BIOENERGY EUROPE

STATISTICAL REPORT 2019

REPORT BIOELECTRICITY

Bioenergy EUROPE

Supported by

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STATISTICAL REPORT

TIMELINE

Every year since its debut release in 2007, Bioenergy Europe's Statistical Report has provided an in-depth overview of the bioenergy sector in the EU-28 Member States.

Bioenergy Europe's Statistical Report has been enriched each year with new figures and information, collecting unique data on the developments of the European bioenergy market from a growing number of international contributors.

Bioenergy Europe is therefore able to develop a detailed report that helps industry leaders, decision makers, investors and all bioenergy professionals to understand the situation of bioenergy in Europe.

With more than 150 graphs and figures, readers of Bioenergy Europe´s Statistical Report can get accurate and up-to-date information on the EU-28 energy system such as the final energy consumption of biomass for heat and electricity, the number of biogas plants in Europe, the consumption and trade of pellets, the production capacity of biofuels and other key information to help break down and clarify the complexity of a sector in constant evolution.

In 2017, the Report was rewarded by the European Association Awards for being the "best Provision of Industry Information and Intelligence", a recognition after a decade of collective work.

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2019

ABOUT

OUR ACTIVITIES

Bioenergy Europe carries a wide range of activities aimed at supporting its members by informing them about latest EU and national policy developments, and by voicing their concerns to EU and other authorities. These include advocacy activities in key policy areas as well as the organisation of dedicated working groups acting as platforms where members can discuss common issues and exchange information on the state of play of bioenergy.

There are currently 7 active working groups:

- Agrobiomass & Energy Crops
- Biopower & CHP
- Competitiveness
- Domestic Heating
- Sustainability
- Pellets
- Wood Chips

In addition, Bioenergy Europe conceives and deploys targeted publications and communication campaigns to inform and educate about the potential of bioenergy for a decarbonised Europe.

Most notably, the association has several years of experience in data collection on the evolution of the bioenergy market and produce unique and tailored analyses along the year.

Thanks to the experience and authority acquired over the last 19 years, Bioenergy Europe successfully established two international certification schemes to guarantee high quality standard for fuels.

Bioenergy Europe is also the umbrella organisation of the European Pellet Council (EPC) and the International Biomass Torrefaction Council (IBTC). These networks have been created thanks to the dynamics of Bioenergy Europe members. Today, these networks bring together bioenergy experts and company representatives from all over Europe.

EUROPEAN PELLET COUNCIL
A NETWORK OF BIOENERGY EUROPE

The European Pellet Council (EPC) is an umbrella organisation of Bioenergy Europe founded in 2010, representing the interests of the European wood pellet sector. Its members are national pellet associations or related organisations from 18 countries.

The EPC is a platform for the pellet sector to discuss the issues related to the transition from a niche product to a major energy commodity. These issues include the standardisation and certification of pellet quality, safety, security of supply, education and training, and the quality of pellet-using devices.

EPC is managing the EN*plus*® quality certification.

www.pelletcouncil.eu
www.enplus-pellets.eu

INTERNATIONAL BIOMASS TORREFACTION COUNCIL
A NETWORK OF BIOENERGY EUROPE

The International Biomass Torrefaction Council (IBTC) is an umbrella organisation of Bioenergy Europe launched in 2012 and aims to building the first platform for companies having common interests in the development of torrefied Biomass markets. Currently, the IBTC initiative is supported by more than 23 companies active worldwide.

IBTC's objective is to promote the use of torrefied biomass as an energy carrier and to assist the development of the torrefaction industry. In this respect, IBTC's key activities are to undertake studies or projects, and to commonly voice its members' concerns to third parties to help to overcome barriers of market deployment.

www.ibtc.bioenergyeurope.org

ABOUT

BIOENERGY EUROPE

BIOENERGY EUROPE is the common voice of the bioenergy sector with the aim to develop a sustainable bioenergy market based on fair business conditions.

BIOENERGY EUROPE is a non-profit Brussels-based international organisation founded in 1990 which brings together national associations and companies from all over Europe – thus representing more than 4000 indirect members, including mainly companies and research centers.

www.bioenergyeurope.org

ASSOCIATIONS

ACADEMIA

ABOUT

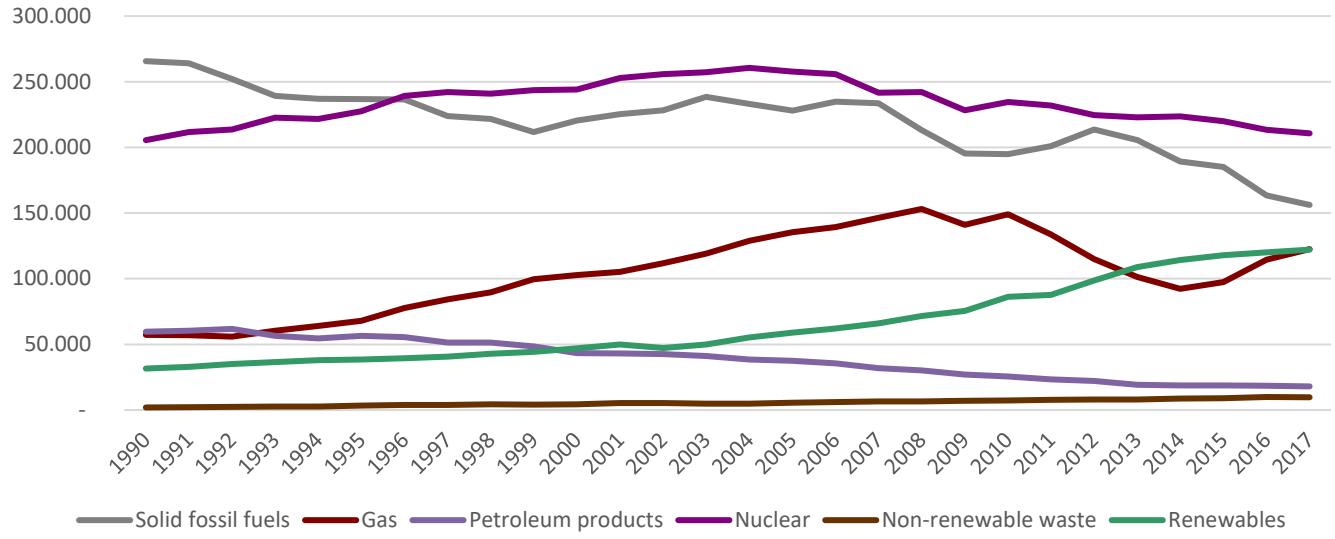
BIOENERGY EUROPE

COMPANIES

Members as of May 2019.

1. Electricity and renewable electricity in Europe

Figure 1 Evolution of fuels inputs for electricity generation in the EU28 (in ktoe)



Source: Eurostat

Table 1 Fuels inputs for electricity generation changes 1990-2017 (in ktoe)

	1990	2017	Absolute change	Growth rate (1990-2017)
Total	621.559	639.501	17.942	3%
Solid fossil fuels	265.694	156.201	-109.494	-41%
Gas	57.144	122.628	65.485	115%
Petroleum products	59.638	17.983	-41.654	-70%
Nuclear	205.540	210.724	5.184	3%
Non-renewable waste*	1.952	9.816	7.864	403%
Renewables	31.592	122.148	90.556	287%

*Non-renewable waste consists of materials coming from combustible industrial, institutional, hospital and household waste such as rubber, plastics, waste fossil oils and other similar types of waste, either solid or liquid.
Source: Eurostat

Table 2 Fuels inputs for electricity generation in EU28 in 2017 (in ktoe)

Fuel	Power only	Combined Heat and Power (CHP)	Total	Growth rate (2016-2017)
Solid fossil fuels	98.693	57.508	156.201	-4,4%
Petroleum products	10.583	7.400	17.983	-2,7%
Gas	63.267	59.361	122.628	7,1%
Nuclear	205.632	5.092	210.724	-1,3%
Non-renewable waste	3.543	6.273	9.816	-1,0%
Renewables	**92.727**	**29.421**	**122.148**	1,7%
Hydro	25.856	/	25.856	-14,3%
Geothermal	5.784	/	5.784	-0,2%
Wind	31.162	/	31.162	19,7%
Solar thermal	2.310	/	2.310	5,4%
Solar photovoltaic	9.773	/	9.773	7,3%
Tide, wave, ocean	45	/	45	5,1%
Solid biomass	9.026	15.908	24.934	2,3%
Biogas	5.231	7.335	12.566	-1,8%
Renewable municipal waste	2.924	5.817	8.742	2,3%
Bioliquids	613	361	975	-3,7%
TOTAL	474.446	165.056	639.501	-0,4%

Note: Transformation input covers all inputs into the transformation plants destined to be converted into derived products or transformation output (electricity and derived heat). Transformation is only recorded when the energy products are physically or chemically modified to produce other energy products, in this case electricity.
Source: Eurostat

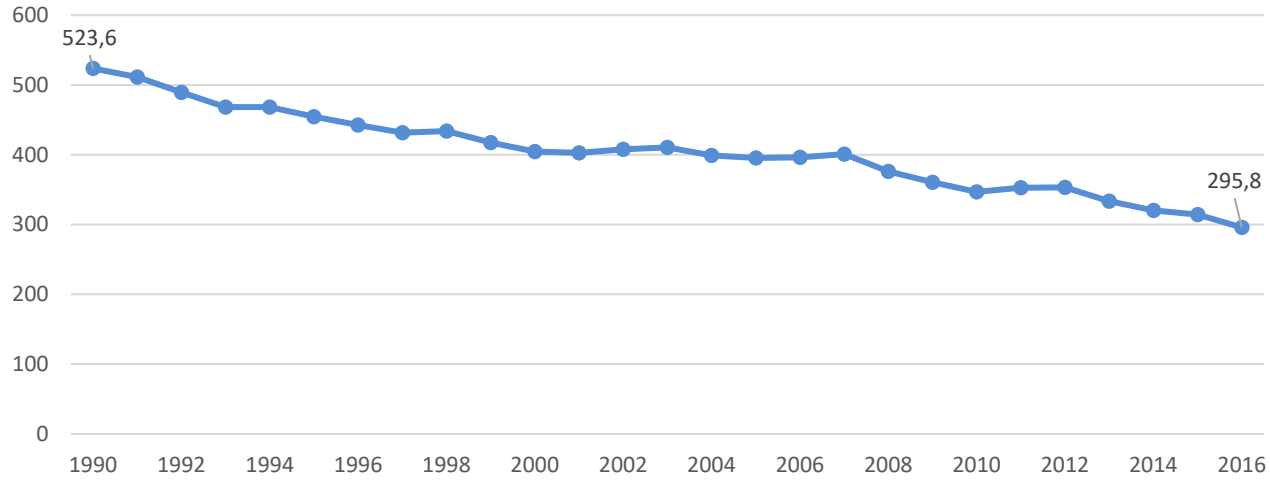
Table 3 Fuels inputs for electricity in EU28 and the member states in 2017 (in ktoe)

	Solid fossil fuels	Petroleum products	Gas	Nuclear	Non-renewable waste	Renewables	Total Biomass
EU28	**156.201**	**17.983**	**122.628**	**210.724**	**9.816**	**122.148**	**47.217**
AT	376	242	2.632	0	378	5.226	1.252
BE	8	35	4.076	11.002	514	2.148	1.282
BG	5.621	164	593	3.941	0	572	79
CY	0	1.019	0	0	0	41	8
CZ	10.836	45	1.430	7.017	55	1.567	1.167
DE	53.306	1.190	18.602	19.655	2.848	25.336	10.988
DK	1.446	75	442	0	372	3.400	2.063
EE	29	2.512	154	0	53	361	297
EL	4.601	1.425	2.615	0	0	1.252	92
ES	10.830	3.240	10.212	15.132	253	10.617	1.736
FI	2.408	128	826	5.390	211	4.485	2.799
FR	3.052	1.652	7.246	103.860	1.186	10.535	3.131
HR	316	47	685	0	0	731	165
HU	1.252	23	1.601	4.084	67	730	616
IE	1.373	35	2.419	0	56	884	183
IT	7.253	4.164	25.642	0	889	17.357	5.291
LT	0	21	240	0	33	400	225
LU	0	0	69	0	23	92	55
LV	1	0	400	0	0	740	350
MT	0	52	232	0	0	28	2
NL	6.126	267	10.243	790	824	2.688	1.584
PL	32.085	393	2.711	0	133	3.029	1.513
PT	3.237	251	3.344	0	103	2.673	829
RO	4.479	203	2.640	2.907	0	2.208	166
SE	263	75	327	16.351	765	11.209	4.081
SI	1.086	4	92	1.488	9	431	73
SK	939	222	512	3.985	16	924	508
UK	5.278	498	22.645	15.124	1.026	12.482	6.681

Source: Eurostat

Germany and Poland are the two main users of solid fossil fuels for electricity generation: together they represent more than 50% of the EU28 solid fossil fuels input for electricity. Within EU28, Italy, Spain and Estonia are the biggest users of petroleum products for electricity generation, representing together around 55% of the petroleum product inputs for electricity. To improve the carbon footprint of their electricity, these countries will need to implement substantial changes: bioelectricity is a good option and it will ensure the grid stability and an efficient use of primary energy via CHP when relevant.

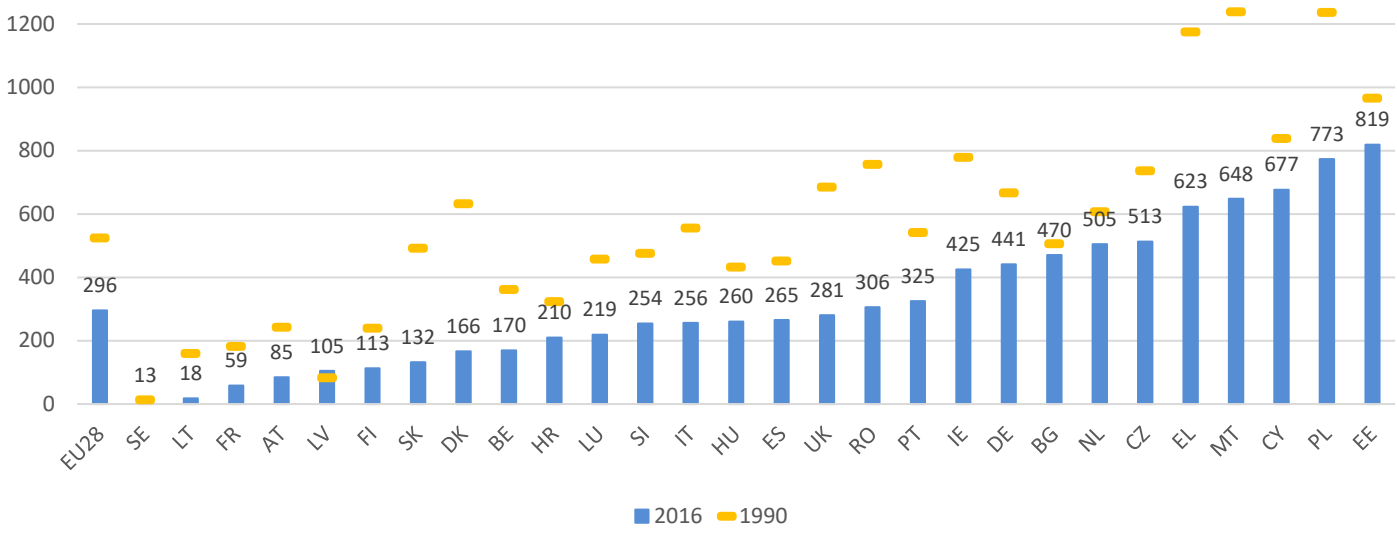
Figure 2 Evolution of the CO_2 emission intensity of electricity generation in EU28 (in gCO_2/kWh)



Source: EEA

Since 1990 the carbon footprint of the kWh of electricity produced in EU28 has dropped by 43,5%. This is mainly explained by a reduction of solid fossil fuel and petroleum products, replaced by gas or renewables.

Figure 3 CO_2 emission intensity of the electricity generation in the EU28 (in gCO_2/kWh) 1990-2016



Source: EEA

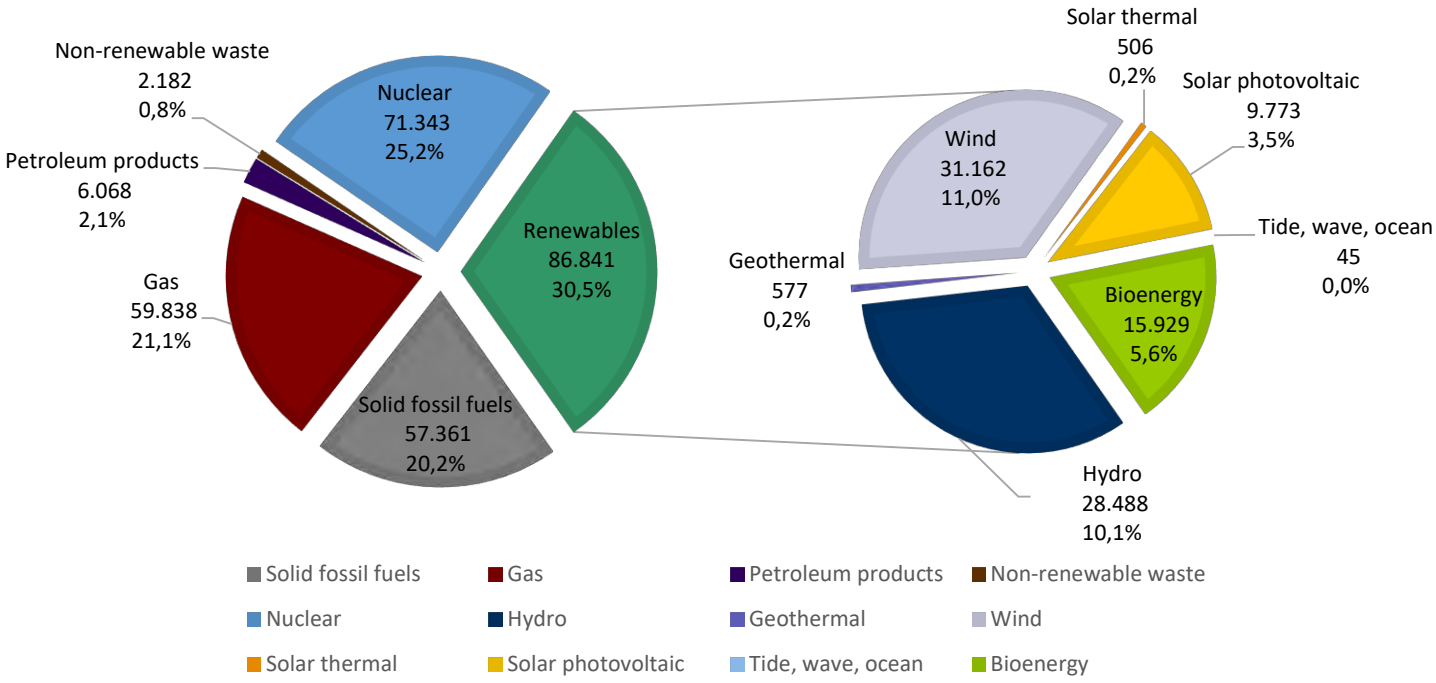
The countries with the highest carbon footprint per kWh are the ones using high shares of solid fossil fuels and/or petroleum products for electricity generation.

Sweden has the lowest carbon footprint since 1990 mainly due to hydro and nuclear plants that have been operating for a long time and due to bioenergy. Latvia has had hydropower installations for a long time; the use of natural gas in CHP plants has slightly increased the carbon footprint of its electricity, but in 2017 this was reduced by around 40%, suggesting a consequent reduction of the carbon footprint. All countries, except Sweden and Latvia for the above-mentioned reason, have reduced the CO_2 intensity per kWh since 1990 by reducing the use of solid fossil fuels and petroleum products in their electricity generation. The biggest electricity producers, considering all forms of

electricity, are (in descending order): Germany, France, United Kingdom, Italy and Spain, all having produced more than 23.000 ktoe of electricity in 2017, followed by Poland and Sweden (see Table 4). This suggests their carbon footprint will have a major impact on the EU28 average: good news as far as Sweden and France are concerned, relatively less for the rest as they are all below the top 12 countries for the CO_2 intensity per kWh.

It is important to note that figure 3 gives information about the carbon footprint of the electricity generation, not the consumption. Some importing countries such as Lithuania or Luxembourg could have very different results due to the imports (Cf. Table 5). Additionally, some countries have a low electricity carbon footprint due to nuclear power and not especially to renewables. These are the main reasons for the disparity of the ranking order between figure 3 and 7 (share of renewables in electricity consumption). It is therefore essential to take into account the overall consumption aspect to implement coherent measures for reducing greenhouse gas emissions linked with the electricity sector.

Figure 4 Gross electricity generation by product type in the EU28 in 2017 (in ktoe)



Note: transformation output refers to the electricity output of the power plants. Hydro and wind are not normalised.
Source: Eurostat

The total gross electricity generation has increased by 1% from 2016 to 2017, the renewable generation has increased by 2,2% while the non-renewable gross electricity generation increased by 0,5%. For non-renewable fuels, all the increase is covered by gas (growth rate of 8,1%). For the other non-renewable fuels, their generation slightly decreased (the main decrease is observed for solid fossil fuel -2.426 ktoe in 2017 compared to 2016). As shown in Table 4, the general growth rate for renewables between 2016-2017 is mainly influenced by wind. Hydro decreased its gross electricity generation due to weather conditions in 2017 while the capacity installed has increased by 0,4% (Cf. Table 6) thus its average capacity factor decreased by around 3,8 percentage points in 2017 compared to 2016.

Table 4 Gross electricity generation from all sources and from renewables in EU28 Member States in 2017 (in ktoe)

	Total gross generation	Renewables	Hydro*	Wind	Bioelectricity	Solar photovoltaic	Solar thermal	Geothermal	Tide, wave, ocean
EU28	**283.273**	**86.481**	**28.488**	**31.162**	**15.929**	**9.773**	**506**	**577**	**45**
Growth rate (2016-2017)	1,0%	2,2%	-13,0%	19,7%	2,2%	7,3%	5,4%	-0,3%	5,1%
AT	6.132	4.706	3.633	565	399	109	0	0	0
BE	7.402	1.458	120	560	495	283	0	0	0
BG	3.919	584	300	129	34	121	0	0	0
CY	430	37	0	18	4	15	0	0	0
CZ	7.476	928	261	51	427	189	0	0	0
DE	56.065	19.118	2.249	9.088	4.379	3.388	0	14	0
DK	2.669	1.885	2	1.271	548	65	0	0	0
EE	1.109	154	2	62	89	0	0	0	0
EL	4.752	1.193	347	476	27	343	0	0	0
ES	23.700	7.796	1.812	4.224	523	732	506	0	0
FI	5.772	2.706	1.270	412	1.020	4	0	0	0
FR	48.277	8.404	4.738	2.125	662	823	0	11	45
HR	1.030	629	474	104	45	7	0	0	0
HU	2.819	298	19	65	184	30	0	0	0
IE	2.654	781	77	640	63	1	0	0	0
IT	25.380	9.091	3.270	1.526	1.666	2.096	0	533	0
LT	339	268	102	117	43	6	0	0	0
LU	192	167	122	20	15	9	0	0	0
LV	648	470	377	13	80	0	0	0	0
MT	155	28	0	0	1	27	0	0	0
NL	10.072	1.499	5	909	395	190	0	0	0
PL	14.652	2.115	261	1.282	558	14	0	0	0
PT	5.110	2.090	656	1.053	277	85	0	19	0
RO	5.528	2.119	1.277	637	45	160	0	0	0
SE	14.123	8.176	5.603	1.514	1.038	20	0	0	0
SI	1.404	406	356	0	25	24	0	0	0
SK	2.372	587	398	1	146	44	0	0	0
UK	29.092	8.788	757	4.300	2.740	991	0	0	0

*The gross electricity production from hydro is higher than its fuel input presented in table 2 because here pumped hydro is included.

Source: Eurostat

94% of Luxembourg's hydropower generation is from pumped hydro, but this is not counted in their gross final renewable electricity consumption (Cf. figure 7) as it is a double counting of the excess electricity that is stored by this pumping. Luxembourg is a net importer of electricity for its consumption.

Table 5 Final electricity consumption and electricity export-import in 2017 (in ktoe)

	Final electricity consumption	Export	Import	Balance (Export - Import)
EU28	**247.797**	**32.204**	**33.081**	**-877**
AT	5.614	1.962	2.525	-563
BE	7.186	702	1.220	-518
BG	2.700	790	319	471
CY	391	n.a.	n.a.	/
CZ	5.078	2.417	1.296	1121
DE	45.686	6.905	2.394	4511
DK	2.772	916	1.309	-392
EE	664	431	196	235
EL	4.782	211	748	-536
ES	20.797	1.255	2.043	-788
FI	7.074	153	1.909	-1756
FR	38.134	5.266	1.817	3449
HR	1.412	447	1.045	-598
HU	3.409	595	1.703	-1107
IE	2.233	154	96	58
IT	25.957	441	3.688	-3247
LT	942	279	1.025	-746
LU	550	119	651	-531
LV	558	356	350	6
MT	200	3	77	-74
NL	9.583	1.630	1.931	-301
PL	12.590	944	1.141	-197
PT	4.098	704	473	231
RO	4.201	665	416	249
SE	11.217	2.656	1.023	1633
SI	1.171	830	785	44
SK	2.323	1.078	1.338	-260
UK	26.476	293	1.562	-1269

*Export and import for the EU28 includes EU internal trades.
Source: Eurostat

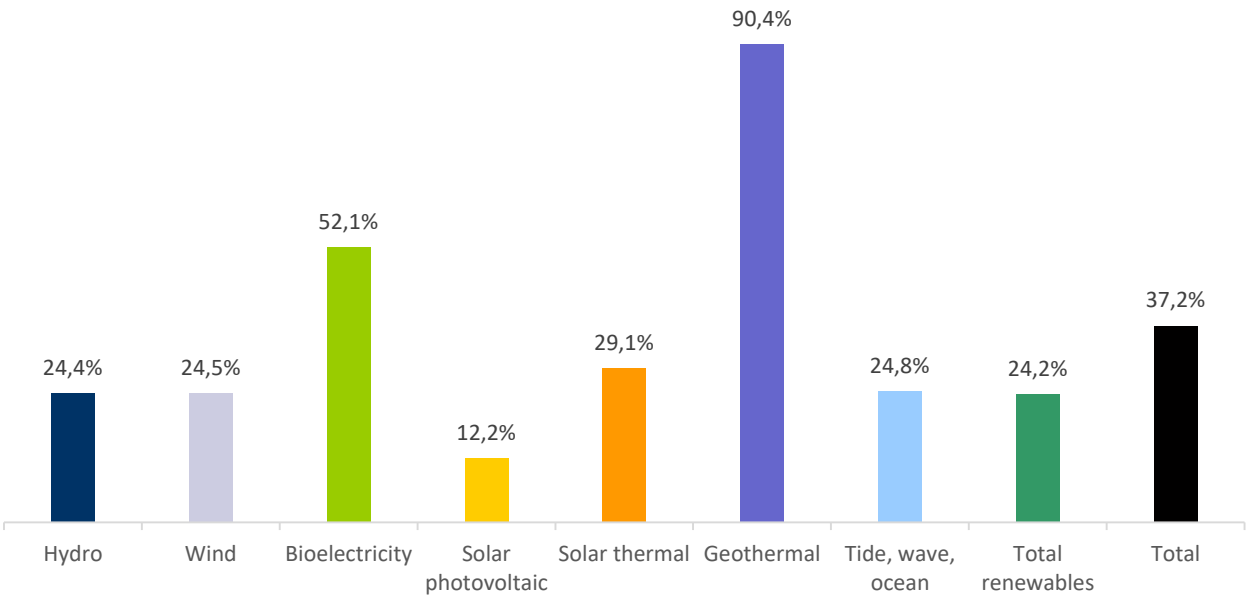
Luxembourg and Lithuania mainly rely on imports for their electricity consumption (96% and 79% respectively). Croatia, Malta, Hungary and Finland are net importers for more than 24% of their consumption. The three main exporters in absolute terms are Germany, France and Sweden.

Table 6 Total electrical installed capacity and electrical capacity for renewables in EU Member States in 2017 (MW) – with growth rate and average load factor* for EU28

	Total	Total renewables	Hydro	Wind	Bioelectricity	Solar photovoltaic	Solar thermal	Geothermal	Tide, wave, ocean
EU28	**1.010.234**	**474.781**	**155.119**	**168.934**	**40.624**	**106.707**	**2.306**	**848**	**242**
Growth rate (2016-2017)	1,7%	5,0%	0,4%	9,5%	3,8%	5,6%	0,0%	1,3%	1,7%
Average load factor	37,2%	24,2%	24,4%	24,5%	52,1%	12,2%	29,1%	90,4%	24,8%
AT	24.919	19.867	14.150	2.887	1.560	1.269	n.a.	1	n.a.
BE	22.261	8.874	1.423	2.806	1.036	3.610	n.a.	n.a.	n.a.
BG	10.858	5.158	3.372	698	52	1.036	n.a.	n.a.	n.a.
CY	1.785	277	n.a.	158	10	110	n.a.	n.a.	n.a.
CZ	22.267	5.471	2.265	308	829	2.070	n.a.	n.a.	n.a.
DE	215.510	119.216	11.120	55.718	10.007	42.337	2	32	n.a.
DK	14.364	8.442	9	5.522	2.004	906	n.a.	n.a.	n.a.
EE	2.527	705	7	312	386	n.a.	n.a.	n.a.	n.a.
EL	19.426	8.686	3.392	2.624	64	2.606	n.a.	n.a.	n.a.
ES	103.840	51.357	20.079	23.100	1.144	4.725	2.304	n.a.	5
FI	17.166	7.356	3.272	2.044	1.966	74	n.a.	n.a.	n.a.
FR	133.101	50.138	25.706	13.512	2.075	8.610	n.a.	16	219
HR	4.982	2.929	2.206	576	87	60	n.a.	n.a.	n.a.
HU	8.858	1.215	57	329	482	344	n.a.	3	n.a.
IE	10.490	4.002	529	3.318	140	16	n.a.	n.a.	n.a.
IT	114.241	56.471	22.426	9.737	3.859	19.682	n.a.	767	n.a.
LT	3.326	1.556	877	518	87	74	n.a.	n.a.	n.a.
LU	1.697	1.623	1.331	120	44	128	n.a.	n.a.	n.a.
LV	2.941	1.796	1.564	77	154	1	n.a.	n.a.	n.a.
MT	n.a.	117	n.a.	0	5	112	n.a.	n.a.	n.a.
NL	33.815	8.264	37	4.202	1.122	2.903	n.a.	n.a.	n.a.
PL	42.793	9.430	2.390	5.759	993	287	n.a.	n.a.	n.a.
PT	20.933	13.582	7.226	5.124	623	579	n.a.	29	0
RO	23.574	11.236	6.692	3.030	140	1.374	0	0	n.a.
SE	39.798	28.746	16.502	6.611	5.389	244	n.a.	n.a.	n.a.
SI	3.618	1.660	1.347	5	62	247	n.a.	n.a.	n.a.
SK	7.671	3.307	2.523	4	252	528	n.a.	n.a.	n.a.
UK	103.473	43.300	4.618	19.835	6.053	12.776	n.a.	n.a.	18

*The load factor represents the percentage of the time (annual average) during which the unit is operating at its nominal capacity.
Source: Eurostat

Figure 5 Average load factor for the different renewable technologies and for the total installed capacities in the EU28 in 2017

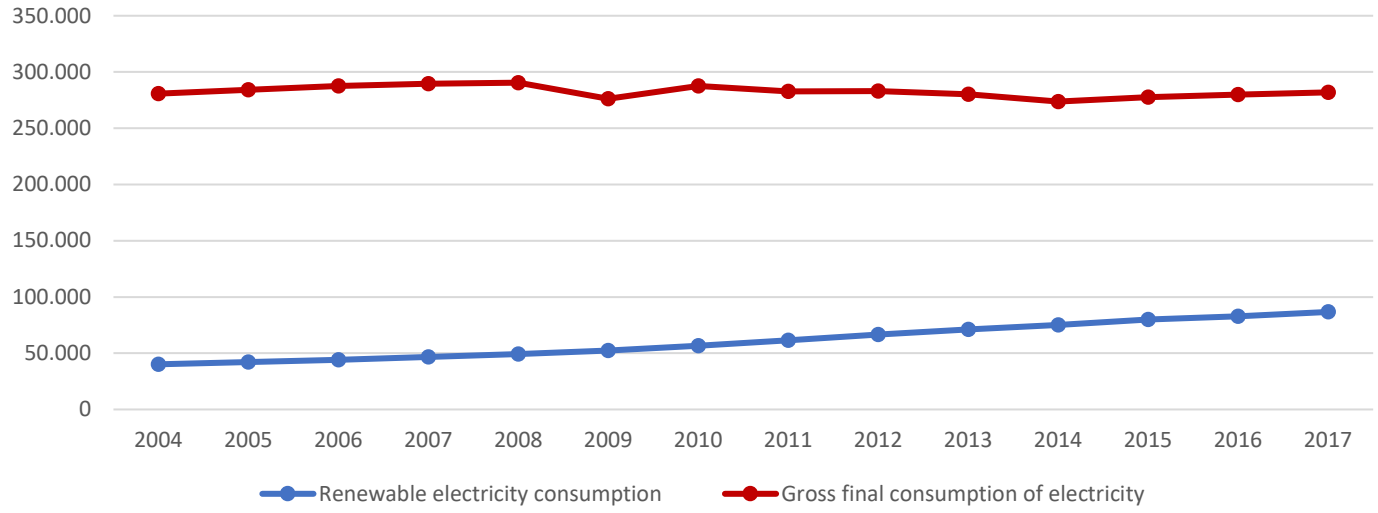


Note: total considers all the electricity sources and technologies.
Source: Eurostat and Bioenergy Europe's calculations

Bioelectricity's load factor is more than twice higher than the average for renewables. Indeed, bioelectricity is dispatchable and allows to adjust production to stabilise the grid. The stability and reliability of the grid is a big challenge for the energy transition due to the large increase of non-dispatchable technologies (wind and solar). Bioelectricity is a very viable solution for the EU being a dispatchable, not site-specific and affordable technology. The average load factor for bioelectricity was stable in 2017 compared to 2016 and, as shown in table 6, it experienced the third largest growth rate within renewables in terms of installed capacity, proving that the advantages of bioelectricity technologies are already being recognised.

The load factor for wind has increased compared to 2016 (22,4%) due to the implementation of more offshore wind parks characterised by better wind conditions and thus higher load factors. Hydropower has seen its average load factor reduced by around 3,7% percentage point from 2016 to 2017, due to less favourable meteorological conditions in 2017.

Figure 6 Evolution of the gross final consumption of electricity* and gross final consumption of electricity from renewable sources in EU28 (ktoe)

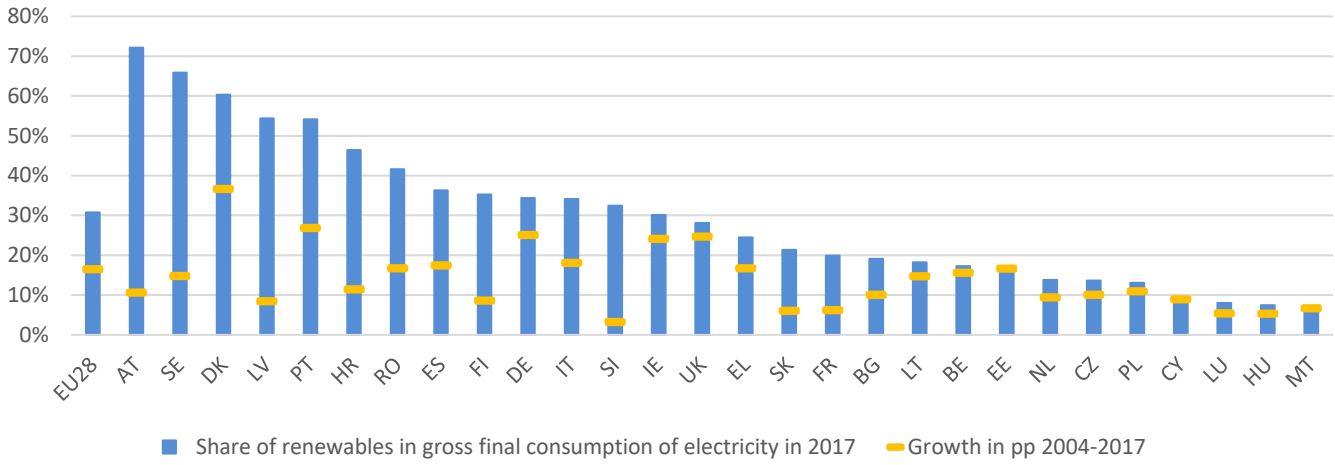


* Gross final consumption of electricity is calculated according to the methodology established by Directive 2009/28/EC and Regulation (EC) No 1099/2008.
Hydro is normalised and excluding pumping. Wind is normalised. Solar includes solar photovoltaics and solar thermal generation.
Source: Eurostat, SHARES 2017

The renewable energy share in the power sector keeps growing. Electricity is the sector where renewables have experienced the largest increase over the last decade while this sector just represents around 25% of the total EU final energy consumption. The share of renewables in the amount of electricity gross final consumption more than doubled between 2004 and 2017 (from 14,3% in 2004 to 30,7% in 2017).

Yet, the graph also shows there is still a large gap to be filled to achieve 100% renewable electricity; further efforts are needed, such as an increased price on carbon or a phase-out of indirect subsidies to fossil fuels. Today and in the near future, electrification is by no means equal to decarbonisation at the EU28 scale.

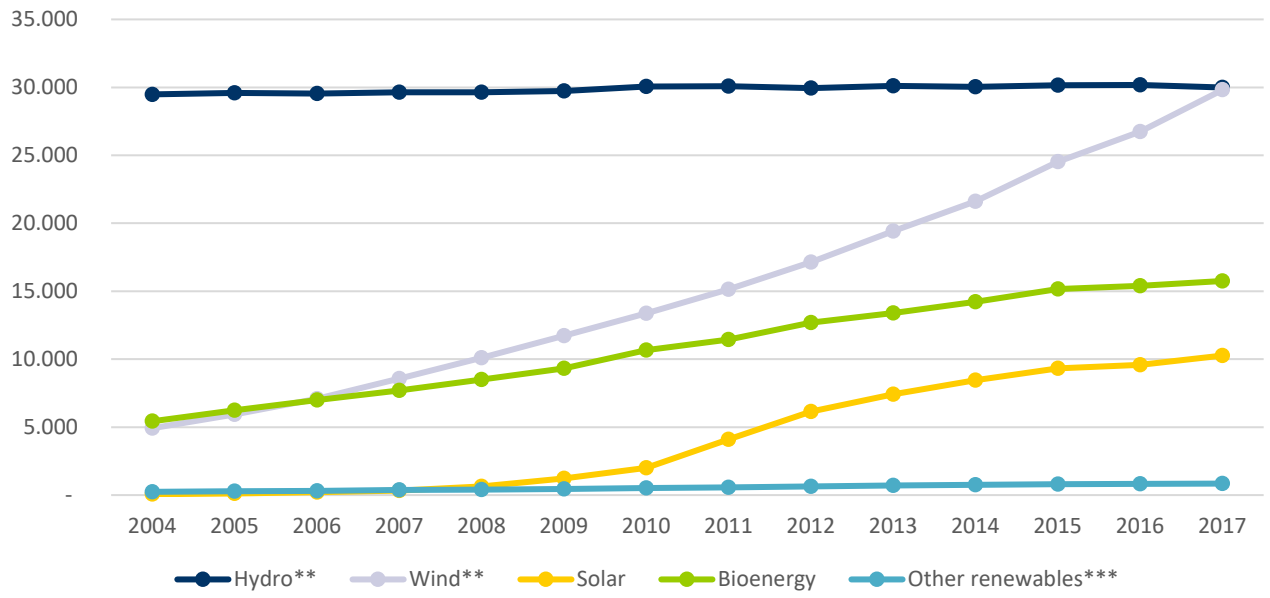
Figure 7 Share of renewables in gross final consumption of electricity* in EU28 Member States in 2017 (%) and growth of this share between 2004 and 2017 (in percentage points)



* Calculated according to the methodology established in Directive 2009/28/EC and also Regulation (EC) No 1099/2008.
Source: Eurostat, SHARE 2017 (Wind and hydro are normalised and hydro excluded pumping).

As figure 7 shows, there still are huge divergences between Member States when it comes to the deployment of renewable electricity in Europe. Austria, Sweden, Denmark and Latvia are leading for the share of renewables in gross final consumption of electricity. Hydropower is the main contributor for Austria, Sweden and Latvia while it is wind power for Denmark (Cf Table 4). Bioelectricity also has an important role in these four countries as it represents their second or third main source of renewable electricity. It has to be noted that figure 7 expresses the contribution of renewables in relative terms; in absolute terms the top countries producing the most renewable electricity are Germany, Italy, United Kingdom, France, Sweden and Spain (Cf Table 4) and the top countries for electricity final consumption are: Germany, France, United Kingdom, Italy, Spain and Poland (Cf. Table 5). Therefore, these seven countries will have the largest influence on the general percentage of renewable electricity in the EU28.

Figure 8 Evolution of gross final consumption of electricity from renewable sources* in EU28 between 2004 and 2017 (ktoe)



* Calculated according to the methodology established on Directive 2009/28/EC and also Regulation (EC) No 1099/2008.
**Wind and hydro are normalised to smoothen the annual changes due to weather conditions
*** All other renewables include electricity generation from geothermal and tide, wave & ocean
Source: Eurostat, SHARES 2017, and Bioenergy Europe's calculations

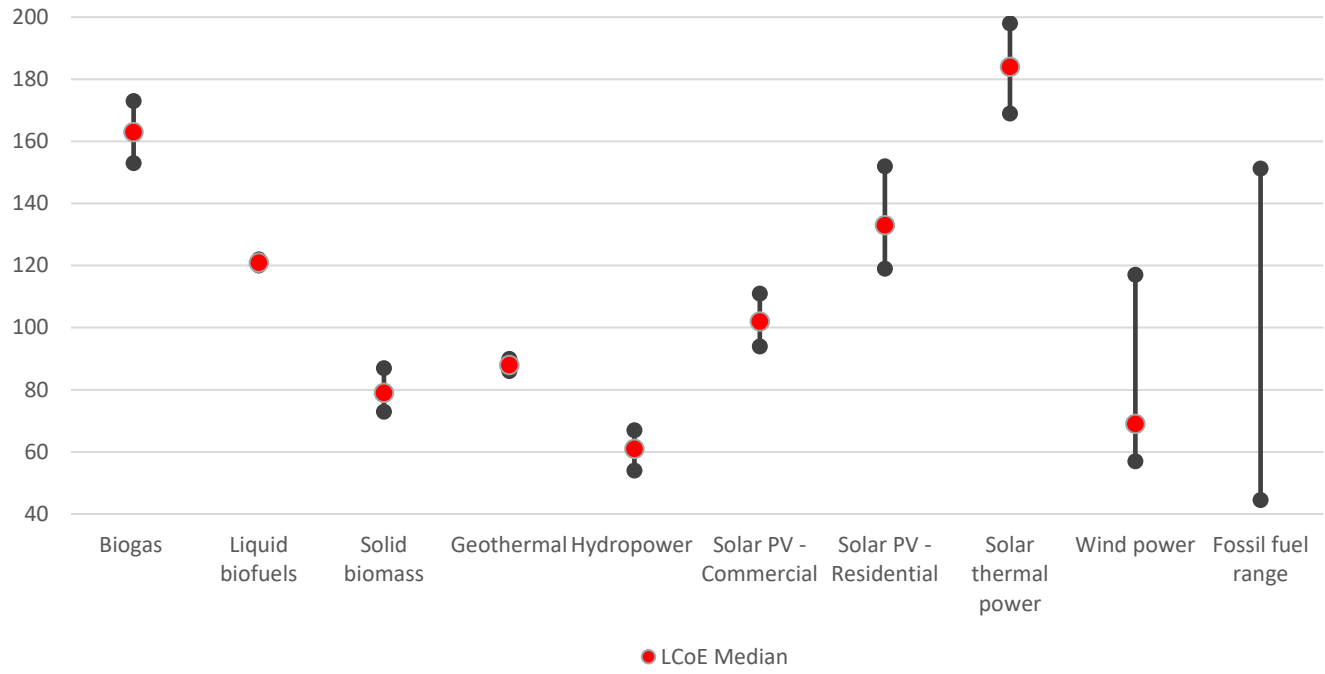
Renewable electricity sources like wind and solar lead the growth in the power sector but, because of their variable nature, require flexible and dispatchable electricity generation to complement them. Bioelectricity is one renewable energy which can be baseload and dispatchable whenever needed (e.g. peak loads). Moreover, biomass fuels (solid, liquid or gaseous) can be used to retrofit existing fossil fuel-based plants, allowing to use existing infrastructure.

In the framework of the discussion on the design of the future electricity market, the proposal of excluding most polluting fuels (emitting more than 550g CO_2/ kWh) from being eligible for the capacity mechanism is a step in the right direction.

It is also interesting to note the decentralisation trend of energy production, which allows the consumer to be put at the centre of the energy system. Not only in the heat sector, where decentralised production of bioheat has an important role to play, but also in the electricity sector where micro- and medium-scale CHP can play an important role in empowering citizens in the fight against climate change.

In the years to come, the role of baseload and dispatchable sources of electricity such as bioenergy will be increasingly important to bring stability to electricity grids and facilitate the fast deployment of other variable sources of renewable electricity. This stabilising service to the grid should be incentivised in the future.

Figure 9 Levelised cost of electricity for different renewable technologies compared with the range cost for fossil fuel technologies (€/MWh).



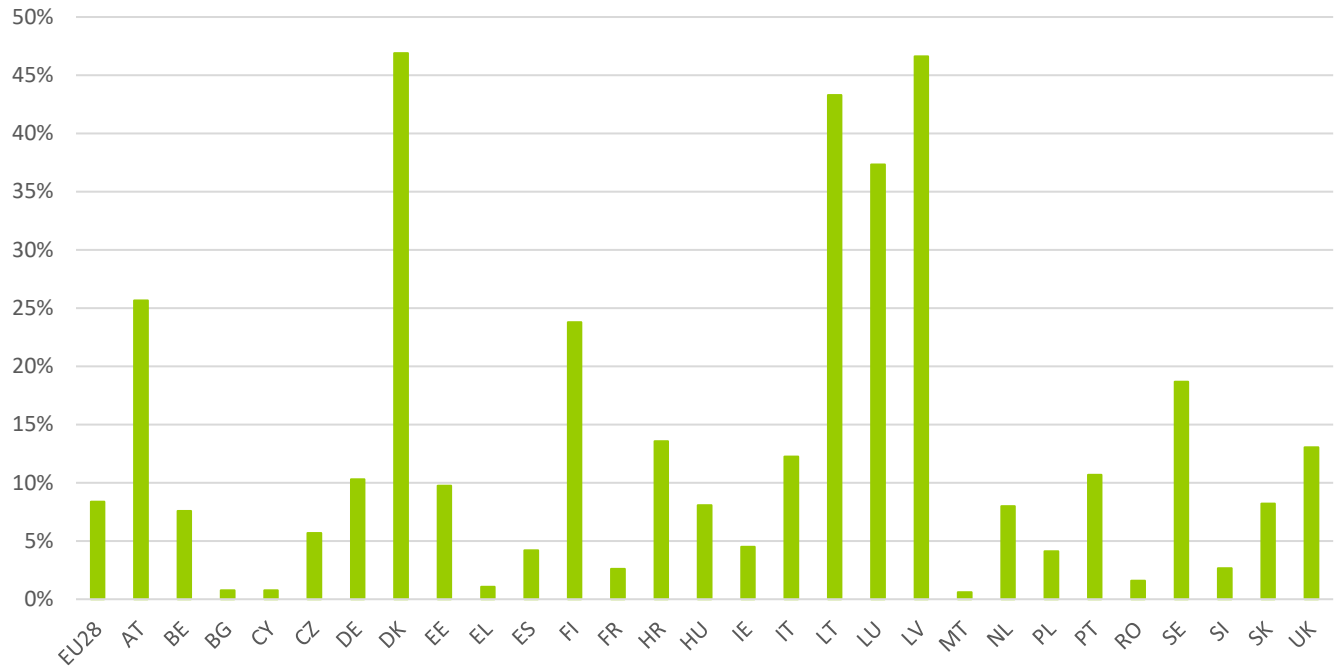
Source: Eurobserv'ER (for renewables) and Irena (for the range of fossil fuel costs)

Figure 9 shows that bioelectricity is competitive. Indeed, generally the LCOE of bioelectricity technologies is in the range of fossil fuels except for biogas technologies where cost reductions are expected. We should also consider the limitations of LCOE: while it allows for a simple comparison of technologies with varied features, it does not cover the "how, when and where" of electricity production, which in turn means there is not distinction between units that are flexible and dispatchable (able to adapt their production to the actual needs of the grid), nor the place of production (grid connection and losses). Furthermore, none of the social and environmental externalities are included in the LCOE and that would lead to a decrease of the performance of the fossil fuel technologies. Additionally, the levelised cost of electricity does not consider the potential valuation of heat within CHP plants that would lead to more advantageous results.

Considering these limits of the LCOE analysis leads to even better results for bioelectricity technologies as they use renewable fuels and are flexible, dispatchable technologies. Additionally, they generally value heat with co-generation plants.

2. Bioelectricity in Europe

Figure 10 Share of biomass fuels within the fuel inputs for electricity generation considering the non-renewable fuels* and biomass fuels per country in 2017



*i.e. fossil fuels, nuclear and non-renewable waste inputs

Source: Eurostat

For Denmark, Latvia, Lithuania, Luxembourg and Austria the fuels inputs from biomass represents more than 25% of the total fuels input for electricity generation from thermal sources (i.e. not considering wind, hydro, solar, and tide, wave, ocean), excluding geothermal and solar thermal. Luxembourg imports most of its electricity and thus has low total fuels inputs for electricity generation The first three also are the countries where 100% of the bioelectricity is produced from CHP. The bioelectricity fuel inputs in Denmark are mainly solid biomass which represents slightly more than the solid fossil fuel inputs for electricity generation. Latvia's percentage is high because hydro is not accounted and is a large part of their electricity generation.

Table 7 Fuels inputs for bioelectricity generation in EU28 and the member states in 2017 (ktoe)

	Total Biomass	Solid biomass	Biogas	Renewable municipal waste	Bioliquids
EU28	**47.217**	**24.934**	**12.566**	**8.742**	**975**
AT	1.252	890	196	167	0
BE	1.282	777	130	370	6
BG	79	40	39	0	0
CY	8	0	8	0	0
CZ	1.167	648	449	70	0
DE	10.988	2.856	5.703	2.341	88
DK	2.063	1.461	147	455	0
EE	297	292	5	0	0
EL	92	3	89	0	0
ES	1.736	1.282	201	253	0
FI	2.799	2.469	84	245	2
FR	3.131	1.464	574	1.092	1
HR	165	101	63	0	0
HU	616	499	60	58	0
IE	183	85	45	53	0
IT	5.291	1.728	1.849	853	861
LT	225	172	24	29	0
LU	55	30	11	14	0
LV	350	265	85	0	0
MT	2	0	2	0	0
NL	1.584	516	138	930	0
PL	1.513	1.282	196	34	1
PT	829	633	77	119	0
RO	166	155	11	0	0
SE	4.081	3.252	5	809	15
SI	73	48	24	0	1
SK	508	372	120	16	0
UK	6.681	3.615	2.230	836	0

Source: Eurostat

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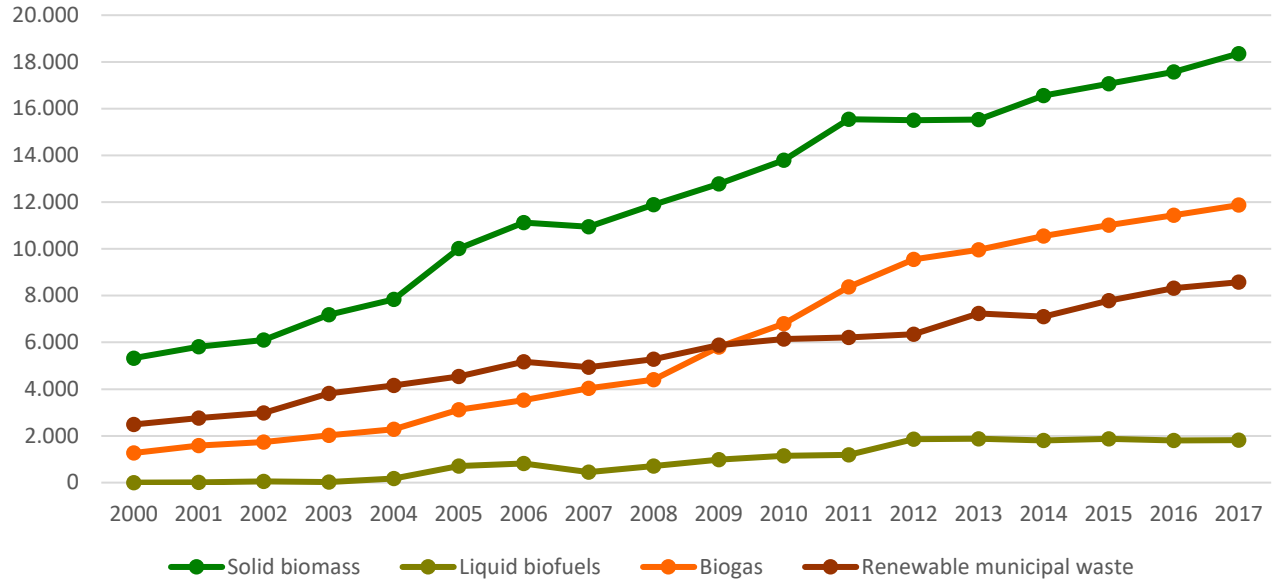
Figure 11 Evolution of electrical capacity from biomass plants by type in EU28 (MW)



Source: Eurostat

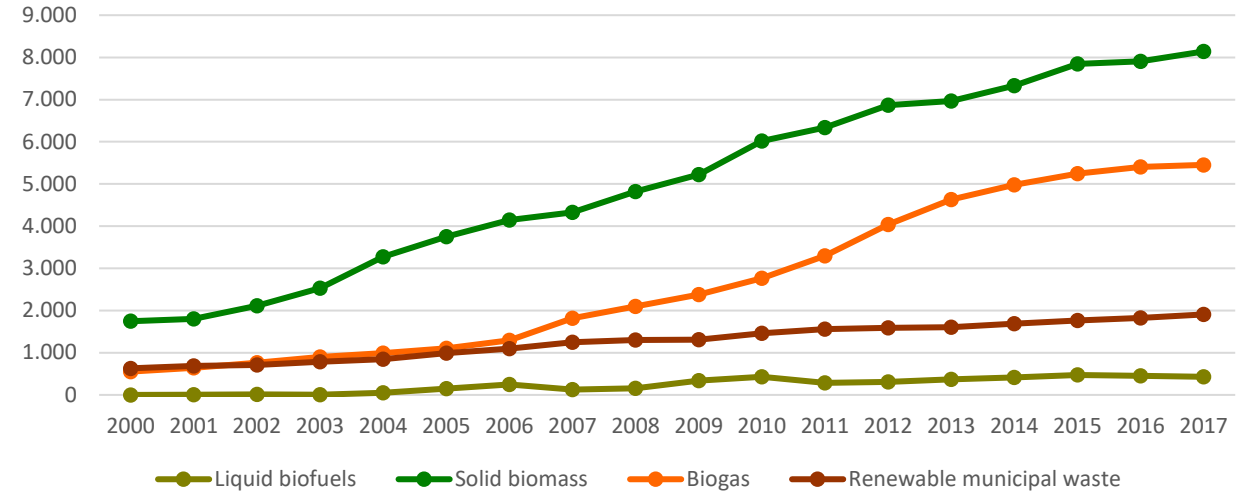
Bioelectricity has experienced a large increase over the last decade with particularly strong growth rates for biogas and solid biomass after the adoption of the first Renewable Energy Directive. The coming years will tell to what extent the recast of the Renewable Energy Directive will lead to similar results in terms of growth rates.

Table 8 Electrical capacity from biomass plants by type in EU28 Member States in 2017 (MW) with average EU load factor

	Total bioelectricity	Solid biomass	Biogas	Renewable municipal waste	Bioliquids
EU28	**40.624**	**18.359**	**11.874**	**8.575**	**1.817**
Growth rate (2016-2017)	3,8%	4,5%	3,8%	3,0%	1,1%
Average load factor	52,1%	58,9%	61,0%	29,5%	31,4%
AT	1.560	838	180	541	1
BE	1.036	559	183	249	46
BG	52	23	29	0	0
CY	10	n.a.	10	0	0
CZ	829	402	372	55	0
DE	10.007	1.600	6.169	2.008	230
DK	2.004	1.504	108	392	1
EE	386	165	11	210	0
EL	64	3	62	0	0
ES	1.144	677	225	242	0
FI	1.966	1.966	0	0	0
FR	2.075	808	386	877	4
HR	87	42	45	0	0
HU	482	356	80	46	0
IE	140	5	56	78	0
IT	3.859	684	1.372	816	987
LT	87	45	25	17	0
LU	44	15	12	17	0
LV	154	94	60	0	0
MT	5	n.a.	5	0	0
NL	1.122	252	221	649	0
PL	993	652	282	59	0
PT	623	471	70	82	0
RO	140	119	22	0	0
SE	5.389	3.706	2	1.134	547
SI	62	33	27	0	1
SK	252	149	91	12	0
UK	6.053	3.191	1.771	1.091	0

Source: Eurostat

Figure 12 Evolution of the gross electricity generation from biomass by type in the EU28 (ktoe)



Source: Eurostat

Table 9 Gross electricity generation from biomass in EU28 Member States in 2017 (ktoe) with growth rate

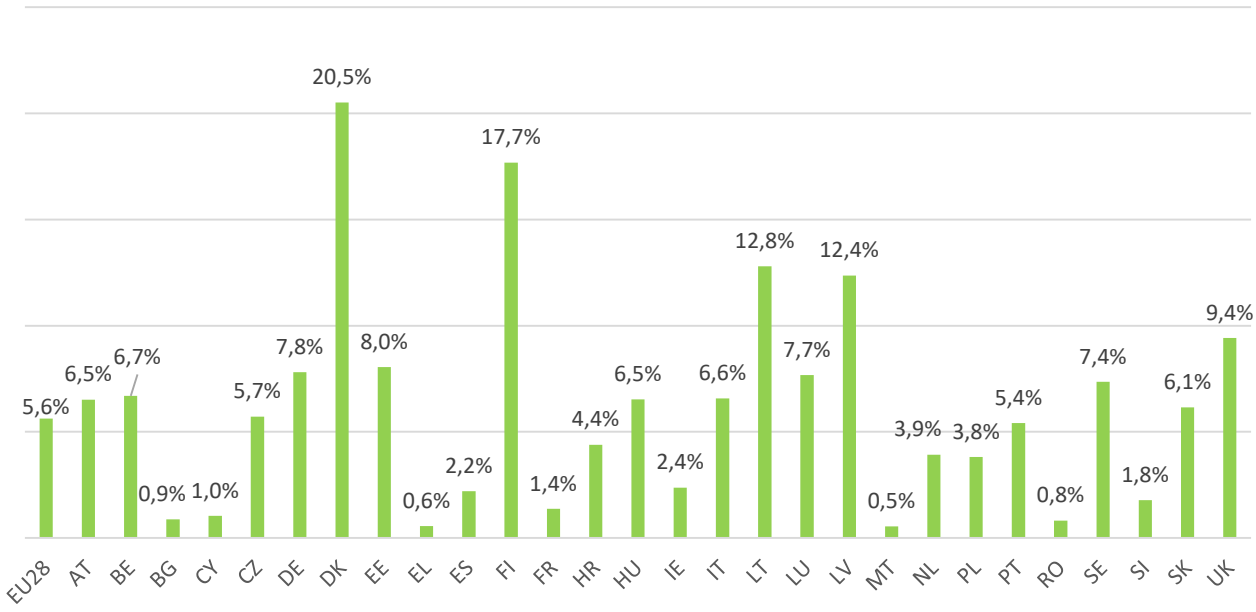
	Total bioelectricity	Growth rate (2016-2017)	Solid biomass	Biogas	Renewable municipal waste	Bioliquids
EU28	**15.929**	**2,2%**	**8.141**	**5.452**	**1.907**	**429**
Share (%)	100%	/	51,1%	34,2%	12,0%	2,7%
Growth rate (2016-2017)		/	3,0%	1,0%	4,6%	-5,8%
AT	399	-1,1%	317	54	27	0
BE	495	6,0%	328	81	84	3
BG	34	12,0%	15	19	0	0
CY	4	-0,5%	0	4	0	0
CZ	427	4,5%	190	227	10	0
DE	4.379	0,0%	916	2.913	512	38
DK	548	29,6%	413	59	76	0
EE	89	17,3%	86	4	0	0
EL	27	13,1%	1	26	0	0
ES	523	6,8%	375	81	66	0
FI	1.020	3,0%	936	35	48	1
FR	662	1,2%	287	180	194	0
HR	45	21,8%	19	27	0	0
HU	184	3,3%	142	29	14	0
IE	63	7,9%	33	17	13	0
IT	1.666	-0,7%	364	714	205	384
LT	43	14,6%	26	11	6	0
LU	15	22,4%	4	6	4	0
LV	80	13,0%	45	35	0	0
MT	1	17,2%	0	1	0	0
NL	395	-6,2%	152	79	164	0
PL	558	-18,5%	456	94	7	0
PT	277	4,9%	221	25	31	0
RO	45	-1,0%	39	6	0	0
SE	1.038	5,1%	881	1	153	3
SI	25	2,9%	13	11	0	0
SK	146	-2,0%	93	51	2	0
UK	2.740	6%	1.785	664	291	0

Source: Eurostat

The top 5 EU28 countries (Germany, United Kingdom, Italy, Finland and Sweden) in bioelectricity represent 68% of the total EU bioelectricity generation. These top 5, led by Germany (27,5%) and the United Kingdom (17,2%), have different approaches regarding bioelectricity. While in Germany and Italy the majority of bioelectricity is produced in a high number of small/medium size biogas plants, the UK has an alternative model with a limited number of large installations consuming woody biomass.

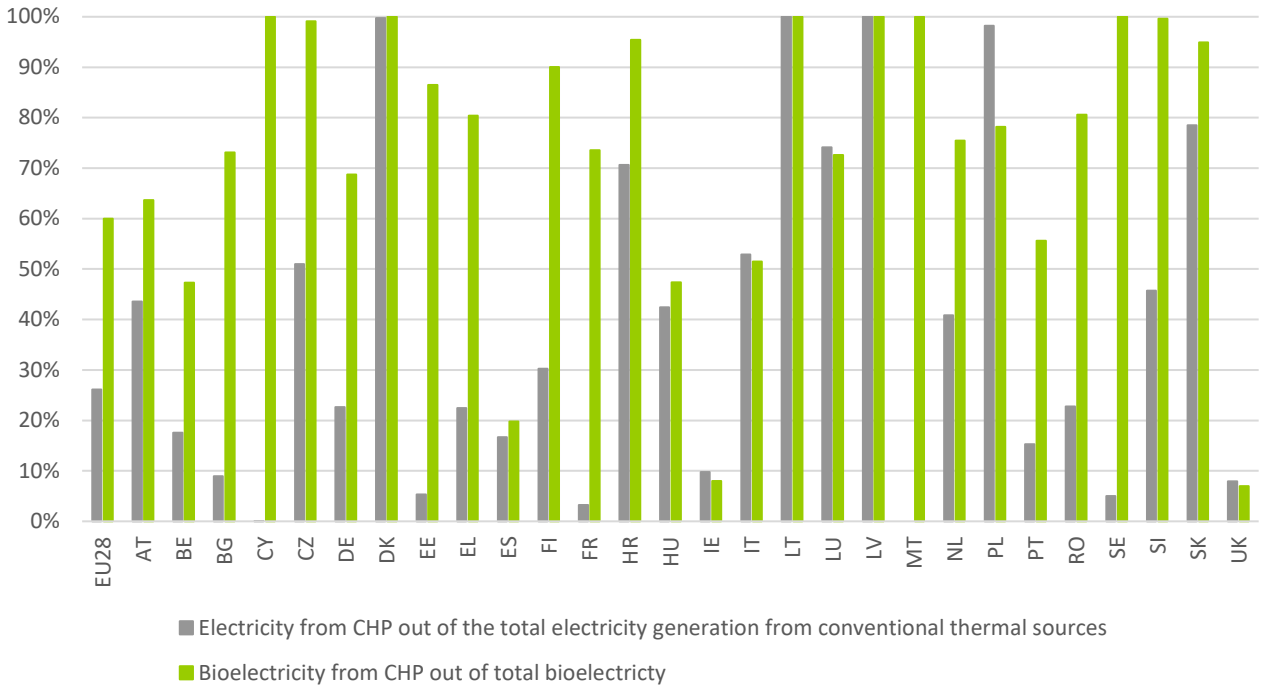
Poland reduced the production of bioelectricity by 18,5% between 2016-2017 due to the decrease of the electrical capacity for solid biomass (around 10%). Denmark shows the highest growth rate at nearly 30%, linked to the increment of around 472 MW of electrical capacity for solid biomass from 2016 to 2017 to convert coal CHP in solid biomass CHP.

Figure 13 Share of bioelectricity generation out of total gross electricity generation in EU28 Member States in 2017 (%)



Source: Eurostat

Figure 14 Share of gross electricity generation of conventional thermal power plants* produced from CHP and share of bioelectricity produced from CHP in 2017 in EU28 Member States (%)



* Conventional thermal power plants: plants producing electricity from gas, coal, petroleum products, nuclear and non-renewable waste.

Source: Eurostat

Most bioelectricity (60% in 2017) is generated in combined heat and power plants. This is the case for 22 of the 28 EU Member States. Only Belgium, Spain, Hungary, Ireland and the United Kingdom have less than 50% of their bioelectricity produced in CHP plants. On the other hand, six countries produce bioelectricity only in CHP plants.

While in 2017 only 26% of the electricity from conventional thermal sources was generated in CHP, this number reached 60% for bioelectricity. This is reflecting the synergies between renewable energies and energy efficiency and is a clear indicator of how bioenergy is a strong promoter of energy efficiency. Bioelectricity is mostly produced in efficient CHP plants, but it is also important to recognise the role of biopower-only installations in locations where heat is less, or not needed at all. In fact, the form of energy needed depends strongly on the local circumstances, suggesting that rigid top-down approaches should be avoided.

Table 10 Evolution of bioelectricity generation 2000-2017 in EU28 Member States (ktoe)

	Total bioelectricity			Bioelectricity from electricity only plants			Bioelectricity from CHP plants		
	2000	2010	2017	2000	2010	2017	2000	2010	2017
EU28	**2.929**	**10.668**	**15.929**	**1.179**	**4.142**	**6.379**	**1.750**	**6.526**	**9.550**
AT	131	384	399	37	167	145	95	216	254
BE	49	372	495	33	231	261	16	142	234
BG	0	3	34	0	0	9	0	3	25
CY	0	3	4	0	0	0	0	3	4
CZ	45	186	427	14	56	4	31	130	423
DE	372	2.950	4.379	372	1.012	1.371	0	1.937	3.009
DK	112	395	548	0	0	0	112	395	547
EE	1	64	89	0	20	12	1	44	77
EL	0	16	27	0	14	5	0	2	21
ES	128	345	523	70	232	419	58	113	104
FI	743	944	1.020	56	146	101	687	798	919
FR	213	382	662	88	197	175	125	185	487
HR	0	3	45	0	0	2	0	3	43
HU	6	197	184	0	170	97	6	28	87
IE	8	27	63	8	23	58	0	4	5
IT	120	812	1.666	64	532	808	56	280	858
LT	0	13	43	0	0	0	0	13	43
LU	2	7	15	2	2	4	0	5	11
LV	0	6	80	0	1	0	0	5	80
MT	0	0	1	0	0	0	0	0	1
NL	171	606	395	107	255	97	65	350	298
PL	19	542	558	3	21	122	16	521	436
PT	111	225	277	23	90	123	89	135	154
RO	0	10	45	0	4	9	0	5	36
SE	352	1.048	1.038	0	0	0	352	1.048	1.038
SI	6	19	25	0	1	0	6	18	25
SK	0	57	146	0	0	7	0	57	138
UK	338	1.054	2.740	304	969	2.549	35	86	191

Source: Eurostat

3. Annexes

Table 11 Country codes

EU28	European Union (28 members)
AT	Austria
BE	Belgium
BG	Bulgaria
CY	Cyprus
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
EL	Greece
ES	Spain
FI	Finland
FR	France
HR	Croatia
HU	Hungary
IE	Ireland
IT	Italy
LT	Lithuania
LU	Luxembourg
LV	Latvia
MT	Malta
NL	Netherlands
PL	Poland
PT	Portugal
RO	Romania
SE	Sweden
SI	Slovenia
SK	Slovak Republic
UK	United Kingdom

Table 12 Symbols and abbreviations

Symbol	Meaning
,	Decimal separator
.	Thousand
n.a.	Data not available

Table 13 Table decimal prefixes

10^{1}	**Deca (da)**	10^{-1}	**Deci (d)**
10^{2}	**Hecto (h)**	10^{-2}	**Centi (c)**
10^{3}	**Kilo (k)**	10^{-3}	**Milli (m)**
10^{6}	**Mega (M)**	10^{-6}	**Micro (μ)**
10^{9}	**Giga (G)**	10^{-9}	**Nano (n)**
10^{12}	**Tera (T)**	10^{-12}	**Pico (p)**
10^{15}	**Peta (P)**	10^{-15}	**Femto (f)**
10^{18}	**Exa (E)**	10^{-18}	**Atto (a)**

Table 14 Table general conversion factor for energy

to from	1 MJ	1kWh	1 kg oe	Mcal
1 MJ	1	0,278	0,024	0,239
1 kWh	3,6	1	0,086	0,86
1 kg oe	41,868	11,63	1	10
1 Mcal	4,187	1,163	0,1	1

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