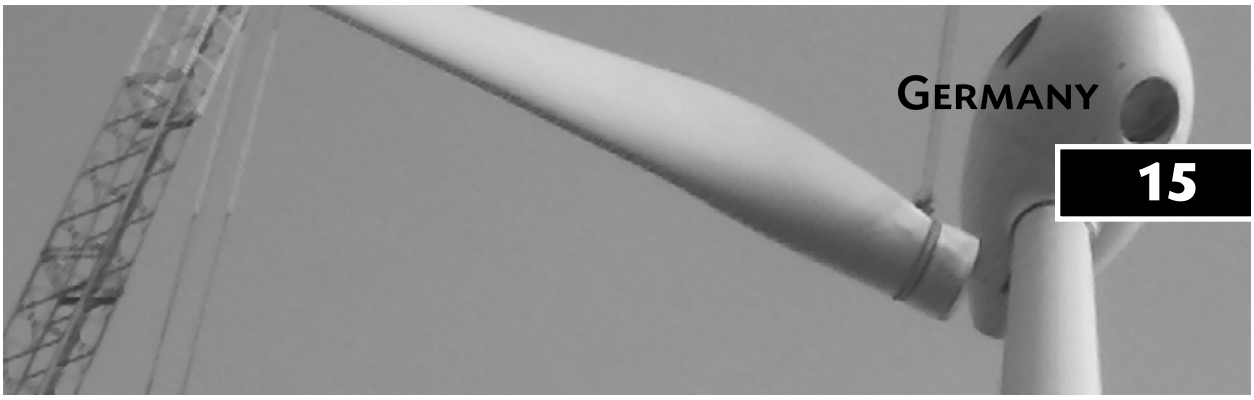

GERMANY

15

1.0 Introduction

Against the predicted trend in market development, new installed onshore wind power in Germany grew again in 2006 to a level higher than it had been two years earlier. Installed power increased by 23.5% in comparison to 2005. At this stage, wind energy is potentially able to produce 7.0% of German annual net electrical energy consumption. Irrespective of a relatively weak wind supply over the year, energy production in 2006 amounted to 30.5 TWh. This is an increase of 12.5% over 2005. Installed capacity exceeded the 20,000-MW mark (Figure 1).

Wind energy is the leading renewable energy in Germany with a share of 5% of national final electrical energy consumption. It is followed by hydropower (3.5%) and electrical energy conversion from biomass (3%). The wind industry is further developing into a powerful industrial market segment with high potential for employment and high demands on R&D activities in a broad spectrum of technical sciences. At least 70,000 employees are working in the wind energy industry to date.

Although offshore development in Germany is currently behind the strategic goal set by the government in 2002, medium- and long-term targets for offshore expansion in the German seas (1,500 MW by 2011; up to 25,000 MW by 2030) are still relevant. Important steps were taken in 2006 toward meeting these targets. Federal authorities have identified suitable areas for offshore wind farms in the North Sea and Baltic Sea, making planning easier for investors. The Infrastructure Acceleration Act came into force at the end of 2006. The law improves conditions for investors in offshore wind because it obligates transmission system operators to pay for and install the grid connection from the onshore grid access point to the offshore wind farm. In addition, relevant research projects flank the legislative improvements. The main activity is to establish an offshore test site in the North Sea. Also of importance is the erection of two more offshore research platforms and further developments to adapt multi-megawatt turbine technology to offshore conditions.

The leading federal state in Germany in wind energy deployment is Lower Saxony, with 5,282 MW installed and potentially 10.0 TWh produced in 2006. In three German states—Saxony-Anhalt, Schleswig-Holstein, and Mecklenburg–Western Pomerania in the northern lowlands—more than 33% of the energy consumed is provided by wind. In the two southernmost states, located nearly in the center of Europe, wind provides about 0.5% of the energy consumed (1).

Repowering is still behind its technical possibilities but became for the first time a visible factor with 135 MW in 2006.

Table 1 Key Statistics 2006: Germany (1,2,3)

Total installed wind generation	20,622 MW
New wind generation installed	2,233 MW
Total electrical output from wind	30.5 TWh
Wind generation as % of national electric demand	5%
Target:	12.5% from renewable energy (RE) in 2010 (status in 2006: 12% from RE)

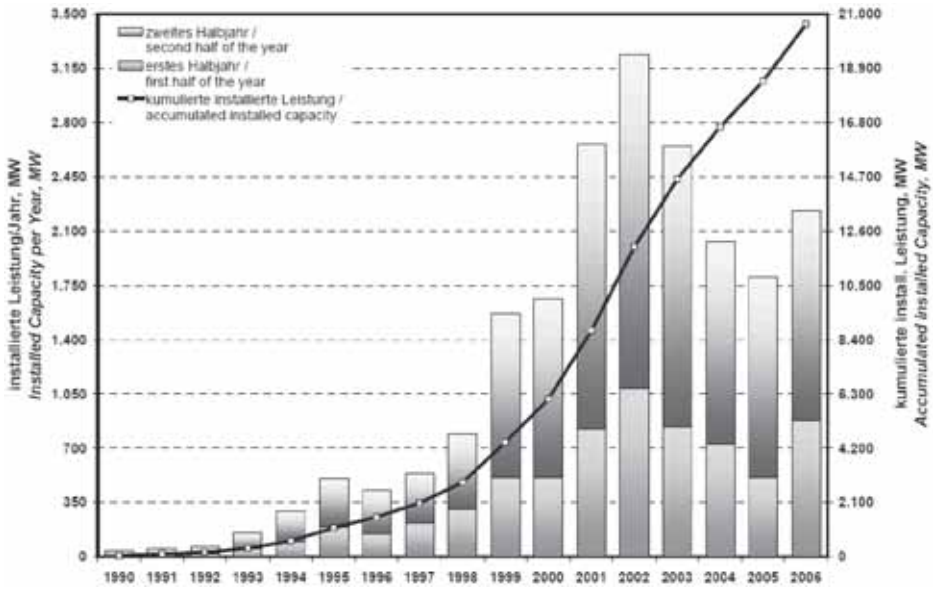

Figure 1 Development of the yearly and total installed capacity, DEWI.

2.0 Progress toward national objectives

The German government acknowledges the importance of renewable energies, and in this regard national policy was generally continued. The legislative framework was improved in 2006 with respect to offshore wind energy (see Section 1.0). The use of renewable energies continued to rise in 2006. Their share in primary energy consumption increased from 4.7% in 2005 to approximately 5.8% in 2006. The contribution by wind to total final energy supply (electricity, heating, fuels) increased to 7.4%.

Renewable energies accounted for 12% of the electrical energy consumption in 2006, compared with 10.4% in 2005—an increase of 15%. According to EU targets, 12.5% of consumption is to be met by renewable energy sources in Germany by 2010 (4). It is realistic to expect that this target will be surpassed in 2007 (Tables 1 and 2).

3.0 Benefits to national economy

German turbine manufacturers participated in the growing world wind market. Some manufacturers doubled their production capacity in 2006. Further new production capacity for 5-MW-class turbines is under construction. Generally, turbines with a capacity of less than 2 MW are increasingly difficult to place in the market. The number of employees in the wind industry has grown continu-

Table 2 Additional data about wind energy deployment in Germany at the end of 2006 (1, 2)

Number of turbines	18,685
Number of new turbines in 2006	1,208
Potential energy production	38.8 TWh
Potential part of German net electrical energy consumption	7.0% *
Total German net electrical energy consumption	540 TWh**
CO_2 reduction in 2006	26.1 Million t.
* Estimation	
** According VDEW	

ously during past years (Figure 2) and was at 70,000 in 2006.

The total contribution of the wind sector to the German economy (wind sector turnover) in 2005 amounted to about 7.3 billion €. The value of domestic manufacturing, taking into account turbine and component suppliers, was 4.8 billion €. Detailed economic data for 2006 will be published in July 2007.

The four leading manufacturers on the German market for turbines installed in 2006 were Enercon, Vestas, REpower Systems, and GE Energy (Table 3) (1).

4.0 National incentive programs

The Renewable Energy Sources Act (EEG; see the report for Germany in IEA Wind Annual Report 2005) provides the main stimulation and incentives for the German wind market. Grid operators must pay 0.0836 €/kWh to the turbine owner for turbines installed in 2006 at least for five years (0.0853 €/kWh for turbines installed in 2005). Depending on how local wind conditions compare to a reference value, the tariff will be reduced after five years. So the median feed-in tariff over 20 years for turbines installed in 2006 ranges from 0.0836 €/kWh to 0.0605 €/kWh. The EEG requires the starting tariff to be reduced by 2% yearly. A turbine installed in 2007 will therefore receive a starting tariff of 0.0819 €/kWh. Special tariffs exist for onshore repowering and for offshore wind farms. The EEG will be audited in 2007 to adapt prices for renewables to new market conditions and technological developments.

5.0 New R, D&D activities

Applied research in the field of renewable energies (except for biomass) is overseen by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). Project Management Jülich (PtJ) is in charge of managing and controlling the wind energy research program on behalf of BMU. In 2006, BMU started 24 wind energy–related projects with a total of 16 million € for the years 2006 through 2009. The funds for ongoing projects for 2006 amounted to 9.6 million € (Figure 4).

A new announcement for proposed research in the field of wind energy published in September 2006 focused on cost reduction; improved reliability; optimization of maintenance; grid integration; and specific technologies for offshore such as foundations, logistics, and reduction of environmental impacts (5). Of special interest in the field of offshore wind energy are demonstration and test activities.

Among other research topics, the subject of grid integration of wind energy became increasingly important. A new research network is dealing with the storage of wind energy in underground air-pressure storage areas in combination with the energetic deployment of low concentrated North Sea gas resources. Existing underground holes resulting from former salt mines and ore mines are being evaluated concerning their availability as air-pressure storage areas for the intermediate storage of wind energy.

A relevant cost factor especially for offshore wind energy utilization in deep waters is the foundation. A new research network of steel and pipe companies, the offshore construction industry, a turbine

Figure 2 Employees in Germany's wind industry.

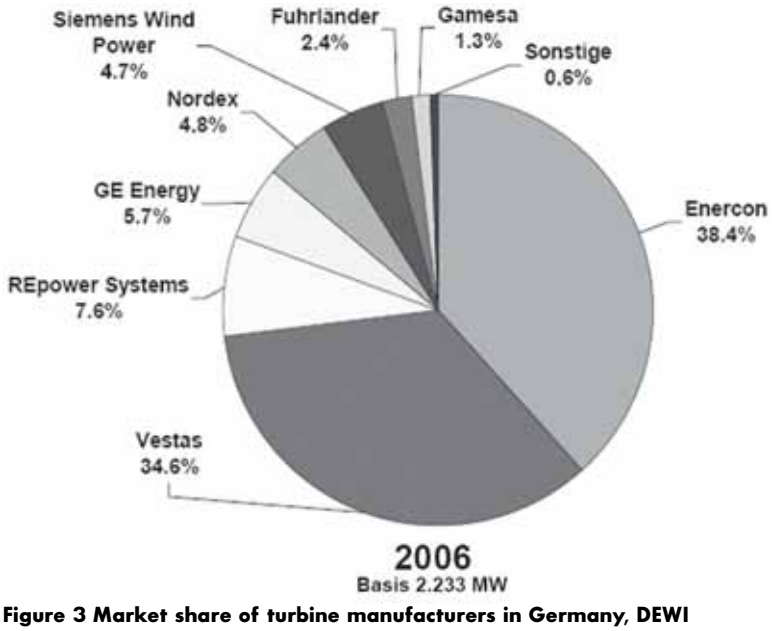

Figure 3 Market share of turbine manufacturers in Germany, DEWI

Table 3 Leading manufacturers for turbines installed in 2006

Company	Market share 2006 (%)	Market share 2005 (%)
Enercon	38.4	41.7
Vestas	34.6	26.8
REpower Systems	7.6	5.5
GE Energy	5.7	8.1

manufacturer, and research institutes was launched in 2006 to work toward the optimization of tripod and jacket foundations. The aim is to optimize the use of materails, the onshore and offshore construction process, and to improve the technical reliability of foundations.

Offshore installation and transport are becoming a bottleneck for Europe's offshore construction activities. Specifications for new offshore transport and construction equipment have been evaluated in a project of the offshore construction industry. The assumptions are for the markets of the Irish Sea, the North Sea, and the Baltic Sea by the middle of the next decade to be 2,500 MW/yr and 550 foundations/yr. Effective equipment should be available at least 75% of each month regardless of weather. Specifications for new equipment have been formulated on the basis of these assumptions.

So far, no German test facility has existed for rotor blade manufacturers to conduct static and dynamic tests of multi-megawatt turbine rotor blades. In 2006, such a test center was launched at the Fraunhofer Center for Wind Energy and Marine Technologies in Bremerhaven, and it will start its work in 2008.

Germany continued bilateral cooperation with Denmark on ecological research in 2006. Common projects investigated harbor porpoises and birds at the two Danish offshore wind farms Horns Rev and Nysted. A new project of the German Marine Museum Stralsund and the Danish National Environmental Institute is to develop standardized methods for the calibration and signal analysis of porpoise hydrophones (PODs). In related work, temperature measurements at the sea bottom above the 110-kV cables of the Nysted wind farm showed no dominant influence by the cable on the tempera-

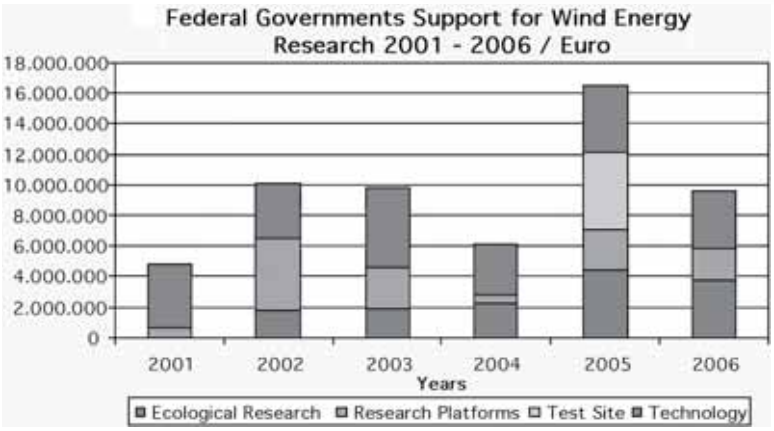

Figure 4 Government funds for wind energy research.

ture of the sediment surface layer above the cable. Compared with a reference site far from the cable, the temperature did not exceed the 2-K threshold at a sediment depth of 20 cm.

5.1 Offshore test site

According to the approval documents of the demonstration offshore wind farm Borkum West (which is near the research platform FINO 1 (www.fino-offshore.de) in the North Sea), a test site will consist of 12 turbines of the 5-MW class. The demonstration project will be operated by the German Offshore Test Site and Infrastructure Ltd. (DOTI), which was launched by the power companies Vattenfall Europe, E.on, and Energiewerke Weser Ems (EWE).

Much effort has been made to establish a comprehensive research program at the German

Figure 5 REpower 5M installed on a jacket foundation in the Scottish North Sea in August 2006. Source: REpower Systems Inc.

offshore test site. Project proposals concerning offshore-specific aspects of generators, gears, and rotor blades as well as investigations of external conditions, grid aspects, and condition monitoring have been evaluated and are in the planning phase. The main research topics have been agreed to by the future operator, and progress has been made in preparing for potential research activities. Test site research will be conducted as a collaborative program of research institutes and industry ranging from basic aspects to demonstration of new technologies as well as accompanying ecological research.

5.2 Multi-megawatt turbine prototypes

Two new multi-megawatt prototype turbines were tested in Germany in 2006. The DeWind Ltd. 2-MW type D8.2 was erected in the near-shore test site of DEWI-OCC in Cuxhaven. The low rotor speed is converted to a constant rotation speed, and the resultant current of the synchronous gen-

Figure 6 M5000 construction on shore in Bremerhaven at an offshore tripod foundation. Source: Multibrid Entwicklungsgesellschaft Ltd.

erator can be directly fed into the electrical grid (6). Another new 2.5-MW prototype is the Fuhrländer FL 2500-100. The first turbine was erected on a 160-m tower manufactured by Seeba. Another eight turbines will be installed in 2007 on 100-m steel towers (6).

Work continued with other large turbines. The Enercon company installed two E 112/6-MW turbines, an enhancement of the E 112/4.5-MW turbine. Special features are the gearless generator and a wide range of usable wind velocities. A REpower 5M was erected in 2006 in the Scottish Sea (Talisman Beatrice Gas Field project) (Figure 5). And two REpower 5MW were erected in November 2006 at the DEWI-OCC near the coast test site in Cuxhaven. A third type of wind turbine in the 5-MW class is the Multibrid Entwicklungsgesellschaft Ltd M5000 (Figure 6). The second M5000 was erected in 2006 near the coast in Bremerhaven on a tripod foundation. This will allow researchers to study how loads affect the overall construction of turbine, tower, and foundation. Results of such onshore experiments will contribute to the optimization of the future serial production of tripod foundations (7). A special feature of this turbine type is the relatively low weight (440 tonnes) of the gearbox and rotor. Finally, a newcomer on the multi-megawatt market is BARD Engineering Ltd. The BARD company is pushing the development of a new 5-MW turbine to be erected in mid-2007 at the company's own near-coast test site. BARD has also developed a new foundation type called "multipile" designed for water depths from 25 m to 50 m.

5.3 Scientific measuring programs

Final results from the Scientific Measuring and Evaluation Programme (WMEP) were presented in 2006. WMEP developed 63,000 reports detailing energy output data; operation experiences; and data about damage caused by lightning, storms, ice, and grid failures. The data were collected from 1,500 wind turbines together with wind data at 60 locations. This unique database will be extended to future offshore wind farms starting with the abovementioned test site.

The research platform FINO 1 (www.fino-offshore.de) in the North Sea has been in operation for more than three years. Wind, wave, and load data are now available online (http://fino.bsh.de). FINO 1 will become still more important for offshore wind energy research after the offshore turbine test site is established there.

FINO 2 (www.fino2.de) is located in the Baltic Sea at the borders of the German, Swedish, and Danish EEZ. The monopile foundation was rammed in October 2006. Offshore installation of the deck and the measuring mast will occur in June 2007.

FINO 3 (www.fino3.de) will be commissioned in summer 2008 in the northern part of the German EEZ of the North Sea about 70 km west of Sylt Island. A special focus of FINO 3 will be geophysical investigations concerning interactions between sediment and monopile and lightning on the open sea and its possible impact on turbine components.

FINO 2 and FINO 3 will be constructed as monopiles. The wind measuring systems of all three platforms are based on the same principles to make the data comparable. All data will be available online at http://fino.bsh.de.

6.0 Next-term activities

The Second Scientific BMU Conference on Offshore Wind Energy Deployment took place in February 2007 in Berlin prior to the European Policy Seminar on Offshore Wind Energy Deployment. It focused on ecological aspects. In conjunction with the BMU-Conference, an IEA topical expert meeting on offshore wind and waves measurements was organized by the IEA Wind Energy Agreement and the FINO 1 team (Germanischer Lloyd Industrial Services Ltd., commissioned with operation and maintenance by BMU).

A kickoff presentation of the offshore test site research network is planned for spring 2008.

The European Policy Seminar on Offshore Wind Energy Deployment proposed the extension of the Danish-German Agreement to a other interested states. Germany, Denmark, and Sweden are in discussion to formulate such an agreement.

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