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### 1.0 Overview

In 2010 electric energy consumption grew 4.7% in Portugal reaching 52.2 TWh, the highest annual value recorded (1). The wind sector continued to grow although at half the rate of 2009. Presently Portugal accounts for an installed capacity of 3,987 MW, which accounted for 17% of the country's electric demand (Table 1). The renewable energy generating capacity arose to 9,490 MW (2) and is now 53% of the total installed capacity in Portugal. During 2010, the Portuguese government approved the PNAER - Plano Nacional de Acção para as Energias Renováveis is setting the pace for continued growth of the wind energy sector, aiming for an installed capacity of 6,800 MW onshore and 75 MW offshore (6, 5).

### 2.0 National Objectives and Progress

#### 2.1 National targets

The targets established within the European Directive 2001/77/CE of 3,750 MW by the end of 2010 (5) were achieved during the first half of the year. In December 2010, a total installed capacity of 3,987 MW were already grid connected, alongside 543 MW that were already licensed (2).

In April 2010, the Portuguese government published the National Energy Strategy until 2020 (ENE2020) with the purpose of reducing by 25% the dependence on foreign energy sources pursuing the commitments with the EU on climate change policies that included a national target of 8.5 GW for the wind capacity (5). In June 2010 the PNAER

was published reviewing the installed capacity targets and establishing a course of action needed to reach an installed a minimum capacity of 6,875 MW by 2020. From which, 6,800 MW will be installed onshore and 75 MW offshore. The efforts will be centered on repowering existing facilities and developing of new licenses in order to reach the proposed targets (3, 5, 6).

#### 2.2 Progress

In 2010, deployment of 371 MW of new wind generation capacity was achieved. This represents a cut of 50% in the installation rate (which had been growing for the last three years) of 2009 which recorded a record value of 797 MW installed. The installed capacity during 2010 is distributed over 13 new wind farms with a total of 188 wind turbines deployed across the country, elevating the number of wind parks to a total of 208 and the number of wind turbines installed to 2,067.

The yield of generated wind energy was 9,024 GWh, which represented 17% of the national electric demand, an increase of 20% compared to the 2009 production (1). Figure 1 shows the evolution of the installed capacity, accumulated capacity, and the percentage of wind in the Portuguese energy demand in the past ten years.

A mean annual production of 2,403 hours at full capacity was observed during 2010, 173 hours more than the average in 2009. The production of wind energy by classes of number of hours at full capacity (NEPs) was mainly concentrated on wind parks with a NEPs ranging from 1,750 to 2,250 hours (46% of the total production) and on wind parks with a NEPs of 2,250 to 2,750 hours (39%). The wind farms with NEPs above 2,750 contributed with 12% of the production and the ones with lower NEPs, below 1,750 hours, contributed with 3% of the production (2) which re-enforces the perception of Portugal as a high wind resource country.

The renewable electricity production represented 52% of the gross electric demand. In renewable energy production, hydropower raised its contribution from

**Table 1 Key Statistics 2010: Portugal**

Total installed wind generation	3,987 MW
New wind generation installed	371 MW
Total electrical output from wind	9,024 TWh
Wind generation as % of national electric demand	17%
Target:	6,875 MW by 2020

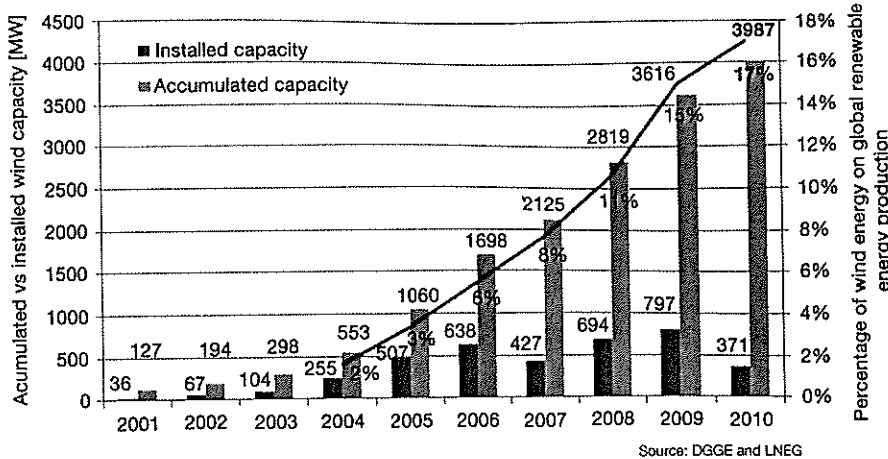


Figure 1 Installed versus accumulated wind capacity and percentage of wind in energy production

47% in 2009 to 57.6% in 2010, a growth of 82% in energy output. The wind energy yield increased by 20% in 2010. However the sector's contribution only represented 32% of the renewable production, decreasing from the 40% registered in 2009. The biomass sector represented 9.7% and PV represented 0.8% of the renewable energy yield (2). The first half of 2010, was especially good hydrologically. Hydropower plants more than doubled their production (approximately 128%) compared to the same period in 2009. This was the main driver for the lower relative contribution of the remaining renewable sources to the energy production of 2010.

### 2.3 National incentive programs

Within the European directive 2009/28/CE, the Portuguese government has approved the National Plan of Action for Renewable Energies (PNAER). This plan establishes minimum targets for all forms of renewable energy generation and energy efficiency (3). Under the scope of this program, several incentive programs are to be developed in order to achieve the proposed targets.

One of the most popular incentive programs for renewable generation has been micro-generation. Working since 2007, the procedure was suspended in the beginning of 2010 for reformulation of tariffs and operating capacity. On 25 October 2010 the Decree-Law 118-A/2010 (7) revising the micro-generation procedure was published. New limits for grid

connected power were established, rising from 14 MW to 25 MW per year. A new tariff, now lower than the previous, of 400 euro/MWh (537.60 USD/MWh) for the first 15 years was set.

Furthering the commitment to incentive programs on small-scale renewable energy generation, the Portuguese government approved in August 2010 (8) a program for facilities with maximum capacity of 250 kW. Named "mini-generation" the program has the target of installing a capacity of 500 MW until 2020 and foresees a total investment of 2,000 million euro (2,688 million USD).

### 2.4 Issues affecting growth

The Portuguese company E.Value publishes a monthly index on energy

generation and CO<sub>2</sub> emissions for the electricity sector. The month of December 2007 is used as a reference (value 1000). The purpose of the index is to follow the evolution of energy consumption and GHG emissions during the implementation period of the Kyoto protocol (2008-2012). The CO<sub>2</sub> emissions have been decreasing since October 2009 reflecting not only the growing importance of renewables on the energy mix but also a transfer of coal-based production to natural gas. The energy index grew steadily during 2010 reflecting as expected the electric demand.

In electric 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 (e.g. wind power or river run-off hydropower). Contribution from these should never exceed the no-load consumption added by a reserve value of conventional controllable power. During the winter of 2010, the power system reached the highest instantaneous penetration (75%) and on the same day a record value of 61% of consumption supplied by wind energy was obtained (Figure 3). It is to be stressed that no technical problems were reported during the occurrence of these extremely high atypical wind penetration values.

## 3.0 Implementation

### 3.1 Economic impact

An economic impact study of wind energy on the Portuguese economy made by the Portuguese Renewable Energy Producers Association (APREN) and

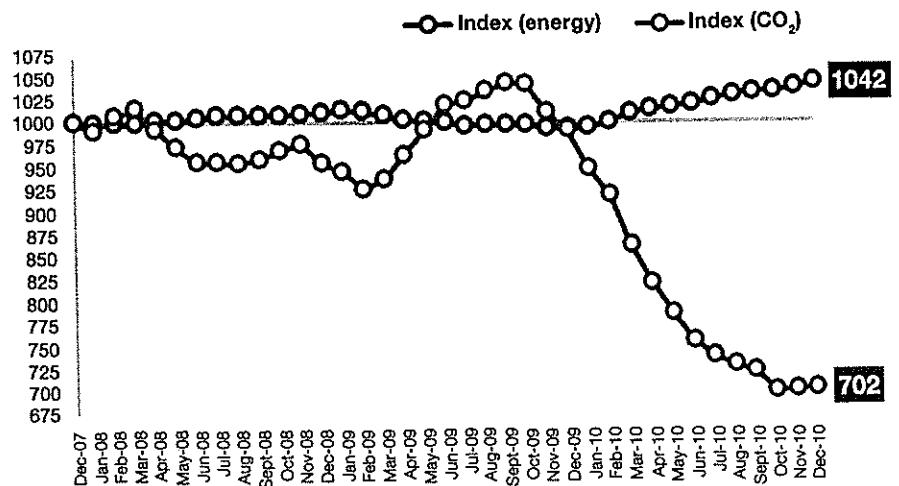


Figure 2 Energy and CO<sub>2</sub> E.Value Index for Portugal. Source: www.evalue.pt

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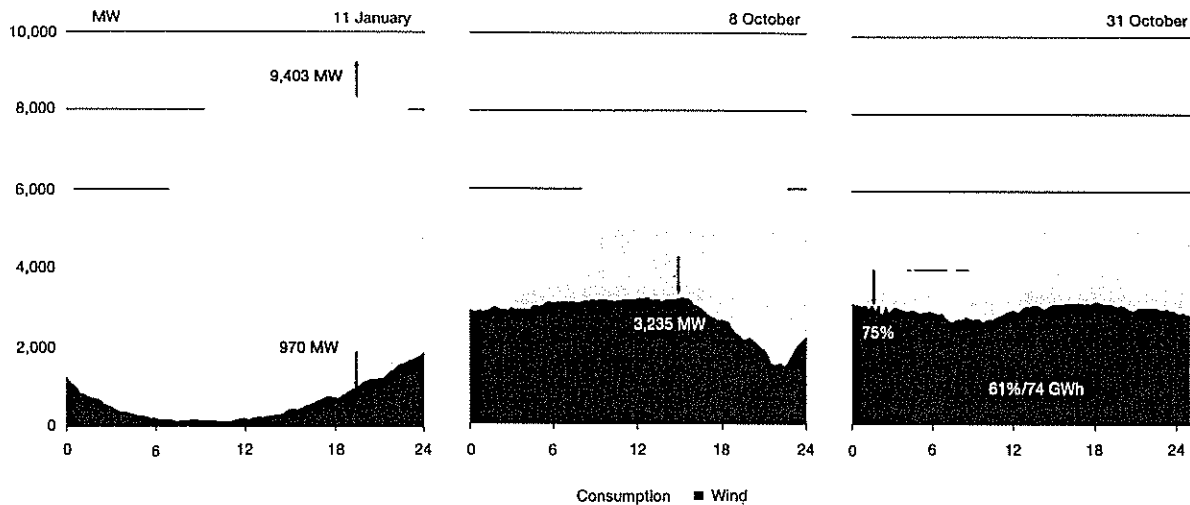


Figure 3 Record wind power penetration and energy generation during 2010 (31 October)

Deloitte (Portuguese economic consultancy company) was recently divulged (9). An analysis of the period between 2005 and 2008 and prospects for 2015 were made. At the end of the analysis period the wind energy sector was valued in 640 million euro (860.2 million USD), which is 32% of the entire renewable sector worth 2,000 million euro (2,688 million USD). The renewable sector came forth as one of most active sectors of the Portuguese economy with an average employment rate of 9% contrasting with the average 0.3% of all economy. The prospects for 2015 are very good for the renewable sector; it is expected that the sector should be responsible for 2.5% of GDP with the creation of 25,000 jobs. Adding to the existing capability, the sector should represent 60,000 jobs or 6% of the current unemployment level (9). The calculated savings on energy importations by the end of the analysis period ascended to 1270 million euro (1,707 million USD). The estimates from APREN and Deloitte point out to accumulated savings by 2015 of 13,000 million euro (17,472 million USD).

### 3.2 Industry status

During 2010, Enercon reinforced its leadership in the Portuguese market with its local production and now has a share of 48.1%. Enercon and Suzlon were the only players to increase their share during 2010. In second place with a share of 16% is Vestas followed by Gamesa (11%), Nordex (9.6%), Repower (4.4%), GE Wind (2.7%), Ecotecnia (2.7%), Suzlon (2.6%), and Izar Bonus (1.9%) (10).

The Enercon's wind technological cluster located in Viana do Castelo, a harbor city on the north of Portugal, employing nearly 1,500 workers has worked at full capacity during 2010 (10). Producing at a weekly average of 15 rotor blades, five concrete towers and three generators, the industrial cluster has already exported to countries like France, Ireland, Italy or even Germany according to its general manager Mr. Francisco Laranjeira. Expansion plans already exist for an investment of 55 million euro (73.9 million USD) that will allow the creation of 500 jobs. The project has been postponed since 2007 due to the financial crisis affecting the industry (11).

### 3.3 Operational details

Reviewing the 208 wind parks installed in Portugal by the end of 2010, 48% have

an installed capacity below 10 MW, 44% have a capacity between 10-50 MW, and the remaining 8% are above 50 MW (2). During 2010, 13 new wind farms were built, compared to the 21 deployed during 2009. From these, approximately half (46%) have a capacity between 10 and 50 MW, 31% have a capacity below 10 MW, and the remaining 23% have a capacity above 50 MW. The tendency to build large wind parks revealed during 2009 was maintained in 2010.

The two typical regions where wind turbines are operating in Portugal are the coastal and the mountainous regions. In terms of wind and production indexes, 2010 has been a contrast year between the two regions. According to LNEG (Figure 4), it was a year below average for resource availability, namely 0.96 at the mountain

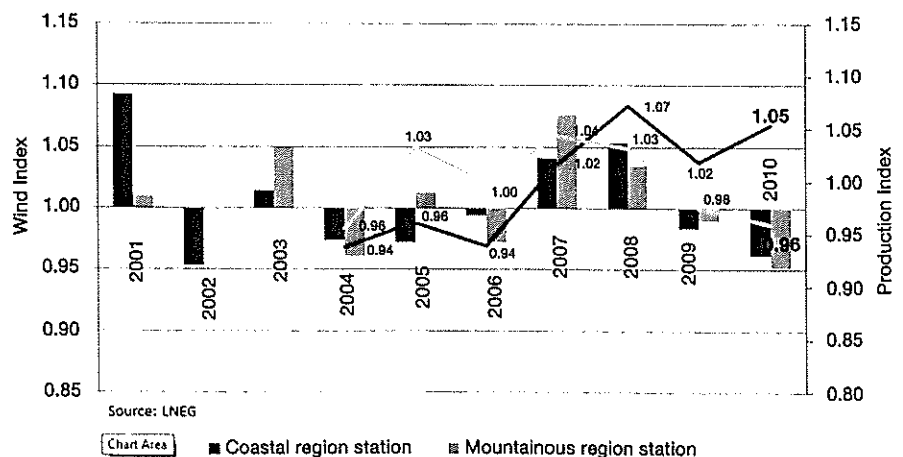


Figure 4 Wind (bar graph) and production indexes (line graph) on the coastal and mountainous regions of Portugal

and 1.05 on the coastal regions. At the latter corresponded a production index of 0.96, the lowest in six years but on the contrary a highly productive period occurred at the coastal region leveling the overall production index to values above one. Data from the Portuguese TSO (1) indicates a historical maximum in the production system with an overall wind generation index of 1.08 above average production between 2001 and 2009.

### 3.4 Wind energy costs

During 2010, the average cost per MW installed laid between 1,060 million euro and 1,470 million euro (1,425 million USD and 1,976 million USD), excluding grid connection and land contracting. The mean tariff paid to wind energy utilities during 2010 was 91.60 euro/MWh (123.10 USD/MWh) for wind power plants and 97.00 euro/MWh (130.37 USD/MWh) for mean tariff of the renewable independent producers (PRE) according to ERSE (the Portuguese energy regulator).

## 4.0 R, D&D Activities

### 4.1 National R, D&D efforts

Continuing the initiatives started in 2009, the national R&D efforts are mainly centered on the development of offshore wind and the development of tools and methodologies to maximize the penetration of renewable energy, as well as promoting energy sustainability.

The wind energy R&D activities are mostly developed in the regions of Oporto and Lisbon, where some of the groups are housed in academic or research institutes and are financed through national or European programs. The main R&D activities ongoing in Portugal include the following projects:

- NORSEWind “Northern Seas Wind Index Database” project, funded by EC FP7 for the characterization and evaluation of wind resource on the northern seas with the Portuguese participation of LNEG;
- ROADMAP project, funded by the Portuguese Foundation (FCT), with the purpose of identifying the constraints and barriers to the development of offshore energy in Portugal, developed by several Portuguese R&D institutes and companies;
- SEANERGY 2020, funded by EC-IEE to evaluate and further develop the maritime spatial planning

on the European space with the Portuguese participation of LNEG;

- REIVE “Redes Eléctricas Inteligentes com Veículos Eléctricos”, in the area of “Smart Vehicle to Grid” funded by FAI (Portugal), coordinated by INESC-Porto with the participation of LNEG and several leading industrial and energy companies;
- ANEMOS PLUS “Advanced Tools for the Management of Electricity Grids with Large-scale wind Generation” project funding by EC FP6 with the Portuguese participation of INESC-Porto;
- TWENTIES “Transmission system operation with large penetration of wind and other renewable electricity sources in networks by means of innovative tools and integrated energy solutions” project funding by EC FP7 with the Portuguese participation of INESC-Porto;
- MERGE “Mobile Energy Resources in Grids of Electricity” project funding by EC FP7 with the Portuguese participation of INESC-Porto among several others.

Assigned by the Portuguese government in 2008, the draft proposal of the Portuguese maritime spatial planning (MSP) was finally completed. Named POEM, the program aims to regulate the usage and coordinate the activities that take place on the Portuguese Exclusive Economic Zone (EEZ). Offshore wind and wave energy development guidelines have been developed and areas for the deployment were identified. LNEG has been at the forefront of the program contributing with the development of the Portuguese offshore Wind Atlas and identification of the sustainable offshore wind potential.

### 4.2 Collaborative research

The European Strategic Energy Technology Plan (SET-Plan) till 2020, has four strategic subjects for funded research. On each of the subjects of the SET-Plan, several projects have kicked off in Portugal. The first subject addresses the development of new turbines, components and materials. Projects FP7 Safetower, RFCS and Phasewind have cooperation of several industrial partners, including ISQ, A. Silva Matos, Martifer and others. The second subject covers offshore technology.

Project WindFloat from Portuguese utility Energias de Portugal (EDP) in collaboration with A. Silva Matos and Principle Power. The latter had already started in 2009 but was further developed when an agreement with Vestas for the supply of a 2-MW Vestas V80 was negotiated during 2010 and announced in the beginning of 2011. The third subject aims at developing the techniques for wind energy grid integration and productive system. Portuguese projects under the third subject involve several research institutions, namely INESC-Porto, LNEG, IST and others, are undergoing projects for clusters and aggregation of wind energy production, namely project FP7 Twenties, FP6 Windgrid, FCT -Fluctwind and IEAWind Task 25. Finally, the fourth subject covers the characterization of the wind resource and planning of its exploitation. Projects under the scope of the fourth subject include: project Norsewind, project IEE Seanergy and project FCT Roadmap(12).

LNEG represents Portugal and participates actively in the European Energy Research Alliance Wind Programme (EERA - Wind), an initiative funded by leading European research institutes. EERA aims to strengthen, expand and optimize EU energy research capabilities and is actively supporting the SET-Plan.

## 5.0 The Next Term

Expectations are high for the recently approved “mini-generation” program as wind developers are awaiting the disclosure of procedures to submit their projects. Another highly expected event is the deployment of a WindFloat prototype equipped with a 2-MW Vestas turbine scheduled for mid-summer on the Portuguese coast.

For the ongoing R&D activities, the next term will bring some important milestones. Project Norsewind has scheduled towards the end of 2011 the publication of the preliminary offshore wind energy map for the Northern seas. The recently approved project Fluctwind is scheduled to kick off during the first months of the year. Financed by FCT, Fluctwind will contribute to characterize and categorize wind power fluctuations by a time-spectral wavelet analysis. Several other R,D&D areas related to wind energy are currently very active in Portugal with electric mobility, smart-grids, and hydro-wind management being the most relevant.

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In what concerns the wind capacity deployment, it is expected that the 2010 installation rate will be maintained in the coming years, at least until 2015.

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