CHAPTER 26

Portugal

1.0 Overview

In 2009, the electricity consumption in Portugal was 49.9 TWh, which represents a reduction of 1.4% in demand, the first decrease since 1981. By the end of December 2009, Portugal had a renewable energy capacity of 9,093 MW, which represents 51% of the total installed capacity (1). The energy generation by the renewable power plants during this year corresponded to 33% of the generated electricity.

The Portuguese wind sector has been growing steadily in the past decade, and in 2009 the country surpassed 3.5 GW of installed wind capacity. Moreover, the wind-generated electricity in Portugal represented 15% of the country's electricity consumption, which is one of the highest wind penetrations in the world (Table 1).

This was a record year not only in terms of yearly wind generation, but also in terms of the technical operation of a power system with a high amount of wind power. In 2009, the Portuguese power systems experienced extremely high wind production, namely an instantaneous power penetration of 70%, on 15 November 2009, during the no-load hours with no operational problems to be reported (1).

2.0 National Objectives and Progress

2.1 National targets

Within the European directive 2001/77/CE, Portugal set national targets for the installation of 3,750 MW of wind capacity by the end of 2010 (2).

Table 1 Key Statistics 2009: Portugal	
Total installed wind generation	3,616 MW
New wind generation installed	797 MW
Total electrical output from wind	7.492 TWh
Wind generation as % of national electric demand	15%
Target:	3,750 MW by 2010 5,100 MW by 2013

This target was nearly accomplished at the end of 2009, with 3,616 MW already installed and commissioned. The remaining capacity that will allow the fulfillment of the wind power contribution to the directive is already under construction. This goal was reviewed in 2005 (3), and the Portuguese government set the new national target at 5,100 MW by the end of 2013.

In July 2007, the European Union country leaders decided to reduce greenhouse gas emissions by 20%, to increase the use of renewable energy systems by 20%, and to increase energy efficiency by 20% by the end of 2020. In accordance with the European Agenda for Energy and Economy defined in the European Strategic Energy Technological Plan (SET-PLAN) 'Towards a low carbon future' (4), new measures for the renewable and wind sectors are being studied in Portugal and many other European countries, although no new wind capacity targets with published during 2009.

2.2 Progress

During 2009, Portugal installed the record value of 797 MW of new wind capacity, which brought the total capacity to 3,616 MW (5). This capacity is distributed among 195 wind parks and 1,879 wind turbines across the country, with a strong concentration in the interior center and north of the country, as well as a relevant capacity in the windy region just northern of Lisbon.

The wind capacity produced 7,492 GWh in 2009 according to the national transmission system operator REN (1), and corresponded to 15% of the Portuguese electricity production and 40% of the renewable generation. Figure 1 represents the installed and accumulated capacity and the wind energy production as a percentage of the national demand.

In Portugal during 2009, the operating wind parks verified a mean annual production of 2,230 hours at rated power. The wind power production by classes of NEPs (number of hours at full capacity) ranged from 7% of the wind power plants above 2,750 NEPs, 46% between 2,250 and 2,750, 39% in the interval from 1,750 to 2,250, and the remaining 8% with a low production below 1,750 NEPs.

In the last year, the energy production from renewable energies was slightly lower than in 2008 for hydropower and biomass, but higher for wind and photovoltaic systems. The annual evolution of the wind contribution in the renewable energy production has consistently increased in the last decade. In 2009, the contribution of wind generation was 40%, almost that of traditional hydropower generation (47% of the total renewable generation). Other contributions came from biomass (12%) and PV systems, already contributing with 0.9% of total renewable production in 2009.

2.3 National incentive programs

There are not specific incentive programs in Portugal for capital investment or tax reduction. The governmental support to wind generation is officially defined by the existence of a "green tariff" that includes the conventional generation avoided costs, as well as the environmental contribution of the renewable energies. Although recent contracts for the purchasing of energy from wind power plants set tariffs much lower (in the order of 75 €/MWh), the mean tariff value practiced in Portugal during 2009 was 93.7 €/MWh (6), since most operating capacity was licensed under previous legislation.

Portugal has a great commitment toward micro-generation, and implemented a procedure in 2007 where the interested consumers can apply over the internet to become "domestic generators." The evolution of the program has shown growth in the PV domestic micro-generation plants much more than in small wind turbine generation plants, a fact partially explained by the high solar resource of the country and the added difficulties with the characterization of the urban resource in constructed areas. The governmental initiative "Renováveis na Hora" (Renewables in the hour) was a major success, and 2009 witnessed 7,286 domestic applications for connection of micro-generation systems with a total capacity of 25.9 MW. From those

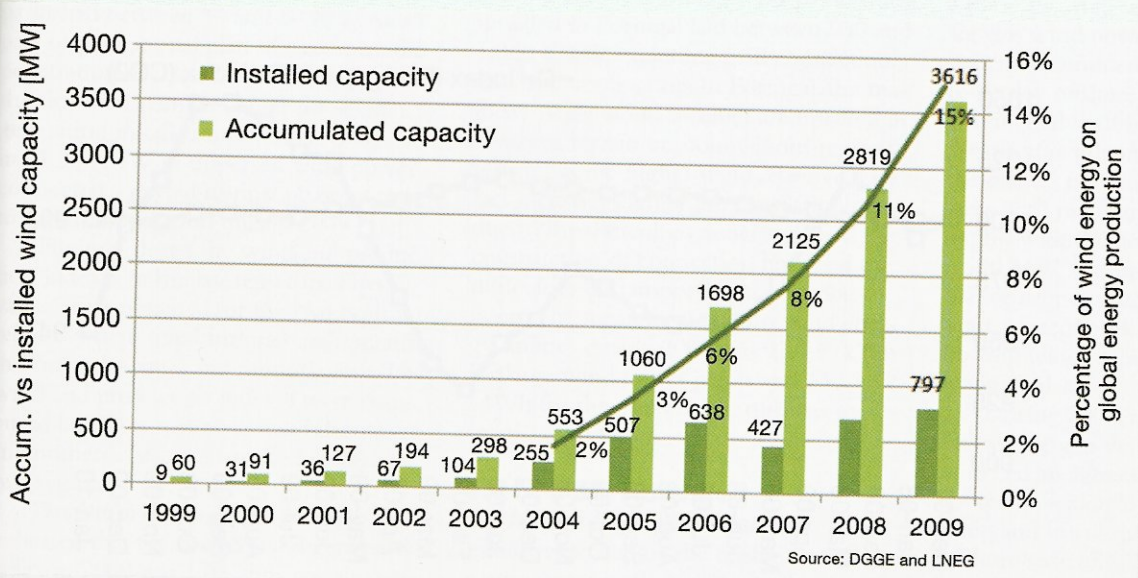

Figure 1 Installed versus accumulated wind capacity and percentage of wind energy in the consumption

applications, 2,506 with a capacity of 8.9 MW are already in the inspections phase.

2.4 Issues affecting growth

No major issues affected the growth of the Portuguese wind sector. Not only there is a strong national commitment to fulfill both the 2010 and 1013 targets, but the fact that Portugal is exceeding the emissions accorded under the Kyoto Protocol ratification will probably lead to an increase of those targets and the reinforcement of those commitments.

An energy index on the evolution of the tendency of the national CO_2 emissions during the implementation period of the Kyoto protocol (2008 to 2012) started to be published in 2009 – the E.Value Index (7). This index is computed by establishing the monthly relation of CO_2/energy referring to December 2007 (base 1000). The most relevant sectors for the fulfillment of the Kyoto protocol in Portugal are the energy and transports area, and these are covered by the E.Value Index represented in Figure 2.

Portugal has installed and is operating a high capacity of both wind power and run-of-river hydropower stations. These electricity sources share the common technical characteristic of being mainly non-controllable power stations – the technical term being non-dispatchable - by the transmission system operator (TSO). This requires the power mix to have a certain amount of controllable sources in order to be able to balance the total sources of generation and the total consumption. In power systems such as the Portuguese, a design parameter limit for the growth of its wind capacity is the excessive penetration of renewable non-dispatchable sources that should never exceed the no-load consumption added by a reserve value of conventional controllable power. During the winter of 2009 this limit was reached in a sequence of very wet and windy days, when the power system reached the limiting instantiations penetration of 70% wind power (Figure 3). This constitutes a record in such a peripheral European country, with a limited interconnection capacity to its neighbor countries (1,000 to 1,800 MW with Spain). Although no technical problems for the power system operation were reported, the occurrence of this design and technical parameter so soon in the progress toward the country objectives and with only 3,616 MW of wind power installed, is expected to introduce a limitation on the growth rate of wind power deployment in the next years in Portugal.

3.0 Implementation

3.1 Economic impact

The record amount of wind capacity installed in 2009 (797 MW), together with the wind industry already settled in Portugal has created an estimated 2,500 jobs. Despite the worldwide economic difficulties, this newly installed capacity represents a private investment by wind power plant developers of over 900 million €. The wind generated electrical energy produced an income of 700 million € for these wind utilities. The continuing increase in the creation of small companies for the assessment and installation of micro-generation systems has also contributed to the economic impact of this sector.

The indirect economic impact of the wind deployment is difficult to assess, but there are a large number of companies, from the construction area to the steel industry, that have a great share of the activity and turnover in the wind sector, and are thus overcoming the actual global economic crisis with a minimized impact.

3.2 Industry status

In 2007, the technological complex of the German company Enercon GmbH, a member of the wind energy consortium Eólicas de Portugal, SA., began construction in the north of Portugal (Viana do Castelo). In 2009, this industrial complex reached its full production potential, and the country passed from an importer of wind technology to an exporter. In the industrial complex in Viana do Castelo, Enercon manufactures almost all components of its model E82, as well as components for other models, including the novel concrete towers.

During 2009, Enercon, reinforced its leading position in Portugal with a of 44% share of the Spanish market, followed by Vestas (17%), Gamesa (12%), and Nordez (10%). The remaining share is divided by Repower (5%), GE Wind (3%), Ecotecnia (3%), Suzlon (2%), and Izar Bonus (2%) (8).

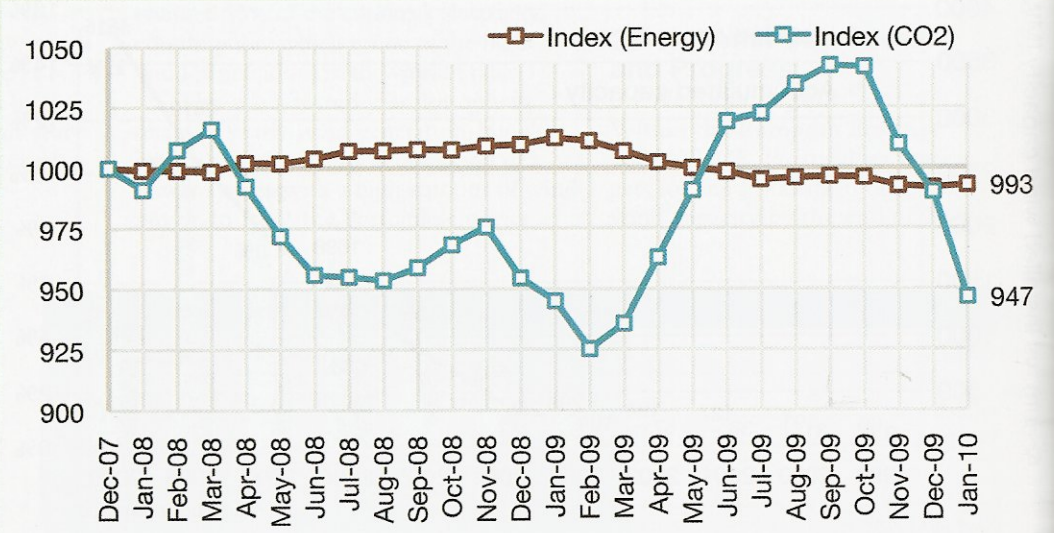

Figure 2 Energy E.Value Index for Portugal (7) Source: www.evalue.pt

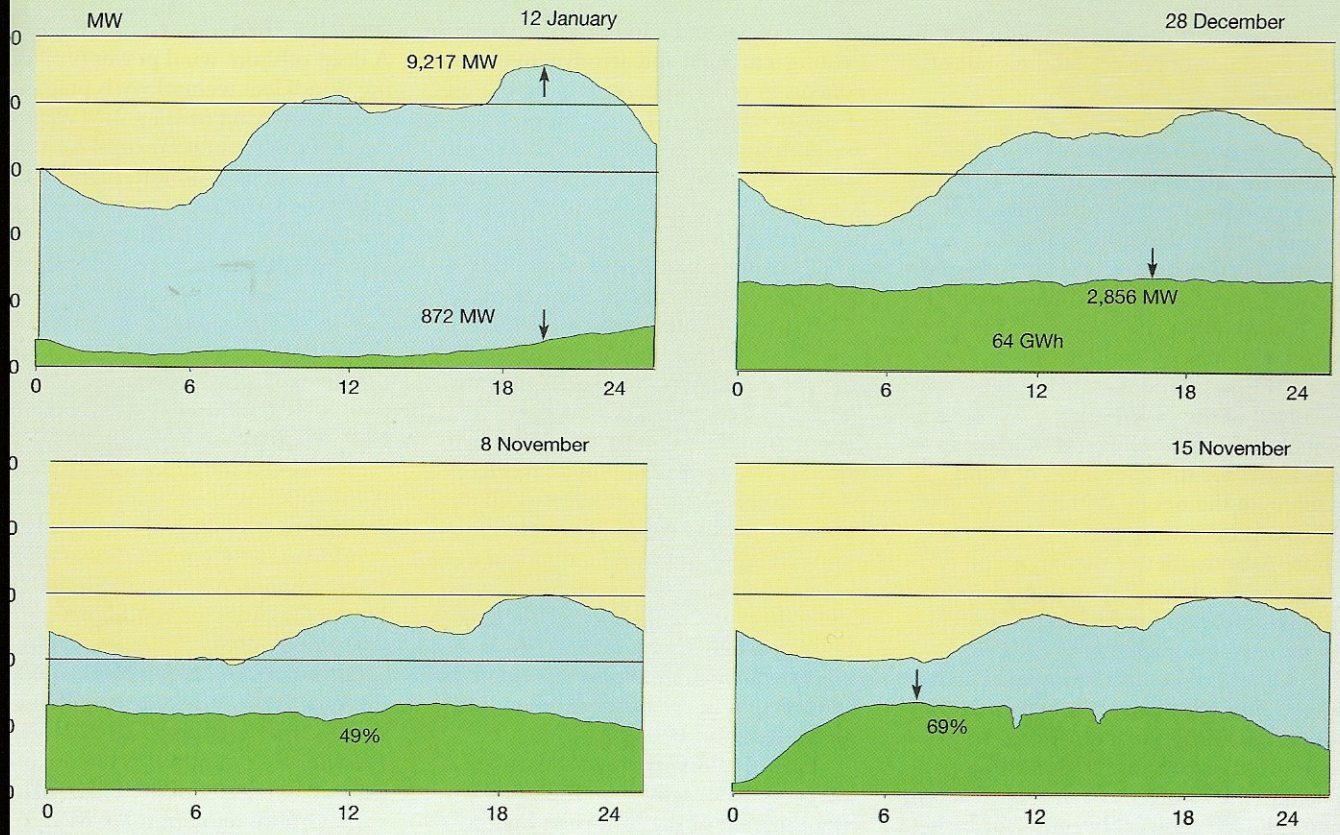

Figure 3 Occurrence of record wind power penetration and energy generation during 2009

perational details

stallation of large wind parks
l wind deployment in 2009, a ten-
in this country for several years
Vind parks with more than 50 MW
ted for 44%, and 47% of wind
ad between 10 and 50 MW. As a
the national plan to maximize the
tion of wind in the energy mix,
t management center for wind
tion installed in Oporto - hav-
00 MW of dispersed wind power
ted - started its final phase of tests
full operation during 2009.
ure 4 shows the wind and produc-
dexes in the last ten years. These
were obtained for the two typical
where wind turbines are operating
ugal: coastal and mountainous. The
nd production indexes were com-
ased on reference wind data from
metric stations installed in these
ions.
ta from the Portuguese TSO (1)
ed that the overall wind generation
n 2009 was 1.03, thus revealing an
cted similarity to the typical coastal behavior, although most of the operating capacity is installed the mountains of the interior.

3.4 Wind energy costs

During 2009, the average cost per kilowatt installed in Portugal laid between 950 and 1,300 €/kW, excluding grid connection and land contracting. In Portugal, the majority of the wind turbines are installed in complex terrain in mountainous regions, which has the higher wind resource. This fact increases slightly the installation costs due to the difficulties associated with the construction of connection lines and the difficulties in transporting the components. The mean tariff paid to wind energy utilities during 2009 was 93.7 €/kWh for large wind power plants and 432.3 €/MWh for the micro wind turbines in domestic applications.

4.0 R, D&D Activities

4.1 National R, D&D efforts

Initiatives to deploy the offshore wind power sector in Portugal started to appear in 2009. This was mainly driven by the exhaustion of windy onshore sites without severe environmental classification. The offshore wind resource, especially in deep waters (40 m to 200 m) is vast in Portugal, with all of the Atlantic coast north of Lisbon showing very favorable conditions for this wind power application. Although generally considered as a difficult coast to deploy offshore wind, the Portuguese continental shelf has a smooth slope until 200 m of depth and only sinks quickly in the first 25 m. Thus, Portugal has some areas with medium depths (until 40 m of depth) with the potential to deploy up to 2,500 MW, and an immense wind potential for deeper waters where fixed structures are economically not feasible and floating wind technology may be applied when available.

During 2009, the Portuguese energy utility, Energias de Portugal (EDP), announced an agreement with the U.S. company Principle Power, Inc., to develop and install the floating deep water offshore structure, WindFloat (Figure 5) designed by Marine Innovation & Technology (http://www.marineitech.com)

and owned by Principle Power, Inc. (9) in a wind power project off the coast of Portugal.

4.2 Collaborative research

There are several companies interested in deploying the Portuguese offshore wind potential these days. Some of them are already performing preliminary offshore wind resource assessments (e.g. Martifer). To contribute to the area of offshore wind deployment, the National Laboratory of Energy and Geology (LNEG) is involved in the Norsewind EC project, which aims to develop and validate methodologies for the assessment of wind resources in the ocean. Within this project, LNEG is operating a LIDAR in the offshore Atlantic islet of Berlengas and running mesoscale models with experimental data assimilation for detailed offshore wind resource mapping.

Other R&D institutions and Portuguese companies are actively participating in several European and national wind energy projects. Some of these projects include the involvement of INESC-Porto with the EC project 'Twenties' for high penetration of renewables, and the participation of the Portuguese TSO in the Project WindGrid. The Instituto de Soldadura e Qualidade (ISQ) and A. Silva Matos are also participating in several projects in the area of failures and condition assessment of existing structural and aerodynamic components in order to contribute to the use of advanced new materials and production techniques (EC projects NIMO and Safetower, and the Portuguese Quadro de Referência Estratégico Nacional (QREN) project Phasewind).

LNEG also participates with other Portuguese R&D entities, the Institute of Mechanical Engineering (IDMEC), Centro de Estudos em Economia da Energia, dos Transportes e do Ambiente (CEEETA), and the Wave Energy Center (WavEC) in the Foundation for Science and Technology (FCT) project Road-Map. This project aims to identify all the requirements and constrains (logistic, economical, technical/scientific, and technological) for the marine energy sector deployment and will create a road map for this sector. The results obtained from this project will have an important role in the development of the offshore renewable energy sector in Portugal.

Finally, LNEG represents Portugal and participates actively in the Wind Energy Program of the European Energy Research Alliance (EERA), a collaborative European platform for governmental laboratories and universities, where UoP is also represented.

5.0 The Next Term

A deep offshore wind power project using WindFloat technology is prepared to manufacture and install a 2-MW prototype off the coast of Portugal for testing.

The official announcement of the rising of the Portuguese wind power targets is expected during 2010, together with plans to mitigate its potential technical impact in the national power system operation and to optimize the integration of a large amount renewable generation in the Iberian electricity market, MIBEL.

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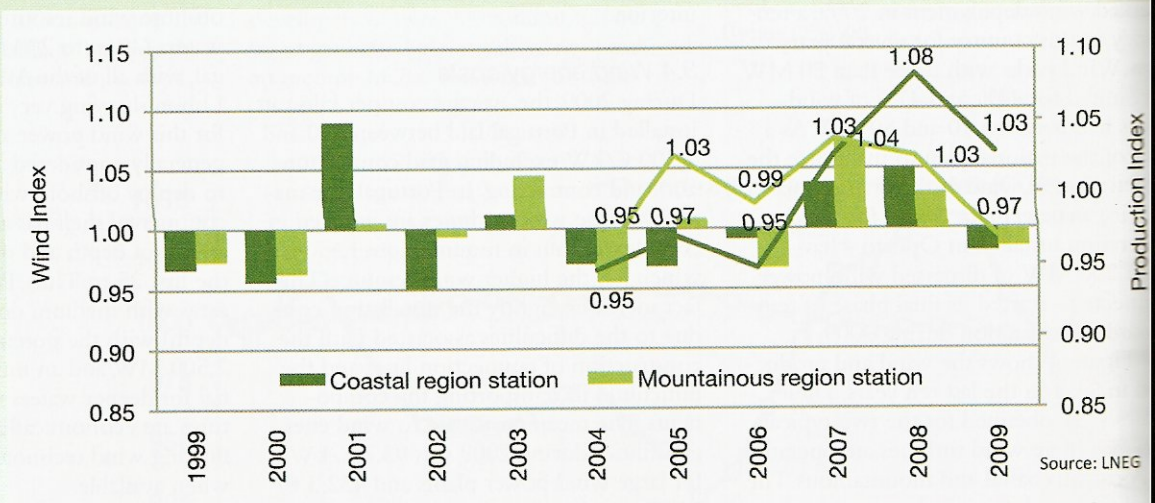

Figure 4 Production and wind indexes in a coastal and in a mountainous region of Portugal

Figure 5 The WindFloat structure

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