

# Chapter 17

# Spain

## 17.1 INTRODUCTION

The production of electricity by wind energy has a strong importance in the energetic national scenario. It covers an important part of the electricity demand without bad side effects to the environment. Wind energy helps reduce the strong dependency on external sources of energy, supports the fulfillment of the Kyoto compromises, and increases the industrial and technological capability of the country.

Wind energy in Spain continues the growth started in the mid-1990s, taking a leading worldwide position along with Germany and the United States. At the end of 2003, the power in operation in Spain was over 6,200 MW. The electricity generated by wind energy represents nearly 5% of the total production, and plans for the future show the possibility of reaching 13,000 MW grid connected by the end of 2010. The wind industry in Spain is a solid sector with great potential and strong investments in R&D activities and job creation.

One explanation for this growth is the existence of a stable legal framework for electricity producers using renewable energy sources (RES). The regulations contained in the *Special Regime of the Electrical Sector Act* imply that electricity producers using wind have guaranteed access to the grid. The price per kilowatt-hour generated has a bonus over the sale price of electricity, and a new regulation is in discussion between the administration and the wind sector in order to ensure the economic regime of

wind farms during the life period of the installations. New manufacturers, investors, producers, and researchers have been incorporated into the wind energy business in the last year, and a process of merge and association between companies has occurred.

## 17.2 NATIONAL POLICY

Spain is a country with a strong dependency on external sources of energy – there are no oilfields or gas fields, and the few coal mines are of low quality coal. Table 17.1 shows the energy balance in both the mainland and island electric systems during the year 2003. During this year, the demand for electricity was 5.9% higher than the previous year, with a total value of 236,538 GWh.

During 2003, the contribution of hydro to total production was 20%; nuclear groups represented 31%; coal represented 37%; and the electricity produced inside the Special Regime, which includes cogeneration, small hydro, and renewable energy, reached 39,563 GWh, 10.6% more than the previous year.

A total of approximately 1,400 MW of new power capacity has been installed in Spain, in gas power plants and RES, mainly wind farms.

### Strategy

The strategy of the Spanish government is summarized in the *Program for Promotion of Renewable Energies*, approved by Parliament.

The overall target is to meet 12% of total primary consumption from RES by 2010. For wind power, the aim is to have ready-installed capacity of 13,000 MW by the end of the year 2011 (according to *Planning of*

Source	Mainland			Islands			Total country		
	Electricity production (GWh)	Variation 2002/2003 (%)	Power installed Dec 31 (MW)	Electricity production (GWh)	Variation 2002/2003 (%)	Power installed Dec 31 (MW)	Electricity production (GWh)	Variation 2002/2003 (%)	Power installed Dec 31 (MW)
Hydro	38,734	72.00	16,657	1	39.00	1	38,735	72.00	16,658
Nuclear	61,848	-1.90	7,816	-	-	-	61,848	-1.90	7,816
Coal	72,562	-7.90	11,565	3,544	0.10	510	76,105	-7.50	12,075
Fuel / Gas	23,146	6.30	11,324	9,669	13.70	2,995	32,815	8.40	14,319
Total norm regime	196,290	5.50	47,362	13,214	9.70	3,506	209,504	5.70	50,868
Special regime	38,852	10.90	12,504	712	-2.90	238	39,563	10.60	12,504
Electricity demand	223,480	5.80	-	13,088	9.30	-	236,568	6.00	-

Source: Red Electrica de España

Table 17.1 Energy balance and power capacity in 2003

the *Utility and Gas Sectors Expansion of Transport of Grids 2002-2011*, approved by the Council of Ministers in September 2002).

The structure of the energy sector for the year 2011 is described in Table 17.2 and illustrates a strong effort to modify the primary energy consumption towards a more clean and efficient system: increasing the contribution of natural gas, saving energy, and using renewable energy sources.

The objectives included the Spanish incorporation of the European recommendations made in the *White Paper on Renewable Energies*. The main measures were as follows:

1. Adequate remuneration for each kilowatt-hour generated
2. Development of infrastructure to transport power away from point of supply
3. Standardization, official type approval, and certification of wind turbines; and consolidation of the technology

	Year 2002	Scenario 2011
<b>Electricity generation</b>	<b>(Percent)</b>	
Natural gas	9.7	34.2
Oil	9.9	4.8
Coal	35.9	12.0
Nuclear	27.6	20.1
<b>RENEWABLES</b>	<b>20.1</b>	<b>28.9</b>
<b>Energy consumption</b>		
Natural gas	12.2	22.6
Oil	51.7	47.6
Coal	17.3	8.2
Nuclear	13.0	9.0
<b>RENEWABLES</b>	<b>5.6</b>	<b>12.0</b>

**Table 17.2 Targets for the year 2011**



**Figure 17.1 Ecotécnia 62 at the La Bandera wind farm**

4. Support for R,D&D of applications before the commercialization stage

### Progress Towards National Targets

The situation for wind energy is optimistic in regard to the fulfillment of the Spanish targets – according to present data, the target will be reached earlier than planned. The power installed at wind farms in operation at the end of 2003 was close to the target for the year 2006, despite the fact that in 2003 the rate of installations had a slight reduction due to grid-connection problems.

The majority of the autonomies have regional wind energy programs that give a total of more than 10,000 MW to be installed in the next years (exceeding the PPRE target).

## 17.3 COMMERCIAL IMPLEMENTATION

### Installed Capacity

In 2003, another 1,320 MW were installed, and the total power as of 31 December 2003 was 6,202 MW. The average power unit installed during 2003 presents a moderate increase, reaching 840 kW (approximately 800 kW during the previous year). The models used in the wind farms are wind turbines ranging from 750-kW to 1,500-kW rated power.

### Rates and Trends in Deployment

Annual power installed continues growing. Figure 17.3 shows the annual power installed in Spain in the last years. The figures for 2003 show a small reduction in the tendency of continuously increasing rates from the previous year. The reasons for this could be that more difficulties than expected in the grid connection of

wind farms have occurred due to the lack of electrical infrastructures, and several projects of wind farms have been delayed. Nevertheless, the wind energy sector – which includes manufactures, suppliers, and investors – is solid and the expectation for the future is optimistic.

The sector requires new regulations of the electricity price for covering long-term price guarantee. The draft of the new regulations is under discussion with the sector.

The distribution of the installations is shown in Figure 17.4. The Association of Promoters of Wind Farms (APPA) supplies the data.

At the present time, almost all the Spanish autonomies are involved in the incorporation of wind energy in their energetic structure. Aragon, Castilla-León, Castilla La Mancha, and Galicia are the autonomous communities with the most activity during 2003. A new strategic plan

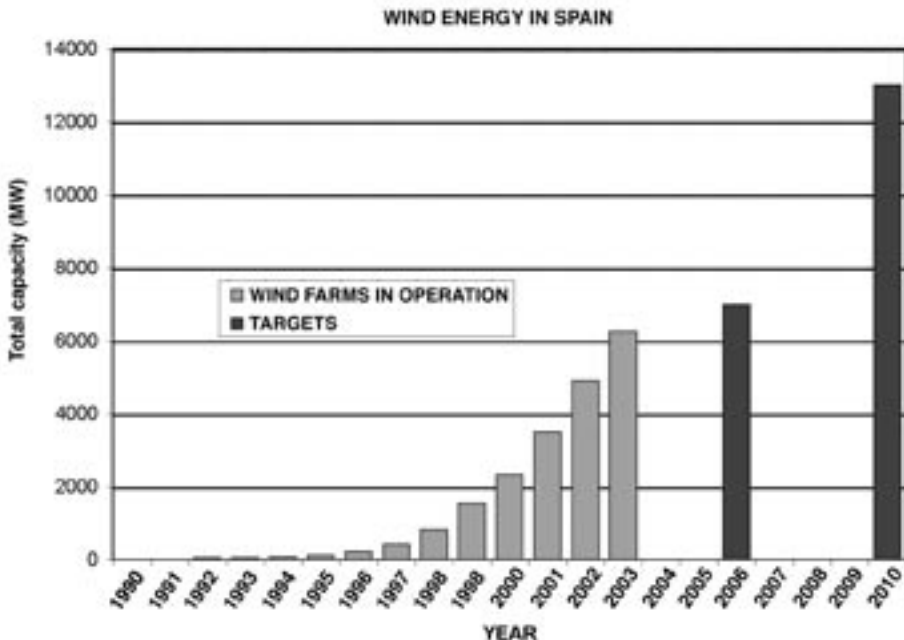
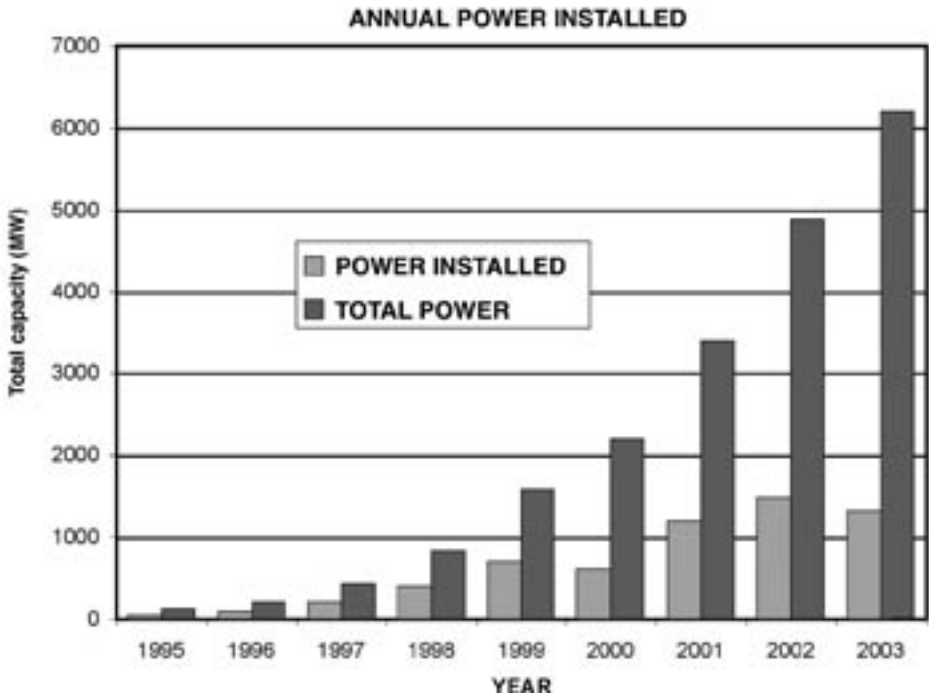


Figure 17.2 Wind installations in Spain and targets for 2011



**Figure 17.3 Annual installed power**

with a total capacity of 2,000 MW has been approved in the Comunidad Valenciana, and preliminary industrial activities in the region have been started.

The profile of the investors in Spain is a big company with strong capability of promotion and development. Several regional governments are interested in the promotion of small investors and municipalities, and they are preparing new regulations in this sense. Galicia, Navarra, and other regions have a special procedure to permit wind farms less than 5 MW when a part of the electrical production is used by the owner of the wind turbines.

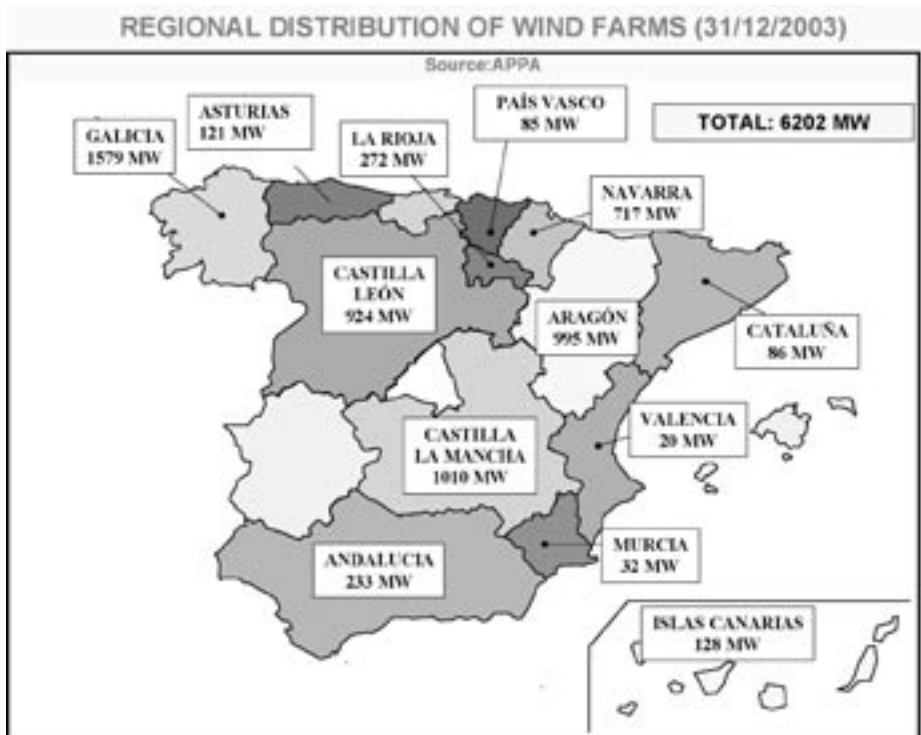
### **Contribution to National Energy Demand**

The total production of wind power plants for 2003 was 11,370 GWh, according to the National Energy Commission. The total

demand for electricity in Spain during 2003 was 236,538 GWh (6% higher than the previous year). The evolution of wind energy production was 2,696 GWh in 1999; 4,700 GWh in 2000; 6,932 GWh in 2001; 9,603 GWh in 2002; and 11,370 GWh in 2003.

In 2003, wind electricity reached 4.8% of the total electricity demand. Figure 17.5 shows the evolution of wind electricity, along with the demand for electricity. The electricity produced by wind farms during 2003 was equivalent to the increase in demand.

Wind energy is already integrated into the electrical system, and there is a regulation of wind farm production at special occasions. For example, during holidays such as on December 25 and January 1 when there is low consumption and strong winds, the production of wind farms has



**Figure 17.4 Regional distribution of wind installations**

been voluntarily reduced, following the recommendations of the organization that manages the grid in order to maintain stability of the system.

## 17.4 MARKET DEVELOPMENT AND STIMULATION

### Main Support Initiatives and Market Stimulation Incentives

The main action for market stimulation is the price paid for electricity generated by RES, and it is regulated through two royal decrees (the latest approved in December 1998), which obligate utilities to pay a guaranteed price to RES generators for a five-year period. This price, and the related bonus, is revised and fixed every year according to the variation of the electricity market price.

Another positive point to stimulate the promotion of wind farms is the regulation of administrative procedures for the authorization of wind power installations.

### Unit Cost Reduction

Does not apply.

## 17.5 DEPLOYMENT AND CONSTRAINTS

The rapid increase of installed power is welcomed by society, which appreciates not only the contribution to environmental conservation but also the industrial development and associated job creation. Job creation is the most important aspect of wind energy for the Spanish population. The development of new installations is

favored at the local level (landowners and municipalities) because of the benefits obtained.

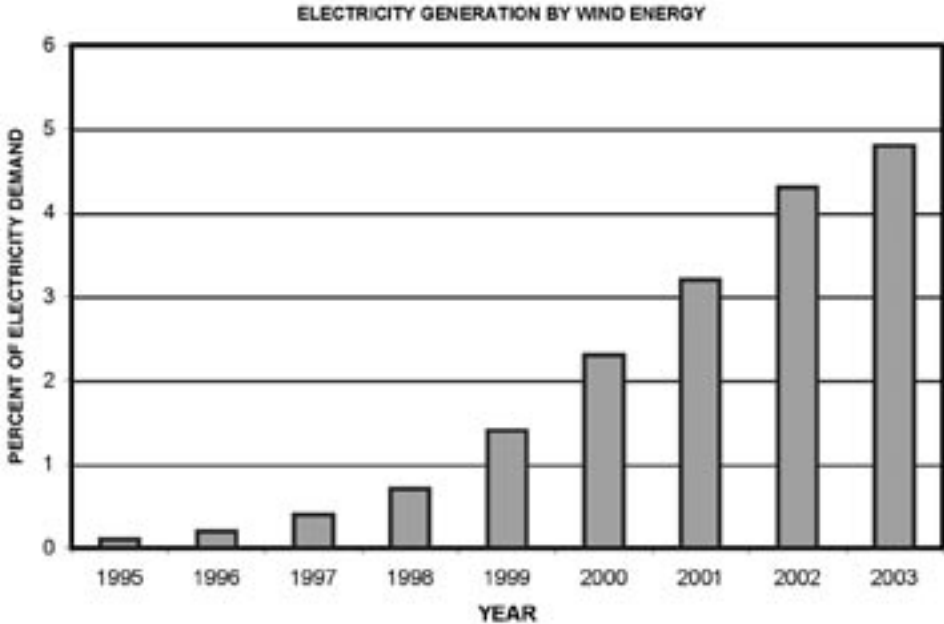
The conditions for developing wind projects in Spain are regulated under the *Law of the Special Regime for Electricity Production (Dec/98)*. The grid operator (REDESA, a national public company) and the utilities have the obligation to allow the connection of wind turbines to the grid. Developers have to fulfill the technical requirements defined in the electrical law. The cost associated to the connection is the responsibility of the plant developer. There are no widespread complaints about the process to obtain permission for connection to the grid.

### Wind Turbines Deployed

The wind turbines installed in 2001 in Spanish wind farms had capacities ranging from 750 kW to 1,500 MW. The average size of the wind turbine installed during 2003 was 844 kW. During 2003, a total of 1,320 MW was installed in Spain.

### Operational Experience

The year 2003 was a little less windy than the previous one, and the operation parameter of the wind farms was lower than in previous years. An estimation of the capacity factor in the country calculated by the monthly values supported by the Comision Nacional de la Energía (CNE) are 0.21 for 2003 and 0.22 for 2002. This variation is according to the perception of the wind farm operator during the actual year.



**Figure 17.5** Electricity generation by wind energy



**Figure 17.6** Caparroso wind farm

The regional distribution of the capacity factor shows variation from the higher values of Andalusia (0.28 capacity factor over 230 MW installed) or Canary Islands (0.31 of capacity factor over 130 MW installed) to the moderate values of Castilla La Mancha in the central part of Spain (capacity factor of 0.17 over 1,010 MW installed).

Information about the instantaneous production of Spanish wind farms (and historical data of previous periods) is available on the Internet at <http://www.ree.es>.

### **Main Constraints on Market Development**

In 2003, some opposition emerged against the installation of new wind farms in areas with strong development. This opposition was launched by local ecologist groups that complain about the landscape impact and the possible impact on bird life. That opposition causes delays in the permission of wind farms.

The main constraint on market development is the existing limitation on the capacity of the grid for energy evacuation. Generally, wind farms are located in areas with low-density population, and the grids are weak and require reinforcement and improvement. Concerted actions between utilities and developers are ongoing in order to solve the problem.

The development of wind power installations is strongly affected by the rigidity of the administrative procedure and the uncertainty to obtain the required permission and authorizations for civil works grid connection and start-up of the wind farm. These limitations imply a period of four years for the completion of all steps – from the first application to wind farm operation – and mean an important increase of wind farm promotion cost. A great number of megawatts planned for 2003 were delayed for these reasons.

## 17.6 ECONOMICS

### Trends in Investment

No information available.

### Trends in Unit Costs of Generation and Buy-Back Prices

The *Royal Law 2818/1998-23 December 1998*, about the Electrical Special Regime for renewable energy plants connected to the grid, fixed the conditions of the plants to be included in this special regime. This law was a new step in the strategy for promoting the use of renewable energies, with the specific target that “the contribution of the renewable energies to the Spanish energetic demand, will be at least 12% for the year 2010.” All installations using renewable energy as a primary source, with an installed power equal to or less than 50 MW, could be included in that regime.

The regime gives two choices to producers: one is a fixed priced for kilowatt-hours generated, and a second option is a variable price, calculated from the average price of the market-pool, plus a bonus per kilowatt-hour produced. The fixed price and the bonus will be up-dated every year by the Spanish Ministry of Energy and Industry according to the annual variation of the market price.

The updated values for are presented in Table 17.3. The evolution of the price of electricity generated by wind is shown in Figure 17.7.

## 17.7 INDUSTRY

Important activity in the wind energy field has intensely activated the development of the Spanish wind industry, covering not only the manufacture of complete wind turbines but also the manufacture of components

for the wind industry, such as blades, generators, gear boxes, towers, and wind sensors. The service sector (e.g., installation, maintenance, engineering) also continues the growth that occurred during the last years.

The estimation of job creation associated with wind energy is, according to promoter associations, approximately 7,000 direct jobs in 2003 (and near 20,000 indirect jobs). The estimation for the total objective in the year 2011 is approximately 51,000 jobs related to wind energy activity when the capacity of 13,000 MW will be reached.

### Manufacturing

The companies leading the Spanish industry are Gamesa Eólica, Ecotécnia, Izar-Bonus, NEG Micon, and GE Wind Energy. Gamesa Eólica is the leading company in the Spanish market, and new manufacturers are emerging, such as MTorres and EHN.

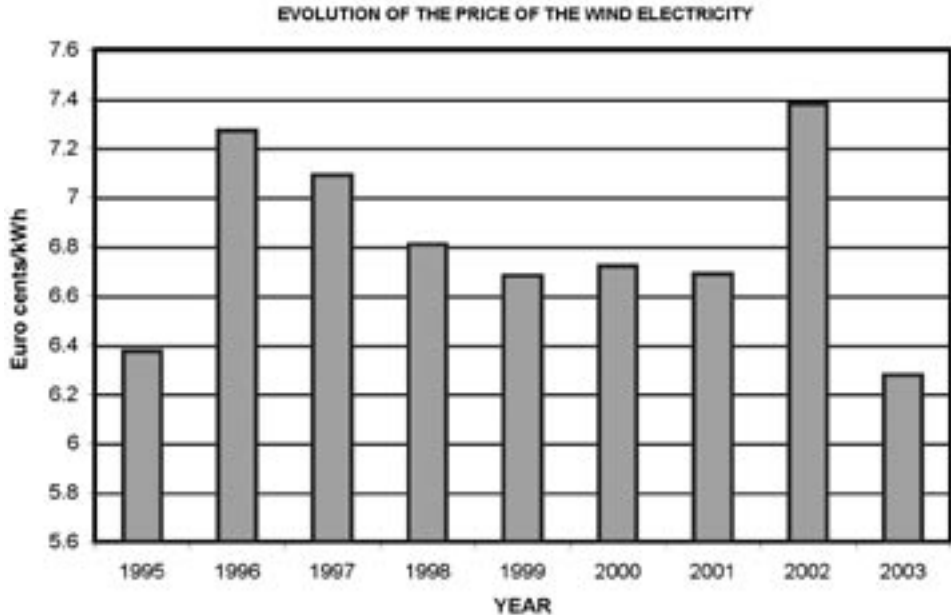
MTorres is a company with activity in the aeronautical field with a prototype of a 1.5-MW, upwind, direct-drive multipole generator, pitch-regulated wind turbine. Five units are in operation in Spain. The next step in the development is to incorporate permanent magnet technology.

EHN is a large wind promoter that has designed and put into operation its own model of a megawatt-class wind machine, which is a pitch-control, variable-speed turbine. The objective of the design is to be able to cover at least 30% of its own installations. A new company, called Ingetur, began manufacturing the models and is also designing new ones.

DeWind, Nordex, and Enercon are also initiating their activities in Spain. Enercon has an ambitious plan in the southeast of the country.

Buy-back electricity prices for RES 2002-2004					
Renewable source	Year 2002		Year 2003		Year 2004
	Bonus added to the base price	Fixed price	Bonus added to the base price	Fixed price	Bonus added to the base price
	Euro /KWh	Euro /KWh	Euro /KWh	Euro /KWh	Euro /KWh
Small hydro	0.030051	0.063827	0.029450	0.064849	0.029450
Wind plants	0.028969	0.062806	0.026625	0.062145	0.026625
Primary biomass	0.027887	0.061724	0.033236	0.068515	0.033250
Secondary biomass	0.025781	0.059620	0.025122	0.060522	0.025136
Primary biomass : Agricultural crops					0.064849
Secondary biomass : Agricultural and forest residues					0.062145
					0.068575
					0.060582

Table 17.3 Buy-back electricity prices for RES in 2003  
 Primary biomass : Agricultural crops  
 Secondary biomass : Agricultural and forest residues



**Figure 17.7 Evolution of the electricity price for wind energy**

Gamesa Eólica is the leading company in the Spanish market. The company manufactures wind turbines between 660 kW and 2 MW, as well as a majority of components (e.g., blades, nacelles, gearboxes, towers). Gamesa Eólica has a total of 2,000 employees and more than 15 subsidiary factories.

Gamesa Energia is also one of the major wind farm developers in Spain. During 2003, the company sold 1,380 MW – most of this for the domestic market and the rest for projects in other countries like China, Germany, Italy, Japan, Portugal, and the United States. The wind turbines are pitch-controlled and variable-speed using the Ingecom system developed by Gamesa Energia. During 2003, Gamesa purchased the company Made, one of the pioneering wind turbine companies in Spain. Since 1982, Made has developed ten different models of wind turbines, ranging from the first design, a 24-kW machine, to the recent

2-MW turbine. The technology involved in the classical Made design is stall-regulated with an asynchronous generator. The most recent model, Made AE/52 (800-kW rated power), changed to a pitch-controlled wind turbine with a synchronous generator and variable-speed design. With this incorporation the Gamesa group increased the capability of design and production and covered a wide range of technologically options.

Ecotécnia started activities in wind technology development in 1981, having more than 20 years of experience in that field. The company has three factories, with a total of 350 workers. During 1999, Ecotécnia was incorporated into the MCC Group, one of the largest, worldwide co-operatives, with activities in the industrial, distribution, and financial sectors. The company has recently opened a new office in France. Ecotécnia has in production models with diameters of 48 m, 62 m,

and 74 m, with rated powers of 750 kW; 1,300 kW; and 1,670 kW, respectively. A prototype of a 3-MW wind turbine with a 100-m rotor diameter is under development. During 2003, Ecotécnia supplied 29 wind turbines of 1,670 kW, 74-m rotor diameter, 64 units of the model 74 m, and 53 units of the Ecotécnia 48. Installations were nearly finished in 2003.

Izar is manufacturing 600-kW and 1.3-MW models of Bonus technology in its factory located in Ferrol (A Coruña). Izar is also developing two new models of 2 MW and 2.3 MW. The company's current annual capacity production is more than 200 MW.

GE Wind Energy is producing a 900-kW wind turbine (with a 55-m diameter) and a 1,500-kW model (with 70.5-m and 77-m rotor diameters) in the factory located in Noblejas (Toledo). GE is also offering new models based on the 2.X criteria with rated power from 2.3 MW to 2.7 MW. These new models are specially designed for onshore applications in a wide variety of landscape situations. GE continues the operation of its prototype of 3.6-MW turbine in Barrax (Albacete).

NEG Micon has three factories in Spain. The company has 160 workers and is manufacturing models from 44-m rotor diameter and 750 kW of rated power to the NM92 model of 2.7 MW covering a wide range of site and wind conditions. In Spain, NEG Micon has the following models in operation: NM44, NM48, NM52, NM64, NM72, and NM82, all manufactured in Spanish factories.

During 2003, NEG Micon supplied 195 wind turbines (154.1 MW) to the Spanish market, plus another five wind turbines to Portugal and nine more for a project located in France. Spanish factories can produce approximately 400 wind turbines per year.

In the sector of small wind turbines, Bornay is the company leader with active development in Spain and in the international market (e.g., Chile, Germany, Japan, Tanzania). Bornay is manufacturing models from 60 W to 6 kW and is developing new models of 7.5 kW, 15 kW, 30 kW, and 50 kW.

Solener is also manufacturing small wind turbines from 300 W to 15 kW and developing new prototypes from 25 kW to 40 kW rated power. Other companies like Atersa and Ecotécnia are supplying small wind turbines using foreign technologies from Vergnet and Bergey. The market for small wind turbines in isolated applications showed an active development during 2003 in Spain.

### Industry Development and Structure

Two Spanish companies Gamesa Eólica and ECOTECNIA were among the world's ten largest manufacturers in 2003. Approximately 400 companies are involved in the wind sector, covering different areas of activity. Manufacturing includes wind turbines, towers, blades, gear-boxes, control systems, and electric and electronic equipment. Other active areas include erection and maintenance of wind turbines, engineering, civil works, wind assessment, and audits.

Domestic manufacturing capability is estimated at more than 1,900 MW/yr. The current state of technology generally implies the following options for providing wind energy:

1. Wind turbine manufacturers using Spanish technology, like Gamesa Eólica and Ecotécnia, which together represented 77% of the total installations during 2002
2. Spanish manufacturers with technology transfer agreements like Izar-Bonus, which represented 4% of the total installations in 2002



**Figure 17.8 Traditional windmill in the south of Spain**

3. Foreign technology with factories in Spain like NEG Micon, GE Wind, and Enercon, which together represented 19% of the total installations during 2002

4. New manufacturers using foreign technology, such as Nordex and DeWind

Currently, Spanish manufacturers are participating in future international projects and also increasing marketing activities in other countries. The wind industries are spread in the Spanish territory (i.e., almost all the autonomous communities are involved in the development of wind energy), and new factories of components for the industry were inaugurated during 2003.

## 7.8 GOVERNMENT-SPONSORED R,D&D

### Priorities

The *National Plan for Scientific Research, Development and Technological Innovation (2000-2003)* continues activity. The target areas defined in the plan for wind energy projects are the following:

1. Environmental Impact Reduction of Wind Systems
2. Technology Cost Reduction
3. Technology Development for Large Wind Turbines (1 MW to 2.5 MW)

4. Small Wind Turbines for Isolated Applications
5. Remote Control Systems for Grid Connection
6. Wind Power Penetration in Weak Grids

During 2003, 16 wind energy projects were submitted to the program, covering all the target areas. The projects approved (a total of 13) present a budget of 15.33 million euro – an important part of the budget was covering soft conditions loans, and the equivalent subsidy was approximately 2.8 million euro. The projects were presented mainly by industrial companies in co-operation with engineering companies and research centers and universities.

### New R,D&D Developments

The centers and universities involved in R&D projects increased their activities during 2003. The wind power industry in Spain has a strong innovative character and its contribution to R&D growth in areas is considered strategic. According to the Manufactures and Promoters Association, Plataforma Eólica Empresarial, the R&D



**Figure 17.9 Manufacturing of a hub by Gamesa**



**Figure 17.10 Hybrid system for an isolated application**

investment by Spanish manufacturers amounts to 11% of the companies gross value added, which is well above the average 1% of Spanish companies as a whole, and higher than other industries such as the electronic equipment industry (5.4%).

The following main projects are supported by the national program and carried out by companies:

1. Developing a new wind turbine with a 100-m rotor diameter for easy transport and installation
2. Integrating wind farms in the electrical grid
3. Developing a new hybrid system, wind-photovoltaics-diesel, of 100 kW
4. Creating a test plant for isolated systems
5. Modeling hydrogen production with wind energy

6. Creating innovative concepts in commercial wind turbines
7. Developing wind turbines for special site requirements
8. Developing new control strategies and preventive maintenance
9. Creating electrical protections in the distributed generation using renewables
10. Developing a hybrid, three-phase system for electricity generation
11. Developing a direct-drive wind turbine prototype

The main public R&D organization in the field of wind energy in Spain is CIEMAT, a center for research in the technologies and environmental aspects of energy production. Inside CIEMAT, the Department of Renewable Energy is stressing activities in the field of autonomous wind systems, with a broad field of activity from development of components (e.g., small wind turbines, flywheel storage, control management units) to the testing of wind turbine components and systems in the test plant located in the CEDER center in the Soria province. Figure 17.11 shows one view of the test plant.

### Offshore Siting

They are two main initiatives in offshore activities in Spain – one of them is a study carried out by Greenpeace Spain called, *Viento En Popa*, or “the need for an offshore wind generation plan in Spain,” June 2003. The main conclusions of the study are an estimation of wind potential of 25,000 MW at the Iberian Peninsula (less than 30 km from the coast, 30 m deep); and the necessity of new regulations covering the public interest of the project, long-term price guarantees, and a plan for the organization of offshore activities.



**Figure 17.11 CIEMAT test plant for small wind turbines**

Another project in offshore activity is called *Mar De Trafalgar*. The first phase of the project is a study of a 1,000-MW wind farm in the south of the country, using wind turbines from 2.5 MW to 5 MW. A preliminary project was presented to the authorities in September 2003.

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