Annual Report 2024

Portugal

Photo: *Measuring at the sea in the coast of Portugal. Credit: José Miguel Garro, EOLOS.* *(Photo credit: José Miguel Garro, EOLOS.)*

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In 2024, the new wind power capacity installed amounted to 64 MW. This capacity results from overcapacity procedures and expansions at existing sites, with only one new wind park being installed.

A new version of the NECP 2030 was released, with wind power continuing to play an important role in decarbonization of the power system, setting targets of 10.4 GW for onshore wind and 2.0 GW for offshore wind.

For the offshore case, these values align with the work achieved by the ministerial working group created by the Portuguese government to accelerate the offshore wind market.

The objective of this group is to establish the necessary conditions for the allocation and installation of 2 GW by 2030 through capacity auctions.

The main R&D work in 2024 was focused on training activities in wind energy digitalisation (project TWEED) and create intelligent systems supporting autonomous wind power plant operations (project INTELLIWIND) as well as in developing new larger segmented wind blades to improve performance and environmental sustainability of the materials (project RiSEnergy).

Total (net) installed wind power capacity	5.957 GW
Total offshore capacity	0.025 GW
New wind power capacity installed	0.064 GW
Decommissioned capacity (in 2024)	NA
Total electrical energy output from wind	14. 45 TWh
Wind-generated electricity as percent of national electricity demand	27.2 %
Average national capacity factor	27.7 %
Target	10.4 GW onshore 2.0 GW offshore by 2030
National wind energy R&D budget	N/A

Table 1. *Key Statistics 2024: Portugal*

Highlights

- New installed capacity during 2024 was 64 MW.

- Wind generation constituted 27% of electricity demand.

- Several 15-minute intervals recorded wind power contributions exceeding 100% of demand, with the peak reaching 113%. A new record for daily contribution by wind: 86% of demand.

- New measures for the National Energy and Climate Plan for 2030 were approved in the end 2024

Market Development

A revised version of the 2030 National Energy and Climate Plan (NECP) [1], released during 2024, outlines the 2030 targets for renewable power capacity. In the case of wind power, the objective is to achieve an accumulated capacity of 12.4 GW by the end of 2030, using strategies such as overcapacity, repowering, and dedicating 2.0 GW to offshore wind energy technology. These new targets reinforce the ambitious goals of Portugal, going beyond some of the targets outlined in the Portuguese Roadmap for Carbon Neutrality 2050 (RCN2050) [2], which projected a vision for 2050 with onshore wind power capacity between 12.0 to 13.0 GW and offshore capacity between 0.2 to 1.3 GW.

During 2024, the development plan for offshore was still under discussion in the involved Ministries for final approval expected for the beginning of 2025, mainly in what concerns the definition of the final areas that were adjusted after the public consultation that occurred until the end of 2023.

A key step to support offshore development is the action RP-C21-I07.02 – Technical Studies for Offshore Energy Potential [3]. Several activities started in 2024, with the investment in experimental campaigns related to geophysics, geotechnics, wind, waves, and currents in the Atlantic Ocean. These studies will support stakeholders in future auctions of offshore zones established in the PSOEM by reducing the uncertainties in the investment.

Progress and Operational Details

During 2024, the wind power cumulative capacity increased by 64 MW (see Figure 1). By the end of year, the cumulative installed capacity was 5,957 MW distributed over 268 wind parks, corresponding to 2,938 wind turbines [4]. The Portuguese wind power fleet generated 14.45 TWh, which accounts for approximately 27.2% of electricity demand [5-7], a share comparable to the record set in 2019.

Decentralized wind power cumulative capacity significantly increased in 2024, mainly for self-consumption, reaching 5.7 MW, 2 MW more than in 2023 [4].

Despite the increment in the total generation, the wind share of the total renewable energy production decreased by 3% from 2023 to reach a total share of 33% in 2024 [4].

In the continent, this decrease is mainly due to the 2% increase in hydropower production attributable to a rainy year, with the hydro generation index reaching 1.16 [5]. In addition, solar power continues to grow significantly in Portuguese power system, increasing its contribution by 2% compared to 2023, now standing at a 16% of total renewable energy generation [4].

The average wind power production at full capacity (including Madeira and Azores islands) stood at 2,346 full load hours, just two hours more than in 2023 [4]. For Portugal mainland, the Portuguese transmission system operator (TSO) indicated an annual wind generation index of 1.06, representing

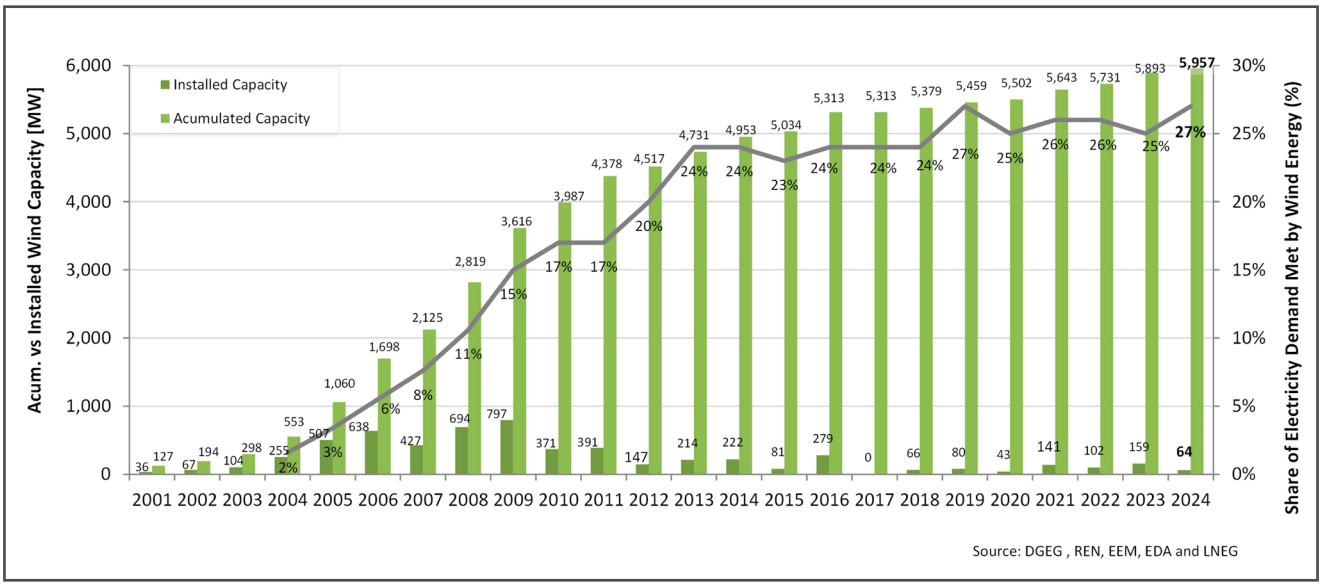

Figure 1. *Installed and cumulative wind power capacities and share of electricity demand met by wind energy (line graph) (source: REN, DGEG, EEM, EDA and LNEG).*

an increase of 7% compared with the previous year [5].

Based on data from TSO, Figure 2 depicts the demand and wind generation profiles on the following:

- The maximum demand day and the respective wind power contribution: The maximum instantaneous demand value (9,739 MW) occurred at 19:45 on the 8th of January 2024, when wind generation was 1,400 MW (24 % of the capacity installed).

- Maximum daily and instantaneous peak wind contributions from the wind: On the 24th of November 2024, wind power supplied Portugal with 110 GWh of electricity, setting a record. On the same day, wind generation reached a peak instantaneous penetration of 113% in a 15-minute interval. The daily wind contribution during this day was 88%.

Of the wind penetration values recorded in 2024, the TSO did not report any technical problems during these events or wind energy curtailment occurrences.

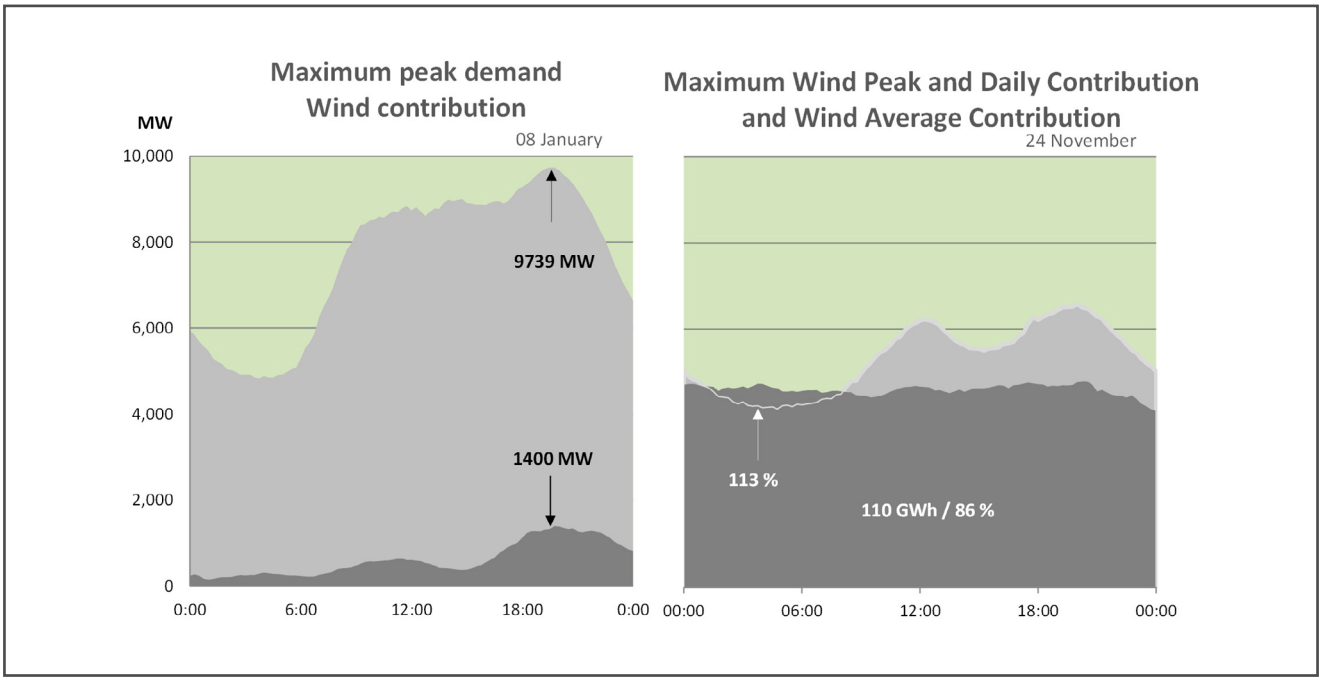

Figure 2. *Demand, wind power contribution and energy generation records during 2024. (Source: REN and LNEG.)*

Matters Affecting Growth and Work to Remove Barriers

According to the NECP 2030, there is additional wind energy potential to be developed in Portugal. At the same time, the plan considered essential to improving the efficiency and competitiveness of existing wind parks through overcapacity and repowering procedures [8]. As in previous years and after the adoption of the Accelerate RES Installation Legislation in 2022 [9], several legal documents were published in 2024 to support and update this legal document. One example is the Dec-Lei nr. 99/2024, 3rd of December that amends the regulatory framework applicable to renewable energies.

Portugal has recently updated its legal framework on environmental and energy matters. Decree-Law No. 151-B/2013, which sets the rules for environmental impact assessments of public and private projects, was amended for the eighth time. Decree-Law No. 15/2022, which governs the National Electric System, underwent its fourth amendment through Law No. 24-D/2022 and Decree-Laws No. 11/2023 and 104/2023, aligning it with national energy goals. Following the energy crisis caused by the Russia–Ukraine conflict, Order No. 15185-C/2024 approved regulations for municipal compensation, initially introduced in 2022, and established a maximum compensation amount. Decree-Law No. 116/2024 extended the exceptional measures adopted in 2022 to simplify renewable energy production procedures.

To support the National Energy and Climate Plan (NCEP) 2030 and complement Decree-Law No. 15/2022, a public consultation was launched for the 2026–2030 investment plan for the national electricity distribution network, held from 19 November 2024 to 2 January 2025.

RD&D Activities

National RD&D Priorities and Budget

National R&D priorities for 2024 include training facilities to create doctoral networks in wind energy digitalization and developing intelligent systems that support autonomous wind power plant operations. The first project has been launched to create an open-source and cybersecure digital twin for onshore wind park investors, providing valuable insights for operational and investment decisions.

Portugal also develops sophisticated world-class robotic solutions for inspecting operations and maintenance for fixed and offshore wind parks. Additionally, a new project to develop larger, segmented wind blades with improved performance and environmental sustainability was launched.

Most R&D activities are developed at R&D institutes and universities and are funded through national and/or European programs. The Portuguese Foundation for Science and Technology (FCT) invested EUR 675 million in science and technology in 2024. Approximately EUR 118 million was for RD&D and innovation projects on different topics, while EUR 147 million went towards scientific jobs [10]. These numbers represent a 2.5 % increase in total investment, 18.8% decrease in RD&D investment and a 2.9 % increase in scientific jobs compared to 2023 [10].

National Research Initiatives and Results

Two demonstration projects were launched: The project SUNRISE [11] deals with the demonstration of a 5 MW grid-connected OFPV (Offshore floating PV) system integrated within a commercial offshore wind park to foster the trust needed for the upscaling of the technology. Prior to the demonstration, its technical reliability will be validated in the most extreme conditions through laboratory measurements, wave-wind tank tests, and modelling studies.
The project FLOATFARM [12] aims to advance the maturity of the floating offshore wind technology for increasing energy production and reduce cost of energy and minimize negative environmental impacts on marine life using innovative codesign approaches.

Test Facilities and Demonstration Projects

Portugal's ongoing R&D activities are as follows:

- RISEnergy: A Horizon Europe project aimed at researching infrastructure services to increase offshore wind energy efficiency and reduce offshore wind technology costs. [13].

- REVOLUTION_WIND: A Horizon Europe Demonstration Project aimed at developing new technology that will enable the production of larger, segmented wind blades with improved performance and sustainability [14].

- NiD4OCEAN: A Horizon Europe Project promoting advancing nature-inclusive designs (NiDs) and nature-based solutions (NBS) for offshore wind renewables supporting sustainable energy and biodiversity goals [15].

Collaborative Research

Portugal currently participates in the following EA Wind tasks:

Task 25 - Design and Operation of Power Systems with Large Amounts of Wind Power

Task 28 - Social Acceptance of Wind Energy Projects

Task 34 - Working Together to Resolve the Environmental Effects of Wind Energy (WREN)

Task 51 - Forecasting for the weather-driven energy system

The Portuguese participation in these tasks provides scientific and technical support to the Secretariat of State (Environment and Climate Action State Secretary) that leads the R&D activities in Portugal, and to the development of R&D projects. Portugal has observer status in Task 49 - Integrated DEsign of floating wind Arrays (IDEA).

In addition to the IEA Wind TCP activities, Portugal is represented in the European Energy Research Alliance

Wind Programme (EERA-Wind), the Energy Systems Integration (EERA-ESI), and the European Sustainable Energy Innovation Alliance (ESEIA).

Portugal continues to coordinate the COST Action, MODENERLANDS, related to sustainable energy islands covering offshore floating power systems, their regulation and grid integration, and their socio-economic and environment aspects.

Concerning R&D in Portugal, the following list presents some examples of Portuguese participation in national and international projects:

AEROSUB: A Horizon Europe project to develop world-class robotic solutions for fixed and floating offshore wind power parks for operation and maintenance (O&M) procedures [16].

WindTwin: A Horizon Europe project to develop a digital twin of an offshore wind park to accurately predict power production and energy demand. [17].

TWEED: A Horizon Europe project to provide Wind Energy Experts on Digitalization (TWEED) to create a doctoral network for training researchers in wind energy digitalization [18].

TWINVEST: A Horizon Europe project to create open-source and cybersecure digital twin to provide investors in onshore wind parks valuable insights for operations and investments [19].

INTELLIWIND: A Horizon Europe project to train multidisciplinary researchers to develop intelligent systems that support autonomous wind power plant operations [20]

Impact of Wind Energy

Based on data from the yearly contribution of each technology used in the Portuguese energy mix, Portugal's dependence on fossil fuels was calculated at nearly 12%. This represents a reduction of 50% when compared with the value observed in 2023, as depicted in Figure 3.

According to the Portuguese Environment Association (APA) the CO2 emissions factor for renewables is 0.169 [21], which corresponds to an estimate of around 1.317 million tons of CO2 emissions avoided due to the wind generation. The share of natural gas contribution in the power system decreased in line with the trend observed in the recent years. This situation resulted in a strong decrease of 49% in CO2 emissions compared to 2023. The 2024 CO2 emissions totalised nearly 1.8 million tons (MT) in mainland Portugal [4, 22]. The trend of rising electricity imports continues, reaching a new record. Portugal imported nearly 20% of its energy to meet the electricity consumption, which reached 51.4 TWh in mainland Portugal [5].

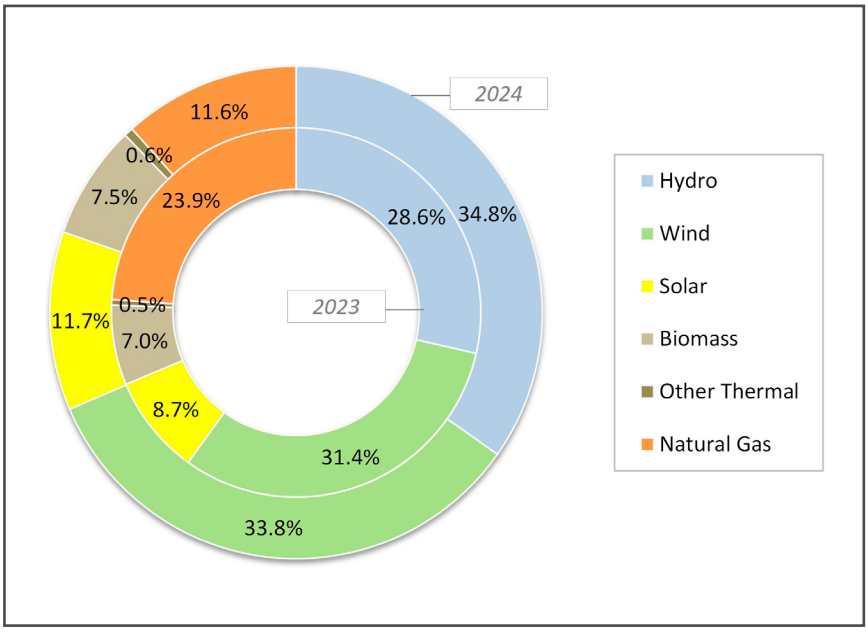

Figure 3. *Generation shares in 2023 and 2024 (only in mainland Portugal) to meet the electricity consumption. Imported electricity is not included.* (Source: REN and LNEG.)

Economic Benefits and Industry Development

The wind industry and deployment activities in Portugal supported approximately 1 to 10 direct and indirect jobs per installed MW [23]. In this sense, in 2024, around 222 jobs were created by this industry, mainly direct jobs. This industry creates around 41% of the jobs in the renewable energy sector, which corresponds, in 2024, to an accumulated value of around 17700 jobs.

In 2024, wind-generated electricity generated EUR 1.284 million for wind power plant developers in Portugal mainland. The mean tariff paid to onshore wind power plants with feed-in-tariff in 2024 decreased by EUR 5.54/MWh from the 2023 rate to EUR 93.07/MWh. For the offshore power plants, the average tariff paid was EUR 162.18 / MWh, representing a slight increase of EUR 1.46 /MWh [22].

Enercon continues as the lead deployer of wind turbines in Portugal, with a share of 49.5% of wind turbines installed. Siemens-Gamesa is the second largest with 18.4%, followed by Vestas 16.7%, Nordex 7.3%, GEWE 2.8%, Alstom 1.8%, Suzlon 1.7%, and Bonus 1.3%. Other manufacturers make up the remaining 0.5 % [24].

Next Term

The publication of the PAER is expected in early 2025. This plan will identify areas within the national maritime space with potential for the commercial development of renewable energy projects. It is a key milestone in achieving the Government's target of installing 2 GW of offshore wind capacity by 2030.

Once the final version is published, the next steps will include defining a competitive auction framework for offshore wind deployment, along with the necessary operational planning. Experimental campaigns for geophysical, geotechnical, and offshore resource assessments will also be carried out. These studies are essential to reducing investment risk for developers and, in turn, minimizing the need for government financial support.

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