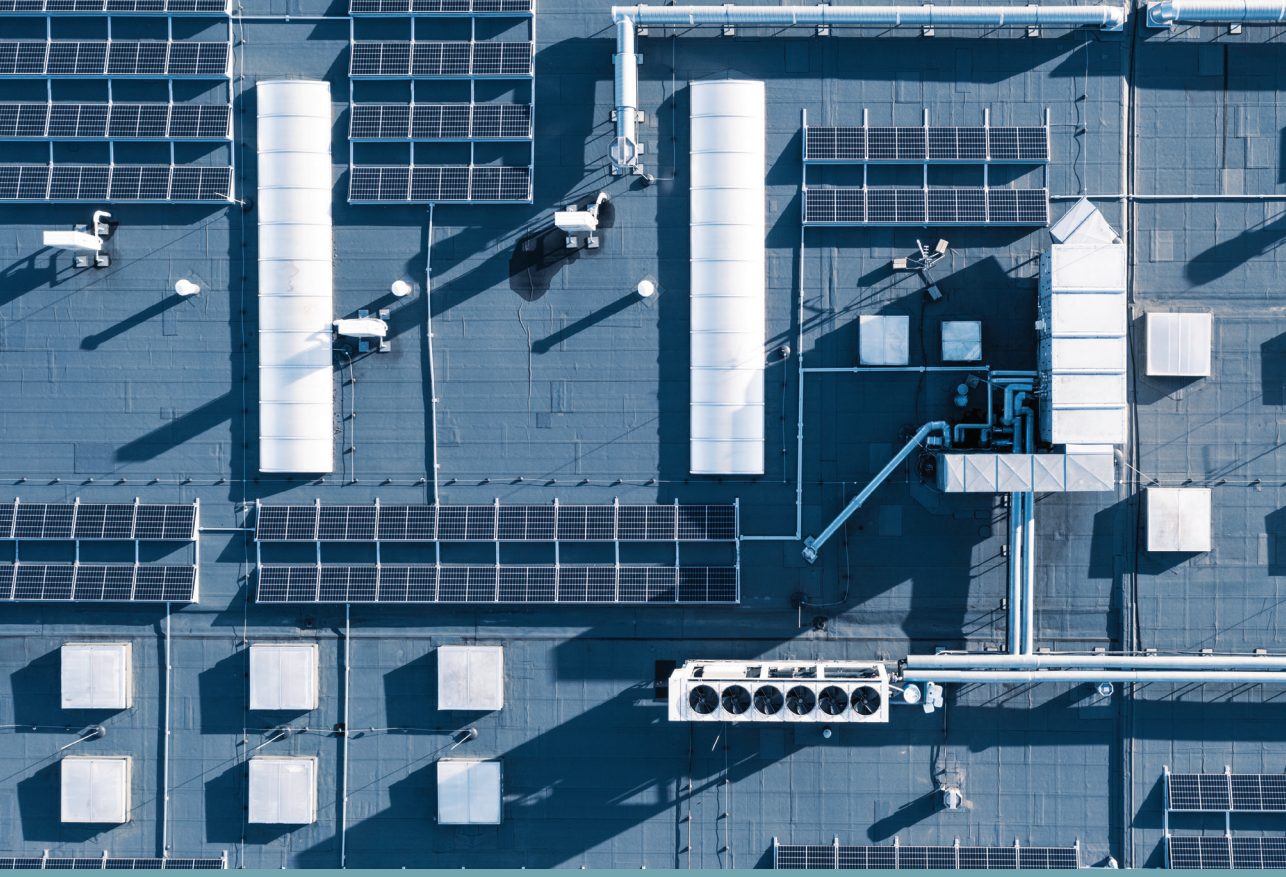


EXECUTIVE SUMMARY

THE STATE OF RENEWABLE ENERGIES IN EUROPE

EDITION 2022

21st EurObserv'ER Report

This barometer was prepared by the EurObserv'ER consortium, which groups together Observ'ER (FR), TNO (NL), Renewables Academy (RENAC) AG (DE), Fraunhofer ISI (DE), VITO (Flemish Institute for Technological Research) (BE) and Statistics Netherlands (NL).

EXECUTIVE SUMMARY

THE STATE OF RENEWABLE ENERGIES IN EUROPE

EDITION 2022

21st EurObserv'ER Report

ENERGY INDICATORS

21.8%

EU-27 RES share in gross final energy consumption in 2021 (22.0% in 2020)

37.5%

EU-27 RES share in gross electricity consumption in 2020 (37.4% in 2020)

22.9%

EU-27 share of energy from renewable sources for heating and cooling in 2021 (23.0% in 2020)

109.8 Mtoe

EU-27 renewable heat and cooling consumption in the EU 27 in 2021 (105 Mtoe in 2020)

1 085 TWh

Renewable electricity generation in the EU-27 in 2021 (1060.5 TWh in 2020)

NEW RENEWABLES MONITORING SYSTEM INTRODUCED BY RED II DIRECTIVE

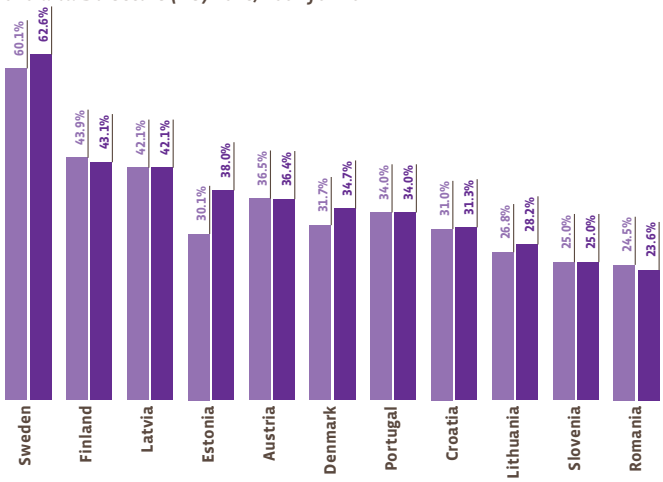
In 2021, the specific calculation provisions of the Renewable Energy Directive (EU) 2018/2001 (RED II) were used for the first time to monitor renewable energy in the balance sheets of each EU country. Therefore, the 2021 results are not directly comparable with those from 2020, which took into account the calculation provisions in the previous directive 2009/28/EC (RED I).

A DIVERSIFIED, COMPLEMENTARY RES MIX

When compared with 2020, 2021 was a bad year for EU renewable electricity output, largely because of the wind deficit that hit the main production areas in North-western Europe. Eurostat data for gross non-normalized European renewable electricity output in 2021, excluding pumped storage output, was 1 085 TWh, which equates to a growth of 1.7% over the year. The figure is only 18.5 TWh higher than in 2020, and a far cry from the additional 81.8 TWh measured between 2019 and 2020. Even so, the increase in renewable electricity output over the past two years has exceeded 100 TWh (100.3 TWh), which shows the resilience of these sectors' momentum. Now in 2021, renewable energies covered 37.5% of the gross total electricity output in the EU-27. Thus 2021 favoured the production of conventional electricity, which increased faster during the post-Covid economic recovery. Renewable energies' main strength is their diversity

1

Share of energy from renewable sources (%) - Directive 2009/28/EC for 2020 and Directive (EU) 2018/2001 for 2021

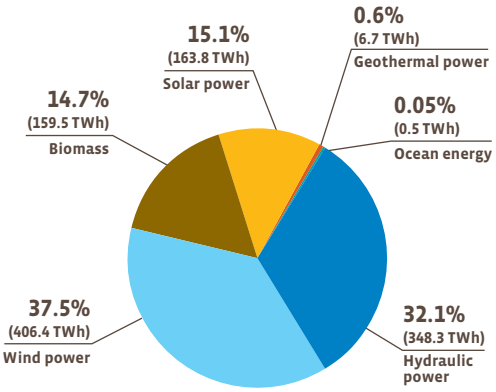


** Data until 2020 are calculated on the basis of Directive 2009/28/EC, while data for 2021 follow Directive (EU) 2018/2001. Source: Eurostat (updated 24th January 2023)*

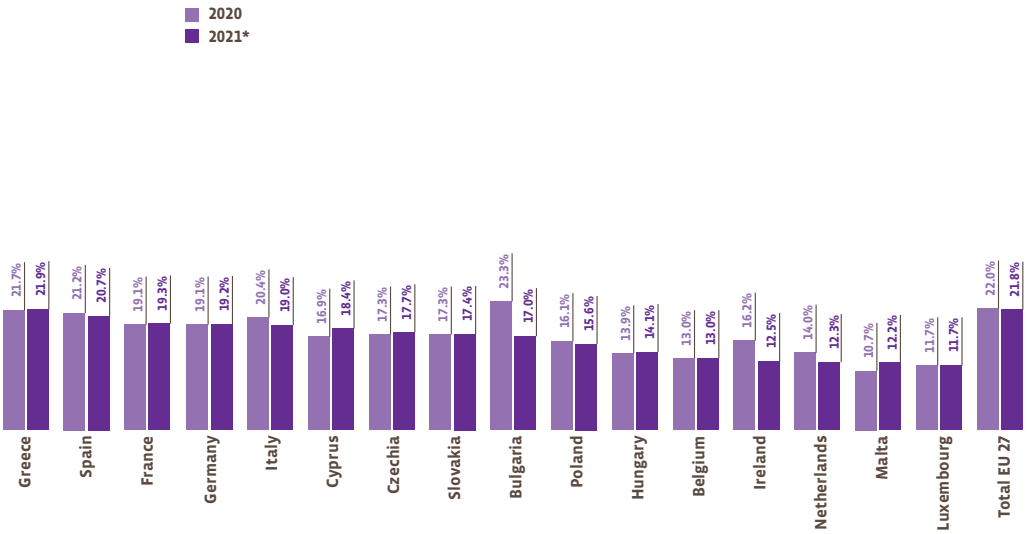
and complementarity. The 10.9 TWh drop in wind energy output across the European Union, was more than offset by the other renewable sectors' output (18.6 TWh for solar, 9.9 TWh for biomass, 1.1 TWh for hydropower excluding pumped storage). Wind energy confirmed its supremacy in the European Union renewable electricity production stakes with an actual output of 386.5 TWh, ahead of hydropower excluding pumped storage (348.3 TWh in 2021). Wind energy thus accounted for 13.3% of the European Union's total gross electricity output in 2021 quantified at 2 781.4 TWh (14.3% share in 2020). Hydropower is the EU renewable electricity production's second mainstay. The sector (excluding pumping and non-normalized output) enjoyed a good year overall across the EU in 2021, as it did in 2020. □

2

Share of each energy source in renewable electricity generation in 2021 in the EU 27 (in %) according to the Directive (EU) 2018/2001 specifications.



Wind is normalised. Solar includes solar photovoltaics and concentrated solar power generation. Biomass includes electricity generation from solid biofuels, liquid biofuels and biogas (pure and blended in the fossil gas grid) calculated according to their compliance with the criteria of Directive (EU) 2018/2001 and also renewable municipal waste. Source: EurObserv'ER.



ENERGY INDICATORS

38.6 GW

Additional electrical renewable capacities connected to EU-27 grids in 2021 (29.4 GW in 2020)

44.4 GW

Electricity storage capacity installed in the EU-27 at the end of 2021 (43.1 GW in 2020)

94.1%

Share of pumped hydro out of total installed EU-27 electricity storage capacity in 2021 (94.4% in 2021)

More than

6500

Collective Action Initiatives supporting around

9650

projects across European Union.

97% OF NEWLY CONNECTED ELECTRICAL CAPACITIES IN 2021 IN THE EU ARE RENEWABLE

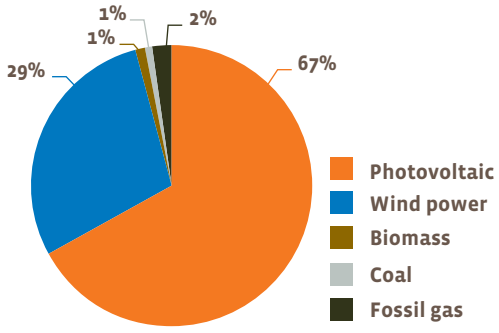
97% of all new electricity capacity installed in 2021 came from renewable sources (37.4 GW out of a total of 38.6 GW). Photovoltaic is the most representative sector with 25.7 MW installed, i.e. 67% of additional electrical capacity in 2021. Driven by a very active European market, this technology establishes its predominance a little more because in 2020 its share had been 55 %. Wind power remains around 30% (29% in 2021 against 32% in 2020) despite a year 2021 marked by low installed capacity at sea. As for fossil fuels, coal and gas together represented 3% and no new nuclear capabilities have been identified.

HEATING AND COOLING FROM RENEWABLES IN THE BUILDING STOCK

The share of renewable heating and cooling in the building stock has grown strongly in recent years. However, natural gas boilers remain the most commonly used heating technology, followed by district heating. Coal boilers, as well as oil boilers, are slowly disappearing. In some countries RES consumption in 2020 was very high (compare Figure 4). In particular, heat pumps are increasingly employed in Scandinavian countries while biomass plays a significant role in several eastern European countries. Overall, there is more dynamic in renewable (and waste) heating, than in the previous years.

3

Distribution of additional electrical capacities connected to EU-27 grids in 2021 by technology

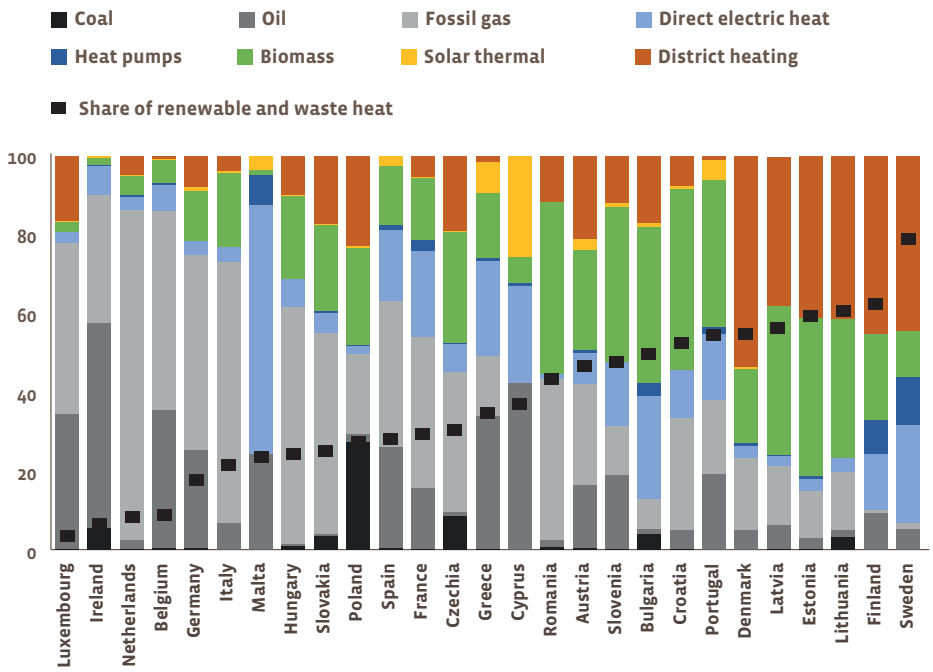


Total : 38.6 GW

Source: EurObserv'ER - Enerdata

4

Consumption shares in heating 2020



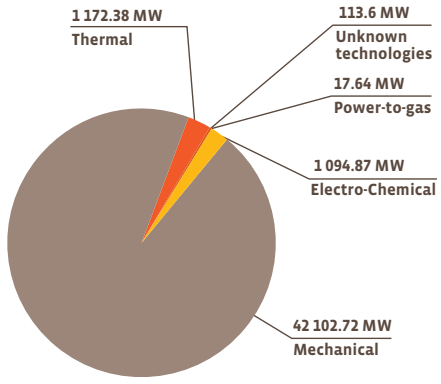
Source: Own assessment based on diverse sources: Eurostat, EHPA Market and Statistic Report and Heat Roadmap Europe project. Notes: District heating contains derived heat obtained by burning combustible fuels like coal, fossil gas, oil, renewables (biofuels) and wastes, or also by transforming electricity to heat in electric boilers or heat pumps. The shares of energy carriers are based on final energy, while the total share of renewable and waste heat is based on useful energy (COP heat pumps = 3).

MORE THAN 44 GW OF STORAGE CAPACITIES IN EU-27

At the end of 2022, a total of 44.4 GW of storage capacity was connected to either the generation or the transmission grids of the EU-27. Pumped hydro storage technology dominates this capacity with 41.8 GW, and is particularly well developed in Italy, Germany, Austria, Spain, and France. Thermal molten salts storage accounts for 1.1 GW, and almost all of it is installed in Spain. Li-ion battery storage accounts for 930 MW, mainly developed in Germany (572 MW). There are some pilot electrolyser sites geared to grid balancing (17.6 MW). □

5

Electricity storage capacities by technologies in the EU-27 at the end of 2021



Source: EurObserv'ER based on the database of the European energy storage technologies and facilities

SOCIO-ECONOMIC INDICATORS

1 470 000

FTE jobs in the European renewable energy industry in 2021 (1 313 300 in 2020)

€184.9 bn

Turnover generated by renewable energy sources in EU-27 in 2021 (€162.9 bn in 2020)

377 300

Jobs in EU-27 heat pump sector in 2021 (318 000 in 2020)

353 800

Jobs in EU-27 solid biofuels sector in 2021 (283 000 in 2020)

223 100

Jobs in EU-27 PV sector in 2021

€52.2 bn

in turnover of heat pumps in the EU in 2021

EMPLOYMENT

Around 1.47 million persons are directly or indirectly employed in the European Union renewable energy sector. This represents a gross increase of 156 700 jobs (12%) from 2020 to 2021. It must be noted that a change in the calculations for heat pumps has a large effect on the total increase. Excluding heat pumps we see an increase of almost 100 000 FTE across the remaining RES sectors.

18 out of 27 Member States either increased or maintained their number of renewable energy jobs, while the top 5 countries in terms of employment are: Germany (256 800 jobs, 17% of all EU renewable employment), Italy (206 100 jobs, 14%), France (167 800 jobs, 11%), Poland (129 300 jobs, 9%), and Spain (124 000 jobs, 8%).

TURNOVER

In total the renewable energy related industry turnover in EU-27 Member States in 2021 amounted to around €185 billion, representing a gross growth of around €22 billion against 2020 (+13%). Also, here it must be noted that a change in the calculations for heat pumps has a large effect on the total increase. Excluding heat pumps we see an increase in turnover of almost €11 billion across the remaining RES sectors.

17 out of 27 EU Member States either increased or maintained their industrial turnover created by renewable energy sources.

The top 5 Member States in terms of turnover are Germany (€39.8 billion), Italy (€28.4 billion), France (€24.8 billion), Spain (€13.8 billion), and the Netherlands with €12.4 billion.

6

2021 Employment distribution in the EU-27

	Country total
Germany	256 800
Italy	206 100
France	167 800
Poland	129 300
Spain	124 000
Netherlands	79 300
Sweden	65 600
Denmark	54 400
Portugal	50 200
Finland	35 500
Hungary	35 500
Romania	33 300
Austria	30 200
Czechia	30 100
Greece	26 600
Lithuania	23 500
Latvia	22 700
Bulgaria	21 100
Croatia	16 500
Slovakia	14 500
Estonia	14 300
Belgium	14 200
Ireland	6 000
Slovenia	5 000
Malta	4 100
Cyprus	1 700
Luxembourg	1 700
Total EU 27	**1 470 000**

Source: EurObserv'ER

7

2021 Total turnover (€M)

	Country Total
Germany	39 770
Italy	28 390
France	24 820
Spain	13 750
Netherlands	12 370
Sweden	11 730
Denmark	10 730
Finland	7 470
Poland	7 470
Austria	5 690
Portugal	3 340
Belgium	3 210
Greece	2 340
Czechia	1 980
Hungary	1 840
Romania	1 680
Estonia	1 230
Latvia	1 170
Slovakia	1 080
Bulgaria	1 070
Lithuania	1 020
Ireland	840
Croatia	780
Slovenia	420
Malta	340
Luxembourg	240
Cyprus	150
Total EU 27	**184 920**

Source: EurObserv'ER

8

2021 Gross value added (€M)

	Country Total
Germany	17 970
Italy	11 360
France	10 350
Spain	6 140
Sweden	5 300
Netherlands	4 790
Denmark	4 430
Finland	3 960
Poland	3 030
Austria	2 500
Portugal	1 430
Belgium	1 150
Greece	970
Hungary	820
Romania	760
Czechia	740
Slovakia	510
Estonia	500
Lithuania	490
Latvia	470
Bulgaria	410
Croatia	390
Ireland	380
Slovenia	220
Malta	190
Luxembourg	130
Cyprus	110
Total EU 27	**79 500**

Source: EurObserv'ER

RENEWABLE ENERGY COSTS AND ENERGY PRICES

€120/MWh

Average estimated cost level for residential solar PV

€0.23/kWh

Average household electricity price in the EU-27 in 2021

2–4%

WACC range for PV in the EU-27

€3.2m/MW

Average investment cost for offshore wind in EU-27

UPDATES TO WEIGHTED AVERAGE COST OF CAPITAL (WACC)

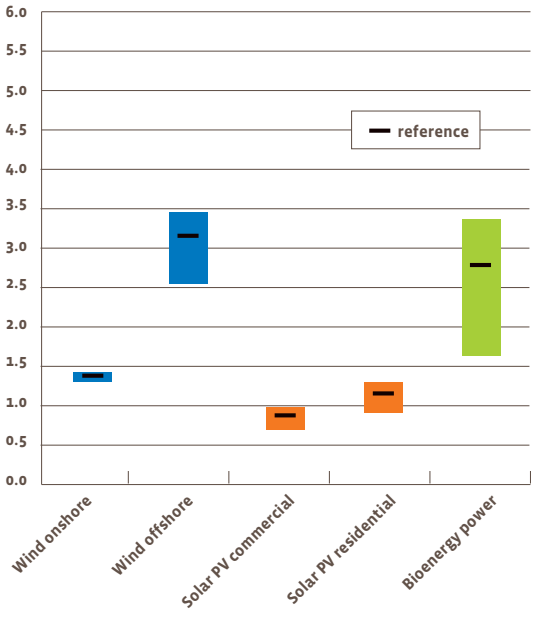
The volatile and uncertain macroeconomic circumstances in 2021 and 2022 make it difficult to generalise the current situation and present up-to-date estimates for investment costs and levelized costs of energy. Estimates for the weighted average cost of capital (WACC) were updated according to similar sources.

We observe that for the low-risk technologies, such as wind onshore and solar PV, the WACC values range from as low as between 2-3% in some member states (e.g., Germany, Netherlands, Denmark) to above 4% in other member states (e.g., Greece, Romania, Poland).

For the higher risk technologies, such as bioenergy, the WACC estimates range from between 4-7% in some member states (e.g., Austria, Belgium, Germany) to 6-9% in other States (e.g., Poland, Hungary, Romania). This can be interpreted as follows: for technologies that are considered relatively mature, and have been deployed at scale, and in member states that have stable economic and political conditions, the WACC is typically lower. The WACC is higher in member states that have low deployment rates for technologies and where the economic and political conditions are less favourable.

9

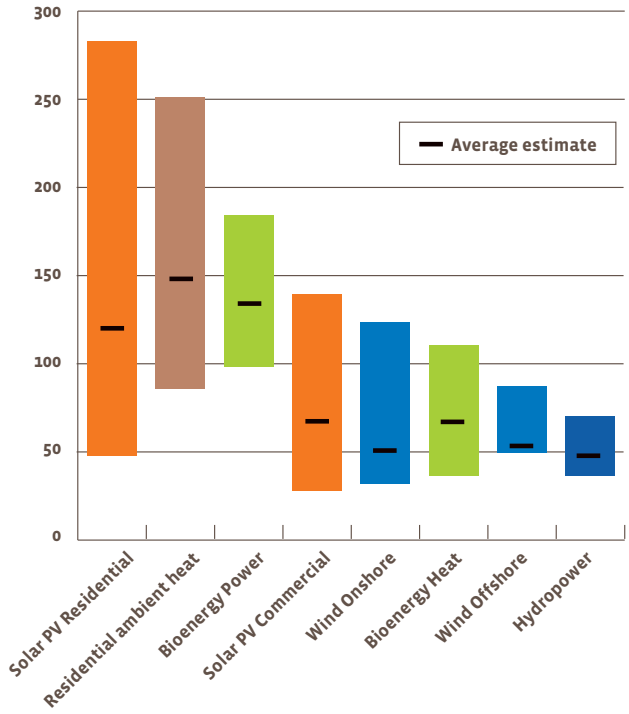
Renewable energy investments costs for the year 2020 according to JRC as used in LCoE section (m€/MW)



Source: JRC

10

Estimated levelised cost of renewable energy in the European Union (€/MWh) for the year 2021.



Note: the investment costs refer to the situation from 2020 and that only WACC estimates have been brought up to date .
EurObserv'ER

LEVELISED COST OF ELECTRICITY (LCOE) HIGHLIGHTS FOR 2021

For electricity production, hydroelectricity had the lowest average LCoE in 2021 (average 47 €/MWh), ahead of onshore wind (average 50 €/ MWh) and offshore wind, which were on a par with photovoltaic in commercial buildings (average 65 €/MWh). For heat production, the lowest average LCoE is for biomass (average 52 €/MWh), far ahead of heat pumps (average 149 €/MWh). However, the development of collective equipment and the association with heat networks can help reduce heat pump costs. Average prices in the European Union Member States for natural gas and electricity for households and non-households show an increase from 2020 to 2021, which is most pronounced for non-households.

RENEWABLE ENERGY INVESTMENT COSTS IN THE EU-27 VARY WIDELY ACROSS TECHNOLOGIES

An overview of the investment costs that are used for the calculation of the levelized costs of energy (LCoE) is depicted in Figure 9. It can be seen that also in this report, all technologies are characterised by data ranges. These ranges refer to the technology in general and do not exclusively target technologies in the European Union. It can be observed that the investment costs vary significantly across technologies. □

AVOIDED FOSSIL FUEL USE AND RESULTING AVOIDED COSTS

192.0 Mtoe

EU-27 substituted fossil fuels by RES in 2021 (171 in 2020)

601 $MtCO_2$ eq

Avoided GHG emissions through RES consumption in the EU-27 in 2021 (538 in 2020)

€48.0 bn

EU-27 avoided expenses through renewable energy sources in 2021 (34.6 in 2020)

MORE FOSSIL FUELS AVOIDED BY RENEWABLE ENERGY IN 2021

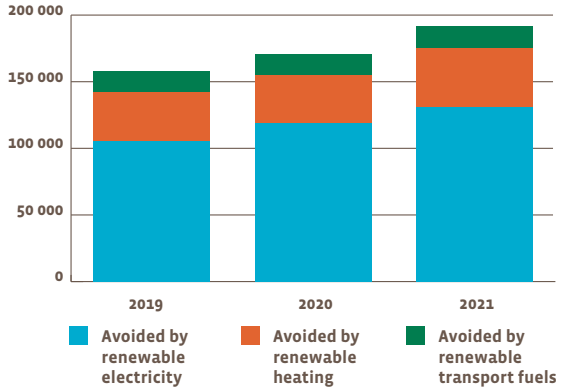
In 2021 and 2020 the use of renewable energy substituted respectively around 192 Mtoe and 171 Mtoe of fossil fuels, compared to the level of use of renewable energy in 2005. These figures correspond to an avoided annual cost of EUR 35 billion for EU27 collectively in 2020, increasing to EUR 48 billion in 2021. In 2021 the largest financial contributions derive from renewable electricity (53% of the total), followed by renewable transport (28% of the total). Finally, renewable heat has a contribution of 19% to the total avoided expenses.

AVOIDED GHG EMISSIONS IN EU-27

In 2021, for the EU27 a gross reduction of 601 Mt CO_2eq of GHG emissions has been realised due to the additional consumption of renewable energy. While total EU27 GHG emissions were approximately 3526 Mt CO_2eq in 2021, the additional uptake of renewable energy has led to a gross reduction of GHG emissions of 14.6% in 2021, compared to the reference year 2005.The gross reduction of GHG emissions due to the additional consumption of renewable energy has increased from 538 Mt CO_2eq in 2020 to approximately 601 Mt CO_2eq in 2021. □

11

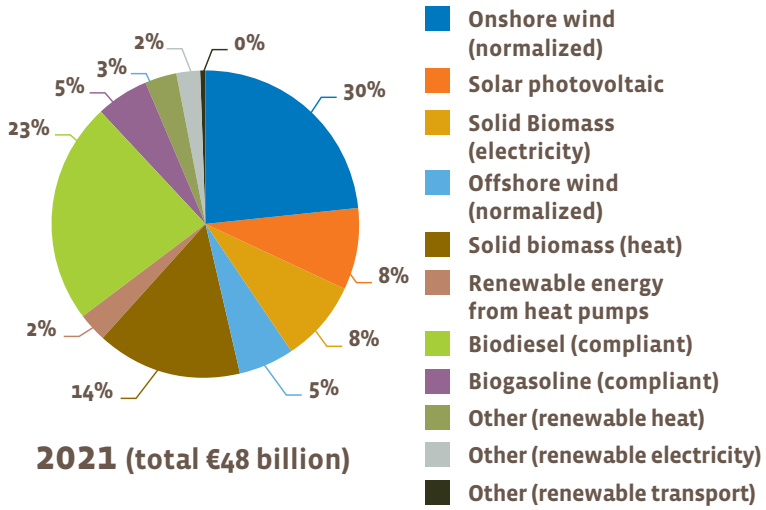
EU-27 avoided fossils fuels per sector (ktoe)



Note: Reference year 2005. Note: for 2021 proxy data are used.
Source: Eurostat, EurObserv'ER based on EEA data.

12

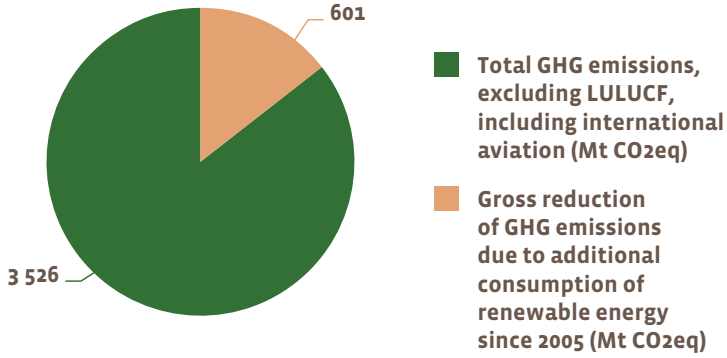
EU-27 avoided expenses through renewables



Note : Reference year 2005. Note: for 2021 proxy data are used.
Source: EurObserv'ER based on EEA data.

13

Effect on GHG emissions in EU-27 in 2021



Note: Reference year 2005. Note: for 2021 proxy data are used.
Source: Eurostat, EurObserv'ER based on EEA data.

INDICATORS ON INNOVATION AND COMPETITIVENESS

€687.5 m

Public R&D expenditure in all renewable energy technologies in 2020 in the EU-27

€2 476 m

Private R&D expenditure in all renewable energy technologies in 2019 in the EU-27

1 269

Number of renewable energy patent filings in the EU-27 in 2019

€16.1 bn

EU-27 trade (exports) in 2021 - all renewable energy sources (RES)

€21.2 bn

EU-27 trade (imports) in 2021 - all renewable energy sources (RES)

R&D INVESTMENTS

The aggregated results of public R&D investments for all renewable energy technologies in the EU-27 reveals a strong position in 2020 with almost €1 billion when accounting for both the national contributions (€687.5 million) and those of the European Commission (€264.5 million) together. The second largest contribution of public R&D investments in renewable energy technologies came from the United States, with €873.7 million. In general, the EU-27 has invested 0.0051% of the GDP in public R&D in 2020. Furthermore, Switzerland, Norway, and Denmark stand out with the highest GDP shares)..

PATENT FILINGS

The EU filed 1 269 patents in renewable energy in 2019, with Germany being the most active country (378 patents). China remains the world leader in number of patents filed in renewable energy, with 8 813 patents. This is by far the largest number of patents in 2019, followed by Korea, the EU-27, Japan, and the US. Within the EU-27, a strong position of Germany is noted followed by Denmark, France, and Spain. When measured in terms of GDP shares, this ranking changes with Denmark being (far) ahead, followed by smaller countries such as Cyprus and Latvia..

INTERNATIONAL TRADE

The trade balance (difference between imports and exports) of the renewable energy sectors in the EU-27 as a whole shows a negative balance in 2021 of EUR €5 034 million. The main partner remains China, which exported €9 671 million of goods and services in renewable technologies to the EU-27. □

14

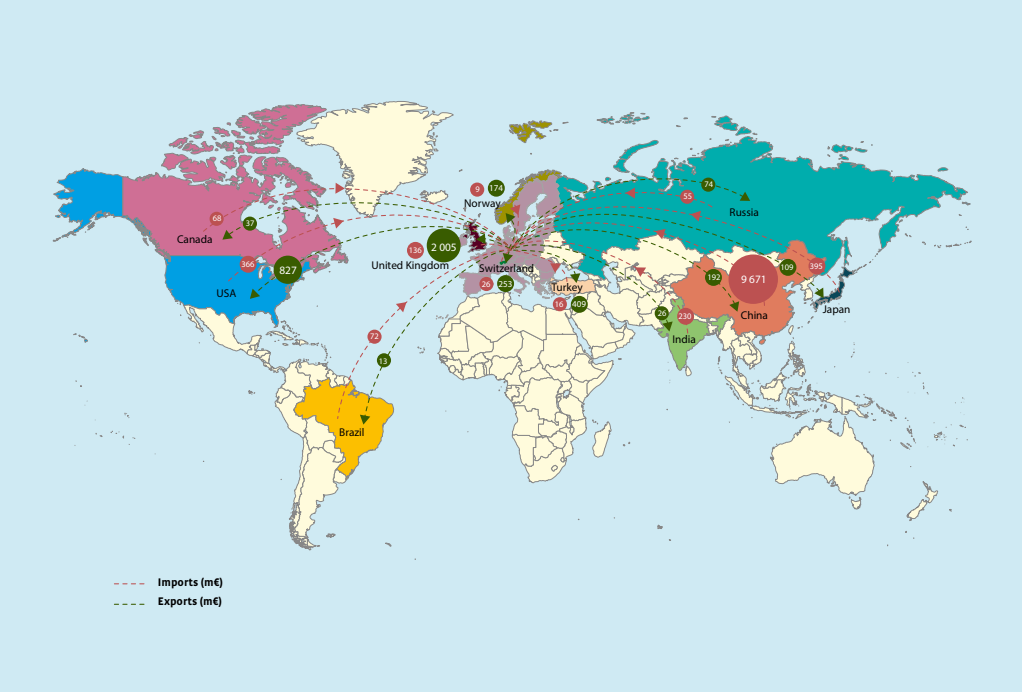
Main EU partners' trade with the rest of the world (including EU-27). 2021 - all RES

	Imports (in € m)	Exports (in € m)	Net exports (in € m)	Share of global exports	Exports specialisation (RCA)
China	8 265	29 744	21 479	37.9%	37
Japan	3 215	3 233	18	4.1%	7
Switzerland	429	185	-244	0.2%	-70
Norway	263	7	-256	0.0%	-96
Russia	397	113	-284	0.1%	-83
Turkey	958	132	-827	0.2%	-66
Canada	1 385	355	-1 030	0.5%	-61
Brazil	2 787	1 058	-1 729	1.3%	1
United Kingdom	2 644	360	-2 284	0.5%	-59
India	3 797	475	-3 322	0.6%	-45
USA	8 641	4 543	-4 098	5.8%	-15
Rest of the world	26 614	22 130	-4 484	28.2%	-1

Source: EurObserv'ER

15

EU-27 trade with its main trading partners, 2021 - all RES



EUROBSERV'ER BAROMETERS ONLINE

All EurObserv'ER barometers can be downloaded in PDF format at the following address:

www.eurobserv-er.org

INFORMATION

For more extensive information pertaining to the EurObserv'ER barometers, please contact:

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Schedule for the 2023 EurObserv'ER barometers

Wind power	**>> March 2023**
Photovoltaic	**>> April 2023**
Solar thermal + CSP	**>> June 2023**
Biogas	**>> Sept 2023**
Renewables in transport	**>> Nov 2023**
Solid biofuels	**>> December 2023**

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