CHAPTER 18
PORTUGAL

1.0 INTRODUCTION

During 2004, Portugal reversed the tendency of slow wind capacity growth observed in previous years. The publication of legislation and tariffs at the end of 2001 and subsequent government simplification of administrative processes concerning the implementation of renewable energy projects resulted in nearly doubled capacity in Portugal during 2004. In the following sections, a summary of the events of the year is presented with a main focus on the current state of development and trends.

2.0 NATIONAL POLICY

Strategy

During 2004, there was no new legislation specifically regarding wind energy or Renewable Energy Systems (RES). The main legal guidelines to achieve the goal of 3,750 MW by 2010 were published in December 2001 within the Decrees of Law (Dec.-Law) 312/01 and 339-C/01. The first covered the technical and licensing procedures and the second covered the tariffs for renewable energy production. The Dec.-Law no. 312/2001 concerns RES and co-generation and "… it establishes the procedures regulating the awarding and management of the interconnection points with the Public Service Electrical System (SEP) for the delivery of electricity received from new power plants, in the framework of the Independent Electrical System (SEI)."

Concerning the interconnection of micro-generators to the low-voltage grid, the applicable legislation during 2004 is stated in the Dec.-Law no. 68/2002, which defined mechanisms intended to speed up administrative and technical procedures associated with the implementation of small units.

The main action taken during 2004 regarding the electric sector was the constitution of the Iberian Market of Electric Energy (MIBEL) decided by Portugal and Spain on 20 January 2004 and officially ratified by both the Portuguese Assembly and Presidency in the Dec-n.o 19-B/2004 (*in* I SÉRIE-A N.o 93).

Some practical measures that were officially approved included: the simplification of administrative processes and environmental license granting (e.g. DC 51/2004 de 31 de Janeiro, DR, nº 26- II série); the approval of the report and conclusions of PNAC –National Plan of Climatic Changes (Resolution of the Council of Ministries (RCM) n.o 119/2004 *in* I SÉRIE-B N.o 179); and the implementation of RCM n.o 171/2004 that promotes the development of a program to diminish the Portuguese dependency on oil and the high energy usage of Portuguese industry.

Progress Toward National Targets

The bulk of renewable energy production in Portugal is supplied by hydropower, biomass/waste sources, and, recently, a steadily growing capacity of wind power. In view of the country's very high dependence on imported fuels, in recent years the government has established a number of policies to increase the level of renewable energy development. The RCM 63/2003 established that the energy policy of Portugal should reduce its external dependency and outlined new objectives to attain in 2010 for the electricity produced by RES.

The 2010 RCM 63/2003 objectives as well as the status of the 2004 RES contribution to this goal are shown in Table 1. Since the installed wind capacity by the end of 2004 only reached 15% of 2010 goal, it is considered quite difficult in the wind sector - although not impossible - to fulfil those national targets. As depicted in Figure 1, a constant annual addition to capacity of slightly higher than 500 MW would guarantee the achievement of that goal. This is considered technically feasible if no delays occur in the reinforcement of the transmission network.

The installation of wind power capacity has been stimulated in recent years by a number of national policies, almost doubling its capacity in 2004 and reaching the level of 562 MW. The supporting policies include financial incentives and reviewed feed-in tariffs (Dec.-Law 339-C/01) to promote an increase of domestic renewable energy production. No further official calls for wind park grid connection were open during 2004 after the high number of applications (7,000 MW approximately) that were received in the last call opened in January 2002.

3.0 COMMERCIAL IMPLEMENTATION

Installed Capacity

The wind capacity and number of turbines installed in Portugal during 2004 is presented in Table 2. Table 3 presents the total accumulated values.

It should be recalled that, although all the turbines of Table 3 had their installation phase completed by December 2004, some wind parks were contractually still not in "operating mode."

Rates and Trends in Deployment

In 2004, an estimated total energy of 1,292 GWh was produced by wind turbines, based on the average capacity factor of different locals (2,300 hours of op-

RES type	2004 [MW]	2010 [MW]
Wind [1]	562	3,750
Small Hydro [2]	331	400
Biomass and biomass cogeneration [3]	111	150
Biogas	2	50
Solid waste [4]	98	130
Wave	3	50
Photovoltaic	3	150
Eq. Solar thermo (0.7 kW = 1m^2)	193	700
Geothermal	4,356	5,000
Large Hydro [2]	18	n.a.
Total	**5,675**	**10,380**

Table 1 National objectives for 2010 domestic planned capacity and 2004 status. Notes: [1] INETI data, [2] acc. REN- Rede Eléctrica Nacional, [3] cogeneration through biomass values were estimated as 25% of total; [4] acc.DGGE- Direcção Geral de Geologia e Energia.

Table 2 Number of installed wind turbines and capacity by wind park in 2004.

Project Name	Local	Owner / Developer	P(WT) [kW]	Manufact.	Model	2004 Inst. cap. [MW]	2004 Inst. WT [nº]
Lomba Seixa II	Montalegre	GRUPO ENERSIS	1500	GEWE	1.5SL	12.0	8
Borninhos	Macedo Cavaleiros	GRUPO ENERSIS	2000	Enercon	E66	2.0	1
Fonte Quelha	Cinfães	GRUPO EDP (ENERNOVA)	1500	GEWE	1.5s	12.0	8
Alto Talefe	Cinfães	GRUPO EDP (ENERNOVA)	1500	GEWE	1.5s	12.0	8
Padrela	Vila Pouca de Aguiar	GRUPO EDP (ENERNOVA)	1500	GEWE	1.5s	7.5	5
Ribamar	Mafra	PE RIBAMAR	2000	Repower	MM82	6.0	3
EEA II	Vila Pouca Aguiar	FINERGE/EHATB	2000	Enercon	E-66	12.0	6
Archeira II	Mafra	NOROESTE	2000	Enercon	E66 20-70	2.0	1
Moinho Velho	Arruda	BIOWATT	2001	Enercon	E66 20-71	2.0	1
Cabreira	Vieira do Minho	GRUPO SIIF (EOLENERG)	2000	Enercon	E66	20.0	10
Dirão Rua	Sabugal	FINERGE	600/ 2000	Enercon	E-66+E-40	2.6	2
Cadraço	Tondela	FINERGE	1200	Enercon	E-58	1.2	1
Amêndoa	Mação	ENERVENTO	1650	Neg Micon	NM82	14.9	9
S. Todo Mundo	Cadaval	GRUPO ENERSIS	2000	Vestas	V80	10.0	5
Vilar Chão	Vieira Minho	ENERMINHO	2000	Enercon	E-66	2.0	1
Açor	Arganil	GRUPO EDP (ENERNOVA)	2000	Enercon	E66/2.0-E70	20.0	10
Sra Vitória	Nazaré	GRUPO ENERSIS	1500	GEWE	1.5SL	12.0	8
Mosteiro	Sabugal	TECNEIRA	1300	Izar Bonus	B62	9.1	7
Moinho Manique	Mafra	FINERGE	600/ 2000	Enercon	E-66+E-40	2.6	2
Escusa	Mafra	GRUPO ENERSIS	1000	Winwind	WW1	2.0	2
Carreço-Outeiro	Viana do Castelo	GRUPO GENERG	2300	Nordex	N90	20.7	9
Amaral	Alenquer	TECNEIRA	2000	Gamesa	G80	8.0	4
Vila Nova	Miranda do Corvo	ENERNOVA	2000	Vestas	V80	20.0	10
Malhadizes	Penela	GRUPO ENERSIS	2000	Enercon	E-66	12.0	6
Teixeiró	Teixeiró	ENERGIA VERDE	2000	Repower	3*MM70+ 4*MM82	15.0	7
Castanheira	Mogadouro	ELINERGIA	2000	Repower	MM82	4.0	2
Alagoa de Cima	Alto Minho	EÓLICA DE ALAGOA	1500	GEWE	1.5s	13.5	9
Chaminé	Sines	GRUPO GENERG	2300	Nordex	N90	6.9	3
TOTAL						264.0	148

	Total installed capacity (Dec. 2004) [MW]	Total installed WT (Dec. 2004) [nº]
Continent	547	448
Azores	5	22
Madeira	10	43
TOTAL	562	513

Table 3 Total installed capacity and number of wind turbines in Portugal (31 Dec 2004).

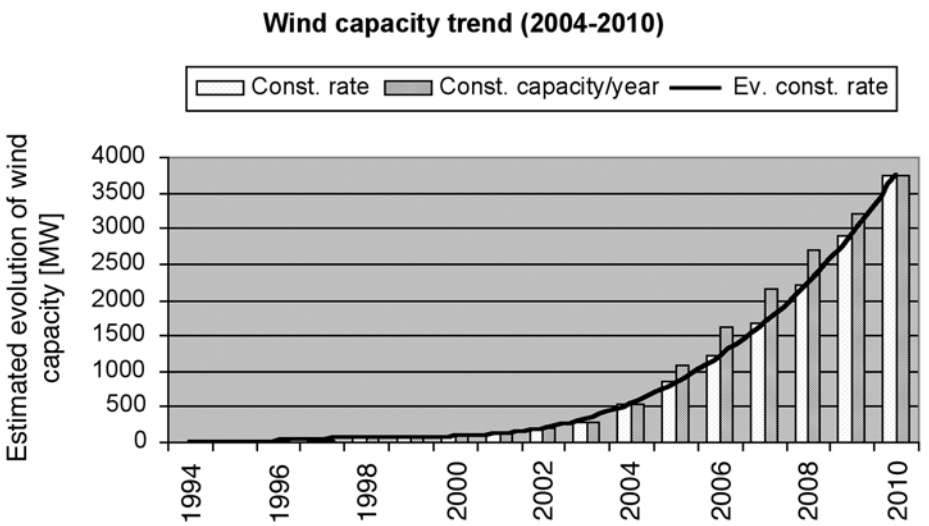


Figure 1 Trend of the wind power capacity installation towards the 2010 national targets.

eration equivalent to nominal power). Figures 2 and 3 show respectively the evolution in the capacity increases and wind energy production. Figure 4 depicts the location of wind parks in continental Portugal.

A rate of growth of approximately 90% was observed in 2004, considerably higher than in the previous years, after steady growth was initiated in 1999. A good number of wind park projects reached their final installation phase during 2004, enabling the installed capacity to almost double during this year. The rate of development for recent years is displayed in Figure 5.

Contribution to National Energy Demand

According to recently published data by the Portuguese Transmission System Operator (REN – Rede Eléctrica Nacional), the net electric energy consumption during 2004 was 45,511 GWh. This represents an increase of 5.7% in absolute terms and a smaller, although still high increase of 4.5%, if the year of 2004 is normalised. Based on these values, it is possible to estimate an approximate value for the wind energy contribution to the Portuguese demand. Since no data on the contribution by each RE technology is available, assuming the operation during 2,300 hours equivalent to nominal power for all wind

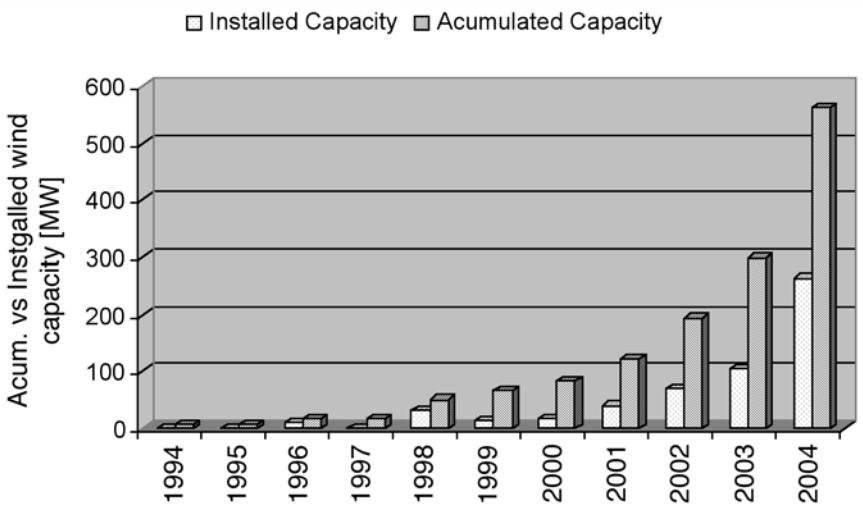


Figure 2 Installed and accumulated wind power capacity (1994-2004).

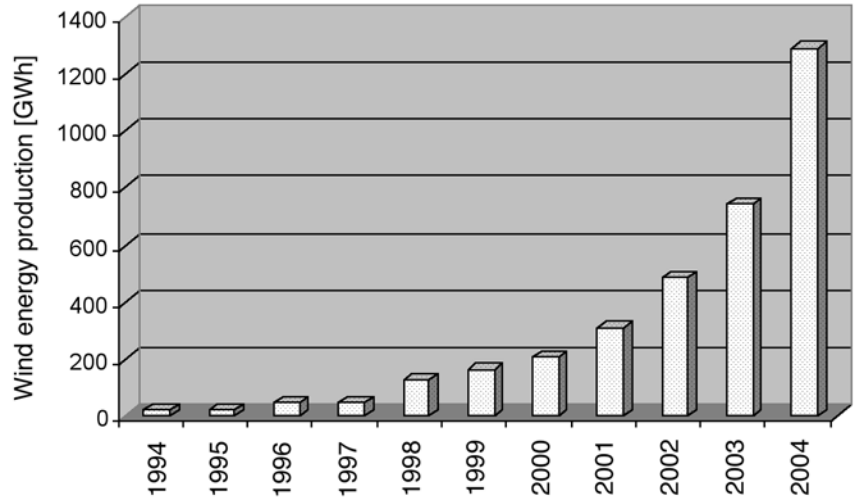


Figure 3 Estimated wind energy production (1994-2004).

parks during this year, one would obtain a wind energy contribution of 2.8% for the 2004 total electric energy demand.

4.0 MARKET DEVELOPMENT AND STIMULATION

Main Support Initiatives

As mentioned, no significant government initiatives concerning wind energy were introduced in 2004, since the main steps to achieve the national objective of promoting the installation of 3,750 MW of wind capacity by 2010 were taken between 2001 and 2003. The financial incentives under the POE/PRIME programme (2000-2006) continued to be applied in 2004, together with tax reductions for RES. The most significant governmental contribution continues to be the POE/PRIME partial support of the costs of the transmission and distribution network reinforcement requested for the grid integration of further wind capacity in remote areas of the country.

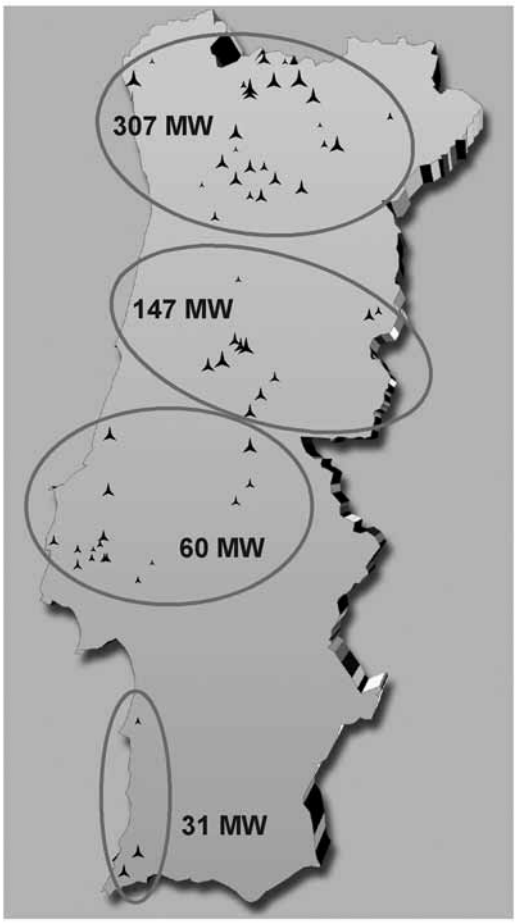


Figure 4 Location of wind parks in Portugal.

Unit Cost Reduction

During 2004, a stable reduction in the cost of wind turbines could be noticed with the actual mean cost per installed kW (excluding terrain cost and grid connection) varying from 650 euro to 900 euro, depending on the country of origin of the turbine and its individual capacity. Unit cost reduction has not been as noticeable in Portugal as in other countries due to the tendency to install large wind turbines with higher individual costs than smaller units. Nevertheless, unit costs started to decrease slowly, but steadily, in 2004.

5.0 DEPLOYMENT AND CONSTRAINTS

Wind Turbines Deployed

In 2004, 148 wind turbines were installed in Portugal with individual capacities ranging from 0.6 to 3 MW, all from European manufacturers. The shares of installed power by wind turbine manufacturer and wind park developer are displayed in Figure 6.

Operational Experience

During 2004, there were no failures of wind turbines reported in Portugal.

Main Constraints on Market Development

The market in Portugal had a major burst of activity in 2004 after the legislation and tariffs published at the end of 2001. Under the new tariffs, wind park projects became easier to license and experienced a mean deployment period of two years. As a result, a large number of wind parks achieved their final construction or operating phase in 2004. The major constraints in Portugal, which are not exclusive to wind park projects, remain the excessively bureaucratic and time-consuming authorization system necessary to obtain all the permits required to install and operate a wind park. In some sites, for example in environmentally protected areas, it may take from four to five years from the time the first permit is granted to the beginning of construction. The permits required to develop a wind park that tend to be most difficult (and long) to obtain continue to be related to the environmental institutions.

6.0 ECONOMICS

Trends in Investment

The trends in investment in the wind sector in Portugal are moving towards multi-megawatt wind machines due to the high cost and the characteristics of land. Although the cost structure of wind park projects is considered a classified subject by most private investors and financial institutions, the total

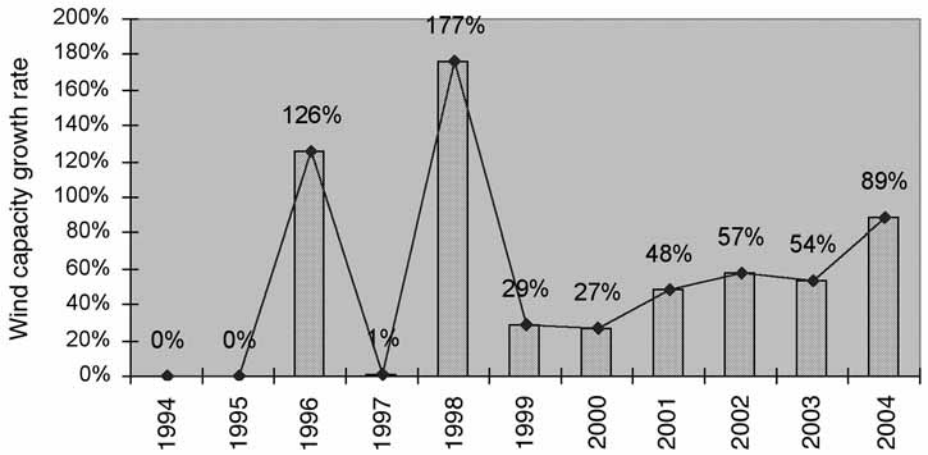


Figure 5 Wind capacity growth rate in the 1994-2004 period.

costs in 2004 are in the range of 1,000 to 1,200 euro per installed kW. Annual contracted costs for operation and maintenance vary between 2 and 4% of the investment cost.

In Unit Costs of Energy and Buy–Back Prices

Production costs including externalities are not normally publicly available for other forms of conventional electrical energy production. The Government Dec-Law 339-C/01 fixed the renewable energy tariffs under application during 2004. The tariff trend for wind energy- based production in the period 1998 -- 2004 is depicted in Figure 7.

The increase in the tariffs during 2004 observed in Figure 7 was not due to a legislation change, but to a lower than normal wind resource year. Since the Portuguese tariffs are step-defined with a higher return to the lower production levels, the equivalent yearly mean values showed an increase of approximately 8 euro/MWh during 2004.

7.0 INDUSTRY

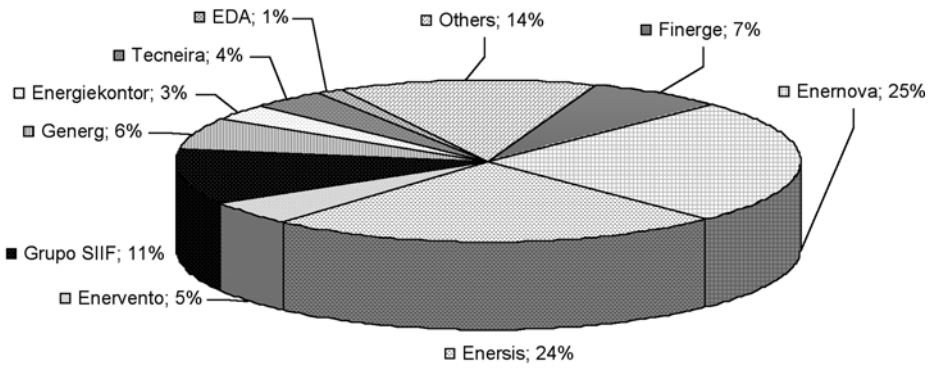
There are no industrial production units of wind turbines in Portugal. However, there are three Portuguese manufacturers of tower technology and electrical equipment, namely power transformers and wind park cabling.

During 2004, the government announced its intention to encourage development of wind turbine industrial and assembling facilities in Portugal under future calls for wind capacity connection. To comply with the national strategy and the intended development of the Portuguese wind energy industrial market, some industrial investments in production units in Portugal were announced. Two assembling factories in the north and center of the country and a new production factory of blades in the northern littoral were announced.

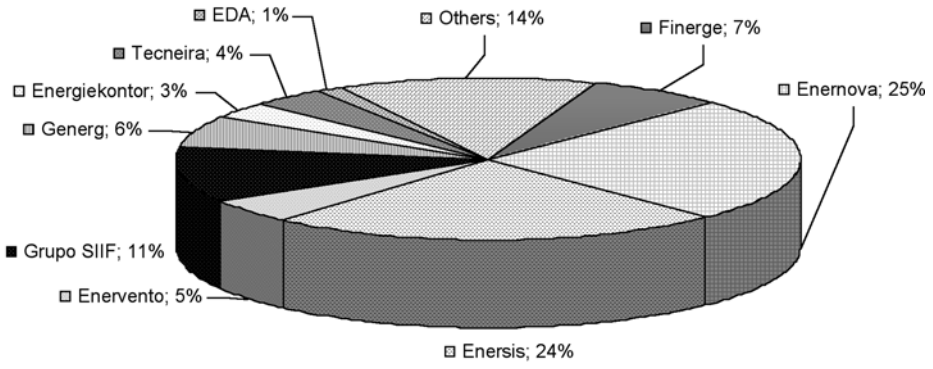
8.0 GOVERNMENT–SPONSORED R, D&D

Priorities

Portugal has no specific governmental program for sponsoring R,R&D activities related to wind energy. Research in the wind energy field is governmentally funded by several programs under the general topics of Energy, Electrical and Mechanical Engineering. There are various active research groups, mainly located in Lisbon and Porto.



a) by wind turbine manufacturer.



b) by wind park developer.

Figure 6 Share of installed capacity by (a) manufacturer and (b) developer.

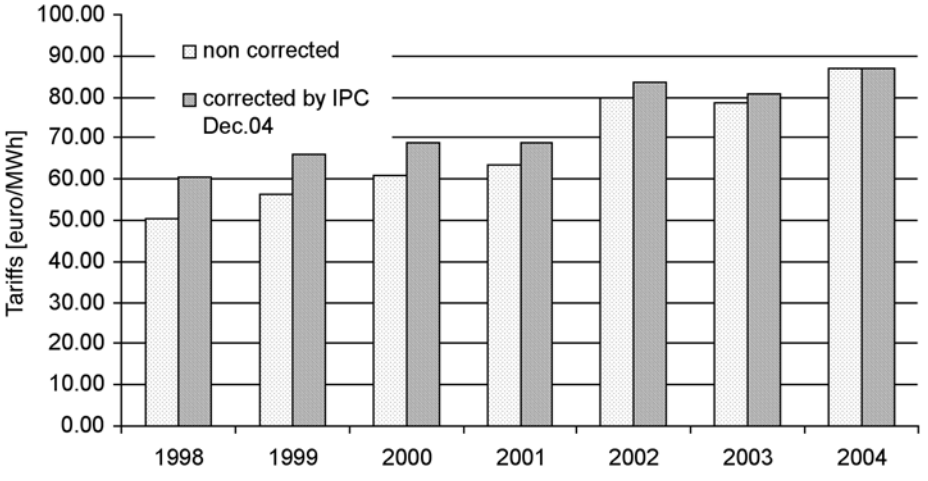
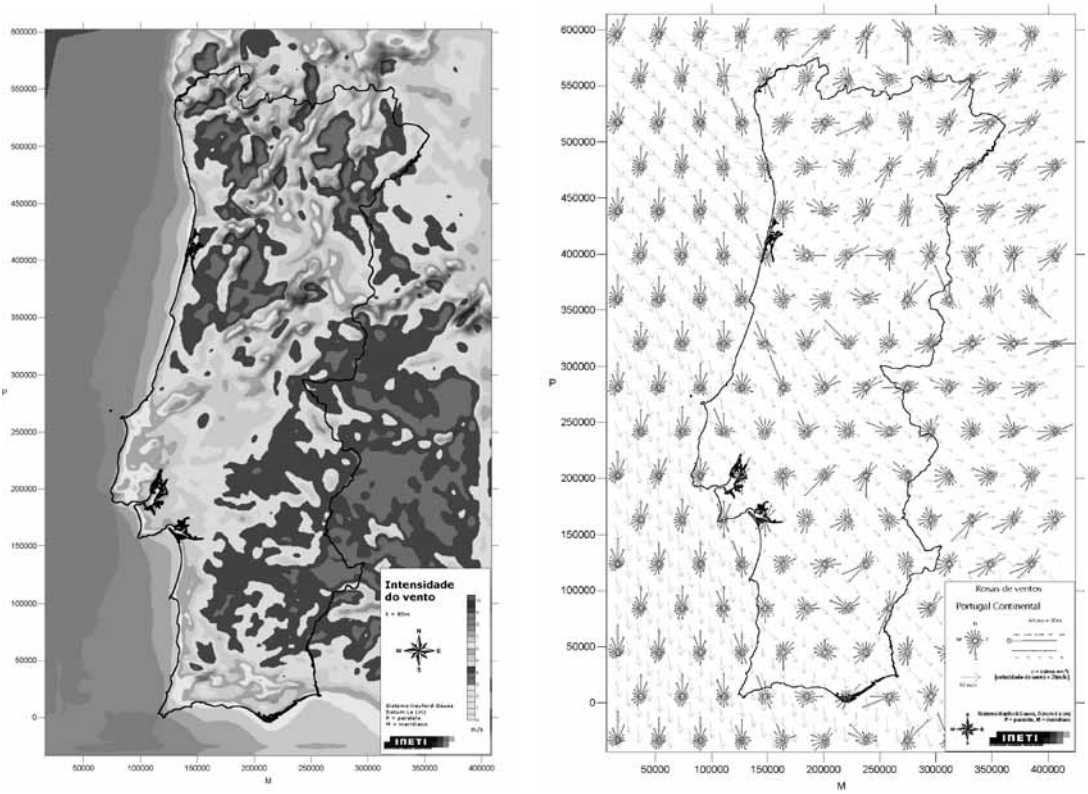


Figure 7 Evolution in wind energy tariffs applied in Portugal in recent years.

The National Institute for Engineering and Industrial Technology (INETI) that was a part of the Ministry of Economy for the last 20 years experienced a re-organization during 2004, the most visible aspect being the change of name to National Institute for Engineering, Technology and Innovation I. P. (the acronym INETI remains) and being now a part of the Ministry of Science and Innovation together with all the other National Governmental Laboratories. INETI activities and R&D projects in the wind energy field are partly financed by the government.

The Portuguese Wind Atlas developed by INETI (Figure 8) was completed and made available to public in September 2004. Also published by INETI in 2004 was a national database of wind characteristics (EOLOS 2.0) with information from more than 50 anemometric stations covering most of the continental territory.

In northern Portugal (Porto), R&D activities are mainly carried out by research groups based at FEUP - Faculty of Engineering of the University of Porto and INEGI - Instituto de Engenharia Mecânica e Gestão Industrial. These activities are part of the research network established by the Portuguese Foundation for Science and Technology (FCT), within the associate laboratory INESC Porto (Instituto de Engenharia de Sistemas e Computadores do Porto) and the Research Centre for Wind Energy and Atmospheric Flows (RCWEAF). Activities of RCWEAF include resource evaluation and development of computational tools for both wind resource evaluation and diagnosis. The software code called VENTOS®, which



a b

Figure 8 Wind atlas (a) mean wind speed at 80 m a.g and (b) wind roses in continental Portugal.

was originated within the research activities of one of the groups, is now being used as a general tool for computer simulation of wind flows over complex terrain with or without vegetation. The network of stations supervised by INEGI has reached more than 300 meteorological masts and covers important regions of the North and Central Portuguese mainland, Madeira Island, and even South America.

Among other projects funded by the Portuguese government through FCT, is project DIPTUNE coordinated by INESC Porto (Nº POCTI /41614/ESE/2001). This project analyzes how wind generation and dispersed generation (DG) can contribute to improving grid operation efficiency and assuring system operation robustness. This is achieved through the delivery of ancillary services from wind generators and other DG units. During 2004, several studies have been developed to identify how, through on-line continuous control of reactive power from DG units and wind parks, it is possible to reduce losses and improve voltage profiles in high-voltage (HV) distribution grids. The identification of control techniques for controlling doubly fed induction generator (DFIG) for the provision of primary frequency control was successfully developed. Also fuzzy control techniques were developed to control crow bar operation in DFIG during grid short-circuits. Definition of distribution management system and energy management system tools able to deal with these DG capabilities was developed. As an outcome of this project, several papers were published in CIGRE Symposia and IEEE transactions.

New R, D&D Developments

The R, D&D needs and trends in what concerns wind energy in Portugal were identified in the following issues:

- Wind power production forecast;
- Wind power production monitoring by the eco nomic dispatch and remote operation by clusters of wind parks;
- Local grid planning and wind park power quality assessment according to IEC standards;
- Wind/hydro production correlation and use of pumping facilities for regulation and storage of excess wind power production;
- Urban and constructed environment wind power applications.

The projects currently underway are mainly oriented to the development of wind/hydro common regulation (wind for hydro pumping use under excessively high penetration), due to the high hydro capacity installed in this country and the high correlation between availability (and sometimes excess of) hydro resource and wind during the winter months. This issue is being studied also by INESC in cooperation with the Portuguese utility (EDP). The development of a wind power forecast tool adapted to Portuguese wind climate and orography is under consideration by REN, the Portuguese TSO.

Offshore Siting

INETI participated in the identification of sites for offshore wind park installations on the Atlantic coast based on the completion of the Portuguese Wind Atlas. Although the sustainable wind resource is not very high due to the bathymetry of the continental platform, some sites have been identified and are currently under study by potential developers.

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