country could be compensated by cross-border transfers or demand side adjustments. Thus, flexibility can be provided not only by the supply side but also by the demand side and by transmission infrastructure between countries and markets. All these options become increasingly important to successfully integrate RE in the system. To account for the complexity of the system a set of flexibility indicators is applied: the capacity and transmission flexibility, which will be complemented by the operational and market flexibility in the following years.

1

Adjustment of generation and demand



	Supply	Load
Increase	• flexible capacities • flexible transmission • flexible markets *	• flexible markets * • flexible transmission • flexible demand *
Decrease	• flexible capacities • flexible transmission • flexible markets * • flexible operation *	• flexible markets * • flexible transmission • flexible demand *

** Those indicators will be discussed in the next issue of this publication.*

Source: EurObserv'ER 2016

To depict how flexible a system is, four indicators are selected. Assuming a given (forecasted) load, generation is planned accordingly day-ahead or intraday. However sudden changes in the supply-demand-balance, be it an unexpected decline or increase in generation capacities, or changes in load challenge a system's flexibility. To adjust the system to changes in supply and demand, different mechanisms are applicable. A mismatch could be adjusted by increasing demand or decreasing generation, decreasing demand and increasing generation, respectively. Flexibilities in generation, transmission, markets and operation address these adjustments mechanism (see Figure 1). Based on these mechanisms, flexibility indicators are derived and explained in the following.

Methodological note

A first key factor for a flexible system is the availability of flexible resources at the supply and demand side. The term flexibility includes a time component. This time component is defined as availability of capacities within 15 min, i.e. all capacities that could be made available for generation or load adjustments within 15 min are included. Thus, it depicts the technically available flexibility of the system to adjust to a situation where generation and demand are in imbalance. In order to allow an unbiased comparison of different power systems or Member States, the ***flexible capacity*** *is compared to the annual peak load and capacity of volatile renewable energies (vRE). A detailed description of the methodological approach can be found under: www.eurobserv-er.org*

The flexibility indicator shows how many times flexible generation is able to cover the peak load or the volatile RE. Thus, this indicator shows the maximum technically available flexibility under the given technology mix.

Transmission capacities between countries allow balancing in times of shortfall or surplus generation due to a regional balancing of different RES generation characteristics and a regional optimization of flexibility resources. Further, a high cross-zonal transfer capacity contributes to an efficient dispatch and promotes the integration of national markets. Thus, high transmission capacities increase a system's flexibility. The ***transmission flexibility*** *is captured by the forecasted day-ahead transfer capacities, which are compared to peak load and vRE per country. A detailed description of the methodological approach can be found under: www.eurobserv-er.org*

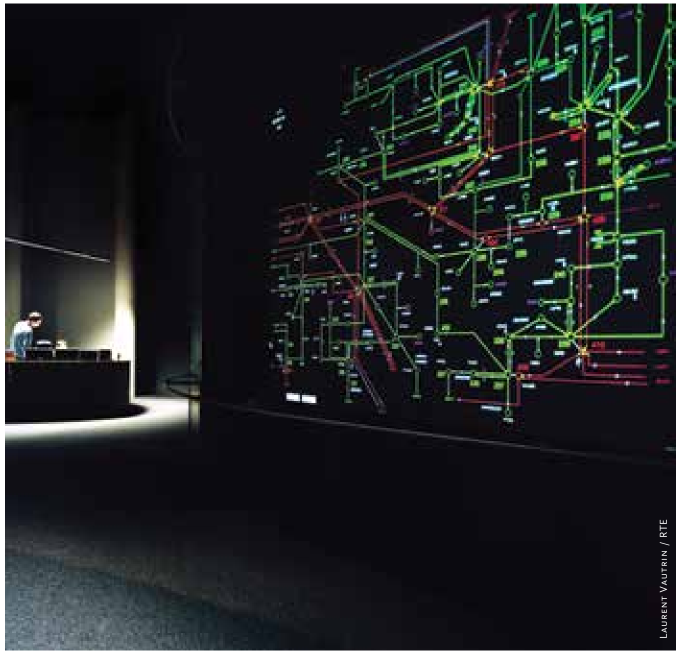
The transmission indicator shows how many times transmission is able to cover changes in peak load or volatile RE. Thus, this indicator shows the maximum available flexibility under the given physical interconnector capacities and allocation mechanisms.

RESULTS AND INTERPRETATION

FLEXIBLE CAPACITIES

The vRE-flexible capacity i.e. flexible capacity per volatile renewable energy (vRE), displays how many times flexible capacities (share of gas, oil, lignite, coal, biomass fired plants and nuclear power capacities with ramp-up times of max. 15 min) could compensate unexpected short-term decreases in vRE generation. A value below one signalizes that a fraction of a hypothetical 100% vRE shortfall could be balanced within 15 min while a value above one ensures a complete compensation potential. However, in reality, only a small fraction of the total vRE generation fails unexpectedly within 15 min.

In contrast the compensating capacity under peak load, i.e. the flexible capacity per peak load signalizes which share of the load is flexible, i.e. can be balanced in case of sudden changes in generation, e.g. due to volatile capacities under peak load conditions. Any value above one shows that the flexible capacities cover not only peak demand but could at the same time compensate potential defaults of vRE. A value below one reveals that under peak load conditions only a share of a hypothetical 100% vRE default might be covered. A value of the compensation capacity under peak load smaller than the vRE share in generation suggests potential constraints in flexibility. Table 1 shows this is not the case. The picture is all the more reassuring that , as only a fraction of the installed RE capacity might actually fail, e.g. 10%, the critical threshold for compensation capacity under peak load is actually a value lower than one tenth of the total installed vRE share.



Laurent Vautrin / RTE

2

Capacity flexibility indicators

	RE-flexible capacity: capacity share to compensate changes in vRE		Compensating capacity under peak load		Share of vRE (vRE to total capacity)	
	2014	2015	2014	2015	2014	2015
Norway	31.9	38.4	1.2	1.5	0.03	0.02
Switzerland	18.5	11.5	2.0	1.0	0.04	0.1
Latvia	15.3	17.0	0.8	1.0	0.02	0.02
Hungary	14.7	11.3	1.0	0.9	0.05	0.1
Lithuania	9.5	7.4	1.9	2.1	0.1	0.1
Finland	8.7	5.3	0.4	0.4	0.04	0.1
Estonia	8.3	6.7	1.5	1.4	0.1	0.1
Cyprus	7.0	6.3	1.7	1.5	0.1	0.1
Slovakia	5.8	5.8	0.7	0.7	0.1	0.1
Luxembourg	5.3		1.0		0.1	0.1
Netherlands	5.1	4.2	1.2	1.2	0.1	0.2
Sweden	4.5	3.9	1.0	1.0	0.1	0.2
Austria	4.4	3.2	1.1	1.0	0.1	0.2
Bulgaria	3.7	3.4	0.9	0.8	0.1	0.1
France	3.7	2.9	0.7	0.5	0.1	0.2
Czech Republic	3.4	3.3	0.8	0.8	0.1	0.1
Slovenia	3.2	5.3	0.4	0.6	0.1	0.1
Croatia	3.0	2.4	0.4	0.4	0.1	0.1
Poland	2.8	2.3	0.5	0.5	0.1	0.1
Italy	2.6	2.8	1.4	1.3	0.2	0.3
Ireland	2.5	2.1	1.2	1.1	0.2	0.3
Greece	2.2	2.2	1.1	1.0	0.3	0.3
Spain	2.0	2.1	1.4	1.5	0.3	0.3
United Kingdom	2.0	1.4	0.7	0.7	0.3	0.5
Belgium	1.9	1.7	0.8	0.8	0.3	0.3
Romania	1.7	2.5	0.9	1.3	0.2	0.2
Portugal	1.6	1.5	1.0	0.9	0.3	0.3
Denmark	0.8	0.8	0.9	1.0	0.5	0.5
Germany	0.7	0.7	0.7	0.8	0.4	0.4

Note: In 2015 data for LU are missing. ***Source: Own calculations based on data from ENTSO-E, ACER and EurObserv'ER***

In Table 2 the vRE-flexible capacity indicator is especially high for Norway and Switzerland, the Baltic States and Hungary. For example the latter disposes of 11 times more flexible capacities to cover total vRE. The values are high mainly due to low wind power and PV shares in Latvia, Hungary, Switzerland and Norway, and due to high flexible resources such as oil and gas power in Estonia, Lithuania, Finland and Cyprus. In contrast, the indicator is lower (< 1) in countries with high shares of vRE such as Denmark and Germany. However, assuming a default rate of 10% for vRE, the electricity system is not endangered unless the flexibility indicator takes a value below the vRE share weighted by its vRE default rate. For example in Germany, with its vRE share of about 0.4 and the vRE default rate of 10%, this threshold is about 0.04. The flexibility indicator in Germany is by far above this threshold.

However, the question is how flexible is the system during peak load. The compensating capacity indicator under peak load reveals what share of peak demand can be covered within 15 min through flexible generation. The values are significantly above one for Lithuania, Norway, Cyprus, Spain and Estonia. While in Lithuania, Estonia and Cyprus oil or gas based generation dominates, it is hydro power (storage) that provides a high flexibility in Norway. In Spain the combination of gas and hydro power keeps flexibility high. Countries with a low flexibility are those with high

3

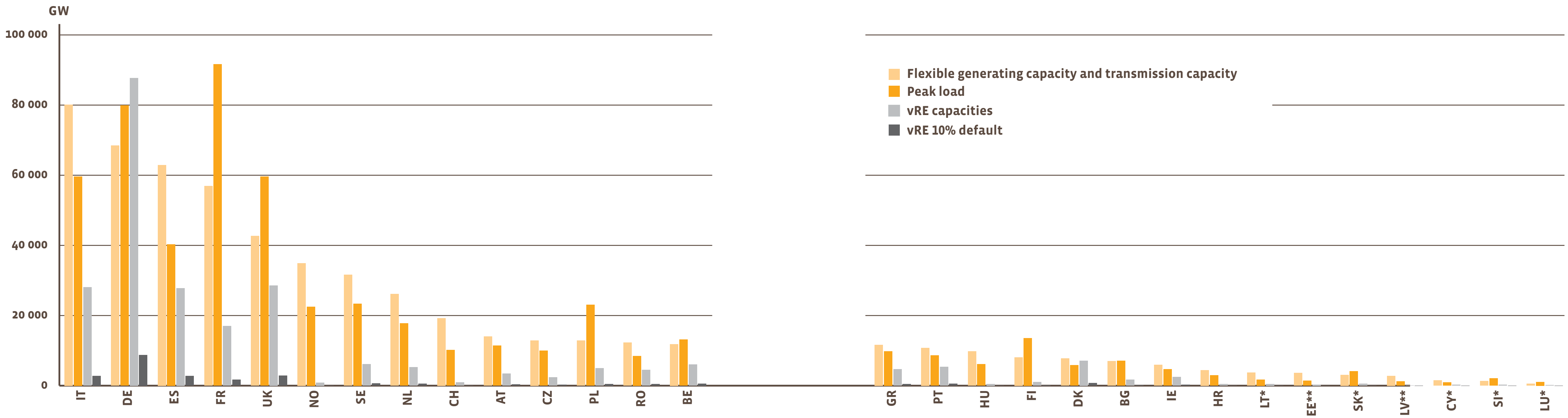
Transmission flexibility indicator

	vRE-flexible transmission		Compensating transfer under peak load	
	2014	2015	2014	2015
Latvia	24		1.2	
Switzerland	11	10	1.1	0.9
Croatia	9	7	1.1	1.1
Hungary	9	8	0.6	0.7
Estonia	6		1.1	
Finland	4.5	2.4	0.2	0.2
Czech Republic	2.0	2.2	0.5	0.5
Norway	1.9	1.6	0.1	0.1
Sweden	1.5	1.3	0.3	0.3
Netherlands	1.2	0.8	0.3	0.2
Austria	0.9	0.9	0.2	0.3
France	0.8	0.5	0.1	0.1
Belgium	0.5	0.3	0.2	0.1
Bulgaria	0.5	0.6	0.1	0.2
Denmark	0.3	0.3	0.4	0.4
United Kingdom	0.1	0.1	0.0	0.1
Italy	0.1	0.1	0.1	0.0
Germany	0.1	0.1	0.1	0.1
Spain	0.1	0.1	0.1	0.1
Portugal		0.5		0.3
Romania		0.3		0.2
Greece		0.3		0.2
Ireland		0.3		0.1
Poland		0.2		0.1

Note: In 2015 cross-zonal transfer data are not available for all Member States.
Source: Own calculations based on data from ENTSO-E, ACER and EurObserv'ER

4

Flexibility capacities in comparison to load, vRE capacities and the critical threshold at vRE 10% default rate



***Note:** In some countries, e.g. FI, FR, UK, flexible capacities are lower than peak load because only a share of their nuclear power, lignite/coal/peat based power are included in flexible capacities. In general, not the peak load but the default share of vRE is critical.*
** No data on transmission capacities, only flexible generating capacities. ** Transmission capacities from 2014.*
Source: EurObserv'ER 2016 based on data from ENTSO-E, ACER and EurObserv'ER

nuclear shares such as France, with dominating lignite or coal based generation such as Poland and Croatia. As Finland relies to a large degree on run-of-river-hydro power and a low fossil fuel share, its technical flexibility is low as well. However, the values of all countries are significantly above the vRE shares in Table 1. Hence, vRE represent in no country any problem for the system yet.

TRANSMISSION FLEXIBILITY ACROSS BORDERS

Transmission flexibility is depicted by the share of forecasted cross-border transfer capacity per vRE capacity and per peak load (Table 3). The first indicator is called vRE-flexible transmission, the second, compensating transmission under peak load. Due to changes in the capacity allocation mechanism (market coupling) and investments into new interconnectors the transmission capacity has increased in many regions. Similarly, due to ongoing investments into RET based electricity generation, vRE capacities have also grown. The vRE-flexible transmission shows whether in case of need due to changes in vRE generation, capacities could be transferred. A value below one signalizes that only a share of vRE generation could be compensated through transfers while above one, all vRE could theoretically be balanced by cross-border transfers. The compensation transmission under peak load shows what share of the peak load could be compensated by cross-border flows in case vRE capacities fail.

Table 3 displays a very high flexible transmission for the Baltic States, Switzerland, Hungary, Croatia. This is mainly due to a low share of vRE or low demand. Low values are depicted especially for Italy, which faces transfer capacity constraints, and the UK. The latter has a low total generation capacity (compared to peak load) as well as low transfer capacity while it holds at the same time a high vRE share. Spain is facing a similar situation while Germany's flexibility is challenged by a high vRE share. There were improvements in market coupling and investments in interconnectors. But in the light of the intended integrated EU electricity market transfer, capacities are still low for many Member States. In general, they reflect still a low cross-border transmission flexibility. This means that changes in generation capacities can only partly be compensated by transfers.

CONCLUSION

Overall, the flexibility of the electricity system, which is based on flexible generating capacities and transmission, is highly sufficient for all Member States. Graph 4 depicts the overall flexibility as a sum of generating and transmission flexibility and compares this value to the load, vRE capacity share and the vRE 10% default, which is here depicted as a critical threshold for a system's flexibility. Regarding the components of the flexibility capacity, the capacity flexibility is sufficient for all Member States. However, the cross-border transmission capacity is still low such that some neighbouring countries could only rely to a small degree on flexible capacities in adjacent countries. The transfer capacities might become a constraint, if some countries significantly increase their vRE shares and might rely on flexible capacities in neighbouring countries. One critical value for flexibility issues is, if transfer and generation capacities together range below the vRE share weighted by the country specific vRE default rate (which can be different from 10%). ■

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- ISF/UTS Institute for Sustainable Futures/ University of Technology Sydney *(www.isf.uts.edu.au)*
- JRC – Joint Research Centre, Renewable Energy Unit *(www.ec.europa.eu/dgs/jrc/index.cfm)*
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AUSTRIA

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- ARGE Biokraft – Arbeitsgemeinschaft Flüssige Biokraftstoffe *(www.biokraft-austria.at)*
- Kompost & Biogas Verband – Austrian Biogas Association *(www.kompost-biogas.info)*
- BIOENERGY 2020+ *(www.bioenergy2020.eu)*
- Bundesverband Wärmepumpe Austria – National Heat-Pump Association Austria *(www.bwp.at)*
- BMLFUW - Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft / Federal Ministry of Agriculture, Forestry, Environment and Water Management *(www.bmlfuw.gv.at)*
- BMVIT – Federal Ministry for Transport, Innovation and Technology *(www.bmvit.gv.at)*
- Dachverband Energie-Klima – Umbrella Organization Energy-Climate Protection *(www.energieklima.at)*
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BELGIUM

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- BioWanze – CropEnergies *(www.biowanze.be)*

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- CWaPE – Walloon Energy Commission *(www.cwape.be)*
- EDORA – Renewable and alternative energyfederation *(www.edora.be)*
- ICEDD – Institute for Consultancy and Studies in Sustainable Development *(www.icedd.be)*
- SPF Economy – Energy Department – Energy Observatory *(economie.fgov.be/fr/spf/structure/Observatoires/Observatoire_Energie)*
- ODE – Sustainable Energie Organisation Vlaanderen *(www.ode.be)*
- Valbiom – Biomass Valuation asbl *(www.valbiom.be)*
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- VWEA – Flemish Wind Energy Association *(www.vwea.be)*
- Walloon Energie Portal *(www.energie.wallonie.be)*

BULGARIA

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- APEE Association of Producers of Ecological Energy *(www.apee.bg/en)*
- BGA – Bulgarian Geothermal Association *(www.geothermalbg.org)*
- Bulgarian Wind Energy Association *(bgwea.org.server14.host.bg/English/Home_EN.html)*
- CL SENES BAS – Central Laboratory of Solar Energy and New Energy Sources *(www.senes.bas.bg)*
- EBRD – Renewable Development Initiative *(www.ebrdrenewables.com)*
- Invest Bulgaria Agency *(www.investbg.government.bg)*
- NSI National Statistical Institute *(www.nsi.bg)*
- SEC – Sofia Energy Centre *(www.sec.bg)*
- SEDA - Sustainable Energy Development Agency *(www.seea.government.bg)*

CYPRUS

- Cyprus Institute of Energy *(www.cie.org.cy)*
- MCIT – Ministry of Commerce, Industry and Tourism *(www.mcit.gov.cy)*
- CERA Cyprus Energy Regulatory Authority *(www.cera.org.cy)*

CROATIA

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- CROATIAN ENERGY MARKET OPERATOR - HROTE *(www.hrote.hr)*
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CZECH REPUBLIC

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DENMARK

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- Dansk Solvarme Forening - Danish Solar Association *(www. dansksolvarmeforening.dk)*
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ESTONIA

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- EWPA – Estonian Wind Power Association *(www.tuuleenergia.ee/en)*
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- MTÜ – Estonian Biogas Association
- STAT EE – Statistics Estonia *(www.stat.ee)*
- TTU – Tallinn University of Technology *(www.ttu.ee)*

FINLAND

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- Finnish Board of Customs *(www.tulli.fi/en)*
- Finnish biogas association *(biokaasuyhdistys.net)*
- Finnish Energy - Energiateollisuus *(energia.fi/)*
- Metla – Finnish Forest Research Institute *(www.metla.fi)*
- Pienvesivoimayhdistys ry – Small Hydro Association *(www.pienvesivoimayhdistys.fi)*
- Statistics Finland *(www.stat.fi)*
- SULPU – Finnish Heat Pump Association *(www.sulpu.fi)*
- Suomen tuulivoimayhdistys – Finnish Wind Power Association *(www.tuulivoimayhdistys.fi)*
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FRANCE

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- CDC – Caisse des Dépôts *(www.caissedesdepots.fr)*
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- DGEC – Energy and Climat Department *(www.industrie.gouv.fr/energie)*
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- Panorama de l'électricité renouvelable *(www.rte-france.com, www.enr.fr)*
- SVDU – National Union of Treatment and Recovery of Urban and Assimilated Waste *(www.incineration.org)*
- SER – French Renewable Energy Organisation *(www.enr.fr)*
- SOeS – Observation and Statistics Office – Ministry of Ecology *(www.statistiques.developpement-durable.gouv.fr)*
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GERMANY

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- AGEB – Arbeitsgemeinschaft Energiebilanzen *(www.ag-energiebilanzen.de)*
- AGEE-Stat – Working Group on Renewable Energy-Statistics *(www.erneuerbare-energien.de)*
- AGORA Energiewende - Energy Transition Think Tank *(www.agora-energiewende.de)*
- BAFA – Federal Office of Economics and Export Control *(www.bafa.de)*
- BBE – Bundesverband Bioenergie *(www.bioenergie.de)*
- BBK – German Biogenous and Regenerative Fuels Association *(www.biokraftstoffe.org)*
- B.KWK German Combined Heat and Power Association *(www.bkwk.de)*
- BEE – Bundesverband Erneuerbare Energie - German Renewable Energy Association *(www.bee-ev.de)*
- BDEW - Bundesverband der Energie - und Wasserwirtschaft e.V *(www.bdew.de)*
- BDW - Federation of German Hydroelectric Power Plants *(www.wasserkraft-deutschland.de)*
- BMUB – Federal Ministry for the Environment, Nature Conservation and Nuclear Safety *(www.bmub.bund.de/en/)*
- BMWi – Federal Ministry for Economics Affairs and Energy *(www.bmwi.de/Navigation/EN/Home/home.html)*
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- BSW-Solar – Bundesverband Solarwirtschaft - PV and Solarthermal Industry Association *(www.solarwirtschaft.de)*
- BWP – Bundesverband Wärmepumpe - German Heat Pump Association *(www.waermepumpe.de)*
- Bundesnetzagentur – Federal Network Agency *(www.bundesnetzagentur.de)*
- Bundesverband Wasserkraft – German Small Hydro Federation *(www.wasserkraft-deutschland.de)*
- BVES - German Energy Storage Association *(www.bves.de)*
- CLEW -Clean Energy Wire *(www.cleanenergywire.org)*
- Dena – German Energy Agency *(www.dena.de)*
- DGS – EnergyMap Deutsche Gesellschaft für Solarenergie *(www.energymap.info)*
- DBFZ – German Biomass Research Centre *(www.dbfz.de)*
- Deutsche WindGuard GmbH *(www.windguard.de)*
- DEWI – Deutsches Windenergie Institut *(www.dewi.de)*
- EEG Aktuell *(www.eeg-aktuell.de)*
- EEX – European Energy Exchange *(www.eex.com)*
- Erneuerbare Energien *(www.erneuerbare-energien.de)*
- Exportinitiative Energie – Export Initiative Renewable Energy *(www.german-energy-solutions.de)*
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- Fachverband Biogas - German Biogas Association *(www.biogas.org)*
- Fraunhofer-ISE - Institut for Solar Energy System *(www.ise.fraunhofer.de/)*
- Fraunhofer-IWES - Institute for Wind Energy and Energy System Technology *(www.iwes.fraunhofer.de/en.html)*
- FNR – Fachagentur Nachwachsende Rohstoffe - Agency for Sustainable Resources *(international.fnr.de/)*
- FVEE – Forschungsverbund Erneuerbare Energien – Renewable Energy Research Association *(www.fvee.de)*
- GTAI – Germany Trade and Invest *(www.gtai.de)*
- GtV – Bundesverband Geothermie *(www.geothermie.de)*
- GWS – Gesellschaft für Wirtschaftliche Strukturforschung *(www.gws-os.com/de)*
- KfW – Kreditanstalt für Wiederaufbau *(www.kfw.de)*
- RENAC - Renewables Academy AG *(www.renac.de)*
- UBA - Federal Environmental Agency *(Umweltbundesamt) (www.umweltbundesamt.de)*
- UFOP – Union for the Promotion of Oil and Protein plants e.V *(www.ufop.de)*
- VDB – German Biofuel Association *(www.biokraftstoffverband.de)*
- VDMA – German Engineering Federation *(www.vdma.org)*
- WI – Wuppertal Institute for Climate, Environment and Energy *(www.wupperinst.org)*
- ZSW – Centre for Solar Energy and Hydrogen Research Baden-Württemberg *(www.zsw-bw.de)*

GREECE

- CRES – Center for Renewable Energy Sources and saving *(www.cres.gr)*
- DEDDIE Hellenic Electricity Distribution Network Operator S.A.*(www.deddie.gr)*
- EBHE – Greek Solar Industry Association *(www.ebhe.gr)*
- HELAPCO – Hellenic Association of Photovoltaic Companies *(www.helapco.gr)*
- HELLABIOM – Greek Biomass Association c/o CRES *(www.cres.gr)*
- HWEA – Hellenic Wind Energy Association *(www.eletaen.gr)*
- MINISTRY OF ENVIRONMENT, ENERGY AND CLIMATE CHANGE *(www.ypeka.gr)*
- Small Hydropower Association Greece *(www.microhydropower.gr)*
- Lagie - operator of electricity market S.A. *(www.lagie.info)*

HUNGARY

- Energiaklub – Climate Policy Institute *(www.energiaklub.hu/en)*
- Energy Centre – Energy Efficiency, Environment and Energy Information Agency *(www.energycentre.hu)*
- Ministry of National Development *(www.kormany.hu/en/ministry-of-national-development)*
- Hungarian Wind Energy Association *(www.mszet.hu)*

- Hungarian Heat Pump Association *(www.hoszisz.hu)*
- Magyar Pellet Egyesület – Hungarian Pellets Association *(www.mapellet.hu)*
- MBE – Hungarian Biogas Association *(www.biogas.hu)*
- MGTE – Hungarian Geothermal Association *(www.mgte.hu/egyesulet)*
- Miskolci Egyetem – University of Miskolc Hungary *(www.uni-miskolc.hu)*
- MMESZ – Hungarian Association of Renewable Energy Sources *(www.mmesz.hu)*
- MSZET – Hungarian Wind Energy Association *(www.mszet.hu)*
- Naplopó Kft. *(www.naplopo.hu)*
- SolarT System *(www.solart-system.hu)*

IRELAND

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- EIRGRID *(www.eirgridgroup.com/)*
- IRBEA – Irish Bioenergy Association *(www.irbea.org)*
- Irish Hydro Power Association *(www.irishhydro.com)*
- ITI – InterTradeIreland *(www.intertradeireland.com)*
- IWEA – Irish Wind Energy Association *(www.iwea.com)*
- REIO – Renewable Energy Information Office *(www.seai.ie/Renewables/REIO)*
- SEAI – Sustainable Energy Authority of Ireland *(www.seai.ie)*

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 dilngegneria 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)*
- Chambre des Métiers du Grand-Duché de Luxembourg *(www.cdm.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

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- 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)*
- IMP – Instytut Maszyn Przepływowych *(www.imp.gda.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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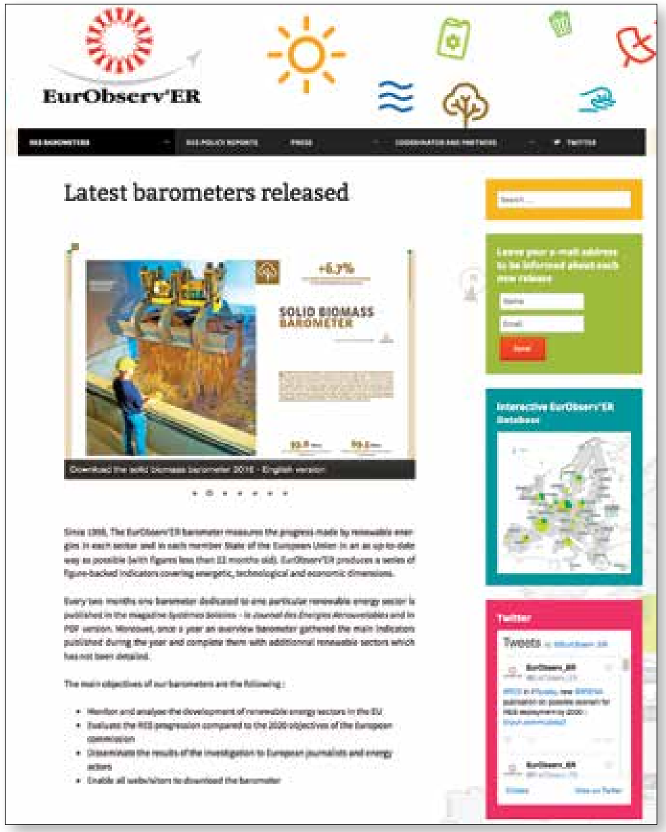

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Schedule for the 2017 EurObserv'ER barometers

Wind power	>> **February 2017**
Photovoltaic	>> **April 2017**
Solar thermal	>> **June 2017**
Biofuels	>> **July 2017**
Biogas	>> **November 2017**
Solid biomass	>> **December 2017**

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