

European Electricity Fuel Mix Summary

Q2-2021

April to June

Generation and Contribution by Fuel Type

Renewables: 287.5TWh (-10%)

Fossil Fuels: 207.2TWh (-20%)

Nuclear: 172.4TWh (-16%)

Percentage changes are from the previous quarter

Contents

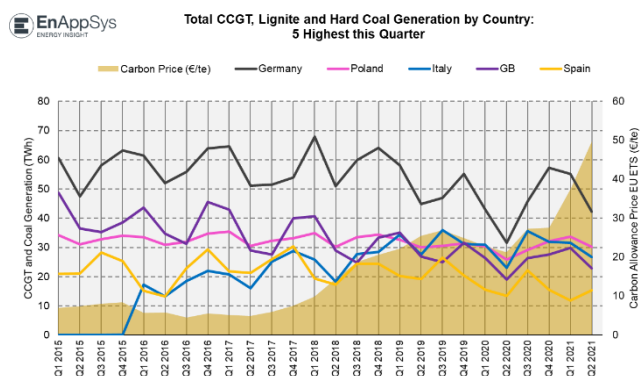
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1 Executive Summary

Impact of Corona on the European demand can finally be declared as completely ended with this quarter, as there is only 0.4% difference from Q2 2019. Germany with 119.7TWh (corresponding to 17% of the total European demand) takes the first place from France in the high demand ranking as usual in the second quarters, with the decreased heating demand of France.

From previous quarter to this quarter, generation levels decreased by 15% across Europe which meant a reduction in the output levels of the most of the fuels, but solar and oil. On the other hand, compared to the past second quarters, all of the renewable generation types saw the highest generation levels, besides hydro (river + reservoir). This is thanks to increasing renewable installed capacities across Europe.

Renewable generation (including biomass and waste) contributed 43% of this total continuing the trend of renewables being the largest share of the generation mix that began in Q4 2019. Hydro generation remained to be the largest individual component of renewable generation with a difference of 39TWh from the second largest renewable generation component, wind at 86TWh. Nuclear contributed 26%, gas 17% and coal/lignite 13%.



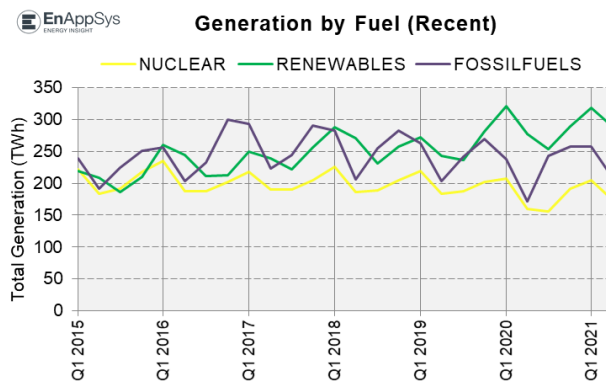
Fossil fuel generation was 20% down from the previous quarter, yet still at highs of 207TWh, despite the coal phase-out efforts and more than the doubled Carbon allowance price in comparison to Q2 2020. In Q2 2021, lignite generation was 43.1TWh, 12TWh higher than hard coal output, as in most of the countries lignite can still be used as baseload.

There is an increasing trend of CCGT generation (10%), as the need for flexible generation increases with the further renewable penetration and due to the generation gap with the phasing out conventionals. The decrease in the carbon allowance cost embedded generation types is mostly driven by the phase-outs, rather than the increasing Carbon allowance prices. EU ETS has seen the record of 56.54€/te on the last day of Q2 2021, which made up ~30% of the breakeven cost of an average coal power plant on that day.

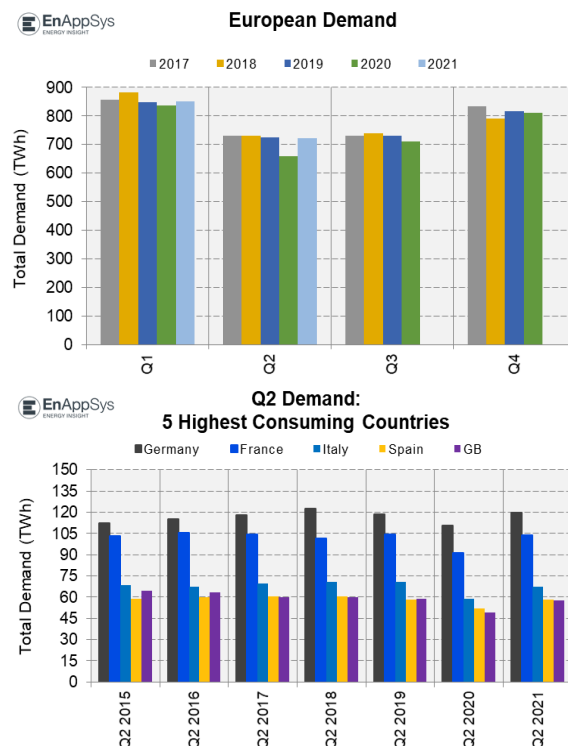
2 Fuel Activity Overview

Europe Totals

Renewable (including biomass and waste) dominance in the European fuel mix since the 4th quarter of 2019 has continued in this quarter as well and its share remained over 40%. This can be seen in the chart on the right, which presents total generation by the grouped categories of renewables, fossil fuels, and nuclear.



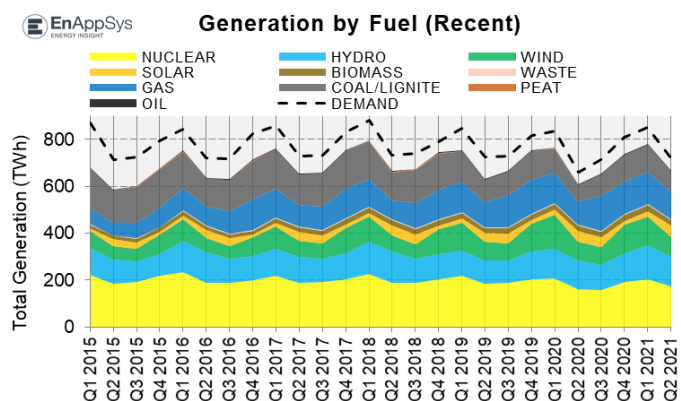
In total, 288TWh was generated by renewables, down 10% from the 319TWh in Q1 of 2021, but up 4% from the 277TWh in Q2 of 2020. The 288TWh of renewables contributed 43.1% of total generation, followed by 207TWh of fossil fuel-fired generation (30.9% contribution) and 172.4TWh of nuclear generation (25.8% contribution).



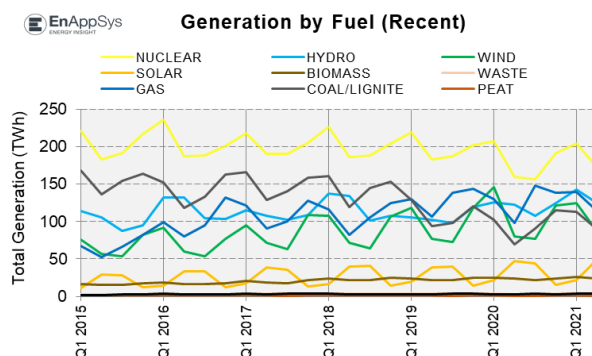
As can be seen from the European Demand chart, the recovery of the demand from the Covid-19 impact is the most visible between Q2 comparisons. **There is about 10% increase in the demand compared to 2020 Q2, yet an a slight decrease in comparison to the earlier second quarters.** 58TWh decrease in the demand (compared to 2020 Q2) might be partially caused by the increased embedded solar generators which has already shown a profound impact on the demand curves across Europe in the past months. Each of the five European countries with the highest demands shows increases in their demands, most significantly by Germany and France as they have the highest demand levels as well.

Fossil fuel generation decreased by 19.6% from the previous quarter, on the other hand increased by 20% in comparison to the previous Q2. Such a significant increase can be explained by the overall demand increase with the Covid-19 recovery. However, there is a usual drop in the fossil fuel consumption in the transitions from Q1 to Q2, as electricity demand for heating decreases. 19.6% drop of this year is the lowest ratio which has been recorded since 2015 with the highest drop being 27.6% recorded between Q1 and Q2 of 2020, which was mostly powered by the Corona measures. The nuclear fleet saw 16% less generation in comparison to the last quarter, yet 8% increase compared to Q2 of 2020. Total generation levels were down across Europe, versus Q1 levels, as summer decreased the demand across the continent. The Q2 total was 667.1TWh, down 15% from the 781TWh in Q1 of 2021.

When individual technology types, rather than groupings (i.e. renewable and fossil fuel), are considered, **all the fuels saw various levels of decrease, besides solar and oil. Nuclear consistently has the largest generation of any single fuel type. This remains true this quarter, in addition to the new second place**



holder hydro which replaced the place of gas in the past quarter. Nuclear generation of Europe was 172TWh being 47TWh higher than the 125TWh of hydro, the second highest individual fuel type which is closely followed by the gas fuelled generation at 114TWh. Whereas nuclear is consistently the highest contributor because of its high installed capacity and consistent operation, the second highest is more variable over time. Third place can be challenged by the wind generation in the next years as more countries adopt offshore installations.



Gas-fired generation had a significant increase of 16% in comparison to the last year's Q2, whereas hydro generation seeing only 2% increase. Nevertheless, it was not enough for gas generation to the second place after nuclear. **The lowest coal generation of 2000s was recorded this quarter, which was**

caused by the coal phase-outs and increasing Carbon allowance prices.

Despite generating only 3.4TWh this quarter, oil generation has increased by 1% from the last quarter on the contrary to the most of the other fuel types. Interestingly there is a 17% increase compared to the Q2 of 2019, which did not have particularly specific condition. Ireland seems to be the only country which has noticeably increased its oil based electricity generation. After a cloudy and cold first quarter, solar generation increased by 124% across Europe, reaching to highest solar generation level in a quarter recorded with 48.8TWh. In addition to the high solar availability and longer day time, there is also a significant contribution of steadily increasing solar capacity.

Statistics

The following tables set out key statistics relating to generation in the quarter:

	Q2 2019	Q3 2019	Q4 2019	Q1 2020	Q2 2020	Q3 2020	Q4 2020	Q1 2021	Q2 2021
TOTAL GENERATION BY FUEL (TWh)									
Biomass	21.4	22.0	25.0	24.5	23.5	21.9	24.4	25.6	23.8
Coal/Lignite	93.7	97.9	120.7	102.9	70.0	91.2	114.9	113.0	89.2
Gas	106.3	139.0	143.7	130.5	98.2	147.8	138.9	139.9	113.8
Hydro	102.4	98.0	119.9	125.9	122.9	108.2	124.8	143.3	125.1
Nuclear	183.1	187.4	202.5	207.2	160.1	156.0	191.4	204.6	172.4
Oil	2.9	3.6	3.4	3.0	3.1	3.3	2.8	3.4	3.4
Peat	1.1	1.0	1.7	1.2	0.7	0.4	1.1	1.4	0.8
Solar	39.0	39.8	14.6	21.3	47.3	43.9	15.5	21.8	48.8
Waste	3.3	3.6	4.0	3.8	3.0	3.2	3.5	3.7	3.6
Wind	76.8	72.6	118.0	146.1	80.2	76.9	121.6	124.5	86.2
FOSSIL FUELS	204.0	241.5	269.5	237.7	172.0	242.7	257.7	257.7	207.2
NUCLEAR	183.1	187.4	202.5	207.2	160.1	156.0	191.4	204.6	172.4
RENEWABLE (INCLUDES WASTE)	243.0	236.1	281.4	321.5	276.9	254.1	289.8	318.9	287.5
TOTAL	630.1	664.9	753.5	766.4	609.0	652.8	738.8	781.1	667.1

Fossil Fuel Percentage	32%	36%	36%	31%	28%	37%	35%	33%	31%
Clean Percentage	68%	64%	64%	69%	72%	63%	65%	67%	69%
Renewable Share of Clean Power	57%	56%	58%	61%	63%	62%	60%	61%	63%

SHARE OF GENERATION (%)									
Biomass	3.4%	3.3%	3.3%	3.2%	3.9%	3.3%	3.3%	3.3%	3.6%
Coal/Lignite	14.9%	14.7%	16.0%	13.4%	11.5%	14.0%	15.5%	14.5%	13.4%
Gas	16.9%	20.9%	19.1%	17.0%	16.1%	22.6%	18.8%	17.9%	17.1%
Hydro	16.2%	14.7%	15.9%	16.4%	20.2%	16.6%	16.9%	18.3%	18.8%
Nuclear	29.1%	28.2%	26.9%	27.0%	26.3%	23.9%	25.9%	26.2%	25.8%
Oil	0.5%	0.5%	0.5%	0.4%	0.5%	0.5%	0.4%	0.4%	0.5%
Peat	0.2%	0.1%	0.2%	0.2%	0.1%	0.1%	0.1%	0.2%	0.1%
Solar	6.2%	6.0%	1.9%	2.8%	7.8%	6.7%	2.1%	2.8%	7.3%
Waste	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Wind	12.2%	10.9%	15.7%	19.1%	13.2%	11.8%	16.5%	15.9%	12.9%
FOSSIL FUELS	32.2%	36.2%	35.6%	30.9%	28.1%	37.1%	34.7%	32.8%	30.9%
NUCLEAR	29.1%	28.2%	26.9%	27.0%	26.3%	23.9%	25.9%	26.2%	25.8%
RENEWABLE (INCLUDES WASTE)	38.6%	35.5%	37.4%	42.0%	45.5%	38.9%	39.2%	40.8%	43.1%

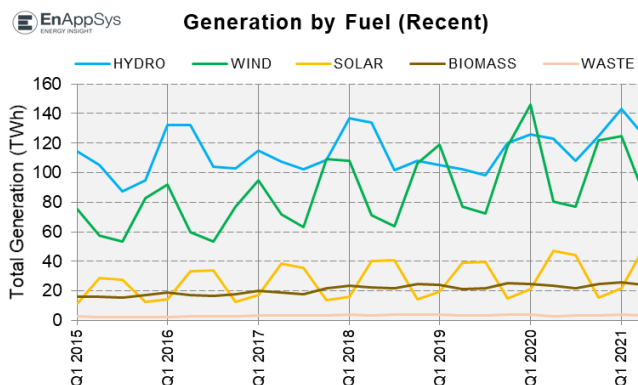
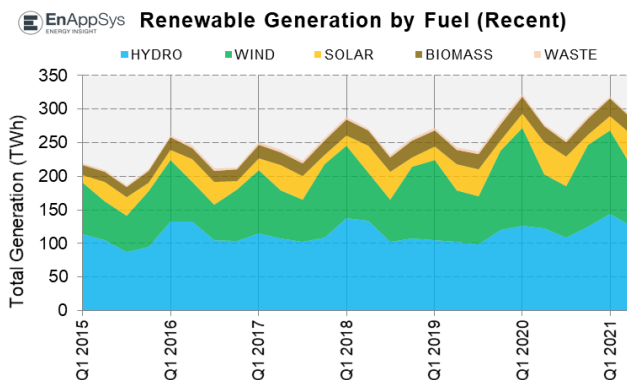
	Q2 2016	Q2 2017	Q2 2018	Q2 2019	Q2 2020	Q2 2021
TOTAL GENERATION BY FUEL (TWh)						
Biomass		16.9	18.6	22.2	21.4	23.5
Coal/Lignite		118.5	129.0	119.4	93.7	70.0
Gas		80.5	90.3	82.6	106.3	98.2
Hydro		132.3	107.3	133.9	102.4	122.9
Nuclear		187.5	190.1	186.7	183.1	160.1
Oil		2.6	2.8	3.0	2.9	3.1
Peat		1.3	1.4	1.4	1.1	0.7
Solar		33.4	38.4	40.1	39.0	47.3
Waste		2.5	3.5	3.4	3.3	3.0
Wind		59.7	71.6	71.5	76.8	80.2
FOSSIL FUELS		202.9	223.5	206.4	204.0	172.0
NUCLEAR		187.5	190.1	186.7	183.1	160.1
RENEWABLE (INCLUDES WASTE)		244.9	239.3	271.1	243.0	276.9
TOTAL		635.3	652.9	664.3	630.1	609.0

Fossil Fuel Percentage		32%	34%	31%	32%	28%
Clean Percentage		68%	66%	69%	68%	72%
Renewable Share of Clean Power		57%	56%	59%	57%	63%

CHANGE SINCE Q2 2016 (%)						
Biomass		10%	31%	27%	39%	40%
Coal/Lignite		9%	1%	-21%	-41%	-25%
Gas		12%	3%	32%	22%	41%
Hydro		-19%	1%	-23%	-7%	-5%
Nuclear		1%	0%	-2%	-15%	-8%
Oil		7%	13%	11%	16%	29%
Peat		4%	5%	-15%	-48%	-39%
Solar		15%	20%	17%	42%	46%
Waste		37%	35%	31%	19%	40%
Wind		20%	20%	29%	34%	44%
FOSSIL FUELS		10%	2%	1%	-15%	2%
NUCLEAR		1%	0%	-2%	-15%	-8%
RENEWABLE (INCLUDES WASTE)		-2%	11%	-1%	13%	17%

3 Renewables

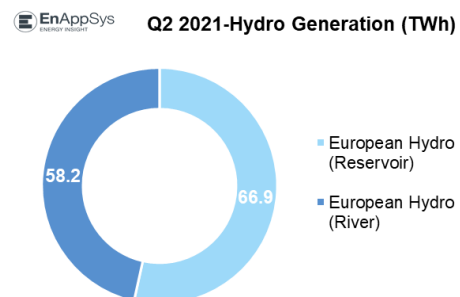
Across Europe as a whole, Q2 2021 saw 288TWh of power production from renewable sources, amounting to 43% of total European electricity generation. This is a decrease of 10% from the 319TWh in Q1 2021, as besides solar the output from all the other generation types decreased between 7% to 31%. On the other hand, all the renewable generation types saw increase from Q2 2020.

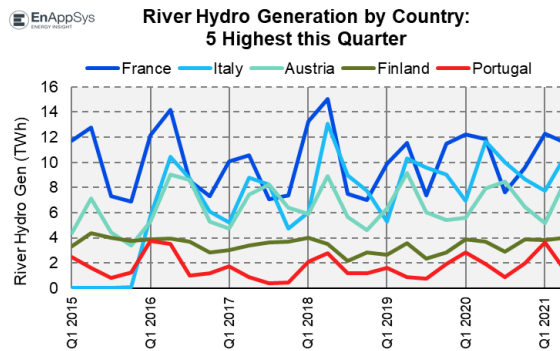


Hydro (reservoir + river) generation remained to be the largest individual component of renewable generation with a difference of 39TWh from the second largest renewable generation component, wind at 86TWh. Despite the fact that almost all the renewable generation types saw a decrease from the previous quarter, in comparison to Q2

2020 all the generation types saw increases with solar having the largest development with 18%. The rule of thumb for relatively low wind generation in the second quarters hold true this year as well, despite the increase in the capacity.

This quarter, Hydro (reservoir + river) reached the highest generation levels above 125TWh again in the second quarter after 3 years with moderate to dry second quarters. In comparison to the first quarter, river hydro generated 10% more reaching to 58.2TWh, whereas reservoir hydro generation significantly decreased by 26%. In comparison to the previous Q2, European reservoir hydro generation almost remained same, whereas the river hydro generation increased by 5%.

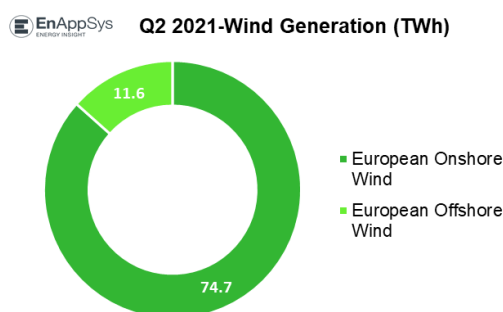
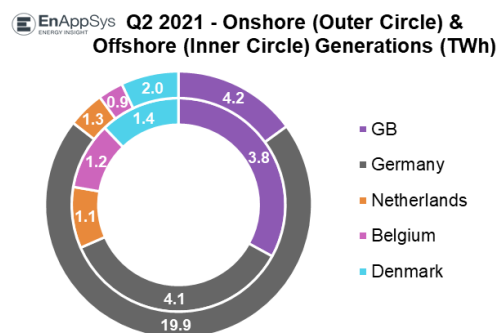




The ranking of the countries at top 3 which produce the largest run-of-river- and reservoir-based generation did not change this quarter either: Norway, Sweden and France, whereas the fourth and fifth places are usually taken by either Italy, Spain or Austria. As Norway and Sweden having the largest reservoirs, the total ranking is usually set by the output of the river

hydro generation. Interestingly, river hydro generation trends from Q1 to Q2 differ between the countries. France and Portugal saw decreases, whereas the output of Italy, Austria and Finland increased. Increase in the river hydro generation of Italy this quarter, brought it to the fourth place among the largest run-of-river- and reservoir-based generators, whereas Austria moved from sixth to fifth place, pushing Spain out of the top 5 ranking.

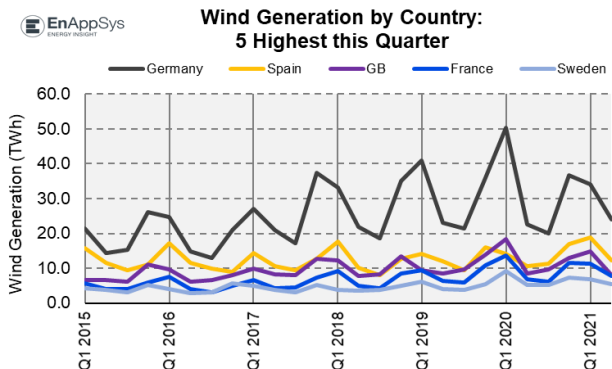
France had the largest level of run-of-river hydro generation in the quarter, at 11.6TWh, a 20% share of the 58.2TWh total, closely followed by Italy with 10.4TWh and an 18% share. Reservoir hydro, on the other hand, is highest in Norway, where 28.9TWh were produced in Q2, a 43% share of the 67TWh total. Norway's reservoir based generation saw only 2% increase compared to the previous Q2. Sweden produced the second largest, at 17.6TWh, a 26% share.



Wind generation decreased significantly from the last quarter (31% in total), yet in comparison the previous Q2, onshore generation increased by 10%, whereas offshore generation decreased by 4%. (Capacity increase of onshore?, how to explain the counter trends in offshore and onshore?) Austria is the only country which saw an increase in the wind generation from Q1 to Q2, despite being a small generator with 2TWh total Q2 generation. Offshore generation of Denmark, Netherlands and Belgium increased by 22% compared to Q2 2020, whereas Germany and GB saw drop of 18%. However, as Germany and GB being the generators of 70% of the total offshore wind electricity, the drop in their output made more impact than the others.

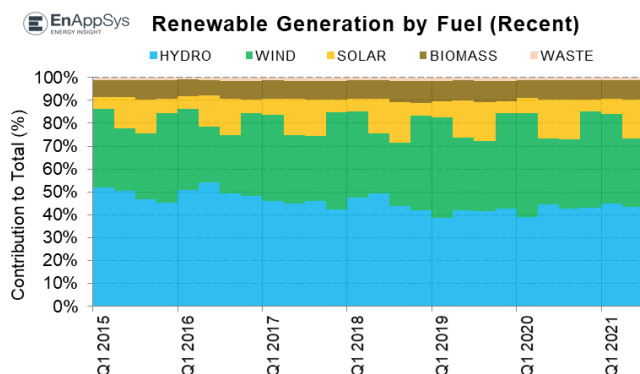
Increases in the offshore outputs are associated with the new installed capacities.

Germany contributed large shares to both onshore and offshore generation with 24TWh, retaining the same share (28%) of the last quarter. GB onshore and offshore installed capacity distribution is unique in Europe with very close output levels. GB onshore generation has never this low (4.2TWh) in a second quarter since 2016, yet it could still remain as the 4th largest wind generator in Europe.



Spain increased its wind output by 14% in comparison to the last Q2 and is still in the 2nd place among the total wind generators, despite having only onshore assets. Similarly, France also showed 14% increase in the wind generation from Q2 2020 to Q2 2021. Denmark is one of the few countries which had a decrease in the onshore generation in comparison to the previous Q2. Increase in the Danish offshore wind generation was overpowered by the 5% decrease in the onshore generation, which stepped Denmark back to 9th place in the total wind generation ranking.

Solar generation has never been this high in Q2. This quarter, solar generation with 48.8TWh took the third place from the biomass fleet which contributed 23.8TWh. Germany is the largest contributor with 38% share of the total European solar generation in Q2 2021. With a large difference, Spain (7.8TWh) came at second and was followed closely by Italy with 6.7TWh generation.



Biomass output remained in between the usual 20-25TWh bandwidth, and recorded a 1% increase from previous Q2. Waste generation increased by 18% compared to Q2 last year, and was the highest waste generation Q2 with 3.6TWh output.

Statistics

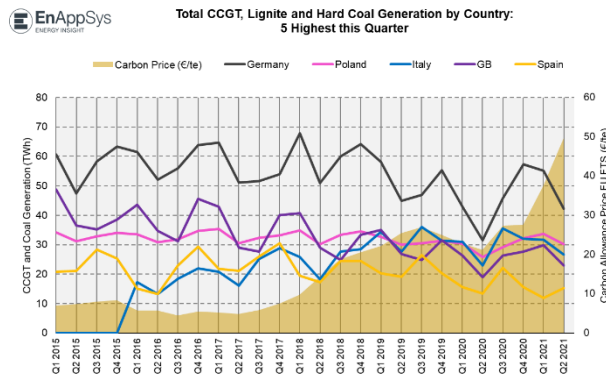
The following table sets out key statistics by quarter:

	Q2 2019	Q3 2019	Q4 2019	Q1 2020	Q2 2020	Q3 2020	Q4 2020	Q1 2021	Q2 2021
TOTAL GENERATION BY FUEL (TWh)									
Biomass	21.4	22.0	25.0	24.5	23.5	21.9	24.4	25.6	23.8
Hydro	102.4	98.0	119.9	125.9	122.9	108.2	124.8	143.3	125.1
Solar	39.0	39.8	14.6	21.3	47.3	43.9	15.5	21.8	48.8
Waste	3.3	3.6	4.0	3.8	3.0	3.2	3.5	3.7	3.6
Wind	76.8	72.6	118.0	146.1	80.2	76.9	121.6	124.5	86.2
TOTAL	243.0	236.1	281.4	321.5	276.9	254.1	289.8	318.9	287.5
Primary Renewable Source	HYDRO	HYDRO	HYDRO	WIND	HYDRO	HYDRO	HYDRO	HYDRO	HYDRO
SHARE OF RENEWABLES (%)									
Biomass	8.8%	9.3%	8.9%	7.6%	8.5%	8.6%	8.4%	8.0%	8.3%
Hydro	42.1%	41.5%	42.6%	39.1%	44.4%	42.6%	43.1%	44.9%	43.5%
Solar	16.1%	16.9%	5.2%	6.6%	17.1%	17.3%	5.3%	6.9%	17.0%
Waste	1.4%	1.5%	1.4%	1.2%	1.1%	1.3%	1.2%	1.1%	1.2%
Wind	31.6%	30.8%	41.9%	45.4%	29.0%	30.3%	42.0%	39.1%	30.0%

The following table contains the key statistics comparing the quarter with the same quarter in previous years:

	Q2 2016	Q2 2017	Q2 2018	Q2 2019	Q2 2020	Q2 2021
TOTAL GENERATION BY FUEL (TWh)						
Biomass	16.9	18.6	22.2	21.4	23.5	23.8
Hydro	132.3	107.3	133.9	102.4	122.9	125.1
Solar	33.4	38.4	40.1	39.0	47.3	48.8
Waste	2.5	3.5	3.4	3.3	3.0	3.6
Wind	59.7	71.6	71.5	76.8	80.2	86.2
TOTAL	244.9	239.3	271.1	243.0	276.9	287.5
Primary Renewable Source	HYDRO	HYDRO	HYDRO	HYDRO	HYDRO	HYDRO
CHANGE SINCE Q2 2016 (%)						
Biomass		10%	31%	27%	39%	40%
Hydro		-19%	1%	-23%	-7%	-5%
Solar		15%	20%	17%	42%	46%
Waste		37%	35%	31%	19%	40%
Wind		20%	20%	29%	34%	44%

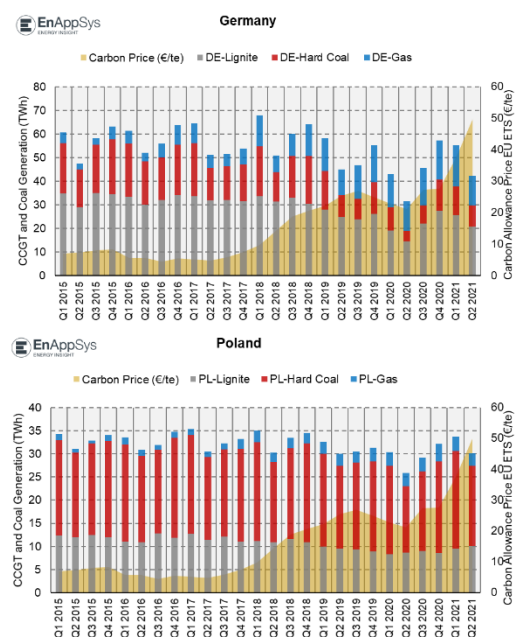
4 Carbon Price Effects



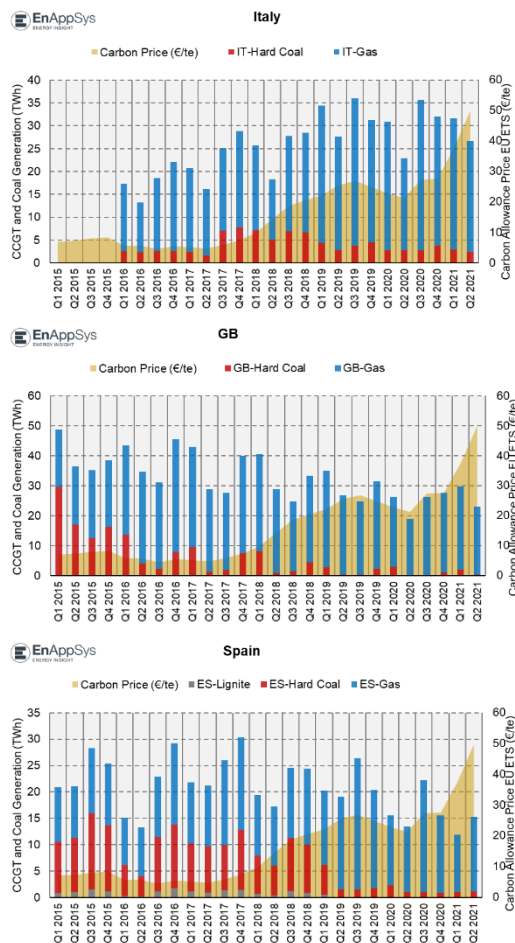
EU ETS extend continues to expand meanwhile the allowance cap decreases each year. On 7th of May 2021, “the barrier” was surpassed and the carbon allowance price was first time over 50€ per ton emission. Since Q4 of 2020, allowance prices increased over 30% per quarter on average and the increasing trend is on-going with the all-time peak recorded on the last day of the second quarter with 56.54 €/te.

Phase-out of lignite and coal power plants already kicked off in 2019 in most of the countries, most importantly in Germany, Spain and Italy. As renewable energy penetration increases in the grid with the increase in the installed capacity and withdrawal of the coal and lignite (in some cases nuclear as well) fleets, a new normal, which is still unrevealing, is settling in the markets. CCGT and OCGT assets are usually the marginal and flexible generators setting the price during peak hours and in the balancing markets. On the other hand, high efficiency coal power plants occasionally have lower breakeven costs than of gas assets with low efficiency, which further limits the gas operators and leads to more extreme prices during the run hours. High day ahead and system prices are almost becoming de facto with the steep increase in the Carbon prices since Q4 of 2020.

Germany is by far taking the lead for generating from the fuel types which have embedded carbon costs, despite the apparent decline after the last quarter of 2020. Germany has the aim of complete coal phase out by 2038, meanwhile nuclear generation is to end by 2022. Germany will need much more flexible assets for integrating the renewable development as planned and compensating for the phasing-out facilities. It is likely that German markets will be insensitive to the Carbon costs, as the flexible gas generation is indispensable under the current conditions. More than 80% of the Polish fuel mix consists of hard coal, lignite and gas regardless of the season. There is no coal phase-out plan in place yet,



nevertheless the renewable development is speeding up. In consideration of Q2 2020 being an exceptional quarter, when the second quarters of 2019 and 2021 are compared, it can be seen that increasing C prices did not have any material impact on the fuel mix. With 30.1TWh total generation from coal and gas, Poland had almost all the time higher day ahead price in this quarter.



Italy, GB and Spain are the other countries with highest generation from coal and gas, yet without any Lignite generation.

Coal generation of Italy is in a continuous decline with 19% average rate since Q4 of 2020 and this quarter there was 14% less coal generation than past Q2. Italian coal phase out is to be completed by 2025, yet currently still using coal as a baseload. Italy was one of the countries whose demand suffered from the Covid impact the most, hence the dramatic reduction in the gas generation in Q2 of 2020. Nevertheless, Italy has been the largest CCGT generation country in Europe since Q3 2019, taking place of GB. There is about 2% decrease compared to Q2 2019, which is mostly to be related with the increased wind capacity, rather than the increasing C prices.

GB is committed to end coal generation by October 2024 with only two coal fleets remaining operational after 2022. GB has introduced its own ETS in association with the decision of leaving EU. UK ETS was launched its first auction in May 19, 2021. The allowance prices are approximately 2€/t on average below the EU ETS so far. GB CCGT generation saw 22.5TWh generation and 15% decrease this quarter in comparison to Q2 2019.

Lastly, Spain is the fifth largest generator of Carbon cost embedded generation types. Spain shut down 7 coal fired power plants on March 2019 to comply with the EU emission standards which almost halved the coal capacity. On the other hand, Spain is still a large generator of CCGT electricity and the only country which increased CCGT generation from last quarter to this quarter. Different than other countries, most of the CCGT plants in Spain are new and efficient, receive capacity payments and might receive subsidies as well.

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. National Grid data is used for GB demand.

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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EnAppSys Ltd.

Blenheim House, 1 Falcon Court, Stockton On-Tees, TS18 3TS, U.K.
Company Registration No.: 04685938

EnAppSys B.V.

Oosterlijk Bolwerk 9, 1st Floor, 4531 GP, Terneuzen, The Netherlands
Company Registration No.: 67992358

