



EXECUTIVE SUMMARY

THE STATE OF RENEWABLE ENERGIES IN EUROPE

EDITION **2023**
22nd 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) and VITO (Flemish Institute for Technological Research) (BE).



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ENERGY INDICATORS

23%

EU-27 RES share in gross final energy consumption in 2022 (21.9% in 2021)

41.2%

EU-27 RES share in gross electricity consumption in 2022 (37.8% in 2021)

1 155 TWh

Renewable electricity generation in the EU-27 in 2022 (1 093 TWh in 2021)

83.3 %

Share of energy from renewable sources in gross electricity consumption in Sweden

RENEWABLE ENERGY DIRECTIVE (RED III): REVISED TARGETS FOR RENEWABLE ENERGY TO ACHIEVE BY 2030

At the end of 2022, renewable energy sources covered 23.0% of gross final energy consumption in the European Union. The pace must greatly accelerate to reach the new 42.5% target set by RED III (adopted in October 2023) by the end of 2030.

The new directive also raises its renewable energy share targets of the EU's gross final electricity consumption in 2030 from at least 32 to 42.5% and encourages the Member States to aim for 45%. The renewable share of gross electricity consumption in European Union reached 41.2% in 2022. In 2022 1 155 TWh of renewable electricity were produced, with wind

power being the most important source (438.8 TWh, i.e. 38.9% of all renewable electricity production), followed by hydro (345.3 TWh) and photovoltaics (210.3 TWh). Biomass came fourth with 166.4 TWh.

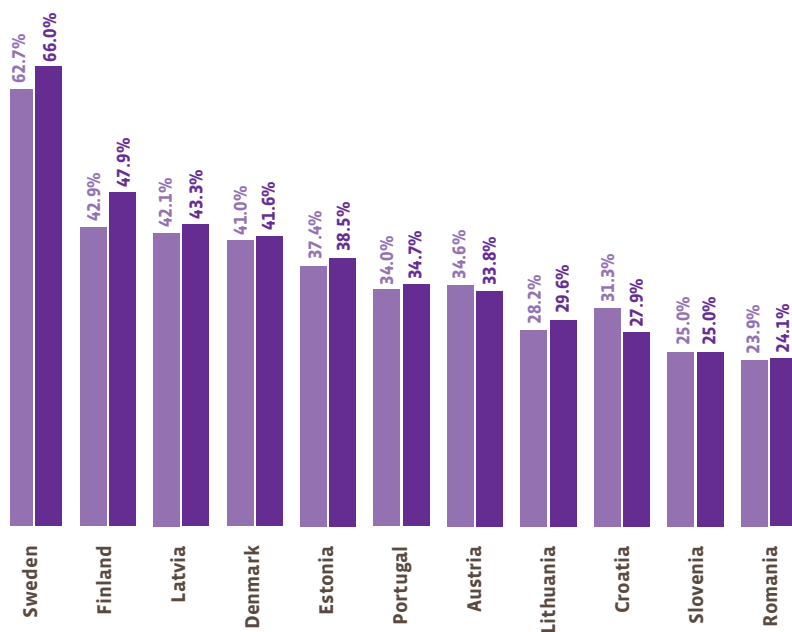
SOLAR AND WIND ENERGY BAIL OUT HYDROPOWER

Renewable electricity production in the European Union can be said to have been trading water, while it concealed an exceptional climate event that affected much of the European continent: The lack of rainfall created a record hydraulic deficit in many countries (France, Italy, Germany, Spain, Portugal, and others).

The dearth of rainfall measured in 2022 coincided with record sunshine levels across the continent.

1

Overall share of energy from renewable sources (%) - According the Directive (EU) 2018/2001



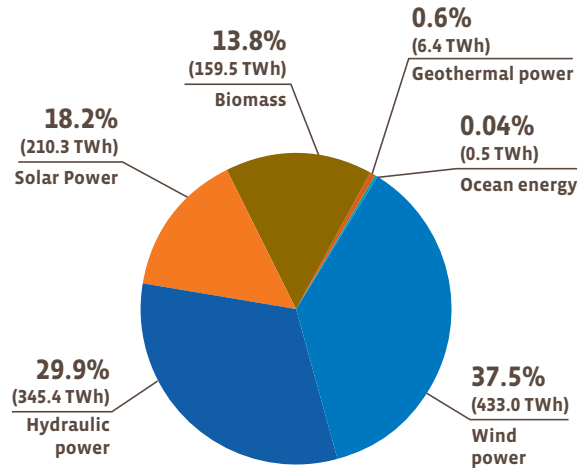
* Eurostat (updated 6th February 2024)



Combined with a record level of photovoltaic grid connections, it enabled solar power output to increase by 28% across the European Union between 2021 and 2022 (46 TWh). In 2022, renewable electricity output was also boosted by wind power rebounding following on from the previous year's wind drought in many regions. □

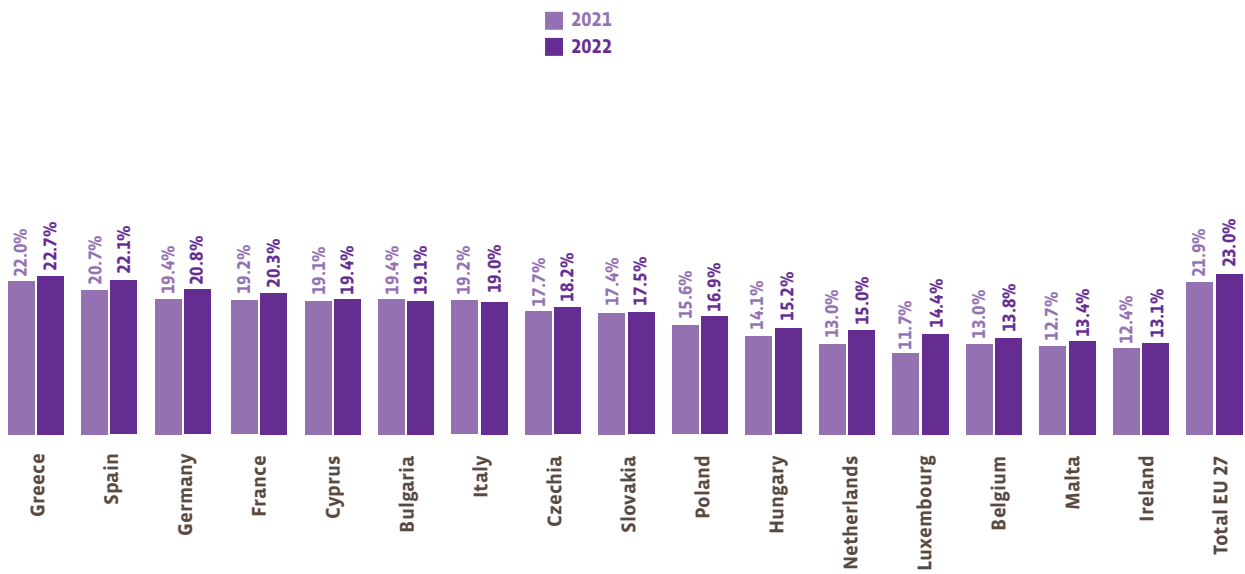
2

Share of each energy source in renewable electricity generation in 2022 in the EU-27 (in %) according the Directive (EU) 2018/2001 specifications



2022: total 1 155.1 TWh

Notes for calculation: Hydro is normalised and excluding pumping. 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 natural gas grid) calculated according to their compliance with the criteria of Directive (EU) 2018/2001 and also renewable municipal waste. Source: EurObserv'ER from Eurostat database (updated 28 January 2024) and SHARES .



ENERGY INDICATORS

4

50.1 GW

Additional electrical renewable capacities connected to EU-27 grids in 2022 (38.6 GW in 2021)

24.8%

EU-27 share of total final energy consumption from RES for heating and cooling (23.0% in 2022)

110.7 Mtoe

EU-27 renewable heat and cooling consumption in 2022 (111.6 Mtoe in 2021)

48.7 GW

Electricity storage capacity installed in the EU-27 at the end of 2023 (44.4 GW in 2022)

3 GW

Installed in electrochemical storage capacities installed in EU-27 at the end of 2023

94% OF NEWLY CONNECTED ELECTRICAL CAPACITIES IN 2022 IN THE EU ARE RENEWABLE

In 2022, 50.1 GW out of a total of 53.5 GW of newly connected electricity capacity in European Union countries came from renewable technologies. Photovoltaic is still the most representative sector with 32 819 MW installed, accounting for 61% of the additional electrical capacity in 2022 slightly below its performance in 2021 (67%). Wind power remains around 30% (28% in 2022 against 29% in 2021).

RENEWABLE HEAT ENJOYS ITS SECOND BEST YEAR

In the long term, there is no doubt that renewable energy consumption for heating and cooling requirements will grow. It passed the 90 Mtoe mark at the beginning of the 2010s, but further action is needed to meet energy and climate goals. In 2022, the renewable share of heat and cooling consumption

was 24.8%; 110.7 Mtoe were produced, of which 72.8% came from solid biofuels in a context of milder winter conditions than the previous year. Heat pumps came second with 6.5 Mtoe.

CONSUMPTION SHARES OF RES-H&C IN BUILDINGS AND SERVICES

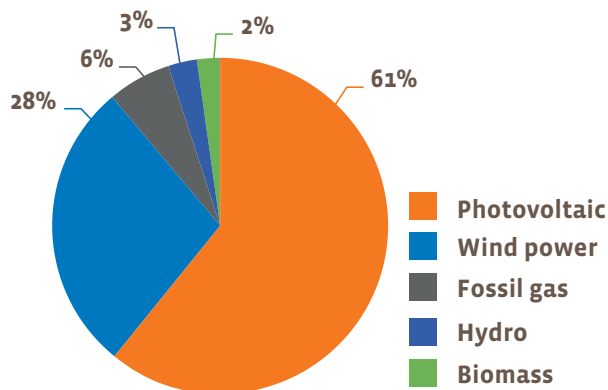
Due to low exchange rates and the long lifetime of heating and cooling systems, the consumption share shows only small changes from one year to the next.

Gas remains an important source of heating in most countries. Although oil boilers are in steady decline, they are still an important source of heating in several countries.

District heating is particularly prevalent in the Scandinavian and Baltic countries, with leading shares. Eastern European countries, with established networks and a long history of district heating, also rely heavily

3

Distribution of additional electrical capacities connected to EU-27 grids in 2022 by technology



Total : 53.5 GW

Source: EurObserv'ER - Ember



on district heating systems. RES and waste heat dominate in Sweden, Estonia, Finland, Denmark, Lithuania and Latvia. These countries also have the highest shares of district heating in Europe, highlighting the advantage of district heating to integrate large shares of RES and waste heat that cannot be used in individual heating systems. In contrast, Croatia, Slovenia and Romania achieve high RES shares due to the highly decentralised use of biomass. Decentralised heat pumps are becoming more important each year. However, higher shares are only reached in the Scandinavian countries.

Solar thermal has the lowest shares in most countries. It is mainly used in southern European countries with high solar radiation potential.

MORE THAN 48 GW OF ELECTRICITY STORAGE CAPACITIES IMPLEMENTED

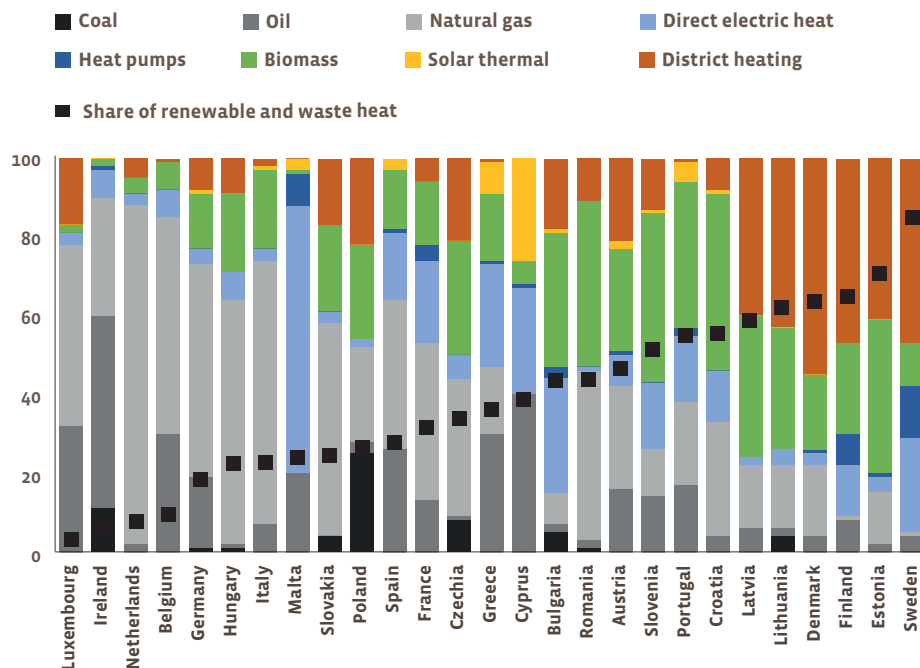
System flexibility is particularly needed in the European Union’s electricity system, where the share of renewable energy is estimated to reach around 69% by 2030 and 80% by 2050 (from 37% in 2021).

Between 200 GW and 600 GW of energy storage capacity will be needed by 2030 and 2050 respectively.

Operational storage increased from around 44.4 GW to 48.7 GW from 2022 to 2023. The majority of storage in Europe is from Pumped Hydro Storage (44 GW), with the majority of facilities in Germany, Italy, France, Spain, Austria and Portugal, their aggregate being 32 GW. The growing capacity of electrochemical projects is significant, as it more than doubled, from around 1 GW to 3 GW over the past year. □

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Consumption shares of heating in the building stock in 2021



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, natural gas, oil, renewables (biofuels) and waste, 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).

SOCIO-ECONOMIC INDICATORS

1 692 100

FTE jobs in the European renewable energy industry in 2022 (1 470 000 in 2021)

416 200

Jobs in EU-27 heat pump sector in 2022 (377 300 in 2021)

346 900

Jobs in EU-27 PV sector in 2022 (223 100 in 2021)

273 500

Jobs in EU-27 wind sector in 2022 (211 500 in 2021)

€210 bn

Turnover generated by renewable energy sources in EU-27 in 2022 (€184.9 bn in 2021)

€57.4 bn

Turnover of heat pump sector in the EU in 2022 (€52.2 bn in 2021)

EMPLOYMENT

Around 1.69 million persons are directly or indirectly employed in the European Union renewable energy sector, which represents a gross increase of 222 100 jobs (15%) from 2021 to 2022. The most significant upward jump in employment was in the PV sector with an additional 123 800 jobs (+55%), followed by wind energy with 62 000 new jobs (+29%). Increases were also observed in the hydropower, biofuels, heat pumps and biogas sectors. The increases balance out declines in the solar thermal, geothermal, MSW and solid biofuels sectors. The heat pump sector once more became the largest in terms of renewable energy induced employment (416 200 jobs, 25% of the total EU). 20 out of 27 Member States either increased or maintained their number of renewable energy jobs, while the largest growth in employment estimates were found in Portugal (+46 400 new jobs, equal to +92%, mostly due to the large hydro power plant commissioned in 2022), Germany (+42 200, equal to +16%), and Spain (+32 400 jobs, equal to +26%).

TURNOVER

In total the renewable energy related industry turnover in European Union Member States in 2022 amounted to around €210 billion, representing a gross growth of around €24.8 billion against 2021 (+13%). 22 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 (€45.9

billion), Italy (€30.0 billion), France (€29.6 billion), Spain (€17.4 billion), and the Sweden with €14.6 billion. As for jobs, the largest renewable energy technologies in terms of industry sector turnover were heat pumps with €57.4 billion. □

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2022 Total turnover (€M)

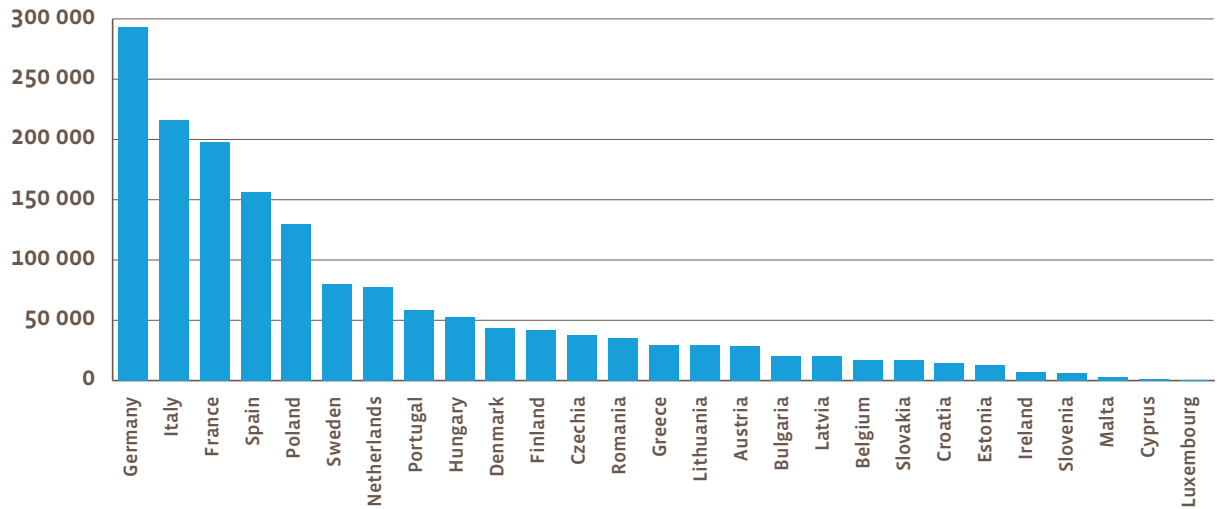
Germany	45 880
Italy	29 980
France	29 660
Spain	17 400
Sweden	14 560
Netherlands	12 010
Denmark	8 960
Finland	8 630
Poland	7 650
Austria	6 250
Portugal	5 850
Belgium	3 880
Hungary	3 100
Greece	2 640
Czechia	2 560
Romania	1 840
Slovakia	1 290
Lithuania	1 270
Estonia	1 140
Bulgaria	1 100
Ireland	1 070
Latvia	1 070
Croatia	700
Slovenia	540
Malta	340
Cyprus	190
Luxembourg	170
Total EU-27	209 730

Source: EuroObserv'ER



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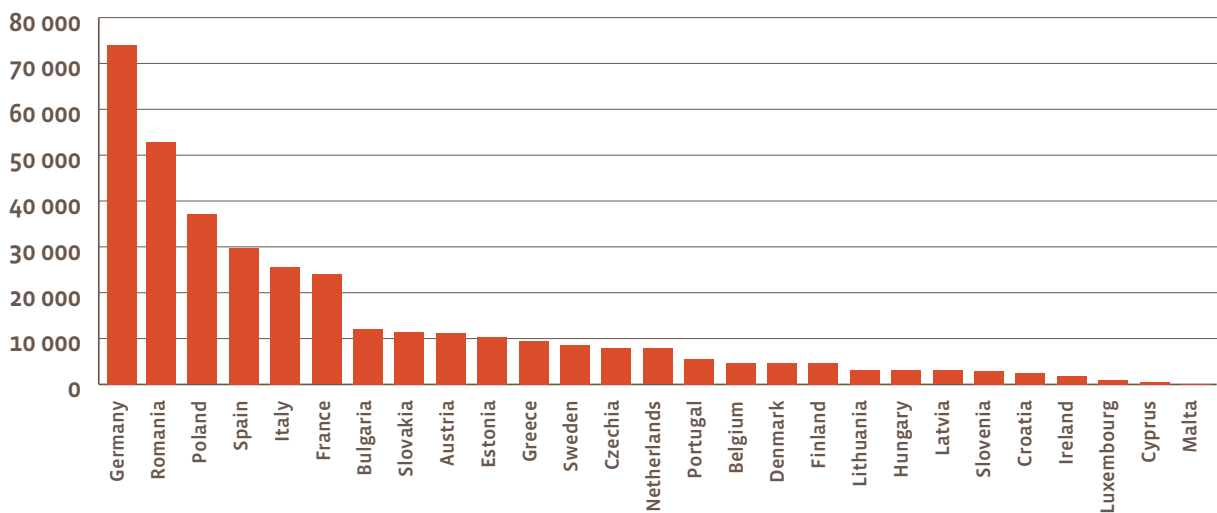
Gross renewable employment by country (data for 2022)



Source: EurObserv'ER

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Indicator for equivalent replaced fossil employment, looking at operation, maintenance, and fuel production activities only (data for 2022)



Source: EurObserv'ER

RENEWABLE ENERGY COSTS AND ENERGY PRICES

€110/MWh

Average estimated cost level for residential solar PV in the EU-27

€72/MWh

Average estimated cost level for commercial solar PV in the EU-27

€95–181 / MWh

Estimated cost level for bioenergy power generation in the EU-27

€48–87 / MWh

Estimated cost level for bioenergy power generation in the EU-27

NAVIGATING UNCERTAINTY: INVESTMENT COSTS ESTIMATIONS

Over the past decades the trend in renewable energy was relatively stable: overall ever lower specific investment costs and increasing energy yields, resulting in lower levelised cost of energy (LCoE) each year. In previous Barometers the cost decreases were reported in comparison to the year 2005. After the uncertain macro-economic circumstances in the years 2021 and 2022 for which assessing costs was difficult, we present investment costs for the year 2023 in line with a literature-based range as used in previous years, using 2023 as the reference

year. Updated estimates for the weighted average cost of capital (WACC) were used to find LCoE.

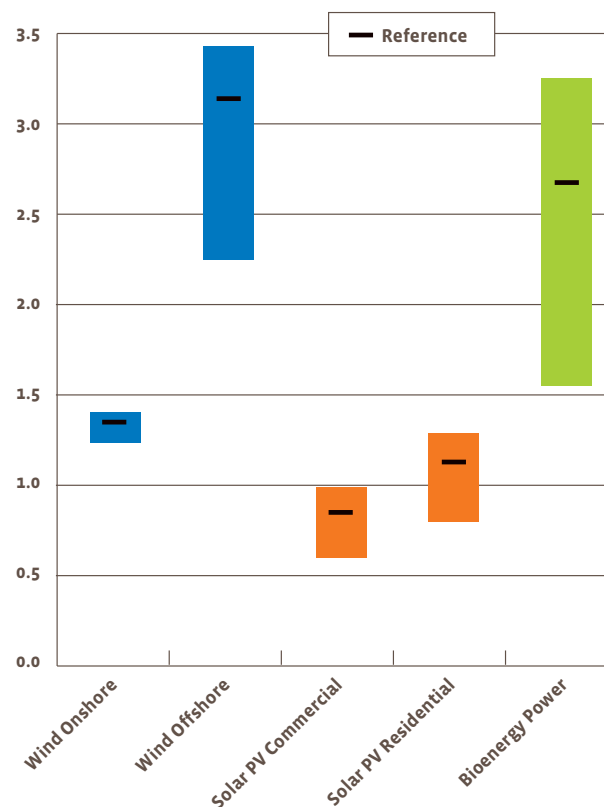
WEIGHTED AVERAGE COST OF CAPITAL (WACC)

Most renewable energy projects for power production are characterised by high upfront capital expenditures, which means that the level of the WACC has a critical impact on the indicators such as the Levelised Cost of Energy (LCoE).

The level and volatility of interest rates has increased sharply over the past 12 months. As a result, the cost of equity and cost of debt have also risen sharply in 2022. The return on equity has increased due

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RE investments costs estimated for the year 2023 (M€/MW)

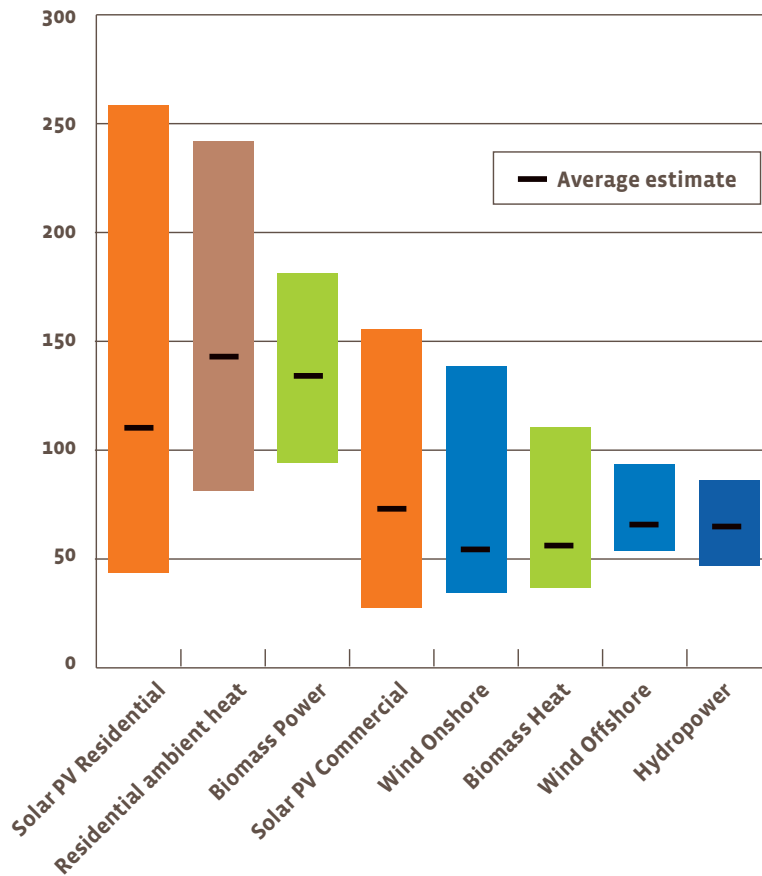


Source: The estimates were based on JRC (2018) and will be used in the LCoE section



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Levelised cost of energy in the European Union (EUR/MWh)



Note: based on investment cost estimates for 2023 and WACC data for 2023. Source: EurObserv'ER

to higher return expectations of equity investors, and an increase in the risk-free rate. The return on equity for medium-risk projects is now 10 percent. For technology categories with higher operational risk or policy risk, the return on equity is unchanged at 11.5 percent. In contrast, wind energy and solar PV technologies are more advanced than other technologies and deployed on a larger scale. Returns on equity for solar PV and wind energy increased to 8 and 9 percent, respectively. We observe that for the low-risk technologies, such as

wind onshore and solar PV, the WACC values range from as low as between 3-4% in some Member States (e.g., Germany, Netherlands, Denmark) to above 5% in other Member States (e.g., Greece, Romania, Poland). For the higher risk technologies, such as bioenergy, the WACC estimates range from between 6-7% in some Member States (e.g., Austria, Belgium, Germany) to 8-9% in other States (e.g., Poland, Hungary, Romania).

LCOE IN 2023

LCoE values differ across countries as a result of varying yield of renewable sources throughout the European Union and differences in financing parameters. The average estimated cost level is 110 EUR/MWh for residential solar PV and 72 EUR/MWh for commercial solar PV. From the calculations it follows that bioenergy power generation is roughly between 95 and 181 EUR/MWh across Europe. The average costs for onshore wind power are lower than for commercial PV, with a comparable cost bandwidth. □

AVOIDED FOSSIL FUEL USE AND RESULTING AVOIDED COSTS

192.0 Mtoe

EU-27 substituted fossil fuels by RES in 2022 (185 Mtoe in 2021)

604 MtCO₂ eq

Avoided GHG emissions through RES consumption in the EU-27 in 2022 (581 MtCO₂ eq in 2021)

€151 bn

EU-27 avoided expenses through renewable energy sources in 2022 (74 bn in 2021)

THE INCREASE IN THE USE OF RENEWABLE ENERGY LEADS TO LESS CONSUMPTION OF FOSSIL FUELS IN 2022

In 2022 the use of renewable energy substituted around 192 Mtoe of fossil fuels, compared to the level of use of renewable energy in 2021. The use of renewable electricity contributed to 70% of the total avoided fossil fuels in 2022, followed by renewables in the heating and cooling sector contributing to 21% and the remaining share was substituted through renewable transport fuels. While the penetration of renewable energy (expressed in avoided fossil fuels) expanded by approximately 4% from 2021 to 2022, the effect of the avoided fossil fuel expenses is, with a 204% increase (from €74 billion to €151 billion) tremendously more pronounced than the growth in renewable energy. Reason for this

is the strong increase in fossil fuel prices in 2022 compared to 2021. In monetary terms, the avoided costs were €95.1 billion in 2022 in the electricity sector. Second, renewable heat contributed to avoided costs reaching to €39.1 billion in 2022. Third is renewable transport which contributed to avoided costs of €16.9 billion in 2022.

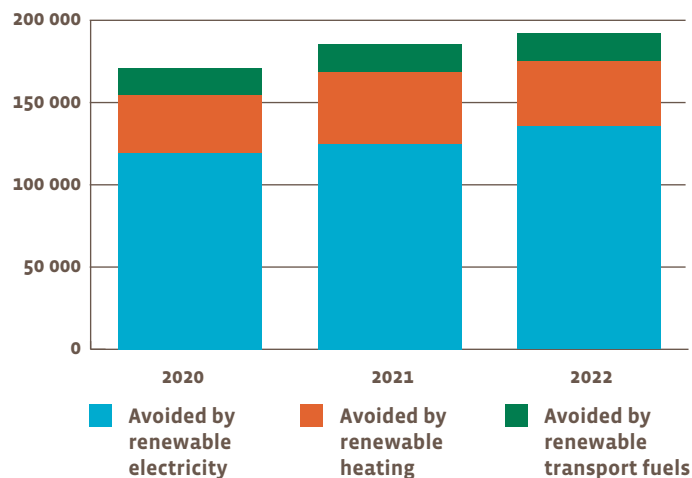
AVOIDED GHG EMISSIONS IN EU-27

While total EU27 GHG emissions were approximately 3 491 Mt CO₂eq in 2022, the gross reduction of GHG emissions due to the additional consumption of renewable energy has increased from 581 Mt CO₂eq in 2021 to approximately 604 Mt CO₂eq in 2022.

The additional uptake of renewable energy has led to a gross reduction of GHG emissions of 14.8% in 2021, compared to the reference year 2005. □

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EU-27 avoided fossil fuels per sector (ktoe)

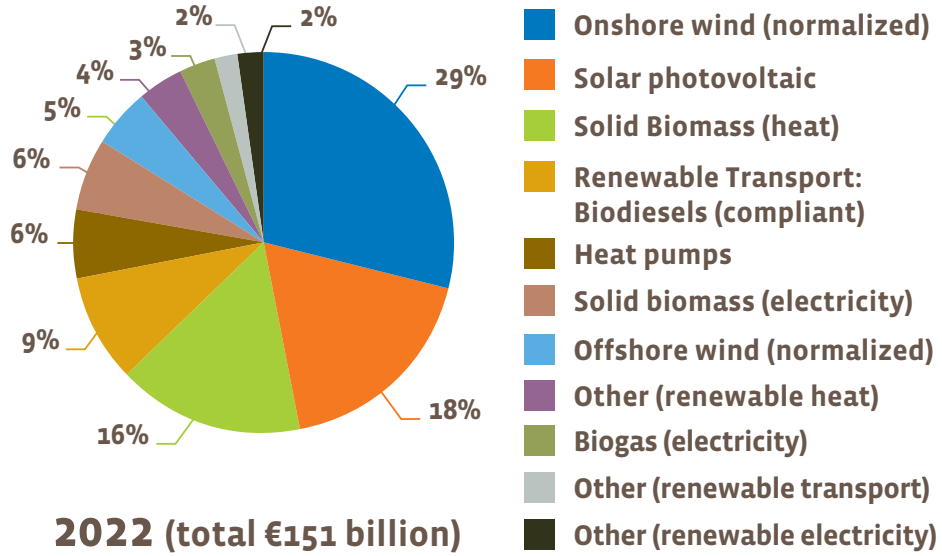


Note: Reference year 2005. Note: for 2022 proxy data are used. Source: EurObserv'ER based on EEA data.



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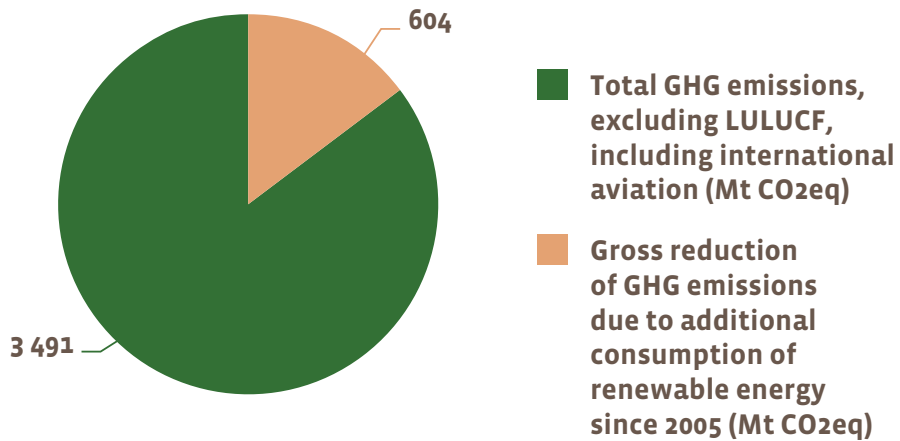
EU-27 avoided expenses through renewables



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

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Effect on GHG emissions in EU-27 in 2022



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

INDICATORS ON INNOVATION AND COMPETITIVENESS

€817.5 m

Public R&D expenditure
in all renewable energy
technologies in 2021 in the
EU-27

€2 220.5 m

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

1 352

Number of renewable
energy patent families in
the EU-27 in 2020

€14.6 bn

EU-27 trade (exports) in
2022 - all renewable energy
sources (RES)

€29.6 bn

EU-27 trade (imports) in
2022 - all renewable energy
sources (RES)

Investments into Research and Development (R&D) and innovation are commonly seen as the basis for technological changes and hence competitiveness. Consequently, they are an important factor for or driver of economic growth. Regarding renewable energy technology, R&D investments drive innovations, which are often measured by the number or share of patent applications in the respective technology field. How well the R&D output translates into a strong market position, i.e., competitiveness in renewable energy technology, on the other hand, can be measured for example by the trade share in renewable energy technology products.

R&D INVESTMENTS

In 2021 €817.5 million of public investment in R&D was invested in

the European Union for renewable technologies; €2 220.5 million were committed by private actors in 2020 (latest year available).

In terms of total public R&D expenditures the European Union and the US are clearly the two most significant among the assessed regions worldwide.

For European Union it shows that private R&D financing by far exceeds public R&D financing. Germany and Denmark are leading, followed by France, Spain, and Sweden (2020).

PATENT FILINGS

The European Union filed 1 352 patents in renewable energy. Within the European Union, it is mostly Germany that files the largest number of patents (378 patents). Analysis in terms of patents per GDP shows again Denmark in an uncontested first position in Europe.

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Main EU partners' trade with the rest of the world (including EU-27).
2022 - all RES

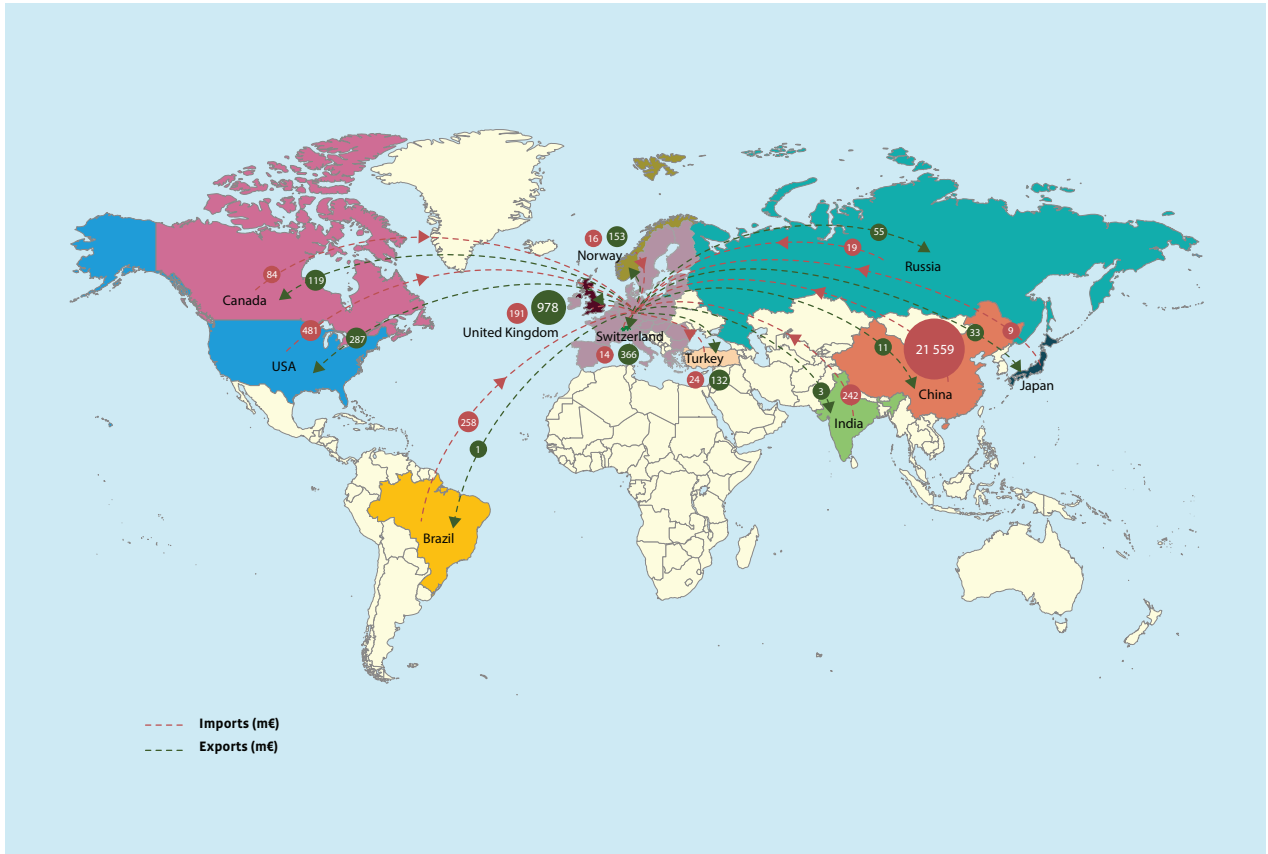
	Imports (in € m)	Exports (in € m)	Net exports (in € m)	Share of global exports	Exports specialisa- tion (RCA)
China	1 473	43 890	42 417	53,9%	49
Russia	-	-	-	0,0%	N/A*
Norway	209	1	-208	0,0%	-99
India	1 458	1 003	-455	1,2%	-20
Switzerland	652	18	-634	0,0%	-96
Turkey	1 362	244	-1 118	0,3%	-51
United Kingdom	2 059	336	-1 723	0,4%	-64
Canada	2 246	392	-1 854	0,5%	-62
Brazil	4 022	1 734	-2 288	2,1%	16
Japan	2 944	66	-2 877	0,1%	-92
USA	11 141	3 806	-7 335	4,7%	-28
Rest of the world	13 228	15 359	2 132	18,9%	-20

*Data not available



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EU-27 trade with its main trading partners. 2022 - all RES



The European Union is in a good position behind the Asian countries but ahead of the US. China remains the world leader in number of patents filed in renewable energy with 8 813 patents.

INTERNATIONAL TRADE

The trade balance of the renewable energy sectors in the European Union as a whole shows a negative balance in 2022 of €15 018 million.

The main partner remains China, which exported €21 559 million of goods and services in renewable technologies to the European Union.

When it comes to photovoltaics,

the European Union share in world exports is small (9%) compared to China's share (68%).

In wind power, Germany (31%) and Denmark (27%) are the major players in terms of export shares. They are followed by Spain, which also shows large export shares in wind energy of more than 6%.

The EU is a large player in the biofuels market, with a 43% share in global exports.

In hydroelectricity, the picture is very balanced; in 2022, net exports of hydropower goods in the European Union increased compared to 2021.

The export share of the EU increased to 50% of global exports.

The largest increase in exports is

observed for Austria, to 15% of the total export.

Overall, the EU displays a strong competitiveness in all renewable energy technology fields, yet the total export share decreased to 18% in 2022, from 21% in 2021. □



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+0,7%
Average annual energy production growth in the EU 27 member states and areas.

BIOGAS BAROMETER

16.6 TWh
62.5 TWh

Since 1998, The EurObserv'ER barometer measures the progress made by renewable energies in each sector and in each member State of the European Union in an up-to-date way as possible (with figures less than 12 months old). EurObserv'ER produces a series of figure-backed indicators covering energetic, technological and economic dimensions.

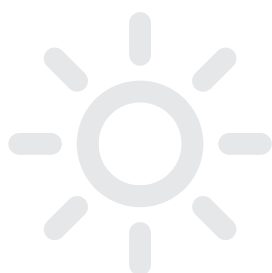
Every two months one barometer dedicated to one particular renewable energy sector is published in the magazine *Systèmes Solaires - le Journal des Énergies Renouvelables* and in PDF version. Moreover, once a year an overview barometer gathered the main indicators published during the year and complete them with additional renewable sectors which has not been detailed.

The main objectives of our barometers are the following :

- Monitor and analyse the development of renewable energy sectors in the EU
- Evaluate the RES progression compared to the 2020 objectives of the European commission
- Disseminate the results of the investigation to European journalists and energy actors
- Enable all webvisitors to download the barometer

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Schedule for the 2024 EurObserv'ER barometers

Wind power >> **March 2024**

Photovoltaic >> **April 2024**

Solar thermal + CSP >> **June 2024**

Biogas >> **Sept 2024**

Renewables in transport >> **Nov 2024**

Solid biofuels >> **Dec 2024**



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