29 Portugal

1.0 Overview

During 2011, Portugal experienced a strong reduction of electricity demand. With a decrease of 2.3%, the total consumption was 50.5 TWh (1). Due to a mild winter season, the most relevant renewable generation facilities (hydro and wind) experienced a strong production reduction in comparison with 2010. In 2011, Portuguese wind farms produced 21 GWh less than the previous year. It is only because of the decrease in consumption that wind penetration achieved a value of 18%.

The growth of the wind sector has maintained the pace of 2010, and 315 MW were added. This amounts to a total installed capacity of 4,302 MW, representing 22% of the electric system's installed capacity (1). In November 2011, a milestone for Portuguese offshore wind development was achieved with the successful deployment of its first offshore floating wind turbine – WindFloat (opening photo).


Photo: Courtesy WindFloat

2.0 National Objectives and Progress

2.1 National targets

The targets for installed capacity currently in place were established in June 2010 by the former government through the Plano Nacional de Acção para as Energias Renováveis (PNAER plan) (1). During 2011, a Memorandum of Understanding (MoU) was signed by the Portuguese government, the European Commission (EC), European Central Bank (ECB), and the International Monetary Fund (IMF) (3) that specifically addressed the renewable energy sector, aiming to reduce its economic impact on Portuguese industrial production costs. Actions regarding the renewable energy sector were studied focusing globally on the reduction of the cost of electricity in Portugal. As a consequence of the economic climate and the public's perception of wind energy as introducing an extra cost on the country's electricity, in 2011 only 11 MW of new wind plants were licensed (2).

2.2 Progress

During 2011, 315 MW of wind power were deployed in Portugal. This figure is on the same level as 2010 but reveals the decreasing trend of the last few years as displayed on the dark green bar graph of Figure 1. The new capacity was distributed over 10 new wind farms that added 207 turbines. The total number of deployed wind turbines in Portugal is now 2,349 of which 2,239 are installed in mainland Portugal (2) and 110 in Madeira and Azores (4).

Considering only mainland Portugal, the yield of generated wind energy was

Table 1. Key Statistics 2011: Portugal

Total installed wind capacity	4,302 MW
New wind capacity installed	315 MW
Total electrical output from wind	9.0 TWh
Wind generation as % of national electric demand	18%
Average capacity factor	26%
Target:	Onshore: 6,800 MW Offshore: 75 MW by 2020

9,003 GWh which is 23 GWh less than in 2010. Nevertheless, wind energy accounted for 18% of the total consumption, a figure 1% above that obtained in the previous year. This was only possible because an historic 2.3% decrease of consumption was recorded (1).

The average production at full capacity was 2,093 hr/MW, which is substantially lower than the 2,348 hr/MW of 2010. The wind energy production by classes of number of hours at full capacity (NEPs) was concentrated (52%) in wind farms with NEPs between 1,750 and 2,250 hours. In 2010 a similar proportion was obtained for wind farms with NEPs between 2,250 a 2,750 hours. Wind farms with NEPs below 1,750 hours increased their production from 1% to 6%. The trend in 2011 was to have the production concentrated in parks that produce less (58%). Therefore, reductions were felt on more productive wind farms, with NEPs between 2,250 and 2,750, reduced from 53% in 2010 to 29% in 2011, and wind farms with NEPs above 2,750 hours saw a reduction of 3% recording 13% in 2011.

The year was atypical for renewable electricity production and far below what Portugal showed it can produce. Renewable energy sources accounted for 45.3% of the gross electric demand which was a severe reduction in the pace established by the 51.6% of 2010. The largest share of renewable production came from hydro power plants which accounted for 49.1%, a figure 8% below what was obtained in 2010. With the reduction of the largest player, the remaining sources were able to augment their contribution, wind energy yielded 37% of production, the biomass sector represented 12.4%, and PV grew from 0.8 to 1.1%.

2.3 National incentive programs

The strategy and incentives for renewable energy investments in Portugal are set by the PNAER plan approved in 2010. The milestones defined by it are set to 2020 and foresee a quota for the renewables contribution to the several energy sectors. The plan considers 2005 as a baseline, where the contributions from renewables were of 0.2 % in transportation, 29.3% in electricity, and 31.9% in heating and cooling. The targets for 2020 are to raise the contribution to 10% in the transportation sector, 30.6% in heating and cooling, and to 60% in electricity (5).

Other incentive programs currently in place in Portugal target micro-generation (up to 11 kW) and mini-generation (up to 250 kW) renewable energy installations. For micro-generation, the yearly feed-in tariffs and limits for grid-connected power are established by dispatch until 31 December of the previous year. The tariffs for 2011 were established on 30 December 2010 by the Energy Sector Regulator Direcção Geral de Energia e Geologia (DGEG) to a value of 380 EUR/MWh (491.7 USD/MWh) and a limit of 29.6 MW of grid-connected power was set. The mini-generation program was established in 2010, but only in March 2011 the Decree-law 34/2011 setting its rules was published (6). This program allows small companies to install renewable-based production centers of up to 250 kW. There are limitations on the yearly amount of energy which will be rewarded at a maximum of 250 EUR/MWh (323.5 USD/MWh).

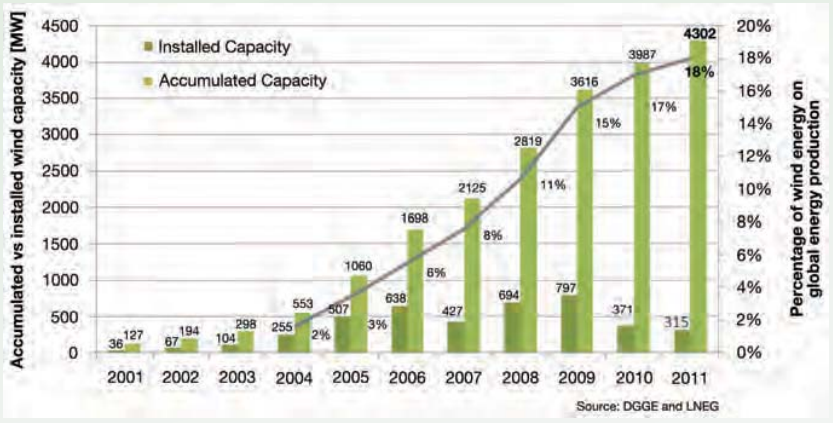

Figure 1. Installed versus accumulated wind capacity (bar graph) and percentage of wind energy production (line graph)

2.4 Issues affecting growth

In May 2011, the Portuguese government agreed with the EU, the ECB, and the IMF on a settlement due to the Euro zone crisis. The agreement resulted a document known as the MoU on Specific Economic Policy Conditionality (3). Regarding the energy markets, the objectives established in the MoU include: complete liberalization of the electricity and gas markets, reduction of the energy dependence from external sources and renewable energy promotion ensuring limited additional costs, a consistent overall energy policy by reviewing existing instruments, and further integrate the Iberian market for electricity and gas (MIBEL and MIBGAS). The most important measures regarding renewable energy are to review the efficiency of support schemes for renewables, covering their rationale, their levels and other relevant design elements; and to assess the possibility to reduce eventual extra costs associated with the renewable sector. For mature technologies, mechanisms alternative to FIT (such as feed-in premiums) are being investigated. Reports on action are to be taken in the third quarter of 2011, third quarter of 2012, and third quarter of 2013.

To follow the trends and evolution of emissions during the implementation period of the Kyoto protocol (2008-2012), the Portuguese company E.Value publishes a monthly index on energy consumption and CO_2 emissions from electricity generation (Figure 2). The month of December 2007 is used as the reference (value 1,000). After reaching record values by the end of 2010 (a value of approximately 1,042), during 2011 the energy index has steadily decreased, ending the year with a value of 1,010. The CO_2 index inverted its tendency,

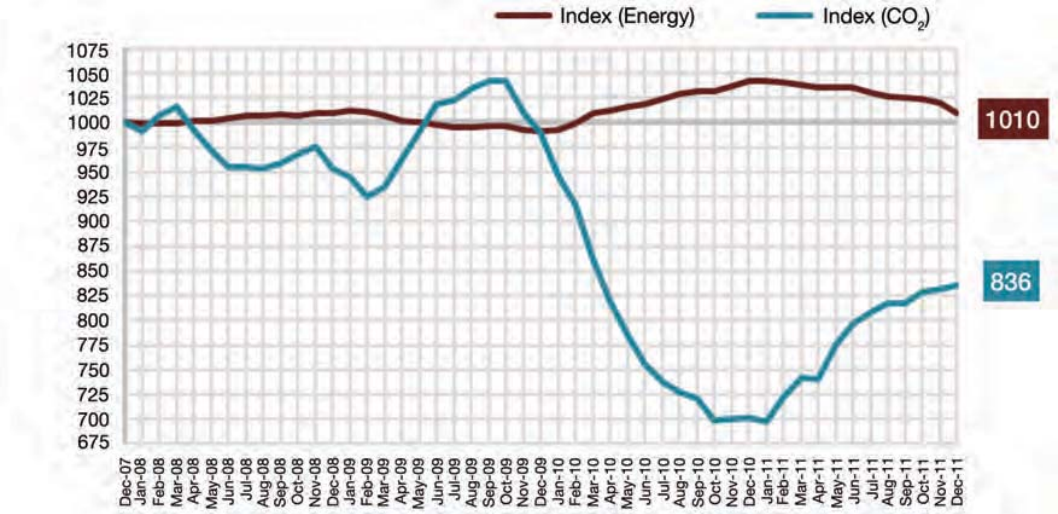

Figure 2. Electricity consumption and CO_2 emission from electricity generation E.Value index for Portugal (Source: www.evalue.pt)

because 2011was a difficult year for renewable energy generation, reflected by a growth of 130 points throughout the year.

A design parameter limit of electric systems like the Portuguese is the extreme penetration of renewable, non-dispatchable sources (e.g., wind power or river run-off hydropower). After 2010 where the records for highest wind instantaneous penetration and daily consumption supplied by wind were set, 2011 saw those figures surpassed again. The highest instantaneous wind penetration was recorded on 13 November 2011 at 4:30 AM with a value of 93%. On this day, 81 GWh of wind energy were produced, which meant 70% of consumption, also a record (1). Figure 3 describes the wind energy timing on the maximum demand day, highest wind penetration, and highest contribution from wind.

3.0 Implementation

3.1 Economic impact

The current wind capacity together with the Portuguese wind industry account for an estimated number of 3,200 jobs. In 2011, wind generated electrical energy produced an estimated income of 842 million EUR (1.090 billion USD) and allowed for savings of 3.1 million tons of CO_2 emissions. The newly installed capacity (315 MW) represented a private investment by wind power developers of more than 400 million EUR (517 million USD). The wind energy sector has an economic impact of nearly 1.3 billion EUR (1.7 billion USD).

In 2011, the Portuguese Renewable Energy Association (APREN) and Roland Berger Strategy Consultants published the study "Assessment of costs and benefits of electricity production from renewable energy sources" (7). This study reviews the period between 2005 and 2010, estimates the costs of energy from renewable sources and conventional sources for the period between 2011

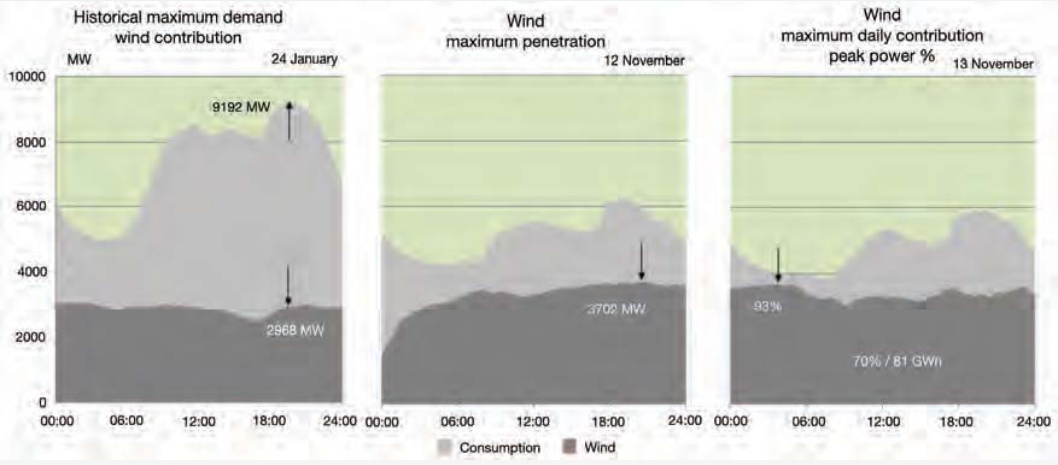

Figure 3. Record wind power penetration and energy generation during 2011 (13 November) (1)

and 2030, and analyzes the current tariff's structure.

3.2 Industry status

The onshore manufacturers market is again led by Enercon in 2011. With 207 wind turbines, Enercon has 87.7% of the market. The closest competitor is Nordex with a share of 7%. The remaining wind turbines (12) were installed in equal parts by REpower and Vestas, amounting to a share of 2.6% each. With this scenario, Enercon increased its share of the overall Portuguese market to 52.2% of the installed capacity. In second place is Vestas with a 14.3% share, followed by Gamesa (9.8%), Nordex (9.4%), REpower (4.2%), GE Wind (2.4%), Ecotecnia (2.4%), Suzlon (2.4%), Izar Bonus (1.7%) and other manufacturers (1.2%) (2 and 4).

An important milestone for offshore wind development in Atlantic waters was achieved in November 2011. The WindFloat, a semi-submersible structure holding a multi-megawatt wind turbine, has been deployed at Aguçadoura, a site located 6 km offshore of Póvoa do Varzim, north of Portugal with a depth of 50 m. It is the outcome of the WindPlus joint venture from EDP – Energias de Portugal, Principle Power, A. Silva Matos (ASM), Vestas Wind Systems A/S, InovCapital and Fundo de Apoio à Inovação (FAI). The assembly, installation, and preparation were performed on a dry dock in Setenave, Setubal, and the WindFloat was towed more than 350 km to its final location.

3.3 Operational details

Ten new wind farms were connected to the grid in 2011. Of these, 92.2% have an installed capacity between 10 and 50 MW, while the remaining 7.2% were installed with a capacity below 10 MW. With the exception of two wind farms, all the new parks have deployed 2.0 MW rated power wind turbines (2). The largest new wind park is composed of 22 wind turbines. The overall installed capacity is distributed mainly in small (<10 MW) and medium sized (10-50 MW) wind farms. The first have a quota of 51.4%, the second of 40.8%, while only 7.8% of the wind farms have a capacity above 50 MW (2).

In Portugal, 2011 was an atypical year for wind availability and production. Here wind turbines operate in two different environments, the coastal or the mountainous region. In both regions, the indexes maintained by LNEG for wind and production (Figure 4) show a pronounced decrease from previous years. The wind availability was far below average, an index of 0.93 was recorded in the coastal region and 0.92 in the mountainous region. Regarding production, wind farms in the coastal region were able to yield a figure close to average (index of 1.0), whereas in the mountainous region only an index of 0.91 was recorded. Data from the Portuguese TSO (1) is in line with the one from LNEG and points to an overall production index of 0.97 in 2011 when considering the period between 2001 and 2010.

3.4 Wind energy costs

During 2011, the average installed cost, excluding grid connection and land contracting, was 1.4 million euro/MW (1.81 million USD/MW). The mean tariff paid during 2011 was 93.5 EUR/MWh (121 USD/MWh) to the wind power plants and 103.4 EUR/MWh (134 USD/MWh) for the renewable independent producers, according to the Portuguese energy regulator (ERSE) (8).

4.0 R, D&D Activities

4.1 National R, D&D efforts

The national R&D efforts during 2011 were mainly focused on offshore wind energy, development of tools and methodologies to maximize the penetration of renewable energy, and promoting energy sustainability. These activities are taking place at the principal institutes and universities of the country financed through national or European programs. The main R&D activities underway in Portugal are:

- Project NORSEWiND: made up of 15 organizations between research institutes and industrial organizations with the Portuguese participation of LNEG funded by EC FP7. The project aims to characterize and evaluate the wind resource on the northern seas.
- Project ROADMAP: a Portugal-based project funded by the Portuguese Science and Technology Foundation (FCT), with the purpose of identifying the constraints and barriers to the development of offshore energy in Portugal.
- Project SEANERGY 2020: an EC-IEE project to evaluate and further develop the maritime spatial planning on the European space with the PT participation of LNEG.
- Project REIVE: a consortium of leading industrial and energy companies with R&D institutes led by INESC-Porto with the

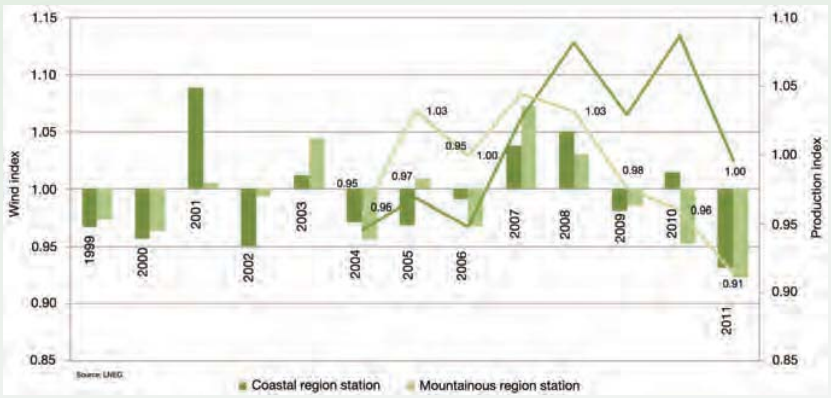

Figure 4. Wind (bar graph) and production indexes (line graph) on coastal and mountainous regions of Portugal

participation of LNEG. A project to deliver the "Smart Vehicle to Grid" funded by FAI (Portugal).

• Project TWENTIES: a project to deal with transmission system operation with large penetration of wind and other renewable electricity sources in networks by means of innovative tools and integrated energy solutions. Is funded by EC FP7 and has the PT participation of INESC-Porto.

• Project MERGE: a consortium of European partners with the Portuguese participation of INESC-Porto and the National Grid Operator (REN), funded by EC FP7 aiming to prepare Europe's grid for electrical vehicles.

• Project MARINA: a project that brings together companies, technology centers and universities from twelve EU countries. Is led by Acciona Energy and funded by EC FP7. The objective is to develop deep water structures that can exploit the energy from wind, waves, tidal and ocean current energy sources.

• Project ORECCA: a collaboration between European organizations and two North American research institutes is funded by EC FP7 and has the Portuguese participation of WavEC and LNEG. The project will stimulate collaboration in research activities leading towards innovative, cost efficient and environmentally benign offshore renewable energy conversion platforms.

• Project DEMOWFLOAT: a project to demonstrate the sustainability of the WindFloat technology deployed in Portuguese Atlantic waters. A consortium of European and North American partners will address the challenge of wind resource assessment in oceanic deep waters. It is funded by EC FP7 and has the participation of LNEG and several Portuguese partners involved in the joint venture led by EDP. LNEG will coordinate a WP to address the deep offshore wind energy challenges.

4.2 Collaborative research

Portugal and LNEG are active partners in international research efforts. The country participates in IEA Wind Task 25 Design and Operation of Power Systems with Large Amounts of Wind Power, and IEA Wind Task 27 Labeling Small Wind Turbines. LNEG is the Portuguese representative in the European Energy Research Alliance Wind Program (EERA-Wind), an initiative funded by leading European research institutes. EERA aims to strengthen, expand, and optimize EU energy research capabilities.

5.0 The Next Term

Due to the Euro zone crisis, 2012 is expected to be a year adjustment. The onshore wind energy market was stagnant in 2011 when only a few megawatts were licensed. The key players will concentrate on the wind farms already built and turn to emergent markets like Brazil or Eastern Europe. Expectations are high in regards to project WindFloat, after its deployment, the first tests and commissioning will take place in the first quarter of 2012.

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