CREDITS: LÍDIA LEAL. LEGEND: WINDFLOAT ATLANTIC OFFSHORE WIND FARM

PORTUGAL

In 2020, no new wind farms were installed in Portugal. However, additional capacity was added to existing wind farms and corresponded, in total, to 41 MW. In this sense, by the end of 2020, 5,478 MW was operating in the country, corresponding to 38% of the national total renewable operational capacity. The wind-based electrical energy in 2020 was 12.36 TWh, meeting [25%] of the Portugal's electricity demand.

PAULA COSTA, TERESA SIMÕES, ANTÓNIO COUTO, ANA ESTANQUEIRO, Laboratório Nacional de Energia e Geologia – LNEG, Portugal.

Considering the overall renewable power capacity installed in Portugal, the electricity production in 2020 reached 64% of the national consumption, a small decrease compared to the previous year. On 25 October 2020, between 03:00 and 08:15 a.m., continental Portugal met 100% of its electricity needs with wind energy during several periods. The instantaneous electricity demand met by wind energy during this period was 105%.

TABLE 1. KEY NATIONAL STATISTICS 2020: PORTUGAL

Total (net) installed wind power capacity*	5.478 GW
Total offshore capacity	0.024 GW
New wind power capacity installed	0.041 GW
Decommissioned capacity (in 2020)	0 GW
Total electrical energy output from wind	12.4 TWh
Wind-generated electricity as percent of national electricity demand	25%
Average national capacity factor**	26%
Target	9.0 GW onshore and 0.3 GW offshore by 2030
National wind energy R&D budget	N/A

*Installed wind power capacity: Use nameplate power ratings of the installed wind turbines

Average National Capacity Calculation: Only include turbines in operation the whole year: **(MWh production/8,760 hrs) / MW installed capacity
MWh total electrical production from wind turbines operating 1 January through 31 December divided by 8,760 hrs divided by the total installed wind capacity (in MW) at the beginning of the year.
[You can also use an estimate based on the average installed capacity during the year: (installed 1 Jan + installed 31 Dec)/2. But in that case, state that this is how the estimate is calculated.]

In 2020, the WindFloat Atlantic wind farm entered full operation after the last wind turbine had been installed. This constituted the start-up of offshore wind energy in Portugal, as well as an action of the utmost importance for the fulfilment of the goals established in the National Energy and Climate Plan 2030. New funded demonstration projects like the 'Carbo4Power' and 'PivotBuoy' are continuing the offshore trend.

Market development

Targets and policy

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

Some legislations were published in 2020, of which the most relevant was the Ordinance No. 10835/2020 from 4 November [3] establishing the "Reduction in the power of production under a special regime that benefits from a guaranteed remuneration or other subsidized support scheme for remuneration". Ordinance No. 10835/2020 is especially relevant for the wind energy producers that are still benefitting from the feed-in-tariff (FIT) and almost entering in a market-based price tariff.

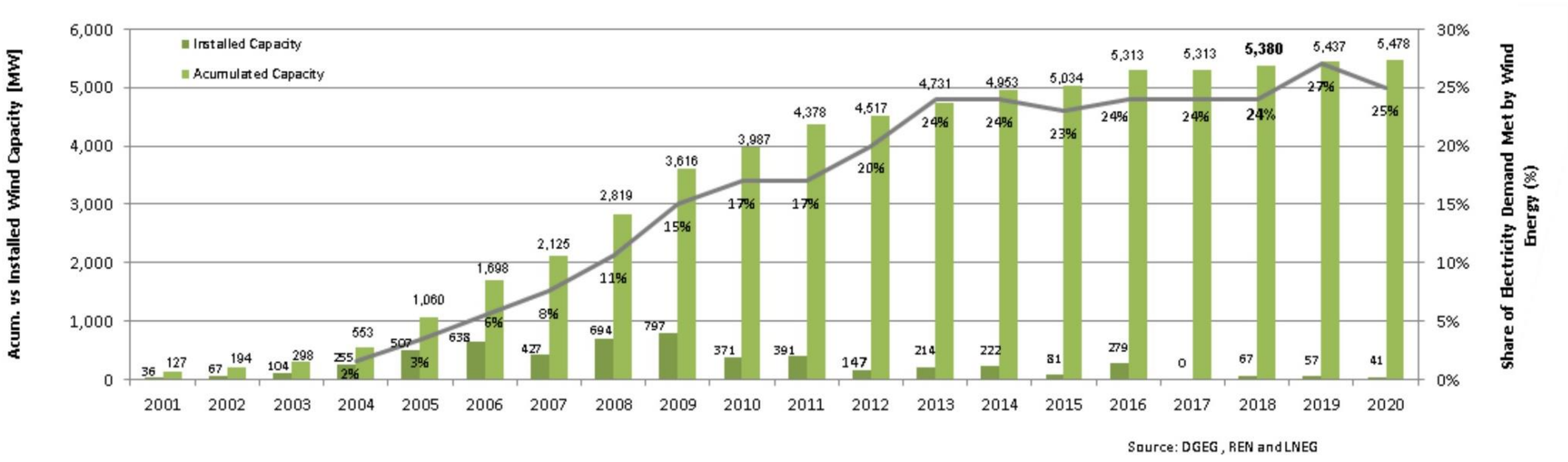

FIGURE 1—INSTALLED AND CUMULATIVE WIND POWER CAPACITIES AND SHARE OF ELECTRICITY DEMAND MET BY WIND ENERGY (LINE GRAPH).

FIGURE 2 – DEMAND, WIND POWER PENETRATION AND ENERGY GENERATION RECORDS DURING 2020 FOR CONTINENTAL PORTUGAL (SOURCE: REN AND LNEG).

Overplanting procedures was altered through Ordinance No. 203/2020 from 21 October 2020 [4] where the regulator is again back as an intervener in the process of adding new capacity to the connected wind farms. The regulator is responsible for ensuring compliance with the criteria established for the authorization of overplanting installation.

Progress and operational details

Cumulative wind power capacity increased 41 MW (Figure 1). The first (floating) offshore wind park with 25.2 MW was installed in Portugal. The remaining installed capacity corresponds to overplanting capacity on current installed wind parks. By the end of 2020, the cumulative installed capacity was distributed over 263 wind parks comprising 2,779 wind turbines [5]. The Portuguese wind power fleet generated 12.3 TWh, meeting more than 25% of the country's electricity demand [6-8].

The wind share of the total renewable production decreased by 9% from 2019 to 39% [5]. This decrease was due to the increased hydropower production (43.6%) attributable to a wet year aligned with a less windy year. The average wind power production at full capacity stood at 2,257 hours (capacity factor 26%), indicating a 10% decrease over 2019 (2,503 hours) [5]. The Portuguese transmission system operator (TSO) indicated an annual wind generation index of 0.94 [6]. This represents a 12% decrease in the index compared to 2019. This decrease is explained by the less wind expected on winter and spring months.

Figure 2 depicts the wind generation profiles on:

- The maximum demand day and the respective wind power contribution: The maximum instantaneous demand value (8,906 MW) occurred at 19:45 on 13 January 2020, but wind generation was 1,831 MW (almost 34%).
- Maximum daily contribution from the wind: On 11 December 2020, wind power supplied Portugal with 103.7 GWh of electricity (new record, on average 79% of capacity), accounting for 66 % of the daily demand.
- Maximum daily penetration and instantaneous peak wind penetration: The highest daily (75 %) and instantaneous (105%) penetration of wind power in the demand values occurred on 25 October 2020.

Despite the wind penetration values recorded in 2020, 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 2020 and following the tendency of previous years (since 2012), the new grid connection capacity still 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: hybridization (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 increasing electricity production from renewable sources while minimizing the costs for the consumer and the environment, since they allow optimization of the network investments already made.

R,D&D activities

National R,D&D priorities and budget

National R&D priorities for 2020 remained focused on training services for offshore wind industry, smart

> Start-up year for offshore wind installations. The first floating offshore wind park with 25.2 MW started full operation.

grid facilities, and new tools and methodologies to maximize the penetration of renewable energy from a grid security operation point-of-view and a market perspective. Most R&D activities are taking place at the main Portuguese institutes and universities and are funded through national and/or European programmes.

The Portuguese Foundation of Science and Technology (FCT) invested nearly 671 million EUR (821 million USD) in science and technology in 2020. Approximately 150 million EUR (184 million USD) was for R,D&D and innovation projects, while 152 million EUR (186 million USD) went towards scientific jobs [9]. These numbers represent a 2% decrease in total investment, 4% increase in R,D&D investment, and a 6% decrease in scientific job investment compared to 2019 [10].

National research initiatives and results

New demonstration projects were launched such as the PivotBuoy [11], ATLANTIS [12], MAREWIND [13] in order to develop infrastructures and materials for floating wind deployments and extending the service life of offshore facilities. The Carbo4Power project [14] was launched to develop a new generation of offshore turbine wind blades with intelligent architecture to maximize performance and durability. New research projects such as the EU-Sysflex [15], TradeRES [16] and COME RES [17] deal with efficiency and flexibilization methodologies for wind integration on a large share of renewable energy systems (RES) in the electricity sector and markets.

Test facilities and demonstration projects

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

- **ReaLCoE:** 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:** H2020-funded project to demonstrate and validate the offshore PivotBuoy system for mooring, connection, Installation and operation of Floating Wind.

- **ATLANTIS:** 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:** H2020-funded project for developing and demonstrate material solutions for cost reduction and extend service life of wind offshore facilities.

- **Carbo4Power:** H2020-funded project to develop new generation of offshore turbine blades with intelligent architectures to increase operational performance and durability.

Collaborative research

Portugal currently participates in 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), and Task 36 – Forecasting For Wind Energy. The Portuguese participation in these tasks has been very interesting and the knowledge acquired in the meetings and discussion has also been the decision-making basis for the support to the Portuguese Secretary of State which heads the R&D activities in Portugal, and also to the development of R&D projects. An example is the recently started H2020 TradeRES project which was founded based on the above Tasks. In addition to the IEA Wind TCP activities, Portugal is also represented in the programme European Energy Research Alliance Wind (EERA-Wind), in the Energy Systems Integration (EERA-ESI), in the European Sustainable Energy Innovation Alliance (ESEIA) and in the International Renewable Energy Agency (IRENA).

Concerning R&D in Portugal, the following list are examples of the Portuguese participation in national and international funding projects.

- **ETIPWind:** H2020 project to create a virtual and physical platform to enable the wind energy community communicate, coordinate, and collaborate on activities related to R&I&T;

- **OptiGRID:** nationally funded project that demonstrates the benefit from the dynamic line rating approach in overhead power lines to increase the integration of renewables into the electric grid, with particular focus on regions with high wind energy potential;

- **TWIND:** H2020 project that aims create a network of specialized scientists and trainers in offshore renewable energy, which will provide support to the rising offshore wind industry of Portugal;

- **FLOAWER:** H2020-funded project to train 13 early-stage researchers (ESRs) to design better performing and economically viable floating wind turbines;

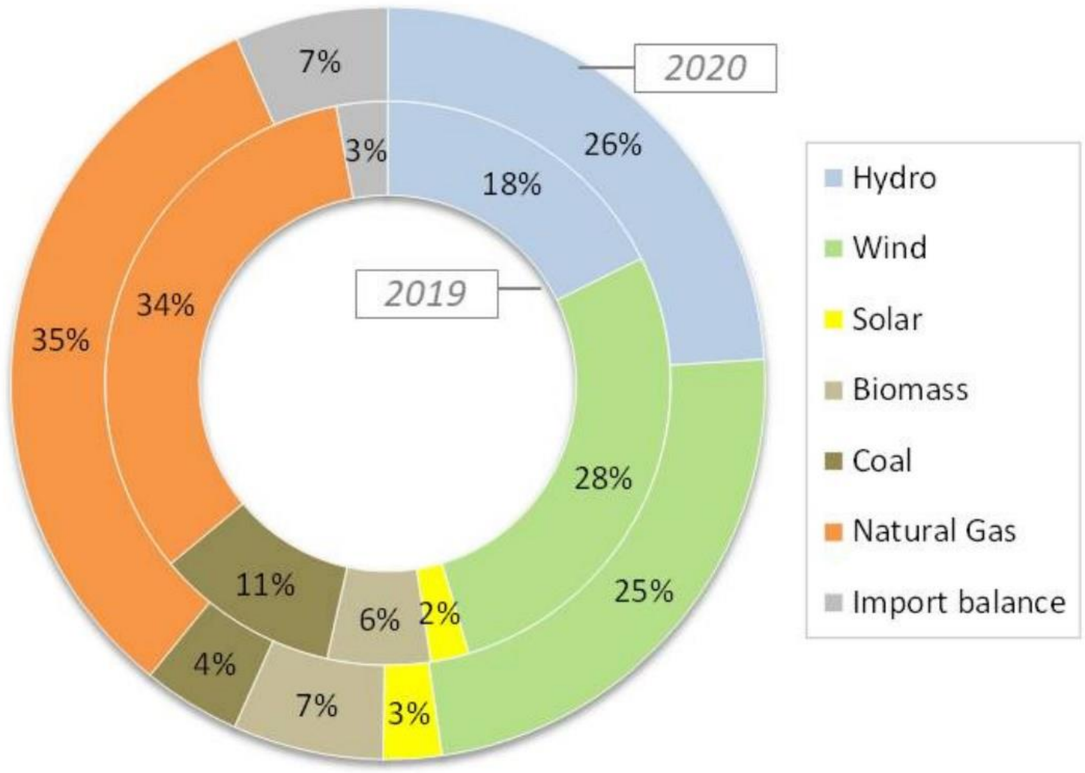

FIGURE 3. GENERATION SHARE AND IMPORT BALANCE IN 2019 AND 2020 (PORTUGAL MAINLAND ONLY) TO MEET ELECTRICITY CONSUMPTION.

- **LIKE: H2020-**funded project to train a new generation of scientists in emerging laser-based wind measurement techniques for prediction of energy yield on wind turbines or entire wind farms;

- **EU-SysFlex:** H2020-funded project provided efficient and a coordinated use of flexibilities for integration of large share or RES in the European electricity system;

- **Smart4RES:** H2020-funded project for provide next generation modelling and forecasting of variable renewable generation for large-scale integration in energy systems and markets;

- **TradeRES:** H2020-funded project to provide tools for design and modelling new markets and negotiation mechanisms for a nearly 100% renewable European power systems;

- **COME RES:** H2020-funded project to develop a community energy platform for the uptake of RES in the electricity sector developing onshore wind integrated solutions;

- **RESET:** H2020-funded project for design reliability and safety engineering and technology for large maritime engineering systems developing offshore wind parks.

Impact of wind energy

Environmental impact

Wind-generated electricity allowed savings of about [5.2] million tons of CO_2 emissions (considering a factor of 430 g/kWh). Based on data from the yearly contribution of each technology in the Portuguese energy mix, and imports, Portugal's dependence on fossil fuels generation was calculated at nearly 40% – slight below the value observed in 2019, Figure 3.

Coal is the cheapest fossil fuel for generating electricity. However, the tendency towards natural gas penetration in the power system continues to increase. For mainland Portugal, contributions from non-renewable generation decreased in 2020 when compared to 2019, see Figure 3. This situation made it possible to decrease the 2020 CO2 emissions to nearly 8.2 million tons (MT) in mainland Portugal—a 24% decrease compared to 2019 [8]. Madeira Island observed an almost 11% decrease in CO2 emissions, reaching 0.42 MT. Portugal imported nearly 3% of energy [6] to satisfy electricity consumption, which decreased to 48.8 TWh (mainland Portugal) mainly due to the COVID-19 pandemic.

Economic benefits and industry development

The wind industry and deployment activities in Portugal supported approximately [3,250] jobs in 2020.

In 2020, wind-generated electricity generated 1.078 million EUR (1.318 million USD) for wind power plant developers [18]. The mean tariff paid to the wind power plants in 2020 decreased by 3.59 EUR/MWh (4.39 USD/MWh) from the 2019 rate to 89.98 EUR/MWh (110.04 USD/MWh) [18].

Most wind turbines installed during 2020 were manufactured by Senvion and Vestas. However, Enercon continues to lead wind power capacity deployment in Portugal with [52.5]% of the country's installed capacity. Vestas is in second place with [12.6%], followed by Senvion ([10.6%]), Siemens Gamesa ([9.0%[), Nordex ([7.5%]), GEWE ([2.0%]), Alstom ([2.0%]), Suzlon ([1.9%]), and Bonus ([1.4%]). Other manufacturers make up the remaining [0.6]% [19].

Next term

2020 marked the first year for full operation of offshore wind energy in Portugal. To meet the goals in terms of renewables for Portugal, almost 4 GW of wind capacity is needed. It is expected that this capacity will be installed in a more extensive way through overplanting, repowering, and hybrid power plants more than through new onshore wind farms, and also a more expressive development of offshore wind farms.

In 2021, a clarification on some of the decentralized legal diplomas are expected, especially in what concerns the development of energy communities. This will also contribute to the national goals.

References

[1] https://ec.europa.eu/energy/sites/ener/files/documents/pt_final_necp_main_pt.pdf (accessed in 27 April 2021)

[2] Resolution of the Council of Ministers (RCM) nº. 107/2019. Diário da República nº. 123/2019, Série I de 2019-07-01. Download from: https://data.dre.pt/application/conteudo/122777644 (accessed in 27 April 2021)

[3] Ordinance No. 10835/2020 published in Diário da República n.º 215/2020, Série II de 2020-11-04. (MAAC/DGEG). pp85 – 88. https://dre.pt/web/guest/pesquisa/-/search/147528354/details/normal?q=n.%C2%BA%2010835%2F2020+. (accessed in 27 April 2021).

[4] Ordinance No. 203/2020 published in Diário da República n.º 163/2020, Série I de 2020-08-21. MAAC. Pp5-6. https://data.dre.pt/eli/port/203/2020/08/21/p/dre (accessed in 27 April 2021)

[5] Direção Geral de Energia e Geologia (DGEG), Renováveis—Estatísticas Rápidas fevereiro 2021, Download from: https://www.dgeg.gov.pt/media/v0la0rem/dgeg-arr-2021-02.pdf (accessed in 26 April 2021)

[6] Redes Energéticas Nacionais(REN), Dados Técnicos Eletricidade Gás Natural – 2020, Download from: https://www.ren.pt/files/2021-03/2021-03-29134252_7a820a40-3b49-417f-a962-6c4d7f037353$$7319a1b4-3b92-4c81-98d7-fea4bfefafcd$$b4f0f693-3d69-48be-b0c8-c8cf5e1127ce$$File$$pt$$1.pdf (accessed in 26 April 2021)

[7] https://www.eem.pt/pt/inicio/ (accessed in 26 April 2021)

[8] https://www.eda.pt/ (accessed in 26 April 2021)

[9] Proposta de Orçamento de Estado para 2021 Ciência, Tecnologia e Ensino Superior (PO13). October 2020. p. 123. Download from: https://wwwcdn.dges.gov.pt/sites/default/files/relatorio_mctes_2021_po13_comissao_educacao_ciencia_juventude_desporto_v18out2020-min.pdf (accessed in 26 April 2021)

[10] Proposta de Orçamento de Estado para 2020. Ciência, Tecnologia e Ensino Superior (PO13). January 2019. p. 64. Download from: https://www.parlamento.pt/Documents/2020/janeiro/Nexplicativa-MCTES.pdf (accessed in 26 April 2021)

[11] https://pivotbuoy.eu/ (accessed in 26 April 2021)

[12] https://www.atlantis-h2020.eu/project/ (accessed in 26 April 2021)

[13] https://www.marewind.eu/ (accessed in 26 April 2021)

[14] http://www.carbo4power.net/ (accessed in 05 August 2021)

[15] https://eu-sysflex.com/ (accessed in 26 April 2021).

[16] https://traderes.eu/ (accessed in 26 April 2021)

[17] https://come-res.eu/ (accessed in 26 April 2021)

[18] https://www.erse.pt/ (accessed in 14 june 2021)

[19] http://e2p.inegi.up.pt/ (accessed in 26 April 2021)