



1.0 Introduction

Portugal has few indigenous energy resources, such as those that satisfy the majority of the energy needs of the economically developed countries, such as oil, gas, and coal. This situation leads to a large dependence on foreign economies for fossil primary resources. In this context, the contribution of renewable energies and the need to improve their penetration becomes of strategic relevance for the country's development.

In 2006, the total renewable sources installed capacity was 6,961 MW. The total electric energy production from renewables has shown an impressive 86% growth rate with respect to the end of 2005, its final value being reported as 16,120 GWh. This growth was strongly correlated with the variation in hydropower production, about 124%.

In what concerns to wind energy, as will be shown in the next paragraphs, there was a moderate growth in the installed capacity when compared to previous years. In 2006, the 2005 policy continuance was verified, with special relevance to the ending of the first phase of the 1,500 MW public call for wind park grid connection opened in July 2005.

Table 1 represents the key statistics for 2006 in Portugal.

2.0 Progress Toward National Objectives

During 2006, Portugal presented a moderate growth rate of wind capacity installation, although it was lower than in previous years. The new wind

capacity installed in the whole Portuguese territory (including the Madeira and Azores archipelagos) was 634 MW. This capacity corresponds to a growth rate of about 59%, and the accumulated installed capacity corresponds to 45% of the 2010 goal. The slowing of the growth rate was already expected since the need to construct new transmission lines and the limited production capacity of the manufacturers of wind turbines is starting to play an important role in the wind capacity installation evolution.

Although the wind capacity installed by the end of 2006 apparently showed a moderate growth rate, and the corresponding generated electrical energy already represents about 6% of the total national electric demand according to Rede Eléctrica Nacional (REN) the Portuguese Transmission System Operator (TSO) (1).

In 2006, 1,681 MW of accumulated wind capacity were installed and operating on the continent corresponding to 964 wind turbines; 7 MW in the Azores archipelago with 28 wind turbines; and 10 MW in the Madeira archipelago corresponding to 43 wind turbines, for a total of 1,698 MW and 1,035 wind turbines. Moreover, there is already 3,073 MW of wind power capacity licensed in continental Portugal, although not all of it is installed, according to the statistics of the official energy board, General Directorate for Geology and Energy (DGGE) (2). Figure 2 represents the total installed wind capacity by the end of 2006.

During 2006, the electric energy generated by wind farms in the continental territory was 2,892 GWh as reported by the annual DGGE statistics. In

Total installed wind generation	1,698 MW
New wind generation installed	634 MW
Total electrical output from wind	2.929 TWh
Wind generation as % of national electric demand	6%
Target:	3,750 MW by 2010 5,100 MW by 2013

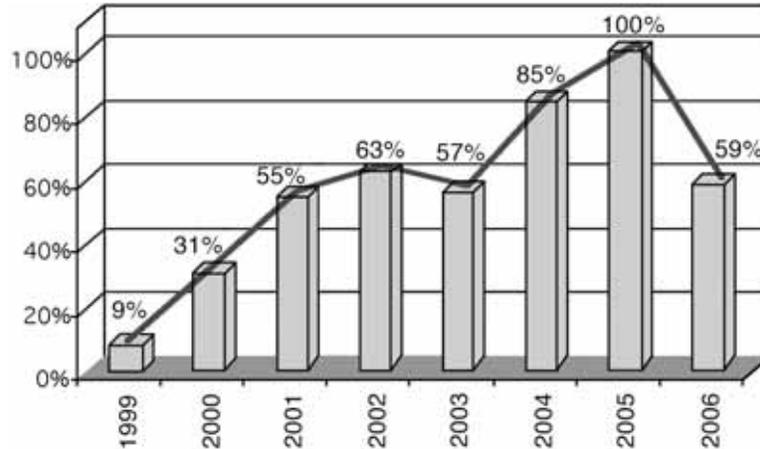


Figure 1 shows the capacity growth rate from 1998 until the end of 2006.

this year, the net electric consumption was in the order of 49.0 GWh. Using estimated production for the Azores and Madeira archipelagos (2000 hours equivalent to nominal power) the 2,929 GWh global generation is obtained. This production would correspond to 2,119 hours of operation at equivalent to nominal power.

Figure 3 shows the evolution of the wind energy generation in the period 1998–2006.

Considering the capacity involved in the call for wind park grid connection and the capacity actually under construction and/or in project, and assuming the annual growth rate until 2010 and 2013 is around 18%, the goals established in the Dec. Law 33-A and in the RCM 169, both published in 2005, will be fully achieved. Figure 4 shows the wind capacity growth rate estimate for the period 2000–2010.

Figure 5 represents a regional distribution of the installed wind capacity in Portugal.

3.0 Benefits to National Economy

3.1 Market characteristics

As a contribution to the 2013 governmental goals published at the RCM 169/2005, by the end of 2006, the first phase of the public call for wind park grid connection opened in July 2005, and corresponding to 1,200 MW was concluded. The winning consortium of developers was lead by the Portuguese electrical utility, Energias de Portugal (EDP) and had as technological partner, the German manufacturer ENERCON.

During 2006, a slight increase of the unit cost of wind turbines was observed. These costs were in the range of 875 to 1,150 €/kW, depending on the characteristics of the wind turbines and/or the country of origin of the manufacturer. O&M costs are approximately 2% of the investment cost, at least for the first decade of the wind power plant operation.

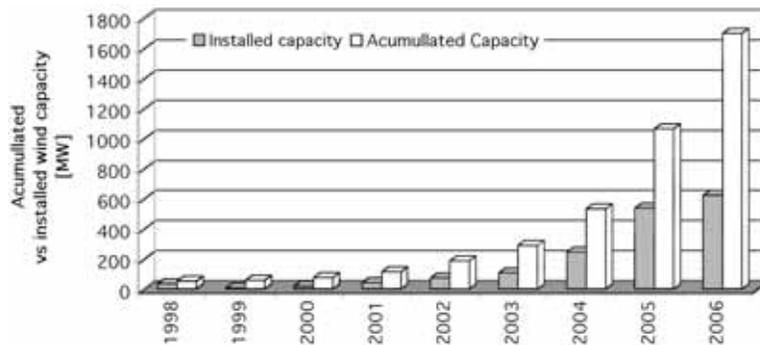


Figure 2 Installed and accumulated wind power capacity (1998–2006).

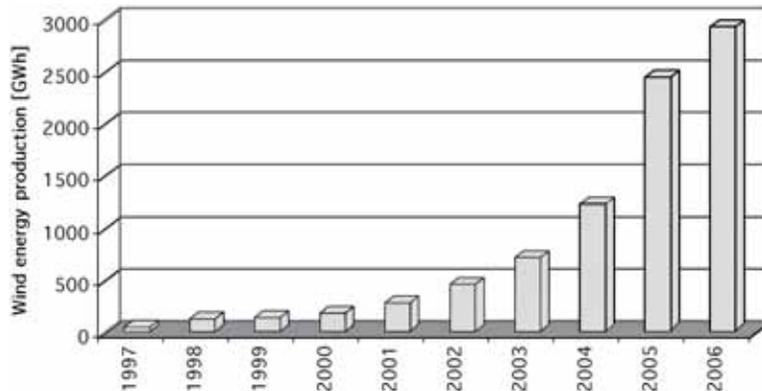


Figure 3 Wind energy production (1998–2006).

The wind farm developers keep reporting that it takes too long to obtain all the required permits and licenses, despite all the official efforts taken in order to simplify the bureaucratic process regarding the installation of renewable power plants.

3.2 Industrial development and operational experience

During 2006, more than 260 wind turbines were installed in Portugal, with a mean nominal power of 2.4 MW, according to DGGE. The turbines range from 0.6 MW to 3 MW. There is a wide distribution in the Portuguese market among the different large manufacturers in this sector. Figure 6 shows this distribution and the share of the main developers of wind farms in Portugal, in 2006.

As a result of the 2005 public call for wind capacity, where indigenous industrial manufacturing capacity was highly valued by the Portuguese government, some foreign industries showed strong interest to establish production facilities in Portu-

gal in the near future. Nevertheless, and in order to respond to the growing national needs of the wind sector, there are several Portuguese high-quality tower manufacturers, already exporting for other foreign markets, as well as specialized construction and electrical companies. Recently, wind energy international consultancy companies have also been observed.

The consortium winner of the 2005 first phase call has large industrial plans for the country and, among other units, has contracted with the Portuguese government the installation of concrete tower and blade factories, these working both for the domestic and the foreign wind markets.

3.3 Economic details

In Portugal, due to terrain orography, together with the fact that sites with suitable wind resource are mostly already taken, turbines with high nominal powers – multi-megawatt – are being installed. This way the total wind farm installation costs, are

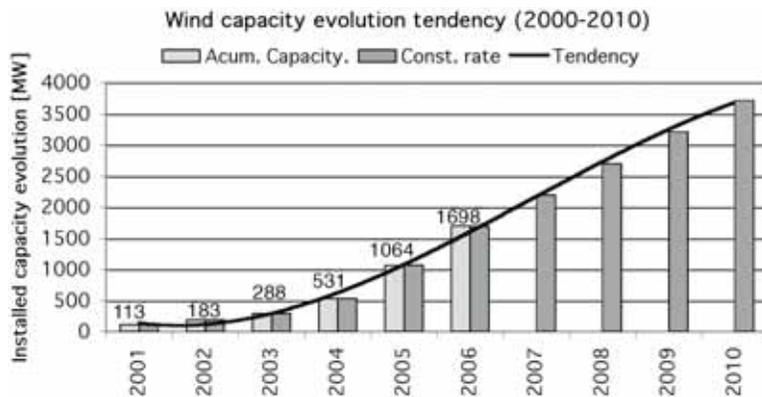


Figure 4 Trend of the wind power capacity installation towards the 2010 national targets.

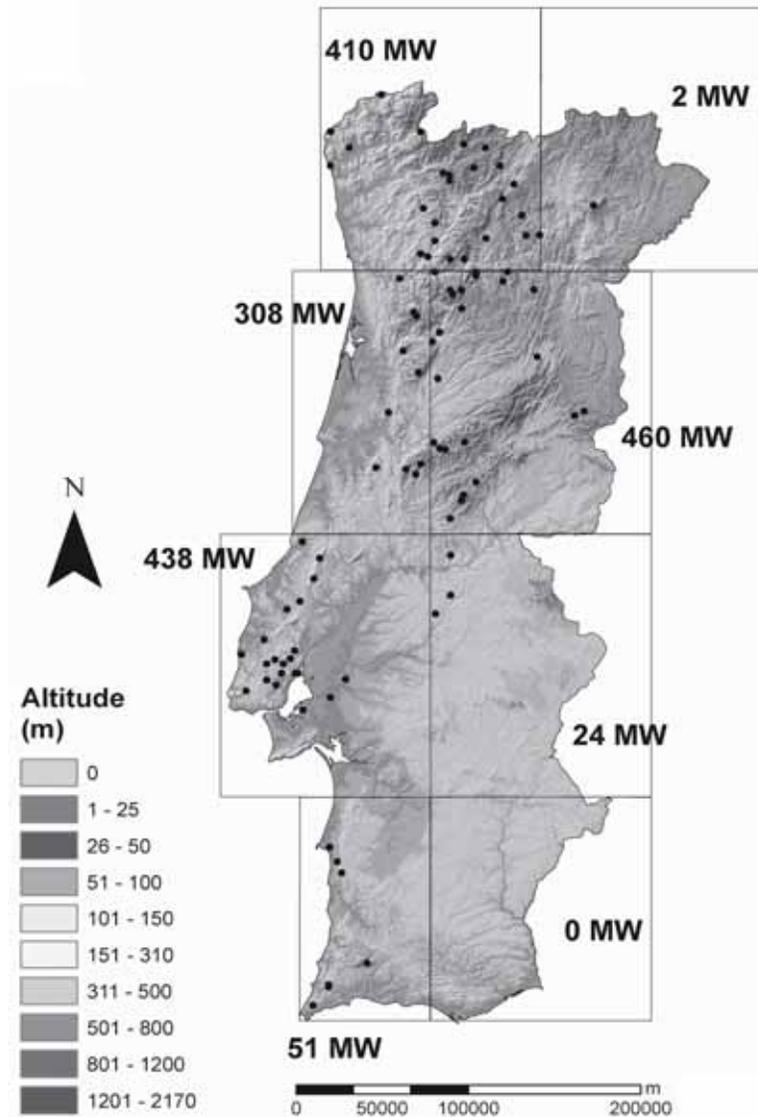


Figure 5 Spatial distribution of the wind capacity in Portugal.

included in the interval 900 to 1100 €/kW, and annual maintenance between 17 and 19 €/MW/year.

Figure 7 represents the tariffs evolution in the period 1998–2006.

Concerning renewable energies tariffs, no new legislation was published. The last one was established in Dec. Law 33 – A/05. This new legislation will only be applied to projects to be installed in the sequence of the 2005 call for wind capacity. The increase in the tariffs seen in the last years is mainly due to the low wind resource that has been charac-

teristic of the Portuguese territory.

4.0 National Incentive Programs

In the last few years, the power capacity installed in Portugal has experienced a steady growth, especially since 2002. This growth was the result of the establishment of several supporting governmental policies published in 2001 to promote national renewable energy production. To reinforce those policies, in 2005 the DL 33-A was also published.



An official call for wind park grid connection was opened by DGGE in the same year, and its first phase was concluded in 2006, with the reserve of 1,000 MW of transmission grid capacity.

There was no new legislation published concerning wind energy in 2006, still the DL33-A prevailed. The changes introduced by this decree of law had as its most relevant measure the reduction of applicable tariffs, resulting in practical terms, on the reduction of national economically sustainable wind power capacity.

The non-actualization of the electricity tariff with inflation is still the most relevant factor for wind energy developers. It severely limits this sector's revenues for future projects as well as its deployment rate, since new investments in wind power will have less favorable economic indicators than the past projects.

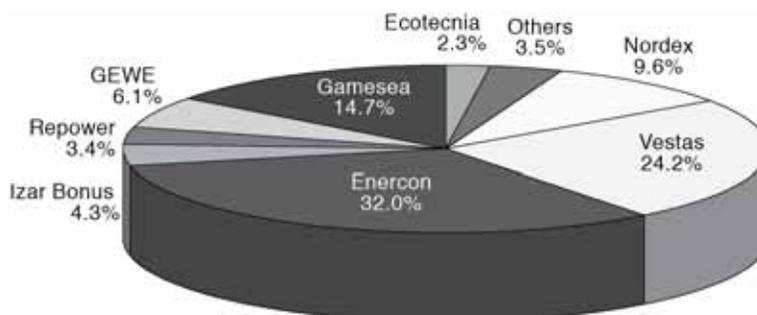
Also, in the area of micro-generation mainly in what concerns interconnection to the low voltage grid and small distributed sources of electrical energy (up to 150 kW), no changes were verified, by the Dec.-Law n° 68/2002 which was the appli-

cable legislation during 2006. This Decree of Law established the mechanisms needed to accelerate administrative and technical procedures associated with the installation of small units.

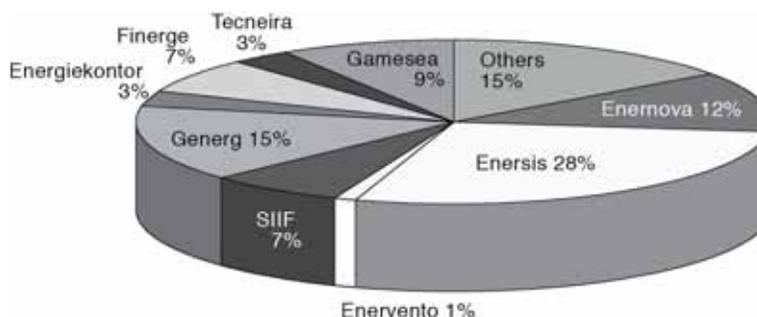
5.0 R D&D Activities

The R D&D activities in Portugal, related to renewable energies in general and wind energy in particular are mainly developed by various active research groups, located in for the most part in Lisbon and Porto. The exception is the Program DEMTEC within Programa de Incentivos à Modernização da Economia (PRIME), which in the 2006 call had a specific line of 5 million € for wind energy related projects. Otherwise there are no specific governmental programs to support the Wind Energy sector.

The R&D groups are mainly included in academic or research institutes, and have their own governmental financing programs and "lines" depending on the international and European Commission projects they are involved with. Moreover, the wind



(a) Wind turbines manufacturers.



(b) Wind park developer group.

Figure 6 Market share of installed capacity.

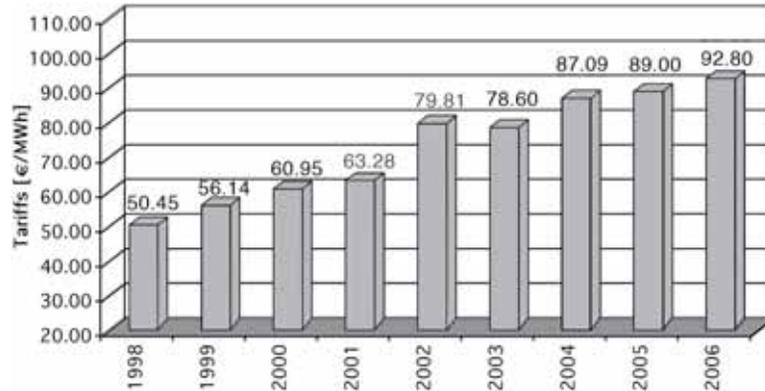


Figure 7 Evolution in tariffs for wind energy based production in the period 1998-2006.

energy developers are slowly beginning to collaborate in academic projects mainly in those concerning doctoral and post-doctoral projects, contributing, although still in a very small part, to the development of research and technology in wind energy in Portugal.

Among R D&D institutes, one of the most relevant regarding the work already developed in this context is the National Institute for Engineering, Technology and Innovation I. P. (INETI). INETI is a part of the Ministry of Economy and Innovation, and its activities and R D&D projects in the wind energy field are partially financed by the national government.

The RD&D needs and trends for wind energy in Portugal were identified as the following issues:

- Wind resource assessment in complex terrain and offshore;
- Wind power production monitoring by economic dispatch and remote operation by clusters of wind parks (DSO – distributed system operator);
- Wind/hydro production correlation and use of pumping facilities for regulation and storage of excess wind power production;
- Wind power applications in urban and constructed environments;
- Development of low-cost small wind turbines;
- New materials and industrial production techniques for wind turbines' cost reduction.

5.1 National RD&D efforts

In the north of Portugal, the main institutes dedicated to R D&D are the Faculty of Engineer-

ing of the University of Porto (FEUP) and the Mechanical Engineering and Industrial Management Institute (INEGI) and are part of the research network established by the Portuguese Foundation for Science and Technology (FCT), namely within the associate laboratory INESC Porto (Computers and Systems Engineering Institute of Porto) and the Research Centre for Wind Energy and Atmospheric Flows (RCWEAF).

INETI is developing a small, high-performance and low-cost turbine for urban use – TURBAN. This is a national project financed by DEMTEC (70/0201), to be nationally conceived and constructed using Portuguese technology. The project will be completed and operational by mid-2008.

5.2 Collaborative research

In 2005, INETI participated in the identification of sites for offshore wind park installations in the Atlantic coast based on the construction of the Portuguese Wind Atlas. This work has demonstrated that there are several coastal areas with high wind potential. As a result of this study, a measurement campaign is underway.

6.0 The Next Term

In what concerns the Wind Potential Portuguese Atlas, its methodology is being applied to other projects, and will be developed for other countries such as Croatia areas in several African countries. This methodology together with the improvement of the geographic information systems knowledge, will contribute to the construction of wind potential atlases for these countries.



The first phase of the call for wind park grid connection was concluded in the mid-2006. The second phase of this call is still underway and will be finished in the summer of 2007, and then the third phase will begin.

Moreover, during 2007, the TURBan project will continue its development and will be in the turbine dimensioning and construction phase. This project, although it is not yet finished is already causing an impact among the sectors investors.

References:

- (1) According to REN – Rede Eléctrica Nacional
- (2) According to General Directorate for Geology and Energy (DGGE).

Authors: Ana Estanqueiro and Teresa Simoes, Department of Renewable Energies, INETI – Instituto Nacional de Engenharia, Tecnologia e Inovação.

