31 Portugal

1.0 Overview

Within a sustainable development framework, wind energy in Portugal during 2013 continued the trend of the previous years and increased its influence in the Portuguese electricity system. This influence was felt in several ways. Portugal added 192 MW of installed wind power capacity and reached 4,709 MW of wind generation. This represents 23% of renewable energy capacity in the country. With this amount of wind capacity, 11.9 TWh was supplied to the electricity system during the year (1), (2). These increases resulted in a wind power penetration rate of 24% in electricity consumption, rising 4% compared to 2012. The high value of wind penetration was influenced by the especially favorable wind conditions observed in mountain areas where the majority of the installed wind capacity is concentrated. It is important to notice that this amount of penetration is only exceeded worldwide by Denmark.

The generation of electricity from renewable energy sources was 57% of the national consumption (which is a new record in Portugal). The individual renewable contribution in Portugal was different from last year. After an atypical year in hydro power production in 2012 (due to the fifth driest year of the last 80 years), the contribution of this renewable energy source grew 17% during 2013 reaching 27 % of electrical demand. Due to this increase, wind energy decreased 12% in its share within the renewable energy production (3). The high contribution from the endogenous resources enabled Portugal to reduce to 6% dependency on foreign energy in meeting consumption after reaching as high as 16% in 2012 (1).

Total electricity consumption in 2013 was 50.6 TWh, which corresponds to a slight increase of 3% compared to 2012 (1), (2). Despite the economic recession that continues in the country and the energy efficiency measures that were implemented in the last years, this small increase reverses the downward trend observed in the last few years.

In 2013, the Portuguese government approved a new National Renewable Energy Action Plan (NREAP). Compared to the previous NREAP 2010, the 2013 NREAP reduced the wind power capacity targets to 5,300 MW compared to the previous 6,875 MW (4).

2.0 National Objectives and Progress

2.1 National targets

During April 2013, the capacity targets for supporting renewable energy systems were modified by the former government through the NREAP 2013–2020 (4). The new targets were amended by taking into consideration the current excess supply of electricity production due to a reduction in demand, and the economic context. Regarding wind power, this action plan sets the need to reach an installed minimum capacity of 5,300 MW by 2020 instead of the previous 6,875 MW. This new value is divided into 5,273 MW installed onshore (with 400 MW corresponded to expanding the capacity of current wind parks—"overcapacity") and 27 MW offshore.

2.2 Progress

During 2013, a net capacity of 192 MW was added, which represents an installed capacity growth rate of 4% above the previous year. From this value, 10.3 MW is

One day in 2013, wind energy reached 90% instantaneous penetration and supplied 69% of the day's electrical consumption...During these events, the TSO reported no technical problems.

Table 1. Key National Statistics 2013: Portugal	
Total installed wind capacity	4,709 MW
New wind capacity installed	192 MW
Total electrical output from wind	11.9 TWh
Wind generation as % of national electric demand	24%
Average national capacity factor	29%
Target:	Onshore: 5,273 MW Offshore: 27 MW by 2020

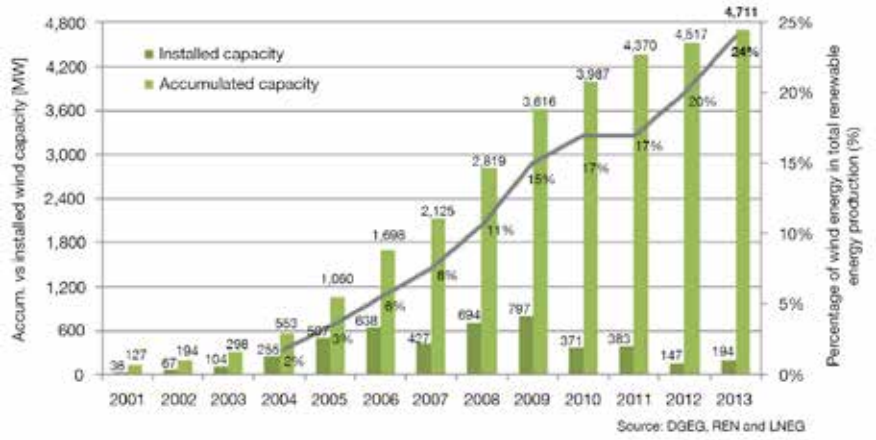

Figure 1. Installed versus accumulated wind capacity (bar graph) and percentage of wind energy production (line graph)

related to the Azores archipelago, and in Madeira Island 0.9 MW was decommissioned (2), (3).

As shown in Figure 1, the added capacity is in line with the year of 2012 demonstrating an onshore wind capacity saturation tendency. Compared with the previous ten years, this value was the second lowest since 2004, when the strongest wind deployment began. The cumulative installed capacity up to 2013 is distributed over 247 wind farms with 2,739 wind turbines operating across the country (mainland and islands), one of them being a floating offshore wind turbine (2), (3).

The Portuguese wind capacity generated in 2013 was 11.9 GWh and corresponded to 24% of the electricity demand. Wind's share of total renewable production was 39%, a decrease of 12% compared to 2012. This reduction was the result of a 17% increase in hydro production over 2012. For the same reason, the remaining mix of renewable sources also reduced their share with the biomass sector representing 10.4% and PV representing 1.5% (2).

In 2013, the average production at full capacity was 2,529 hours at the continental wind parks, which corresponds to a 9% increase with respect to the same period of 2012 (2,313 equivalent hours per MW), as shown in Figure 2. This result is mainly explained by the increased rate of wind energy index. The wind energy production by classes of number of hours at full capacity (NEPs) was concentrated in the wind farms with NEPs between 2,500–2,750 hours and above 3,000 hours. These represent a strong increase of 34% over the previous year and 62% of the total wind energy production. On the other hand, wind farms with NEPs between 2,000–2,500 hours diminished their contribution to the total from 58% to 36%, during 2013. Given the high wind energy index, the wind farms with NEPs below 2,000 reduced their share in 2013 from 14% to 1% (2).

2.3 National incentive programs

In 2013, a new NREAP for 2013–2020 was established as part of the new strategic vision for the energy sector for 2020. It revoked the previous NREAP established in 2010. This new plan to support the promotion of

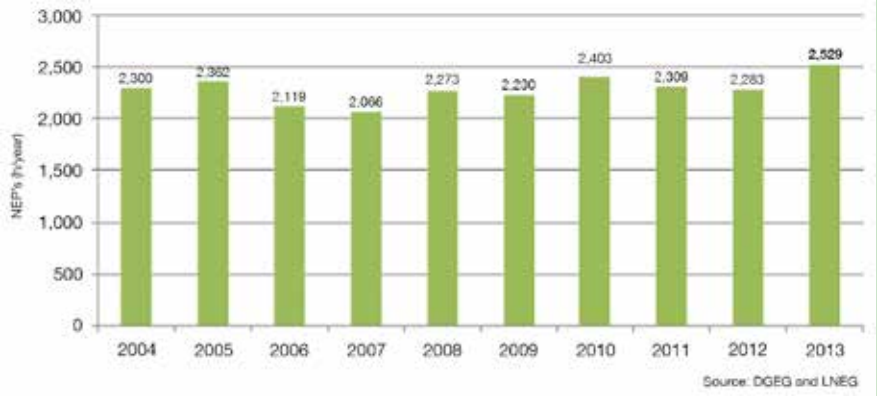

Figure 2. Average number of hours at full capacity per year

renewable energies is based on the indicators from 2010 where the contributions from renewables were of 5.5% in transportation, 34.5% in heating and cooling, and 41.1% in electricity. The targets for 2020 aim to raise those contributions to 10.0% in the transportation sector, 35.9 % in heating and cooling, and to 59.6% in electricity. Compared to the NREAP 2010, the new NREAP reduces the 2020 targets for the installed capacity of renewable energy source based technologies by 18%. Despite this reduction, a higher renewable energy share (60% versus the previous 55%) is expected in 2020 by increasing energy efficiency (reducing demand) (4).

In order to ensure the economic sustainability of the National Electric System, a further remuneration regime was created in Decree-Law 35/2013 (5) for the renewable energy producer (except non-hydro). This law determines that wind power producers may remain in a guaranteed tariff regime for an additional period (five or seven years) after the end of the initial 15-year term (6). The option for this new remuneration scheme implies the payment of annual compensation by the producers to National Electric System of: a) 5,000 EUR/MWh (6,890 USD/MWh) of installed power during a period of eight years with a guaranteed tariff for an additional five years; or b) 5,800 EUR/MWh (7,992 USD/MWh) of installed power during a period of eight years with a guaranteed tariff for an additional period of seven years.

Renewable energy installations for micro-generation (up to 11 kW) and mini-generation (up to 250 kW) units were still the object of incentive programs through a feed-in tariff (FIT) in Portugal during 2013. The micro-generation law was established by the Decree-law 118-A/2011 (7) that regulates the micro-production of electricity from renewable energy sources and provides a simplified framework and licensing regime for connecting renewable energy producers to the distribution grid. The tariffs for 2013 were set by the energy sector regulator—Direcção Geral de Energia e Geologia—to a value of 272 EUR/MWh (375 USD/MWh) for the first eight years of operation and 150 EUR/MWh (207 USD/MWh) for the second period of seven years with a limit of 11.0 MW for annual grid-connected power approved by ordinance number 431/2012 (8). For PV based technology the FIT values are lower and are justified by the reduction in the materials costs.

The mini-generation program was published in Decree-law 34/2011 (9). This program enables small companies to install renewable-based production centers of up to 250 kW. During 2013, Direcção Geral de Energia e Geologia reduced the reference tariff by 14%, reducing the values from a maximum of 215 EUR/MWh (296 USD/MWh) to 185 EUR/MWh (255 USD/MWh) with an annual maximum of power injection of 30 MW.

2.4 Issues affecting growth

In 2012, the Portuguese government suspended the capacity attribution for grid connection to reevaluate the legal framework for electricity generation (10). Therefore, the deployment of onshore wind projects during 2013 (and in the next years) corresponds to the installation of the remaining power previously attributed.

Through 2013, Portugal reached wind penetration of 24% of the annual energy consumed—a very high value and the second highest in the world, only surpassed by Denmark.

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). A new record for instantaneous wind contribution was reached on 10 December 2013 at 23:15; wind generation was 3,878 MW with 58% of power connection. On 25 December 2013 at 8:30 AM, an instantaneous penetration of 90% from wind generation was recorded. Wind contributed 3,330 MW and on the same day a record

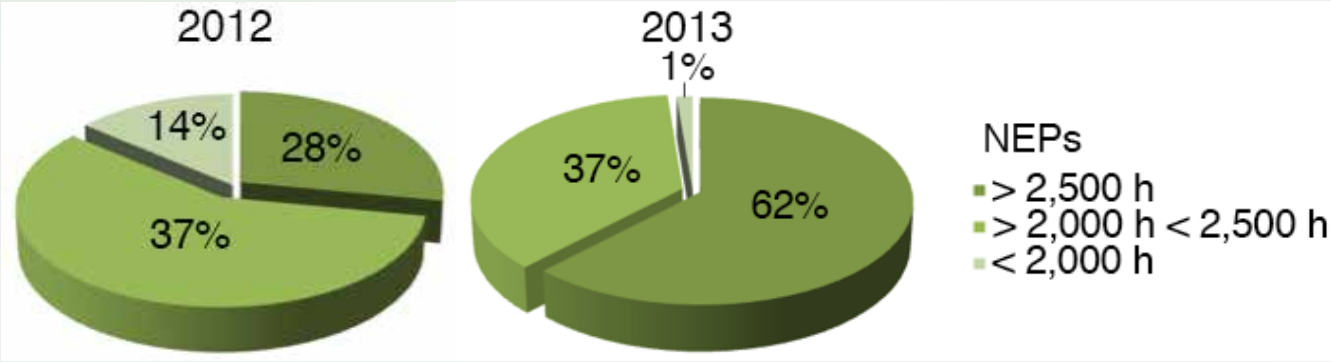

Fig. 3. Wind energy production by classes of number of hours at full capacity (NEPs) for 2012 and 2013.

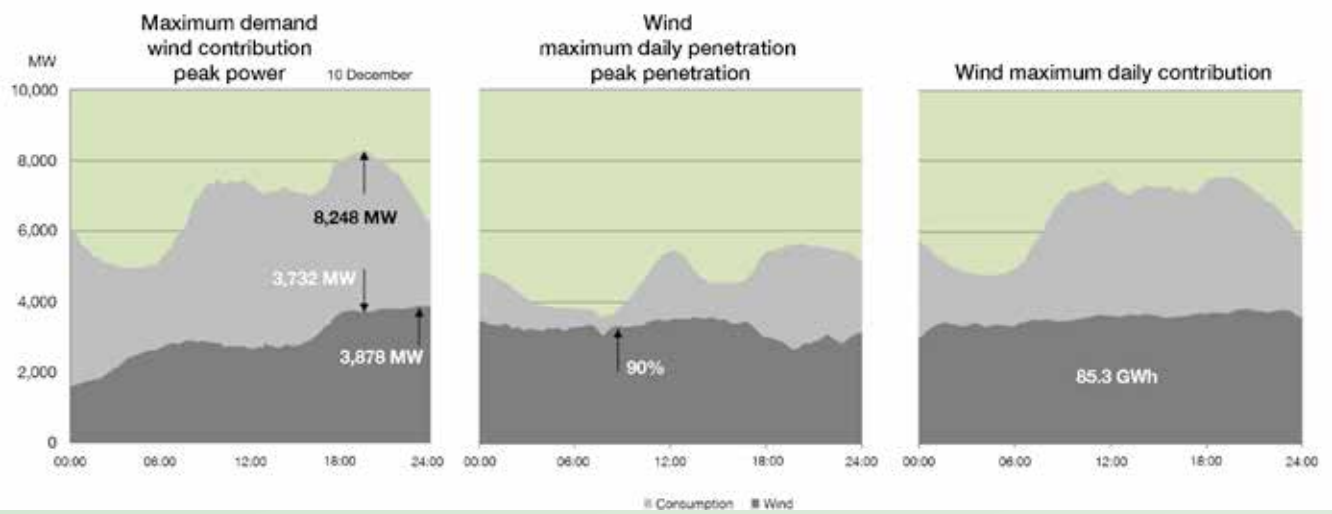

Figure 4. Record wind power penetration and energy generation during 2013 (1)

69% of the consumption was supplied by wind energy. The highest daily wind energy production occurred on 18 January 2013 with 85.3 GWh, which accounted for 55% of the daily demand (1). Despite the high wind penetration values recorded it should be noted that no technical problems were reported during these occurrences by the Portuguese transmission system operator.

Figure 4 depicts the wind generation profiles on: (i) the maximum demand day; (ii) maximum daily and peak penetration from wind; and (iii) maximum wind daily contribution.

3.0 Implementation

3.1 Economic impact

The wind industry in Portugal, together with the wind deployment activity (192 MW) supported an estimated 3,200 jobs. In 2013, wind generated electricity produced an estimated income of 1,170 million EUR (1,612 million USD) and allowed the estimated saving of 4.3 million tons of CO_2 emissions.

3.2 Industry status

During 2013, Enercon reinforced its leading position in Portugal as the most important supplier of turbines. In fact, from the 108 wind turbines installed in 2013, 100 corresponded to Enercon wind turbine models (Enercon E82 and E92 models). The remaining new wind turbines were installed by Vestas. As a consequence, Enercon increased its share of the overall Portuguese market to 55.3% of the installed capacity. In second place is Vestas with a 14.0% share, followed by Gamesa (9.3%), Nordex (8.7%), Senvion (former Repower) (3.9%), GEWE (2.3%), Alstom (2.3%), Suzlon (2.2%), Bonus (1.6%), Furlander (0.2%), and other manufacturers (0.4%) (Figure 5)(2).

After the initial commission procedures, the offshore floating wind turbine installed in northern Portugal is still in the demonstration stage. So far, it has proved to be a technically viable solution for future floating offshore wind parks despite the adverse storm conditions observed in the open sea environment. By November 2013, the WindFloat turbine had produced about 7.9 GWh (11). This project is being developed by WindPlus as a joint venture from Energias de Portugal (EDP), Principle Power, A. Silva Matos (ASM), Vestas Wind Systems A/S, InovCapital, and Fundo de Apoio à Inovação (FAI). The performance achieved with this floating system has allowed this consortium to transfer knowledge, technology, and innovation to begin designing the first wind park with floating technology in Portugal and in the U.S. coastal waters.

3.3 Operational details

In mainland Portugal five new wind parks were connected to the grid in 2013. In Açores Island, two new wind parks were connected with capacities of 4.25 MW and 3.60 MW. The overall installed capacity of the 247 wind parks in Portugal by the end of 2013 can be grouped into three categories where 52% have a small installed capacity (<10MW), 40% have a medium capacity (10–50 MW) and the remaining 8% are above 50 MW (3).

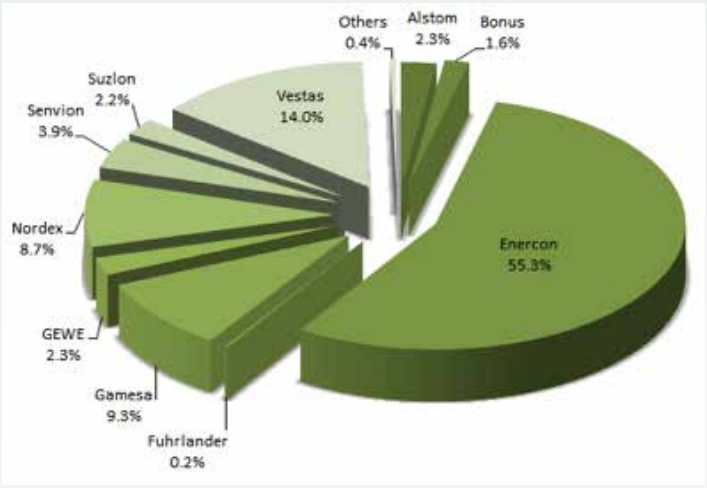

Figure. 5. Distribution of installed wind capacity by manufacturer

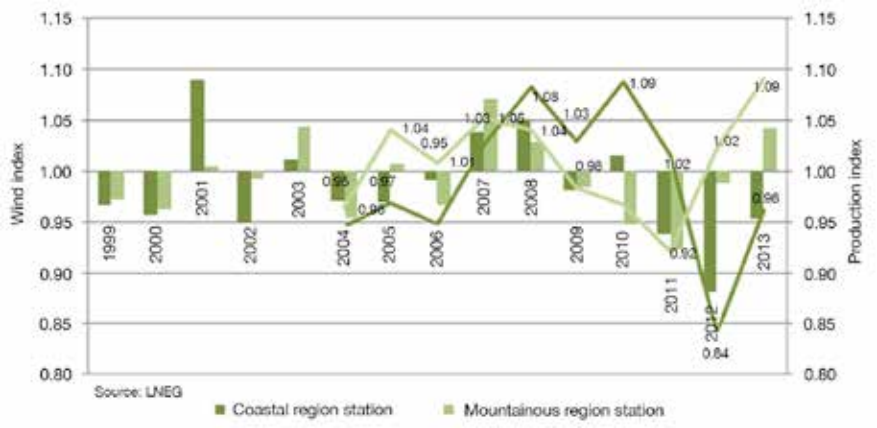

Figure 6. Wind (bar graph) and production indexes (line graph) on coastal and mountainous regions of Portugal.

Figure 6 shows the wind and production indexes for the last fourteen years. These values were achieved for two typical regions where wind turbines are operating in Portugal: coastal and mountainous. In both regions, Laboratório Nacional de Energia e Geologia (LNEG) indexes for wind and production show a pronounced increase from the previous year. In 2013, the production availability for mountainous regions was the best year since 1999. The wind availability was 4% above the average while the production index stood at 9% above the average. These results justify the high level of wind penetration in Portugal since most of the operating capacity is installed in mountainous regions. In the coastal region, the scenario reversed the last year's tendency, with wind growing 7% (index 0.95) and production 12% (index 0.96).

Data from the Portuguese operation of power systems (1) is in the line with the results presented from LNEG, indicating an annual wind generation index of 1.18, when considering the period between 2001 and 2013.

3.4 Wind energy costs

During 2013, wind turbine and installation costs remained unchanged from 2012. The average cost per MW installed was 1.35 million EUR (1.86 million USD). This amount includes associated costs of project installation and grid connection, among others. Turbine costs were around 80% of the total installation costs and corresponded to approximately 1.08 million EUR (1.48 million USD) per MW.

The mean tariff paid to the wind power plants in 2013 was 93.90 EUR/MWh (129.40 USD/MWh), according to the Portuguese energy regulator (ERSE). This tariff decreased 4.40 EUR/MWh (6.06 USD/MWh) when compared to the previous year (12).

4.0 R, D&D Activities

4.1 National R, D&D efforts

The national R&D efforts during 2013 were mainly focused on offshore wind energy, development of tools and methodologies to maximize the penetration of renewable energy, and promoting energy sustainability. Also a national funded program to constitute an R&D Infrastructures Roadmap in Portugal took place at the end of 2013. This program is aimed at the constitution of R&D infrastructures and valued the connections between national and international R&D Infrastructures Networks. These activities are taking place at the main institutes and universities of the country being financed through national or European programs. The following paragraphs describe the main projects underway in Portugal.

- Project FCT Roadmap: a Portugal-based project funded by the Portuguese Science and Technology Foundation (FCT). Its purpose is to identify the constraints and barriers to the development of marine energies in Portugal. This project ended in the second half of 2013.
- Project FCT Fluctuating Wind: a Portugal-based project funded by FCT with the coordination of LNEG. One of the main goals is to create a tool that will serve as a warning to the power system operators for possible severe wind power ramps.
- Project IRPWind: European-wide Measures and Structures for a Large-scale Wind Energy Integration: an FP7 European-funded project with the participation of LNEG. This project combines wind energy research projects and activities with the objective of fostering innovation, collaboration, and knowledge transfer between European researchers and leading R&D entities, with the participation of European energy Research Alliance (EERA) Joint Programme on Wind Energy partners.
- 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. It is funded by EC FP7 and has the Portuguese participation of INESC-Porto.
- Project MARINA: a project that brings together companies, technology centers, and universities from 12 EU countries. It is led by Acciona Energy and funded by EC FP7 with the Portuguese participation of University of Algarve. The objective is to develop deep-water structures that can exploit the energy from wind, waves, tidal, and ocean current energy sources.
- Project FP7 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 and international partners involved in a consortium led by EDP.
- Project ESFRI WindScanner: the project intends to establish in several European countries a network of innovative R&D for the acquisition of three-dimensional components of the atmospheric flow and characterization of wind turbulence. It is funded by EC FP7 and has the participation of the Portuguese entities LNEG and Porto University.
- Project TROPOS: the project aims to develop a floating modular multi-use platform system for use in deep waters, with an initial geographic focus on the Mediterranean, tropical, and sub-tropical

regions. It will be flexible enough so as to not be limited in geographic scope. It is funded by EC FP7 and has the Portuguese participation from WavEC.

• Project Atlantic PC: the project seeks to develop cooperation and joint approaches to facilitate the identification of new market niches and redefine educational and training programs as per the needs of the offshore and marine energy sector in the Atlantic Area. It is funded through the European Regional Development Fund (ERDF) and has the Portuguese participation from WavEC.

• Project OTEO: a Portugal-based project funded by the System Support for Collective Actions (SIAC) and has the participation of Instituto de Engenharia Mecânica e Gestão Industrial (INEGI), EnergyIN, Oceano XXI and WavEC. The project established a strategy to apply the Portuguese and international knowledge of offshore energy and to support technologies that increase competitiveness and entrepreneurship in this sector.

• Project EERA-DTOC: the project combines expertise to design a tool for the optimized design of offshore wind farms and wind farm clusters. It is funded by EC FP7 and has the Portuguese participation from Porto University.

• Project KIC-OTS: a technology project focused on the needs of the market, which was created under KIC-InnoEnergy, a company funded by the European Institute of Technology European Commission. The aim of the project OTS is developing a range of projects and services targeted to current and future needs for offshore renewable parks. This project has the Portuguese participation of WavEC.

• Project WindMETER: the project was developed to fill a gap and meet a growing opportunity in the wind energy market, as fiber optic sensors play an increasing role in the structural health monitoring of wind turbines. The project is co-funded by the Portuguese National Strategic Reference Framework (QREN) and is led by the consortium INEGI (technological consultant) and Fibersensing (industrial partner).

• Project OceanNET: an international project concerning floating offshore wind and wave energy funded from the PEOPLE Programme (Marie Curie Actions) of the EC FP7. The main goal of this project is to educate a new generation of engineers and scientists in the area of floating offshore wind and wave renewable energies to support the emerging offshore renewable energy sector. This project has the Portuguese participation of WavEC and Instituto Superior Técnico.

4.2 Collaborative research

In Portugal, LNEG and other Portuguese R&D entities 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 Small Wind Turbines in Turbulent Sites. During 2012, Portugal joined the IEA Wind Task 30 Offshore Code Comparison Collaboration Continuation (OC4) through Wavec and Centec. This participation is co-sponsored by EDP-Inovação. In addition to the IEA Wind activities, 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

For the onshore wind energy market, 2014 is expected to be a stagnant year due to the few pending licensing procedures. Regarding offshore wind energy, a better scenario is foreseen with some expectation due to the success achieved with the WindFloat project. With the NER300 program support, the first offshore floating wind park on the Portuguese coast will be installed, with an estimated capacity of 25 MW.

National incentives, especially for micro-generation and mini-generation, are under evaluation and might be merged into a single category and changed to a market regime (4). At end of 2013, a new reference FIT value was established for 2014 by the energy sector regulator with a reduction in the incentives.

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Opening photo: Windfarm in Portugal (Credit: Vitor Andrade)

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