

European Electricity Fuel Mix Summary

Full Year 2021

Generation and Contribution by Fuel Type

Renewables: 1,168TWh (+0.2%)

Fossil Fuels: 1,003TWh (+7%)

Nuclear: 783TWh (+10%)

Percentage changes are from the previous year

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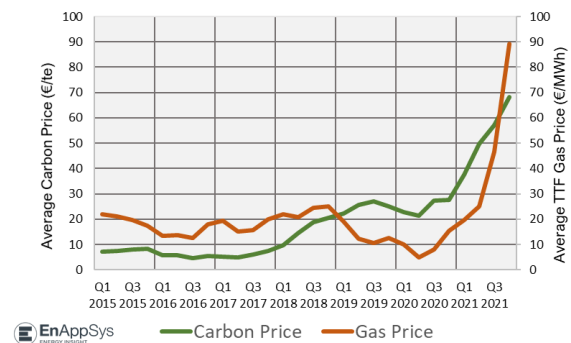
1 Executive Summary

Prices

Europe saw very high levels of wholesale prices driven by the gas prices breaking new records day after day from the early days of the third quarter and reaching the unprecedented level of €182.5/MWh by the end of the year. This was driven by European gas markets tightening with the increasing demand from Asia combined with the increased levels of willingness to pay and Nord-Stream 2 suspension. However, prices tipped down toward the end of the December with the large volumes of shale gas dispatched from USA.

Generation

In the meantime, there were significant volumes of gas-to-coal and gas-to-lignite switches in the countries with available installed capacity, such as Netherlands and Germany. Coal/lignite-fired output was 448TWh for 2021 compared with 383TWh for 2020. This had a compounding impact on the ETS prices, as the spread



between break-even ranges of gas and coal/lignite units reached over 200€/MWh at times. Just before the increasing wholesale prices, Spain removed the price cap of 100€/MWh (and the price floor as well), a decision unrelated to market circumstances, but with unprecedented price consequences.

Nuclear output recovered from 713TWh last year to 783TWh this year which was more in line with pre-2020 levels albeit still slightly lower, reflecting a declining trend from 813TWh (2015) to 792TWh (2019).

Although generation increased to higher levels of demand seen this year (following the recovery from Covid lockdowns), the proportion of renewables in the fuel mix did not match the historical trend. In the past, renewable generation has made up an increasing proportion of generation with each year. In 2021, however, the renewable proportion of the fuel mix (including biomass and waste) decreased from 41.4% to 39.5%. This was primarily a result of two factors. Due to extended periods of low wind speeds across Europe, wind generation was lower in 2021 than 2020 by 2% despite an increase in wind capacity. Consequently, total European coal/lignite generation increased by 17%, giving it a 15.2% proportion of the total fuel mix and marking the first time coal/lignite generation has increased year-on-year since 2017.

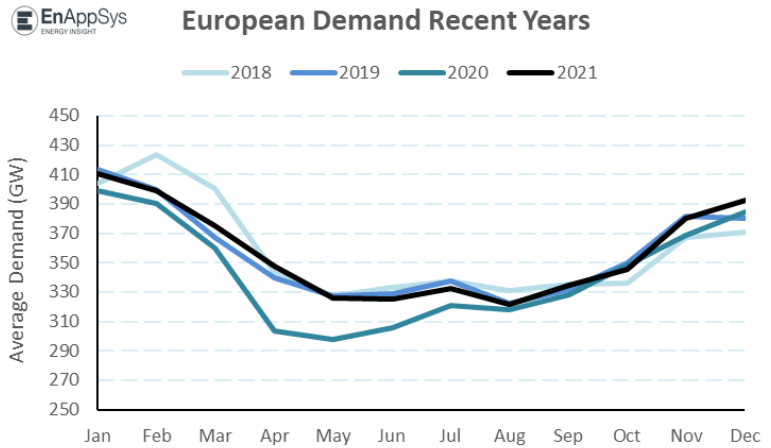
The proportion of the fuel mix occupied by fossil fuels therefore increased from 33.1% in 2020 to 33.8% in 2021, indicating that the stability brought about by the increase in demand to normal levels was offset by the decrease in wind generation and subsequent increase in dependence on fossil fuels

Demand

Following 2020, which saw a sharp decline in demand when the COVID-19 pandemic began, 2021 saw a return to levels of demand more closely aligned with those seen in 2019 and before. From 2020 to 2021 demand increased 4% to 3,131TWh, restoring demand to normal levels.

2 Demand

After the COVID-19 pandemic began in March 2020, demand was significantly affected in all European countries, with more restrictions generally resulting in reduced demand. The demand profile for 2020 is therefore lower after March but as restrictions were eased throughout the year, demand returned to more normal levels.



Continuing this trend, 2021 saw demand being restored to levels more in line with pre-2020 levels.

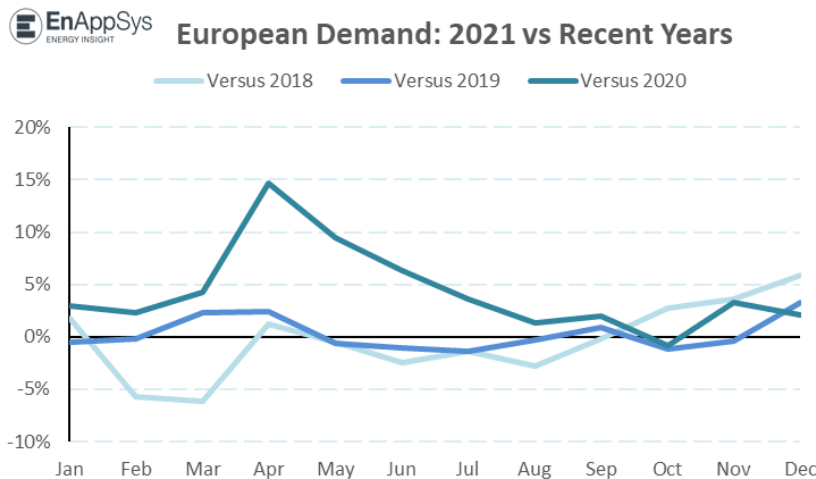
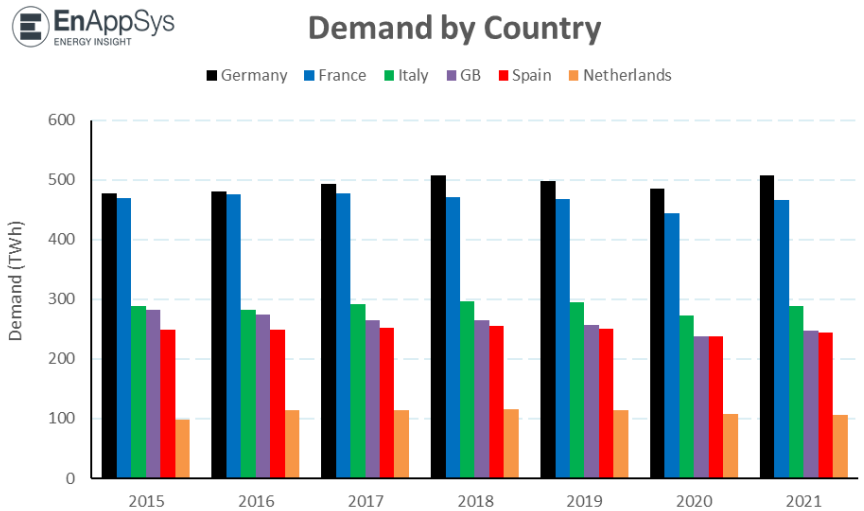


Figure 1: European Demand: 2021 vs Recent Years

The total demand of 3131TWh in 2021 was closer to the 3121TWh seen in 2019 than the 3018TWh seen in 2020. This is the first time that demand has increased year-on-year since 2017, but this increase is caveated by the fact that it is an increase from an abnormally low

level. The demand profiles for each year can be seen in figure 1.

With 507.5TWh, Germany had the highest demand of any European country which is in line with previous years. This is a 4% increase on the 486TWh in 2020 and a 2% increase from the 498TWh in 2019. Following Germany was France with 466TWh, Italy with 289TWh, GB with 247TWh and Spain with 243TWh.



Each of these countries saw increases in their demands in 2021 compared to that of 2020, indicating that the demand patterns generally returned to normal across Europe in the absence of such strict lockdown restrictions as were seen in 2020.

Figure 2: Demand by country for a selection of the countries with highest demand

3 Fuel Activity Overview

Europe Totals

Total generation levels for 2021 across Europe were 2,954TWh representing an increase of 5% compared with the 2814TWh seen in 2020 and an increase of 1% compared to 2019 levels.

Renewable generation (including biomass and waste) contributed 1,168TWh to the total generation for 2021 (39.5%), continuing the trend of renewables contributing more to the generation mix than fossil fuels which began in 2018. This renewable total is very close to the 1,165TWh seen in 2020, despite a reduction in wind generation. There were extended periods in the summer of 2021 in which wind generation was low across

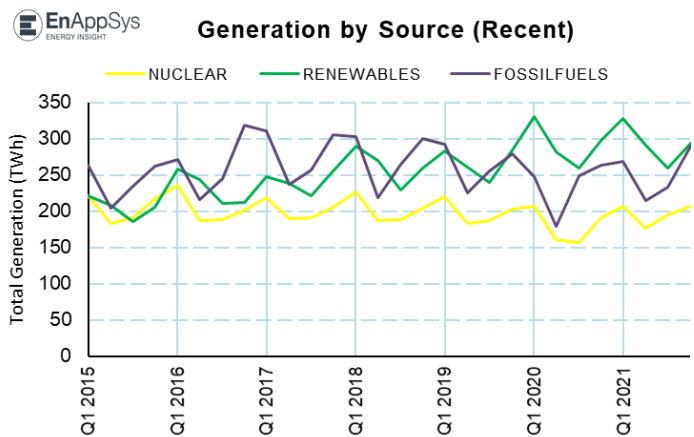


Figure 3: Generation by source for recent years (aggregated by category)

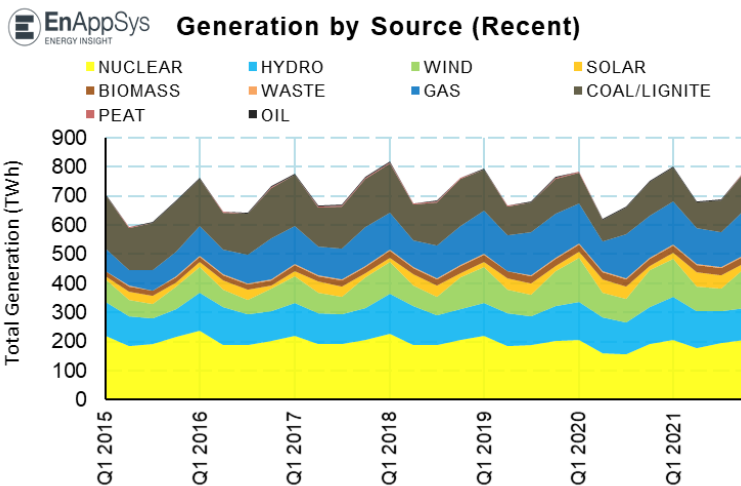


Figure 4: Generation by source for recent years (stacked)

In order to meet an increased demand with similar renewable generation to 2020, fossil fuel generation increased from 9366TWh in 2020 (33.8% of the fuel mix) to 1003TWh in 2021 (33.2%). This increase was primarily the result of a dramatic rise in coal/lignite generation. Since 2017, coal/lignite generation has decreased every year by an average of 80TWh, but this year saw an increase of 65TWh from 383TWh in 2020 to 448TWh in 2021. This is the largest year-on-year increase in coal/lignite generation in our data set back to 2015, giving it a larger proportion of the total fuel mix than wind generation. However, compared to the 464TWh in 2019, before the impact of COVID-19 on demand and generation, this is a 3% (15TWh) reduction.

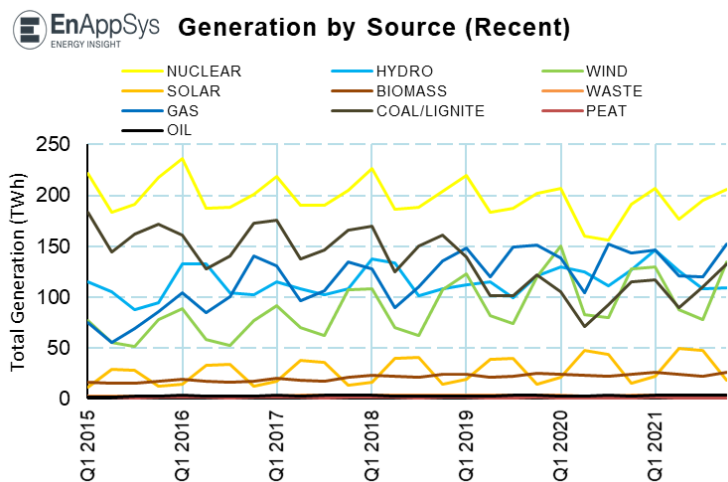


Figure 5: Generation by source for recent years

Gas generation, on the other hand, saw only a minor increase from 537TWh to 537TWh despite the lack of renewables in the fuel mix – this reflected the increased use of coal/lignite displacing gas-fired generation. Despite the increase in coal/lignite-fired generation, it was not enough to displace gas-fired as the second largest contributor to total generation.

Nuclear has consistently had the largest proportion of the fuel mix of any generation source and the same was true in 2021. In 2020 the nuclear fleet generated 713TWh across Europe (25.3%), but in 2021 this rose to 783TWh (26.5%). This is 245TWh more than the gas fleet, which saw 537TWh

Europe, resulting in a decrease in year-on-year wind generation from 439TWh in 2020 to 428TWh in 2021 despite the continual underlying increase of wind capacity. 2021 marked the first year in our data set back to 2015 that wind has decreased from the previous year. An increase in solar generation was the largest factor in offsetting this reduction in wind, as solar generation increased from 128TWh in 2020 to 138TWh in 2021.

(18.2%) in 2021. Hydro came third with 488TWh (16.5%) and coal/lignite came fourth with 448TWh (15.2%).

Statistics

The following tables set out key statistics relating to generation this year and the six previous years:

	2015	2016	2017	2018	2019	2020	2021
TOTAL GENERATION BY FUEL (TWh)							
Biomass	64.7	69.8	78.4	92.0	92.7	94.0	98.4
Coal/Lignite	660.9	601.3	625.0	605.8	463.5	383.4	448.2
Gas	285.5	428.5	467.2	462.9	569.5	536.7	537.4
Hydro	402.3	470.6	434.9	480.9	447.4	491.2	488.0
Nuclear	813.1	810.5	803.8	805.8	792.2	712.8	782.7
Oil	9.3	11.9	13.3	11.9	12.5	12.2	13.3
Peat	6.2	6.4	5.3	6.1	5.7	3.4	4.1
Solar	80.4	94.0	104.7	111.2	113.1	127.6	137.8
Waste	9.6	10.8	13.9	14.9	14.7	13.4	15.5
Wind	262.4	275.7	331.1	349.0	399.8	439.1	428.3
FOSSIL FUELS	962.0	1048.1	1110.7	1086.7	1051.2	935.7	1003.0
NUCLEAR	813.1	810.5	803.8	805.8	792.2	712.8	782.7
RENEWABLE (INCLUDES WASTE)	819.4	921.0	963.1	1048.0	1067.7	1165.4	1168.0
TOTAL	2594.5	2779.7	2877.6	2940.5	2911.0	2813.9	2953.8

Fossil Fuel Percentage	37%	38%	39%	37%	36%	33%	34%
Clean Percentage	63%	62%	61%	63%	64%	67%	66%
Renewable Share of Clean Power	50%	53%	55%	57%	57%	62%	60%

SHARE OF GENERATION (%)

Biomass	2.5%	2.5%	2.7%	3.1%	3.2%	3.3%	3.3%
Coal/Lignite	25.5%	21.6%	21.7%	20.6%	15.9%	13.6%	15.2%
Gas	11.0%	15.4%	16.2%	15.7%	19.6%	19.1%	18.2%
Hydro	15.5%	16.9%	15.1%	16.4%	15.4%	17.5%	16.5%
Nuclear	31.3%	29.2%	27.9%	27.4%	27.2%	25.3%	26.5%
Oil	0.4%	0.4%	0.5%	0.4%	0.4%	0.4%	0.5%
Peat	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%
Solar	3.1%	3.4%	3.6%	3.8%	3.9%	4.5%	4.7%
Waste	0.4%	0.4%	0.5%	0.5%	0.5%	0.5%	0.5%
Wind	10.1%	9.9%	11.5%	11.9%	13.7%	15.6%	14.5%
FOSSIL FUELS	36.8%	37.5%	38.4%	36.8%	35.9%	33.1%	33.8%
NUCLEAR	31.3%	29.2%	27.9%	27.4%	27.2%	25.3%	26.5%
RENEWABLE (INCLUDES WASTE)	31.6%	33.1%	33.5%	35.6%	36.7%	41.4%	39.5%

	2015	2016	2017	2018	2019	2020	2021
TOTAL GENERATION BY FUEL (TWh)							
Biomass	64.7	69.8	78.4	92.0	92.7	94.0	98.4
Coal/Lignite	660.9	601.3	625.0	605.8	463.5	383.4	448.2
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TOTAL	2594.5	2779.7	2877.6	2940.5	2911.0	2813.9	2953.8

Fossil Fuel Percentage	37%	38%	39%	37%	36%	33%	34%
Clean Percentage	63%	62%	61%	63%	64%	67%	66%
Renewable Share of Clean Power	50%	53%	55%	57%	57%	62%	60%

CHANGE SINCE 2015 (%)

Biomass	8%	21%	42%	43%	45%	52%
Coal/Lignite	-9%	-5%	-8%	-30%	-42%	-32%
Gas	50%	64%	62%	99%	88%	88%
Hydro	17%	8%	20%	11%	22%	21%
Nuclear	0%	-1%	-1%	-3%	-12%	-4%
Oil	28%	42%	27%	34%	31%	43%
Peat	3%	-15%	-2%	-9%	-45%	-35%
Solar	17%	30%	38%	41%	59%	71%
Waste	13%	45%	56%	53%	40%	62%
Wind	5%	26%	33%	52%	67%	63%
FOSSIL FUELS	9%	15%	13%	9%	-3%	4%
NUCLEAR	0%	-1%	-1%	-3%	-12%	-4%
RENEWABLE (INCLUDES WASTE)	12%	18%	28%	30%	42%	43%

4 Renewables

Europe saw a collective 1,168TWh of renewable generation in 2021, representing 39.5% of the overall fuel mix. This was a minor increase on the 1,165TWh of renewable generation in 2020 despite a reduction in wind generation.

Renewable Generation by Source (Recent)

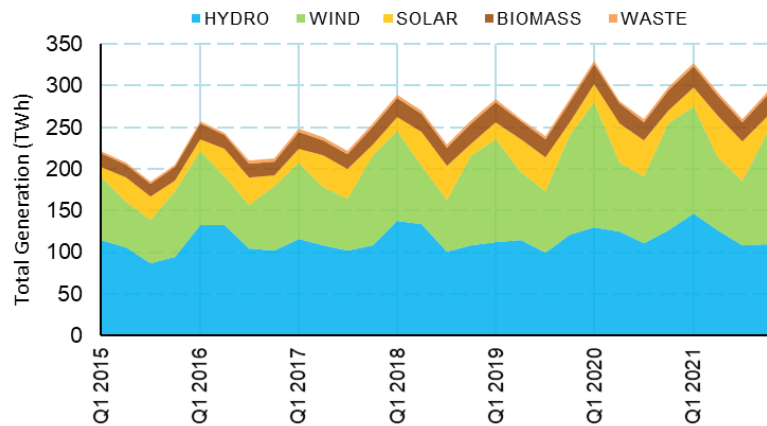
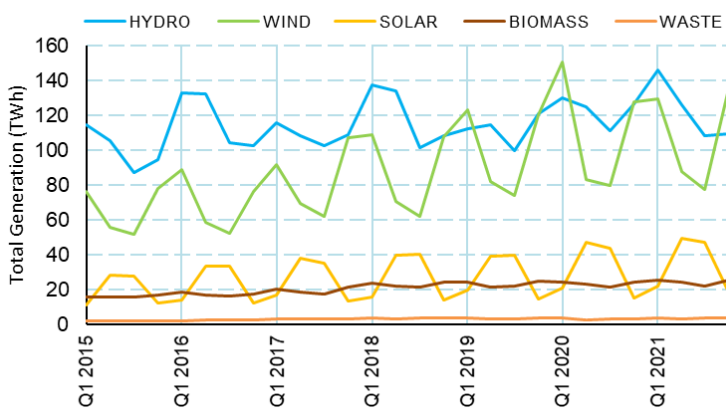


Figure 6: Renewable generation by source for recent years (stacked)

Generation by Source (Recent)



Hydro (including reservoir and river) remains the largest contributor to renewable generation with a total of 488TWh, representing 41.8% of the total renewable generation. This is, however, a minor decrease of less than 1% from the 491TWh seen in 2020.

Figure 7: Renewable generation by source for recent years

Solar and waste, on the other hand, saw increases from their respective generation levels in 2020, with solar increasing from 128TWh (11.0% of total renewables) to 138TWh (11.8%) and waste increasing from 13TWh (1.2%) to 16TWh (1.3%) from 2020 to 2021. Biomass also increased its generation from 2020 to 2021, as it has done consistently for every year in our data-set back to 2015.

River Hydro Generation by Country: 5 Highest this Year

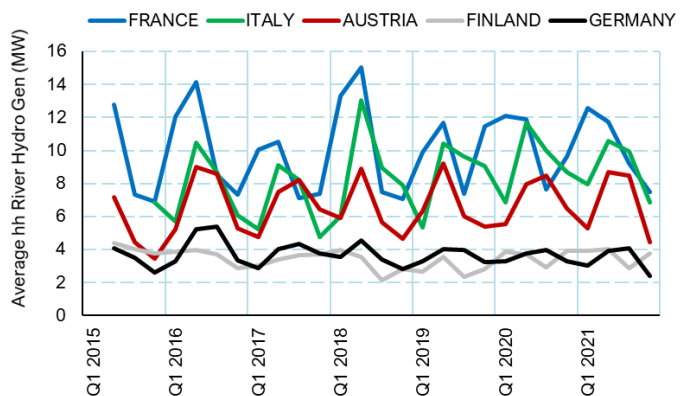


Figure 8: River (hydro) generation for the top 5 generating countries this year

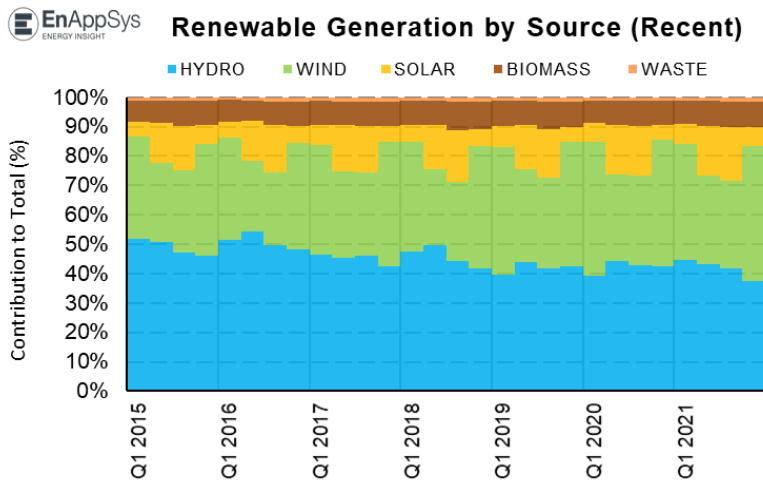


Figure 9: Renewable generation by source (as a percentage of total renewables)

In 2020, biomass generated 94TWh (8.1%) but in 2021 this increased to 98TWh (8.4%). These increases helped retain renewable generation at around the same level as in 2020 despite a reduction in wind and hydro generation. Wind generation decreased from 439TWh (37.7%) in 2020 to 428TWh (36.7%) in 2021. This was the largest year-on-year difference of any

renewable generation source and the largest decrease in any generation source overall.

In line with historical precedent, Germany had the highest wind generation of any European country with 114TWh. GB had the second highest with 62TWh and Spain followed with 59TWh. France, meanwhile, had the most hydro (river) generation with 41TWh which also follows the pattern of previous years. Italy and Austria had the second and third highest hydro (river) generation this year with 35TWh and 26TWh, respectively. Norway and Sweden were again the only countries to have a notable hydro (reservoir) generation, with 31TWh and 20TWh, respectively.

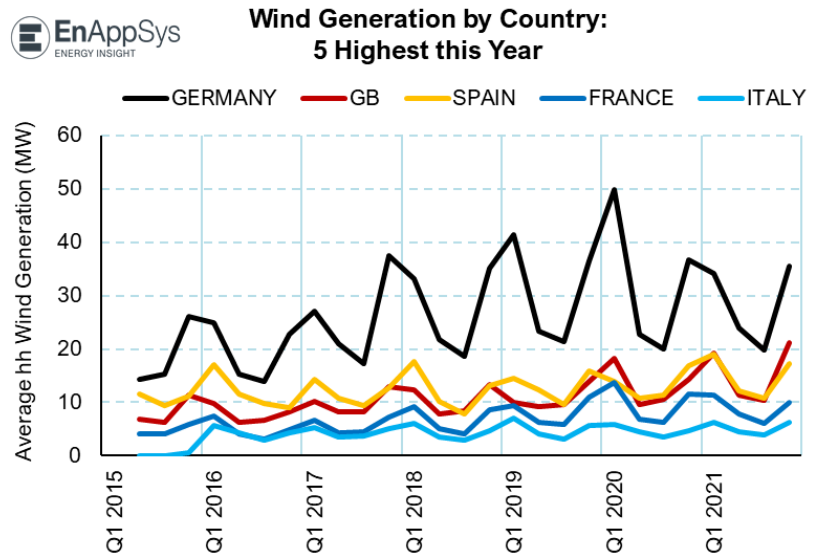


Figure 10: Wind generation for the top 5 generating countries this year

Statistics

The following tables contain some of the key statistics relating to renewable electricity output during the year and the six previous years:

	2015	2016	2017	2018	2019	2020	2021
TOTAL GENERATION BY FUEL (TWh)							
Biomass	64.7	69.8	78.4	92.0	92.7	94.0	98.4
Hydro	402.3	470.6	434.9	480.9	447.4	491.2	488.0
Solar	80.4	94.0	104.7	111.2	113.1	127.6	137.8
Waste	9.6	10.8	13.9	14.9	14.7	13.4	15.5
Wind	262.4	275.7	331.1	349.0	399.8	439.1	428.3
TOTAL	819.4	921.0	963.1	1048.0	1067.7	1165.4	1168.0
Primary Renewable Source	HYDRO	HYDRO	HYDRO	HYDRO	HYDRO	HYDRO	HYDRO
SHARE OF RENEWABLES (%)							
Biomass	7.9%	7.6%	8.1%	8.8%	8.7%	8.1%	8.4%
Hydro	49.1%	51.1%	45.2%	45.9%	41.9%	42.1%	41.8%
Solar	9.8%	10.2%	10.9%	10.6%	10.6%	11.0%	11.8%
Waste	1.2%	1.2%	1.4%	1.4%	1.4%	1.2%	1.3%
Wind	32.0%	29.9%	34.4%	33.3%	37.4%	37.7%	36.7%
CHANGE SINCE 2015 (%)							
Biomass		8%	21%	42%	43%	45%	52%
Hydro		17%	8%	20%	11%	22%	21%
Solar		17%	30%	38%	41%	59%	71%
Waste		13%	45%	56%	53%	40%	62%
Wind		5%	26%	33%	52%	67%	63%

5 Notes on the Report

The figures used in the report refer to data provided through ENTSO-E which have been aggregated by EnAppSys into a European total. This data does sometimes suffer from outages or gaps in reporting but is considered to be generally complete. This report is based on the most recently available data as at quarter and year ends.

Included Countries

Albania	Germany	Norway
Austria	Great Britain	Poland
Belgium	Greece	Portugal
Bosnia & Herzegovina	Hungary	Romania
Bulgaria	I-SEM	Serbia
Croatia	Italy	Slovakia
Czech Republic	Latvia	Slovenia
Denmark	Lithuania	Spain
Estonia	Montenegro	Sweden
Finland	Netherlands	Switzerland
France	North Macedonia	

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