Report 2023

Portugal

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In 2023, the new installed wind power capacity amounted to 159 MW. This capacity refers to overcapacity procedures, building on existing sites. Important milestones were attained by the ministerial working group created by the Portuguese government to accelerate the offshore wind market, expecting a total installed capacity of 10 GW.

The main R&D work in 2023 was related to concrete tension leg platforms anchored with an innovative tendon-based mooring system (Project INFINITE); the next-generation 12+ MW Offshore wind turbine (Project ReaLCoE); deployment of a hybrid 3 MW grid-connected solar PV and offshore wind park off the Belgian coast (Project EU-SCORES) and production of multi-materials to enhance the performance of offshore turbine rotor blades (project Carbo4Power).

Highlight(s)

- New installed capacity reached 159 MW in existing wind power plant sites (overcapacity procedures).
- Wind generation constituted 25% of electricity demand.
- A new record in the 15-minutes instantaneous share of wind power of demand: 108%, and a new record for the daily

Table 1. Key National Statistics 2023: Portugal

Total (net) installed wind power capacity	5.889 GW
Total offshore capacity	0.025 GW
New wind power capacity installed	0.0159 GW
Decommissioned capacity (in 2022)	N/A
Total electrical energy output from wind	13.2 TWh
Wind-generated electricity as percent of national electricity demand	25.1%
Average national capacity factor**	25.9%
Target	9.0 GW onshore and 0.3 GW offshore by 2030
National wind energy R&D budget	N/A

contribution of wind: 76% of demand.

- Allocation Plan for Offshore Renewable Energy out for public consultation to be included in the Maritime Spatial Planning Situation Plan.
- Legislation for the acceleration of environmental permitting for RES installation was revised and complemented.

Market Development

Targets and Policy

The National Energy and Climate Plan (NECP) [1] outlined the 2030 targets for renewable power capacity. In the case of wind power, the objective is to achieve an accumulated capacity of 9.3 GW by the end of 2030, using strategies such as overcapacity, repowering, and dedicating 0.3 GW to offshore wind energy technology. Additionally, the Portuguese Roadmap for Carbon Neutrality 2050 (RCN2050) [2], has established a vision for 2050, projecting an onshore wind power capacity between 12.0 to 13.0 GW and offshore capacity between 0.2 to 1.3 GW. However, in response to the global energy crisis, the NCEP2030 plans are currently under review, with a draft version indicating an increased ambition for Portugal by 2030.

The development of offshore wind continued to be of special concern for the Portuguese with several contributions published aiming to update the Maritime Spatial Planning Situation Plan - PSOEM [3]. A Consulting Committee involving several actors in the offshore renewables' area for the development of the Allocation Plan for Offshore Renewable Energy (PAER) were established in order to obtain the necessary consensus for the development of this technology. The final result was approved unanimously by this committee and subjected to public consultation at the end of 2023. The outcome of this plan will be included in the PSOEM.

Progress and Operational Details

During 2023, the cumulative capacity of wind power increased by 159 MW (See Figure 1). By the end of year, the cumulative installed capacity was 5,889 MW distributed over 267 wind parks, corresponding to 2,872 wind turbines [6]. The Portuguese wind power fleet generated 13.16 TWh, which accounted for approximately 25.1% of electricity demand [6] [9], nearly 1% less than that of the record year of 2019.

The share of wind from total renewable energy production decreased by 9% from 2022 to reach a total share of 36% in 2023 [6]. On the continent, this decrease is mainly due to the 12% increase in hydropower production attributed to a normal year where the hydro generation index stood at 0.99 [7]. Solar power similarly increased by 3% from 2022, now standing at a 15% share [6].

The average wind power production at full capacity stood at 2,265 full load hours, indicating a slight decrease of 2.3"% over 2022 [6]. The Portuguese transmission system operator (TSO) indicated an annual wind generation index of 0.99, which is equal to the previous year [7].

Figure 2 depicts the demand and wind generation profiles on the following:

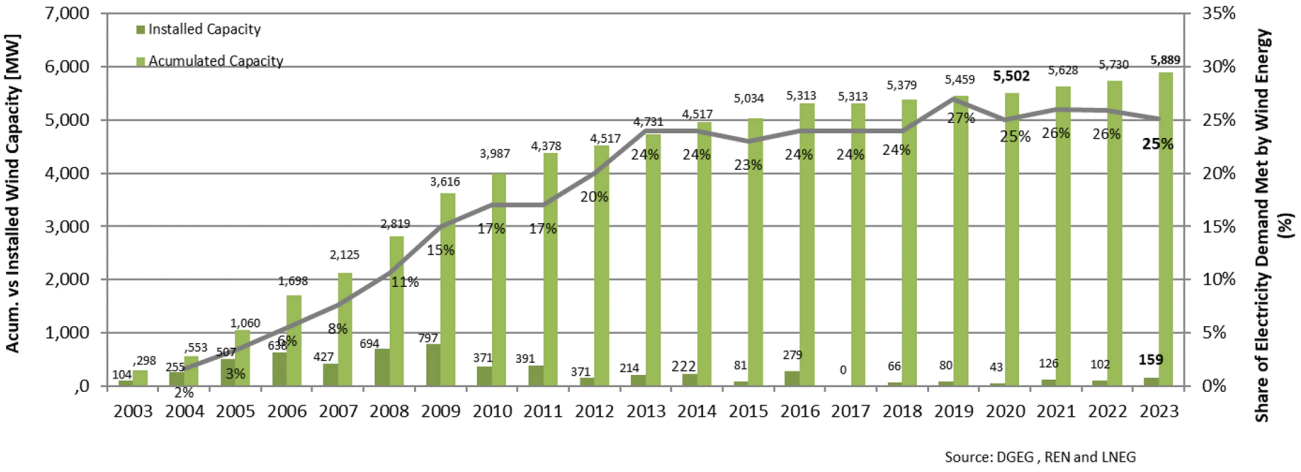

Figure 1: Installed and cumulative wind power capacities and share of electricity demand met by wind energy (line graph). *Source: REN, DGEG, EEM, EDA and LNEG.*

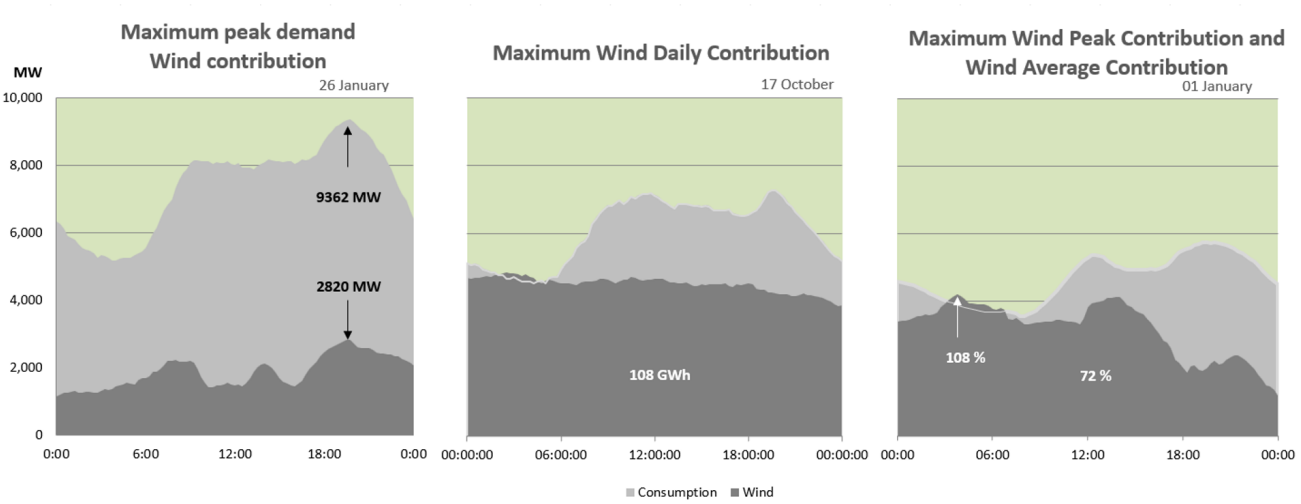

Figure 2: Demand, wind power contribution and energy generation records during 2023. *Source: REN and LNEG.*

- The maximum demand day and the respective wind power contribution: The maximum instantaneous demand value (9,362 MW) occurred at 19:45 on the 26th of January 2023, when wind generation was 2,820 MW (49"% of the capacity installed).
- Maximum daily contribution from wind: On the 17th of October 2023, wind power supplied Portugal with 108.0 GWh of electricity, setting a record. This accounted for 76% of daily demand.
- Instantaneous peak wind contribution: A maximum of 108% of 15-minutes instantaneous penetration of wind power in the demand value occurred on the 1st of January 2023. The daily wind contribution during this day was 72%.

Of the wind penetration values recorded in 2023, the TSO did not report any technical problems during these events or wind energy curtailment occurrences.

Matters Affecting Growth and Work to Remove Barriers

New grid connection capacity for wind energy projects still remains on hold as in previous years. Following the legislation published in 2022 to accelerate the installation of renewable energy systems (Dec-law 15/2022 [4]), new legal documents have been published in 2023 to continue this process. An example is the Dec-law 11/2023 [5] and the subsequent rectifications that redefine the conditions that subject projects to the need for EIA.

Also, keeping in mind the

acceleration of the installation of renewable energy systems, at the end of 2023, the government created the "Working Group for the Definition of Renewable Energy Acceleration Areas (GTAER))", Office no. 11912/2023 [10]. The work developed in the scope of this group enabled the identification of the wind capacity that could be subjected to simplified environmental licensing and constitutes a major step towards the REPower EU strategy. The government established another working group to identify less environmentally intrusive locations for the hybridisation of a hydroelectric power plant with wind power in the North of Portugal [11]. Regarding the repowering of wind power plants, the previous Dec-Law 15/2022 was further described in the Clarification 01/2023 [12] providing additional information to the developers and accelerating this type of procedure.

During the previous year, efforts to accelerate licensing procedures for RES installation were enabled through the publication of Dec-Law 15/2022 [4]. In 2023, the Dec-Law 11/2023 [5] was published and reviewed the thresholds for environmental impact assessment (EIA) required of RES projects, namely by eliminating case-by-case in specific situations.

Other legal documents were published to accelerate the energy transition and mitigate the impacts on the climate such as; Ordinance No. 298/2023 [13], which established the delimitation of the technological free zone (ZLT) of renewable energies of oceanic origin or location off the coast at Viana do Castelo; the Dec-Law 80/2023 [14], which establishes the exceptional procedure for the allocation of capacity to connect electricity consumption installations to the grid in areas of high demand; and Law 43/2023 [15], which establishes a Climate Action Council its composition, organisation and functioning rules.

RD&D Activities

National R,D&D Priorities and Budget

National R&D priorities for 2023 remained focused on training facilities and the design of different innovative processes, and services for the green offshore wind industry. This includes international collaboration between countries to develop new-prediction methods and load performance of modern and future 400-metre-tall offshore wind systems. Additionally, a new pioneer pilot project concerning the study of the benefits of aquaculture integration with offshore wind parks was launched.

Most R&D activities were developed at R&D institutes and universities and were funded through national and/or European programmes. The Portuguese Foundation of Science and Technology (FCT) invested EUR 658 million (USD 706 million) in science and technology in 2023. Approximately EUR 153 million (USD 164 million) was for RD&D and innovation projects on different topics, while EUR 142 million (USD 152 million) went towards scientific jobs [16]. These numbers represent a 3.5% increase in total investment, a 0.7% increase in RD&D investment, and a 9.4% increase in scientific jobs compared to 2022 [16].

National Research Initiatives and Results

Two similar demonstration projects, GREENH2ATLANTIC [17] and HOPE [18], commenced their activity in 2023 and both projects deal with the hybridisation of offshore and onshore wind parks with electrolysers dedicated to the hydrogen production. The first project will develop a test for a 100 MW flexible system in Sines while the second will develop flexible systems in a larger European scale. Additionally, some new research projects were launched, for instance, the GreenOffshoreTech [19] dedicated to providing innovative products and processes for green offshore production.

Test Facilities and Demonstration Projects

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

- INFINITE: an H2020 demonstration project of a floating offshore wind system at 100 m water depths, equipped with a tension leg platform anchored with an innovative tendon-based mooring system [20].
- EU-SCORES: an H2020 demonstration project to display the benefits of continuous energy production based on the renewable energy sources: wind, sun and waves in Belgium and Portugal [21].
- Carbo4Power: An H2020-funded project for demonstrating a new generation of offshore turbine blades with intelligent architecture, which increases operational performance and durability [22].

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.

Portuguese participation in these Tasks continues to provide 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. Por-

tugal is also an observer in Task 49, relating to offshore floating systems.

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 environmental aspects.

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

- FLOW: A Horizon Europe project to develop new prediction methods for production statistics and load performance of modern GW-scale and future 400-metre-tall offshore and onshore wind systems [23].
- AptWind: A Horizon Europe project to provide training in atmospheric physics and turbulence for wind energy for creative, entrepreneurial, innovative and resilient industry-oriented academic generation [24].
- ULTFARMS: A Horizon Europe project to provide low trophic aquaculture pilot studies, mainly in the North and Baltic Sea areas to study aquaculture integration with offshore wind parks [25].
- EuReComp: A H2020 project aimed at developing strategies to reuse, repair, refurbish, remanufacture, recycle and repurpose composite materials from components used in wind energy [26].
- TradeRES: A H2020 project that aims to develop and test new market designs for the RES sector that can meet society's needs for a (near) 100% renewable power system [27].

Impact of Wind Energy

Environmental Impact

Based on data from the yearly contribution of each technology used in the Portuguese energy mix and imports, Portugal's dependence on fossil fuels was calculated at nearly 24%. This represents a reduction of 15% when compared with the value observed in 2022, as depicted in Figure 3. According to the Portuguese Environment Association (APA) the CO2 emissions factor for renewables is [0.242] [28], which corresponds to an estimate of around [3.21] million tons of CO2 emissions avoided due to wind generation.

The share of natural gas contribution in the power system decreased in contrast with the trend observed in recent years. This situation resulted in a strong decrease of 40% in CO2 emissions compared to 2022. The 2023 CO2 emissions totalled nearly 3.7 million tons (MT) in mainland Portugal. Portugal imported nearly 16% of its energy to meet the electricity consumption, which reached 50.7 TWh in mainland Portugal [7]. In fact, 2023 was one of the years with higher imports of electricity, especially due to the shutdown of coal plants which occurred a few years ago.

Economic Benefits and Industry Development

The wind industry and deployment activities in Portugal supported approximately three to four direct and indirect jobs per installed MW [29]. In this sense, in 2023, around [556] jobs were created by this industry, mainly

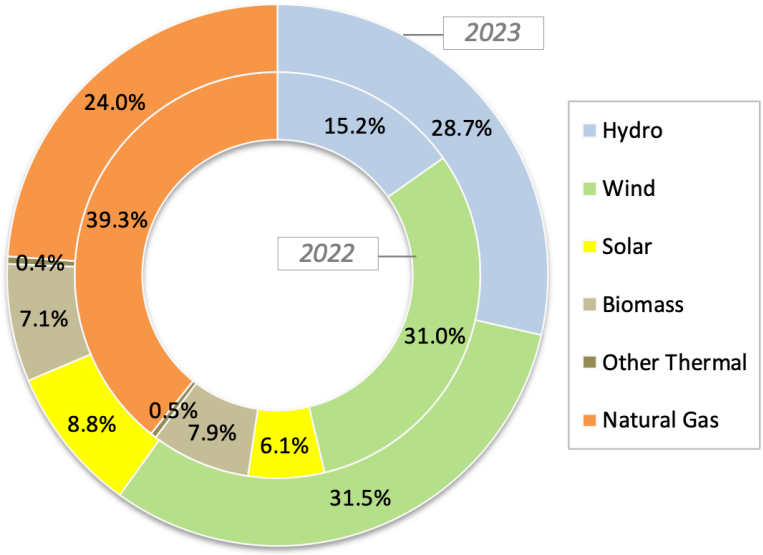

Figure 3: Generation shares in 2022 and 2023 (only in mainland Portugal) to meet the electricity consumption.

consisting of indirect jobs. This industry creates around 41% of the jobs in the renewable energy sector, which corresponded to an accumulated value of around [17,700] jobs in 2023.

In 2023, wind-generated electricity generated EUR 1.219 million (USD 1.308 million) for wind power plant developers. The mean tariff paid to onshore wind power plants in 2023 increased by 3.89 EUR/MWh (7.44 USD/MWh) from the 2022 rate to 98.19 EUR/MWh (105.36 USD/MWh), while in the offshore power plants, the average tariff paid was 160.72 EUR/MWh (172.45 USD/MWh) [30].

Enercon continues as the lead deployer of wind turbines in Portugal, with a share of [50.9]% of wind turbines installed. Siemens-Gamesa is the second largest with [18.9]%, followed by Vestas ([15.2]%), Nordex ([7.5]%), GEWE ([1.9]%), Alstom ([1.9]%), Suzlon ([1.8]%), and Bonus ([1.3]%). Other manufacturers make up the remaining 0.5"% [31].

Next Term

Year 2024 will be of particular relevance to Portugal since new targets are planned to be defined for 2030 in RES, under the revision of NCEP2030. Hybridisation of existing wind parks is anticipated, with numerous projects under evaluation by the end of 2023. The government's efforts to simplify the permitting procedures for RES installation with the publication of clarification notes and new diplomas are expected to accelerate the permitting to develop of new wind energy projects. In the offshore wind area, particularly the work developed so far will continue in the following year with the publication of the final version of PAER and subsequent integration in the PSOEM. In addition, a stakeholders' consultation to support the design of the future tenders (auctions or similar schemes) for offshore development will be arranged.

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