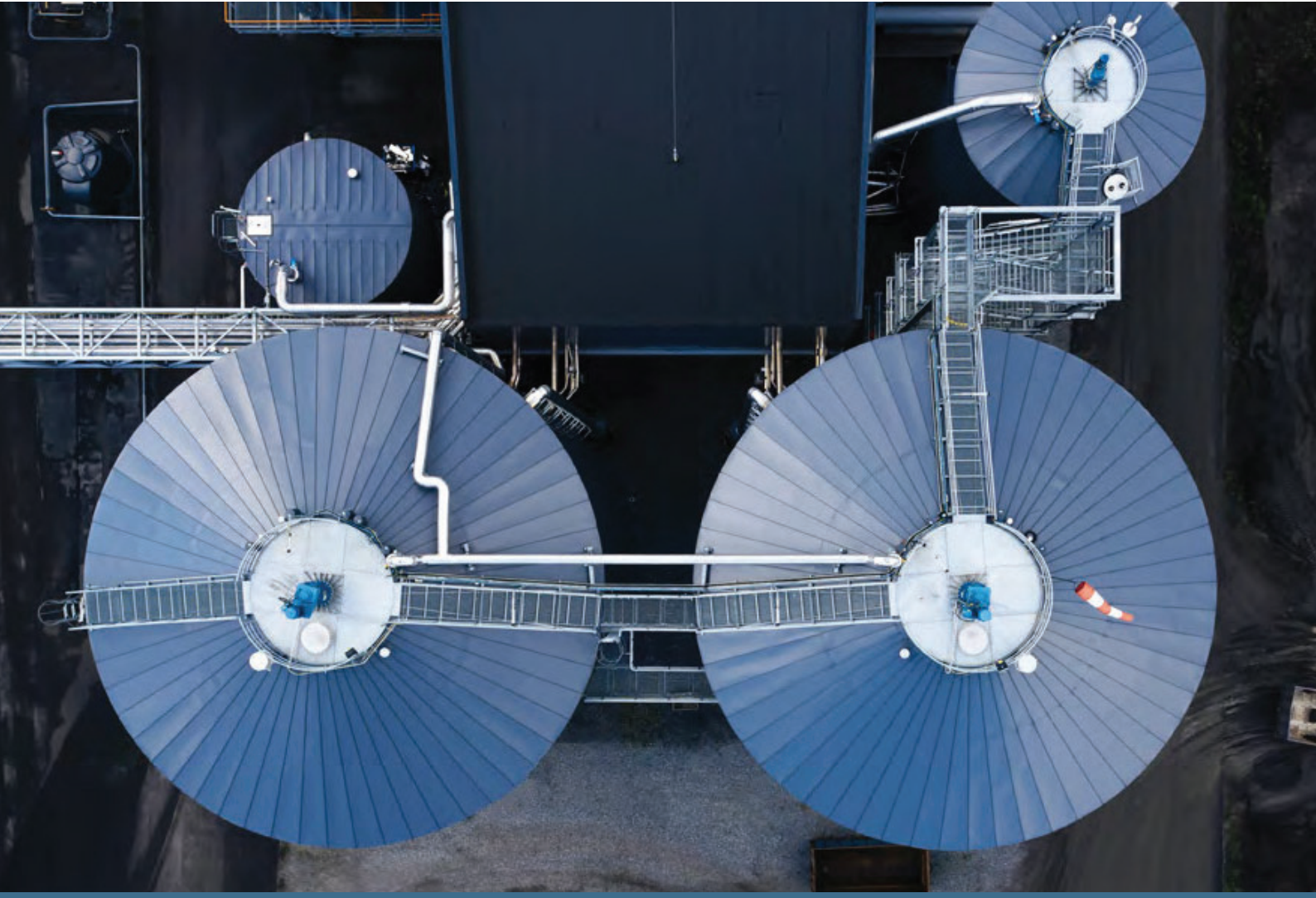


EXECUTIVE SUMMARY

THE STATE OF RENEWABLE ENERGIES IN EUROPE

EDITION 2024

23rd 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).

Funded by the

EXECUTIVE SUMMARY

THE STATE OF RENEWABLE ENERGIES IN EUROPE

EDITION 2024

23rd EurObserv'ER Report

ENERGY INDICATORS

24.6%

EU-27 RES share in gross final energy consumption in 2023 (23.1 % in 2022)

45.3%

EU-27 RES share in gross electricity consumption in 2023 (41.2% in 2022)

26.2%

EU-27 share of energy from renewable sources sources for heating and cooling in 2023 (25% in 2022)

110.8 Mtoe

EU-27 renewable heat and cooling consumption in 2023 (110.9 Mtoe in 2022)

1 230.1 TWh

Renewable electricity generation in the EU-27 in 2023 (1 156.5 TWh in 2022)

RENEWABLE ENERGY DIRECTIVE (RED III): THE RENEWABLE TARGET IS TO RISE FROM 24.6 TO 42.5% IN 7 YEARS

Renewable energies covered 24.6% of gross final energy consumption in the EU-27 in 2023. The pace must greatly accelerate to reach the new 42.5% target set by RED III by the end of 2030. As a result, EU countries must redouble their efforts to collectively meet the new EU target for 2030.

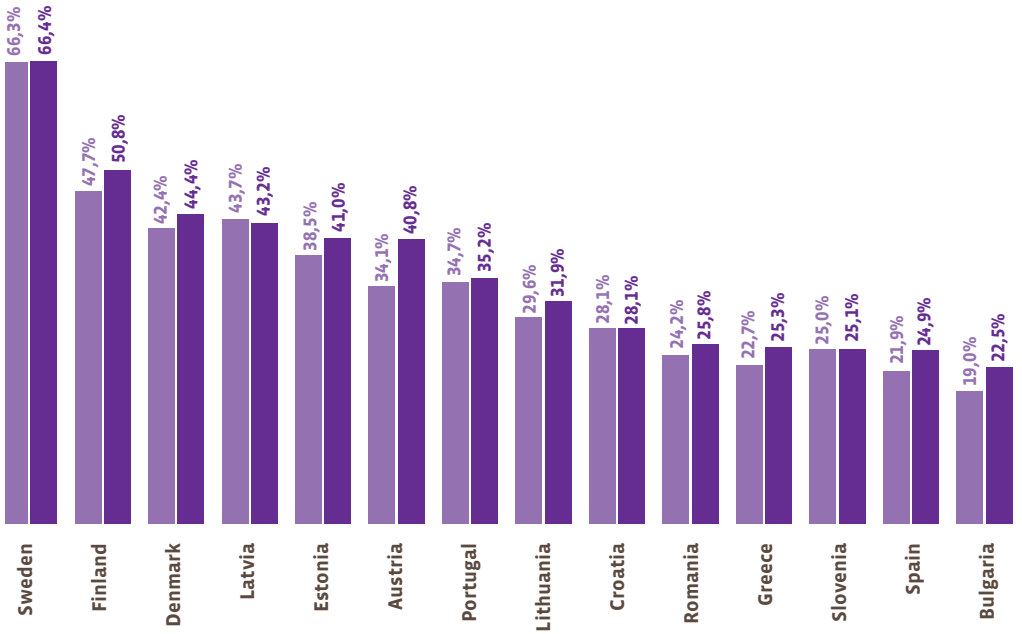
A BREATH OF FRESH AIR FOR RENEWABLY SOURCED ELECTRICITY

EU electricity production output saw a rise of 12.7% from 2022 to 2023.1 230.1 TWh of renewable electricity was produced in 2023, with wind power being the largest source (478.1 TWh, i.e., 39.1% of total renewable electricity production), followed by hydropower (329.9 TWh) and photovoltaics (252.1 TWh). Biomass came again fourth with 156.4 TWh.

The renewable share of gross electricity consumption in European Union reached 45.3% in 2023 recording 10% more than in 2022 when the RES share was measured at 41.2%. □

1

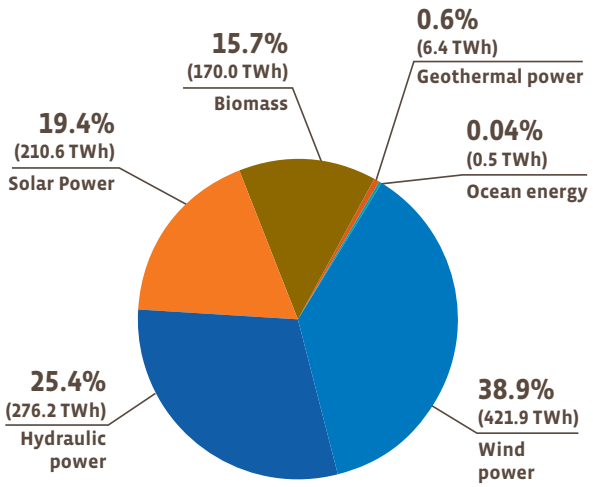
Overall share of energy from renewable sources (%) - According the Directive (EU) 2018/2001



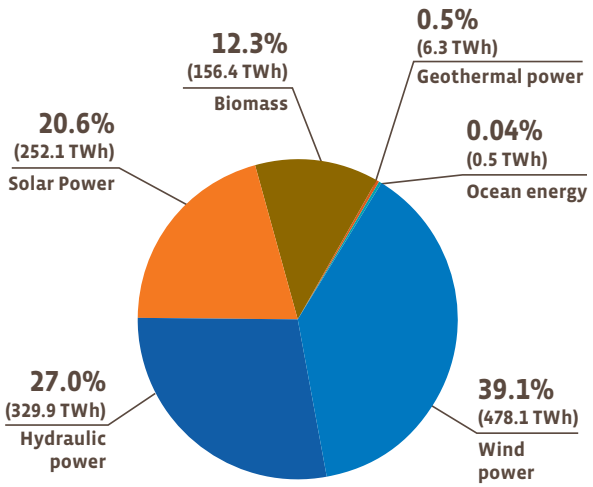
Source: Eurostat (updated 14th February 2025)

2

Share of each energy source in renewable electricity generation in 2022 and in 2023 in the EU-27 (in %) according the Directive (EU) 2018/2001 specifications.

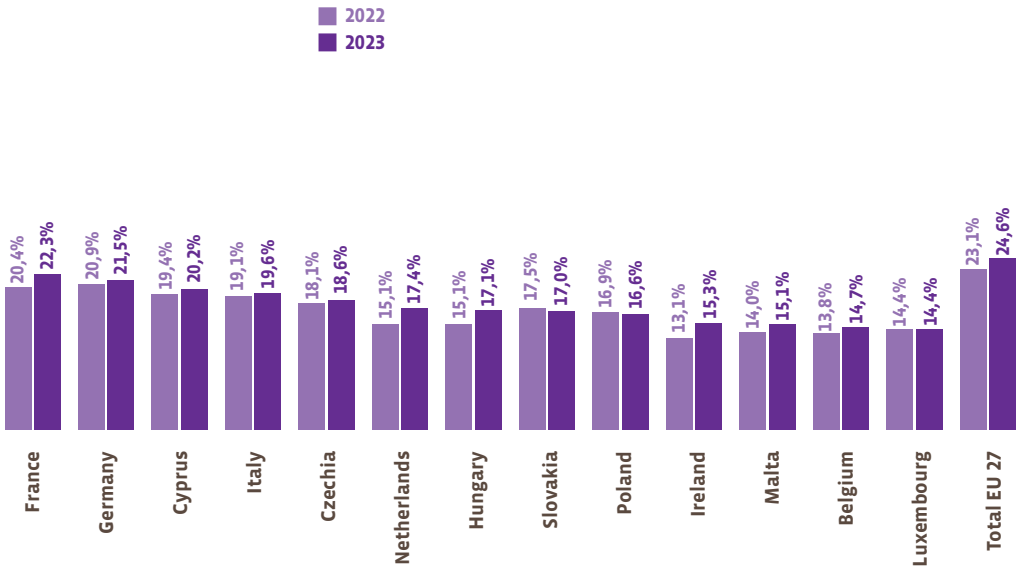


2022: total 1 085.6 TWh



2023: total 1 232.2 TWh

Notes for calculation: Hydro is actual (not normalised) and excluding pumping. Wind is actual (not normalised). All electricity production, compliant or not with renewable Directives, from solid biofuels, biogas (pure and blended in the gas natural grid) and bioliquids is included. Source : EurObserv'ER from Eurostat database (updated 28 january 2025).



ENERGY INDICATORS

69.3 GW

Additional electrical renewable capacities connected to EU-27 grids in 2023 (50.1 GW in 2022)

54.8 GW

Electricity storage capacity installed in the EU-27 at the end of 2024 (48.7 GW in 2023)

4.76 GW

Installed in pumped hydro storage capacities installed in EU-27 at the end of 2024

87.8 %

Share of energy from renewable sources in gross electricity consumption in Sweden (2023)

MARKET SHARES OF THE POWER GENERATING CAPACITIES INSTALLED IN 2023 BY TECHNOLOGY

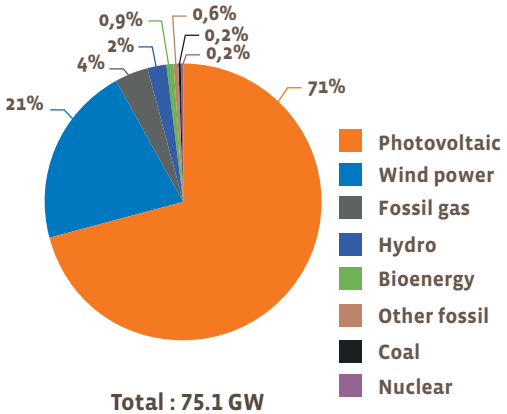
In 2023, 92% of newly connected electricity capacity within the EU was related to renewable technologies (compared to 94% in 2022). Photovoltaics remains by far the leading technology ahead of wind power. Graph 3 shows the breakdown of additional electricity capacity connected in 2023 according to the different technologies within the European Union. 69 345 MW out of a total of 75 105 MW came from renewable technologies. Photovoltaic is still the most representative sector with 53 124 MW installed, accounting for 71% of the additional electrical capacity clearly ahead from its performance in 2022 (61%). Wind power remains around 21%. As for fossil fuels, gas represented 8%. It has to be noted that 1,6 GW from nuclear sector has been connected in Finland.

RENEWABLE HEATING AND COOLING

In 2023 renewable sources accounted a little over 26.2% of the EU'S total final energy consumption for heating and cooling, recording 12% more than that in 2022. The total renewable energy used for renewable heating and cooling is 110.8 Mtoe in 2023 as compared to 110.9 Mtoe in 2022. In 2023, the renewable share of heat and cooling consumption was 26.2%. According to the specifi[1] cations of Directive (EU) 2018/2001, 110.8 Mtoe was produced, 69.9% of which came from solid biofuels (77.4 Mtoe) in a context of prevai[1] ling low heating requirements and higher biomass fuel prices. Heat pumps ranked second with 19.8 Mtoe. In buildings, consumption and market shares of coal and oil boilers are slowly decreasing, while heat pumps and district heating are increasing (see Figures 4 and 5). □

3

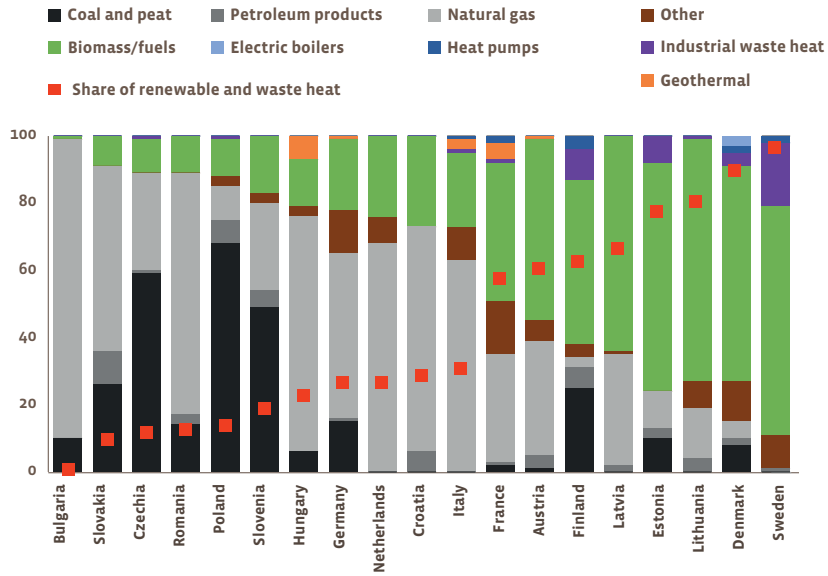
Distribution of additional electrical capacities connected to EU-27 grids in 2023 by technology



Source: EurObserv'ER - Ember

4

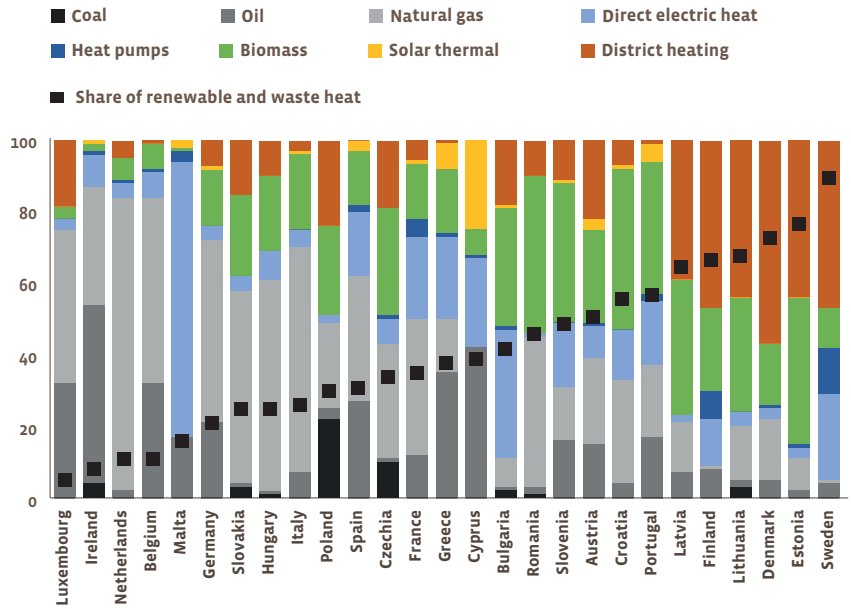
District heating supply mix in 2022



Source: Own assessment based on diverse sources: Eurostat, Euroheat & Power DHC Market Outlook Insights & Trends 2023 and data from national statistic institutes of the MS. *Notes: Based on 2021 data for: BG, DE, AT, FI, SE, HR, RO, PO, CZ, SI, HU, IT, EE, FR, DK, LT; 2018 data for: NL, SK. Other includes renewable and non-renewable forms of energy such as non-renewable waste, solar thermal, etc.. 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).*

5

Consumption shares in heating in 2022



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

1 864 600

FTE jobs in the European renewable energy industry in 2023 (1 692 000 in 2022)

560 300

Jobs in EU-27 PV sector in 2023 (346 900 100 in 2022)

432 900

Jobs in EU-27 heat pump sector in 2023 (416 200 in 2022)

333 800

Jobs in EU-27 wind sector in 2023 (273 500 in 2022)

€233 bn

Turnover generated by renewable energy sources in EU-27 in 2023 (€205.5 bn in 2022)

€66.3 bn

Turnover of photovoltaic sector in the EU in 2022

EMPLOYMENT

Around 1.86 million persons are directly or indirectly employed in the European Union renewable energy sector, which represents a gross increase of 229 500 jobs (14.0%) from 2022 to 2023.

The solar PV sector became the largest sector in terms of employment with 560 300 jobs, making 30% of the total EU. It was followed by heat pumps contributing 432 900 jobs (23% of the total EU) and wind with 333 800 jobs (18% of the EU) respectively. Increases were also observed in the hydropower, heat pumps and MSW sectors. The increases balance out declines in the solar biomass, biofuels, biogas, solar thermal and geothermal sectors.

22 out of 27 Member States either increased or maintained their number of renewable energy jobs, while the largest growth in employment estimates was found in Spain (+73 900 new jobs, equal to +47%, mostly due to growth of solar PV), Germany (+63 600, equal to +22%), and Netherlands (+27 800 jobs, equal to +36%).

TURNOVER

In total the renewable energy related industry turnover in European Union Member States in 2023 amounted to around €233 billion, representing a gross growth of around €27.5 billion against 2022 (+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 (€54.6 billion), Italy (€31.5 billion), France (€30.9 billion), Spain (€25.3 billion), and the Netherlands with €16.2 billion.

As for jobs, the largest renewable energy technologies in terms of industry sector turnover were solar PV with €66.3 billion, followed by heat pumps at €58.8 billion and wind at €51.4 billion. □

6

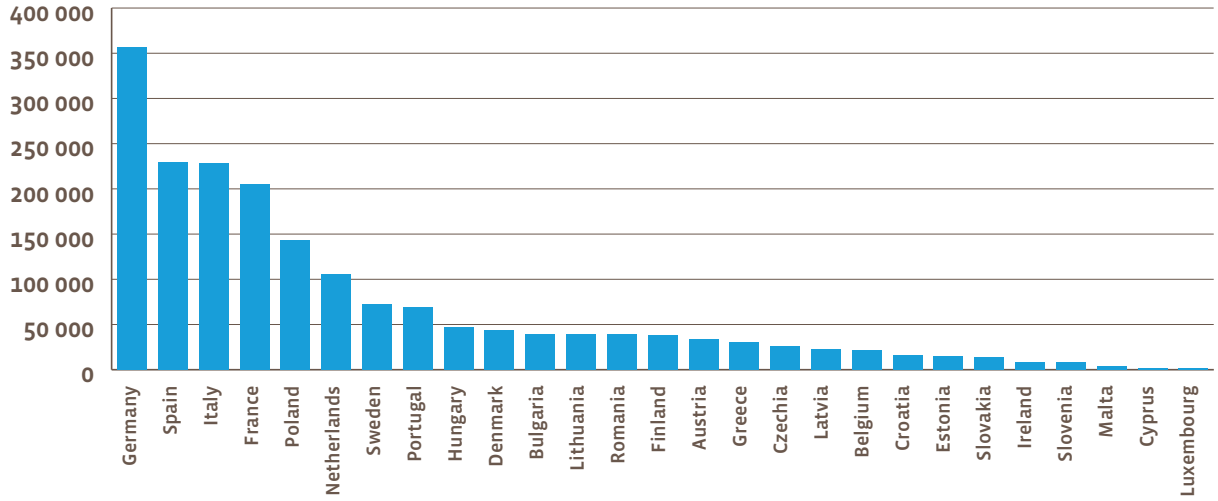
2023 Total turnover (€M)

Germany	54 560
Italy	31 530
France	30 920
Spain	25 350
Netherlands	16 160
Sweden	13 050
Denmark	9 160
Poland	8 530
Finland	8 040
Austria	6 290
Belgium	4 800
Portugal	4 300
Greece	2 810
Hungary	2 570
Romania	2 100
Bulgaria	2 020
Czechia	1 740
Lithuania	1 700
Estonia	1 260
Ireland	1 260
Latvia	1 190
Slovakia	1 040
Croatia	810
Slovenia	670
Malta	360
Luxembourg	250
Cyprus	190
Total EU-27	**232 660**

Source: EurObserv'ER

7

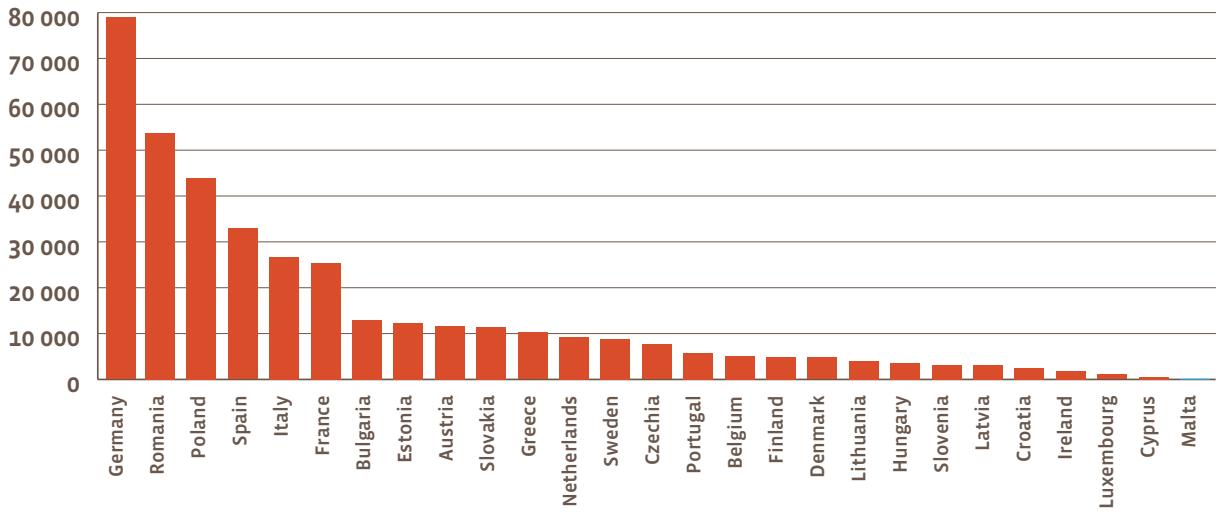
Gross renewable employment from previous sections (data for 2023)



Source: EurObserv'ER

8

Indicator for equivalent replaced fossil employment, looking at operation, maintenance, and fuel production activities only (data for 2023)



Source: EurObserv'ER

RENEWABLE ENERGY COSTS AND ENERGY PRICES

€128/MWh

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

€82/MWh

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

€114–211 / MWh

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

€55–98 / MWh

Estimated cost level for hydropower generation in the EU-27

NAVIGATING UNCERTAINTY: INVESTMENT COSTS ESTIMATIONS

Over the past decades the trend in renewable energy was relatively stable: for solar PV and wind power 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. We have based the investment cost estimate on a range from literature, with 2024 as a reference year.

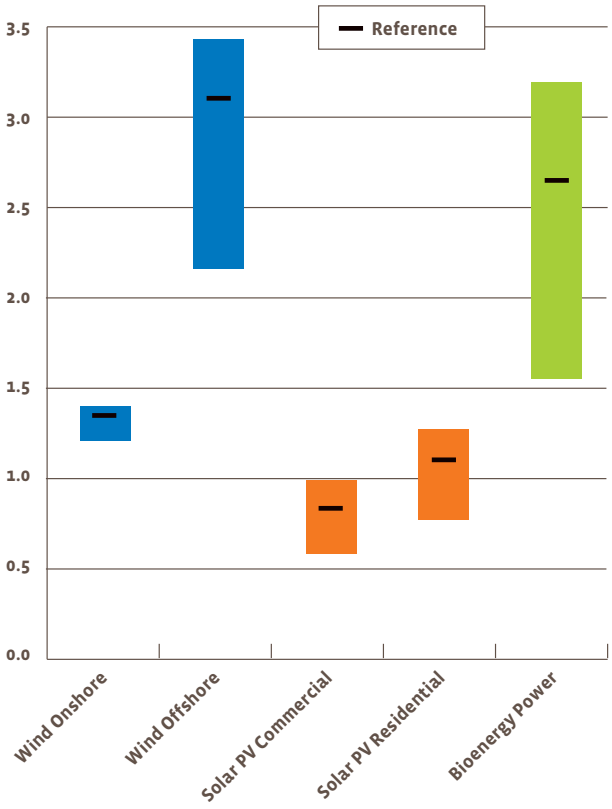
WEIGHTED AVERAGE COST OF CAPITAL (WACC)

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 Levelized Cost of Energy (LCoE).

WACC values have decreased across almost all technologies and member states in 2024, compared to 2023. This effect can be explained mainly by the decrease in debt interest rates. Decreasing interest rates lower the cost of debt, making borrowing cheaper, which in turn reduces the overall WACC. For categories with significantly higher operational risk or policy risk, bioenergy and other technologies, the return

9

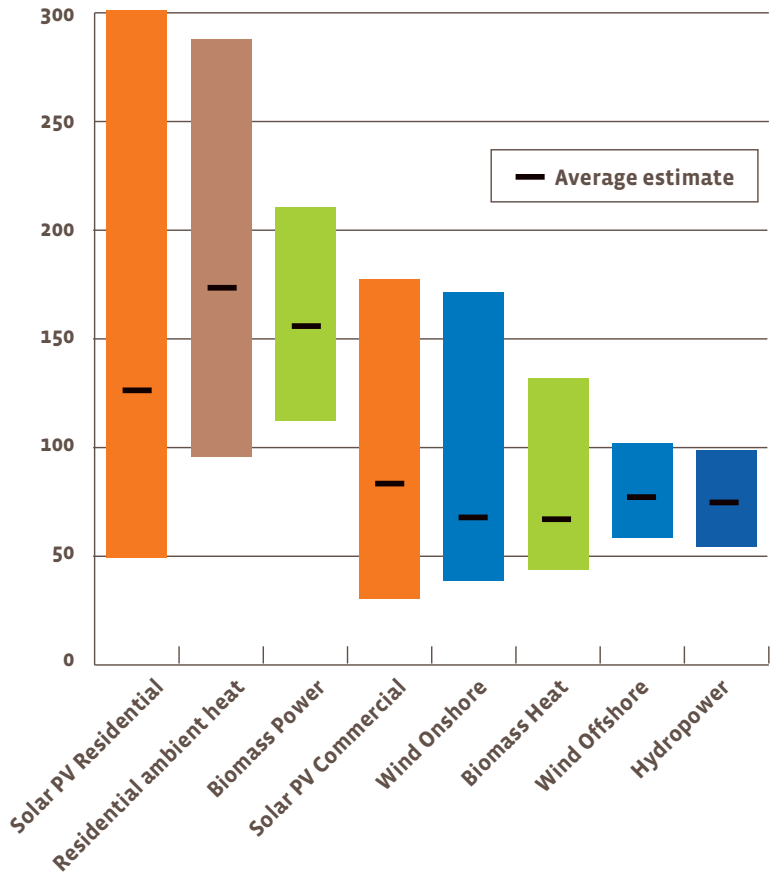
Renewable energy investments costs estimated for the year 2024 (M€/MW)



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

10

Levelised cost of energy in the European Union [€/MWh] based on investment cost estimates for 2024 and WACC data for 2024



Note: based on investment cost estimates for 2024 and WACC data for 2024.
Source: EurObserv'ER

on equity is unchanged at 11.5 percent. In contrast, returns on equity for solar PV and wind power have reduced by one percentage point from the previous year to 7.0 and 8.0 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, Luxemburg) to above 5-6% 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 2024

LCoE values differ across countries because of varying yield of renewable sources throughout the European Union and differences in financing parameters.

For electricity production, onshore wind has the lowest average LCoE in 2024 (55 €/MWh), ahead of hydropower (65 €/MWh) and offshore wind (68 €/ MWh), followed by power from large commercial photovoltaic plants (72 €/MWh). For heat production, the lowest average LCoE observed is for heat from biomass (55 €/ MWh).

PRICES OF ENERGY

Prices for natural gas and electricity for households and non-households show an increase from 2022 to 2023. The effect of higher energy and supply prices on the average household price level was mitigated by tax alleviation and other support measures against high energy prices, as introduced by many European Union Member States. □

AVOIDED FOSSIL FUEL USE AND RESULTING AVOIDED COSTS

206 Mtoe

EU-27 substituted fossil fuels by RES in 2023 (194 Mtoe in 2022)

653 MtCO2 eq

Avoided GHG emissions through RES consumption in the EU-27 in 2023 (614 MtCO2 eq in 2022)

€117 bn

EU-27 avoided expenses through renewable energy sources in 2023 (165 bn in 2022)

MORE RENEWABLE ENERGY MEANS LESS FOSSIL FUELS AND ASSOCIATED COSTS

In 2023 and 2022 the use of renewable energy substituted around 206 Mtoe of fossil fuels, compared to the level of use of renewable energy in 2005.

The use of renewable electricity contributed to 71% of the total avoided fossil fuels in 2023, followed by renewables in the heating and cooling sector contributing to 20% and the remaining share was substituted through renewable transport fuels.

While the penetration of renewable energy (expressed in avoided fossil fuels) expanded by approximately 6% from 2022 to 2023, the effect of the avoided fossil fuel expenses is, with a 29% decrease (from €165 billion to €117 billion) more pronounced than the growth in renewable energy. Reason for this is the strong decrease in fossil fuel prices in 2023 compared to 2022.

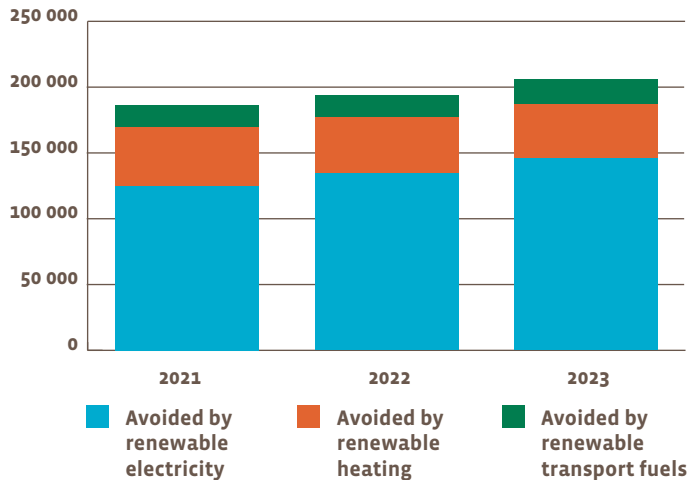
In monetary terms, the avoided costs were €30.4 billion in 2023 in the on-shore wind sector. Second, solar photovoltaics contributed to avoided costs reaching to €20.6 billion in 2023. Third is solid biomass for heat purposes which contributed to avoided costs of €17 billion in 2023.

AVOIDED GHG EMISSIONS

While total GHG emissions in the European Union were approximately 3239 Mt CO2eq in 2023, the gross reduction of GHG emissions due to the additional consumption of renewable energy has increased from 614 Mt CO2eq in 2022 to approximately 653 Mt CO2eq in 2023. The additional uptake of renewable energy has led to a gross reduction of GHG emissions of 16.8% in 2023, compared to the reference year 2005. □

11

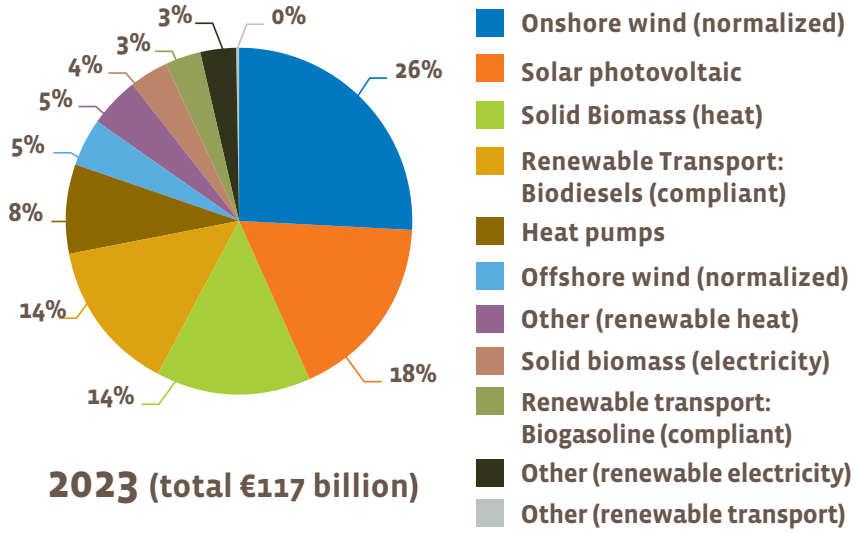
EU-27 avoided fossils fuels per sector (ktoe)



Note : Reference year 2005. Note: for 2023 proxy data are used.
Source: EurObserv'ER based on EEA data.

12

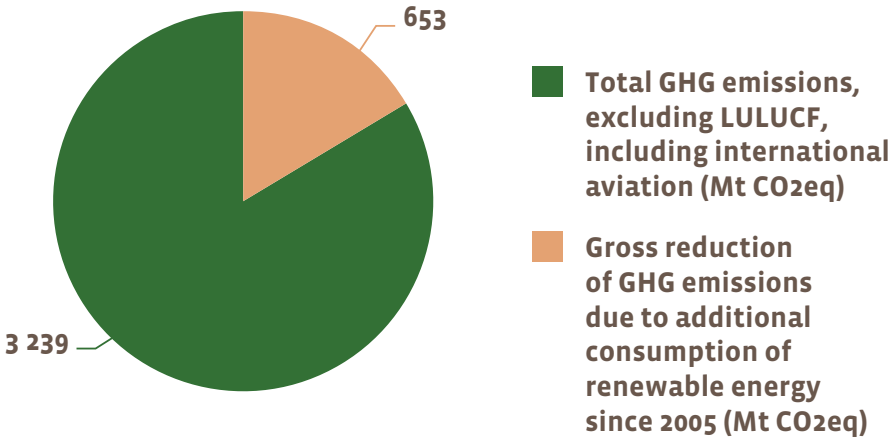
EU-27 avoided expenses through renewables



Note : Reference year 2005. Note: for 2023 proxy data are used. Source: EurObserv'ER based on EEA data.

13

Effect on GHG emissions in EU-27 in 2023



Note: Reference year 2005. ***Source: Eurostat, EurObserv'ER based on EEA data.***

INDICATORS ON INNOVATION AND COMPETITIVENESS

€1 070.0 m

Public R&D expenditure in all renewable energy technologies in 2022 in the EU-27 (€852.71 m in 2021)

€2 232.23 m

Private R&D expenditure in all renewable energy technologies in 2021 in the EU-27 (€2 964.52 m in 2020)

1 081.1

Number of renewable energy patent filings in the EU-27 in 2021

€14.4 bn

EU-27 trade (exports) in 2023 - all renewable energy sources (RES)

€29.7 bn

EU-27 trade (imports) in 2023 - 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 2022 €1 070.0 million of public investment in R&D was invested in the European Union for renewable technologies; €2 032.23 million were committed by private actors in 2021 (latest year available).

In terms of total public R&D expenditures the European Union and the US are still 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. Denmark and Germany are leading, followed by Spain, France, and Netherlands (2021)..

PATENT FILINGS

The European Union filed 1 081.1 patents in renewable energy for the year 2021(latest available). For the same year, within the EU, it is mostly Denmark that filed the largest number of patents (228.1 patents) ahead of Germany that filed the largest number for 2020. Analysis in terms of patents per GDP shows again Denmark in

14

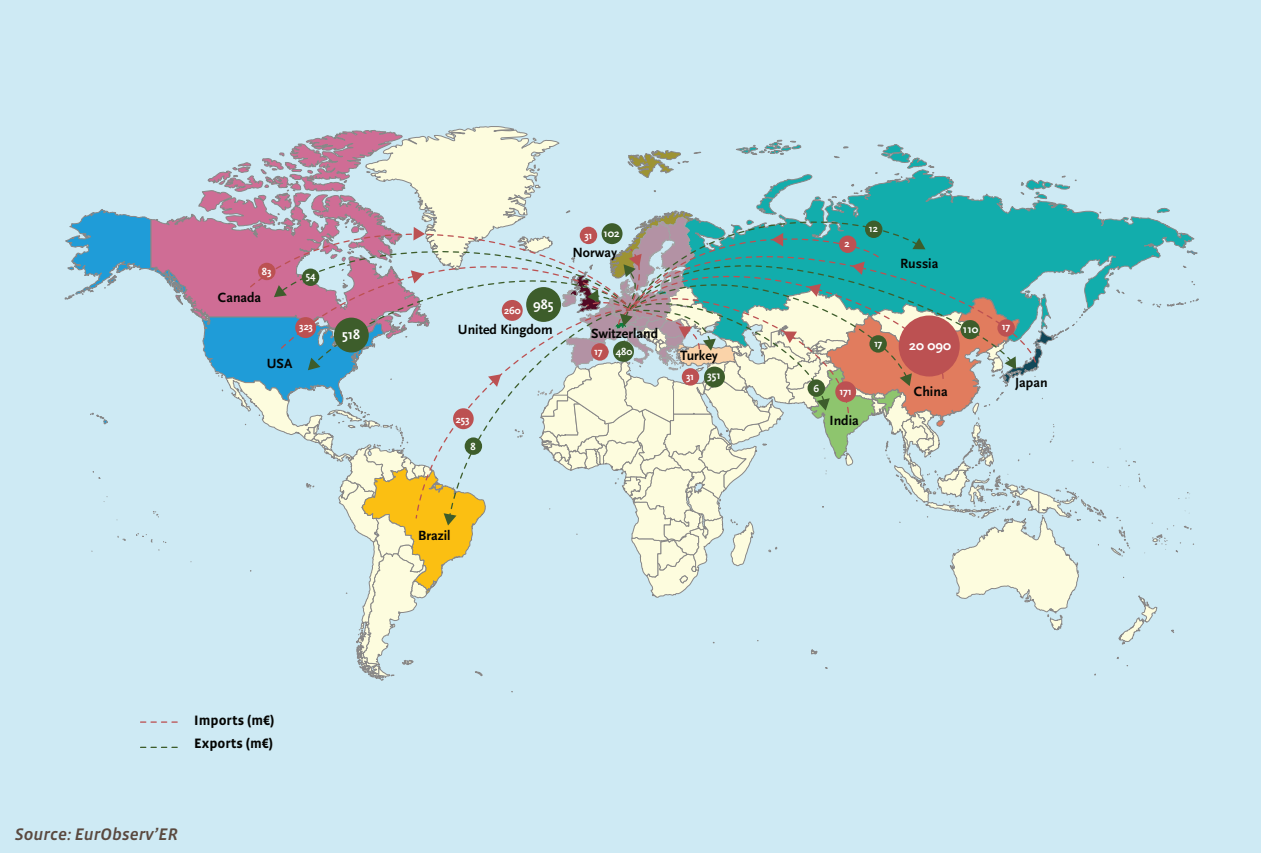
Main EU partners' trade with the rest of the world (including EU-27). 2023 - all RES

	Imports (in € m)	Exports (in € m)	Net exports (in € m)	Share of global exports	Exports specialisation (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

Source: EurObserv'ER

15

EU-27 trade with its main trading partners. 2023 - all RES



Source: EurObserv'ER

an uncontested first position in Europe for 2021.

The European Union is in a good position behind the Asian countries but ahead of the US. China remains the world leader with 16 540.8 patents filed in renewable energy for 2021.

INTERNATIONAL TRADE

The trade balance of the renewable energy sectors in the European Union shows a negative balance in 2023 of €15 325 million. The main partner remains China, which exported €42 753 million of goods and services in renewable technologies to the European Union in 2023.

When it comes to photovoltaics, the European Union share in world exports is small (9%) compared to China's share (67.9%).

In wind power in 2023, Germany (31.2%) and Denmark (26.8%) 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 5.8%.

The EU is a large player in the biofuels market, with a 43% share in global exports in 2022 (latest data available)

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 has slightly decreased to 17% in 2023, from 18% in 2022. □

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:

Diane Lescot or Frédéric Tuillé
Observ'ER
20 ter rue Massue
94300 Vincennes
Tél. : +33 (0)1 44 18 00 80
E-mail: diane.lescot@energies-renouvelables.org
Internet: www.energies-renouvelables.org

Schedule for the 2025 EurObserv'ER barometers

Wind power	**>> March 2025**
Photovoltaic	**>> April 2025**
Solar thermal	**>> June 2025**

Editorial director: Diane Lescot
Deputy editor-in-chief: Frédéric Tuillé
Editorial coordination: Romain David
Editors: Observ'ER (FR), TNO (NL), Renewables Academy (RENAC) AG (DE), Fraunhofer ISI (DE), VITO (Flemish Institute for Technological Research) (BE) and Statistics Netherlands (NL)
Translation: Lise Decaunes - Traduction 64, Shula Tennenhaus
Graphic design: Lucie Baratte/kaleidoscopeye.com
Production Executive Summary: Uta Zähringer, Susanne Oehlschlaeger / Renewables Academy (RENAC) AG
Pictograms: bigre! et Lucie Baratte/kaleidoscopeye.com
Cover photo credit: EDF Renouvelables/Rémi Flament

Observ'ER
20 ter rue Massue
94300 Vincennes
Tél. : +33 (0)1 44 18 00 80
www.energies-renouvelables.org