Report 2021

Portugal

Photo: Rita Candeias/Unsplash

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In 2021 a total of 126 MW was installed in Portugal through two new wind farms and overplanting capacity procedures. By the end of 2021, 5,628 MW was operating in the country, corresponding to 37% of the national total renewable operational capacity.

The wind-based electrical energy in 2021 was 13.27 TWh, meeting 26% of the country's electricity demand.

Renewable electricity production in 2021 reached 65% of the national consumption, a small increase when compared to the previous year. On 31 October 2021, between 01:00 to 07:45h, Portugal (Mainland) met 100% of its electricity needs with wind energy during several periods. The instantaneous electricity demand met by wind energy during this period was 108%. Values above 100% were also observed for some hours on 27th December 2021.

The main R&D project tasks were ongoing as expected. Project Carbo-4Power provided an innovative design of a modular rotor offshore blade, while project PivotBuoy unveiled the new prototype of the floating offshore wind turbine. Project Atlantis performed the first scenario test on using

Table 1. Key National Statistics 2021: Portugal

Total (net) installed wind power capacity	5.628 GW
Total offshore capacity	0.025 GW
New wind power capacity installed	0.126 GW
Decommissioned capacity (in 2021)	0 GW
Total electrical energy output from wind	13.27 TWh
Wind-generated electricity as percent of national electricity demand	26.0%
Average national capacity factor	25.6%
Target	9.0 GW onshore and 0.3 GW offshore by 2030
National wind energy R&D budget	N.A

robotics to inspect a turbine tower and blades at Viana do Castelo.

Highlight(s)

- Wind generation was 26% of electricity demand, close to the record year 2019.
- The new wind power capacity installed during 2021 was 126 MW, the highest value since 2016.
- The highest 15-minutes instantaneous penetration of wind power in the demand value was 109% - a value similar to the record observed in 2017.
- Four important new R&D Projects started their activities in the wind energy sector.

Market Development

Targets and Policy

The targets for renewable power capacity by 2030 were published in the National Energy and Climate Plan (NECP) [1]. Targets are ambitious, and by 2030 an expected wind power capacity of 9.3 GW (including overcapacity, repowering, and 300 MW for offshore wind energy systems) is projected, representing an increase of more than 3.7 GW when compared with 2020 [1]. The vision for 2050 was established in the Portuguese Roadmap for Carbon Neutrality 2050 (RCN2050) [2]. The wind power capacity scenarios expected by 2050 range between 12.0 to 13.0 GW onshore and 0.2 to 1.3 GW offshore.

During 2021, there was new legislation published on the scope of renewable energies in Portugal. Some of the most relevant legal documents are related to the regulation of additional capacity (overplanting) and energy production on wind power plants that still beneficiate from Feed-in-Tariffs – Regional Legislative Decree n.º 16/2021/M, from the 27th of July [3]. It is also concerned with the establishment of transition rules for the alternative remuneration provided in Decree-Law No. 35/2013, of February 28, in the case where only part of the total energy produced in a wind farm entered into operation staggered in time, under successive licenses.

In terms of renewable energies in general, at the end of 2021, the Climate Basis Law – Law n.º 98/2021, 31st of December [4] – was published, including a set of measures to overcome the energy crisis and drawing the guidelines for an effective energy transition.

Progress and Operational Details

Wind power cumulative capacity increased by 126 MW (Figure 1). Two new onshore wind parks were installed in Portugal, while the remaining installed capacity corresponds to overplanting on currently installed wind parks. By the end of 2021, the cumulative installed capacity was distributed over 265 wind parks, with 2,836 wind turbines [5]. The Portuguese wind power fleet generated 13.27 TWh, meeting 26% of electricity demand [6-8].

The wind share of the total renewable production increased by 2% from 2020 to 40% [5]. This is a slight increase due to the decrease in hydropower production (41%) attributable to a below-average hydro year aligned with an average year regarding the wind regime. The average wind power production at full capacity stood at 2,359 hours, indicating a 5% increase over 2020 (2,235 hours) [5]. The Portuguese transmission system operator (TSO) indicated an annual wind generation index of 1.01 [6]. This represents a 7% increase in the index compared to 2020.

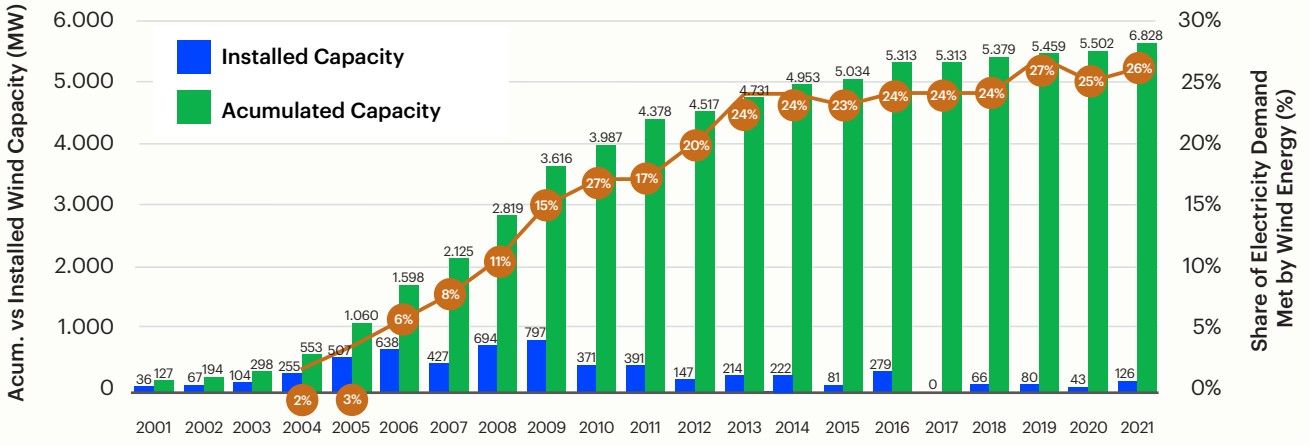

Figure 1. Installed and cumulative wind power capacities and share of electricity demand met by wind energy

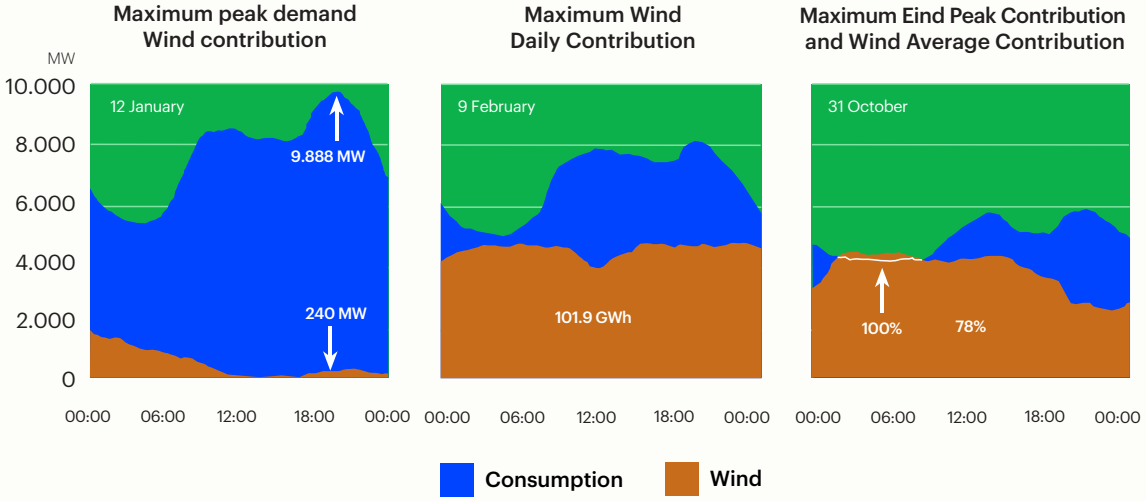

Figure 2. Demand, wind power penetration, and energy generation records during 2021 (*Source: REN and LNEG*).

Figure 2 depicts the wind generation profiles on:

- The maximum demand day and the respective wind power contribution: The maximum instantaneous demand value (9,888 MW) occurred at 19:30 on 12 January 2021, but wind generation was only 240 MW.
- Maximum daily contribution from the wind: On 9 February 2021, wind power supplied Portugal with 103.9 GWh of electricity (new record), accounting for 67% of the daily demand.
- Instantaneous peak wind penetration: The highest 15-minutes instantaneous (109%) penetration of wind power in the demand value occurred on 31 October 2021. This value is equal to the maximum observed in 2017. The daily wind penetration during this day was 78%.

Despite the wind penetration values recorded in 2021, the TSO did not report any technical problems during these events. Moreover, the TSO also did not report wind energy curtailment occurrences.

Matters Affecting Growth and Work to Remove Barriers

In 2021, and following the previous years (since 2012) tendency, the new grid connection capacity remains on hold for wind technology. According to the Portuguese 2030 NCEP, the focus in the wind sector for the next decade will be the exploitation of existing wind power parks through the three following approaches: hybridi-

zation (power plant which generates electric power using two or more renewable technologies, including energy storage system, and inject electricity in the same interconnection grid busbar), overplanting and repowering. These approaches, already foreseen in the Portuguese legislation, enable to increase the production of electricity from renewable sources and, at the same time, minimise the costs for the consumer and the environment since they allow optimising the network investments already made.

R,D&D Activities

National R,D&D Priorities and Budget

National R&D priorities for 2021 are similar to 2020, so they remain on training facilities and designing services for the offshore wind industry, the adaptation of the 5G technology on smart-grids, and developing tools and methodologies to maximise the penetration of renewable energy into the power system. Most R&D activities are taking place at the main Portuguese institutes and universities and are funded through national and/or European programs.

The Portuguese Foundation of Science and Technology (FCT) foreseen an investment of [653] million EUR ([743] million USD) in science and technology during 2021. Approximately [150] million EUR ([171] million USD) was for R,D&D and innovation projects, while [152] million EUR ([173] million USD) went towards scientific jobs [9]. These numbers represent a [2] % decrease in total investment, [12.3] % increase in R,D&D investment, and a [6] % decrease in scientific job investment compared to 2020 [9].

National Research Initiatives and Results

Two demonstration projects, the EU-SCORES [10] and FIBREGY [11], started activities. The EU-SCORES project links the complementary of renewable energy sources of wind, waves, and sun to build a more resilient and stable mixed power system to optimise the production capacity at the lowest cost. The FIBREGY project emphasises the advantage of a new fiber-reinforced polymer in substitution of steel to provide more immunity to corrosion and provide superior fatigue performance of the platforms. Two new research projects were launched, project REMARO [12] for training researchers in designing new robotic devices for underwater inspection of offshore wind technology, and project SMART5GRID [13] turns smart grids using the new 5G technology, enabling a more efficient management of the smart-grid for dealing with low-voltage connection devices and low-demand connections.

Test Facilities and Demonstration Projects

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

- **EU-SCORES**: A H2020 demonstration project to show the benefits of continuous energy production based on the complementary energy sources - wind, sun, and waves in Belgium and Portugal;
- **FIBREGY:** A H2020 demonstration project to enlighten the benefits of substitution of steel by fiber reinforced polymers in the structures and components of large tidal and offshore wind power platforms;
- **ReaLCoE:** A H2020 demonstration project to accelerate a new generation of competitive and subsidy-free clean energy from offshore wind energy converters with a high-performance 12+MW demonstration turbine.
  ;
- **PivotBuoy:** A H2020-funded project to demonstrate and validate the offshore PivotBuoy system for mooring, connection, installation, and operation of Floating Wind;
- **ATLANTIS:** A H2020-funded project for demonstration and developing a pioneer pilot infrastructure capable of enabling robotic technologies for inspection and maintenance of offshore wind parks;
- **MAREWIND:** A H2020-funded project for developing and demonstrating material solutions for cost reduction and extending the lifetime of wind offshore facilities;
- **Carbo4Power:** A H2020-funded project demonstrating a new generation of offshore turbine blades with intelligent architectures to increase operational performance and durability.

Collaborative Research

Portugal currently participates in Tasks 25 - Design and Operation of Power Systems with Large Amounts of Wind Power, 28 - Task 28 Social Acceptance of Wind Energy Projects, 34 - Working Together to Resolve the Environmental Effects of Wind Energy (WREN), and 36 - Forecasting of wind energy. The Portuguese participation in these Tasks provided support to the secretariat of state that leads the R&D activities in Portugal and to the development of R&D projects. In addition to the IEA Wind TCP activities, Portugal is represented in the European Energy Research Alliance Wind Program (EERA-Wind), in the Energy Systems Integration (EERA-ESI), and in the European Sustainable Energy Innovation Alliance (ESEIA), and in the International Renewable Energy Agency (IRENA). Recently, Portugal (Coimbra University) is coordinating a COST Action – MODENERLANDS – related to sustainable energy in Islands where the foreseen activities cover renewables resource assessment with special incidence on offshore floating power systems, regulation, and grid integration, socio-economic aspects, and environment. This Action started in October 2021.

Concerning R&D in Portugal, below a list of some examples of Portuguese participation in national and international funding projects is provided.

- **REMARO:** A H2020 project for training researchers on design robotics for underwater applications, Artificial Intelligence Software, and safety expertise applied to offshore wind d technology;

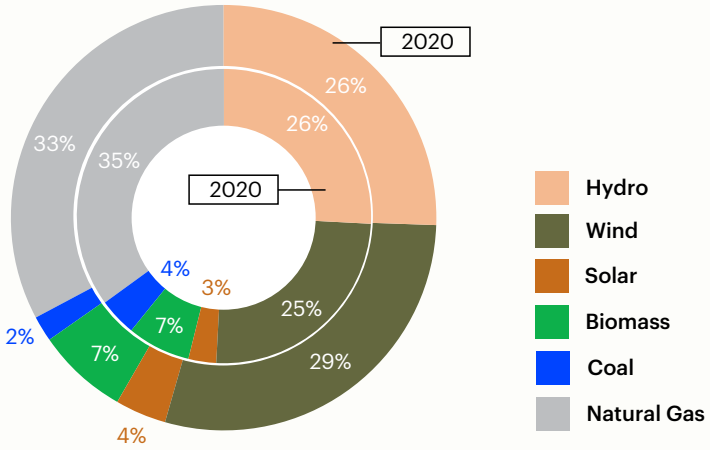

Figure 3. Generation share in 2020 and 2021 (Portugal mainland only) to meet the electricity consumption.

- **SMART5GRID:** A H2020 project for the adaptability of the RES sector to the 5G technology applied to modern smart grids by efficiency multiple low-voltage devices and low-demand connections;
- **TWIND**: A H2020 project that aims the creation of a network of specialised scientists and trainers in offshore renewable energy, which will provide support to the rising offshore wind industry of Portugal;
- **FLOAWER:** A H2020 project to train 13 early-stage researchers (ESRs) to design better performing, economically viable floating wind turbines;
- **LIKE:** A H2020 project to train a new generation of scientists on emerging laser-based wind measurement techniques for the prediction of energy yield on wind turbines or entire wind farms;
- **EU-SysFlex:** A H2020 project provided efficient and coordinated use of flexibilities for high RES shares in the European electricity system;
- **TradeRES:** A H2020 project to provide tools for design and modeling new markets and negotiation mechanisms for a nearly 100% renewable European power system;
- **COME RES:** A H2020 project for developing a community Energy Platform for the uptake of RES in the electricity sector evolving onshore wind integrated solutions;
- **RESET:** A H2020 project for design reliability, safety engineering, and technology for large maritime engineering systems that are evolving offshore wind parks.

Impact of Wind Energy

Environmental Impact

Wind-generated electricity allowed a savings of about [5.7] million tons of CO2 emissions (considering a factor of 430 g/kWh). Based on data from the yearly contribution of each technology to the Portuguese energy mix and imports, Portugal's dependence on fossil fuels generation was calculated at nearly 35%—a decrease of 5% when compared with the value observed in 2020, Figure 3.

In November 2021, Portugal stopped using coal to produce electricity. Thus, natural gas penetration in the power system continues to increase. In Portugal's mainland, contributions from non-renewable generation decreased in 2021 when compared to 2020, Figure 3. This situation enabled to decrease in the 2021 CO2 emissions to nearly 6.2 million tons (MT) in mainland Portugal—a 19% decrease compared to 2020. Madeira Island observed an almost 6% decrease in CO2 emissions, reaching 0.39 MT [7]. Portugal imported nearly 10% of energy to satisfy electricity consumption, which increased to 49.5 TWh (Portugal mainland) after the country partially recovered from the COVID-19 pandemic situation [6].

Economic Benefits and Industry Development

The wind industry and deployment activities in Portugal supported approximately [3,250] jobs during 2021.

In 2021, wind-generated electricity generated 1.117 million EUR (1.271 million USD) for wind power plant developers [18]. The mean tariff paid to the onshore wind power plants in 2021 decreased by 2.98 EUR/MWh (3.39 USD/ MWh) from the 2020 rate to 87.74 EUR/MWh (99.96 USD/MWh) [14]. For the offshore power plant, the average tariff paid was 146.46 EUR/MWh (166.67 USD/MWh) [14].

Siemens Gamesa and Vestas manufactured most wind turbines installed during 2021. Although, Enercon continues to lead wind power capacity deployment in Portugal,

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with [52.4%] of the country's installed capacity. Siemens Gamesa is in second place with [19.1%], followed by Vestas ([13.4%]), Nordex ([7.4%]), GEWE ([1.9%]), Alstom ([1.9%]), Suzlon ([1.9%]), and Bonus ([1.4%]). Other manufacturers make up the remaining [0.6]% [15].

Next Term

2021 was the first year for full operating offshore wind energy, but to meet the goals in terms of renewables for Portugal, almost 4GW of wind capacity is still needed. The new legislation foreseen for the beginning of 2022 is expected to motivate investment in the wind energy sector through overplanting, repowering, and hybrid power plants (solar photovoltaic and wind sharing a single interconnection busbar). In this new legislation, special incentives for fully repowered projects are expected. Auctions for offshore wind farms are also expected to occur in the next year.

References

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