

IEA WIND ENERGY

Annual Report 2008

Executive Committee for the
Implementing Agreement for Co-operation in the
Research, Development, and Deployment
of Wind Energy Systems of the
International Energy Agency

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Front cover: The NedPower Mount Storm 264-MW wind energy project is located about 120 miles west of Washington, D.C. in Grant County, West Virginia. Owned by Dominion and Shell WindEnergy Inc., the project began construction in 2006, consists of 132 wind turbines along 12 miles of the Allegheny Front, and can generate enough electricity to serve about 66,000 homes and businesses. Output from the wind farm will be sold into PJM Interconnection, a regional transmission operator and wholesale electricity market serving 51 million people in 13 states and the District of Columbia. Photo Credit: Vetter, Moe.

Under the auspices of the International Energy Agency (IEA*), the Implementing Agreement for Co-operation in the Research, Development, and Deployment of Wind Energy Systems (IEA Wind**) is a collaborative venture among 24 contracting parties from 20 Member Countries, the European Commission, and the European Wind Energy Association (EWEA). In this thirty-first IEA Wind Energy Annual Report, experts describe activities in the research, development and deployment of wind energy within their countries in Section II, Member Activities. The managers (Operating Agents) of the IEA Wind cooperative research Tasks report progress for the year and plans for the coming year in Section I, Implementing Agreement and Active Annexes. The Executive Summary compiles information from all countries and Tasks in a shorter format suitable for decision makers.

This IEA Wind Energy Annual Report for 2008 is published by PWT Communications in Boulder, Colorado, United States, on behalf of the IEA Wind Executive Committee. It was edited by P. Weis-Taylor, with contributions from experts in participating organizations from Australia, Austria, Canada, Denmark, the European Commission, the EWEA, Finland, Germany, Greece, Ireland, Italy (two contracting parties), Japan, the Republic of Korea, Mexico, the Netherlands, Norway (two contracting parties), Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

Ana ESTANQUEIRO
Chair of the Executive Committee
2006-2008

Patricia WEIS-TAYLOR
Secretary to the Executive Committee
1998-present

*The IEA was founded in 1974 within the framework of the Organization for Economic Co-operation and Development (OECD) to collaborate on international energy programs and carry out a comprehensive program about energy among Member Countries. In 2008, 28 countries and the European Commission participated in 42 Implementing Agreements of the IEA. OECD Member countries, non-Member countries, and international organisations may participate. For more information, visit www.iea.org.

**The IEA Wind implementing agreement functions within a framework created by the International Energy Agency (IEA). Views and findings within this Annual Report do not necessarily represent the views or policies of the IEA Secretariat or of its individual member countries.

Web site for additional information on IEA Wind
www.ieawind.org

Message from the Chair



Welcome to the 2008 IEA Wind Annual Report where we document the record increases in wind energy capacity and its contribution to satisfying electrical demand around the world! The member countries of IEA Wind added more than 17,000 megawatts (MW) with growth rates up to 58% over 2007.

Amidst all of this work in our home countries, we managed to work together to achieve significant results in IEA Wind. Following the 2003 Strategic Plan, IEA Wind has addressed key issues of integration of wind power into the electricity system, offshore wind development, and social acceptance of wind energy projects. For example the final report of the first term of Task 25, Power Systems with Large Amounts of Wind Power showed that the impact of wind power can be controlled by appropriate grid connection requirements, extension and reinforcement of transmission networks, and integration of wind power production forecasts into system and market operation. This work is having significant impact on expanded wind energy development.

In 2008, we produced an End-of-Term Report documenting that the cooperative research tasks are rewarding participants with benefits totaling many times the value of the monetary and in-kind efforts they contribute. Industrial and utility participation is informing the research tasks, and the information sharing and distribution of the ExCo is contributing to policy development in the Member Countries and at IEA. We extended our cooperation for another five years and approved a Strategic Plan to guide our work in 2009 through 2013.

Also this year, work has been completed in two tasks on issues of offshore wind energy deployment and integration of wind and hydropower systems. Final reports are expected next year and this work will provide the foundation for continuing work in these areas. Four important tasks illustrating the importance of technical as well as social issues moved forward. Consumer labeling of small wind turbines demands technical expertise as well as policy sensitivity. Cost of wind energy will provide important methodologies to compare technologies and approaches. Social acceptance of wind energy projects will translate the findings of social scientists into the language of planners, developers, and engineers to enhance the process of wind power development. And following on the successes of two previous tasks on aerodynamics, a new task will bring the combined efforts of organizations in eleven countries to process and use the massive amounts of data collected by the European Union "MEXICO" aerodynamic experiment. Improving aerodynamic models is an important element of improving wind turbine durability.

I personally have been honored to participate in the progress of IEA Wind and to serve as Chair these three years. Now I confidently pass these important duties on to Brian Smith of the United States.

Ana Estanqueiro

A handwritten signature in black ink, appearing to read "A. Estanqueiro". The signature is stylized and cursive.

Chair of the Executive Committee, 2006 to 2008

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Executive Summary

1.0 Introduction

In 2008, cumulative installed wind power capacity increased nearly 29% (1) worldwide and nearly 23% (2) in the member countries of the IEA Wind Implementing Agreement. In the IEA Wind member countries, 17,000 MW was added in 2008 for a total of close to 92 GW of generating capacity. Even more encouraging, electrical production from wind increased more than 25% in IEA Wind countries to about 194 TWh (Table 1). This electrical production from wind met 2% of the total electrical demand in the reporting IEA Wind member countries—up from 1.6% in 2007. The percentage contribution from wind is growing steadily even in this time of economic slowdown. Electrical output from wind in the world was enough to cover the electricity consumption of Australia.

At the close of 2008, three-quarters of the nearly 121 GW (Table 2) of the world's wind generating capacity was operating in the IEA Wind member countries. Located in Europe, North America, Asia, and the Pacific Region, the member countries are sharing information and research efforts to increase the contribution of wind energy to their electrical generation mix. They are also reaching out to other countries to join this co-operation.

2.0 Progress Toward National Objectives

2.1 Wind generation capacity

The dramatic increase in electrical generation capacity and output from wind in the IEA Wind member countries as a whole can be seen in Figure 1. Capacity has increased from less than 5 GW in 1995 to nearly 92 GW in 2008. In 2008, the member countries added more than 17 GW of new wind generating capacity, and much more is being planned for 2009 and beyond. Thirteen countries added more than 100 MW of new capacity, and four countries added more than a gigawatt of new capacity: the United States (8,558 MW), Spain (1,609 MW), Germany (1,665 MW), and Italy (1,010 MW) (Table 3). In addition, Australia, Canada, Japan, the Netherlands, and Portugal added 300 MW or more. The Netherlands reached an all-time record of 490 MW of new installed wind capacity in 2008. Australia, Italy, and the United States also broke their national records due to favorable changes in domestic programs. Increases in capacity were less than hoped for in other countries such as Austria, Denmark, Finland, Korea, Mexico, Norway, and Switzerland because of uncertainty about government programs or very low competing energy prices. Total

Table 1 Key Statistics of IEA Wind Member Countries 2008

	2007	2008
Total installed capacity	74.84 GW	91.77 GW
Total offshore wind capacity	1,125 MW	1,431 MW
Total new wind capacity installed	13,315 MW	17,000 MW
Annual increase in capacity from previous year	21%	23%
Total annual output from wind	155 TWh/yr	194 TWh/yr
Wind generation as % of national electric demand	1.6%	2.3%

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Table 2 Worldwide Installed Capacity for 2008

IEA Wind Members		Rest of World (2)	
Country	MW	Country	MW
United States	25,369	China	12,200
Germany	23,902	India	9,645
Spain	16,740	France	3,387
Italy	3,736	New Zealand	468
United Kingdom	3,331	Poland	405
Denmark	3,163	Belgium	384
Portugal	2,819	Turkey	383
Canada	2,369	Egypt	365
Netherlands	2,214	Brazil	336
Japan	1,880	Taiwan	224
Australia	1,306	Bulgaria	158
Sweden	1,047	Morocco	134
Ireland	1,002	Czech Republic	133
Austria	995	Hungary	127
Greece	990	Ukraine	90
Norway	430	Costa Rica	92
Republic of Korea	236	Estonia	78
Finland	143	Iran	67
Mexico	85	Caribbean	57
Switzerland	14	Tunisia	54
Total	91,771	Lithuania	52
		Luxembourg	35
		Philippines	33
		Argentina	30
		Latvia	27
		Pacific Islands	24
		Colombia	20
		Chile	20
		Uruguay	18
		Croatia	17
		Russia	11
		Romania	10
		Reunion (France)	10
		Others (<10 MW)	38
		Total	29,132
		World Total	120,903

generating capacities of each country varied greatly, from the United States with 25,369 MW to Switzerland with about 14 MW.

The growth rate in many countries far exceeded the respectable average of 23% (Table 4). In the United States, wind energy capacity grew more than 50% in 2008 and accounted for 42% of that nation's new electrical generation for the year. Australia had the highest growth rate at 58%, while 11 countries had growth rates exceeding 23% for the year. Looking regionally, in Europe wind power installations alone made up almost 36% of new power installations and grew more than any other power generating technology there.

Many countries report significant amounts of capacity in the planning stages, including planning applications submitted, successful acquisition of land leases, projects under construction, and projects awaiting final connection to the grid. The capacity of projects planned or under construction is more than three times the capacity added in 2008 (Table 5). Mexico has 330 MW of capacity under construction, nearly four times the capacity operating at the close of 2008. In the United States, more than 4,000 MW were under construction at the beginning of 2009, more than half the capacity added in 2008. In the United Kingdom, more than 7,000 MW had received planning approval and 1,665 were under construction. And Australia is poised to repeat its 2008 record year with another 6,359 MW planned or under construction.

Offshore generating capacity was added in the Netherlands and in the United Kingdom. The UK is now the world leader in offshore wind energy, with 598 MW installed capacity. Much more offshore capacity is in the planning stages and could be connected as early as 2009: Denmark (28 MW), Germany (512 MW), Sweden (30 MW), and the UK (90 MW). Significant offshore resources to be exploited in the near future have been identified in Finland, Ireland, Italy, the Netherlands, Norway, and Spain.

Another trend in wind capacity increases is repowering—the replacement of older, smaller turbines with fewer, larger turbines representing the state of the art in power production. Especially for countries that have been installing wind turbines for a decade or more, repowering onshore is expected to increase in years ahead. In 2008, the Netherlands decommissioned 37 turbines (total capacity 14.6 MW) and replaced them with 53 turbines (total capacity 126 MW). The net repowering effect was an increase of about 112 MW. In Denmark, 164 turbines were removed and 51 new turbines were installed for a net addition of 39 MW, and the new incentive structure will encourage more repowering.

Increased interest in small wind systems (less than 40 kW) was reported in several countries (Canada, Ireland, Italy, Japan, Portugal, Spain, the United Kingdom, and the United States). In the United States, the small wind turbine industry (turbines rated at less than 100 kW) grew by almost 78% in 2008. The industry added 17.3 MW of new capacity, bringing the total small wind capacity to more than 80 MW. In Portugal, an active research program has developed and is testing a small vertical-axis turbine for urban applications.

2.2 Contribution to electrical demand

Total electrical production from wind energy in the IEA Wind member countries has increased from less than 10 TWh in 1995 to nearly 194 TWh in 2008 (Figure 1 and Table 3). The contribution from wind energy to the combined electricity demand has increased from under 0.2% overall in 1995 to well over 2% in 2008. In 2008, electrical generation from wind increased even as national electrical demand decreased or remained nearly constant in several countries (Denmark, Finland, Germany, Greece, Ireland, Italy, Portugal, Spain, Sweden, Switzerland, United Kingdom, and the United States). As a result of these two factors, the contribution of wind energy to electrical demand increased significantly in 2008.

Wind's contribution to national electrical demand varied from under 1% in several countries to nearly 20% in Denmark. In five countries, the wind energy contribution to national electrical demand exceeded 5%, and in 14 countries it met or exceeded the 1% mark (Table 3). Portugal and Spain both got more than 11% of electricity demand from wind energy. In Ireland, nearly 9% of electricity demand was satisfied by wind energy in 2008. In the United States, as a result of record growth the past three years, wind energy for the first time supplied close to 2% of that country's electrical demand.

In Europe overall, total wind power capacity operating at the end of 2008 produced 142 TWh, or 4.2% of EU power demand in an average wind year, and avoided emissions of about 108 million tons of CO₂ annually. In 2000, less than 0.9% of EU electricity demand was met by wind power.

Wind energy is becoming a significant source to meet peak demand. In Spain, wind energy covered more than 40% of hourly demand on several occasions in 2008, and for several days it supplied more than 30% of daily electricity demand.

2.3 Environmental benefits

Wind power's contribution to providing for the world's electrical demand reduces the amount of conventional fuel burned to generate electricity. Many countries evaluate their generation mix and calculate the effects of using wind power. For example, the total U.S. wind generation capacity at the end of 2008 produced enough electricity to power approximately seven million U.S. households. Generation from these projects over their lifetime will displace nearly 44 million tons of carbon emissions—the equivalent of taking more than seven million cars off the road. In Ireland, a nation that is more than 90% dependent on imported energy supplies, wind power displaced almost 1.28 million metric tonnes of CO₂ emissions and primary energy imports of 215,000 metric tonnes of oil equivalent.

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Table 3 National Statistics of the IEA Wind Member Countries for 2008									
Country	Total installed wind capacity (MW)	Offshore installed wind capacity (MW)	Annual net increase in capacity (MW)	Total No. of Turbines	Average new turbine capacity (kW)	Wind generated electricity (GWh/yr)	National electricity demand (TWh/yr)	% of national electricity demand from wind ^a	
Australia	1,306	0	482	756	2,000	3,462	267.0	1.3%	
Austria	995	0	14	618	2,000	2,050	70.7	2.9%	
Canada	2,369	0	523	1,681	1,863	5,800	575.0	1.0%	
Denmark	3,163	423	39	5,101	2,000	6,975	36.2	19.3%	
Finland	143	13	33	118	3,000	260	87.0	0.3%	
Germany	23,902	0	1,665	19,568	1,667	40,400	615.1	6.5%	
Greece	990	0	115	1,190	1,650	2,300	51.0	3.7%	
Ireland	1,002	25	207.7	834	1,696	2,298	26.2	8.8%	
Italy	3,736	0	1,010	3,588	1,566	6,637	337.6	1.9%	
Japan	1,880	11	342	1,508	1,247	2,856	913.2	0.3%	
RP of Korea	236	0	43	152	1,579	421	422.0	0.1%	
Mexico	85	0	0	104		254	209.7	0.1%	
Netherlands	2,214	228	490	2,053	2,219	4,259	119.3	3.6%	
Norway	430	0	45	200	2,531	921	128.6	0.7%	
Portugal	2,819	0	694	1,500	1,900	5,737	50.6	11.3%	
Spain	16,740	0	1,609	>16,000	1,600	31,100	266.5	11.7%	
Sweden	1,047	133	216	1,151	1,700	1,974	145.9	1.4%	
Switzerland	14	0	2.3	28	2,000	19	57.4	0.03%	
United Kingdom	3,331	598	912	1,952	2,060	5,274	406.0	1.3%	
United States	25,369	0	8,558	>15,000	1,670	71,000	3,736.8	1.9%	
Totals	91,771	1,431	17,000	58,102	1,886	193,997	8,521	2.28%	

^a% of national electricity demand from wind = (wind generated electricity/national electricity demand)*100

Bold italic= estimated value

Table 4 Wind Energy Capacity Increases		
Country	Capacity added in 2008	Percent wind capacity increase
United States	8,558	51%
Germany	1,665	7%
Spain	1,609	11%
Italy	1,010	37%
United Kingdom	912	38%
Portugal	694	33%
Canada	523	28%
Netherlands	490	28%
Australia	482	58%
Japan	342	22%
Sweden	216	27%
Ireland	208	26%
Greece	115	13%
Norway	45	12%
Korea	43	22%
Denmark	39	1.0%
Finland	33	30%
Austria	14	1%
Switzerland	2.3	19%
Mexico	0	0%
Average rate		23%

The environmental benefit of wind power production in Finland is about 0.2 million tons of carbon dioxide savings per year. In Austria, 162 wind parks with 618 wind turbines generated 2.1 TWh of electricity, enough to power 570,000 households. This generation displaced 1.3 million tonnes of CO₂ for the year. In Spain, the use of wind power lowered CO₂ emissions by about 18 million tons just during 2008. Furthermore, wind generation saved up to 6 million tons of conventional fuels

and supplied the electrical consumption of more than 10 million households.

2.4 National targets

All IEA Wind member countries recognize that renewable energy in general and wind and solar energy in particular offer great potential to reduce overall carbon emissions of the power industry. In addition, reducing the cost of electricity and decreasing reliance on imported fuels are justifications for several national targets

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Table 5 Potential Increases to Capacity After 2008

Country	Planning application* (MW)	Planning approval** (MW)	Under construction*** (MW)	Total planned and/or under construction (MW)
Australia	2,767	3,057	535	6,359
Austria	150	30	0	180
Canada				5,834
Denmark		200	200	500
Finland	80	30	3	113
Germany				
Greece				
Ireland	11,000	1,400	580	12,980
Italy				2,885
Japan		134		134
Korea			420	420
Mexico	2,500	2,000	330	4,830
Netherlands				200
Norway	4,535	2,095	0	2,095
Portugal	3,880	971	739	5,590
Spain				
Sweden	1,140		125	1,265
Switzerland	50	26	4	80
United Kingdom		7,093	1,665	8,758
United States			4,451	4,451
Totals	26,102	17,036	9,052	56,674
	*Means all paperwork has been submitted to official planning bodies	**Means all relevant planning bodies have approved the projects	***Means all approvals are received and physical work has begun on the projects	

for renewable energy. In 2008, success in meeting targets for renewable energy contribution to electricity demand prompted several countries to propose or adopt more

aggressive targets. In Australia, the renewables target set for 2010 was met, so the Australian federal government proposed a new target of 20% by 2020.

Along with new targets, some countries are also changing the incentive structures. In Finland, the new target is 2,000 MW of wind power in 2020. This would be about 6% of the total electricity consumption in Finland. A new subsidy system is proposed to start in 2010. Projects that are planned, are under feasibility studies, or have just been proposed equal 1,100 MW onshore and 5,700 MW offshore. Ireland could reach its 2010 target if 60% to 70% of contracted wind farms are connected by 2010. This seems likely, so Ireland increased its target from 33% renewables by 2020 to 40%, and this target is now described as a minimum. In Germany, the EU target for renewables was exceeded in 2007, so the German government set a new target that at least 25% of electricity consumption should come from renewable sources. This translates to a strategic goal for offshore wind development of 1,500 MW by 2011 and 25,000 MW by 2030. This effort may be facilitated by the Infrastructure Acceleration Act, which requires transmission system operators to pay for and install the grid connection from the

onshore grid access point to the offshore wind farm.

An important goal has been set for the European market for wind energy technology by EU framework legislation combined with legislation at the national level aimed at reducing barriers to the development of wind energy and other renewables. The EU has issued a new Renewable Energy Directive for a binding 20% renewable energy target by 2020. The EU's overall 20% renewable energy target for 2020 has been divided into legally binding targets for the 27 member states, averaging out at 20%. These targets must be implemented at the national level.

Studies of wind energy potential are also driving policy and planning. In the United States, a report published in 2008 examined the potential for wind energy to provide 20% of U.S. electricity by 2030. Wind capacity contributing 20% would support 500,000 jobs, reduce greenhouse gas emissions equivalent to taking 140 million vehicles off the road, and save 4 trillion gallons of water. The report concluded that reaching such capacity will require

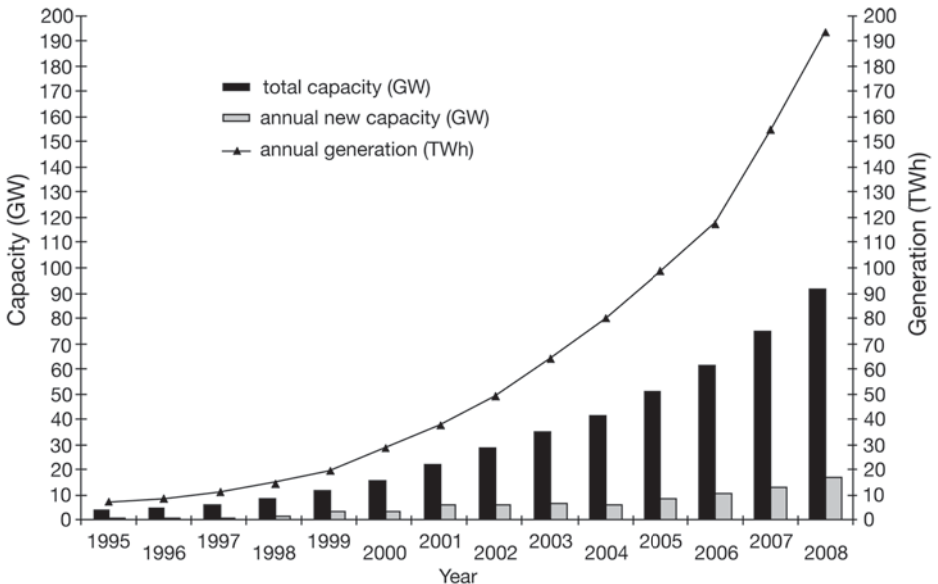


Figure 1 Annual installed capacity, cumulative installed capacity, and annual generation as reported by IEA Wind member countries, 1995–2008.

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an increase from the current 25.3 GW to more than 300 GW. To achieve this increase by 2030, annual increases in wind capacity will need to exceed 16 GW after an initial 10-year ramp-up period. The 8.5-GW increase in 2008 is a significant step toward meeting this goal. In Italy, the maximum wind potential is considered to be 12,000 MW by 2020 according to the 2007 Renewable Energy Position Paper of the Italian government. Offshore installations should contribute 2,000 MW to this target, corresponding to a total annual production of 22.6 TWh. (See Table 1 of the each country chapters for specific national targets.)

2.5 Issues affecting growth

IEA Wind member countries report several key issues affecting increased deployment of wind energy. Work in the countries and co-operative research tasks (annexes) within the IEA Wind Implementing Agreement are under way to address some of these issues. (See also Section 5.0, R, D&D Activities, of each country chapter.) Countries experiencing rapid growth attributed the growth to favorable financial incentives and regulatory environments that allowed for efficient approval and construction of projects. Slower growth was often attributed to uncertainty about the future of incentives, lack of sufficient incentives, or difficult regulatory issues that prevented timely approval of projects.

2.5.1 The world economy

The economic situation referred to as a credit crisis, economic slowdown, or economic crisis began to affect wind energy development in the second half of 2008 in some countries. All countries mentioned this issue when discussing prospects for 2009.

2.5.2 Grid capacity, integration, and transmission

Today's grids are mostly the result of previous planning and are adapted to the needs of an electricity system made up of

centralized, large-scale power plants. The move toward smaller and more decentralized generation plants thus requires adaptation of the grid.

Integrating wind energy and hydropower renewable resources for the benefit of consumers and the electrical generation system is appealing, and its technical and economic issues have been explored by IEA Wind Task 24, Integration of Wind and Hydropower Systems. Expected outcomes of this work, to be published in 2009, include the identification of practical wind/hydro system configurations and an understanding of the costs, benefits, barriers, and opportunities when integrating wind and hydropower systems.

System operation impacts from wind power are a concern of transmission system operators. Responding to the need to explore this issue, IEA Wind Task 25, Power Systems with Large Amounts of Wind Power, began work in 2005. The final report of the first phase of 2006–2008 shows the error of claims that wind power requires large amounts of reserve power and that integration costs erode the benefits of wind power. The report finds that a substantial tolerance to variations is already built in to our power network. This is why the influence of wind power fluctuations can be further balanced through a variety of relatively easy and inexpensive measures for reasonably large penetrations (10% to 20%). The impact of a large share of wind power can be controlled by appropriate grid connection requirements, extension and reinforcement of transmission networks, and integration of wind power production and production forecasts into system and market operation.

Forecasting the output of wind plants can increase the value of wind generated electricity and make system impacts more manageable. IEA Wind Task 11 Base Technology Information Exchange held a Joint Action Symposium that gathered experts on wind forecasting techniques. The value of the wind forecasts depends on several factors like the characteristics of the system, the way the system is operated, regulations,

climatic conditions, and so on. To continue the exchange between modelers and users of information, IEA Wind may sponsor additional meetings on this topic. In Australia, the variability of wind generation prompted implementation of the Australian Wind Energy Forecasting System (AWEFS), a sophisticated forecasting model that predicts wind generation for use with the National Electricity Market management systems.

Limited capacity of the transmission system has prompted rationing of capacity and construction of expanded systems. In Ireland, the electricity regulator directed system operators as to how they should control the connection of wind applicants in the coming years. Those wishing to connect to the grid join an applicant queue once their application is “deemed complete.” The options considered for accepting applicants included a date-order approach, a mixed date-order/optimization approach, or a Grid Development Strategy, which will result in the issuance of offers to selected applicants in the connection queue when the application process closes. To gain full advantage of its abundant wind resource, Ireland should have a 500-MW East-West Interconnector with the mainland by 2012. Another 350-MW high-voltage direct-current interconnector between Ireland and Britain is planned by Imera Power, a private asset-investment company that will build and operate the interconnector on a merchant basis.

The Mexican government awarded a 209-million-USD contract in August 2008 for the construction of a 300-km electrical transmission line for wind energy projects. The new line will be rated at 2,000 MW and will be shared by wind project developers who will also pay for the line over the long term. The transmission line will be commissioned by the end of 2010.

In the United States, a study by an investor-owned utility and the trade association concluded that a transmission superhighway will be needed for the United States to obtain 20% of its electricity from wind. More than 19,000 miles of new

765-kV (high-efficiency) transmission lines are proposed, costing 60 billion USD. To improve grid access, planning and construction of multistate, extra-high-voltage transmission lines is under way.

2.5.3 Planning issues and public resistance

Planning issues were mentioned as both benefiting wind development (when planning proceeded smoothly) or obstructing projects. Complex requirements in plans can obstruct wind development. In Japan, a building code that became effective in June 2007 classified wind turbines over 60 m high (highest point of blade tip) as a kind of building. Under this code, the installation of wind turbines requires the minister’s sanction, and the application procedure for planning permission is very complicated, time consuming, and expensive. Only in July 2008 was the first project approved under this new code. After that, the permission process became more standardized, and many other projects are being authorized.

In Korea, wind farm development has been slow for several reasons, including the complex system for approval of developments caused by conflict among existing laws, public acceptance issues, and difficulty getting permits for grid connection. Also, onshore sites are limited because of mountainous terrain.

Some countries have improved the permitting process in recent years. In the United Kingdom, the approval rate for new wind energy projects in 2007 was 70.1%. This was significantly greater than the rates of 54.7% in 2006 and 59.6% in 2005. In 2008, the approval rate dropped to 61%. Although this rate was lower than the 2007 rate, significantly more capacity was approved in 2008 (almost 4 GW) than in 2007 (2,300 MW).

In response to growing concerns about public acceptance of wind energy development, IEA Wind Task 28 Social Acceptance of Wind Energy Projects was approved in 2008. The work will collect case studies of successful community and market engagement and will publicize

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successful strategies for developing wind power.

In Denmark, public resistance is being addressed by government regulation. Beginning in 2009, the owners of new turbines to be installed will pay neighbors for resulting loss of property value. The compensation will be based on an individual evaluation of the loss of property value.

3.0 Benefits to National Economy

3.1 Market characteristics

The economic impact of wind energy development is estimated in various ways by the IEA Wind member countries (Table 6). Monetary values in this report are calculated using the exchange rates effective on December 31, 2008 (Appendix C Currency Conversion Rates). One measure of benefit, sometimes referred to as economic turnover or contribution to gross domestic product, is the value of all economic activity related to such development. It includes payments to labor, cost of materials for manufacture and installation, transportation, sales for export, and value of electricity generated. Other values reported include industrial activity, construction, and value of exports. Many countries are estimating the number of jobs created by wind energy manufacturing, development, and operation. According to the EWEA, 15.1 jobs are created in the EU for every megawatt installed. In addition, 0.4 jobs are created per megawatt of cumulative capacity in operations, maintenance, and other activities. About half of these jobs are associated with wind turbine and component manufacturing. For offshore, the numbers are higher.

The rapid growth of Canada's wind energy industry has resulted in a growing number of firms entering the market, resulting in increased activity in a variety of areas including resource assessment, project development, manufacturing, construction, and operations. In fact, the Canadian Wind Energy Association's (CanWEA) corporate membership has grown from 86 members to about 400 members over the past five years.

In Italy, the economic turnover of the wind sector in the past two years rose to more than 1 billion €, including turbines and components delivered to foreign countries. At the end of 2008, 18,309 employees were involved in the wind sector, of which 5,353 are directly employed. The total personnel involved is subdivided as follows: feasibility studies, 2,240; manufacturing of turbines and related industry, 3,033; development and civil works, 5,246; installation, 1,421; and management O&M, 6,369. A study estimated that by 2020, assuming full exploitation of an Italian wind potential of 16,200 MW and energy production of 27.2 TWh, some 66,000 people would be employed (including indirect employment). This development is taking place in rural areas needing employment. Another positive aspect ensuing from the rising wind power capacity is increased investment in upgrading electrical grid infrastructures.

Total investment in wind energy installations in the Netherlands for 2008 can be estimated at 850 million €, assuming an average investment cost of 1,250 €/kW for the 370 MW installed onshore and an investment cost for the Q7 Offshore Wind Farm of 3,192 €/kW for the 120 MW installed. The total investment in wind energy installations from 1989 to 2008, not corrected for inflation, is estimated at some 3 billion €. For the 490 MW installed in 2008, an estimated 4,000 jobs were involved in the Netherlands. Further, for the 2,214 MW of total installed capacity, about 1,000 jobs are created permanently in operations, maintenance, and other activities.

In Spain, investment in wind energy was more than 2,250 million € in 2008. About 50% of Spanish wind energy equipment production is exported. According to a study, the number of jobs related to wind power reached more than 40,000 in 2008. Of this total, the number of direct jobs in operation and maintenance of wind farms, manufacturing, assembly, research, and development is estimated at more than 21,800. The number of indirect jobs (linked

mainly to components) is estimated to be more than 17,000.

In the United Kingdom, it is estimated that companies working in the renewables sector currently sustain about 16,000 domestic jobs. If the UK meets its proposed 2020 RE target, 122,000 to 133,000 jobs will be involved, although not all of these will necessarily be in the UK.

In the United States, the new wind generating capacity installed in 2008 represents an investment of about 17 billion USD (12.2 billion €). About 85,000 people were employed in the wind industry, up from 50,000 in 2007. The share of components for wind systems made domestically has increased from less than one-third in 2005 to about half in 2008. In 2007 and 2008, manufacturers of turbines and components announced additions to or expansions of 70 facilities, which created an estimated 8,400 new jobs in 2008 alone.

Even countries with small increases in domestic wind capacity are benefiting from the industrial activity of the wind industry. The Austrian component suppliers specialize in wind turbine control systems, blade materials, generators, and wind turbine design. Last year the turnover of these companies rose by 25% to about 300 million €. About 35,000 MW of wind capacity worldwide is equipped with the control systems of the Austrian company Bachmann electronic. The sale of wind turbines from Denmark in 2008 is estimated to be about 7 GW. Nearly all turbines manufactured were exported.

3.2 Industrial development and operational experience

3.2.1 Turbines

The average rated capacity of new turbines installed in 2008 increased slightly to 1,872 MW. The increase is mainly thanks to a large contribution provided by 2-MW turbines and a number of other machines ranging from 1.35 MW to 3 MW. For example, in the Netherlands the average generation capacity per installed turbine increased to 2.2 MW in 2008. This was

mainly due to the large number of 3-MW turbines. Of the 221 turbines installed, 97 had a capacity of 3 MW. The average hub-height has risen to nearly 80 m, and 91 turbines installed in 2008 have a hub-height of 100 m. The swept area per unit of power decreased from 2.5 m²/kW in 2007 to about 2.1 m²/kW, because of the 64 turbines with 82-m-diameter rotors and 3-MW generators installed in 2008.

The IEA Wind member countries contain turbine manufacturers that serve global as well as national markets. Countries reporting a national manufacturer of 1-MW or larger turbines include Denmark, Finland, Germany, Italy, Korea, the Netherlands, Norway, Portugal, Spain, and the United States. A broad spectrum of R&D activities are financed by the industry or supported by state governments to develop larger wind turbines.

Domestic manufacturing is a goal of many countries. In Finland, WinWinD presented its first 1-MW pilot plant in spring 2001 and erected the 3-MW pilot plant in 2004 in Oulu. By the end of 2008, WinWinD had installed 142 MW in seven countries including Estonia, France, Portugal, and Sweden. WinWinD has supplied 39% of all the turbines in Finland (57 MW). In 2008, the number of employees grew to 270 (190 in Finland). In Korea, three new big players—Hyundai Heavy Industries, Samsung Heavy Industries, and Hyundai-Rotem—entered the wind turbine manufacturing market in Korea with megawatt-scale wind turbines. In addition to the existing turbine manufacturers market initially formed by companies such as Unison, Hanjin, Doosan Heavy Industries, and Hyosung Heavy Industries, all major shipbuilding heavy industries are ready to begin manufacture of wind turbines. Competition among these major heavy industries might open a new era of accelerating technology development.

Several countries that do not have local turbine manufacturing capabilities report the manufacture of supporting components

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(Australia, Austria, Canada, Greece, Ireland, Mexico, Switzerland, and the United Kingdom). These include blades, control systems, power inverters, generators, gearboxes, nacelle assembly, or towers.

In addition to megawatt-scale wind turbines, intermediate-sized turbines of 660 to 850 kW are being manufactured in several countries for single turbine installations or small wind power plants (Denmark, Germany, Italy, Korea, and the Netherlands).

Small wind turbine domestic manufacturing and encouragement of micro-generation are expanding the market for small wind turbines in Canada, Denmark, Italy, Japan, Portugal, Spain, and the United States. In Ireland, a microgeneration field trial is planned for 2009 and 2010. The study will offer a financial incentive for host sites to get involved. In Canada, several companies are proposing small wind turbines that are at various stages of

Table 6 Capacity in Relation to Estimated Jobs and Economic Impact in 2008 Where Data Available

Country	Capacity (MW)	Estimated number of jobs	Economic impact (million euro)
United States	25,369	85,000	12,206
Germany	23,902	90,000	
Spain	16,740	40,000	2,250
Italy	3,736	18,309	1,800
United Kingdom	3,331	16,000	
Denmark	3,163	25,000	5,300
Portugal	2,819	2,500	900
Canada	2,369	3,340	873
Netherlands	2,214	5,000	850
Japan	1,880	6,000	3,200
Australia	1,306	1,600	1,104
Sweden	1,047		
Ireland	1,002	600	60
Austria	995	2,500	300
Greece	990		
Norway	430		
Korea	236		
Finland	143		
Mexico	85		
Switzerland	14	600	200
Total	91,771	296,449	29,043

development. Some of the designs feature a vertical axis. The Wind Energy Institute of Canada has begun testing the small turbines that were selected following an RFP process completed in December 2007. The turbines being considered under this program have a capacity of not more than 100 kW.

In the United States, more than 10,000 domestically manufactured small wind turbines were sold in 2008, equal to about 50% of the global market share and involving about one-third of the 219 identified manufacturers worldwide. With the increasing number of small turbines entering the market, consumers are questioning product safety and quality. To help consumers compare products or estimate performance, a Small Wind Certification Council (SWCC) has been formed as an independent certification body for North America. Some turbines submitted by manufacturers for certification will be tested in the United States; others may be tested in Canada.

3.2.2 Projects

The size of new wind energy projects is increasing in many countries. In the United States, more than 100 new wind projects larger than 2 MW were installed in 25 states and resulted in nearly 5,000 turbines being commissioned in 2008. The average size of the turbines installed in 2008 was 1.67 MW, a slight increase from the 1.65 MW in 2007. More than half of the turbines were 1.5 MW, and the largest turbines were 3 MW. The average project size was about 70 MW. The world's largest operating wind plant is the 735-MW Horse Hollow facility, which covers 47,000 acres (190 km²) in Texas. In Spain, the average size of an installed wind farm in 2008 was 24 MW. Canada has also experienced an increase in the size of wind farms, especially in provinces with existing wind installations. This is mainly because smaller projects (less than 50 MW) can cost from 10% to 30% more because of economies of scale.

Interest in offshore wind development even in lakes is growing because it offers the possibility of huge increases in capacity

with fewer public acceptance obstacles and fewer issues of complex terrain. By the close of 2008, more than 1,400 MW of capacity was located offshore in seven IEA Wind member countries, with about 300 MW added for the year. Many countries report enormous offshore wind potential. The significant technical issues remaining for offshore wind development are the topic of research in many of the participating countries and within the IEA Wind agreement in Task 23 Offshore Wind Technology Deployment.

3.2.3 New products and applications

The Dutch company Advanced Tower Systems, designed and developed a hybrid concrete/steel tower for wind turbines on land with hub-heights of 100 m to 150 m. The tower is a prefabricated segmented pre-cast concrete tower with a conventional tubular steel tower on top. The concrete part is made of sections that are easy to transport with ordinary trucks. The expected reduction in the costs of energy is up to 10%. At the end of 2008, the construction of the demonstration project with the 100-m-high ATS tower and a Siemens Wind Power SWT2.3-93 wind turbine started at Windtest Grevenbroich in Germany.

The wind turbine manufacturer DarwinD developed a 5-MW direct-drive wind turbine with a rotor diameter of 115 m for offshore applications. It includes a 5.3-m-diameter 3-kV direct-drive generator with permanent magnets, a single main bearing, innovative blades, a modern fully sealed overpressured tower and nacelle, external air generator cooling, and an integrated management control system. The tower head mass is only 265 tons and promises a minimum of maintenance because there are fewer components. The first prototype will be erected late in 2009 on a 100-m tower at the ECN test field in Wieringermeer in the province of Noord Holland.

ChapDrive AS is a newly established company in Norway developing a system for hydraulic transmission of wind power.

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The gearbox and the generator will be at ground level to reduce the weight at the top of the tower. A pilot project has been operating on a 225-kW wind turbine at VIVA AS test facility. An upgraded version will be connected on a 900-kW wind turbine by spring 2009. A 5-MW version is planned.

Another system for locating the generator at ground level is being developed by Anglewind, Norway. The system uses an “angle” concept and a new drivetrain system for mechanical transmission of power. Installation of a prototype (225 kW) is expected by the end of 2009.

Autoproducers have on-site generation installed with the aim of displacing purchased electricity at retail rates. In Ireland, following the success of the 850-kW turbine installed on campus in Dundalk Institute of Technology, some industrial customers are exploring their options. Several energy services companies offer to take on all the risk in planning, designing, procuring, installing, and operating megawatt-scale turbines. They then offer to the energy user on site a tariff for the power produced that is guaranteed to be a percentage below the retail rate for the period of the long-term contract. With competitiveness becoming increasingly difficult for industry in Ireland, this arrangement is likely to be attractive to high energy users with suitable sites.

In Norway, a wind/hydrogen demonstration project at Utsira has now been in operation for two years. The purpose of the project is to demonstrate how renewable energy can provide safe and efficient energy supply to isolated areas. The system is based on wind energy as the only energy source. Excess power is used to produce hydrogen, which is to be used later in a fuel cell.

3.2.4 Operational experience

Turbine availability is high in all countries, ranging between 80% (for isolated areas) and 99%, with most countries reporting 98% or higher. In Denmark, the technical availability of new wind turbines on land is between 98% and 100%. For offshore wind,

the availability of turbines on the small nearshore farms is also high. Since 2005, all Horns Rev offshore turbines operated at nearly 100%, with an availability of 95% to 97%. In Sweden, the availability of turbines at Lillgrund offshore wind park during its first full year of operation in 2008 was 94%.

Productivity is also relatively high—the result of good siting of farms based on national wind atlas data and the use of taller towers to reach better wind resource. Reported capacity factors ranged from 16% (Switzerland) to 40% (Japan). In Mexico, wind power plants La Venta I (1.3 MW) and La Venta II (83.3 MW) operated at an annual capacity factor of 34%, according to the manager of the wind power plants. It had been expected that the capacity factor of La Venta II would exceed 40%; however in 2008, there were some constraints regarding the availability of the transmission line and some of the wind turbines.

Reports are becoming available on offshore projects. In the Netherlands, for example, results of the monitoring and evaluation program of the offshore wind farm OWEZ, formerly known as NSW, became available in 2008. The General Report covers the period from June 2005 until commissioning at the end of 2006.

In its Operations Report 2007, NoordzeeWind gives an account of the first year of operation of the wind farm. It contains monthly statistics and figures about the availability of the wind farm and its energy production. Calculated losses and downtime per subsystem affecting this energy yield are also presented. It also contains a complete overview of all data and reports delivered by NoordzeeWind on behalf of the MEP-NSW in 2007. NoordzeeWind’s general conclusion in this Operations Report 2007 is that the wind farm, having generated 330 GWh, has performed satisfactorily. The Operations Report 2008 will be available in mid-2009.

Other data have been collected during 2008 on corrosion and lightning; dynamics of turbines; aeroelastic stability; scour protection; electricity production, disruptions,

failure data, availability, maintenance, and reliability; power quality, grid stability and power forecasts; and wind turbine Power/Voltage curve and wake effects. ECN and Delft Technical University have started several projects with some of these data under an NDA agreement with NoordzeeWind.

3.3 Economic details

3.3.1 Turbine and total installed project costs

Although many countries do not report cost information, several member countries reported stable or slightly increasing wind turbine costs from 2007 to 2008 (Figure 2 and Table 7). Turbine costs reported by the IEA Wind member countries averaged from a low of 977 €/kW (U.S.) to a high of 1,800 €/kW (Austria) for 2008. Total installed costs onshore for 2008 in the reporting countries ranged from a low of 984 €/kW (Mexico) to a high of 1,885 €/kW (Switzerland). Total installed costs offshore ranged from 2,100 €/kW (UK) to 3,230 €/kW (Germany).

Some member countries have reported how costs of wind projects are distributed. In Italy, the cost of installed wind turbines is at substantially the same level as it was in 2007. The average installed plant cost of a medium-sized wind farm (30 MW) at a site of medium complexity, with 15 km of paths/roads and 12 km of electric line for connection to the high-voltage grid, is approximately 1,800 €/kW. This cost is generally subdivided as follows:

- Turbines, installation, and commissioning, 1,270 €/kW: 70.6%
- Development, namely site qualification, design, administrative procedures, and so on, 236 €/kW: 13.1%
- Interest on loans, 196 €/kW: 10.9%
- Connection to the grid, 73.8 €/kW: 4.1%
- Civil engineering work, 23.4 €/kW: 1.3%.

Annual cost of operation and maintenance has been estimated to be about 54 €/kW, which includes leasing of terrain, insurance,

and guarantees. Decommissioning cost has been estimated at approximately 5 €/kW.

Explanations for higher costs varied by country. Spain reports that the increasing use of large wind turbines (2 MW of nominal power), the increasing prices of raw materials, the shortage of main components, and the excess demand for wind turbines have increased prices for wind generators. In Portugal, the cost depends on the turbines' characteristics and/or the country of manufacture.

In the United Kingdom, the higher capital costs of offshore are due to the increase in size of structures and the logistics of installing the turbines at sea. The costs of foundations, construction, installations, and grid connection are significantly higher offshore than onshore. Typically, for example, offshore turbines are 20% more expensive, and towers and foundations can cost more than 2.5 times offshore than onshore for a project of similar size.

3.3.2 Operation and maintenance costs

Costs for service, consumables, repair, insurance, administration, lease of site, and so on, for new large turbines ranged from 1.3% to 1.5% of capital cost per year. When O&M costs are mentioned by the member countries, they are reported as fairly constant over the years. O&M costs are higher for offshore turbines.

3.3.3 Tariffs and cost of energy

Key to the economic viability of a wind project is the balance of costs and revenue. Wind energy tariffs, feed-in tariffs, and buyback rates are the payments to the wind farm owner for electricity generated. In some countries, this is the market price of electricity. In others, the wind energy tariff includes environmental bonuses or other added incentives to encourage wind energy development. In many countries, the revenue of each wind farm is governed by the contract (power purchase agreement) negotiated with the power purchaser, so the numbers reported by the IEA Wind member countries are estimated averages or

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ranges. For explanations of revenue to wind park owners, including tariffs and buyback rates, refer to the country chapters of this report.

IEA Wind Task 26 Cost of Wind Energy, which will begin work in 2009, will survey the state of the art of calculating the cost of wind energy in preparation for developing recommended practices for such calculations.

Several countries explained how cost of energy might be calculated. In Finland, on coastal sites the cost of wind energy production could be about 50 €/MWh to 80 €/MWh without subsidies (15 years, 7% internal rate of return), while the cost of offshore production could be about 80 €/MWh to 100 €/MWh. The average spot price in the electricity market Nord Pool was 51 €/MWh in 2008 (30 €/MWh in 2007). Emission trade effects on the operating costs of thermal power have resulted in an increase of spot market prices; however,

emission permit prices have been volatile and future and forward prices are about 40 €/MWh for 2009–2010. Wind power still needs subsidies to compete, even on the best available sites in Finland.

In Canada, wind generation costs are estimated to be between 44 €/MWh and 70 €/MWh. For example, provincial calls for power in British Columbia, Ontario, and Québec and the Renewable Portfolio Standard (RPS) in Prince Edward Island resulted in electricity prices from wind energy in the range 45 €/MWh to 56 €/MWh. In most cases, the latest price proposals have shown the highest prices. The primary variables associated with this cost range are the cost of the wind turbines themselves, the quality of wind resources, transmission connection fees, the scale of operation, and the size of turbines.

In Greece, the cost of wind generated electricity could be assumed to be between 26 €/MWh and 47 €/MWh, depending on

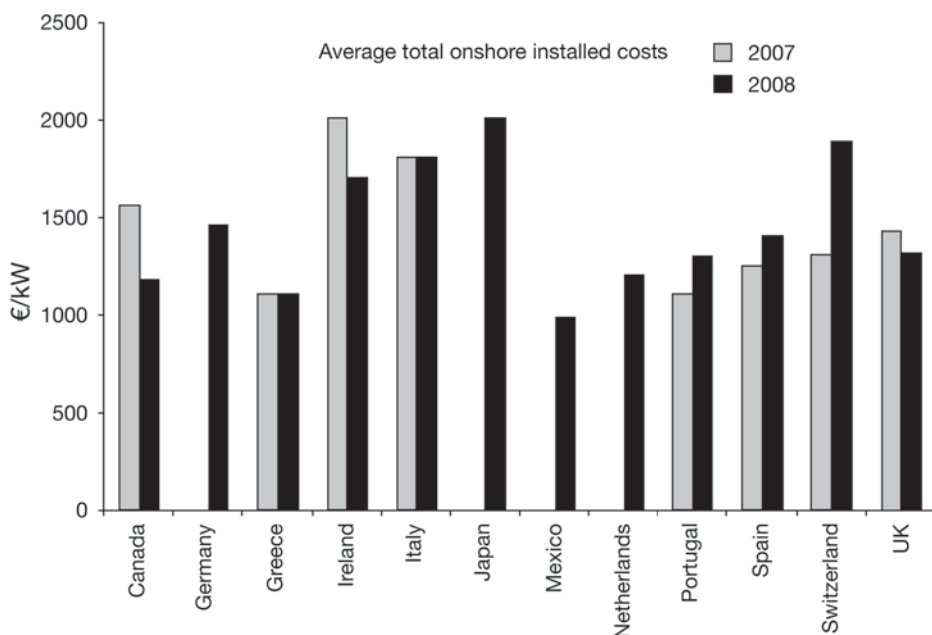


Figure 2 Average total installed costs of wind projects 2007–2008 as reported by IEA Wind member countries. These include costs for turbines, roads, electrical equipment, installation, development, and grid connection.

Country	Turbine cost (€/kW)	Total installed cost (€/kW)
Austria	1,400 to 1,800	
Canada		1,057 to 1,291
Germany	941 to 1,340 onshore; 1,350 to 1,500 offshore	1,260 to 1,659 onshore; 2,625 to 3,230 offshore
Greece		1,000 to 1,200
Ireland	1,100	1,700
Italy	1,270	1,800
Japan	1,000 to 1,200	1,800 to 2,200
Mexico		984
Netherlands		1,200 onshore; 3,200 offshore
Portugal	1,061	1,297
Spain		1,400
Switzerland	1,450	1,885
United Kingdom		1,050 to 1,575 onshore; 2,100 to 3,150 offshore
United States	977	

the site and project cost. The typical interest rate for financing wind energy projects is 7% to 8%.

In Norway, estimates of production costs from sites with good wind conditions suggest a production cost of about 66 €/MWh, including capital costs (discount rate 8.0%, 20-year period), operation, and maintenance. During 2008, the spot market electricity price on the Nord Pool (Nordic electricity market place) increased until autumn 2008 and then dropped noticeably. The forward price by the end of December 2008 was 38 €/MWh. So far, wind energy is not competitive with the price of many new hydropower projects; hydro still is an option for new green power in Norway.

Wind energy tariffs or buyback rates vary by country according to the incentive structure. In Germany, the wind energy

tariff includes an initial remuneration of 92 €/MWh for at least 5 years and a maximum of 20 years. After the initial period, the tariff is 50.2 €/MWh for a maximum of 20 years. Offshore turbines put into operation by 31 December 2015 receive an initial remuneration of 150 €/MWh for 12 years. After that period, the basic tariff is 35 €/MWh until the maximum remuneration period (20 years plus year of commissioning) is reached. Wind farms more than 12 nautical miles away from the coast and in waters deeper than 20 m receive a longer initial period.

In Spain, payment for electricity generated by wind farms is based on a feed-in scheme. The owners of wind farms can choose payment for electricity generated by a wind farm independent of the size of the installation and the year of start-up.

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For 2009, the value is 78.183 €/MWh; the update is based on the Retail Price Index minus an adjustment factor. They can choose instead payment calculated as the market price of electricity plus a premium, plus a supplement, and minus the cost of deviations from energy forecasting. There is a lower limit to guarantee the economic viability of the installations and an upper limit (floor and cap). For instance, the values for 2009 are reference premium 31.27 €/MWh, lower limit 76.098 €/MWh, and upper limit 90.692 €/MWh. In 2008, the market price of electricity in Spain reached 64.43 €/MWh.

In the United States, the sales price of electricity was estimated by weighing projects by nameplate capacity to represent actual market prices. The average electricity sales price for projects built in 2008 was roughly 51.5 USD/MWh (36.98 €/MWh), up from a low of 30.9 USD/MWh (22.19 €/MWh) for projects built in 2002 to 2003. This price is what the utility pays to the wind plant operator and includes the benefit of the federal production tax credit and state incentives.

4.0 National Incentive Programs

In each country, the mix of incentive types and the level of government at which they are applied is unique and changing. Widely ranging incentives are operating in the IEA Wind member countries (Table 8). Those mentioned most often include direct capital investment such as subsidies or grants for projects, providing a premium price for electricity generated by wind (tariffs or production subsidies), obliging utilities to purchase renewable energy, and providing a free market for green electricity.

Tax credit incentives based on investment or electrical generation are also gaining popularity. In the United States, the very effective production tax credit (PTC) and investment tax credits (ITC) for wind energy development were extended through 2012. The PTC provides an income tax credit based on electricity

production from wind projects. The ITC allows 30% of the investment in wind projects to be refunded in the form of reduced income taxes. The ITC may also be taken in the form of an up-front grant equivalent to 30% of the project value. The inflation-adjusted value of the PTC in 2008 was 21 USD/MWh (15 €/MWh) for wind energy. In Canada, the ecoENERGY for Renewable Power program provides tax write-offs as a production incentive to all renewable energy technologies. The 14-year program will invest close to 1.5 billion CAD (0.88 billion €) to increase Canada's supply of clean electricity from renewable sources such as wind, biomass, low-impact hydro, geothermal, PV, and ocean energy. In 2007, the tax write-off was increased from 30% to 50% per year on a declining-balance basis.

Some IEA Wind member countries have national and state governments that require utilities to purchase a percentage of their overall generating capacity from renewable resources. Often called renewable portfolio standards (RPS) or renewables production obligation (RPO), they allow utilities to select the most economical renewable technology. The preferred option by most utilities to satisfy this obligation is wind energy. In the United States, 28 of the 50 states had adopted RPS approaches that collectively called for utilities to procure about 23 billion kWh of renewable energy in 2008.

Wind energy qualifies as green electricity used to meet utility RPOs, to trade as certificates, or to meet consumer preferences. In Australia, a state-based renewable energy target scheme requires electricity retailers and wholesale purchasers in Victoria to acquire Victorian Renewable Energy Certificates. Because wind projects can create these certificates, at least two large wind energy projects were able to move forward. Clear, consistent programs give the industry a firm foundation.

Other kinds of support have also accelerated the development of wind energy in the IEA Wind member countries. For

Table 8 Types of Incentive Programs in IEA Wind Member Countries	
Type of program	Description
Enhanced feed-in tariff	An explicit monetary reward is provided for wind-generated electricity, paid (usually by the electricity utility) at a rate per kilowatt-hour somewhat higher than the retail electricity rates being paid by the customer
Capital subsidies	Direct financial subsidies aimed at tackling the up-front cost barrier, either for specific equipment or total installed wind system cost
Green electricity schemes	Allows customers to purchase green electricity based on renewable energy from the electricity utility, usually at a premium price
Wind-specific green electricity schemes	Allows customers to purchase green electricity from wind plants from the electricity utility, usually at a premium price
Renewable portfolio standards (RPS) or renewables production obligation (RPO)	A mandated requirement that the electricity utility (often the electricity retailer) source a portion of its electricity supplies from renewable energies
Wind requirement in RPS	A mandated requirement that a portion of the RPS be met by wind electricity supplies (often called a set-aside)
Investment funds for wind energy	Share offerings in private wind investment funds plus other schemes that focus on wealth creation and business success using wind energy as a vehicle to achieve these ends
Income tax credits	Allows some or all expenses associated with wind installation to be deducted from taxable income streams
Net metering	In effect the system owner receives retail value for any excess electricity fed into the grid, as recorded by a bidirectional electricity meter and netted over the billing period
Net billing	The electricity taken from the grid and the electricity fed into the grid are tracked separately, and the electricity fed into the grid is valued at a given price
Commercial bank activities	Includes activities such as preferential home mortgage terms for houses including wind systems and preferential green loans for the installation of wind systems
Electricity utility activities	Includes green power schemes allowing customers to purchase green electricity, wind farms, various wind generation ownership and financing options with select customers, and wind electricity power purchase models
Sustainable building requirements	Includes requirements on new building developments (residential and commercial) to generate electricity from renewables including wind microgeneration
Special planning activities	Areas of national interest set aside for considering wind energy development

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example, publishing wind energy atlases developed with public research money helps developers select productive sites (Austria, Finland, Italy). In Canada, some provincial initiatives require projects to have elements manufactured in the region. This has helped develop a wind industrial base in Canada. To stimulate the industrial base, Portugal has also used domestic manufacturing as a requirement for government-supported project proposals.

Microgeneration (i.e., small wind turbines) is being promoted in several countries with new incentive approaches. An indirect incentive for the deployment of microgeneration is provided in Ireland under the Building Energy Ratings scheme (BER). Irish building regulations require that new dwellings have a portion of their energy demands met by renewable sources on site. The designer has a choice between sourcing this energy through either renewable thermal or renewable electrical means (4 kWh/m²/year electrical or 10 kWh/m²/year thermal). The contribution of a wind turbine can be included in the BER once its performance over a year has been verified. In the United States, many states also have policies and incentives for small wind electric systems. These incentives include rebates and buy-downs, production incentives, tax incentives, and net metering. The subsidy or rebate may be as much as 50% of the cost of a small wind turbine. The rebates become even more effective when combined with low-interest loans and net metering programs. In Ireland, there is growing interest in microgeneration. Interest is expected to increase further now that the largest electricity supplier intends to offer 0.09 €/kWh to its domestic customers for electricity they deliver to the grid.

Areas of national interest have been designated in Sweden to promote good management from the point of view of public interest. These areas for fishery, mining, nature preservation, outdoor recreation, and so on, can be of national interest for several kinds of land use. Forty-nine areas in

13 counties have been identified as areas of national interest for electricity production to protect the potential for wind energy development.

5.0 R, D&D Activities

5.1 Setting priorities

An important activity of the wind energy research community is the setting of priorities for investment of precious research money. In 2008, the IEA Wind agreement developed a new strategic plan to guide the agreement for another five years from 2008 through 2013. The key R, D&D areas identified include:

1. Wind technology research to improve performance and reliability at competitive costs
2. Power system operation and grid integration of high amounts of wind generation, including development of fully controllable, grid-friendly “wind power plants”
3. Planning and performance assessment methods for large wind integration
4. Offshore wind in shallow and deep waters
5. Social, educational, and environmental issues

In the EU, the European Wind Energy Technology Platform (TPWind), operating since 2006, is an industry-led initiative to identify and prioritize areas for increased innovation, new and existing research, and development tasks. In June 2008, TPWind issued its Strategic Research Agenda and Market Deployment Strategy documents. In 2009 it will release a list of projects constituting the implementation plan of the strategic research agenda of the European wind energy sector.

In Canada, a wind energy technology roadmap is being developed. The goal is to determine investment areas in research and development required to achieve overall (social, environmental, and technological) cost reductions and to increase Canadian industrial and economic benefits.

In Germany, the aims and priorities of wind power research are determined at regular strategy meetings with experts. The

most recent strategy meeting led to the new government funding announcement for research projects to reduce costs, increase yields, and improve the availability of wind turbines. Projects will also develop technologies to expand offshore wind power (including research at the alpha ventus test site) and perform the ecological research and improve the technology of wind turbines to reduce ecological impacts.

In Spain, a new R&D plan was developed in 2008 that covers 2008 to 2011 for the national government. It is based on the national science and technology strategy instead of on thematic areas as in previous calls for proposals.

In the United Kingdom, wind power, both onshore and offshore will be a key growth area. One scenario is that by 2020, offshore wind capacity could be ~14 GW, compared with less than 1 GW today. This would require the installation of a further 3,000 offshore turbines, rated at 5 MW. Initial government models indicate that ~13 GW of onshore wind generation capacity will be required by 2020, as compared with 2.7 GW in early 2009. This equates to approximately 4,300 onshore turbines rated at 3 MW. It is expected that a large proportion of this onshore wind development will take place in Scotland.

5.2 Research funding

Some countries report increased budgets for R&D in 2008 and 2009. In the EU, more than 20 R&D projects were running with the support of the Sixth and Seventh Framework Programmes of the EU (the Framework Programmes are the main EU-wide tool to support strategic research areas). Many IEA Wind member countries participate, often in leadership roles, in these joint research projects. Denmark's funding for wind energy R&D was increased about 1.3 million € in 2008. In Germany, R&D support from the Federal Ministry for the Environment grew from 35 million € in 2007 to 40.1 million € in 2008. Additional research into grid integration technologies

related to wind energy has also been launched in 2008, for another 14.6 million €. In the United States, the budget for the federal Wind Program was close to 50 million USD (36 million €) for fiscal year (FY) 2008 (1 October 2007 through 1 October 2008). The budget approved for FY 2009 was 55 million USD (39.5 million €). The budget for FY 2010 will be 75 million USD (53.9 million €).

5.3 Test site news

Test sites for large and small wind turbines and for components comprise an important part of the national research programs.

A new research center has been established in Québec, Canada, for the study of wind turbine operation in cold climates. The Corus Centre is surrounded by two wind farms with a total capacity of 108 MW, making it a unique natural laboratory. An icing wind tunnel for instrument and material research and testing in icing conditions was put up in 2008 at the VTT Technical Research Centre of Finland. It will be used to develop technologies, components, and solutions for large wind turbines.

The first German offshore wind farm alpha ventus began construction in 2008 45 km north of the North Sea island of Borkum. The wind farm will begin with 12 5-MW wind turbines from Multibrid and REpower, with a total installed capacity of 60 MW. The transformer substation was completed in 2008 with a height of 60 m and weighing more than 1,300 tons. The transformer substation is located about 2 km from the BMU research platform FINO 1. The submarine cable was also laid in 2008. As a test and demonstration project, alpha ventus will be the first use of offshore wind power in Germany.

A miniature version of a full-scale wind farm was completed for research at ECN, the Netherlands, as an integral part of ECN's test field for multimewatt-class wind turbines. The scaled wind farm research facility has 10 10-kW turbines and 14 carefully placed wind metering masts at two distinct heights, 7.5 m and 18.9 m.

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ECN will use the scaled wind farm for research on wind turbine wake modeling and verification.

In September, a new Wind Turbine Test Laboratory (www.cener.com) was inaugurated at CENER, Spain. It includes a Blade Test Plant to characterize physical properties and to conduct static and fatigue tests for blades of up to 85 m. long. The Power Train Test Bench can perform mechanical durability tests on low speed shaft, multiplier, high speed shaft and generator for turbines of up to 5 MW. The Electrical Test Bench can test generators and power electronics equipment. The Nacelle Test Bench tests complete nacelles and tooling trials and is used to train personnel in assembly and maintenance. The Composite Material Laboratory addresses manufacturing processes of components with composite materials and characterizes process control variables and the physical, chemical and mechanical properties of materials.

5.4 Large turbine development

Larger turbines are being designed for both onshore and offshore applications, and several new designs and approaches appeared in 2008.

In Korea, as a result of government support in previous years, 750-kW and 1.5-MW wind turbines were successfully tested and certified by GL and DEWI Offshore and Certification Centre GmbH, respectively. In 2008, two 2-MW wind turbines from different manufacturers were installed and remained under field testing through mid-2009.

Gearbox reliability was addressed in an IEA Wind Task 11 Base Technology Information Exchange Topical Experts Meeting in 2008. Several countries are conducting research to improve reliability. The U.S. Wind Program initiated a wind turbine Gearbox Reliability Collaborative to validate the design process, including everything from calculating system loads to rating bearings to testing full-size gearboxes. In 2008, an international team of analysts

compared their predictions of gear-tooth loads and bearing loads. Next they will compare these predictions with test data, improve design codes, and improve gearbox designs. An instrumented drivetrain and gearbox will be tested in a 2.5-MW dynamometer test facility at NREL in Colorado, United States.

Better understanding of aerodynamics and wind turbines can contribute to improving reliability. This is the goal of the IEA Wind Task 29 MexNex(t) which is the successor of IEA Wind Task 20 HAWT Aerodynamics and Models from Wind Tunnel Measurements. It will use wind tunnel measurements from the EU project Model Experiments in Controlled Conditions (MEXICO) to validate the design codes and aerodynamic models used by wind turbine developers.

5.5 Small wind turbines

Increased interest in small wind turbine technology was mentioned by several countries. In Spain, work is under way to support the small wind turbine sector through promotion, dissemination, sensitization, and information collection. In line with this work, CIEMAT will serve as Operating Agent for the new IEA Wind Task 27 Consumer Labeling of Small Wind Turbines.

In Portugal, the T-URBan project, a prototype small (2.5-kW) wind turbine with horizontal axis, is in the test phase. This turbine has a 2.3-m rotor diameter and is designed for a 10- to 15-m-high tower. This project, designed and constructed using Portuguese technology, continues demonstration testing as part of the urban wind power effort.

In Ireland, a major wind R, D&D activity in 2009 will support 40% of the start-up and short-term-maintenance costs of small wind turbines. The support will be available in approximately 50 trial locations. Overall budget for the study is 2 million €. Data monitoring at all of the sites for the 18-month duration of the study will assess the performance of the technologies

and inform future decisions on possible incentives, tariffs, or deployment programs. To protect customers and prescribe best practices in the pilot, turbine suppliers and manufacturers applying for inclusion in the pilot will be required to supply equipment that conforms to the appropriate European standards (EN 61400-2/11/12), as will the associated inverters (EN 50438). Best practices are prescribed in an effort to ensure high-quality and safe installations in a fledgling sector sensitive to the impact of bad customer experiences on future growth.

5.6 Costs

The members of IEA Wind have agreed that a clear, impartial voice regarding the costs of wind systems is needed to avoid the publication of erroneous costs of wind systems. Task 26 Cost of Wind Energy will provide the tools to compare the costs of wind energy with other electricity-generating technologies. It will modify the underlying assumptions that are applied to the different technologies. Finally, this task aims to form the basis for a more comprehensive analysis of the value of wind energy. The Netherlands, for example, participates in Task 26 because it will give insight into international cost data for offshore wind energy that can be used for policy decisions.

5.7 Grid integration

IEA Wind Task 25 Power Systems with Large Amounts of Wind Power published the final report of its first phase showing that the impact of a large share of wind power can be controlled by appropriate grid connection requirements, extension and reinforcement of transmission networks, and integration of wind power production and production forecasts into system and market operation.

A study in the Netherlands of the operational effects, cost/benefits, costs of grid integration, and market effects of storage concluded that integration of 4 GW to 10 GW of wind power in the Dutch Electricity generation system is possible without

large-scale electricity storage. This is mainly because of the increasing flexibility of the system and the expansion and better use of interconnectors.

The University of Genoa, Italy, has developed a model to study the variable character of wind energy and its consequences for electrical power systems. The model identifies the optimal allocation of wind power plants over an extended geographic territory. This allows lower temporal variability of the aggregate wind power output and guarantees a contribution to base-load power supply. To date, this model has been applied on the island of Corsica, and by means of this optimization, wind energy fluctuation in the power supply system of Corsica has been reduced by about 58%, with an energy production loss of 23%.

5.8 Environmental impacts

Preserving bats and birds in areas of wind power development is a goal of work in the United States. Changes to operations during low wind conditions at a plant in rural Pennsylvania, owned and operated by Iberdrola Renewables, demonstrated nightly reductions in bat fatality ranging from 53% to 87% with marginal annual power loss. In other studies, an acoustic system to discourage bats from entering wind facilities will be field tested, and researchers are investigating whether artificial intelligence can be used to detect the presence of birds using Next-Generation Radar (NEXRAD) data. NEXRAD is a network of 158 high-resolution Doppler weather radars operated by the National Weather Service. The program is working with the U.S. Geological Survey and Montana State University to develop algorithms to differentiate biological (bird) echoes in the NEXRAD data to help identify migratory flyways.

In the United States, in 2008, a study funded by the Department of Homeland Security concluded that wind farms can interfere with radar tracking of aircraft and weather but that no fundamental physical constraint prohibits the accurate detection

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of aircraft and weather patterns around wind farms. Interference occurs when radar signals are reflected back by wind turbines, causing clutter on the radar screens. The report also concluded that it is difficult to distinguish wind farm signatures from airplane and weather signatures and that quantitative evaluation tools and metrics are needed to determine when a wind farm poses a sufficient threat to a radar installation.

Environmental impacts were studied during the construction of the German FINO 3 offshore research platform. To reduce noise emissions, an air bubble curtain was constructed with a radius of 70 m around the construction site. Scientists recorded the sound pressure levels at various distances from the site. Initial data analysis suggests that the air bubble curtain achieved a total noise reduction of 12 decibels, with a reduction of 30 to 35 decibels in the frequency range between 1 and 7 kilohertz. Biologists also spent several days studying the effectiveness of measures to protect porpoises. Initial results indicate that during construction, no porpoises entered the hazardous zone around the site. Two weeks later, the number of porpoises had returned to the preconstruction level.

6.0 Next Term

Continued growth in deployment is expected in most IEA Wind member

countries. To support the increasing need for durable, cost-effective machinery, larger technology research budgets will be provided by growing national and industrial research programs.

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- (5) Wind Directions, http://www.ewea.org/fileadmin/ewea_documents/documents/publications/WD/WD22vi_public.pdf
- (6) British Wind Energy Association (BWEA) report, <http://www.bwea.com/pdf/planning/planningdelays.pdf>
- (7) IEA Wind, 2008, End-of-Term Report and Strategic Plan, 1 November 2008 to 31 October 2013, www.ieawind.org.

Author: Patricia Weis-Taylor, Secretary, IEA Wind.

1.0 Introduction

The International Energy Agency (IEA) Implementing Agreement on wind energy began in 1977 and is now called the Implementing Agreement for Co-operation in the Research, Development, and Deployment of Wind Energy Systems (IEA Wind). The 24 participating countries and international organizations (contracting parties) work to develop and deploy wind energy technology through vigorous national programs and through cooperative international efforts. The participants exchange information on their continuing and planned activities and participate in selected IEA Wind Research Tasks. In 2008, 24 contracting parties from 20 countries, the European Commission, and the European Wind Energy Association (EWEA) participated in IEA Wind (Table 1).

2.0 National Programs

The national wind energy programs of the participating countries are the basis for the IEA Wind collaboration. These national programs are directed toward the evaluation, development, and promotion of wind energy technology. An overview and analysis of national program activities is presented in the Executive Summary of this Annual Report. Individual country activities are presented in Chapters 11 through 31.

3.0 Collaborative Research

In 2008, participants in the IEA Wind Agreement worked on nine cooperative Research Tasks, which have been approved by the ExCo as Annexes to the original Implementing Agreement text. Each member country must participate in at least one cooperative research Task. Countries choose to participate in Tasks that are most relevant to their current national research and development programs. Additional Tasks are planned when new areas for cooperative research are identified by Members. Progress in cooperative research is described in chapters 2 through 10. Tasks are referred

to by their annex number. The numbers of active Tasks may not be sequential because some Tasks have been completed and so do not appear as active projects in this report (Table 2).

The combined effort devoted to a task is typically the equivalent of several people working full-time for a period of three years. Some tasks have been extended to continue the work. The projects are either cost-shared and carried out in a lead country, or task-shared, when the participants contribute in-kind effort, usually in their home organizations, to a joint research program coordinated by an Operating Agent. In most projects each participating organization agrees to carry out a discrete portion of the work plan. This means that each participant has access to research results many times greater than could be accomplished in any one country. For example, as reported in the End-of-Term Report submitted to IEA, the following statistics for recently completed tasks show the benefit of cooperative research.

- Task 20 HAWT aerodynamics and models from wind tunnel measurements.
 - Contribution per participant: \$9,375 USD plus in-kind effort
 - Total value of shared labor received by each participant: \$2,036,300 USD
- Task 21 Dynamic models of wind farms for power system studies
 - Contribution per participant: 15,500 Euro plus in-kind effort
 - Total value of shared labor received: 4,760,000 Euro
- Task 24 Integration of wind and hydropower systems
 - Contribution per participant: \$16,430 USD plus in-kind effort
 - Total value of shared labor received: \$6,237,000 USD

By the close of 2008, 18 tasks had been successfully completed and two tasks had been deferred indefinitely (Table 3).

Table 1 Contracting Parties in 2008 to the International Energy Agency Implementing Agreement for Co-operation in the Research, Development, and Deployment of Wind Energy Systems (IEA Wind)	
Country/Organization	Contracting Party to Agreement
Australia	Clean Energy Council
Austria	Republic of Austria
Canada	Natural Resources Canada
Denmark	Danish Energy Authority
European Commission	Commission of the European Communities
Finland	National Technology Agency of Finland (TEKES)
Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Greece	Center of Renewable Energy Resources (CRES)
Ireland	Sustainable Energy Ireland
Italy	CESI RICERCA S.p.A. and ENEA Cassaccia
Japan	National Institute of Advanced Industrial Science and Technology (AIST)
Korea	Government of Korea
Mexico	Instituto de Investigaciones Electricas (IIE)
Netherlands	Netherlands Agency for Energy and the Environment (SenterNovem)
Norway	Norwegian Water Resources and Energy Directorate (NVE) and Enova SF
Portugal	National Institute for Engineering and Industrial Technology (INETI)
Spain	Instituto de Energias Renovables (IER) of the Centro de Investigación; Energetica Medioambiental y Tecnologica (CIEMAT)
Sweden	Swedish Energy Agency
Switzerland	Swiss Federal Office of Energy
United Kingdom	Department for Business, Enterprise & Regulatory Reform
United States	U.S. Department of Energy
Sponsor Participants	
EWEA	European Wind Energy Association

Table 2 Active Cooperative Research Tasks Defined in Annexes to the IEA Wind Implementing Agreement (OA indicates operating agent that manages the task)

Task 11	Base technology information exchange OA: Vattenfall, Sweden (1987 to 2008) changing to CENER, Spain (2009-2010)
Task 19	Wind energy in cold climates OA: Technical Research Centre of Finland - VTT (2001 to 2008)
Task 23	Offshore wind energy technology deployment OA: Risø National Laboratory, Denmark and NREL, United States (2004 to 2008)
Task 24	Integration of wind and hydropower systems OA: NREL, United States (2004 to 2008)
Task 25	Power systems with large amounts of wind power OA: Technical Research Centre of Finland – VTT, Finland (2005 to 2008)
Task 26	Cost of wind energy OA: NREL, United States (2008 to 2011)
Task 27	Consumer labeling of small wind turbines OA: CIEMAT, Spain (2008 to 2011)
Task 28	Social acceptance of wind energy projects OA: ENCO Energie-Consulting AG, Switzerland (2008 to 2011)
Task 29	MexNex(T): Analysis of wind tunnel measurements and improvement of aerodynamic models OA: ECN, the Netherlands (2008 to 2011)

Final reports of tasks are available through the IEA Wind Web site: www.ieawind.org. Table 4 shows participation by members in active research tasks in 2008.

To obtain more information about the cooperative research activities, contact the Operating Agent Representative for each task listed in Appendix B or visit our Web site at www.ieawind.org under the tab for cooperative research or follow the links to individual Task Web Sites.

4.0 Executive Committee

Overall control of information exchange and of the R&D tasks is vested in the Executive Committee (ExCo). The ExCo consists of a Member and one or more Alternate Members designated by each contracting party that has signed the IEA Wind Implementing Agreement. Most countries are represented by one contracting party that is a government department or agency. Some countries have more than one contracting party within the country. International organizations may join IEA Wind as sponsor members. The contracting

party may designate members or alternate members from other organizations within the country.

The ExCo meets twice each year to exchange information on the R&D programs of the members, to discuss work progress on the various Tasks, and to plan future activities. Decisions are reached by majority vote or, when financial matters are decided, by unanimity. Members share the cost of administration for the ExCo through annual contributions to the Common Fund. The Common Fund supports the efforts of the Secretariat and other expenditures, such as preparation of this Annual Report, approved by the ExCo in the annual budget.

Officers

In 2008, Ana Estanqueiro (Portugal) served as Chair. Morel Oprisan (Canada) and Brian Smith (United States) served as Vice Chairs. Brian Smith was elected to serve as Chair in 2009. Hannele Holttinen (Finland) and Joachim Kutscher (Germany) were elected to serve as Vice Chairs in 2009.

Implementing Agreement

Table 3 Completed or Inactive Cooperative Research Tasks Defined in Annexes to the IEA Wind Implementing Agreement (OA indicates operating agent that manages the task)	
Task 1	Environmental and meteorological aspects of wind energy conversion systems OA: The National Swedish Board for Energy Source Development (1978 to 1981)
Task 2	Evaluation of wind models for wind energy siting OA: U.S. Department of Energy - Battelle Pacific Northwest Laboratories (1978 to 1983)
Task 3	Integration of wind power into national electricity supply systems OA: Kernforschungsanlage Jülich GmbH, Germany (1978 to 1983)
Task 4	Investigation of rotor stressing and smoothness of operation of large-scale wind energy conversion systems OA: Kernforschungsanlage Jülich GmbH, Germany (1978 to 1980)
Task 5	Study of wake effects behind single turbines and in wind turbine parks OA: Netherlands Energy Research Foundation (1980 to 1984)
Task 6	Study of local flow at potential WECS hill sites OA: National Research Council of Canada (1982 to 1985)
Task 7	Study of offshore WECS OA: UK Central Electricity Generating Board (1982 to 1988)
Task 8	Study of decentralized applications for wind energy OA: UK National Engineering Laboratory. (1984 to 1994)
Task 9	Intensified study of wind turbine wake effects OA: UK National Power plc (1984 to 1992)
Task 10	Systems interaction. Deferred indefinitely
Task 12	Universal wind turbine for experiments (UNIWEX) OA: Institute for Computer Applications, University of Stuttgart, Germany. (1988 to 1995)
Task 13	Cooperation in the development of large-scale wind systems OA: National Renewable Energy Laboratory (NREL), USA. (1990 to 1995)
Task 14	Field rotor aerodynamics OA: ECN, the Netherlands (1992 to 1997)
Task 15	Annual review of progress in the implementation of wind energy by the member countries of the IEA OA: ETSU, the United Kingdom (1994 to 2001)
Task 16	Wind turbine round robin test program OA: NREL, the United States. (1995 to 2003)
Task 17	Database on wind characteristics OA: RISØ National Laboratory, Denmark (1999 to 2003)
Task 18	Enhanced field rotor aerodynamics database OA: Netherlands Energy Research Foundation - ECN, the Netherlands. (1998 to 2001)
Task 20	HAWT aerodynamics and models from wind tunnel tests OA: NREL, the United States (2003 to 2007)
Task 21	Dynamic models of wind farms for power system studies OA: SINTEF Energy Research, Norway (2003 to 2007)
Task 22	Market development for wind turbines. Deferred indefinitely.

Table 4 Participation of Member Countries in Tasks During 2008. (OA indicates operating agent that manages the task)									
	11	19	23	24	25	26	27	28	29
Australia				x			x		
Austria									
Canada	x	x		x			x	x	x
Denmark	x		OA		x	x			x
European Commission	x								
European Wind Energy Association					x				
Finland	x	OA		x	OA			x	
Germany	x	x	x		x	x		x	x
Greece									
Ireland	x				x				
Italy	x								
Japan	x						x	x	x
Republic of Korea	x		x						x
Mexico	x								
Netherlands	x		x		x	x			OA
Norway	x	x	x	x	x			x	x
Portugal			x		x				
Spain	x		x		x	x	OA		x
Sweden	OA	x	x	x	x	x	x		x
Switzerland	x	x		x		x		OA	
United Kingdom	x		x		x		x		x
United States	x	x	OA	OA	x	OA	x	x	x
Totals	17	7	10	7	12	7	7	7	11

Participants

In 2008, there were no changes in IEA Wind country participation however there were personnel changes among the Members and Alternate Members. (See Appendix B for Members, Alternate Members, and Operating Agent representatives who served in 2008.)

Meetings

The ExCo meets twice a year to review ongoing Tasks; plan for new Tasks; and report on national wind energy research, development, and deployment activities

(RD&D). The first meeting of the year is devoted to reports on R&D activities in the member countries and in the Tasks, and the second meeting is devoted to reports about deployment activities.

The 61st ExCo meeting was hosted by Denmark in the city of Aalborg on 22, 23, and 24 April 2008. There were 32 participants from 15 of the contracting parties. Attendees included eight operating agent representatives of the Tasks and a representative of IEA Paris. The ExCo approved the final report of Task 20 HAWT Aerodynamics and Models from Wind Tunnel

Implementing Agreement

Measurements and closed the project. The ExCo approved the final report of Task 21 Dynamic Models of Wind Farms for Power System Studies and closed the project. Technical progress reports of ongoing tasks were also approved: Task 11 Base Technology Information Exchange, Task 19 Wind Energy in Cold Climates, Task 23 Offshore Wind Technology Deployment, Task 24 Integration of Wind and Hydropower Systems, Task 25 Power Systems With Large Amounts of Wind Power, and Task 26 Cost of Wind Energy. Proposals for three new Tasks (27 Consumer Labeling of Small Wind Turbines, 28 Social Acceptance of Wind Energy Projects, and 29 MexNex(T) Aerodynamics) were approved to move forward. The audit report of 2007 Common Fund accounts was approved. On 24 April 2008, the ExCo visited Aalborg University's Institute for Water, Earth, and Environment and the test sites in Fredrikshavn Harbour. Siemens welcomed the ExCo to tour the new Blade Factory in Aalborg.

The 62nd ExCo meeting was hosted by the United States and the Commonwealth of Massachusetts in Boston, Massachusetts on 23, 24, and 25 September 2007. There were 29 participants from 15 contracting parties, including nine operating agent representatives of tasks, and six observers. The ExCo approved the budgets for the ongoing tasks and for the Common Fund for 2009. On 25 September, the ExCo visited the town of Hull and met with the utility and town officials about the town's two wind turbines which have tremendous support in the community. They also viewed the site of the future blade test facility on Boston Harbor.

5.0 Outreach activities

The 30th issue of the IEA Wind Energy Annual Report was published in July 2008 and the Web site, www.ieawind.org continued to expand coverage of IEA Wind activities.

The IEA Wind ExCo unanimously approved the End-of-Term Report and Strategic Plan documents to extend the Implementing Agreement for another 5 years by email ballot on 15 August 2008.

The key RD&D areas for the wind energy sector were identified by the IEA Wind ExCo as follows:

1. Wind Technology Research to Improve Performance and Reliability at Competitive Costs
2. Power System Operation and Grid Integration of High Amounts of Wind Generation Including Development of Fully-controllable, Grid-friendly "Wind Power Plants"
3. Planning and Performance Assessment Methods for Large Wind Integration
4. Offshore Wind in Shallow and Deep Waters
5. Social, Educational, and Environmental Issues

In the next five years the IEA Wind Agreement will focus on the completion of the R&D work already initiated and develop new research Tasks related to these five key research areas.

A planning committee consisting of the Chair, Vice Chairs, the Secretary, the former Chair, and the Operating Agent Representative for Task 11 Base Technology Information Exchange perform communication and cooperation activities between ExCo meetings. Support for IEA Paris initiatives has been provided by the Planning Committee. This support included attending NEET meetings in Russia, attending IEA meetings to present the End-of-Term Report and Strategic Plan for extension of the IEA Wind agreement, supplying materials for ministerial meetings, reviewing draft IEA documents that address wind technology, and supplying text for drafts of IEA annual reporting documents.

Base Technology Information Exchange

1.0 Introduction

The objective of this research Task is to promote wind turbine technology by co-operative activities and information exchange on R, D&D topics of common interest. These particular activities have been part of the IEA Wind Implementing Agreement since 1978. Most of the IEA Wind member countries participate in this Task so that researchers in their countries can benefit from this information exchange (Table 1). Proceedings of the meetings are

immediately available to countries that participate in the Task. After one year, proceedings are made public on the IEAWind.org Web site. Only experts from participating countries may attend meetings.

2.0 Objectives and Strategy

The Task includes activities in two sub-tasks. The first is to develop recommended practices for wind turbine testing and evaluation by assembling an Experts Group for each topic needing recommended practices.

Table 1 IEA Wind Task 11 Participants in 2008	
Country	Contracting Party
Canada	Natural Resources Canada
Denmark	Danish Energy Agency
European Commission	European Commission
Finland	Technical Research Center of Finland (TEKES)
Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Ireland	Sustainable Energy Ireland
Italy	CESI RICERCA S.p.A.
Japan	National Institute of Advanced Industrial Science and Technology (AIST)
Korea	New & Renewable Energy Division of the Ministry of Knowledge Economy
Mexico	Instituto de Investigaciones Eléctricas (IIE)
The Netherlands	Senter/Novem
Norway	Enova SF
Spain	CIEMAT
Sweden	Swedish Energy Agency; Vattenfall (OA)
Switzerland	Swiss Federal Office of Energy
United Kingdom	Department for Business, Enterprise & Regulatory Reform
United States	U.S. Department of Energy

Task 11

In the series of Recommended Practices, 11 documents have been published. Five of these have appeared in revised editions (Table 2). Many of the documents have served as the basis for both international and national standards.

The second sub-task is to conduct two types of meetings of experts on topics designated by the IEA Wind ExCo. The first kind of meeting is a Joint Action Symposium at which experts meet regularly to share progress. So far, Joint Action Symposia have been held on aerodynamics of wind turbines, wind turbine fatigue, wind characteristics, offshore wind systems, and wind forecasting techniques. The second type of meeting, Topical Expert Meetings, are arranged on topics decided by the IEA Wind ExCo. Proceedings are distributed to attendees and to the countries that pay fees to participate in IEA Wind Task 11. Sometimes Topical Expert Meetings result in a recommendation for a Joint Action, so participants can continue to share information on a regular basis.

Topical Expert Meetings can also begin the process of organizing new research tasks as additional annexes to the IEA Wind Implementing Agreement. For example, in 2007, the meeting on social acceptance issues of wind energy projects brought together interested experts who wrote a proposal for a new research task, Social Acceptance of Wind Energy Projects. This task began its work in 2008.

During these 28 years of activity to promote wind turbine technology through information exchange, 57 volumes of proceedings from Topical Expert Meetings (Table 3) and 27 volumes of proceedings from Joint Action Symposia (Table 4) have been published. The Task 11 Joint Action Symposium on Aerodynamics was previously arranged co-operatively by Task 20 HAWT Aerodynamics and Models from Wind Tunnel Measurements and Task 11. Task 20 is now finished. Aerodynamic challenges will be further studied by Task 29 MexNex(T) Analysis of Wind Tunnel Measurements and Improvement of Aerodynamic Models.

3.0 Progress in 2008

To complete the work plan approved by the ExCo, three meetings were planned and completed during 2008:

- 57th Topical Expert Meeting on Wind Turbine Drivetrain Dynamics and Reliability
- 3rd Joint Action Symposium on Wind Forecasting Techniques.

The fourth meeting of the year will be arranged during 2009.

3.1 *Smart structures for large blades*

The objective of the 56th Topical Expert Meeting on the Application of Smart Structures for Large Wind Turbine Rotor Blades, held in 2008, was to report and discuss progress of R&D in this relatively new field of wind turbine technology. Much knowledge had been accumulated since the previous meeting on this topic in December 2006. In 2006, participants discussed basic performance of materials and flap principles. In 2008, they were able to report results of actual tests that incorporated blade profiles equipped with movable flaps. Micro-tabs equipped with control algorithms and actuators were also tested. The field now applies a more integrated approach by testing materials, measuring loads, and evaluating control strategies.

During final discussions, participants agreed that this is a new and challenging area of wind turbine research that may result in more effective ways of controlling power production. Highlights of the discussion include the following:

- Shape memory alloys (SMAs) have a slow reaction as actuators, which could be a problem.
 - Surface suction and rubber trailing edges were mentioned as promising technologies.
 - New types of sensors with increased performance are needed.
 - Blade failure today is less of an issue than gearboxes.
 - Reliability should be increased and incorporated in new system solutions.
- The participants agreed that it was too

Table 2 List of Recommended Practices Developed by IEA Wind						
No	Area	Edition	Year	First Ed.	Valid	Status
1	Power Performance Testing	2	1990	1982	no	Superceded by IEC 61400-12, Wind power performance testing
2	Estimation of Cost of Energy from WECS	2	1994	1983	yes	
3	Fatigue Loads	2	1990	1984	yes	Part of IEC 61400-13 TS, Measurement of mechanical loads
4	Acoustics Measurement of Noise Emission From Wind Turbines	3	1994		no	Superceded by IEC 61400-11, Acoustic noise measurement techniques
5	Electromagnetic Interference	1	1986		yes	
6	Structural Safety	1	1988		no	See also IEC 61400-1
7	Quality of Power Single Grid-Connected WECS	1	1984			See also IEC 61400-21
8	Glossary of Terms	2	1993	1987		See also IEC 60030-413 International Electrotechnical vocabulary: Wind turbine generator systems
9	Lightning Protection	1	1997		yes	See also IEC 61400 PT24, Lightning protection for turbines
10	Measurement of Noise Immission from Wind Turbines at Receptor Locations	1	1997		yes	
11	Wind Speed Measurement and Use of Cup Anemometry	1	1999		yes	Document will be used by IEC 61400 MT 13, updating power performance measurement standard

early for a co-operative research task on this topic. However, another meeting to discuss progress should be held in one or two years.

3.2 Wind turbine drivetrain dynamics and reliability

The intention of this meeting was to facilitate an in-depth discussion of both research

and application engineering of the current state of the art of drivetrain systems for wind turbine applications. The great interest in gearbox and drivetrain dynamics resulted in a large number of participants in this meeting, with 47 people registered for the event. All types of stakeholders were represented: sub-suppliers, manufacturers, utilities, and R&D.

Task 11

Many talks focused on the analysis and validation of the complete drivetrain. It was concluded that the analytical capabilities are strong, and the challenge is to apply these capabilities appropriately. Validation using field data was considered as most important. Despite these efforts, there are still extensive problems with failures in gearboxes and gearbox subcomponents.

One cause of these problems may be incomplete load cases and transients used in the design process. The aeroelastic models of the turbine are sufficiently accurate; however, the elastic properties of the components in the nacelle and geometric nonlinearities are not fully understood.

To understand load flow and resulting forces in nacelles and bedplates, a number of dynamometers are available for tests. In addition to this, new dynamometers are planned, e.g., by the United Kingdom. The United States Gearbox Reliability Collaborative (GRC) was mentioned as a step forward and a possible source of future cooperation. A task force was set up to prepare for formulating a new task on this subject. An alternative would be to arrange a new meeting on the subject within one to two years to exchange information.

3.3 Wind forecasting techniques

The aim of this meeting was to gather a group of experts in the field of forecasting who were interested in sharing their expertise regarding optimal use of information in wind power forecasting. Wind energy forecasting has evolved rapidly during the past several years, both technically and from the point of view of its implementation. Wind forecasting models are now used operationally in some countries. The tendency is to increase the use of wind power forecasting to manage grids, trade in the market, perform maintenance, and so on.

Presentations by participants showed results coming from the meteorological community that can be applied to improve the prediction of wind power, and also improvements in the models specifically

dedicated to forecast the power production of wind farms. There are many different approaches to the problems that use the fields of meteorology and mathematics.

End users of the forecasts explained what they need and how they would use wind forecasts in their environment. The circumstances and needs of the users can be very different depending on the country, area of interest, and so on. Another workshop with end users should be considered to better understand the various scenarios and their priorities regarding the use of wind predictions. The users present at the meeting were interested in extreme events, specifically on ramp forecasting.

The value of wind forecasts depends on factors including the characteristics of the system, the way the system is operated, regulations, climatic conditions, and so on. Some studies conclude that improvements in forecasting accuracy do not have an impact on the management of the system. These studies should be extended to consider extreme events (where the value of forecasting a single event can be enormous) and to other systems with different operational conditions. There was a consensus about the need to reduce errors and uncertainties, especially under extreme conditions.

Workshops with wind energy forecasters, meteorologists, and end users are needed to improve the quality of the forecasts and to improve decision-making processes involving wind energy management and integration with the electricity system. It was also mentioned that it is difficult to attract end users to these events, especially transmission system operators (TSOs) and large utilities.

There was interest in establishing a new task on wind power prediction. This new task should promote a “dynamic benchmarking” of wind power prediction models; organize a meeting with utilities, meteorologists and end users of wind power forecasting to share experiences; use meeting attendees to identify areas of interest to the end users.

Table 3 Topical Expert Meetings Held Since 2001*			
57	Wind Turbine Drivetrain Dynamics and Reliability	Jyväskylä, Finland	2008
56	The Application of Smart Structures for Large Wind Turbine Rotor Blades	Albuquerque, USA	2008
55	Long-Term Research Needs – In the Frame of the IEA Wind Co-operative Agreement	Berlin, Germany	2007
54	Social Acceptance of Wind Energy Projects	Luzerne, Switzerland	2007
53	Radar, Radio, and Wind Turbines	Oxford, United Kingdom	2007
52	Wind and Wave Measurements at Offshore Locations	Berlin, Germany	2007
51	State of the Art of Remote Wind Speed Sensing Techniques Using Sodar, Lidar and Satellites	Risoe, Denmark	2007
50	The Application of Smart Structures for Large Wind Turbine Rotor Blades	Roskilde, Denmark	2006
49	Challenges of Introducing Reliable Small Wind Turbines	Stockholm, Sweden	2006
48	Operation and Maintenance of Wind Power Stations	Madrid, Spain	2006
47	Methodologies for Estimation of Cost of Wind Energy and the Methodologies to Estimate the Impact of Research on the Cost	Paris, France	2005
46	Obstacle Marking of Wind Turbines	Stockholm, Sweden	2005
45	Radar, Radio, Radio Links, and Wind Turbines	London, UK	2005
44	System Integration of Wind Turbines	Dublin, Ireland	2004
43	Critical Issues Regarding Offshore Technology and Deployment	Skærbæk, Denmark	2004
42	Acceptability of Wind Turbines in Social Landscapes	Stockholm, Sweden	2004
41	Integration of wind and hydropower systems	Portland, OR, USA	2003
40	Environmental issues of offshore wind farms	Husum, Germany	2002
39	Power performance of small wind turbines not connected to the grid	CEDER, Soria, Spain	2002
38	Material recycling and life cycle analysis (LCA)	Risø, Denmark	2002
37	Structural reliability of wind turbines	Risø, Denmark	2001
36	Large scale integration into the grid	Hexham, UK	2001
35	Long term research needs - for the time frame 2000 – 2020	Petten, The Netherlands	2001

*For meetings prior to 2001, see www.ieawind.org

4.0 Plans for 2009 and Beyond

The current Operating Agent (OA), Vattenfall, has resigned from managing this task. Several potential candidates were invited to apply, and CENER of Spain was selected to

become the new Operating Agent beginning in January 2009.

Task 11 will continue coordinating Topical Expert Meetings and Joint Action Symposia. Four meetings of this type will be held in 2009. Examples of meetings

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Table 4 Joint Action Symposia Held Since 2001*			
	Aerodynamics of wind turbines	Boulder, USA Athens, Greece	2003 2001
	Wind assessment	Roskilde, Denmark	2003
	Wind forecasting techniques	Madrid, Spain Lyngby, Denmark Norrköping, Sweden	2008 2004 2002
*For symposia held prior to 2001, see www.ieawind.org			

include but will not be limited to the following:

- Wind park performance assessment in complex terrain
- Wind turbine performance in complex terrain and cold climate
- Sound propagation models and validation
- Follow-up on wind measurements using sodar and lidar
- Micro-meteorology inside wind farms and wakes between wind farms
- Radar, radio links, and wind turbines, follow-up meeting.

Work related to the development of a Recommended Practice on the use of sodar for measuring wind speeds will continue.

All documents produced under Task 11 are available to organizations in countries that participate in the task. Organizations in these countries can receive the newest documents from the Operating Agent. All documents more than a year old can be accessed on the public web pages for Task 11 at www.ieawind.org.

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Wind Energy In Cold Climates

1.0 Introduction

Wind energy is increasingly being used in cold climates, and technology has been adapted to meet these challenges. As the turbines that incorporate new technology are being demonstrated, the need grows for gathering experiences in a form that can be used by developers, manufacturers, consultants, and financiers. To supply needed information on the operation of wind turbines in cold climates, Annex 19 to the IEA Wind Implementing Agreement was officially approved in 2001. The resulting research Task 19 began in May 2001 and continued for three years. At the end of the first three-year period, the participants decided to extend the collaboration. The main drivers were the need to better understand wind turbine operation in cold climates and to gain benefit from the results of the national projects launched during the first three years. Continuation of Task 19 through 2008 was approved by the ExCo. Table 1 lists the participating countries in 2008.

The expression “cold climate” was defined to apply to sites where turbines are exposed to low temperatures outside the standard operational limit and to sites where turbines face icing. These cold conditions

retard energy production during the winter. Such sites are often elevated from the surrounding landscape or located in high northern latitudes (1).

2.0 Objectives and Strategy

The objectives of Task 19 are as follows:

- Determine the current state of cold climate solutions for wind turbines, especially anti-icing and de-icing solutions that are available or are entering the market.
- Review current standards and recommendations from the cold climate point of view and identify possible needs for updates. Possibly recommend updates to standards that include comments from planners and operators.
- Find and recommend a method to estimate the effects of ice on production. A better method would reduce incorrect estimates and therefore the economic risks currently involved in cold climate wind energy projects. As possible, verify the method on the basis of data from national projects.
- Clarify the significance of extra loading that ice and cold climate induce on wind turbine components and disseminate the results.

Table 1 IEA Wind Task 19 Participants in 2008

Country	Contracting Party; Organizations
Canada	Natural Resources Canada
Finland	TEKES; VTT Technical Research Centre of Finland (OA)
Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety; ISET
Norway	Enova SF; Kjeller Vindteknikk
Sweden	Swedish Energy Agency; WindREN AB
Switzerland	Swiss Federal Office of Energy; ENCO
USA	U.S. Department of Energy; NREL

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- Perform a market survey for cold climate wind technology, including wind farms, remote grid systems, and stand-alone systems.
- Define recommended limits for the use of standard technology (site classification).
- Create and update the Task 19 state-of-the-art report and expert group study on guidelines for applying wind energy in cold climates.

The national activities of task participants are designed to provide new information on issues that are preventing cold climate development today. The results of these activities will enable improvements of the overall economy of wind energy projects and lower the risks involved in areas where low temperatures and atmospheric icing are frequent. The reduced risk would thereby reduce the cost of wind electricity produced in cold climates.

Participants in Task 19 are active in several international projects and co-operative efforts. Some take part in the European Union-funded COST727 action, which aims to improve the Europe-wide ice measurement network and to forecast atmospheric icing. This information directly benefits Task 19's work.

The collaboration will continue to actively disseminate results through the Internet page of Task 19 (<http://arcticwind.vtt.fi>) and in conferences and seminars (2–6). At the end of the current task period, a final report will be published that describes updated state-of-the-art technology and issues updated recommendations regarding the use of wind turbines at sites where winter conditions prevail a significant amount of time during the year.

One important dimension of this work will be the initiation of conversation about whether cold climate issues should be recognized in future standards that set the limits for turbine design.

3.0 Progress in 2008

Three meetings were organized in 2008: the first in April in Anchorage, Alaska (United States), hosted by NREL; the second in September in Espoo, Finland, hosted by VTT; and the third in Norrköping, Sweden, hosted by WindREN Ab.

The need to continue the work of Task 19 in one way or another was expressed during 2008. The issue of low temperatures is mentioned in standards and recommendations; however, icing is rarely taken into account. Many projects are in the planning stage, but there is a lack of commercially available solutions especially for ice detection and blade anti-icing and de-icing. The development of such solutions may not be a suitable topic for an IEA Wind Task, but pointing out the needs and recommending tools to compare the solutions are goals of Task 19. It was decided to propose a third term to the ExCo at the first meeting of 2009.

The project web site at <http://arctic-wind.vtt.fi> has been updated and serves as an extranet among Task 19 participants.

4.0 Plans for 2009 and Beyond

Final results of the task to be achieved by the end of the term include these:

- Publish updated state-of-the-art-report
- Publish updated recommendations report
- Complete database of wind turbines in cold climates
- Complete database of relevant reports
- Prepare a proposal for the extension of Task 19

The activities will help solve the most common issues causing uncertainty for cold climate wind energy development. These task activities are intended to match well with the national activities of participants.

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Offshore Wind Energy Technology and Deployment

1.0 Introduction

Installing wind turbines offshore has several advantages over onshore development. Onshore, difficulties in transporting large components and opposition due to various siting issues, such as visual and noise impacts, can limit the number of acceptable locations for wind parks. Offshore locations can take advantage of the high capacity of marine shipping and handling equipment, which far exceeds the lifting requirements for multi-megawatt wind turbines. In addition, the winds blow faster and more smoothly at sea than on land, yielding more electricity generation per square meter of swept rotor area. On land, larger wind farms tend to be in somewhat remote areas, so electricity must be transmitted over long power lines to cities. Offshore wind farms can be closer to coastal cities and require relatively shorter transmission lines, yet they are far enough away to reduce visual and noise impacts.

Recognizing the interest and challenges of offshore development of wind

energy, IEA Wind Task 11 Base Technology Information Exchange sponsored a Topical Expert Meeting (TEM 43) in early 2004 in Denmark on Critical Issues Regarding Offshore Technology and Deployment. The meeting gathered 18 participants representing Denmark, Finland, the Netherlands, Sweden, the United Kingdom, and the United States. Presentations covered both detailed research topics and more general descriptions of current situations in the countries. After the meeting, the IEA Wind ExCo approved Annex 23 (Task 23) to the Implementing Agreement as a framework for holding additional focused workshops and developing research projects. The work would increase understanding of issues and develop technologies to advance the development of wind energy systems offshore. In 2008, 10 countries have chosen to participate in this task, and many research organizations in these countries are sharing their experiences and conducting the work (Table 1).

Table 1 IEA Wind Task 23 Participants in 2008

Country	Contracting Party
Denmark	Danish Energy Agency; Risø DTU (OA)
Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Republic of Korea	Government of Korea
The Netherlands	Senter/Novem
Norway	Norwegian Water Resources and Energy Directorate
Portugal	INETI
Spain	CIEMAT
Sweden	Swedish Energy Agency
United Kingdom	Department for Business, Enterprise & Regulatory Reform
United States	U.S. Department of Energy; NREL (OA)

2.0 Objectives and Strategy

The overall objectives of Task 23 include the following:

- Organize workshops on critical research areas for offshore wind deployment. The goal of the workshops is to identify R&D needs of interest to participating countries, publish proceedings, and conduct joint research activities for task participants.
- Identify joint research tasks among interested countries based on the issues identified at TEM 43.
- Conduct R&D activities of common interest to participants to reduce costs and uncertainties.

This task has been organized as two sub-tasks. Sub-task 1, Experience with Critical Deployment Issues, is led by Risø National Laboratory (Risø) in Denmark, and Sub-task 2, Technical Research for Deeper Water, is led by the National Renewable Energy Laboratory (NREL) in the United States.

3.0 Progress in 2008

3.1 Sub-task 1: Experience with critical deployment issues

Statistics show a global wind energy capacity in 2008 approaching 1% of the global electricity capacity. Estimates predict a huge increase in wind energy development over the next 20 years. Much of this development will be offshore wind energy. This implies that billions will be invested in offshore wind farms over the next decades. The aim of Sub-task 1, therefore, has been to support this development by arranging workshops in which participants will inspire each other and test and improve research results. The work in Sub-task 1 has been divided into three research areas.

Research Area 1, Ecological Issues and Regulations, held a workshop in Petten, the Netherlands, in February 2008, and was attended by more than 20 experts. The workshop objectives were to

- provide a state-of-the-art overview of

knowledge about impacts of offshore wind turbine systems on the marine environment.

- get a picture of the consequences for regulatory frameworks, such as requirements for environmental impact assessments (EIAs) and protection measures for nature reserve areas.
- generate ideas for frameworks on how results of nature research can be used to (re)formulate regulations and legislation.

Discussion and final recommendations fell into three categories. First, the knowledge base for planning and designing offshore wind farms needs strengthening. As ecological research progresses and experience from the planning and operation of existing wind farms emerges, documents covering the following issues need to be produced and distributed about offshore (wind energy) legislation, guidelines for EIAs and strategic environmental assessments (SEAs), and best practices.

Second, transfer is required between R&D establishments and the users who include wind farm planners and designers, as well as authorities responsible for approving wind farms and specifying EIAs and SEAs. A lack of knowledge for integrated spatial marine planning, was identified compared to other offshore activities such as sand mining, shipping, military activities, oil and gas production, and nature conservation.

Third, specific areas of and methods for co-operation between countries were identified during the workshop.

- Regular meetings of multidisciplinary research and industry groups, representing disciplines in the fields of ecology and wind energy technology. It appeared that the Task 23 workshop was one of the rare opportunities for representatives from both fields to meet and exchange views.
- Cumulative effects of an increasing number of wind farms on the marine ecosystem. There is an urgent need to

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address this issue for spatial planning purposes.

- Integral risk analysis as part of the planning process and SEA.
- Geographic information system (GIS) mapping as a basis for representing R&D results.
- Integration of the three major issues for offshore wind energy planning: impacts on ecology, electrical infrastructure, and wind farm layout. This requires integration with other activities of IEA Task 23.
- Co-operation on the government level. Governments, which usually finance ecological research, should facilitate the exchange of information by disclosing results as they become available.
- Database formation.
- How to use ecological and environmental networks within the European Union (EU) (such as the Environmental Impact Information Tool [EIIT], which the European Wind Energy Association is designing, and possibly the Global Wind Energy Council [GWEC]) and other countries for the benefit of making knowledge available to potential users.
- Reviewing of siting decisions by international experts with the aim of learning and criticizing possible poor-quality decisions.
- How to deal with shipping safety and siting of wind farms with respect to shipping lanes.

Research Area 2: Grid Connection held a workshop in September 2005, at Manchester University in the United Kingdom. There it was decided to focus the work program on five issues: (1) offshore wind meteorology and impact on power fluctuations and wind forecasting, (2) behavior and modeling of high-voltage cable systems, (3) grid code and security standards for offshore versus onshore, (4) control and communication systems of large offshore wind farms, and (5) technical architecture

of offshore grid systems and enabling technologies. A planning meeting at Risø in 2006 set up workshops where the five issues would be addressed. Also, participants agreed to supply information about projects in the member countries including results, to help coordinate activities under this IEA Wind task.

A workshop called Grid Integration of Offshore Wind conducted in June 2007 in London, included a brief overview of the situation in the UK. In that country, a number of early (Round 1) offshore wind farms are already connected to the onshore grid via low-voltage connections (33 kV). Larger Round 2 projects will be connected via offshore transmission systems (132+ kV). Significant work has been undertaken by the Department for Trade and Industry and the industry regulator, Ofgem, to develop an appropriate regulatory framework for offshore transmission. The UK government announced the appropriate model to follow for offshore, tenders will be held for regulated licenses to connect specific offshore projects, and minimum security standards which should apply to offshore have been consulted on. A final workshop, Power Fluctuation, is planned to take place in Denmark February 2009.

Research Area 3: External Conditions, Layouts, and Design of Offshore Wind Farms held a workshop in December 2005 at Risø, Denmark where wake modeling and benchmarking of models, marine boundary layer characteristics, and met-ocean data and loads were identified for inclusion in the future work program. As a result, another workshop on wake modeling and benchmarking of models was held at the Danish test station for large wind turbines, Høvsøre and Billund, in Jutland, Denmark. A great need was identified for further collaboration and exchange of data to develop and verify computational models and to understand the physics of wakes and meteorological backgrounds.

In addition to the work of IEA Wind Task 23, the EU R&D project UpWind includes similar activities. To multiply the

benefits from both activities, during 2008, the benchmarking experience and results obtained from collaboration with UpWind were analyzed and discussed.

For marine boundary layer characteristics and met-ocean data and loads, a collaboration between two IEA Wind tasks (11 Base Technology Information Exchange and 23) resulted in a Topical Expert Meeting under Task 11 in January 2007. The meeting was titled *The State of the Art of Remote Wind Speed Sensing Techniques Using Sodar, Lidar, and Satellites*. These are very important techniques to explore boundary layer characteristics and offshore loads to wind turbines. Additional collaboration took place when an IEA Wind Task 23 meeting was held in February 2007 in conjunction with a German offshore conference and the EU policy seminar on offshore wind.

A follow-up workshop with focus on continued benchmarking was scheduled to take place in Denmark during the second half of 2008. However, it was postponed to February 2009 and held in conjunction with the workshop on power fluctuation as a back-to-back workshop, *Wake Effects and Power Fluctuations*.

A summary of the workshops described in this section will be published in 2009.

3.2 Sub-task 2: Technical research for deeper water

Sub-task 2 is intended to focus on technical issues associated with deeper-water implementation of offshore wind energy. In practice, however, the project has focused on the activities of the working group known as the *Offshore Code Comparison Collaborative (OC3)*, which includes the analysis of shallow, transitional, and deep-water offshore wind turbine concepts.

The OC3 project is benchmarking system-dynamics models (i.e., design codes) used to estimate offshore wind turbine dynamic loads. Currently, conservative offshore design practices adopted from marine industries are enabling offshore wind development to proceed. But if offshore

wind energy is to be economical, reserve margins must be quantified, and uncertainties in the design process must be reduced so that appropriate margins can be applied. Uncertainties associated with load prediction are usually the largest source and hence the largest risk. Model comparisons are the first step in quantifying and reducing load prediction uncertainties. Comparisons with test data would be the next step.

This project is designed to address near-term needs of the industry as well as future needs. Currently, the industry is focused on bottom-fixed, shallow-water applications, especially in Europe where shallow-water sites are plentiful. Deeper-water sites are more common in Greece, Republic of Korea, Japan, Norway, Spain, the United States, and many other countries. This project includes support structures that are likely to become solutions for these markets also. The scope of this collaboration includes technologies ranging from the current shallow-bottom monopiles to transition-depth tripods to deep-water floating platforms.

To test the offshore wind turbine system-dynamics models, the main activities of the OC3 project are (1) discussing modeling strategies, (2) developing a suite of benchmark models and simulations, (3) running the simulations and processing the simulation results, and (4) comparing the results. But these activities fall under the following much broader objectives:

- Assessing the accuracy and reliability of results obtained by simulations to establish confidence in the predictive capabilities of the models
- Training new analysts to run and apply the models correctly
- Identifying and verifying the capabilities and limitations of implemented theories
- Investigating and refining applied analysis methodologies
- Identifying further R&D needs.

In the past, such verification work has led to dramatic improvements in model accuracy as the code-to-code comparisons and lessons learned have helped identify

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deficiencies in existing models and needed improvements. These results are important because the advancement of the offshore wind industry is closely tied to the development and accuracy of system-dynamics models.

The simulation of offshore wind turbines under combined stochastic aerodynamic and hydrodynamic loading is very complex. The benchmarking task, therefore, requires a sophisticated approach that facilitates the identification of sources of modeling discrepancies introduced by differing theories and/or model implementations in the various codes. This is possible only by meticulously controlling all of the inputs to the codes and carefully applying a stepwise verification procedure in which model complexity is increased in each step.

The fundamental set of inputs to the codes controlled in OC3 relates to the specifications of the wind turbine. The OC3 project uses the publicly available specifications of the 5-MW baseline wind turbine developed by NREL (1), which is a representative utility-scale multimegawatt turbine that has also been adopted as the reference model for the integrated EU UpWind research program. This wind turbine is a conventional three-bladed upwind variable-speed blade-pitch-to-feather-controlled turbine. The hydrodynamic and elastic properties of the varying offshore support structures used in the project are also controlled. Furthermore, the turbulent full-field wind inflow and regular and irregular wave kinematics are model inputs controlled in the OC3 project. This approach reduces possible differences brought about by dissimilar turbulence models, wave theories, or stochastic realizations.

The key component of the stepwise procedure is the enabling and disabling of features of the model among different load-case simulations. Simulations are defined with and without aerodynamics and hydrodynamics, with and without the control system enabled, and with individual subsystems both flexible and rigid.

The OC3 project emphasizes

verification of the offshore support structure dynamics as part of the dynamics of the complete system. This emphasis is a feature that distinguishes the OC3 projects from past wind turbine code-to-code verification exercises. Nevertheless, it was important to test the aerodynamic models separately so that modeling differences resulting from the aerodynamics could be identified. This identification is important because the aerodynamic models are routinely a source of differences in wind turbine code-to-code comparisons.

To encompass the variety of support structures required for cost-effectiveness at varying offshore sites, different types of support structures (for the same wind turbine) are investigated in separate phases of the OC3 project:

- In Phase I, the NREL offshore 5-MW wind turbine is installed on a monopile with a rigid foundation in 20 m of water.
- In Phase II, the foundation of the monopile from Phase I is made flexible by applying different models to represent the soil-pile interactions.
- In Phase III, the water depth is changed to 45 m and the monopile is swapped with a tripod substructure, which is one of the common space frame concepts proposed for offshore installations in water of intermediate depth.
- In Phase IV, the wind turbine is installed on a floating spar-buoy in deep water (320 m).

The OC3 project is performed through technical exchange among a group of international participants who come from universities, research institutions, and industry. Although several participants have come and gone, the main participants in 2008 were Acciona Energia (Spain), CENER (Spain), Fraunhofer Institute IWES (Germany), Garrad Hassan (United Kingdom), Institute for Energy Technology IFE (Norway), Marintek (Norway), NREL (United States), NTNU (Norway), Ramboll

(Denmark), Risø-DTU (Denmark), Siemens Wind Power (Denmark), Statoil-Hydro (Norway), University of Stuttgart (Germany), and University of Hannover (Germany).

Most of the codes that have been developed for modeling the dynamic response of offshore wind turbines are tested in OC3. Although more codes have been tested to some extent over the course of the project, the main codes currently being tested are ADAMS, ADCoS, ANSYS, BHawC, FAST, FLEX5, GH Bladed, HAWC2, NAS-TRAN, Poseidon, WAMIT, WaveLoads, and SESAM.

The OC3 project started in October 2004 and is scheduled to be completed in the fall of 2009. Over this time, Internet meetings have been held approximately every two months, which continue to be productive and significantly reduce the need for physical meetings and travel. In addition, nine physical meetings have been held at key points in the project: United States, October 2004; Denmark, January 2005; Norway, June 2005; Denmark, October 2005; United States, June 2006; Germany, January, September, and December 2007; and Denmark, September 2008.

Since the start of the project, the

reference 5-MW wind turbine, including the control system, has been developed; the wind and wave data sets have been generated; the simulations and code-to-code comparisons of Phases I, II, and III have been completed; and Phase IV has been initiated. Three conference papers have been published and presented—one for summarizing the results of each of the completed phases—see references (2), (3), and (4) for Phases I, II, and III, respectively. Figure 1 illustrates the model used in Phase III (4). A paper summarizing the results of Phase IV is tentatively planned to be published and presented at a conference in 2009. A final report will be compiled from all the conference papers, with new results added (from new participants, etc.) that have been contributed after the papers were first published. This report will be written after the Phase IV paper has been completed, and its publication is tentatively planned for fall 2009.

The natural next step for the OC3 project is to compare the analytical models to real test data—a significant increase in complexity. Usually it is difficult for a public project to gain access to the needed data. Obtaining the model properties is difficult, and they are usually proprietary. The

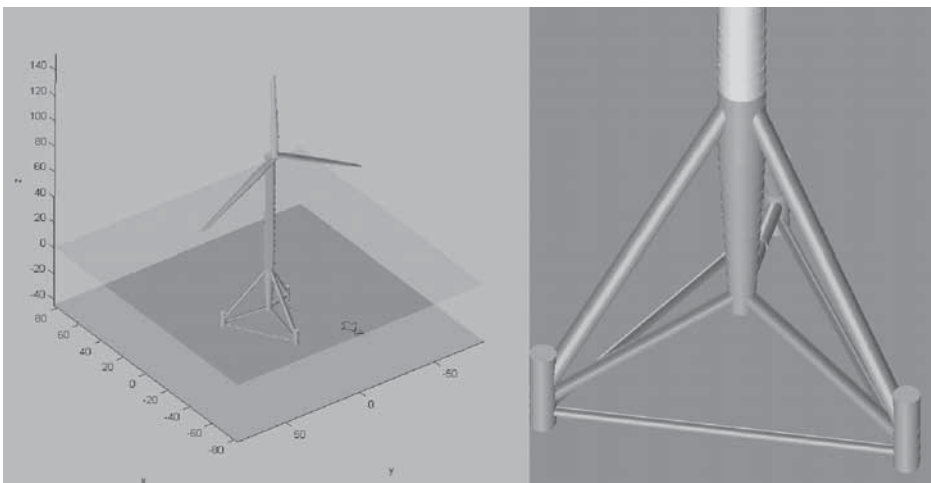


Figure 1 NREL 5-MW wind turbine with tripod support structure used in OC3 Phase III.

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data sets are rarely complete enough for a good comparison with analytical models. Wind inflow data are usually from a single anemometer. Wave data are usually from a single point source. Currents might not be available. So comparisons are usually made on a statistical basis. However, even comparisons relying on statistical data are better than no comparisons at all. The value of such comparisons is that they give analysts and designers a measure of confidence that the loads they are predicting are representative of the conditions the turbines are actually operating in. Therefore, even though such a project is bound to be imperfect, it is essential.

4.0 Plans for 2009 and Beyond

In 2009, the 10 participating countries will continue work in both sub-tasks to complete final reports which will be posted to the Task Web site at www.ieawind.org. The task will end in December 2009 with approval of these reports.

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Authors: Jørgen Lemming, Risø National Laboratory, Denmark; and Walt Musial, Sandy Butterfield, and Jason Jonkman, National Renewable Energy Laboratory, United States.

Integration of Wind and Hydropower Systems

1.0 Introduction

About 450 GW of hydropower capacity is operating in the IEA Wind Member Countries along with approximately 92 GW of wind power capacity. Because of the natural variability of wind power production and the inherent uncertainty in its prediction, integrating wind power into utility operations typically increases the amount of generation reserves required as well as the need for flexible, rapidly responding generation resources. Since hydropower is a generation resource that is generally quite flexible and able to provide reserves, many utilities are making use of these characteristics to help meet the balancing needs due to wind power. This approach raises many questions concerning economics, overall benefit to the electrical system, impacts on hydropower operations, and more. To address some of these questions, seven IEA Wind countries participated in Task 24 in 2008 (Table 1).

The proposal for Task 24 Integration of Wind and Hydropower Systems arose from an IEA Wind Topical Expert Meeting in 2003. It was approved by the ExCo in May 2004. This co-operative research effort was

completed in 2008 and will publish its final report in 2009. It has allowed participating organizations to multiply the experience and knowledge gained from their individual efforts. This is particularly important since there are many different hydro system configurations in many different electricity markets. In addition, the IEA Wind Task 24 worked in co-operation with the IEA Hydropower Implementing Agreement, which is investigating integration of hydropower and wind through a complementary set of investigations. Task 24 is also working with IEA Wind Task 25 on the Design and Operation of Power Systems with Large Amounts of Wind Power.

2.0 Objectives and Strategy

Task 24 has two primary purposes: (1) to conduct co-operative research concerning the generation, transmission, and economics of integrating wind and hydropower systems, and (2) to provide a forum for information exchange.

The specific objectives of the task are as follows:

- To establish an international forum

Table 1 IEA Wind Task 24 Participants in 2008

Country	Contracting Party; Organizations
Australia	Clean Energy Council; Hydro Tasmania
Canada	Natural Resources Canada; Manitoba Hydro, Hydro Quebec
Finland	TEKES; VTT
Norway	Norwegian Water Resources and Energy Directorate; Sintef Energy Research, Statkraft Energy
Sweden	Swedish Energy Agency; KTH Swedish Institute of Technology
Switzerland	Swiss Federal Office of Energy; EW Ursern
United States	U.S. Department of Energy; NREL, (OA) Arizona Power Authority, Bonneville Power Administration,

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for exchange of knowledge, ideas, and experiences related to the integration of wind and hydropower technologies within electricity supply systems

- To share information among participating members concerning grid integration, transmission issues, hydrological and hydropower impacts, markets and economics, and simplified modeling techniques
- To identify technically and economically feasible system configurations for integrating wind and hydropower, including the effects of market structure on wind-hydro system economics with the intention of identifying the most effective market structures.

The expected outcomes of the work conducted under Task 24 include the following:

- The identification of practical wind-hydro system configurations
- A consistent method of studying the technical and economic feasibility of integrating wind and hydropower systems
- The technical and economic feasibility of integrating wind and hydropower systems in specific case studies
- The ancillary services required by wind energy and the electric system reliability impacts of incorporating various levels of wind energy into utility grids that include hydro generation
- An understanding of the costs and benefits, and the barriers and opportunities, related to integration of wind and hydropower systems
- A database of reports describing case studies and wind-hydro system analyses conducted through co-operative research of the task.

Four types of case studies will be conducted by the participants: grid integration, hydrologic impact, market and economics, and simplified modeling of wind-hydro integration potential. While many case studies may involve all four of these topics, some

studies may only address and share information related to one or two. Each case study will address problem formulation and assumptions, analysis techniques, and results.

2.1 Grid integration case studies

The wide variety of hydropower installations, reservoirs, operating constraints, and hydrologic conditions combined with the diverse characteristics of the numerous electrical grids (balancing areas) provide many possible combinations of wind, hydropower, balancing areas, and markets, and thus many possible solutions to issues that arise. Hydro generators typically have very quick start-up and response times and may have flexibility in water-release timing. Therefore, hydro generators could be ideal for balancing wind energy fluctuations or for energy storage and redelivery. Studying grid integration of wind energy, particularly on grids with hydropower resources, will help system operators understand the potential for integrating wind and hydropower resources. Each of the seven countries participating in the task is planning to contribute at least one case study covering a wide variety of system configurations and sizes ranging from <1,000 MW peak load such as Grant County Public Utility in Washington State, United States to >35,000 MW peak load such as Hydro Quebec, Canada. There is also a wide variety of hydropower facilities, ranging from essentially run-of-the-river with little storage capacity (a day or two) to very large hydro plants associated with reservoirs that have multiyear storage capability. This diversity should allow for a comprehensive look at grid integration scenarios.

2.2 Hydropower system impact case studies

Depending on the relative capacities of the wind and hydropower facilities, integration may necessitate changes in the way hydropower facilities operate to provide balancing or energy storage. These changes may affect operation, maintenance, revenue, water storage, and the capability of the

hydro facility to meet its primary purposes. Beyond these potential changes, integration with wind may provide benefits to the hydro system related to water storage or compliance with environmental regulations (e.g., fish passage) and create new economic opportunities. Without a proper understanding of the impacts and benefits, it is unlikely that many hydro facility operators will be interested in using their resources to enable integration of wind power into their respective balancing areas. Thus, study of the impacts of wind integration on hydropower operations to determine the benefits and costs could help pave the way for implementation of wind-hydro projects. Four of the seven participating countries expect to contribute to these studies (Australia, Canada, Norway, and the United States). Examples of hydropower system impacts include the effects on meeting fish flow requirements, reservoir levels for recreation, irrigation deliveries of water, or other priorities in running a hydro facility that may supersede power production. It is worth noting that some of the hydropower facilities being considered have these constraints while others do not.

2.3 Market and economic case studies

While grid integration and hydrologic impact studies may demonstrate the technical feasibility of integrating wind and hydropower systems, implementation will often depend on the economic feasibility of a given project. Such economic feasibility will depend on the type of electricity market in which the wind and hydro projects are considered. Addressing economic feasibility in the electricity market will provide insight into which market types are practical for wind-hydro integration, as well as identify the key factors driving the economics. This understanding may provide opportunities to devise new methods of scheduling and pricing that are advantageous to wind-hydro integration and permit better use of system resources. These market and economic case studies will address the effects of today's market structures

on wind-hydro system economics with the intention of identifying the most effective market structures. Economic studies that consider the value of wind energy generation and hydropower to the electricity customer are of greatest interest. Because economic feasibility is germane to integrating wind and hydropower, each participating country will contribute to these studies. Initial results of the case studies are consistent with other wind integration studies in that the efficiency and liquidity of the electricity market has a large influence on the economics, frequently dominating all other factors. Further, an important factor in interpreting the economic consequences of integrating wind with hydro is the perspective taken by the study—whether it is for the overall benefit of the electric customer or of a single actor in the market (e.g. a utility or wind developer).

2.4 Simplified modeling of wind-hydro integration potential case studies

Approximate methods for estimating the amount of wind power that can be physically or economically integrated into a balancing area with existing hydropower generation—based on the characteristics of the balancing area loads, hydropower facilities, and the wind power resource—are of keen interest. Such methods will be considered as the case studies of the participants come to a close, and a search for basic indicators for such methods will be conducted. The analysis methods should include only the most influential operational constraints for hydro and electric reliability concerns. The goal is to develop a technique to approximate the potential for integrating wind and hydropower without the need to conduct an in-depth study. However, any simplified method must still take a system-wide perspective, with the understanding that wind and hydropower interact within a larger grid that includes other generation resources. Because of this, it may be more fruitful for some investigators to consider simplified methods that study how much wind can be integrated into a large interconnected

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grid that includes significant hydropower resources but not to consider specific hydropower resources. Three of the participating countries expect to contribute to the simplified modeling (Australia, Norway, and the United States).

As the breadth of these case studies indicates, integrating wind and hydropower can be quite complex. Figure 1 provides a conceptual view of the relationships of wind, hydropower, and the transmission balancing area along with “surrounding” issues for a case study in the Southwestern United States.

3.0 Progress and Plans

By the end of 2008, six meetings of Task 24 participants had been held. The general work plan for participating countries was developed at the kickoff meeting in 2005 at Hoover Dam, Nevada, United States. The work of the task over these first two years was focused on initiating participant case

studies and finding how best to collaborate. Differences in terminology and techniques inherent in an international collaboration made it necessary to create a consistent framework for formulating problems and presenting results (a matrix). Participants also decided to with a similar task of the IEA Hydropower Implementing Agreement. Thus a joint task or annex was approved by the IEA Wind and Hydropower ExCos in 2006.

In 2006, an R&D meeting was held online using a web meeting tool (Webex) through the U.S. Department of Energy. Meeting participants called into a central voice conference, while viewing and manipulating a common presentation accessed and displayed over the Internet. The matrix and details of the upcoming R&D meeting were discussed.

At the next R&D meeting in Launceston, Tasmania, it became clear that to achieve the expected results defined in the

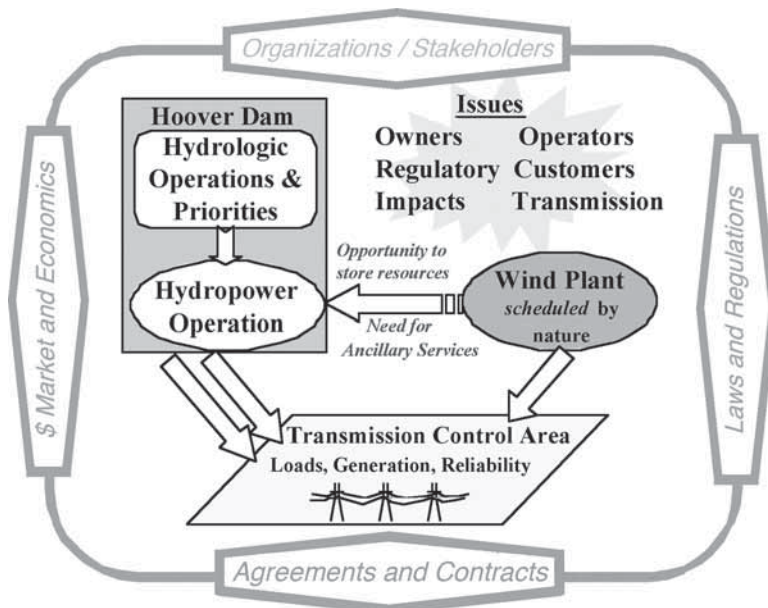


Figure 1 Conceptual view of the relationships of wind power, hydropower, and the transmission control area, and the issues surrounding their integration.

task work plan, distilling information from the case studies and describing the results in the final report will be necessary. Additional outcomes from the work plan were added as a result of collaborating with participants from the IEA Hydropower Implementing Agreement.

During 2007, two R&D meetings were held in collaboration with the participants of Task 25 on the Design and Operation of Power Systems with Large Amounts of Wind Power. Joint meetings with Task 25 were initiated because the tasks had some similar goals. The first was held in Milan, Italy in conjunction with the European Wind Energy Conference 2007. Twenty people from 11 countries attended the meeting. Participants discussed methods for determining the impacts of wind energy in power systems, what these impacts are, and how they are modeled and predicted.

The second joint R&D meeting, held in Oslo, Norway, was attended by 21 people from 12 countries. Task 24 participants presented updates on their case studies and addressed the primary hydropower impacts of integration of wind power. In all countries except the United States, the only impact on their hydropower utilities from wind power is in the optimal economic use of the hydro resource in the system. The United States is the only member country with specific flow constraints due to non-power requirements. The general consensus was that when considering energy storage, including that in hydro impoundment of

water, wind integration requires no backup and/or storage. Wind generation is a system integration issue, and no local dedicated storage is needed. However, storage may make sense when considered in the context of the efficiency of the entire system.

Other important issues include how to properly define the wind penetration level, creating a “flexibility index,” and the required success factors for wind integration studies. Participants agreed that wind integration studies should take a cost-benefit perspective of wind in the grid rather than a perspective of limited integration cost due to the variability and uncertainty of wind energy.

A final version of the matrix was adopted at the end of 2006, and each of the task participants has completed a matrix to describe its case study projects. This allows comparison and reporting of the results from the various case studies.

In June 2008, the final R&D meeting was held in Quebec City, Canada and was attended by 13 people from five countries. Task participants presented their case studies and discussed the similarities and differences among the various systems and studies. The outline for the final report was approved, and the participants will complete the case studies and produce the final report in 2009.

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Power Systems with Large Amounts of Wind Power

1.0 Introduction

Wind power will introduce more uncertainty into operating a power system; it is variable and partly unpredictable. To meet this challenge, more flexibility will be needed in the power system. How much extra flexibility is needed depends on how much wind power there is and on how much flexibility exists in the power system. To explore issues of wind power's effects on the overall power system, Annex 25 to the IEA Wind Implementing Agreement was approved in 2005 for three years (2006–2008) and was granted a second term (2009–2011) in September 2008. Table 1 shows

the participants in the task. During the first term, 11 countries plus the European Wind Energy Association (EWEA) participated in the Task; for the second term, Canada and Japan also have joined.

The existing targets for wind power capacity anticipate a quite high penetration in many countries. It is technically possible to integrate very large amounts of wind capacity in power systems; the limits arise from how much can be integrated at socially and economically acceptable costs. So far, the integration of wind power into regional power systems has mainly been studied on a theoretical basis, as wind power penetration

Table 1 IEA Wind Task 25 Participants, Second Term (2009–2011)

Country	Contracting Party; Organizations Coordinating Work; [TSO participants in brackets]*
Canada	National Resource Canada; [Hydro Quebec]
Denmark	Danish Energy Agency; Risø-DTU; [Energinet.dk]
EWEA	European Wind Energy Association
Finland	TEKES; VTT Technical Research Centre of Finland (OA)
Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety; ISET; [RWE and E.ON Netz]
Ireland	Sustainable Energy Ireland; ECAR; [Eirgrid]
Japan	AIST
Netherlands	SenterNovem; ECN
Norway	Enova SF; SINTEF Energy Research; [Statnett]
Portugal	INETI; [Rede Electrica Nacional (REN)]
Spain	CIEMAT; Universidad de Castilla–La Mancha
Sweden	Swedish Energy Agency; Kungliga Tekniska Högskolan (KTH)
UK	Department for Business, Enterprise & Regulatory Reform; Centre for Distributed Generation and Sustainable Electrical Energy; [National Grid]
United States	U.S. Department of Energy; NREL; Utility Wind Integration Group (UWIG)

*In some countries, such as Finland and Sweden, the TSO follows the national advisory group. CIGRE JWG C1,3,6/18 and European TSO consortium EWIS have sent observers to meetings.

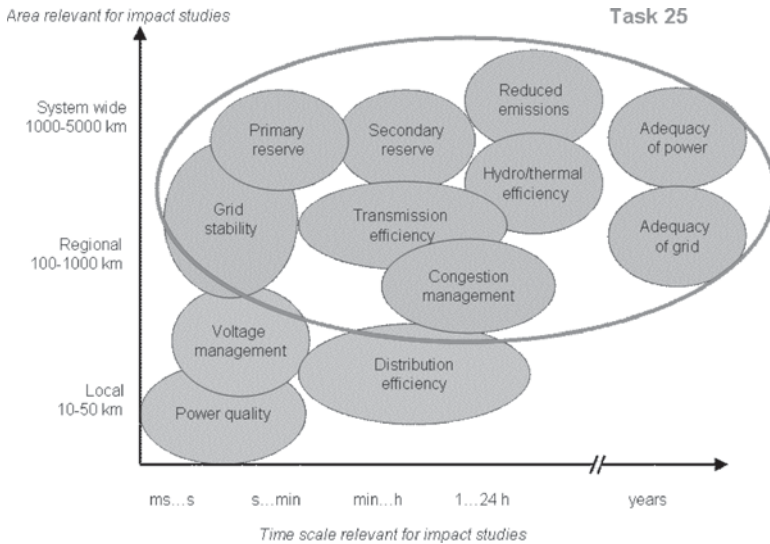


Figure 1 Impacts of wind power on power systems, divided into different timescales and sizes of area relevant for the studies. Primary reserve is denoted for reserves activated in seconds (frequency activated reserve; regulation) and secondary reserve for reserves activated in 5–15 minutes (minute reserve; load following reserve).

is still rather limited in most countries and power systems. However, some regions— e.g., western Denmark, northern Germany, and the Iberian Peninsula (Spain and Portugal)— have significant practical experience with wind integration and already show a high penetration of above 10% of electricity consumption coming from wind power.

In recent years, several reports have been published investigating the power system impacts of wind power. However, results on the costs of integration differ substantially, and comparisons are difficult to make. This is due to using different methodology, data, and tools during the investigations and different terminology and metrics in representing the results. An in-depth review of the studies has been started in Task 25 to draw any conclusions on the range of integration costs for wind power. Because system impact studies are often the first steps taken toward defining wind penetration targets in each country, it is important that commonly accepted standard methodologies are applied in system impact studies.

2.0 Objectives and Strategy

The ultimate objective of IEA Wind Task 25 is to provide information to facilitate the highest economically feasible wind energy penetration in electricity power systems worldwide. Task 25 work supports this objective by analyzing and further developing the methodology to assess the impact of wind power on power systems. Task 25 has established an international forum for exchange of knowledge and experiences related to power system operation with large amounts of wind power. The challenge is to create coherence between parallel activities with transmission system operators and other R&D task work and to remain as the internationally accepted forum for wind integration.

The participants will collect and share information on the experience gained in current and past studies. Their case studies will address different aspects of power system operation and design: reserve requirements, balancing and generation efficiency, capacity credit of wind power, efficient

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use of existing transmission capacity and requirements for new network investments, bottlenecks, cross-border trade, and system stability issues. The main emphasis is on technical operation. Costs will be assessed when necessary as a basis for comparison. Also, technology that supports enhanced penetration will be addressed: wind farm controls and operating procedures, dynamic line ratings, storage, demand side management (DSM), and so on.

The task work began with a state-of-the-art report collecting the knowledge and results to date. This report was updated as a final report of 2006–2008 work during spring 2009. The task will end with developed guidelines on the recommended methodologies when estimating the system impacts and the costs of wind power integration. Best-practices recommendations will be formulated on system operation practices and planning methodologies for high wind penetration.

3.0 Progress in 2008

3.1 Research progress

The meetings organized by Task 25 have established an international forum for exchange of knowledge and experiences. The spring task meeting in 2008 was organized in Denmark and hosted by the TSO Energinet.dk. In the autumn meeting, hosted by ECAR and SEI in Dublin, participating countries presented the national results in a one-day seminar followed by discussions about the final report.

Coordination with other relevant activities is an important part of the Task 25 effort. The meetings in 2007 were organized in conjunction with Task 24, Integration of Wind and Hydropower Systems. The system operators of Denmark, Germany, Ireland, Portugal, and the UK have joined the meetings organized thus far. Links between TSO organization working groups at CIGRE and ETSO European Wind Integration Study (EWIS project) have been formed, and observers have joined Task 25 meetings in 2008 and 2009.

Publication of the work is a key goal of Task 25 co-operative research. In 2007, national case studies presented in a session organized for the European Wind Energy Conference (EWEC) in Brussels in April 2008. Task 25 work and results were presented at several other key meetings in 2008: the CIGRE C6-08 meeting in Berlin, Germany; the Irish Wind Energy Association meeting; a wind integration workshop in Madrid, Spain; the Windpower 2008 conference in Houston, Texas, United States; and the IEEE Power Engineering Society meeting in Pittsburgh, Pennsylvania, United States.

Work has begun on a simplified assessment of wind integration effort and power system flexibility. The assessment draws on the work done by the Operating Agent for an IEA Secretariat study for the G8 on integrating renewable energy sources. In addition, a paper collecting results on statistical methods assessing short-term reserve requirements of wind power from Finland, Sweden, and the United States was published in *Wind Engineering*.

The Task 25 web site has been established at <http://www.ieawind.org> under Task Web Sites. The public portion of the site contains the Task 25 publications and a bibliography completed in 2008 in conjunction with Task 24 that lists publications related to system integration. The members-only section details the meeting presentations and information relevant to task participants.

3.2 Results of the final report 2006–2008

The results of the final report of the first phase of 2006–2008 can be used by participating countries to show the error of claims that wind power requires large amounts of reserve power and that integration costs erode the benefits of wind power. The report finds that a substantial tolerance to variations is already built in to our power network. This is why the influence of wind

power fluctuations can be further balanced through a variety of relatively easy and inexpensive measures for reasonably large penetrations (10% to 20%). The impact of a large share of wind power can be controlled by appropriate grid connection requirements, extension and enforcement of transmission networks, and integration of wind power production and production forecasts into system and market operation.

The report emphasizes the benefits of operating the power systems in a coordinated manner and/or with larger balancing areas. The aggregation benefits of a power system that covers a large area help to reduce wind power fluctuations and improve predictability. A large power system also has more generation reserves available, and the increased regulation effort can be implemented cost-effectively. The transmission capacity between areas is crucial for the use of the benefits arising from large production areas. An electricity market in which production forecasts can be updated a few hours ahead also helps in limiting forecast errors and thereby the costs of balance power.

The main results of the state-of-the-art report can be divided into three categories:

(1) Additional costs arising from the balancing of wind power fluctuations. With wind power penetrations amounting to 10% to 20% of the gross electricity demand, the additional cost (per megawatt hour of wind power) arising from the balancing of wind power fluctuations is estimated to range between 1 and 4 €/MWh. This is less than 10% of the long-term market value of electricity.

(2) Grid reinforcement needs due to wind power. Current wind power technology makes it possible for wind power plants to support the grid in the event of faults such as significant voltage drops and to participate in voltage regulation. Wind power plants are also able to limit their production fluctuations. Grid reinforcement needs related to wind power vary among countries depending on the

distance between consumption centers and wind power plants and the strength of the existing grid.

(3) Capacity value of wind power, i.e. the ability of wind power to replace other power plant capacity. Even though wind power is mainly an energy resource that replaces fossil power generation, it can also be used for replacing existing power plant capacity. In areas where the overall wind penetration level is low, wind power can replace other capacity by its average power, typically 20% to 40% of the installed wind power capacity. However, when penetration levels are high (e.g., 30%) and in areas where wind power production during peak demand is always low, wind power can only replace other capacity by 5% to 10% of the wind power capacity.

Figures 2 through 4 summarize the results from case studies reviewed in the final report for 2006–2008. They also illustrate the difficulties in comparing the results from existing studies. The range evident in the results is great due to the different power systems in question and different methodologies applied in the studies. Comparison of the studies showed that assumptions concerning the use of international transmission connections and the timescale of updating wind power forecasts had major impacts on the results.

4.0 Plans for 2009 and Beyond

The final report for 2006–2008 will be published in 2009. Journal articles will be written about some of the issues in the final report. A meeting is scheduled for early in the year hosted by Imperial College (DG&SEE) and National Grid. Another meeting is planned for mid-October in Germany in conjunction with the 8th International Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Farms, where Task 25 will organize a session. Task 25 work and results will be presented at several other meetings

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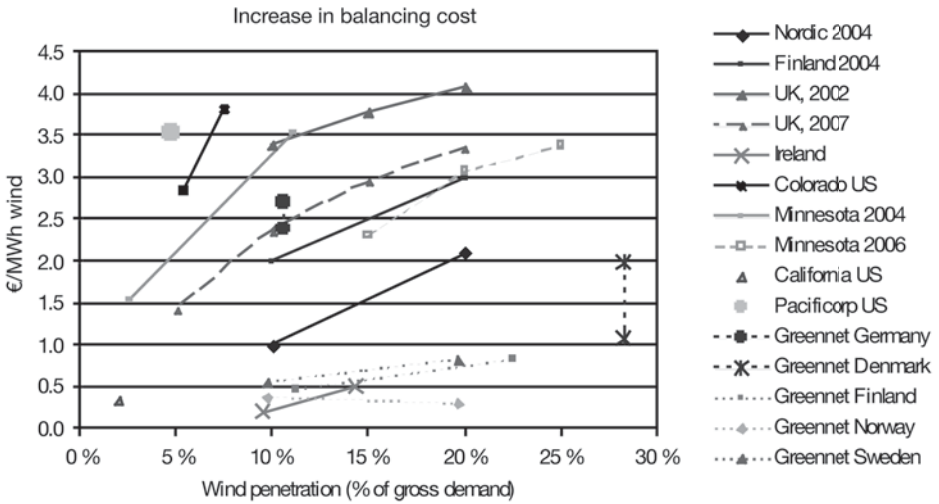


Figure 2 Results from estimates for the increase in balancing and operating costs due to wind power. The currency conversion used here is 1 € = 0.7 £ and 1 € = 1.3 USD.

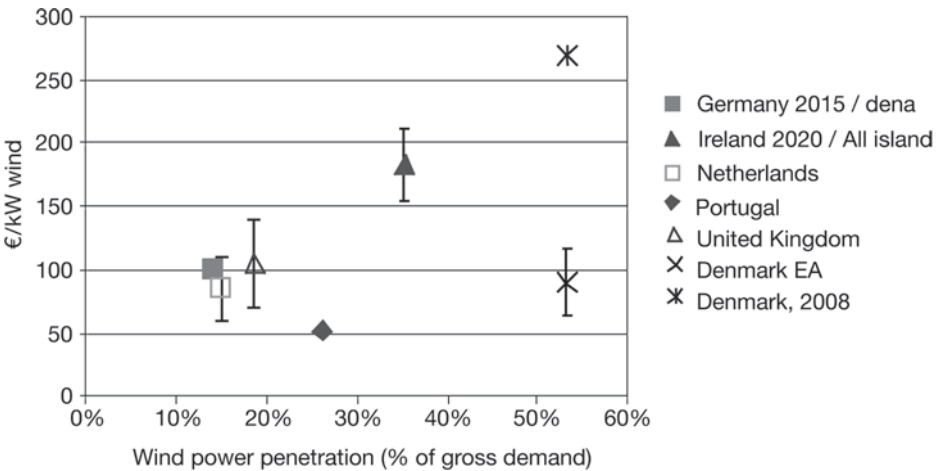


Figure 3 Results from studies on grid reinforcement costs due to wind power (for Denmark, the results are to reach from 20% to 50% penetration).

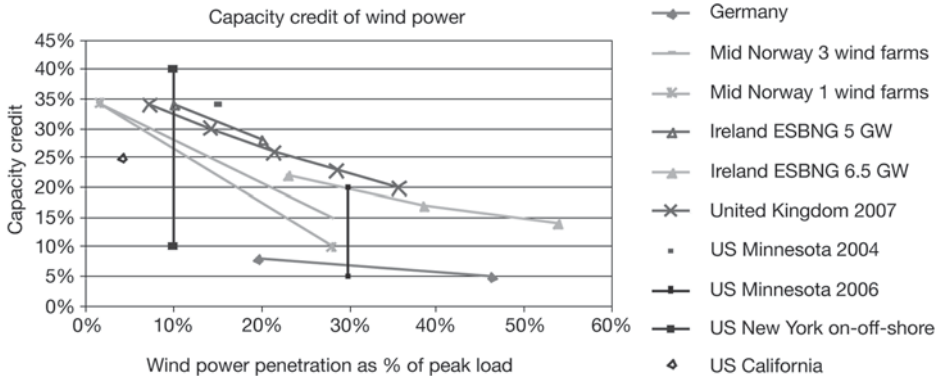


Figure 4 Results from studies on the capacity value (capacity credit) of wind power.

in 2009, including EWEC 2009 and the 14th Kasseler Symposium Energie-System-technik, Germany.

The topic being addressed by Task 25 is growing exponentially in importance in the member countries and more broadly. There is consensus that the work of the task has only just begun. During the second term, participants will expand into studies of higher-penetration that will address the important topic of cost/benefit analysis of wind power integration and will go more deeply into the subject of modeling power

systems with wind power. Work on creating simple rules of thumb stating the probable impacts and cost ranges for different power systems with different levels of wind penetration will be continued in collaboration with the IEA Secretariat's IREG2 project. The library on the Task 25 web site will be complemented and updated.

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1.0 Introduction

Wind power generation has come to a “historical” point at which, just as installed costs were becoming competitive with other conventional technologies, the investment cost per megawatt for new wind power projects has started increasing. This is believed to be the result of increasing commodity prices (mainly raw material such as copper and steel, plus a bottleneck in certain sub products) and the current tightness in the international market for wind turbines. Signals in the U.S. market indicate a 50% increase in the investment cost of wind systems, up to approximately 1,800 USD/kW. Other important markets for wind energy are also experiencing a rising costs, although noticeable differences still exist among countries.

This is precisely the background that justifies the initiation of a new task. Because wind is becoming an important source of electricity generation in many markets and is competing with other technologies—notably natural gas and nuclear—in terms of new installed capacity, it is crucial that governments and the wind research

community are able to discuss the specific costs of wind systems on the basis of a sound methodology. Without a clear impartial voice regarding costs, organizations without a good understanding of wind systems are left to determine and publicize their costs, often in error. These issues are exacerbated by the diversity of the wind portfolio and variations in international project development costs assumptions. The work undertaken in this cost task is also expected to provide a methodology for projecting future wind technology costs. Finally, this task aims to form the basis for a more comprehensive analysis of the value of wind energy. Table 1 lists participants in the task for 2008.

2.0 Objectives and Strategy

The objectives of this task are

- To establish an international forum for exchange of knowledge and information related to the cost of wind energy.
- To identify the major drivers of wind energy costs—e.g., capital investment, installation, operation and

Table 1 IEA Wind Task 26 Participants in 2008	
Country	Contracting Party; Organizations
Denmark	Danish Energy Agency; Risø National Laboratory /DTU, EA Energy Analyses
EWEA	European Wind Energy Association
Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety; WindGuard
Netherlands	SenterNovem; ECN
Spain	CIEMAT; AEE
Sweden	Swedish Energy Agency; Vattenfall
Switzerland	Swiss Federal Office of Energy
United States	U.S. Department of Energy; NREL (OA)

maintenance, replacement, insurance, finance, and development costs—and to quantify the differences of these cost elements among participating countries.

- To develop an internationally accepted, transparent method for calculating the cost of wind energy that can be used by the International Energy Agency (IEA) and other organizations.
- To derive wind energy cost and performance projections, or learning curves, that allow governments and the research community to anticipate the future trends of wind generation costs.
- To compare the cost of wind energy with those of other electricity generation technologies, making sure that the underlying assumptions used are compatible and transparent.
- To survey various approaches to estimating the value of wind energy, e.g., carbon emission avoidance, fuel price stability.

Three activities are proposed to achieve these objectives: 1) development of a transparent method for estimating cost of wind energy and identification of major cost drivers; 2) estimation of future cost and performance of land-based and offshore wind projects; and 3) assessment of methodologies and results for estimating the value of wind energy.

Providing transparency in the cost elements of wind projects among all participating countries will result in better understanding of the cost drivers of wind technology and the reasons for differences among participating countries. Development of a simple spreadsheet model that represents the major elements of wind projects' costs will result in a tool that could be used by IEA or others in estimating wind project costs. The model inputs and methodology will be clearly defined and documented. A representative set of input parameters specific to each participating country will be collected. These data should represent typical costs and project

performance for proposed or installed projects, for both land-based and offshore wind technology. Manufacturers, developers, and other wind industry participants should be engaged to obtain these representative costs. Methods such as surveys or interviews could be used. Based on this common set of data from each participating country, assumptions for a generic estimate of wind energy costs will be determined. Each participant will provide documentation of their representative cost data and will quantify the differences between their country's cost structure and that of the generic model. A report will summarize these results, providing insight into the different cost drivers for each participating country.

Estimates of future cost and performance for wind technology are important for analyses of the potential for wind energy to meet national targets for carbon emission reductions or renewable electricity generation. Learning curves are one method for assessing the effects of technology development, manufacturing efficiency improvements, and economies of scale. National laboratory component-level cost and scaling relationships can also be used to estimate future technology development pathways. Although costs have decreased since the early 1980s, recent trends indicate rising costs that have been attributed to tight supply, commodity price increases, and other influences. These effects may continue in the future, and it is important to identify the contribution of such market influences to wind technology costs. These effects, and their relation to technology advances, should be incorporated into methods to project future costs and performance for wind technology. A thorough assessment of the effect of wind technology changes such as increased generator size, larger rotors, and taller towers over the past decade will help inform the use of learning curves and engineering models to develop future cost and performance trajectories.

Wind energy technology ultimately operates in an electricity system that includes conventional and other alternative

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electricity generation technologies. Wind energy technology adds value to a system in several ways, including reducing carbon emissions, diversifying the fuel supply, and providing stable energy production prices. Various methods and approaches are used to quantify these impacts of wind energy deployment. This work package will provide a summary of these concepts and approaches.

3.0 Progress in 2008

Development of the work plan for this task was the primary activity in 2008. All participants agreed to the work plan in early 2009. Development of a cost of wind energy discounted cash flow model was also agreed on as the approach for the first work package.

4.0 Plans for 2009

During 2009, the primary activity will be directed toward the development of a cost of wind energy discounted cash flow model and a comparison of input data from each of the participating countries. Each country will provide specific guidance to ECN and NREL for development of a spreadsheet model and a glossary of terms. Next, input

data representing the various wind energy costs in each participating country will be collected, and the model will be exercised to represent costs in each country. A generic representation of wind energy costs will be agreed on by all participants. Finally, an analysis in which each country identifies the primary differences between actual costs and the generic cost model will be conducted. A report summarizing the influences of different costs among the participating countries will be compiled in the following year. Most of this work will be conducted by web-based meetings. However, an in-person meeting will be held in Sweden in September. At this meeting, assumptions for a generic cost of wind energy model will be determined. An approach to begin the work of identifying future wind energy cost and performance projections will also be addressed. The work for this task formally began in January 2009 and is expected to continue for three years until the end of 2011.

Author: M. Maureen Hand, National Renewable Energy Laboratory, the United States.

Consumer Labeling of Small Wind Turbines

1.0 Introduction

This task, approved in April 2008, will develop and deploy a system of quality labeling for consumers of small wind turbines. The task will also contribute to and use an IEA Wind Recommended Practice for labeling small wind turbines. For anyone interested in buying a small wind turbine, this work will also provide information such as recommended methodologies and independent test reports on power performance curves, acoustic noise emissions, strength and safety, and duration tests. The actual testing of the wind turbines is beyond the scope of Task 27. Reliable third-party testers such as national laboratories, universities, and certification entities already exist. The Operating Agent of this task will direct small wind turbine manufacturers to these testers in order to get a label for their products.

The task's primary goals are to 1) build bridges between small wind turbine manufacturers and third-party testers and 2) to provide private companies with a commonly accepted testing methodology (IEA Wind Small Wind Turbine Recommended Practice). Table 1 lists the countries participating in Task 27 in 2008.

2.0 Objectives and Strategy

The entire wind energy sector should support the labeling initiative to reduce the risk of accidents with small wind turbines and to minimize deceptive investments in less than optimum equipment. The primary objective of this new task is to give incentives to this industrial sector to improve the technical reliability, and therefore the performance, of small wind turbines. The intention is to define a globally standardized product label for small wind turbines and minimum requirements for a testing process that would allow a label to be placed on products. This would give customers and governments minimum assurances regarding the safety and performance of small wind turbines. Common methodologies to test equipment and test results displayed in a form understood by consumers will increase the maturity of the small-scale wind power sector. In addition, consumer quality labels will benefit manufacturers of high-quality small wind turbines, that compete in a marketplace with outdated or untested technologies. But mostly, the outcome of this task will benefit potential buyers and installers of small wind turbines and the official energy entities that give permits to connect them to the electric grid.

Table 1 IEA Wind Task 27 Participants in 2008

Country	Contracting Party; Institutions Coordinating Work
Australia	Clean Energy Council; RISE, Murdoch University
Canada	Natural Resources Canada; WEICan
Japan	AIST; JEMA
Spain	CIEMAT (OA)
Sweden	Swedish Energy Agency; INTERTEK
United Kingdom	Department for Business, Enterprise & Regulatory Reform; BWEA, TUV-NEL
United States	U.S. Department of Energy; NREL, Small Wind Certification Corporation

Task 27

To accomplish these outcomes, several goals must be met.

- To build up a critical mass of involvement the task will include government agencies, wind turbine manufacturers, and third-party testers (primarily universities, national laboratories and institutes, and companies having considerable experience in testing wind power devices) to develop methodologies for testing and presenting results and for labeling classification. This critical mass should provide the necessary basis for development and wide use of the IEA Wind Recommended Practices for the small-scale wind power sector.
- To test methodologies and labels on several small wind turbines and provide feedback to entities that are working to update methodologies in this area.
- Strongly increase consumer and official entities awareness.

The main deliverables of this new task are a system of quality labels for small wind turbines and an IEA Wind Small Wind Turbine Recommended Practice as a pre-normative international standard for testing and labeling small wind turbines.

During the preparation of the IEA Wind Task 27 work plan, several initiatives to develop domestic small wind turbine quality label procedures have been launched. Among them are the British Wind Energy Association (BWEA) Small Wind Turbine Performance and Safety Standard in February 2008 and the American Wind Energy Association Small Wind Certification Corporation (AWEA-SWCC) initiative in the United States proposed for January 2009. However, no systematic international approach for quality labeling of small wind turbines has yet been established.

3.0 Progress in 2008

In response to the same pressures that prompted development of the IEA Wind

Task 27 proposal, IEC TC 88 proposed developing a third edition of the standard 61400-2 Ed 2 “Requirements for Small Wind Turbines.” This initiative to improve the standard was presented and approved in the plenary meeting of the IEC in Beijing (China) in September 2008. In addition to the existing areas of 61400-2 Ed 2, the new edition would introduce changes desired by the small wind turbine industry relating to power performance testing; acoustic sound testing; strength, safety, and design requirements; duration testing; reporting and certification; change control of certified products; and, consumer labeling.

The IEC TC 88 revisions to 61400-2 and IEA Wind Task 27 initiatives regarding small wind turbine labeling have some important conceptual differences. IEC TC 88 prepares and publishes international standards for wind energy technology. IEA Wind will provide private companies with a commonly accepted methodology for labeling so they can enter or remain in the market. The IEC TC 88 proposal to revise 61400-2 is a very ambitious initiative that will take years to complete. The IEA Wind Task 27 initiative could be developed more quickly to deliver international recommendations for manufacturers and end users. By focusing on labeling, the Task 27 activities will complement the work of IEC TC 88 to produce 61400-2 Ed 3.

4.0 Plans for 2009 and Beyond

An IEA Wind Task 27 kickoff meeting was held in Madrid, Spain in February 2009 to analyze the status of the small wind sector in terms of quality certification in the various countries. This meeting was organized in liaison with the IEC TC 88. After this kickoff meeting, several other IEA-IEC liaison meetings were scheduled for 2009 in the United Kingdom, the United States, Canada, and Japan. The agenda for these meetings is to complete task planning and assign working groups for proposed activities.

The expected results of this task are as follows:

- An IEA Wind Small Wind Turbine Recommended Practice that is a base document in pre-normative form to guide and aid manufacturers, independent organizations acting as testers of small wind turbines, and public entities and investors involved in developing, selecting, and licensing wind turbines.
- An expanding worldwide list of manufacturers that have submitted their equipment to third-party tests according to the IEA Wind Small Wind Turbine Recommended Practice.
- An expanding list of third-party testers according to the IEA Wind

Small Wind Turbine Recommended Practice.

- Within three years, to convey the work to IEC to develop an international standard, and/or to establish a more permanent hosting/funding of the management of the labeling effort.
- Higher consumer awareness of small wind turbines, resulting in the use of better equipment.
- Improved awareness of IEC standards in this area.

Author: Ignacio Cruz, CIEMAT, Madrid, Spain.

Social Acceptance of Wind Energy Projects

1.0 Introduction

The mission of the IEA Wind Implementing Agreement is to stimulate co-operation on wind energy research and development and to provide high quality information and analysis to member governments and commercial sector leaders by addressing technology development and deployment and its benefits, markets, and policy instruments. Within IEA Wind, environmental and societal issues are sometimes referred to as 'soft issues' to differentiate them from technology aspects. However, environmental and societal issues have become pivotal to the deployment of wind energy in many countries. Even where the economics of wind energy are favorable, deployment can only occur when the public and the planning authorities accept the technology. This requires an appreciation of the benefits of wind energy that weigh against any local visual and environmental effects. To address these issues, seven countries participate in IEA Wind Task 27 (Table 1).

2.0 Objectives and Strategy

A first short report on social acceptance was presented to the IEA Wind ExCo at the end of 2007. Specific or partial objectives of this task are to establish an international forum for exchange of knowledge and

experiences related to social acceptance and other societal issues. The work will produce a state-of-the-art report on the knowledge and results so far on social acceptance of wind power installations, including a list of studies and online library of reports and articles. The participants will establish "Best Practices" and tools for policy makers and planners to reduce project risks due to lack of social acceptance, accelerate time of realization of projects, accelerate the exploitation of the full potential of wind energy in the concerned countries, and establish strategies and communication activities to improve or to maintain the image of wind power.

Three different groups of people participate in Task 28. The *Working Group* (1 or 2 people per participating country) represents the main working body of the task. Its members make the essential contributions to the task goals by working out the results of the work packages (Table 2). Members of the *Support Group* (1 or 2 people per participating country) re-views and contributes to the results of the working group by commenting on the proposed reports and suggesting future activities to the working group. Members have yet to be defined. Members of the *Social Acceptance and Wind Energy Community* are the

Table 1 IEA Wind Task 28 Participants in 2008

Country	Contracting Party; Institution(s)
Canada	Natural Resources Canada; University of Québec at Montréal
Finland	TEKES; wpd Finland Oy
Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety; Martin-Luther-University, Otto-von-Guericke-University
Japan	AIST; the University of Tokyo
Norway	Enova SF; Centre for Energy and Society, NTNU
Switzerland	Swiss Federal Office of Energy; ENCO Energie-Consulting AG (OA)
United States	U.S. Department of Energy; NREL

Table 2 Members of Working Group for Task 28	
Canada	University of Québec at Montréal, Department of Political Science
Finland	wpd Finland Oy
Germany	Martin-Luther-University Halle-Wittenberg, Institute for Psychology; Federal Ministry for the Environment, Nature Conservation and Nuclear Safety; Otto-von-Guericke-University Magdeburg, Institute for Psychology
Japan	The University of Tokyo
Norway	Center for Energy and Society, Department of Interdisciplinary Studies and Culture
Switzerland	Swiss Federal Office of Energy, Wind Department; ENCO Energie-Consulting AG
United States	National Wind Technology Center, NREL

recipients of the task's results, persons to be invited to seminars, and scientists and researchers to be informed about the task activities.

2.1 Overview of anticipated results

The participants have formulated the possible results from the task's activities:

- State-of-the-art report
- Guidelines with a list of best practices (methodology, input data, especially how so-cial acceptance to be considered in project development)
- Translation of the existing knowledge of social scientists into the language of planners and engineers to improve and speed up wind energy planning processes, e.g. how to elicit participation or how to turn affected people into positively involved parties
- Description of successful participation models
- Curricula on social acceptance issues for seminars, training courses, and teaching units for wind power people
- Conference on social acceptance with developers and politicians (in 2-3 years), and perhaps scheduled around an EWEA conference
- Published results of the task in reports and available on a server

- Proceedings from workshops (presentations given at research meetings plus notes of the summary discussions)
- An online library of case study reports generated by the research participants

Due to the expected relevance of the outcomes of this task to the policy makers of the different countries, results on guidelines, new methodologies, strategies, and best practices will be available to all participating countries, even when not directly represented in the task.

2.2 Structure of activities and projects

Based on the Task Proposal, the participants structured the possible activities and projects according to the list in Table 3. The website, the on-line library, and the questionnaire concerning various projects will be ordered in this way.

3.0 Progress in 2008

The Task proposal was approved to move forward by the ExCo at the meeting in April 2008. The proposed Operating Agent is ENCO Energie-Consulting AG Switzerland represented by Robert Horbaty. A first Pre-kick-off Meeting was held in August Bubendorf, Switzerland. Seven countries

Task 28

Table 3 Structure of activities of Task 28	
0 Definition of Social Acceptance - What it is and why we need it.	4 Instruments - Visual impacts - Photomontage - Communication campaigns.
1 National Wind Energy Concepts - National / State incentive programs - Spatial planning, planning aid.	5 Stakeholders - e.g. Utilities - Financial institutions - NGO.
2 Distributional Justice - Burden sharing - Compensation of land use - Compensation of impacts.	6 Well-being - Standard of living - Quality of life - Health.
3 Procedural Design - Communication strategy - Step by step procedure - Participation of locals - Social design process - Siting.	

committed and another five expressed interest. A website has been developed that can be accessed through www.ieawind.org or www.socialacceptance.ch, internal pages are accessed by a password issued by the OA representative.

4.0 Plans for 2009 and Beyond

Task 28 work will officially start in 2009 and will conduct activities for three years— from 2009 through the end of 2011 (Figure 1). The participants discussed the work plan at the pre-kick-off meeting and agreed upon three work packages.

4.1 Work Package 1: State-of-the-art

- Produce a questionnaire for persons and projects
- Make a list for the Kick-off Meeting to state “Wishes” / “Needs” / “Requirements” and specify relevant projects (existing, planned, or open)
- Collect information on researchers and projects in different countries: Who is doing what
- Create a website and an online library

• Write a State-of-the-art Report

- The report should have the same structure as in Table 1, except there will be an Introduction (What it is and why we need it), a detailed Description of Task 28, and Definitions.
- Every chapter should distinguish between “What do we know?” and “What do we want to know?”
- Arrange a 1st workshop with the Support Group
 - Present state-of-the-art report
 - Define open questions
 - Define possible new case studies and research content
 - Evaluate key factors for success and non-success in the siting and micro-siting processes

4.2 Work Package 2: Best practice

- Analyse the various projects
- Analyse case studies to determine which strategy leads to the best results
- Compare and evaluate national and regional policy frameworks

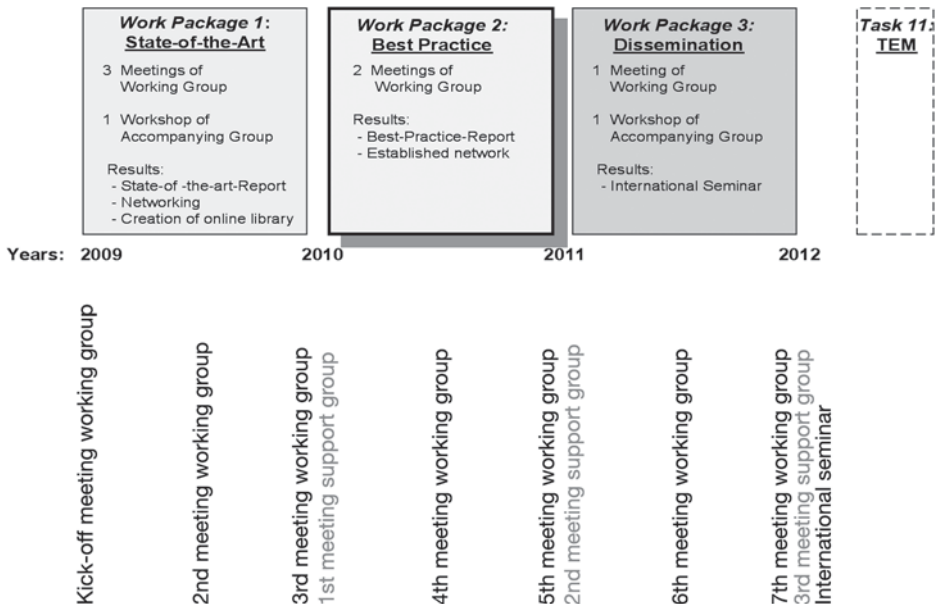


Figure 1 Work plan of Task 28 Social Acceptance of Wind Energy Projects.

- Verify the underlying concept of social acceptance (triangle model)
- Compare and evaluate different participation models (“How to turn affected people into involved parties”)
- Understand and describe the concept of “procedural fairness”
- Describe proposed processes and strategies in the fields of:
 - Stakeholder analysis,
 - Participation processes, and
 - Planning procedures
- Write Best Practice Report
- Arrange a 2nd workshop with the Support Group.

4.3 Work Package 3: Dissemination

- Collect existing material on courses, etc.
- Produce manuals and instructions for planners
- Organize an international seminar or workshop in conjunction with the 3rd workshop of the Support Group.

4.4 Next Meetings

The following dates are proposed for the next meetings:

- Kick-off Meeting: 20–21 March 2009 (Magdeburg, Germany), only Working Group
- 2nd Meeting, Autumn 2009, Tentative dates: 26–27 October 2009 (Boulder, Colorado, United States), only Working Group
- 3rd Meeting, Spring 2010 with EWEA Conference, Tentative dates: 20–23 April 2010 (EWWC 2010 in Warsaw, Poland), Working Group and Support Group.

Reference:

(1) Strategic Plan of IEA R&D Wind, 1 November 2003 – 31 October 2008, www.ieawind.org.

Author: Robert Horbaty, ENCO Energie-Consulting AG, Switzerland

Analysis of Wind Tunnel Measurements and Improvement of Aerodynamic Models

1.0 Introduction

The accuracy of wind turbine design models has been assessed in several validation projects (1, 2, 3). They all show that the modeling of a wind turbine response (e.g. the power or the loads) is subject to large uncertainties. These uncertainties mainly find their origin in the aerodynamic modeling where several phenomena such as 3-D geometric and rotational effects, in-stationary effects, yaw effects, tower effects, and stall, amongst others contribute to unknown responses, particularly at off-design conditions. These unknown responses make it very difficult to design cost-effective and reliable wind turbines. Turbines behave

unexpectedly; they experience instabilities, power overshoots, or higher loads than expected. Alternatively, the loads may be lower than expected which implies an over dimensioned (and costly) design. To improve these models used to design wind turbines the countries and institutes listed in Table 1 have expressed their interest to participate, although some are not yet sure about the availability of funding (4).

The availability of high quality measurements is considered to be the most important pre-requisite to gain insight into these uncertainties and to validate and improve aerodynamic wind turbine models. However, conventional experimental

Country	Contracting Party; Institution(s)
Canada	Natural Resources Canada; École de technologie supérieur, Montreal
Denmark	Danish Energy Agency; RISØ DTU/DTU-MEK, and LM-Glasfiber
Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety; University of Stuttgart, University of Applied Sciences, Kiel and Forwind
Japan	AIST; Mie University, and National Institute of Advanced Industrial Science and Technology
Korea	New & Renewable Energy Division of the Ministry of Knowledge Economy; Korea Institute of Energy Research, and Korea Aerospace Research Institute
The Netherlands	Senter/Novem; ECN (OA), University of Delft, TUDelft, and AE-Rotortechneik
Norway	Enova SF; Institute for Energy Technology/Norwegian University of Science and Technology, IFE/NTNU
Spain	CENER
Sweden	Swedish Energy Agency; Royal Institute of Technology/University of Gotland
UK	Department for Business, Enterprise & Regulatory Reform; University of Liverpool
USA	U.S. Department of Energy; NREL

programs on wind turbines generally do not provide sufficient information for this purpose, since they only measure the integrated, total (blade or rotor) loads. These loads consist of an aerodynamic and a mass induced component and they are integrated over a certain spanwise length. In the late 1980's and the 1990's it was realized that more direct aerodynamic information was needed in order to improve the aerodynamic modeling. For this reason several institutes initiated experimental programs in which pressure distribution and the resulting normal and tangential forces at different radial positions were measured. Under previous research tasks of the IEA Wind, many of these measurements were stored in a database in Task 14 Field Rotor Aerodynamics and Task 18 Enhanced Field Rotor Aerodynamics Database (5). The results of these measurements turned out to be very useful and important new insights about 3-D stall effects, tip effects, and yaw were formed. However, the measurements were taken on turbines in the free atmosphere, where the uncertainty due to the in-stationary, inhomogeneous, and uncontrolled wind conditions formed an important problem (as it is in all field measurements).

This problem was overcome when the National Renewable Energy Laboratory (NREL) National Aeronautics and Space Administration (NASA)-Ames wind tunnel experiment that was carried out in 2000 in the United States (2). In this experiment, a heavily instrumented rotor with a 10 m diameter was placed in the 24.4-m by 36.6-m wind tunnel and measured with few blockage effects. Although this rotor diameter is still much smaller than the diameter of modern commercial wind turbines, the blade Reynolds number (in the order of 1 million) was sufficiently high to make the aerodynamic phenomena, at least to some extent, representative of modern wind turbines. NREL made the measurements from this experiment available to other institutes and they were analyzed within IEA Wind Task 20 HAWT Aerodynamics and Models

from Wind Tunnel Measurements, completed in 2007.

IEA Wind Task 29 MEXNEX(T) is the successor of Task 20. It will use the wind tunnel measurements from the EU project Model Experiments in Controlled Conditions (MEXICO) that became available in December 2006 (1). In this project, detailed aerodynamic measurements were carried out on a wind turbine model with a diameter of 4.5 m, which was placed in the 9.5 m² LLF facility of the German Dutch Wind Tunnel (DNW). Within the MEXICO project, pressure surface data were measured at five radial positions (25%, 35%, 60%, 82%, and 92% span) together with blade root bending moments and tower bottom moments from a tunnel balance from DNW (Figure 1). Perhaps the most important feature of the measurements is the extensive flow field mapping from the stereo Particle Image Velocimetry (PIV) technique.

Although the size of the wind turbine rotor used is smaller, the MEXICO experiments were designed to be complementary with the NREL measurements at NASA-Ames. The most important difference between the two experiments is that the MEXICO project includes extensive flow field measurements, simultaneous with the pressure and load measurements. Also, the MEXICO model was three bladed, whereas the NREL model used at NASA-Ames was two bladed. Furthermore, the majority of the NREL measurements concern (the very important) stalled flow, while the entire operational envelope was covered in the MEXICO measurements. Finally, the MEXICO measurements made use of fast Kulite pressure transducers, which measure absolute pressures, whereas differential pressures were measured in the NREL experiment (both techniques have pros and cons).

The MEXICO database is still in a rather rudimentary form and only limited analyses have been carried out (6, 9, 10). This is the case because the amount of data is vast and the time needed to analyse all



Figure 1 The MEXICO model turbine in the LLF tunnel of DNW. The blue box is the yawable balance and the (vertical) yaw axis passing through the rotor center. The tunnel collector is shown in the background and the nozzle in the foreground. The nozzle measures 9.5 m², the collector 9.7 m².

data is extremely long for a single country. A cooperative research task under IEA Wind is an efficient way to organize the analysis of the MEXICO data. Added value also lies in the fact that the task will serve as a forum for discussion and interpretation of the results. This will generate more value from the data than the summed value from the individual projects.

In the IEA Wind Task 29 MEXNEX(T), the data will be accessible and a thorough analysis will take place. This includes an assessment of the measurement uncertainties and a validation of different categories of aerodynamic models (rotor aerodynamics and near wake models, where the latter type of models form part of wind farm models as well). The insights will be compared with the knowledge that was gained from IEA Wind Task 20 on the NASA-Ames experiment and from other experiments such as wind tunnel measurements from the Technical University of Delft (7) and FFA (8).

2.0 Objectives and Strategy

The objective of the IEA Wind Task MEXNEX(T) is a thorough investigation of the measurements which have been

carried out in the EU-sponsored MEXICO project. Special attention will be paid to yawed flow, instationary aerodynamics, 3-D effects, tip effects, non-uniformity of flow between the blades, near wake aerodynamics, turbulent wake, standstill, tunnel effects, etc. These effects will be analysed by means of different categories of models (computational fluid dynamics (CFD), free wake methods, engineering methods, etc.). A comparison of the MEXICO findings with the findings of the NASA-Ames and other experiments will also be carried out, providing insight on the accuracy of different types of models and descriptions for improved wind turbine models.

In order to reach the objective, the work plan is divided into five work packages (WP):

- WP1: Processing/presentation of data, uncertainties. The aim of this work package is to provide high quality measurement data to the calculational parties. In principle, the data is organized in a self explanatory way but it will be investigated whether some further processing, explanations, corrections, and descriptions are needed. Furthermore, an uncertainty analysis

will be performed in the form of consistency checks and an investigation of the reproducibility of the data. The WP also includes an assessment of the blade manufacturing (note that the actual blade shape has been measured). This shape will be compared with the specified geometry.

- WP2: Analysis of tunnel effects. The 4.5 m diameter wind turbine model was placed in the open jet section of the 9.5 m² LLF facility. This ratio of turbine diameter to tunnel size may make the wind tunnel situation not fully representative of the free stream situation. Therefore tunnel effects will be studied with advanced CFD models. Supporting information on tunnel effects will also be obtained from eight pressures, which were measured with taps in the collector entrance. These pressures measure the speedup in the outer flow (outside the wake) needed for the mass conservation of the tunnel flow.

- WP3: Comparison of calculational results from different types of codes with MEXICO measurement data. In this WP the calculational results from the codes which are used by the participants are compared with the data from the MEXICO experiment. It is meant to be a thorough validation of different codes and it provides insights into the phenomena which need further investigation (see WP4). The following quantities will be compared:

- Pressure surface data
- Aerodynamic normal force coefficients
- Aerodynamic tangential force coefficients
- Blade root bending moments and tower bottom loads
- PIV flow field data.
- P4: Deeper investigation into phenomena.

In this WP a deeper investigation of different phenomena will take place.

The phenomena will be investigated with isolated submodels, simple analytical tools, or by physical rules.

Phenomena that will be investigated include 3-D effects, instationary effects, yawed flow, non-uniformity of the flow between the blades (i.e. tip corrections), and the wake flow at different conditions, among other things.

- WP5: Comparison with results from other (mainly NASA-Ames) measurements. The results from WP3 and WP4 are expected to provide many insights into the accuracy of different codes and their underlying sub-models. Within WP5 it will be investigated whether these findings are consistent with results from other aerodynamic experiments, particularly the data provided within IEA Wind Task 20 from NREL's NASA-Ames experiment.

3.0 Progress in 2008

A kick-off meeting in September 2008 was attended by interested participants. Although formal work in the task begins in 2009, some interesting results were published in January 2009 (9, 10, 11).

4.0 Plans for 2009 and Beyond

As mentioned in section 3.0, Task 29 started only in September 2008 with a kick-off meeting which was attended by almost all interested participants. At this meeting a detailed time line was discussed. In 2009, the emphasis of the activities will lie on WP1 (Processing/presentation of data, uncertainties), WP2 (Analysis of tunnel effects), and WP3 (Comparison of calculational results from different types of codes with MEXICO measurement data). The time line of the project leads to production of the final report in 2011.

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(4) It is noted that Israel (Technion) is also interested in participating in MEXNEX(T), but Israel has not yet joined the IEA Wind Implementing Agreement. Actions have been taken to extend membership to Israel.

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Author: J. Gerard Schepers, ECN, the Netherlands.

1.0 Introduction

In 2008, Australia's renewable energy industry rapidly expanded due to a growing commitment from governments, communities, and investors to reduce carbon emissions. Renewable energy has proven to be an integral part of the energy mix as well as providing marked increase in national energy security.

In 2007, the government committed to ensuring that 20% of Australia's electricity supply would come from renewable energy sources by 2020 by establishing the expanded national Renewable Energy Target (RET) scheme. Draft legislation on the design of the RET was released in December 2008. The final legislation to implement the RET is expected to pass through parliament in mid-2009 and is due to commence on 1 January 2010. The national RET scheme will increase the existing MRET by more than four times to 45,000 GWh in 2020 to ensure that Australia reaches the 20% target by 2020.

Correctly drafted legislation such as the RET will be an important complementary measure in the government's climate change strategy. Its primary objective should be to develop a dynamic and internationally competitive clean energy industry in Australia. Its success will be demonstrated by its ability to stimulate investment

and innovation to exploit our abundant suite of world-class clean energy resources. This will foster accelerated development of emerging technologies and drive down costs for those already proven. Further, the 10,202 MW of projects currently in either development or evaluation (Table 2) is a clear indication of the potential of sound supportive policy for the industry.

2.0 Progress Toward National Objectives

2.1 Industry growth in 2008

The Clean Energy Council (CEC) exists as Australia's peak industry body to drive accelerated deployment and uptake of clean energy technologies and energy efficiency measures. It is funded by members to advocate policy on their behalf at an industry level, and it profiles the industry through forums such as conferences, seminars, and related publications.

In Australia, wind energy is a proven and reliable technology that can be and is readily deployed. At the close of 2008, there were 50 wind farms in Australia, with a total of 756 operating turbines. The total operating wind capacity was 1.3 GW

Total installed wind generation	1,306 MW
New wind generation installed	482 MW
Total electrical output from wind	3.462 TWh
Wind generation as % of national electric demand	1.3%
Target:	The Mandatory Renewable Energy Target, 9,500 GWh from renewables by 2010, has been met. The new government has promised a further Renewable Energy Target, 45,000 GWh from renewables by 2020, beginning in 2010 (combining and extending state targets). Legislated targets introduced by state governments: Victoria – 10% by 2016

National Activities

Table 2 Installed wind capacity in Australia 2008

Sum of installed capacity MW	
Operating	1,306
Construction	535
Development	5,824
Evaluation	4,378
Potential	484
Total	12,527

(Table 3). Several new projects also became fully operational throughout the year, adding capacity to the Australian electricity grid. These include Hallett Stage 1 (AGL, 95 MW), Lake Bonney Stage 2 (Babcock & Brown Wind Partners, 159 MW), Mt. Millar (Transfield Services Infrastructure Fund, 70 MW), and Snowtown Stage 1 (TrustPower, 99 MW), all in South Australia; Portland Stage 2—Cape Bridgewater (Pacific Hydro, 58 MW) in Victoria; and Kalbarri (VerveEnergy, 1.6 MW) in Western Australia.

Another six projects totaling 535 MW are under construction and expected to be commissioned in 2009. These include

Table 3 Total installed capacity in Australia

Year	MW
2000	32
2001	73
2002	105
2003	198
2004	380
2005	708
2006	817
2007	824
2008	1,306

Capital Wind Farm (Babcock & Brown Wind Partners, 140 MW) and Cullerin Range (Origin Energy, 30 MW) in New South Wales and Hallett Stage 2 (AGL, 71 MW) and Clements Gap (Pacific Hydro, 58 MW) in South Australia. In Victoria this includes Waubra (Acciona Energy, 192 MW) and Portland Stage 3—Cape Nelson South (Pacific Hydro, 44 MW), which is part of the Portland Wind Project.

The proposed target will stimulate more than 20 billion AUD of investment in Australia's emerging renewables industry. The wind industry will be a major contributor to Australia meeting this target.

2.2 The emissions trading scheme

The Australian federal government released its Carbon Pollution Reduction Scheme White Paper in late December 2008. It proposed that the emissions trading scheme start in 2010, assuming a starting carbon price of around 25 AUD/tonne. The price of emissions is set to be capped at 40 AUD/tonne, escalating at 5% real per annum. This rate is too low on its own to trigger investment in large-scale renewables. Allowing importing of emissions credits means the eventual carbon price is likely to be driven by international rather than Australian activity.

The industry is encouraged by the government's move to maintain momentum by starting the scheme in 2010 and highlighting the importance of stabilizing greenhouse gas concentrations at around 450 ppm CO₂e. Importantly, the white paper has for the first time outlined a set of principles by which all complementary measures will be developed. This will serve as a useful guide for future discussion relating to emission reductions. The principles focus on delivering against specific market failures and must ensure efficiency, effectiveness, equity, and administrative simplicity.

3.0 Benefits to National Economy

3.1 Market characteristics

The Australian wind power sector continues to make a significant contribution to

Australia's economy (Table 4), particularly in regional areas. Given that Australia is rich in renewable resources, it is likely that regional areas will see an influx of new clean energy developments such as wind or solar farms and bioenergy plants. Such changes will create great economic opportunities both regionally and nationally.

3.2 Grid connection issues

In mid-2008, an Australian wind energy forecasting system was implemented by NEMMCO, the operator for the National Electricity Market (NEM). This sophisticated forecasting model is called the Australian Wind Energy Forecasting System (AWEFS). It was established in response to the growth in intermittent generation such as wind and the increasing impact this growth is having on NEM's forecasting process. Wind energy's variability presents challenges for electricity system management.

The ability to better forecast wind power generation will assist in the management of the NEM and allow higher penetration of wind in the market. The AWEFS is a centralized system that provides predictions of wind energy generation compatible with NEMMCO's NEM management

systems. It takes weather forecasts from meteorological bureaus and operational data from wind energy generators, such as site wind speed and direction and turbine availability and output, to produce forecasts of expected wind energy generation.

The base AWEFS became operational in late 2008; Australia-specific functionality and enhancements are expected to be in place by 2010. While the AWEFS will initially operate in the NEM, the system is capable of being extended to other Australian electricity markets. The levels of available wind forecast information include dispatch forecast information from a single wind farm or all wind farms in a region.

In 2008, an amendment was made to the National Electricity Rules to allow for semi-dispatch of new generators, including wind farms. This allows generation from wind farms to be limited when required to better manage the constraints on the grid.

4.0 National Incentive Programs

4.1 State-based incentive programs

The Victorian Renewable Energy Target (VRET) scheme that commenced on 1 January 2007, mandates Victoria's consumption of electricity generated from renewable sources be 10% by 2016. Under the scheme,

Table 4 Australian wind energy industry 2008: Economic, environmental, and social benefits*

Installed megawatts	1,306
Average number of Australian households powered by wind energy	487,537
Number of wind energy projects (two or more turbines)	37
Annual greenhouse gas emissions displaced (tonnes CO ₂ /yr)	3,530,744
Equivalent number of cars taken off the road/yr	784,610
Total capital investment (billion AUD)	2.207

*All figures are estimates only based on current available information obtained by the Clean Energy Council.

National Activities

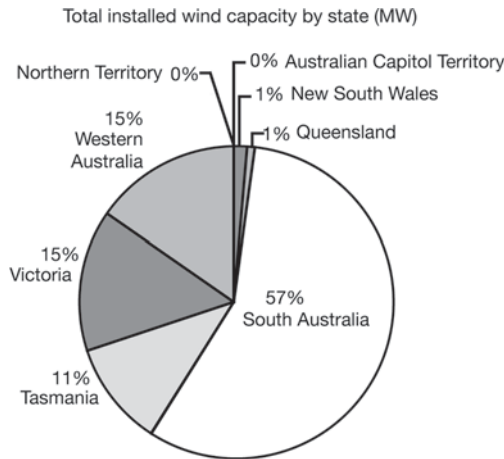


Figure 1 Installed wind capacity in Australia by state.

all retailers and wholesale purchasers of electricity in Victoria will have a legal liability to contribute toward the generation of additional renewable energy by acquiring Victorian Renewable Energy Certificates (VRECs). Relevant entities are required to surrender VRECs in proportion to their acquisitions of electricity. A penalty will be imposed on entities that fail to surrender sufficient VRECs to offset their liability. Accredited renewable energy power stations and small generation unit owners are eligible to create VRECs under the scheme. The VRET scheme has allowed large wind farm projects such as the Portland Wind Energy Project and Waubra to go ahead.

4.2 Green Power national accreditation program

Renewable energy development is also encouraged by the nationally accredited program Green Power, which sets stringent environmental and reporting standards for renewable energy products offered by electricity suppliers to households and businesses across Australia. Since Green Power's inception in 1997, more than 740,880 domestic and commercial customers have contributed to reducing greenhouse gas emissions by buying green power across Australia. The total Green Power sales since

the program's establishment in 1997 is equivalent to 4,777,881 MWh.

4.3 Department of Climate Change initiatives

The Department of Climate Change was established on 3 December 2007 as part of the Prime Minister and Cabinet Portfolio. The Australian government has committed to:

- Reducing emissions in Australia in the short and long term—reduce Australia's greenhouse gas emissions by 60% on 2000 levels by 2050;
- Working with the international community to develop a global response; and
- Preparing for the inevitable impacts of climate change.

5.0 RD&D Activities

5.1 Significant funding announcements

The Renewable Energy Fund that was announced in the May 2008 budget will be brought forward to be spent over the next 18 months rather than the original five-year time frame. This fund includes 15 million AUD for second-generation biofuels and 50 million AUD specifically for geothermal drilling. The remainder of the fund will go toward large-scale demonstration

projects that will deliver technology from the laboratory straight to homes and businesses, helping to prove a project's viability on a technical and economic basis. Under the fund, the private sector must contribute at least 2 AUD for every 1 AUD provided by the government. The fund will be launched in 2009 with the release of guidelines for applicants and a call for a first round of applications. The Renewable Energy Fund is for large-scale demonstration projects; wind will not be a big recipient as it is already a well-established market sector in Australia. Rather, this investment is expected to provide great impetus for the early development of geothermal, solar thermal, bioenergy, and ocean generation projects.

5.2 Environmental and amenity impacts

The Brolgas project is a collaborative project between wind industry representatives and Australian state and federal government to research the Brolga (*Grus rubicunda*) bird population in the region. The project has been initiated in response to a rapidly emerging wind energy industry within the Brolga's range in southwestern Victoria and the need to assess accurately the potential impacts of an increasing number of wind energy proposals. The project's overall objective is to develop a scientific framework for understanding and assessing the potential impacts of the wind energy industry on the southwest Victorian Brolga bird population, including the effectiveness of mitigation strategies. This framework will be based on a three- to four-year research program into the Brolga in that region.

The outcomes of this project will ensure that wind development in the region is sensitive to the preservation needs of the species, and conversely that projects are not unduly impacted and made financially unviable by unreasonable or unscientific approaches to conservation of the Brolgas in the southwest of Victoria. This project is a clear demonstration of the industry working cooperatively with both government and key stakeholders to

address areas of potential environmental concern before they arise.

Wind farm lighting and aircraft safety is another area where there is concern among local communities with respect to amenity issues where turbines are required to be lit at night. The industry is seeking to work proactively with government and the Civil Aviation Safety Authority to develop world best-practices guidance on this issue. This work is expected to be finalized by mid-2009.

The South Australia Environment Protection Authority (EPA) is currently undertaking a review of noise guidelines for wind farms. Although these guidelines are specific to South Australia, many other state jurisdictions use them as a reference point when setting policy and approving wind farm projects. The industry is actively involved in providing input into this review to ensure that the resulting guidelines are reasonable from both amenity and industry development perspectives.

6.0 The Next Term

6.1. Priorities for industry growth

At the close of 2008, the Australian federal government released draft legislation to implement its promised RET of 20% by 2020. Now the challenge for Australia's clean energy industry is to help the government get the design right and implement the legislation as quickly as possible.

The Clean Energy Council has already begun framing its position to guide negotiations on the policy details. The first half of 2009 will be a crucial time for the industry to ensure the target delivers against its primary objective—providing an effective and reliable industry development mechanism for the coming decade.

In 2009, the federal government is also moving to

- Implement its carbon pollution reduction scheme;
- Develop a national strategy for energy efficiency; and
- Begin deployment of its 435 million AUD Renewable Energy Fund and

National Activities

the new 500 million AUD Innovation in Climate Change Fund (announced in 2008).

These measures will all require the considered input of our industry to assist governments in extracting the maximum value from proposed initiatives.

All this will culminate at the United Nations Framework Convention on Climate Change (UNFCCC) meeting in Copenhagen in 2009, considered the most

important in the history of global climate change negotiations. The Clean Energy Council's international team is in consultation with U.S., UK, and EU counterparts through the alliance of the International Council for Sustainable Energy to develop a collective strategy for the renewable industry's policy position.

Author: Felicity Sands, Policy Research, Clean Energy Council, Australia.

1.0 Introduction

In 2008, 14 MW of new wind generation was installed for a total of 995 MW. The 162 wind parks with 618 wind turbines generated 2.1 TWh of electricity, enough to power 570,000 households. This generation avoided 1.3 million tonnes of CO₂ for the year.

Surveys and assessments show a potential of 7.2 to 7.3 TWh of wind energy by 2020. This would comply with 10% of the total energy expenditure. In strong contrast to this great potential, the construction of new wind turbines in Austria came more or less to a standstill in 2008. An amendment to the green electricity law worsened the framework conditions significantly. Recently new planning has been agreed. Now, also because of the financial crisis, planning of Austrian Projects is gaining attention, even though they can only be realized when the green electricity law, especially the funding guidelines are improved.

2.0 Progress towards National Objectives

There is no Austrian wind energy target yet. Nevertheless, there are two compulsory targets for the whole renewable energy sector. The old EU target of 78.1% of the national electric demand by 2010 (the current percentage lies at about 60%). The other target is the EU resolution RES, where

Austria has committed itself to an increase in alternative energy from the current 23.3% to 34% by 2020.

3.0 Benefits to the National Economy

The Austrian wind energy sector consists on one hand of the operators of wind farms and on the other hand of the supplying industry. The Austrian component suppliers are specialized in wind turbine control systems, blade materials, generators and wind turbine design. Last year the turnover of these companies rose by 25% to about 300 million €. The Austrian wind power association estimates that about 2,500 jobs have been created in the whole wind energy sector.

3.1 Market characteristics

About 40% of all existing wind plants are owned by cooperatives; another 40% are owned by utilities; and the rest are owned by private companies. The first wind turbines in Austria were built in 1994. At that time, cooperatives or single wind turbines built by farmers were most common. Due to a more stable framework in the support system since 2000, but

Total installed wind generation	995 MW
New wind generation installed	14 MW
Total electrical output from wind	2.1 TWh
Wind generation as % of national electric demand	3.0%
Target:	2010: 78.1% electricity from renewable sources; 2020 RES should reach 34% of the total energy production. For reaching this target, according to our estimations 10% of the total electricity consumption are achievable

Wind Power Capacity in Austria Total Wind Power Capacity [1994,9 MW]

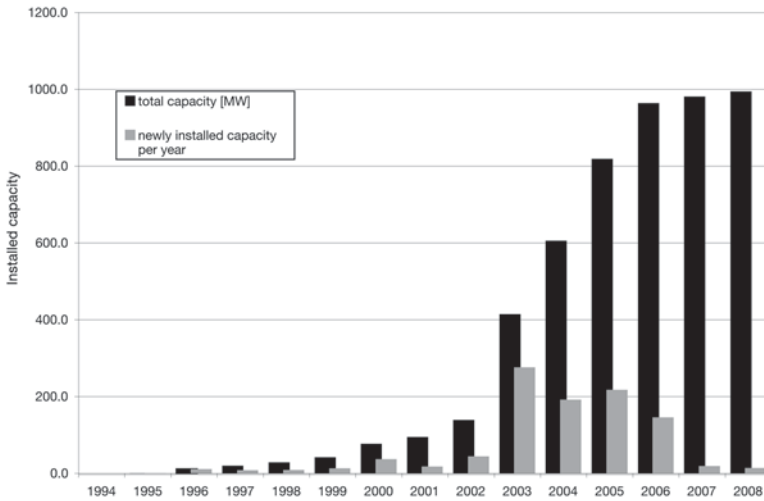


Figure 1 Development of wind power installations.

especially in 2003, utilities and other companies got into the market on a larger scale. Today the most successful players planning new wind projects are cooperatives, which were able to grow over the years, and utilities.

The Austrian operators are very active in the neighboring countries of Central and Eastern Europe. When prospects worsened in 2006, operators concentrated on project developments abroad. In spring 2009, some of the independent companies formed “The Wind Company GmbH” which is planning the development of projects in regions outside of Europe.

In 2008, the first wind projects were repowered. Four 600-kW wind turbines were replaced by six 2-MW machines. Since Austria only recently began building of wind plants, most of the turbines are already in the 1.8-MW to 2-MW size range. The two main suppliers in the Austrian market are Enercon and Vestas.

Component suppliers are the main economic activity in Austria related to wind energy. Bachmann electronics GmbH is one of the world’s leading manufacturers of turbine control systems. About 35,000

MW of wind capacity is equipped with the control systems of Bachmann electronics. Hexcel Composites GmbH develops and produces materials for blades. Elin EBG Motoren GmbH expanded its production of generators in 2008. It established a joint venture with Suzlon in India. Windtec GmbH develops customized wind turbine concepts and helps its customers to set up their own production. They find their market mainly in the Far East. At the moment they are also working on a 10-MW wind turbine.

Other companies are benefiting from the booming world market for wind energy. Companies from traditional branches are now building wind power components, often unknown to the public, the trade unions, or even the wind energy association. Therefore in 2009, a new market analysis will be initiated by the Federal Ministry of Transport, Innovation and Technology.

3.3 Economic details

Since there were only a few wind turbines installed in 2008, it is difficult to tell the exact prices. Quotations from wind turbine manufacturers to developers for

some defined projects include prices ranging from 1,400 €/kW to 1,800 €/kW for machines in the 2-MW, 100-m hub-height class.

4.0 National Incentive Programs

Back in 2003 to 2004, Austria had a working support system for wind energy development. The nationwide green electricity act (“Ökostromgesetz”) supported all kinds of renewables (except large hydro) with feed-in tariffs lasting 13 years. A boom was triggered in all kinds of renewables, but only projects that received their permission by the end of 2004 were supported. Those projects were completed through 2006. Since then, only a few wind turbines have been installed.

Since 2004 there has been discussion of amending the law. In 2006, an amendment brought deep cuts in the security for investors. Also the tariff was cut from 0.078 €/kWh to 0.075 €/kWh. After 2006, the law was amended three more times with the last decision in July 2008. For wind energy, this last amendment was seen at least as a step in the right direction, but unfortunately it has not yet come into power. In 2009, the discussion with the European Commission was still going on. It was not clear if a new cost ceiling for energy-intensive industries was in line with the EU regulation of state

aid. According to the existing law the feed-in tariff has to be lowered every year. The tariff for 2008 is 0.0743 €/kWh.

In the new (decided, not yet implemented) green electricity law there is a goal of 700 MW until 2015. But this goal can only be reached if great effort will be made in the next few years.

5.0 R, D&D Activities

In the last several years some studies were conducted in the field of wind energy potential (1) including studies on social acceptance of wind energy in Austria or integration of wind power through load management. Furthermore, the Energy Economics Group (EEG) of Vienna’s Technical University is working in many fields of renewable energy on the topics such as: costs, potential, grid integration etc. of renewable energies (2).

As stated above a new market survey is planned which will start in summer 2009. Its aim is to get a realistic overview of the economic activities in the Austrian wind sector.

Another project wants to create a wind atlas for Austria and a map and an estimation of the realistic wind potential. The same company, which is managing the Wind Atlas, “Energiewerkstatt Verein” wants to start to do more research work in

Marketshares Austria 2008 (994.9 MW)

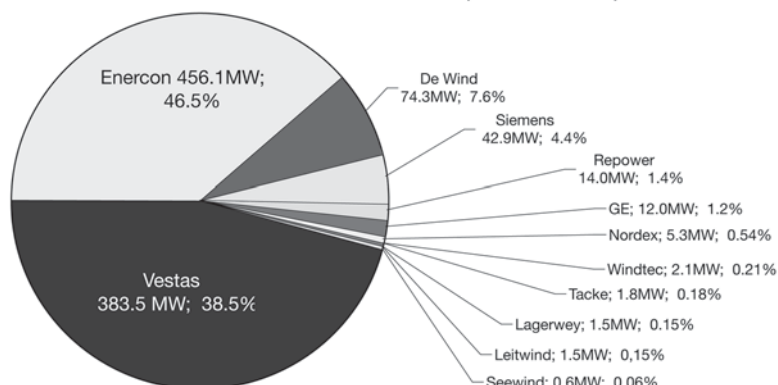


Figure 2 Market share of wind turbine suppliers to Austria.



Figure 3 Tauern wind park Oberzeiring (Credit: Stefan Hantsch).

the field of wind energy and cold climate (See Figure 3).

6.0 The Next Term

A summary of expected and needed activities in 2009 will be presented by the Austrian Wind Energy Association, including expected growth, industrial trends, policy trends and planned R&D activities. The necessary components for continued or increased growth will be listed and any key lessons to learn or major trends of interest to decision makers identified.

It is likely that in 2009 no wind turbines will be installed in Austria. For increased capacity, an improved law is crucial, and also feed-in tariffs at the level of the other European states that encouraged wind energy development. It is not clear when a new law will come into force in

Austria and whether it will help wind energy development.

On the other hand, the component suppliers are optimistic. Even with the difficult economic situation they expect to continue the very good growth rates of recent years. They have achieved this growth by recruiting new customers and increasing their share of the world market.

References:

- (1) http://ispace.researchstudio.at/products/products_eea_wind_de.html
- (2) (www.eeg.tuwien.ac.at)

Authors: Stefan Hantsch Austrian Wind Energy Association and Susanne Glanzegg, Federal Ministry of Transport, Innovation and Technology, Austria.

1.0 Introduction

Following on the success of the Wind Power Production Incentive, which funded approximately 1,000 MW of new wind capacity since 2002, the ecoENERGY for Renewable Power program was launched in April 2007 to provide the same kind of production incentive to all renewable energy technologies. The 14-year program will invest close to 1.5 billion CAD to increase Canada's supply of clean electricity from renewable sources such as wind, biomass, low-impact hydro, geothermal, solar photovoltaic, and ocean energy.

The influence of the federal program on the development of wind energy in Canada can readily be seen when reviewing yearly installed capacities (Figure 1). The capacity added in 2006 was not replicated in 2007 or 2008. While it can be inferred that wind energy in Canada still requires financial support to make it consistently appealing and competitive with conventional energy sources, other factors like the unavailability of turbines and the turmoil in the financial markets can also explain the lower numbers of the last two years. Research support measures are also needed to stimulate domestic manufacturing and assembly operations.

While wind capacity currently represents about 1% of Canada's total capacity, future growth will depend on how well new capacity can be integrated into the grid. It is expected that major investments in transmission and distribution

infrastructure will be needed in the short to medium term for wind to reach significant levels of penetration.

2.0 Progress Toward National Objectives

Although there are no national wind energy deployment targets, the federal government's wind and renewable energy programs provide considerable economic incentives for the accelerated introduction of new capacity. In April 2007, the federal government launched a new ecoENERGY for Renewable Power program to pursue the efforts that began with the Wind Power Production Incentive (WPPI) program. The new program will fund an additional 4,000 MW of renewable energy technologies by 2011 out of which 3,000 MW is expected to be wind capacity. This program, along with numerous provincial initiatives, is the main driver for future wind energy deployment in Canada.

By December 2008, a total of 2,369 MW of wind power had been installed in Canada. In 2008, Canadian wind installed capacity increased by 28% from 2007 with the addition of 523 MW of installed capacity (Figure 1). This annual increase ranks Canada tenth in the world in annual installed capacity for 2008 and eleventh in the world in total cumulative capacity.

Total installed wind generation	2,369 MW
New wind generation installed	523 MW
Total electrical output from wind	[5.8] TWh*
Wind generation as % of national electric demand	[1.0]*
Target: n/a	Progress to target: n/a
* Estimated and based on installed capacity with a 30% capacity factor and new capacity with 15% capacity factor. Source: StatsCan: 57-601-XWE	

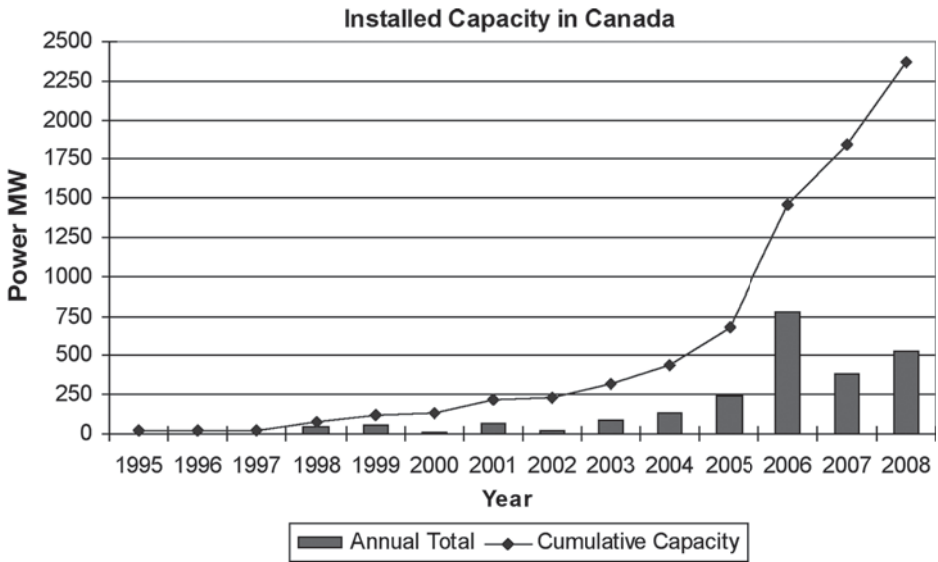


Figure 1 Installed capacity per year in Canada. Source: Natural Resources Canada (NRCan) 2009.

In 2008, the expansion of wind energy production continued across Canada’s large and geographically diverse land mass (Figure 2). By December 2008, the central province of Ontario had the largest total installed wind capacity, with 782 MW, followed by the central province of Québec at 532 MW, and Western province of Alberta at 523 MW (Figure 3). Only one out of Canada’s ten provinces does not have installed wind capacity, the Western province of British Columbia. British Columbia is expecting the commissioning of its maiden wind farms in 2009.

The largest total for new installations in 2008 occurred in Ontario with 281 MW, much of which resulted from the commissioning of the Melancthon Project Phase 2 (132 MW) and the Port Alma Wind Farm (101.2 MW). Figure 3 shows the Cultus and Frogmore wind farms (19.8 MW) in Norfolk County, Ontario. In Québec, the Carleton Wind Farm (109.5 MW) represented the single largest commissioned wind farm in 2008. This farm is the third project to be commissioned from the

awarded 990 MW Request for Proposal (RFP) process issued in 2004 by Hydro-Québec. In New Brunswick, the Kent Hills Wind Farm (96 MW) was commissioned in 2008. This wind farm represents the first step taken by the province to achieve its target of generating 400 MW from wind power by 2016. Finally, in Newfoundland and Labrador, the St. Lawrence Wind Farm (27 MW) was completed in late 2008. This project contributes to the provincial target of 80 MW of wind energy on the island of Newfoundland.

2.1 Rates and trends in deployment

Installed wind power capacity in Canada has experienced an average annual growth rate of 52% over the past five years. Canada enjoyed its second best year in new capacity installations in 2008 with 523 MW installed. In spite of this achievement, Canada did experience a drop in annual installed wind power capacity from its record year in 2006 (776 MW). Factors contributing to this decrease include the uncertainty concerning the federal incentive for wind energy during 2008 and the renewal of the

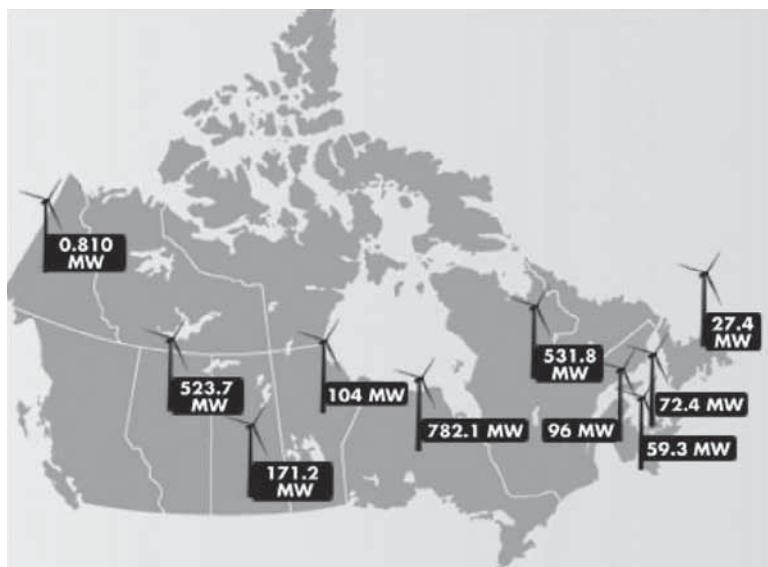


Figure 2 Canada's installed wind capacity. Source: Canadian Wind Energy Association Web Site, February 2009.

production tax credit in the United States, which increased the competition for equipment and reduced the availability of turbines in the Canadian market.

Canada is poised to set an annual installation record in 2009 with a minimum of 650 MW expected to be installed before year's end. This anticipated capacity growth is a result of the ecoENERGY for Renewable Power program launch in early 2007 coupled with a record number of provincial wind farms expected to be commissioned in 2009. Strong annual growth rates for wind power installations in Canada are expected to continue for the foreseeable future, but the impact of the global credit crisis remains unclear. According to the Canadian Wind Energy Association (CanWEA), projects currently under construction or with signed power purchase agreements amount to approximately 5,800 MW of additional wind energy capacity by 2013. All provinces either have wind energy targets or RFPs in place or being planned, with a total of at least 10,000 MW of installed capacity by 2015 (see Section 4.0 for list of initiatives).

2.2 Contribution to national energy demand

In 2005, Canadian national electrical energy generation totaled 557 TWh (1) and was estimated to reach approximately 575 TWh in 2008. Total installed generation capacity, which includes hydropower, coal, nuclear, natural gas, oil-fired, wood-fired, tidal, and wind plants, totaled 124 GW in 2006 and was estimated to reach a similar level in 2008. The installed wind capacity was 2,369 MW at the end of 2008, producing an estimated 5,800 GWh of wind energy per year (about 1.0% of total electricity production).

3.0 Benefits to National Economy

3.1 Market characteristics

In Canada, wind farms are usually owned by private corporations (independent power producers or IPPs), by utilities, or by income funds. The electricity is sold to utilities by means of a PPA or, as in the case of deregulated markets such as in Alberta, it is sold on the spot market. In some jurisdictions, including in Québec and British Columbia, a call for tenders is issued so



Figure 3 Cultus and Frogmore wind farms (19.8 MW) in Norfolk County, Ontario. Source: Stewart C. Russell 2008.

provincial utilities can obtain the electricity at the best rate.

The main constraints for wind energy development in Canada are the lower cost of conventional energy, a surplus of generation capacity in many areas, and a lack of transmission capabilities in areas with promising wind potential. Another constraint is Canada's weather. Wind turbines installed at high elevations are affected by rime ice. Icing can occur anytime between October

and May and reduce wind energy production substantially. In addition, icing can be a safety concern and also negatively impacts the fatigue properties of turbine materials. Cold air temperatures also increase loading on turbines due to increased air density. Components such as the gearbox and generators are affected by the resulting increased power output.

To reach its full potential, the Canadian wind energy industry will also have to overcome the following barriers:

- While no fuel cost is associated with wind energy, the cost of wind power is still higher than the current cost of electricity from conventional sources of energy in Canada.
- Wind energy is a variable source of electricity. As a result, local wind installations cannot be relied on for base load requirements, posing challenges to electricity generation and transmission system operators.
- Although wind energy is a clean technology, it is not completely free of environmental effects such as visual impacts, noise pollution, and potential effects on wildlife such as birds and bats. Community acceptance of wind projects depends on these challenges being addressed.
- Codes and standards need to be developed for local interconnection and safety issues. These are usually harmonized with international standards and should be adapted to ensure Canadian conditions are addressed. Canada is currently involved in updating the following wind energy standards:
 - Design Requirements
 - Small Wind Turbine Design Requirements
 - Acoustic Noise Measurement
 - Power Performance Testing
 - Lightning Protection.

The issue of variability does not yet appear to be a major problem for most regions of Canada, namely because of the wide availability of hydropower facilities, which can act as energy storage, and because wind energy is still only a small fraction of the total electricity production. Hydro-Québec, however, is addressing the issue of variability by accounting for a ‘balancing fee’ in the cost structure of its supply of wind-generated electricity. For levels of penetration higher than 20%, more sophisticated network management strategies will be needed. These issues are now being addressed in Europe, and Canada could benefit from Europe’s experience.

The lack of grid transmission availability can be a problem in regions where the wind resource is promising but grid capacity is inadequate. This is particularly the case in Southern Alberta where wind projects have been developing at a fast pace but the accessibility to the one transmission line is limited. Recently, a 900 MW cap limit for wind was lifted but development in increasing grid capacity has been slow.

Canada also has more than 300 off-grid remote sites that could benefit from the integration of wind on diesel mini-grids. Demonstration projects in the past have not been very successful but there is a renewed interest to develop the market.

3.2 Industrial development and operational experience

3.2.1 Industry development and structure

The Canadian industry is composed mainly of companies that manufacture wind-related components such as rotor blades, control systems, inverters, nacelles, towers, and meteorological towers. The rapid growth of Canada’s wind energy industry has resulted in a growing number of firms entering the market, resulting in increased activity in a variety of areas including resource assessment, project development, manufacturing, construction, and operations. In fact, the Canadian Wind Energy Association’s (CanWEA) corporate membership has grown from 86 members to about 400 members over the last five years. This growth has had an impact on the Canadian economy in terms of job creation, direct investment, contribution to Gross Domestic Product (GDP), and induced benefits.

A recent survey by InSightrix (2) commissioned by CanWEA, shows that the Canadian wind industry consists of a wide variety of organizations. Among the respondents, 66 companies (30% of the total) identified their primary activity as wind power development. A further 49 companies (22%) identified themselves as wind energy consultants, 19 (9%) indicated that they are accessory equipment

National Activities

manufacturers, and another 14 (6%) identified themselves as wind turbine manufacturers. The industry remains largely Canadian and based in the private sector, with 74% of respondents indicating that they are privately-held companies, and 77% indicating that their head offices are in Canada. There is some diversity in terms of scope of project activity: 43% indicated that their organizations' scope of operations is "international," another 30% indicated "provincial or regional," while 22% are "national."

3.2.2 Manufacturing

As shown above, the Canadian industry is mainly comprised of developers that are backed by large energy firms, industrial corporations, and income funds that bring with them financial resources and commercial credibility. SaskPower and other leaders such as TransAlta, Suncor, and Canadian Hydro Developers have significant operations behind them. Large energy related firms, such as TransCanada with Cartier Wind Energy Group, Epcor, Nexen, and Brookfield Power have created subsidiary power firms to develop wind projects. International firms such as Airtricity, Suez Renewable Energy, and Acciona/EHN have purchased shares in companies and projects. This phenomenon points to the continuing role of major energy companies in the growth of the industry and the challenge and increased competition ahead for existing market leaders.

Canada is still in the early stages of developing a local manufacturing industry. As a result of the two Québec RFP processes, GE Wind Energy has contributed to establishing facilities in the province to enable up to 60% of wind turbine components to be manufactured and assembled locally. LM Glasfiber has installed a blade-manufacturing unit in the Gaspé region, and in Matane, Marmen is manufacturing towers and Composites VCI is manufacturing nacelles. Elsewhere, DMI Industries (U.S.) acquired a manufacturing plant in Fort Erie, Ontario, to expand its heavy steel wind tower fabrication operations and Hitachi

Canadian Industries is manufacturing wind towers in Saskatoon, Saskatchewan. AAER has started a blade and tower manufacturing unit in Bromont, Québec and the company shipped its first turbine in December. AAER Systems has licensed Fürhlander and American Superconductor Corp. to manufacture complete turbines ranging from 1 to 2 MW. Also, in May, Hydro-Québec announced that Enercon and RePower were the winning manufacturers of the second wind energy RFP process in the province's history. It is expected that these two manufacturers will establish facilities in the province to address the regional content requirements.

From the Inshgtrix survey (2) , of the 19 companies who are primarily involved in accessory manufacturing, six companies manufacture electrical components, five companies produce wind turbine towers, three companies manufacture monitoring devices, and the remainder produce other accessories. Of the 14 companies primarily involved in turbine manufacturing, six manufacturer turbines of more than 300 kW capacity, six manufacture turbines with a capacity between 20 kW and 300 kW, and another three manufacture turbines with a capacity of less than 20 kW.

The small wind turbine manufacturers are comprised of the following:

- Wenvor Technologies, Énergie PGE, and Vergnet Canada are developing small wind turbines in the size range of 10 to 30 kW.
- Entegrity Wind Systems Inc., Vergnet Canada, Wind Energy Solutions, Cleanfield Energy, and Atlantic Orient Canada Inc. are offering turbines in the size range of 50 to 250 kW.

In addition, several companies are proposing small wind turbines that are at various stages of development. Some of the designs feature a vertical axis. The Wind Energy Institute of Canada has begun testing the small turbines that were selected following an RFP process completed in December 2007. The turbines being considered under this program have a capacity of not more than 100 kW.

3.3 Economic details

No fuel costs are associated with wind energy; therefore, capital, operating, and maintenance costs largely determine generation costs. Recent calls for tenders and RFPs have shown that the capital costs to install wind farms in Canada range from 1,800 to 2,200 CAD/kW, while the generation costs are estimated to be between 0.075 and 0.12 CAD/kWh. For example, provincial calls for power in British Columbia, Ontario, and Québec, and the Renewable Portfolio Standard (RPS) in Prince Edward Island resulted in electricity prices from wind energy in the range 0.0775 to 0.096 CAD/kWh. In most cases, the latest price proposals have shown the highest prices. The primary variables associated with this cost range are the cost of the wind turbines themselves, the quality of wind resources, transmission connection fees, the scale of operation, and the size of turbines.

Although the cost of wind power has declined steadily in the past 20 years, recent cyclical factors in effect until mid-2008 (the ongoing boom in prices for commodities such as steel and oil, variations in currency exchange, and shortages in wind turbine supply due to a sudden increase in world and U.S. demand) have led to an increase in capital costs of approximately 20%, mitigated slightly by the strength of the Canadian dollar against the U.S. dollar. Furthermore, the current economic crisis has made investors nervous, which in turn has resulted in an increase in the cost of debt. Thus, in Canada, wind power is still more expensive than electricity generated by conventional sources, and federal and provincial support is still needed to close the price gap.

Canada has also experienced an increase in the size of wind farms, especially in provinces with existing wind installations. This is mainly because smaller projects (less than 50 MW) can cost from 10% to 30% more because of economies of scale. This trend may be reversed in regions where a focus on decentralized generation is made, such as in Ontario, which intends to attract new capacity on its distribution

lines by providing a fixed-price tariff for clean energy projects less than 10 MW in capacity.

According to the survey by CanWEA referenced above, Canada's wind energy industry contributed 1,490 million CAD to the country's GDP in 2006, which is double the impact in 2005. That same year, there were 3,340 full-time equivalent jobs in the wind energy industry, an increase of 178% over 2005. This reflects the intense activity carried out in 2006, a record year of installation for wind.

The credit crisis of 2008 is also affecting wind energy in Canada. Wind farms are projects that by nature require a massive influx of capital. Promoters are affected by the tightening in the credit markets and this delays the completion of projects. This could have a significant impact in 2009.

4.0 National Incentive Programs

Since 2002, the most influential market stimulation instrument had been the federal government's incentive programs (WPPI and ecoENERGYRP) for wind energy developers. Qualifying wind energy facilities received an incentive payment of 0.01 CAD/kWh of production. The incentive is available for the first ten years of production and helps to provide a long-term stable revenue source.

The 14-year ecoENERGY for Renewable Power program will invest close to 1.5 billion CAD to increase Canada's supply of clean electricity from renewable sources such as wind, biomass, low-impact hydro, geothermal, solar photovoltaic, and ocean energy. The objective of the ecoENERGY for Renewable Power program is to help position low-impact renewable energy industries to make an increased contribution to Canada's energy supply, thereby contributing to a more sustainable and diversified energy future. The program will provide the same production incentive of 0.01 CAD/kWh for up to 10 years for electricity generated from eligible renewable energy projects commissioned between 1 April

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2007 and 31 March 2011. The program will encourage the production of 14.3 TWh of new electricity from renewable energy sources, enough electricity to power approximately one million homes.

In another incentive, Class 43.1 and 43.2 of the federal Income Tax Act provide an accelerated rate of write-off for certain capital expenditures on equipment that is designed to produce energy in a more efficient way or to produce energy from alternative renewable sources. In 2007, the tax write-off was increased from 30% to 50% per year on a declining-balance basis. In addition, the Canadian Renewable and Conservation Expense (CRCE) category in the income tax system allows the first exploratory wind turbines of a wind farm to be fully deducted in the year of its installation or transferred to investors using flow-through share financing.

Provincial governments provide market stimulation through an array of initiatives. Request for Proposals are a popular method of allowing market participants to bid and compete for a specific wind capacity target. Some provinces, notably Nova Scotia and Prince Edward Island, have implemented Renewable Energy Standards, similar to Renewable Energy Portfolios, where the government legislates that a designated percentage of the provinces' electricity capacity is sourced from wind energy. North America's first Standard Offer Program, or feed-in tariff program, was launched in Ontario in late 2006. Through this program the Ontario government establishes a fixed price for production from various renewable energies, including wind, and allows the market to determine the amount produced. Ontario's program aims to reduce the barriers for small renewable generators, and is therefore limited to projects under 10 MW. Table 2, compiled by CanWEA, shows the wind objectives and level of commitment from each province.

In parallel, various agencies are working to provide tools needed by industry to address the market created by these incentives. The federal government and provincial

governments working directly with industry have supported a better understanding of the wind resource in Canada. The Canadian Wind Energy Atlas developed by the Meteorological Service of Canada (MSC) of Environment Canada is now well established and is used by most developers in pre-siting their projects. The provinces of B.C., Ontario, Quebec, PEI, and New Brunswick have also produced their own wind atlases, often using the database generated by the Canadian Wind Atlas to provide maps with greater resolution. The Alberta Electricity System Operator with CanWEA has started a one-year pilot project to provide wind data to a centralized forecasting service. Industry is also developing its own commercial forecasting services.

5.0 R, D&D Activities

5.1 National R, D&D efforts

The fiscal year 2008/2009 budget for the Wind Energy R&D (WERD) group at Natural Resources Canada (NRCan) was about 3 million CAD, with contributions of about 2.5 million CAD from contractors, research institutions, and provinces. The focus of the Canadian national wind energy R&D activities continues to be the development of safe, reliable, and economic wind turbine technology to exploit Canada's large wind potential, as well as supporting field trials.

NRCan also supports a recently formed national wind institute. Since 1981, the Atlantic Wind Test Site (AWTS), located in North Cape, PEI, has been Canada's primary facility for wind turbine testing, technical innovation, and technology transfer. The national Wind Energy Institute of Canada (WEICan) evolved from the regionally-based AWTS, and focuses on four strategic areas: testing and certification, research and innovation, training and public education, and technical consultation and assistance. WEICan supports the development and implementation of wind power generation and wind energy products and services for Canada and export markets. It has signed an exclusive framework



Figure 4 Mount Miller wind farm in Murdochville, Québec. Source: Antoine Lacroix 2005.

agreement with Deutsches Windenergie-Institut (DEWI) in order to provide the North American wind industry with Type Testing services. Type Testing is undertaken in order to demonstrate a turbine's power performance and is typically comprised of safety tests, load and power performance measurements, as well as static and fatigue blade tests.

In the province of Québec, the Wind Energy TechnoCentre, as part of a collaborative effort involving several Québec universities closely connected to the wind energy industry, has set up the Corus Centre. Located in Murdochville, on the Gaspé Peninsula, the Corus Centre is an organization dedicated to research, development, and the transfer of technology mainly in the area of wind turbine operation in cold climates. It is surrounded by two wind farms with a total capacity of 108 MW (Figure 4). This location makes the research center a unique natural laboratory in which to study the impact of the Nordic environment on

the extraction of wind energy. NRCan has supported the Corus Centre through the acquisition of scientific material.

NRCan's WERD group continues to support new technology development activities related to:

- Small wind turbines (< 300 kW), including the testing of turbines connected in single-phase for net-metering applications, verifying electricity production, reliability of system components, and ability to withstand the Canadian climate
- Large wind turbines (>300 kW), including the support of market infrastructure for large wind technologies through the development of industry standards and planning aids such as the Canadian Wind Energy Atlas, a tool that identifies areas best suited for wind power
- Wind energy in cold climates, participating in a wind energy R&D project in the Northwest Territories. Turbines

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Table 2 Federal and provincial objectives for wind energy		
Jurisdiction	Initiative	Status
Federal	Announced the ecoEnergy for Renewable Power program in January 2007 to support the deployment of 4,000 MW of renewable energy between 2007 and 2011.	The program was not expanded or extended in the 2009 federal budget. It is anticipated that all remaining funds will be allocated by Fall 2009.
British Columbia	Government aims to achieve energy self-sufficiency by 2016. 50% of new generation to come from clean energy sources (no specific wind energy target).	325 MW of wind energy contracts in place. BC Hydro Call for Clean Power in 2008 sought 5,000 GWh and received 17,000 GWh in bids. Results of process expected in early 2009.
Alberta	There is currently no provincial target.	Alberta was the first jurisdiction in Canada to pass 500 MW of installed wind energy capacity. Now designing transmission upgrades to connect 3,000 MW of wind in southwestern Alberta.
Saskatchewan	Provincial energy plan seeks to have 300 MW of wind energy in Saskatchewan by 2011.	171 MW currently in place.
Manitoba	Manitoba government seeking 1,000 MW of wind energy by 2016.	Currently 104 MW in place. Manitoba Hydro has announced that it is pursuing a contract for an additional 300 MW.
Ontario	The Ontario Power Authority's Integrated Power System Plan called for 4,600 MW of wind energy by 2020. IPSP is currently being revised following a Ministerial directive. New Green Energy Act expected to be announced in March 2009.	782 MW currently in place, with almost 400 MW of additional wind energy projects currently under construction. In January 2009, OPA announced contracts for six new wind energy projects in Ontario totaling 492 MW.
Québec	Québec government seeking 4,000 MW of wind energy by 2015	531 MW currently in place and nearly 3,000 MW contracted. 500 MW of new Requests for Proposals for First Nations/ Municipalities to be issued in 2009.
New Brunswick	NB Power seeking 400 MW of wind energy by 2016.	96 MW currently in place. 300 MW of additional contracts announced in 2008.

Nova Scotia	The Renewable Energy Standards (RES) put in place by the government of Nova Scotia require that 5% of the total Nova Scotia electricity requirement be supplied by new (post 2001) renewable energy sources by 2010, rising to 10% by 2013.	59 MW currently in place. If all wind capacity, the RES will require some 210 MW of additional wind capacity by 2010 and a total of some 510 MW of additional wind capacity by 2013.
Prince Edward Island	Government target of installing 500 MW of wind power by 2013.	72 MW of wind energy already in place. Exploring opportunities to bring more wind energy onto the grid.
Newfoundland	Target of 80 MW of wind energy on the island of Newfoundland and exploring wind development potential in Labrador.	27 MW currently in place and a further 27 MW contracted.
Source: Canadian Wind Energy Association Web site, February 2009.		

will be instrumented to document the performance of the system in Arctic conditions and monitor several parameters. In addition, foundations will also be instrumented to observe and monitor the behavior of concrete foundations in permafrost

- Offshore wind, laying the groundwork for development on the Great Lakes through research on the behavior of the wind resource, on the tools that can be used to assess the resource, and through participation in projects to assess the impacts of offshore wind development.

NRCan is currently involved in the development of a wind energy technology roadmap (TRM). A key objective of this TRM is to identify the priority areas for stakeholders, both the technology providers and technology adopters or ultimate users. The goal is to determine investment areas in research and development required to achieve overall (social, environmental, and technological) cost reductions, and increased Canadian industrial and economic benefits. Reducing the cost will increase the deployment of wind energy in Canada, addressing the government's goal of increasing the contribution of renewable energy to Canada's energy supply. Increased Canadian

industrial benefits address the government's goal of "Providing Effective Economic Leadership for a Prosperous Future." Taken together, these two goals support Canada's strategy for GHG reductions, and address energy, economic, and environmental priorities of Canadians.

The TRM comprises six workgroups that are:

- Market and Economics
- Wind Energy Resources
- Wind Energy Systems – Large Wind Turbines and Components
- Wind Energy Systems – Small Wind Turbines
- Wind Energy Integration – Planning
- Wind Energy Integration – Operations.

The TRM deliberations will take place over three one-day meetings to be held in three different cities across Canada. The first meeting took place in November 2008 in Montreal. The other meetings are planned for Toronto and Vancouver in early 2009.

NRCan is one of the sponsors of the Canadian Wind Energy Strategic Network (WESNet). WESNet is the first network of its kind in Canada and is comprised of leading Canadian wind energy researchers from 16 universities, working in

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collaboration with 15 contributing partners from Canadian industry, wind institutes, and government. WESNet will realize its vision and achieve its objectives through a research program organized into four wind energy theme areas, led by internationally recognized Canadian researchers.

- Theme 1 Wind Resource Assessment
- Theme 2 Wind Energy Extraction
- Theme 3 Wind Energy in Power Systems
- Theme 4 Techno-Economic Modeling and Optimization of Wind Energy Systems.

5.2 Collaborative research

Canada participates in the following tasks of the IEA Wind R&D Implementing Agreement:

- Task 11—Base Technology Information Exchange
- Task 19—Wind Energy in Cold Climates
- Task 25—Design and Operation of Power Systems with Large Amounts of Wind Power.

Canada participates in the International Electrotechnical Commission's technical committee TC88 on Wind Turbines.

6.0 The Next Term

Although a sustained effort is required to address both technical and non-technical issues, cost of generation in Canada remains the most important barrier to increased wind deployment. Since wind is not yet cost competitive with more traditional sources of electricity in Canada, incentives will still be required in the next few years to sustain the actual growth rate of commercial turbine installations. The federal wind incentive by itself is insufficient to bridge the cost gap, but it has provided partial funding along with a stable planning framework for both industry and the provinces. This has made a difference, and the Canadian wind market is now growing rapidly. Provincial initiatives requiring

minimum regional manufacturing content have contributed to the inception of a wind industrial base in Canada. Some provinces have required a portfolio share for wind electricity or have found other means to encourage wind development.

In the past, cost reductions have come about mainly through a combined effort on improved design and manufacturing. This has led to the development of a growing sustainable market serviced by large, globally competitive, mostly European companies that have the means to fund R&D and improve products and manufacturing methods.

Another key to cost reduction has been better siting of wind turbines and wind farms; this is directly dependent on better knowledge of the geographical distribution of the wind resource. The development of the Canadian Wind Energy Atlas and the development of detailed provincial wind atlases are providing assistance in this area.

Technology and standards development will emphasize adaptation of international standards to the Canadian context and remote communities. For example, NRCan is currently supporting the demonstration of a wind-hydrogen-diesel system for a remote community in the province of Newfoundland. Canada will continue to maximize information exchange with national and international collaborators through renewable energy technology networks, such as the IEA's Wind Implementing Agreement, the Wind Energy Institute of Canada, and through a newly formed network of Canadian university researchers.

Canada will pursue its valuable work quantifying and qualifying wind resources through continued work with onshore and offshore resource assessment and forecasting tools.

Environmental impact and mitigation studies are shedding new light on turbine interactions with wildlife as well as noise and radiofrequency interference assessment and mitigation.

Interest in offshore wind projects in Canada is growing, with the West coast and

Great Lakes being considered the first areas to be developed.

References:

(1) Energy Statistics Handbook 2007
File: 57-601-X

(2) CANSIA: The Economic Contribution of the Wind Energy Industry to

Canada in 2006, A Summary of Results of the 2007 Annual Survey of CanWEA Members, Insightrix 2007.

Author: Antoine Lacroix, NRCan, Canada.

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1.0 Introduction

Approximately 17% of Denmark's energy supply came from renewable sources in 2008, and the production from wind turbines alone corresponded to 19.3% of the domestic electricity supply. Another 20% of energy supplies came from natural gas and 23% from coal. Dependence on oil has been about 40%.

The installation of new wind power capacity in Denmark has been low during the past years. In 2008, the net capacity installed was 38.9 MW, with 77.6 MW of new wind generation installed, and 38.7 MW removed. The key statistics for 2008 are shown in Table 1.

The Danish government has continued the energy policy introduced in 2006 which was based on the Strategy 2025, published June 2005 (2), and later followed by A Visionary Danish Energy Policy 2025, published 19 January 2007 (3). This policy includes initiatives that emphasize globalization and the improved use of renewable energy sources, including stronger support for energy research, development, and demonstration.

At the end of 2007, the Danish government established a new Ministry for Climate and Energy to strengthen efforts to abate climate change and to prepare for the Climate Summit COP 15 in Copenhagen in 2009.

1.1 Installed capacity and production in 2008

The capacity of wind power in Denmark increased by 39 MW in 2008, bringing the total up to 3,163 MW. The total number of turbines was reduced to 5,101. During 2008, 51 new wind turbines were installed, and 164 turbines were decommissioned. The average capacity of those installed in 2008 was 1.52 MW, but excluding a number of small turbines under 55 kW, the average was nearly 2 MW. A detailed history of installed capacity and production in Denmark can be downloaded at the Danish Energy Agency Web site (www.ens.dk) (1).

As shown in Table 1 and Figure 1, electricity from wind energy covered 19.3% of the electricity consumption in Denmark in 2008 compared to 19.9% in 2007. The total electricity production from wind energy in 2007 was 6,975 GWh, a decrease from the unusually high value of 7,171 GWh in 2007 due to high wind.

The largest onshore turbine installed in Denmark by the end of 2008 was one 3.6-MW Siemens Wind Power turbine. Other sites with large turbines include three Vestas 3-MW turbines on the Island of Lolland, two Vestas 3-MW turbines in

Table 1 Key Statistics 2008: Denmark

Total installed wind generation	3,163 MW
New wind generation installed*	38.9 MW
Total electrical output from wind	6.975 TWh
Wind generation as % of national electric demand**	19.3 %
Target***	Not specified for wind
* 77.5 MW installed; 38.7 MW removed ** In 2008 the wind index was 100% *** Target for Renewable is 20% in 2011 of gross energy consumption.	

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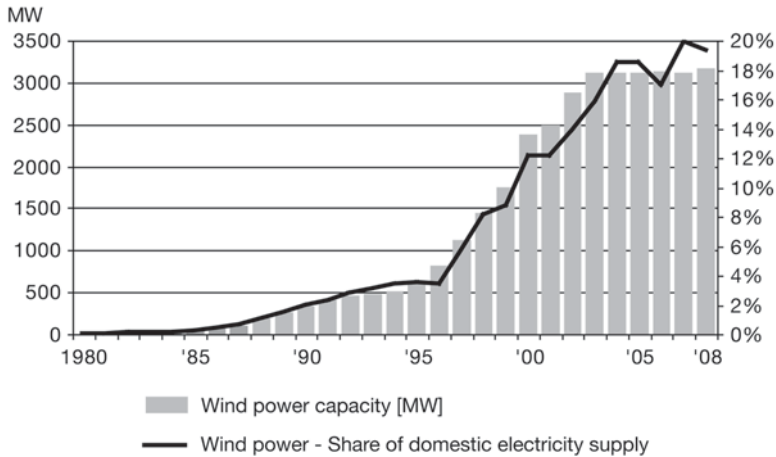


Figure 1 Danish wind power capacity and its share of domestic electricity supply (1).

Frederikshavn, and five 2.75-MW turbines at the Tjaereborg site near Esbjerg.

The two largest offshore wind farms are still the 160-MW offshore wind farm at Horns Rev (80 Vestas 2-MW wind turbines placed in the North Sea 14 km to 20 km offshore Blaavands Huk), and the wind farm at Nysted (Roedsand I) south of Lolland in inland waters (72 Bonus 2.3-MW wind turbines).

2.0 Progress Toward National Objectives

A new February 2008 Agreement on Danish energy policy for the years 2008–2011 (4) includes better terms for wind turbines and other sustainable energy sources such as biomass and biogas. The initiatives in the agreement combine policy regulation and market mechanisms. With an aim to realizing its vision, the agreement has set the following targets and initiatives relevant to renewable energy and wind power:

- The goal for the renewable energy share of gross energy consumption is 20% in 2011
- The subsidy to the central power plants' biomass-based electricity production shall be increased from 0.10 to 0.15 DKK/kWh.
- The subsidy for new wind turbines shall be raised to 0.25 DKK/kWh for

22,000 full load hours + 0.023 DKK/kWh in balancing costs

- Turbines under the repowering scheme shall be given an extra fixed supplement of 0.08 DKK/kWh for the first 12,000 full load hours
- Municipalities shall secure reservation of land for 75 MW of wind turbines in each of the years 2010 and 2011
- Allocation of 10 million DKK to a guarantee fund for supporting financing of local mill guilds' preliminary studies, etc.
- A compensation scheme to ensure neighbors of new wind turbines receive compensation for loss of property value due to the installation. Compensations shall be paid by wind turbine owners in connection with installation of the turbines. The object of compensation responsibility shall be based on the ordinary principle of the right to compensation, including a concrete individual evaluation of the loss of property value
- Invitations to tender for two 200 MW offshore wind farms to come into operation in 2012
- All new and existing biogas plants shall be subject to a fixed electricity price of 0.745 DKK/kWh or a fixed-price premium of 0.405 DKK/

kWh when biogas is used along with natural gas. The fixed electricity price and price premium shall be adjusted by 60% of the increases in the net price index

- A pool of 30 million DKK over two years for information campaigns, labeling of efficient heat pumps, limited subsidy schemes, etc. aimed at heat consumers outside the areas of district heating
- 25 million DKK/year for four years shall be allocated to small renewable energy technologies such as solar cells and wave power
- CO₂ taxes shall be raised from 3 to 90 DKK/ton CO₂ to the expected CO₂ quota price, which for 2008-2012 is provisionally estimated at 150 DKK/ton
- A new NO_x tax of 5 DKK/kg effective from 1 January 2010 for partial fulfillment of the Danish NO_x obligation
- A significant increase in funding of research, development, and demonstration in energy, in order to increase the overall publicly financed effort to a total of 750 million DKK in 2009 and to one billion DKK per year from 2010.

To reach the goals mentioned above and fulfill the February 2008 Agreement, several priorities were set. These include additional support for R, D&D in fuel cells, development of second-generation bio-ethanol production, and promotion of new research in wind energy and other renewables. Information about the Danish wind energy policy can be downloaded from the Danish Energy Agency Web site (www.ens.dk).

Based on the initiatives already taken, the Danish government expects that 1,300 MW of new wind power capacity will be installed by 2012 (Figure 2). This additional capacity could potentially cover another 12% of total electricity consumption, thus bringing the total contribution to electrical demand to over 30%.

As reported in 2007, the Danish Energy Authority made a plan for sites for the next generation of offshore wind farms between 2010 and 2025. Three committees have finished their reports on layout and plans for future Danish offshore wind turbine development, sites for future onshore turbines, and sites for testing new industrially developed turbines (0-series) by manufacturers and developers.

In April 2007, the Danish Energy Authority published the report: Future Offshore Wind Turbine Locations – 2025 (4), where the offshore committee charted a number of possible areas where offshore turbines could be built with an overall capacity of some 4,600 MW, which can generate approximately 18 TWh, or just over 8% of energy consumption in Denmark. This corresponds to approximately 50% of the Danish electricity consumption. The committee examined in detail 23 specific possible locations, each of 44 km², for an overall area of 1,012 km² divided into seven offshore areas.

The completed and planned offshore wind developments in Denmark are shown in Figures 3 and 4.

2.1 Horns Rev II

The offshore wind farm Horns Rev II is to be located about 10 km west of the existing wind farm at Horns Rev (Figure 5). Construction of the wind farm will start in 2008, and will cover a total area of about 35 km² when it is commissioned during 2009. Energinet.dk is responsible for extending the electricity grid to the wind farm. The energy company DONG Energy will own and build the farm. The price to be paid for the electricity was negotiated with the government, and is set to 0.518 DKK/kWh for the first 50,000 full-load hours, which corresponds to about 12 years of electricity production. The wind farm will consist of 91 2.3 MW Siemens turbines on monopiles. The turbines are sited in a fan formation with 13 rows going from East to West and with seven turbines in each row. The site also gives room for three large test

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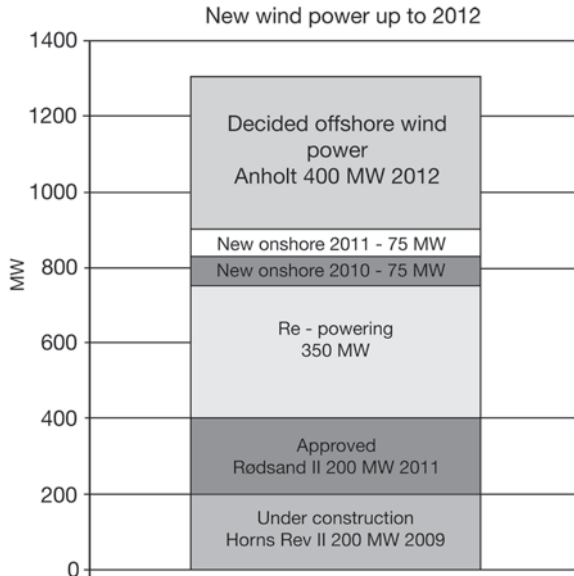


Figure 2 Approved and planned onshore and offshore capacity up to 2012 (4).

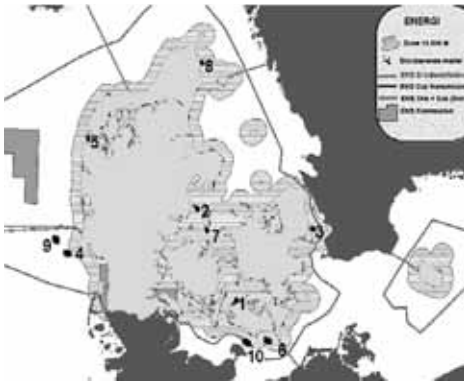


Figure 3 Locations, composition, and commissioning dates of offshore wind farms in Denmark (5).

1. Vineby	11 windturbines, 5 MW 1991
2. Tunø Knob	10 windturbines, 5 MW 1995
3. Middelgrunden	20 windturbines, 40 MW 2000
4. Horns Rev 1	80 windturbines, 160 MW 2002
5. Rønland	8 windturbines, 17 MW 2003
6. Nysted	72 windturbines, 158 MW 2003
7. Samsø	10 windturbines, 23 MW 2003
8. Frederikshaven	4 windturbines, 10.6 MW 2003
9. Horns Rev II	95 windturbines, c. 200 MW 2009
10. Rødsand II	92 windturbines, c. 200 MW 2010



Figure 4 Potential locations for offshore wind farms (5).

turbines with a total capacity of 15 MW. The distance from the shore (Blåvands Huk) is 30 km. The water depth in the area is between 6 and 18 m.

2.2 Roedsand II

E.ON Sverige AB has won the public tender for an offshore wind farm at Roedsand. DONG Energy Roedsand II A/S also turned in a bid for establishing the 200 MW offshore wind farm south of Lolland, but E.ON offered the lowest price (0.629 DKK/kWh for 50,000 peak load hours) and thereby won the tender process.

The offshore wind farm Roedsand II will be able to supply 200,000 households with electricity, which accounts for around 2% of the Danish power consumption. The wind farm will cover an area of 35 km² and will be placed around 3 km West of the existing offshore farm at Roedsand (Figure 6). The farm will supply the grid with electricity by 30 September 2011 at the latest.

2.3 Djursland/Anholt

In the Energy Policy Agreement of February 2008, it was decided to call for tender for two 200-MW offshore wind farms to come into operation in 2012. Later in the year it was agreed to locate a 400-MW offshore wind farm between Djursland and Anholt (Figure 7).

Following experience with previous tenders for offshore wind farms in Denmark, the Danish Energy Agency has adjusted the tendering procedure, which was used for the tenders for Roedsand II and Horns Rev II. This means that the 400 MW Djursland/Anholt offshore wind farm will first undergo site development before being opened for public tenders. The Danish TSO, Energinet.dk, is responsible for the site development, which already has commenced.

The Danish Energy Agency expects to offer the 400 MW farm for tender in the first half of 2009 while the preliminary

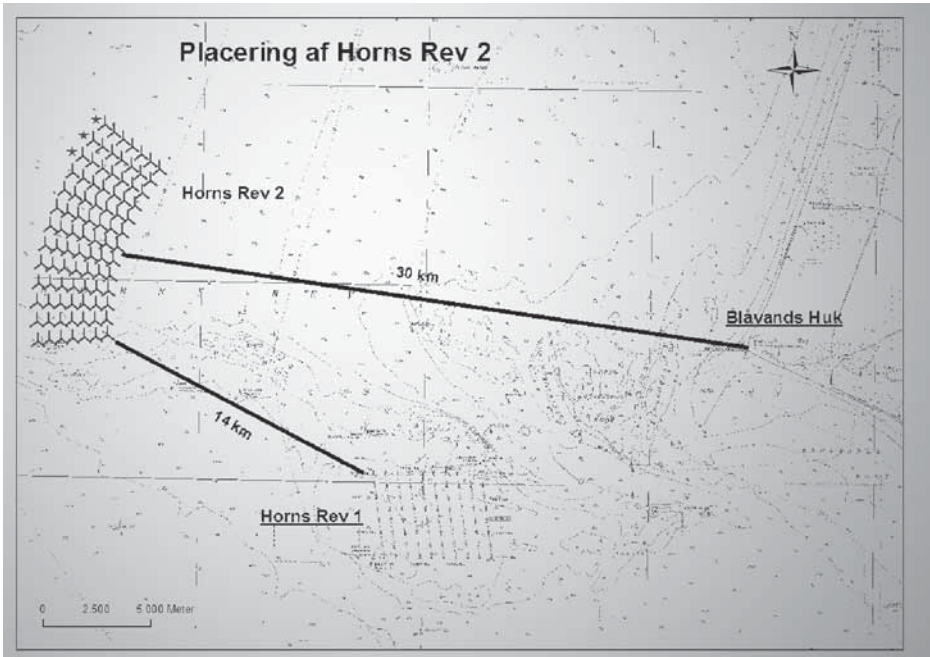


Figure 5 Site and layout of Horns Rev I and II (6).

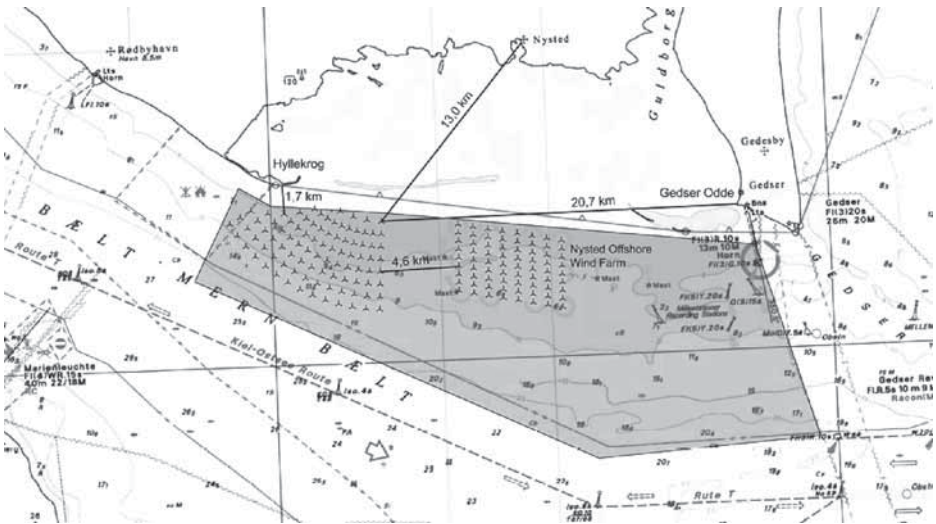


Figure 6 Definition of the pre-investigation area, base-case scenario, toponomy, distance to Nysted Offshore Wind Farm, and distance to Hyllekrog, Nysted, and Gedser (7).

investigations are still being carried out. The tendering procedure will end when the EIA consultation procedure is over, which is expected to be in the first half of 2010. The winner of the tender will then be awarded a concession, permission for preliminary investigations, and permission to establish the farm, after which the main contractor can finalize contracts and start the detailed planning.

The adjusted model for the tendering procedure of the 400-MW farm at Djursland/Anholt is also characterized by the following factors:

- The environmental impact (EIA) report will include the proposed sites for the farm and proposals for alternative sites. The sites will be mapped as early as possible during the process.
- The results of the ongoing analyses

of the area will be presented by Energinet.dk. These include for example, analyses of geotechnical surveys, the environment, and sailing/navigation. Tenders will have access to these results. All communication concerning these results must be in writing and will be accessible for all possible tenders simultaneously.

- The Danish Energy Agency will submit the EIA report for a broad public consultation.

3.0 Benefits to National Economy

3.1 Market characteristics

The sale of wind turbines from Denmark in 2008 is estimated to about 7 GW. As it is noted above, the Danish home market was a low contributor to these sales in 2008. Therefore, nearly all turbines manufactured

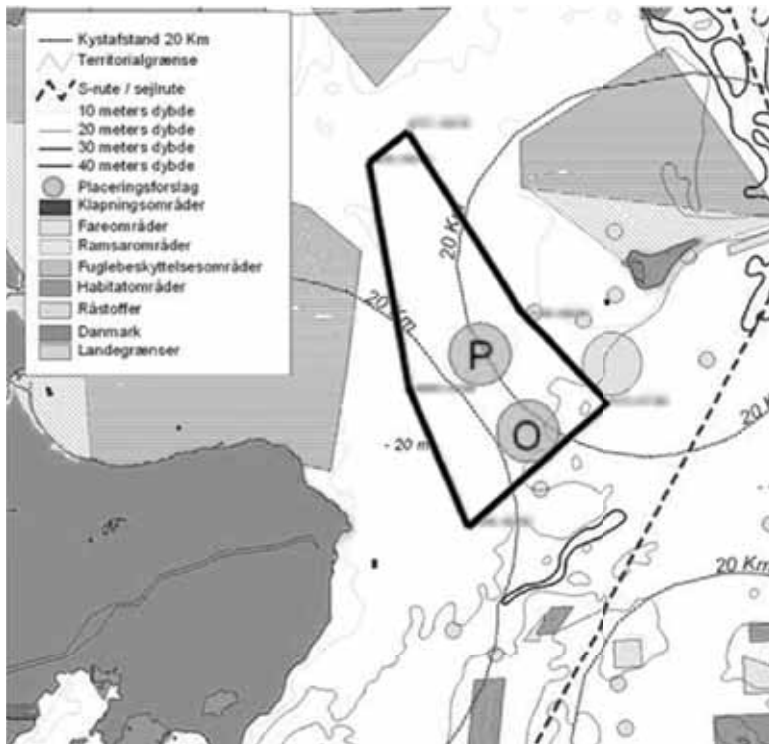


Figure 7 Map of investigation area (the box) between Anholt and Djursland. O and P are suggested sites from the Follow up to Future Offshore Wind Power Sites -2025 (8).

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were exported and contributed approximately 40 billion DKK to the national economy in 2008. The two large wind turbine manufacturers, Vestas and Siemens Wind Power, together had a world market share of about 25%. It is estimated that more than 25,000 people are employed in the Danish wind industry.

The market for onshore wind power in Denmark in 2008 was characterized by a high electricity purchase price based on the market-based price plus a premium of 0.25 DKK/kWh for 22,000 full-load hours.

Offshore, the future market will be driven by political decisions based on the plan described above.

3.2 Industrial development and operational experience

Today, the major Denmark-based manufacturers of large commercial wind turbines up to a size of some MW are Siemens Wind Power (formerly Bonus Energy A/S) and Vestas Wind Systems A/S. Only one company, Gaia Wind Energy A/S (owned by Mita Teknik A/S), currently produces wind turbines for households, but a couple of small companies are planning to produce or import micro-turbines.

The most important suppliers of major components for wind turbines are still LM Glasfiber A/S, a leading producer of composite blades for wind turbines; Mita Teknik A/S, which produces controller and communication systems; and Svendborg Brakes A/S, a leading vendor of mechanical braking systems.

The 3-MW turbines are still the largest commercial turbines installed in Denmark. As a result of experiences at Horns Rev and the problems with the 3-MW turbines, Vestas has made a strong effort to improve the quality of its offshore wind turbines, and the 3-MW turbines are once again for sale to offshore projects.

The technical availability of new wind turbines on land in Denmark is usually in the range of 98% to 100%. For offshore

wind, the availability of turbines on the small near-shore farms is also high. Since 2005, all Horns Rev offshore turbines operated at nearly 100%, with an availability of 95% to 97%. During the same time period, the Siemens (Bonus) turbines at Nysted were at the same level except for the three month period in 2007 where the main transformer was out of order.

3.3 Economic details

No new data on operation and maintenance costs (service, consumables, repair, insurance, administration, lease of site, and so on) have been reported. Growing commercialization in the wind energy market makes it more difficult to have data on hardware and O&M costs. The information from a study by the Danish Wind Turbine Owners' Association about O&M for turbines between 600 kW and 1,300 kW was reported in the *2004 IEA Wind Energy Annual Report*.

3.4 Certification of wind-power installations

Wind turbines installed in Denmark must fulfill the Danish Wind Turbine Certification Scheme. The scheme is based on the IEC WT01 System for Conformity Testing and Certification of Wind Turbines. In June 2008, a supplementary set of rules for maintenance and service of the turbines was implemented. Wind turbine owners must now ensure that the wind turbines are maintained and serviced by a certified or approved company, as long as the wind turbines are in operation. Further, the service company must have documented sufficient basis, experience, and expertise in maintenance and service of the specific type of wind turbine that they are contracted to maintain. All documents related to the certification scheme can be found on the Web site: www.wt-certification.dk.

4.0 National Incentive Programs

In 2008, the subsidy for new wind turbines was increased from a premium of

0.10 DKK/kWh on the top of the market price for 20 years to a premium of 0.25 DKK/kWh for 22,000 full load hours plus 0.023 DKK/kWh for compensation for balancing costs, etc. For turbines under the repowering scheme there is an extra fixed supplement of 0.08 DKK/kWh for the first 12,000 full-load hours.

From 2009, owners of new turbines shall pay neighbors compensation for loss of property value due to the installation. Compensation shall be paid in connection with installation of the turbines. The object of compensation responsibility shall be based on the ordinary principle of the right to compensation, including a concrete individual evaluation of the loss of property value. Details about the incentive system for turbines installed before the end of 2004 and in the years 2005–2007 can be found at www.ens.dk.

5.0 R, D&D Activities

The annual report: Energy 2008 on public grants from the energy research programmes (9) provides overviews of projects that were funded, in progress, and completed under the following research programs:

- The Energy Development and Demonstration Program (EUDP) including Energy Agency's Energy Research Program (ERP) and Nordic Energy Research (NEF)
- Energinet.dk's ForskEL program and ForskNG program
- The Danish Council for Strategic

Research's (DCSR) Programme Committee on Energy and Environment

- The Danish National Advanced Technology Foundation.

Grants to wind energy projects supported in 2007–2008 totalled 63 million DKK.

Funding of energy R, D&D was increased in 2006 and again in 2007 and 2008, as shown in Figure 9. The funding will increase to about 750 million DKK in 2009 and about 1 billion DKK annually from 2010. The trend in public funding for energy research and technological development is shown in Figure 8. Funds are available under the annual Finance Act and Public Service Obligation funds (PSO), which Energinet.dk as TSO is entitled to collect from the electricity users under the Danish Electricity Supply Act and apply toward research in environmentally friendly electricity generation and efficient energy use.

The development of the funding for wind energy is illustrated on figure 9.

5.1 EUDP

In 2008, the former ERP was replaced by the EUDP. Additionally, the National Research Councils and the newly established High Technology Foundation may also provide funds for energy research. The Danish Energy Authority is responsible for the administration according to the regulation of the new EUDP, which covers research

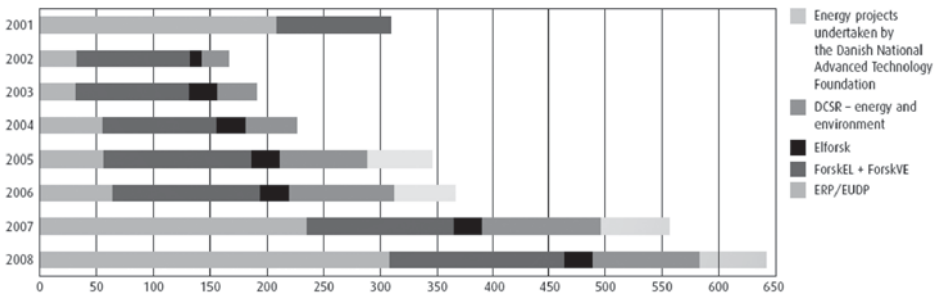


Figure 8 Funding for energy research and technological development, million DKK (9).

National Activities

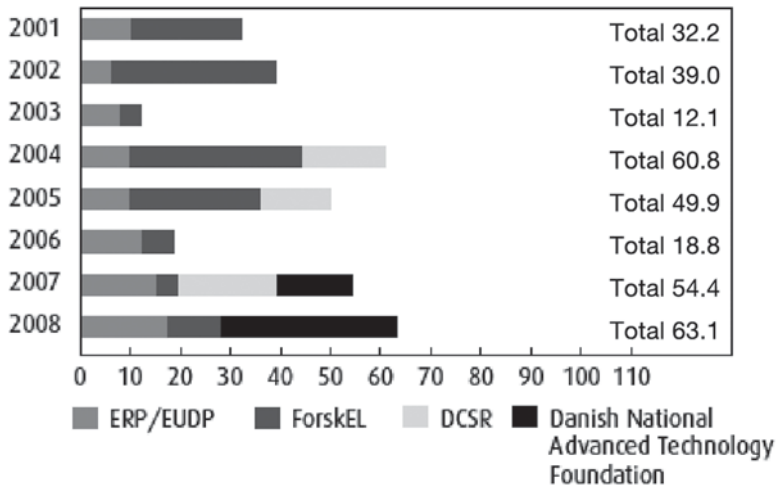


Figure 9 Funding for wind energy, million DKK (9).

in both conventional energy and renewable energy. Additionally, the EUDP supported international R&D cooperation through the IEA.

The EUDP also includes funding for quality assurance for renewable energy devices, including wind turbines. The secretariat of the Danish Wind Turbine Certification Scheme is assigned to manage quality assurance of turbines. The actual certification of turbines and installations is carried out by private certification companies like DNV and GL. Denmark has also been active in international standardization through IEC and CEN/CENELEC for several years.

5.2 ForskEL and ForskNG programs

Transmission system operators have had PSO-subsidized R&D programs for non-commercial projects concerning new and environmentally friendly energy technologies since 2000. The Energinet.dk's ForskEL programme and ForskNG programs focus on the development of renewable energy technologies including wind power. Priority areas and the total budget are to be approved by the responsible minister and the Danish Energy Authority. The PSO program emphasizes the interaction between turbines and the power system,

including the ability of wind power plants to contribute to regulation and stability.

5.3 Programme Committee on Energy and Environment

Since its establishment in 2004, the Danish Council for Strategic Research (DCSR) has had strategic research funds of various sizes at its disposal for research related to the value chain of energy research. Energy research has enjoyed high political priority since 2004 and represents a limited thematic area. The Danish parliament decides the amount for strategic research funds in the annual Appropriation Act. The DCSR's Supervisory Board sets up program commissions consisting of acknowledged scientists who are charged with allocating the funds.

In 2007, the Programme Commission on Sustainable Energy and Environment advertised a total of 200 million DKK to be allocated on five research areas. The two themes relevant to energy research were: "organized sustainable energy," and "energy and the environment," totaling approximately 100 million DKK. The other three themes advertised were: "water as a resource and element in nature's cycle," "environmental technology including climate," and "marine environment research."

5.4 Danish National Advanced Technology Foundation

The objective of the Danish National Advanced Technology Foundation is to support risky and capital intensive research and development which would otherwise not be possible without the active participation of the Foundation. The focus, therefore, lies on potentially value-creating technologies which have not yet been sufficiently matured for the commercial market. The tools of the Foundation are twofold:

1. Advanced technology platforms, which involve research in a phase of considerable risk and a correspondingly very large potential for value creation. Research is planned with a view to radical innovation. The platforms, which usually involve private enterprises as well as research institutions, serve as a stepping-stone for future commercial activities in a number of fields. Each platform has a budget of 30–150 million DKK, of which the Danish National Advanced Technology Foundation typically provides 50%. The time frame for the advanced technology platforms is 3–5 years.

2. Advanced technology projects, the focus of which is often closer to the market than that of the platforms. The participating businesses move into new business areas where they develop existing strengths by, for instance, developing a next-generation technology or by applying innovative combinations of know-how and technology. The total budget of the advanced

technology projects is 5–30 million DKK, of which the Danish National Advanced Technology Foundation typically provides 50%. The duration of advanced technology projects is 2–4 years.

5.5 Funded projects 2007–2008

Funded wind energy project in Denmark for the period 2007–2008 are presented in Table 2.

5.6 Test sites

Risø DTU still owns and manages the test site for multi-megawatt wind turbines at Høvsøre, a site on the northwest coast of Jutland with high wind speeds. The annual average wind speed at the site at a height of 78 m is 9.1 m/s. The test site consists of five test stands allowing turbines with heights up to 165 m and a capacity of up to 5 MW each. The test site is shown in Figure 10.

5.7 Collaborative research

Risø DTU plays a leading role in the large European Union project called UpWind. This project aims to design a wind turbine of 8 to 10 MW that will be able to operate onshore and offshore on wind farms of several hundred megawatts. With Risø DTU as the coordinator, 38 partners participate in the project, which started early in 2006.

In 2008, Denmark participated in the following IEA Wind Tasks: Task 11 – Base Technology Information Exchange; Task 23

Project title Project manager	Support Total budget Completion date	Short description
Offshore wind dynamics Department of Wind Energy/Risø-DTU	DKK 1,366,000 DKK 2,350,530 3rd quarter 2010	Wind field calculation at large offshore wind farms and subsequent flow involves some uncertainties. The project tries to apply a fundamentally different formulation of the physics in the atmospheric boundary layer, i.e. Bergmann's balance of preserved sizes in their steady-state formulation.

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<p>Shadow effects of large wind farms</p> <p>Department of Wind Energy/Risø-DTU</p>	<p>DKK 2,446,000 DKK 4,892,000 4th quarter 2009</p>	<p>The project aims at developing a meteorological software tool for large wind farm planning. The project is based on data from previous projects on large wind farm shadow effect. The existing tools have proven too optimistic and the close siting of wind farms is not considered properly.</p>
<p>Main electrical wind turbine components</p> <p>DTU Electrical Engineering</p>	<p>DKK 4,000,000 DKK 6,943,000 2nd quarter 2011</p>	<p>The cooperation project is conducted as a PhD study as its central element and its research will be used directly in wind turbine and wind farm development so as to prepare common guidelines under calls, during planning and design and in connection with a risk analysis of these systems.</p>
<p>Aero-Hydro-Elastic Simulation Platform for Floating Systems</p> <p>Department of Wind Energy/Risø-DTU</p>	<p>DKK 2,679,000 DKK 3,137,000 4th quarter 2009</p>	<p>The project focuses on a theoretical and experimental study of floating platforms for wind turbines, wave power systems and the relationship between wind and wave power. The project basis is the existing wave-wind power plant 'Poseidon's Organ'.</p>
<p>Estimation of extreme response and structural reliability of wind turbines under normal operation by means of controlled Monte Carlo simulation</p> <p>Department of Civil Engineering-AAU</p>	<p>DKK 950,000 DKK 1,203,000 1st quarter 2010</p>	<p>The project aims to develop controlled Monte Carlo simulation algorithms for wind turbine dimensioning to obtain a more precise estimate of how extreme values and failure probabilities are distributed in the reference interval. By extrapolation, the distribution of extreme responses can be determined for the entire life of the construction.</p>
<p>Nano-filtration of oil</p> <p>C.C. Jensen A/S</p>	<p>DKK 1,944,000 DKK 2,985,000 4th quarter 2010</p>	<p>To extend the life of gear oil – not least for use in offshore wind turbines – the project aims to investigate whether nano-filtration using CJC filters (cellulose fibres) with zeolites eliminates the carbonyl compounds which increase oil oxidation. The project also involves the long-term testing of nano filters.</p>
<p>Noise emission from wind turbines in wake</p> <p>DELTA Dansk Elektronik, Lys og Akustik</p>	<p>DKK 1,693,000 DKK 3,208,000 3rd quarter 2009</p>	<p>Acoustic measurements will be performed at various degrees of wake using several measuring techniques. The results will be compared with aerodynamic measurements to enhance knowledge of wind turbine noise emission at low, medium and high frequencies. The objective is to improve noise prediction and thus optimise wind farms.</p>

Wind energy economy EMD International	DKK 2,285,000 DKK 1,726,000 4th quarter 2009	The project aims to generate up-to-date knowledge on the trend in Danish wind turbine economy for use in an IEA project on 'Cost of Wind Energy'. Against the background of reliable operational data and analyses of project development costs, learning curves and scenarios will be set up for the technological and economic development.
Design and optimisation of wing tips for wind turbines DTU Mechanical Engineering	DKK 2,131,000 DKK 3,049,000 4th quarter 2009	Using new mathematical methods – topological fluid mechanics – and computer simulations, the exact vortex at the blade tips of a number of blade designs will be analysed. The analysis will result in new blade tip designs enhancing mechanical turbine power and reducing noise.
Integrated design of wind power systems Institute of Energy Technology-AAU	DKK 1,499,200 DKK 2,345,200 4th quarter 2009	By combining dynamic simulations and dedicated tools for electric design and control, aero elastic design and integration into the electricity system, attempts will be made at fully integrating the considerable dynamic interaction between these areas in a future wind energy system design.
Programme for research in applied aeroelasticity Wind Energy Department at Risø-DTU	DKK 4,147,000 DKK 6,549,000 1st quarter 2009	For 2008, the multi-annual programme includes seven specific milestones for maintaining Denmark's unique position in the fields of aerodynamics and aero elastic research as part of the Wind Power Hub vision. Thus, the programme plays a key role in training engineers and researchers for the wind turbine industry.
Improved design basis for large wind turbine blades (Phase 4) Materials Research Department at Risø-DTU	DKK 2,000,000 DKK 4,093,000 1st quarter 2009	The project aims to develop experimental methods for characterising material properties for relevant types of damage to wind turbine blades made of composite materials as well as calculation methods and procedures. Blade manufacturers will be able to use the results to improve their blade designs and the damage tolerance level.
Research and development centre for wind turbine components The Danish Wind Industry Association	DKK 1,484,000 DKK 1,981,000 2nd quarter 2008	During this second phase of the project to establish a Danish knowledge centre for wind turbine components, the draft design of the centre will be initiated. Initially, a test bed for a 200-300 kW drive train will be established, and work on the construction of the large-scale test bed will be initiated to provide a decision basis for the detailed planning.

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Interaction between seabed and offshore wind farms DTU Mechanical Engineering	DKK 9,400,000 DKK 14,500,000 2011	Offshore wind farm foundations are complex and expensive, one reason being the seabed which shifts due to wave and current impact. The project is looking into seabed conditions, erosion and the quicksand-like conditions that may arise due to impacts. The results are important for the assessment of foundation embedding and dimensioning.
Integrated aero-servo-elastic analysis and design of wind turbines Wind Energy Department at Risø-DTU	DKK 10,000,000 DKK 12,600,000 2011	Today, wind turbine control systems are designed separately from its structural, aerodynamic qualities, but to achieve cheaper, more reliable wind turbines, the design phases need to be united into one integrated aero-servo-elastic process. The project will develop new models, methods and guidelines for integrated aero-servo-elastic wind turbine design.
Wind turbines inspired by nature Vestas Wind Systems A/S	DKK 15,000,000 DKK 30,000,000 2011	The project group aims to develop a flexible flap for continuous wind turbine blade adaptation under turbulent wind conditions. Special wind detector sensors send data to a computer which calculates flap position. This reduces turbine weight as well as production costs.
Development of ground-breaking wind turbine blade technology LM Glasfiber A/S	DKK 35,000,000 DKK 65,000,000 2013	In the course of the next five years, the project group aims to develop and mature a wind turbine blade which by way of a new "Blade King" technology using new fibre types and increased production automation will increase production as well as cost effectiveness. The first Blade King blades are expected to be introduced in 2015 at the latest.

– Offshore Wind Energy Technology Deployment; Task 25 – Operation and Design of Power Systems with Large Amounts of Wind Power; and Task 26 – Cost of Wind Energy. In Task 23, the Department of Wind Energy, Risø DTU serves as one of the task Operating Agents.

6.0 The next term

It is expected that focus on wind power and other renewables will continue with emphasis on the new, large, offshore projects that are currently in the planning process with the framework of the COP 15 Climate Change Meeting to be held in Denmark in late 2009. The new political agreement for

energy begun in 2008, including more offshore wind power and better terms for wind power on land in Denmark, emphasizes that there is a strong political will. The recently enacted initiatives to fulfill the Energy Strategy 2025 will strengthen wind energy R, D&D in Denmark. It is expected that focus in the new EUDP program will be shifted to increase demonstration of new technologies.

References:

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- (2) Strategy 2025, published June 2005.
- (3) A Visionary Danish Energy Policy 2025), published 19 January 2007.



Figure 10 Test site at Høvsøre for multi-MW wind turbines (Photo credit: Risø DTU).

(4) Energy Policy Statement 2008, February 2008.

(5) Future Offshore Wind Power Sites -2025. Danish Energy Agency, April 2007.

(6) Horns Rev II project description posted on www.ens.dk (in Danish).

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(9) Annual report 2008 on public grants from the energy research programmes, ForskEL, EUDP/ERP, Elforsk and DCSR. Energy and Environment. November 2008.

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1.0 Introduction

Europe has historically been and continues to be the world's strongest market for wind energy development. In 2008, the European Union (EU) saw another record year with installations of almost 8.5 GW, thereby reaffirming its undisputed status as the world's biggest wind market (1). Industry statistics released by the EWEA show that in 2008, cumulative wind capacity increased by 15% to reach a level of 64.935 GW; this was up from 56.535 GW at the end of 2007 (Figure 1). This 8.4 GW of new wind power capacity represents a wind turbine manufacturing turnover of some 11 billion €.

1.1 Overall capacity increases

In the EU, wind power continues to be one of the most popular electricity generating technologies for expanding capacity. Since 2000, almost 178 GW of new electricity generating capacity has been installed in the EU. During that time, the installed wind capacity has increased almost seven times from 9.7 to 64.9 GW. Over these last eight years, according to figures from Platts PowerVision and EWEA, new gas installations totaled 96 GW, while wind energy installations totaled more than 55 GW. This represents 31% of the total new generation installations over the period between 2000 and 2008 (Figure 2).

In 2008 alone, wind power installations made up almost 36% of new power installations in Europe and grew more than any other power-generating technology. Wind energy now represents 8% of the total EU installed power capacity (Figure 3). Total wind power capacity installed by the end of 2008 will produce 142 TWh, or 4.2% of EU power demand in an average wind year, and will avoid about 108 million tons

of CO₂ annually. In 2000, less than 0.9% of EU electricity demand was met by wind power.

The 2008 capacity increase was driven by Italy, Germany, and Spain, together representing 53% of the total. Today, 19% of Denmark's electricity comes from wind, 12% in Spain, and 7% in Germany. The growth was sustained in Italy – which added 1,010 MW to reach 3,736 MW – and France, which installed 950 MW for a total of 3,404 MW. The new Member States of the EU performed well and increased their installed wind capacity by 63%, with Poland, the most successful, reaching a total of 472 MW. In 2008, Bulgaria tripled its capacity and Hungary doubled its capacity. Over the last ten years, cumulative wind energy installations in the EU have increased by an average of 26%/yr. The overall market growth in 2008 was 15%. Looking beyond Europe, the global market for wind turbines grew by 28.7% last year to 121 GW.

The slow pace of development in some European countries can be explained by a mixture of slow administrative processes, problems with grid access, and legislative uncertainty. The figures demonstrate the existence of continuous barriers to wind energy development. One critical element for a massive and sustained expansion of wind energy in all countries of the EU is the swift and rapid implementation of the European directive for the promotion of renewable energy sources, with an objective of 20% of renewable energy in the European energy mix in 2020. This could represent 35% of European electricity coming from renewables in 2020.

1.2 Offshore wind

Offshore wind, seen as a key market for European expansion, is now near take off. By 2008, the industry had developed 32

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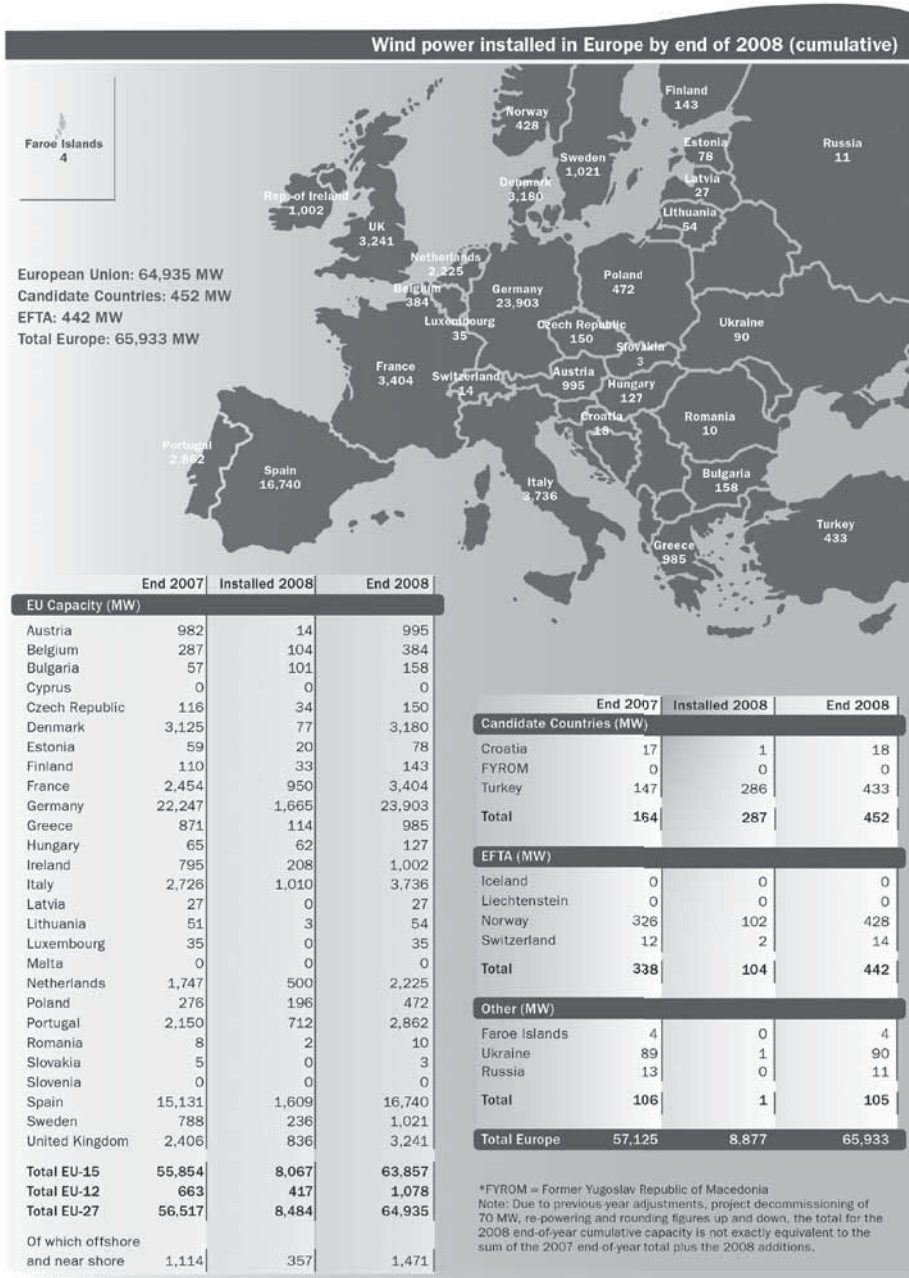


Figure 1 Wind power installed in Europe by end of 2008.

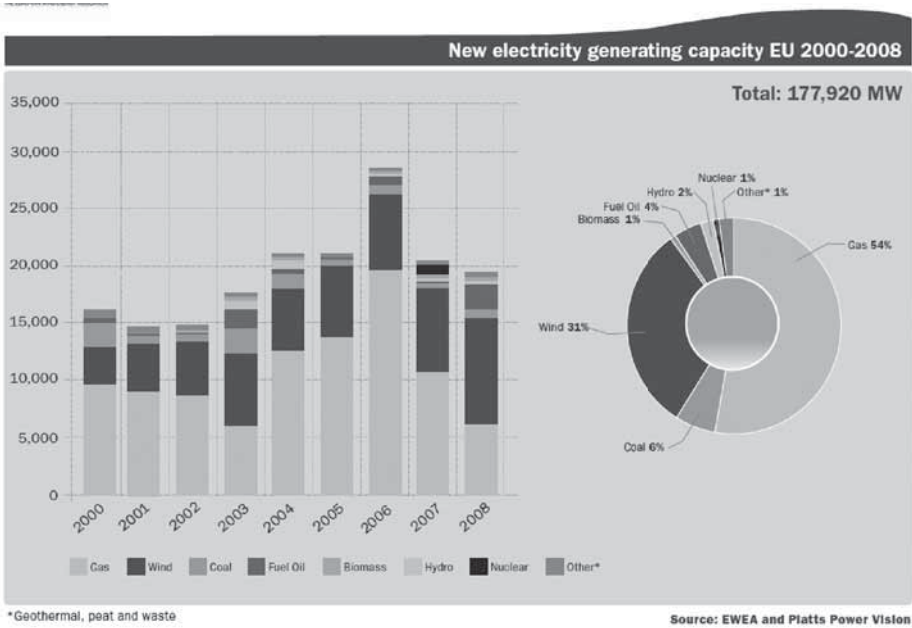


Figure 2 New electricity generating capacity in the EU from 2000 to 2008.

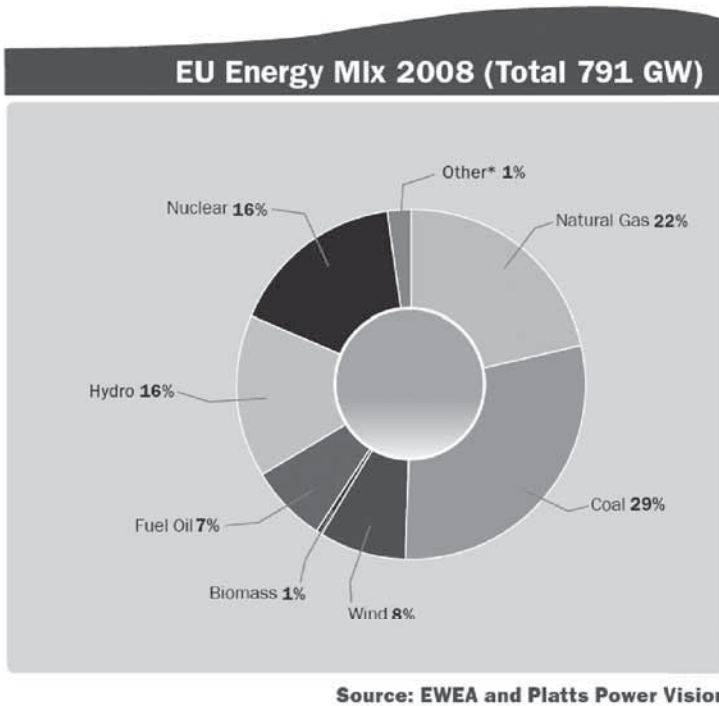


Figure 3 Cumulative installed capacity per Member State by end of 2007.

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projects in ten countries, many of them large scale and fully commercial, with a total capacity of around 1,471 MW (Figure 4). At the end of 2008, offshore wind farm installations represented nearly 2.3% of the total installed wind power capacity.

The short-term prospects for offshore wind are promising, with several projects planned to be connected to the grid in 2009 in Germany (512 MW), France (105 MW), the United Kingdom (90 MW), Sweden (30 MW), and Denmark (28 MW).

Prospects for 2015 look bright, with a total of more than 37 GW planned (Figure 5). One critical element for an acceleration of the development of offshore wind energy in the EU is the rapid publication of the Commission's blueprint for a North Sea grid, the Baltic interconnection plan, and the Mediterranean ring, as announced by the second Strategic Energy Review. However, the current global financial environment is also a potential delaying factor for the foreseen deployment.

2.0 The EU Legislative Framework for Wind Energy

2.1 The RES-E Directive

Up until now, an important factor behind the growth of the European wind market has been strong policy support both at the EU and at the national level. The EU's Renewable Electricity Directive (77/2001/EC) has been in place since 2001. The aim is to increase the share of electricity produced from RES in the EU to 21% by 2010, up from 15.2% in 2001. This target was established by the EU Renewable Electricity (RES-E) Directive, which set out differentiated national indicative targets. The RES-E Directive has been a historical step in the delivery of renewable electricity and constitutes the main driving force behind recent policies being implemented.

In the pursuit of the overall target of 21% of electricity production from renewable sources by 2010, the RES-E Directive gives EU Member States freedom of choice regarding support mechanisms. Thus,

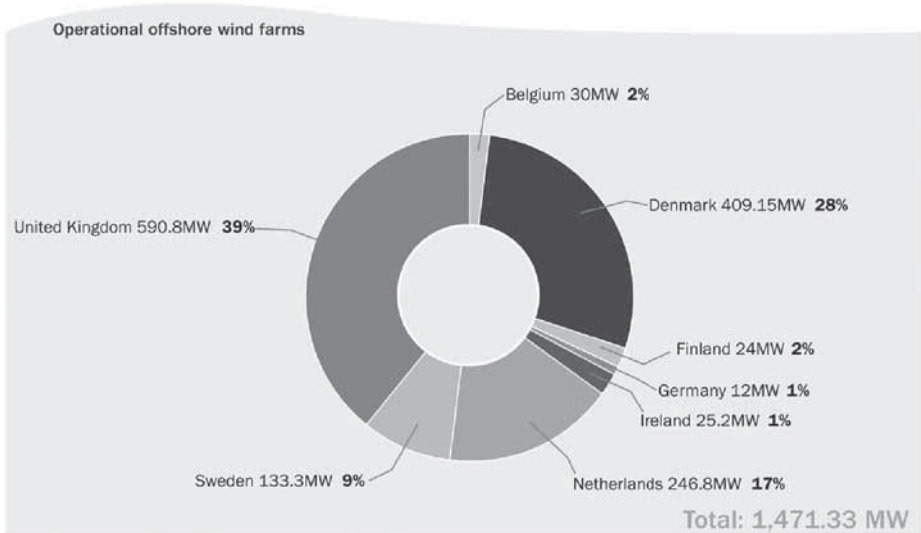


Figure 4 Offshore wind power installed by the end of 2008 by Member States of the EU. Source: EWEA (2009) Offshore Wind Farms 2008.

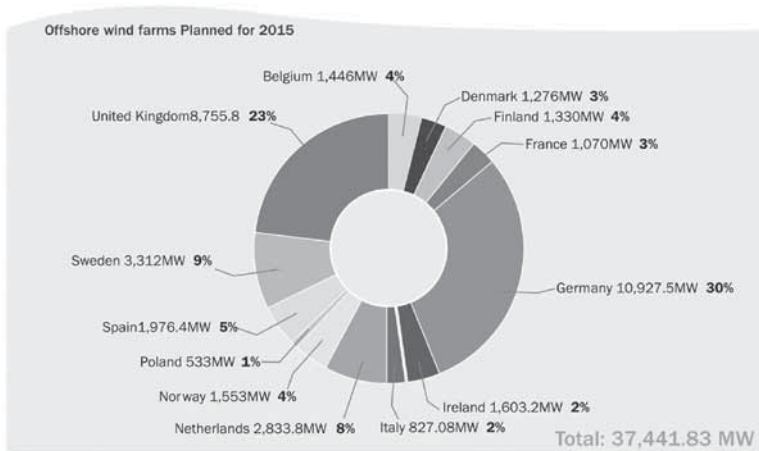


Figure 5 Offshore wind power planned for 2015.

various schemes are operating in Europe, mainly feed-in tariffs, fixed premiums, green certificate systems, and tendering procedures. These schemes are generally complemented by tax incentives, environmental taxes, contribution programs, or voluntary agreements.

The European Commission (EC) reports COM (2005) 627 and COM (2008) 19 have highlighted that despite the requirements of Directive 77/2001/EC, the efforts of Member States, and some improvements of the regulatory frameworks, major barriers to the growth and integration of renewable electricity remain. In relation to wind, the progress report highlights that even if the level of payment is sufficient to cover costs, it may not increase deployment of wind. The main cause of the slow development in some Member States is not deliberate policy barriers, but delays in authorization, unfair grid access conditions, and slow reinforcement of the electric power grid. The reports invite the Member States to give a high priority to removing administrative barriers and improving grid access for renewable energy producers.

Finally, the EC reports conclude that the harmonization of support schemes for economic efficiency, single market, and state aid remains a long-term goal, but that harmonization in the short-term is

not appropriate. By adopting best practices or combining national support schemes, Member States can continue to reform, optimize, and coordinate their efforts to support renewable electricity. According to the European Wind Energy Association, a hasty move toward a harmonized EU-wide payment mechanism for renewable electricity would have a profoundly negative effect on the markets for wind power and put European leadership in wind power technology and other renewables at risk.

2.2 EU Legislative Framework

In December 2008, the European Union agreed a new Renewable Energy Directive to implement the pledge made in March 2007 by the EU Heads of State for a binding 20% renewable energy target by 2020. The EU's overall 20% renewable energy target for 2020 has been divided into legally binding targets for the 27 Member States, averaging out at 20%. The Member States are given an 'indicative trajectory' to follow in the run-up to 2020. By 2011-12, they should be 20% of the way toward the target (compared to 2005); by 2013-14, 30%; by 2015-2016, 45%; and by 2017-18, 65%.

In terms of electricity consumption, renewables should provide about 35% of the EU's power by 2020. By 2020, wind energy is set to contribute the most - nearly

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35% of all the power coming from renewables. The directive legally obliges each EU Member State to ensure that its 2020 target is met and to outline the 'appropriate measures' it will take to do so in a National Renewable Energy Action Plan to be submitted by 30 June 2010 to the EC.

The National Action Plans (NAPs) will set out how each EU country is to meet its overall national target, including sector targets for shares of renewable energy for transport, electricity, and heating/cooling. The NAPs will also describe how Member States will tackle administrative and grid barriers. If they fall significantly short of their interim trajectory over any two-year period, Member States will have to submit an amended NAP stating how they will make up for the shortfall.

Every two years Member States will submit a progress report to the EC, containing information on their share of renewable energy, support schemes, and progress on tackling administrative and grid barriers. Based on these reports from the Member States, the EC will publish its own report the following year.

Certain measures to promote flexibility have been built into the directive in order to help countries achieve their targets in a cost-effective way without undermining market stability. For example, Member States may agree on the statistical transfer of a specified amount of renewable energy between themselves. They can also co-operate on any type of joint project relating to the production of renewable energy, including projects involving private operators if relevant. Thirdly, two or more Member States may decide, on a voluntary basis, to join or partly coordinate their national support schemes in order to help achieve their targets.

Under certain conditions, Member States will be able to help meet their national electricity sector target with imports from non-EU countries. The electricity will have to be produced by a newly constructed installation that became operational after the directive enters into force, or by the

increased capacity of an installation that was refurbished after the directive enters into force, and the electricity must be consumed within the EU community.

Regarding administrative procedures, the Member States will have to make sure that the authorization process for renewable energy projects is proportionate, necessary, and transparent. This should reduce the time a new project takes to become operational and help the 2020 targets be met more easily.

For integration to the electricity system, the agreement requires EU countries to take "the appropriate steps to develop transmission and distribution grid infrastructure, intelligent networks, storage facilities, and the electricity system" to help develop renewable electricity. They must also speed up authorization procedures for grid infrastructure.

EU countries must ensure that transmission system operators and distribution system operators guarantee the transmission and distribution of renewable electricity and provide for either priority access to the grid system – meaning connected generators of renewable electricity are sure that they will be able to sell and transmit their electricity – or guaranteed access – ensuring that all electricity from renewable sources sold and supported gets access to the grid.

The EC will publish, by 2018, a Renewable Energy Roadmap for the post-2020 period. This is a very welcome development that will allow the wind power sector to ensure that a stable regulatory framework replaces the Renewable Energy Directive of 2009 when it expires at the end of 2020.

3.0 R, D&D Wind Energy Projects

In 2008, around 20 R&D projects were running with the support of the Sixth and Seventh Framework Programmes of the EU (the Framework Programmes are the main EU-wide tool to support strategic research areas). The management and monitoring of these projects is divided between two Directorate-Generals (DGs) of the EC: the

Directorate-General for Research (DG Research) for projects with medium- to long-term impact, and the Directorate-General for Transport and Energy (DG TREN) for demonstration projects with short- to medium-term impact on the market. The following paragraphs summarize both the nature and the main data of EU R&D initiatives funded projects during 2008.

3.1 DG Research activities

In 2008, the two projects POW'WOW and UPWIND continued their activities, and three wind-related projects started in 2008.

POW'WOW, which stands for Prediction Of Waves, Wakes and Offshore Wind (powwow.risoe.dk), is a three-year coordination action that started in October 2005 with the aim to co-ordinate activities in the fields of short-term forecasting of wind power, offshore wind and wave resource prediction, and estimation of offshore wakes in large wind farms. The purpose of the POW'WOW project is to spread the knowledge gained in these fields among the partners and colleagues, and to start work on some roadmaps for the future. A first workshop on "Best Practice in the Use of Short-Term Forecasting of Wind Power" was held in Delft, the Netherlands in 2006. In September 2007, a workshop on "Integration of Wind and Wave Resource Assessment" was organized in Porto, Portugal. In May 2008, a second workshop on "Best Practice in the Use of Short-Term Forecasting of Wind Power" was held in Madrid, Spain.

UPWIND, which stands for Integrated Wind Turbine Design (www.upwind.eu), started in March 2006 to tackle, over six years, the challenges of designing very large turbines (8 to 10 MW), both for onshore and offshore. UPWIND focuses on design tools for the complete range of turbine components. It addresses the aerodynamic, aero-elastic, structural, and material design of rotors. Critical analysis of drive train components is also being carried out in the search for breakthrough solutions. UPWIND is a large initiative with a

consortium composed of 40 partners and brings together the most advanced European specialists of the wind industry.

Following the first call for proposals by the EC's Seventh Framework Programme, three wind-related projects started in 2008.

RELIAWIND: The EU Council of Ministers, held on 8 and 9 March 2007, examined energy issues and agreed, amongst other things, that "renewable energy will cover at least 20% of the EU's energy demand by 2020." Wind power can make the most important contribution to this target, if sufficient emphasis is placed on technological R&D and market development. Because of the current European scenario and its forecasted evolution toward 20% renewables by 2020, offshore wind energy is called to play a key role. Currently, offshore maintenance costs are still too high and thus require higher feed-in tariffs for the private investor's business case to reach minimum profitability. The RELIAWIND project aims to offset this paradigm and allow offshore wind power to be deployed in the same way onshore has been. Based on the success of collaborative experiences in sectors such as aeronautics, members of the European wind energy sector established the RELIAWIND consortium to jointly and scientifically study the impact of wind turbine reliability. The mission of the consortium is to change the paradigm of how wind turbines are designed, operated, and maintained. This will lead to a new generation of offshore (and onshore) wind energy systems that will hit the market in 2015.

The objectives of this research project are:

- To identify critical failures and components (WP-1: Field Reliability Analysis)
- To understand failures and their mechanisms (WP-2: Design for Reliability)
- To define the logical architecture of an advanced wind turbine generator health monitoring system (WP-3: Algorithms)
- To demonstrate the principles of the project findings (WP-4: Applications)

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- To train internal and external partners and other wind energy sector stakeholders (WP-5: Training)
- To disseminate the new knowledge through conferences, workshops, web site, and the media (WP-6: Dissemination).

PROTEST: One of the major causes of failures of mechanical systems (e.g. drive trains, pitch systems, and yaw systems) in wind turbines is insufficient knowledge of the loads acting on these components. The objective of this pre-normative (2) project is to set up a methodology that enables better specification of design loads for the mechanical components. The design loads will be specified at the interconnection points where the component can be “isolated” from the entire wind turbine structure (in gearboxes for instance, the interconnection points are the shafts and the attachments to the nacelle frame). The focus of this activity will be on developing guidelines for measuring load spectra at the interconnection points during prototype measurements and to compare them with the initial design loads. Ultimately, these new procedures will be brought to the same high level as the state-of-the-art procedures for designing and testing rotor blades and towers, which are critical to safety. A well-balanced consortium consisting of a turbine manufacturer, component manufacturer, certification institute, and R&D institutes will describe the current practice for designing and developing mechanical components. Based on this starting point, the project team will draft improved procedures for determining loads at the interconnection points. The draft procedures will then be applied to three case studies, each with a different focus. They will determine loads at the drive train, pitch system, and yaw system. The yaw system procedures will take into account complex terrain. The project team will assess the procedures, and (depending on the outcome) the procedures will be updated accordingly and disseminated. All partners will incorporate the new

procedures in their daily practices for designing turbines and components, certifying them, and carrying out prototype measurements. Project results will be submitted to relevant standardization committees.

SAFEWIND: The integration of wind generation into power systems is affected by uncertainties in the forecasting of expected power output. Misestimating of meteorological conditions or large forecasting errors (phase errors, near cut-off speeds, etc), are very costly for infrastructures (such as unexpected loads on turbines) and reduce the value of wind energy for end-users. The state-of-the-art techniques in wind power forecasting have focused so far on the “usual” operating conditions rather than on extreme events. Thus, the current wind forecasting technology presents several strong bottlenecks. End-users argue for dedicated approaches to reduce large prediction errors and for scaling up local predictions of extreme whether (gusts, shears) to a European level because extremes and forecast errors may propagate. Similar concerns arise from the areas of external conditions and resource assessment where the aim is to minimize project failure. The aim of this project is to substantially improve wind power predictability in challenging or extreme situations and at different temporal and spatial scales. Going beyond this, wind predictability will be considered as a system parameter linked to the resource assessment phase, where the aim is to make optimal decisions for the installation of a new wind farm. Finally, the new models will be implemented into pilot operational tools for evaluation by the end-users in the project. The project concentrates on:

- Using new measuring devices for a more detailed knowledge of the wind speed and energy available at local levels
- Developing strong synergy with research in meteorology
- Developing new operational methods for warning/alerting that use coherently collected meteorological and wind power data distributed over Europe for

early detection and forecasting of extreme events

- Developing models to improve medium-term wind predictability
- Developing a European vision of wind forecasting that takes advantage of existing operational forecasting installations at various European end-users.

The 2009 call for proposals brought two cross-cutting topics about platforms for deep water offshore multipurpose renewable energy (wind/wave/ocean). Several proposals were received by 25 November 2008 and were being evaluated.

3.2 DG TREN activities

The two projects discussed below represent demonstration actions funded within the Seventh Framework Programme (FP7- 1st Call) of the EU and managed by the DG TREN.

7-MW-WEC-by-11: This action focuses on demonstrating a cost-effective large-scale high-capacity wind park using new state-of-the-art multi-megawatt turbines coupled with innovative technology used to stabilize the grid. A key objective of the '7-MW-WEC-by-11' project is to introduce a new class of large-scale Wind Energy Converters (WEC), the 7-MW WEC, onto the market. Such WECs could contribute to higher market penetration levels for wind electricity in Europe. The new 7-MW WEC should be designed and demonstrated at a large scale: 11 such WECs will be demonstrated in a 77-MW wind park close to Estinnes, Belgium. The wind park will be the first large-scale on-shore wind park in Belgium and the first in the world that will consist of this 'mega' turbine power class. Key-challenges related to wind power will be addressed in this demonstration action ranging from technical issues (network stability and security), to financial aspects (cost effectiveness), to environmental issues (landscape pollution). First, the 'mega' turbines will be developed and installed in series; this is envisioned to

significantly reduce costs and increase the market value. Second, new power electronics technology and improved wind forecasting will be used to stabilize the grid in the high-capacity wind park. Improved forecasting is envisioned to further improve the cost-effectiveness of the high-capacity wind park by reducing imbalance costs and improving commercial value. Third, the 7-MW turbines will be used to maximize wind energy capacity, while reducing landscape pollution and environmental impact. Such large WECs generate more than double the energy in the same given area when compared to conventional 2-MW turbines and require fewer turbines when compared to conventionally used wind turbines. After the 77-MW demonstration, lessons learned in developing the high-capacity Estinnes wind park will be adapted to a different national context with a weak grid system, Cyprus, Greece.

NORSEWInD will provide a wind resource map covering the Baltic, Irish, and North Sea areas. The project will acquire highly accurate, cost effective, physical data using a combination of traditional meteorological masts, ground-based remote sensing instruments (LiDAR & SoDAR), and Satellite acquired synthetic aperture radar (SAR) wind data. The vertical resolution of the ground-based instruments will be used to calibrate the satellite data to provide hub-height, real-world data. The resultant wind map will be the first step for all potential developers in the regions being examined, and as such represents an important step forward in quantifying the quality of the wind resource available offshore. The techniques employed can be repeated in any offshore environment. This will be showcased in the NORSEWInD validation task. Remote sensing technologies have an important role to play in the wind industry, and their use within the NORSEWInD program to reduce the cost and increase the accuracy of offshore wind measurements will increase acceptance and showcase the ability and power of the techniques.

National Activities

3.3 Future R&D projects

Several wind projects are expected to start in 2009 under the Seventh Framework Programme. The new projects will address deep-offshore multipurpose renewable energy platforms, the demonstration of innovative multi-MW machines, and wind mapping for offshore applications.

3.4 Plans and initiatives

The Strategic Energy Technology Plan (3) is a pragmatic and pioneering tool for supporting the development of low carbon technologies to significantly contribute to the European energy and climate change objectives. Part of this plan, the European Industrial Initiatives will be set up to include the industrial sector in setting priorities, objectives, and activities, and in identifying the financial and human needs to make a step change in the energy sector.

The European Wind Industrial Initiative has the objective to make wind one of the cheapest sources of electricity and to enable a smooth and effective integration of massive amounts of wind electricity into the grid. To achieve this objective, special efforts will be dedicated to greatly increase the power generation capacity of the largest wind turbines (from 5-6 MW to 10-20 MW) and to tap into the vast potential of offshore wind. This will pave the way for achieving ambitious targets by 2020:

- Supplying up to 20% of the EU electricity consumption
- Reducing the cost of electricity from wind energy by 20%
- Enabling the development of new types of turbines reaching up to 20 MW.

The European Wind Industrial Initiative will integrate the following elements:

1. Reinventing wind turbines through innovative design, integration of new materials, and development of advanced structures with particular emphasis on offshore wind applications that are far from shore and water depth independent

2. Putting an automated wind manufacturing capacity in place

3. Reducing the cost and enabling large wind energy integration into the grid by adapting the network and its operation to a progressive but fast up-take of on and offshore wind electricity

4. Accelerating market deployment through a deep knowledge of wind resources and a high predictability of wind forecasts.

3.5 European Commission contacts

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4.0 The European Wind Energy Technology Platform

The European Wind Energy Technology Platform (TPWind) was officially launched on 19 October 2006, with the full support of the EC and the European Parliament. TPWind is an industry-led initiative. The Secretariat is composed of the European Wind Energy Association, Garrad Hassan, and Risø DTU. Its objective is to identify and prioritize areas for increased innovation, new and existing research, and development tasks.

Historically, the principal drivers for wind energy cost reductions have been R, D&D, for approximately 40%; and economies of scale, for around 60%. The scope of TPWind mirrors this duality. TPWind

focuses not only on short- to long-term technological R&D but also on market deployment. This is reflected in the TPWind structure, as defined by the Steering Committee in 2007. TPWind is composed of four technical working groups responsible for building a Strategic Research Agenda, two working groups responsible for building a Market Deployment Strategy, a Finance Group responsible for exploring and proposing funding mechanisms, and a Mirror Group gathering representatives from national governments. The platform is lead by a Steering Committee of 25 members, representing a balance between industry and research, and between European countries. Altogether, this represents a group of 150 high-level experts representing the whole wind industry.

TPWind is the indispensable forum for the crystallization of policy and technology research and deployment pathways for the wind energy sector. It also provides an opportunity for informal collaboration and coordination between EU Member States, including those less developed in wind energy terms.

In June 2008, TPWind issued its Strategic Research Agenda and Market Deployment Strategy documents. These documents were debated during the two General Assemblies of the Technology Platform. TPWind is now moving to its next operation phase, focused on implementing its Strategic Research Agenda. Therefore, in March 2009, TPWind released a document proposing a list of concrete projects in order to enable a swift implementation of the priorities of the European wind energy sector.

Figure 6 (pg. 130) reflects the TP-Wind structure. The secretariat of the platform is funded by the Sixth Framework Programme.

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References and notes

(1) Note that due to differences in statistical methodology, there may be slight differences between the figures quoted in this section and those in other sections of the IEA Wind Annual Report.

(2) Pre-normative research is R&D likely to generate new matters for standardisation, usually in advance of these activities, (i.e. work anticipating future standards).

(3) Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions - A European strategic energy technology plan (SET-plan) - 'Towards a low carbon future', COM/2007/0723 final.

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National Activities

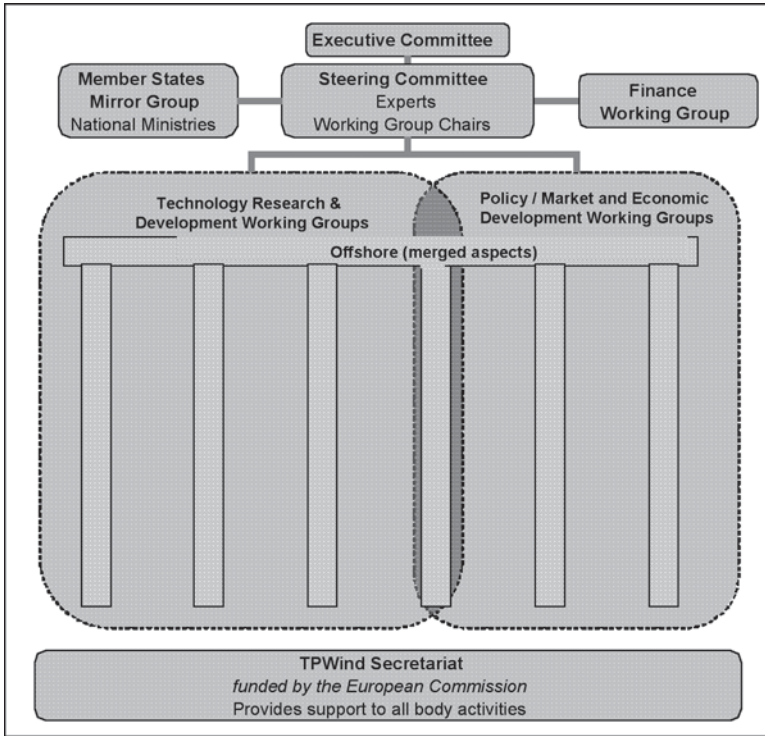


Figure 6 Structure of TPWind. SOURCE: European Wind Energy Technology Platform. Available at <http://www.windplatform.eu>.

1.0 Introduction

Energy in Finland is generated using a high share of renewables, mainly hydropower and biomass. Finland's generating capacity is diverse. In 2008, 25% of gross demand was produced by nuclear, 19% by hydropower (it was a good hydropower year), and 31% from combined heat and power (coal, gas, biomass, and peat). Gross electricity demand is about 87 TWh and is dominated by energy-intensive industry. About half of the electricity is consumed by the paper and metal industries. About 15% of electricity was imported, mainly from Russia.

Most of Finland's hydropower resource has already been used; there is potential for about 1 TWh/yr more. Biomass is used intensively by the pulp and paper industry, raising the share of biomass-produced electricity to 10% in Finland. There is still biomass potential available, and this is reflected by the national energy strategy, which foresees biomass as providing most of the increase in renewables.

Wind energy potential is located mostly on coastal areas. There is a huge technical potential offshore, with ample shallow sites available. Offshore, nearly 10,000 MW of wind power potential has been identified in the process of renewing regional plans in Finland.

A feed-in premium has been proposed to begin in 2010 to promote investments in wind power. A guaranteed price of 83.5 €/MWh has been proposed for wind power. The difference between the guaranteed price and spot price of electricity will be collected from the consumers and paid to the producers as a premium.

2.0 Progress Toward National Objectives

The progress in wind power capacity has been slow compared with other European countries. The funds available for investment subsidies have been inadequate to achieve any large increases in wind-power capacity. From 2005 to 2008, no specific goal for wind power was set.

The new target proposed in the climate and energy strategy in 2008 is 2,000 MW of wind power in 2020. This would be about 6% of the total electricity consumption in Finland. A new subsidy system is proposed to start in 2010. This reflects the increased targets for renewables arising from the EU target of 20% of energy consumption from renewable sources in 2020. The target for Finland is 38% of final energy consumption by RES (current RES share 28.5%).

The development in wind power capacity and production is presented in Figure 1. Eleven new turbines totaling 33 MW were installed, bringing the total capacity to 143 MW at the end of 2008 (30% growth from the previous year). Total wind energy production in 2008 increased by 38% compared to 2007. The production of 260 GWh corresponds to 0.3% of the annual gross electricity consumption of Finland (Table 1).

There were 118 wind turbines in operation in Finland at the end of 2008. The average wind turbine size is 1,210 kW.

Total installed wind generation	143 MW
New wind generation installed	33 MW
Total electrical output from wind	0.26 TWh
Wind generation as % of national electric demand	0.3%
Target:	2,000 MW by 2020

National Activities

About 37% of the equipment originates from Denmark, 20% from Germany, 39% from Finland, and 4% from the Netherlands. The size of the installed capacity ranges from 75 kW to 3 MW. The eleven new turbines installed in 2008 were all 3 MW turbines (Figure 2).

Only a few projects could still be built in 2009, (1 MW in Ii, 3 MW in Pori, and 12 MW in Hamina), but more than 80 MW received investment subsidy decisions in 2008 and in the first part of 2009. There are a huge number of projects that are planned, under feasibility studies, or have just been proposed: 1,300 MW onshore and 4,700 MW offshore. Several large offshore project plans were published in 2007 and 2008, and Environmental Impact Analyses have been started for Suurhiekkä (400 MW), Oulu-Haukipudas (500 MW), Maakrunni (350–450 MW), Pitkämatala (800–900 MW), Oulunsalo-Hailuoto (150–210 MW), and Raahe (300–500 MW) on

the Northern part of the West coast, as well as Kristiinankaupunki (240–400 MW), Siipyy (about 250 MW), and Inkoo (180–300 MW) on the Southern part of the West coast. Pori offshore demonstration is the closest to the building phase (100 MW). The largest onshore projects are in Tornio (28 MW), Muonio (30–40 MW), Raippaluoto (45 turbines), Teuva (30 turbines), Kristiinankaupunki (45 turbines), Ilmajoki (20 turbines), Maahti (35 turbines), Raahe (30 turbines), and Närpiö (30 turbines).

The Åland islands between Finland and Sweden constitute an autonomous region with its own legislation, budget, and energy policy. Wind energy deployment there is steady and, considering the population, the targets are ambitious. Wind energy was expected to cover 10% of electricity consumption in the region by 2006. This figure stood at 23% in 2008 for the 22 MW installed and will further increase as 18 MW Eckerö project will be built in 2010.

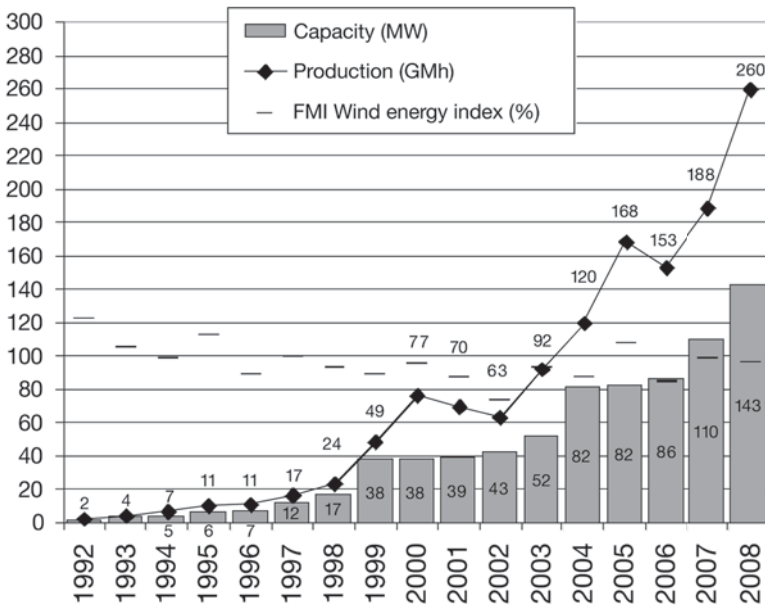


Figure 1 Development of installed wind power capacity (MW) at end of 2008, yearly wind power production (GWh), and wind production index (calculated from Finnish Meteorological Institute (FMI) wind-speed measurements converted to wind power production, 100% is average production from 1987–2001).

The environmental benefit of wind power production in Finland is about 0.2 million tons of carbon dioxide savings per year.

3.0 Benefits to National Economy

3.1 Market characteristics

Most of the turbines in Finland are located along the coast and are owned by power companies and local energy works (Figure 3). Green electricity is offered by most electric utilities; however, the marketing is not very active. In 2008, the companies reported thousands of new customers for the renewable electricity products. The supply of used turbines from the first demonstration projects in Finland and from the Netherlands has encouraged some farmers to acquire second-hand turbines—they are located inland where the wind resource is limited at heights below 60 m.

Good sites for larger wind farms on the coastal areas are scarce. This is one reason

for interest in offshore projects. The first semi-offshore projects were built in 2007 (six 2.3-MW turbines in Åland Båtskär) and 2007–08 (ten 3-MW turbines in Kemi, of which 12 MW are offshore) (Figure 4). A demonstration project in Pori is still in the planning phase (100 MW).

3.2 Industrial development and operational experience

3.2.1 Industrial development

The Finnish manufacturer WinWinD presented its first 1-MW pilot plant in spring 2001 and erected the 3-MW pilot plant in 2004 in Oulu. Their turbines operate at variable speed with a slow speed planetary gear box and a low-speed permanent-magnet generator. This solution combines the best features of a direct drive and gear system, producing efficient and reliable turbines. By the end of 2008, WinWinD had installed 142 MW in seven different countries including Estonia, France, Portugal,



Figure 2 Oulunsalo saw two new 3-MW WinWinD turbines added to the existing wind park in 2008 (three 1-MW WinWinD turbines; one 1.3-MW Nordex turbine). (Photo: WinWinD).

National Activities

Finland 2008:

143 MW, 118 wind turbines

- Wind park > 5 MW
- Wind park 0.6...5 MW
- Single turbine 1...3 MW
- Single turbine < 1 MW

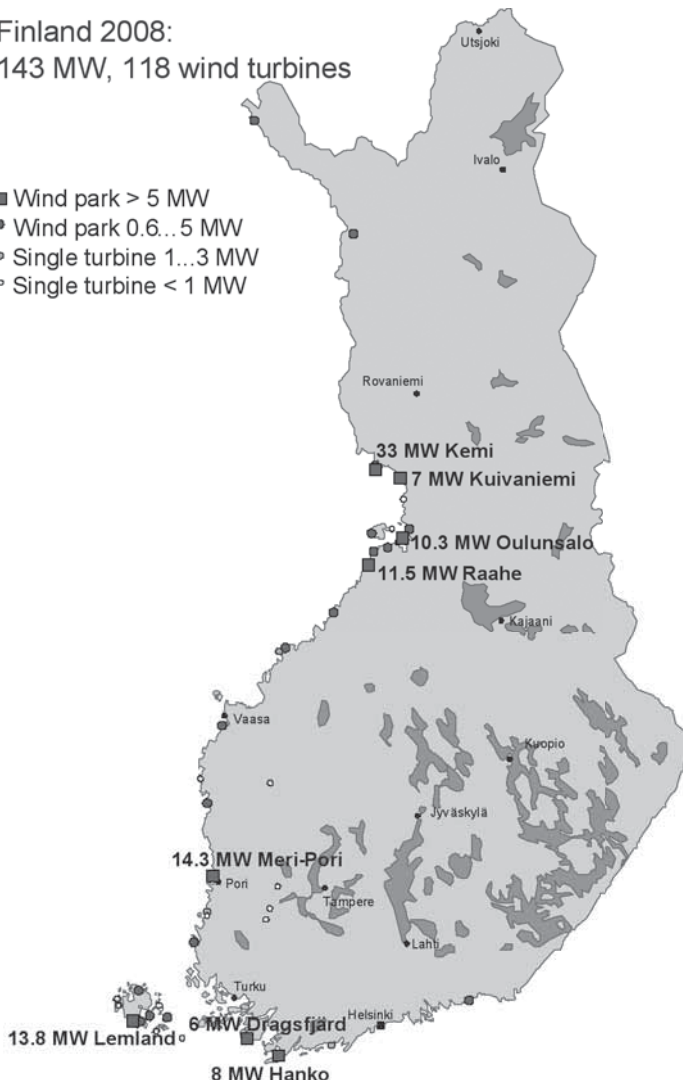


Figure 3 Locations of wind turbines in Finland at the end of 2008..

and Sweden. WinWinD has manufactured 39% of all the turbines in Finland (57 MW) (Figure 5). In 2008, the number of employees grew to 270 (190 in Finland). WinWinD has two manufacturing facilities in Finland. An assembly plant for 3-MW turbines is currently being constructed in Hamina, Finland. An assembly and blade manufacturing plant for 1-MW turbines is starting operation in 2009 in Chennai, India. The main owner of WinWinD since

2006 is Sterling Group (India) and in 2008 Masdar (Abu Dhabi) became a major shareholder, too. This has led to a steady expansion in the company and an increase in the production capacity to meet the demand for turbines.

Several industrial enterprises have developed important businesses as suppliers of major components for wind turbines. For example, Moventas Oy (earlier Metso Drives Oy) is the largest independent



Figure 4 New semi-offshore wind farm (ten 3-MW WinWinD turbines) installed in Kemi Ajos. (Photo: Eero Kokkonen, PVOI).

manufacturer of gears and mechanical drives for wind turbines. ABB Oy is a world-leading producer of generators and electrical drives for wind turbines. The Switch company supplies individually tailored permanent-magnet generators and full-power converter packages to meet the needs of wind turbine applications, including harsh conditions. Hollming has an assembly plant for wind turbines and components in Loviisa. The 3-MW WinWinD turbines, as well as direct-drive generators for the Switch company, are assembled there. In addition, materials such as cast-iron products, tower materials, and glass-fiber products are produced in Finland for the main wind turbine manufacturers. As shown in Figure 6, the total turnover has grown to about 1,000

million € according to the industry's own estimates. The manufacturing industry has a branch group under Technology Industries in Finland, to promote technology development and to export wind technology.

The benefit to the national economy was estimated by the wind technology manufacturing industry under Technology Industries in Finland in its road map for wind power technology in November 2005. According to the calculations, investing a total of 220 million € for wind energy from 2006 to 2020 could result in raising the yearly wind technology exports from 200 million € to 1,400 million €/yr in 2020 and creating 18,000 new jobs. According to this scenario, the total investment for wind power in Finland would be 100 million €/yr on average from 2006 to 2020 (1,500 MW), and this would result in a carbon dioxide reduction of 7 million tons during those years (10 TWh total).

3.2.2 Operational experience

According to the statistics portrayed in Figure 7, performance of wind power production has improved. The average capacity factor was higher between 2000 and 2006 than it had been in the 1990s, even though the FMI wind energy production index has been lower in recent years. This improved production is mainly because more megawatt-scale machines are reaching a higher wind resource (Figure 8).

The average availability of wind turbines operating in Finland was 96% in 2008 (94% in 2007). Two old 300-kW turbines were not operational all year after gearbox problems late in 2006 – they are now up for sale. There were not many large failures in 2008: three generator failures, one blade failure, and one gear-box failure were reported from the 96 turbines reporting.

3.3 Economic details

On coastal sites in Finland, the cost of wind energy production could be about 50 to 80 €/MWh without subsidies (15 years, 7% internal rate of return), while the cost of offshore production could be about 80

National Activities

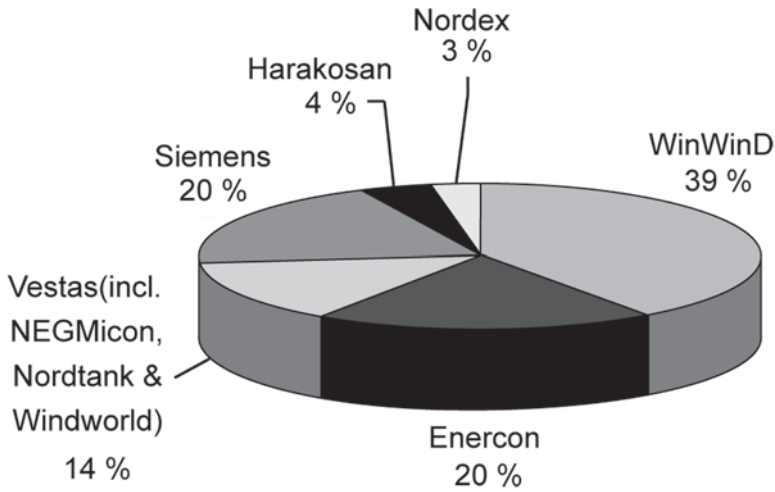


Figure 5 Market shares of turbine manufacturers in Finland as a percentage of the total capacity at the end of 2008 (143 MW).

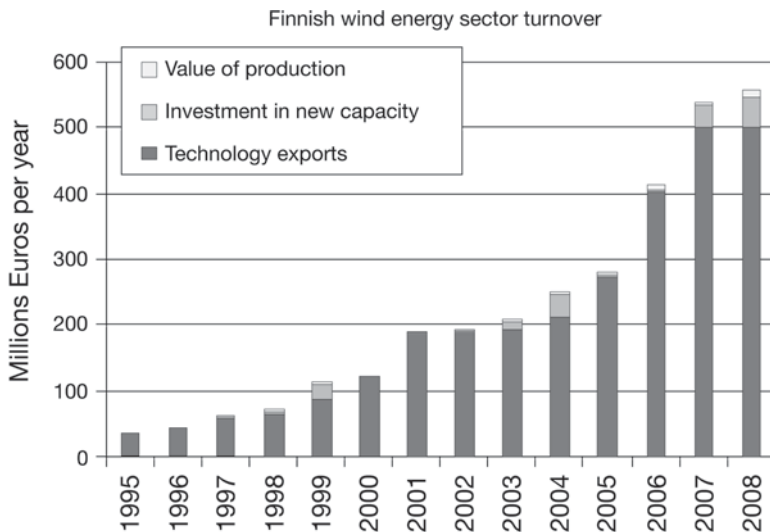


Figure 6 Finnish wind-sector turnover: wind power technology exports, electricity investments, and electricity production turnover. Turnover from electricity production sales has been estimated from the average spot price.

to 100 €/MWh. The average spot price in the electricity market Nordpool was 51 €/MWh in 2008 (30 €/MWh in 2007). Emission trade effects on the operating costs of thermal power have resulted in an increase of spot market prices, however, emission permit prices have been volatile

and future and forward prices are about 40 €/MWh for 2009–2010. Wind power still needs subsidies to compete even on the best available sites.

All wind energy installations are commercial power plants and have to find their customers via a free power market. In most

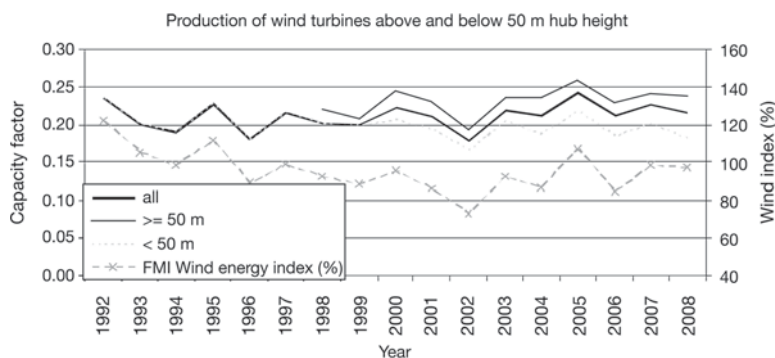


Figure 7 Average capacity factor of wind turbines in Finland for all turbines and for higher- and lower-hub-height turbines. The production index calculated from FMI wind-speed measurements is also shown (100% corresponds to average production in 1987–2001). Turbines with low availability (< 80 %) have been excluded in this analysis.

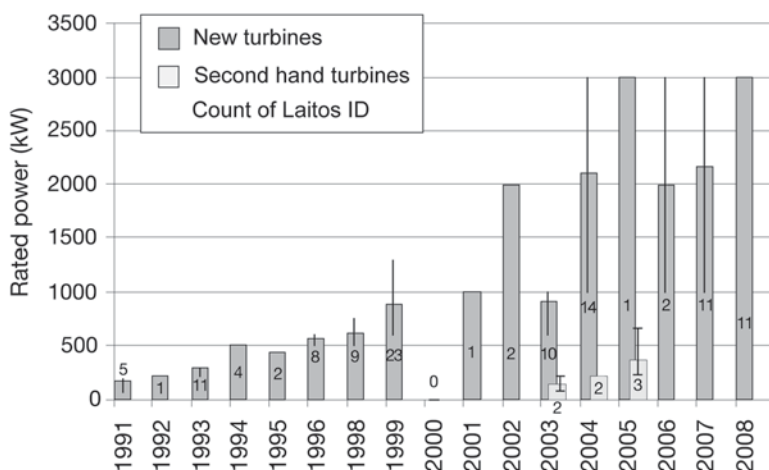


Figure 8 The average size of installed capacity (rated power in kilowatts) is indicated by the bar (for new and second-hand turbines). The number of installed turbines is marked in the bars. The vertical line represents minimum and maximum capacity of turbines installed.

cases, an agreement with a local utility is made that gives market access and financial stability. Several companies offer green or specifically wind electricity certified by the Association for Nature Conservation.

A feed-in premium for wind energy has been proposed, and this would greatly increase the wind power market in Finland. A guaranteed price of 83.5 €/MWh is currently proposed for wind power, where the

difference between the guaranteed price and a three-month-average spot price of electricity will be collected from the consumers and paid to the producers as a premium. This is a system that fits the Nordic electricity markets, as the producers will sell their energy in the market or by bilateral contracts, and account for the balancing costs for their production.

National Activities

4.0 National Incentive Programs

As the main incentive to promote wind investments, an investment subsidy of up to 40% has been possible depending on the level of novelty of a wind energy installation. In addition to the investment subsidy, a tax refund of 6.9 €/MWh is awarded. A new incentive system based on a guaranteed price has been proposed in 2009.

Projects that applied for a subsidy between 2001 and 2006 received an average investment subsidy of 35% (Figure 9). In 2008, investment subsidies were granted to two projects with offshore foundations developed for ice infested waters (subsidy of 1.6 million €, representing 35% of the total investment). To speed up wind power development, additional funds for investment subsidies have been made available for 2009. Already by April 2009, more than 13 million € have been granted, and 80 MW

had received an investment subsidy decision by June 2009.

In 2007, the EU published a target of 20% of energy consumption to be sourced from renewable energy in 2020. The target for Finland was set to 38% of final energy consumption by RES (current share 28.5%). The new climate and energy strategy given by the government in 2008 has a target of 2,000 MW of wind power in 2020. A change in the incentive program is currently prepared: a feed-in premium for wind power, biogas, and possibly other RES.

A guaranteed price of 83.5 €/MWh has been proposed for wind power, where the difference between the guaranteed price and spot price of electricity will be collected from the consumers and paid to the producers as a premium. This proposal, from April 2009, has yet to be approved

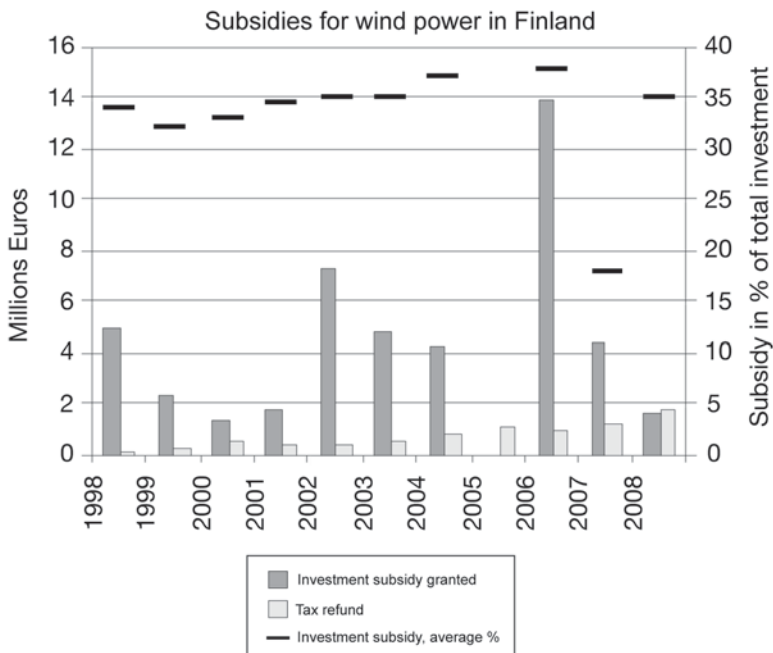


Figure 9 Investment subsidies granted for wind power and the total amount of tax refunds for wind electricity in Finland. The average investment subsidy as a percent of total investment costs is also shown. Most of the capacity granted with investment subsidies in 2006 (total 25 MW) was built in 2007.

by the government and the parliament to enable the new incentive system. A three-month average spot price has been proposed as the comparison price to determine the payments to the producers (the guaranteed price minus the average spot price). Should the (average) spot price rise to above the guaranteed price, the producers will get this higher price. Wind power producers will be responsible for their forecast errors. If the impacts of emission trading continue to raise electricity market prices, this will reduce the consumer payments for this subsidy. An increased level of guaranteed price for the first projects, a reduced level of guaranteed price for new projects during the later years, and a special subsidy for offshore wind power will still be considered.

A new wind atlas is currently being developed by FMI with government budget funding, and will be published at the end of 2009. This will help reduce uncertainty when estimating the production potential of the taller multi-megawatt machines in the forested coastal areas of Finland.

An addition to the electricity market act was approved in 2007 where a ceiling to the distribution network charges was set for distributed generation, including wind. The distribution charges vary across the country and in some areas have hindered local generation. The act also stated that grid reinforcement payments must be borne by the consumers, not by the producer. Before becoming effective in February 2008, project size for grid reinforcement exemption was limited to 2 MW from the original 20 MW. This means that the promoting effect of the grid reinforcement exemption will remain small for wind power.

Wind energy deployment is slow in Finland, but even so there is discussion of the environmental impact of wind turbines. Land-use restrictions and visual pollution, especially in relation to summer residents and vacation activities, might yet prove a significant obstacle to development. To overcome these problems, the Ministry

of Environment published guidelines for planning and building permission procedures for wind power plants. Sites for wind power have been added to regional plans by the authorities. This will help future wind power projects. Large areas mostly offshore have already been added for the Gulf of Bothnia, North (about 4,000 MW), and the Gulf of Finland, West (about 200 MW). The planning process is ongoing for the Gulf of Bothnia, South, and the Gulf of Finland, East.

5.0 R, D&D Activities

5.1 National R, D&D efforts

Since 1999, Finland has not had a national research program for wind energy. Individual projects can receive funding from the National Technology Development Agency (Tekes) according to the general priorities and requirements for technical R&D. Benefit to industry is stressed, as is the industry's direct financial contribution to individual research projects (Figure 10). Priority is given to product development and the introduction of new products. National projects for collaboration with IEA Wind Tasks 19, 21, 24, and 25 have been under the DENSY program (Distributed Energy Systems) (2003–2007).

The VTT Technical Research Centre of Finland is developing technologies, components, and solutions for large wind turbines. An icing wind tunnel for instrument and material research and testing in icing conditions was put up in 2008. Industrial collaboration in the development of reliable and cost-efficient solutions for drive trains and ice prevention systems in large wind turbines has been started.

Of the 3.5 million € granted for wind power projects in 2008, only 0.4 million € was for public research (like the national projects for IEA Wind Tasks), and the rest was for company projects for wind technology development. WinWinD has developed 1-MW and 3-MW turbines for different weather conditions. ABB has developed a direct-drive multi-pole permanent-magnet

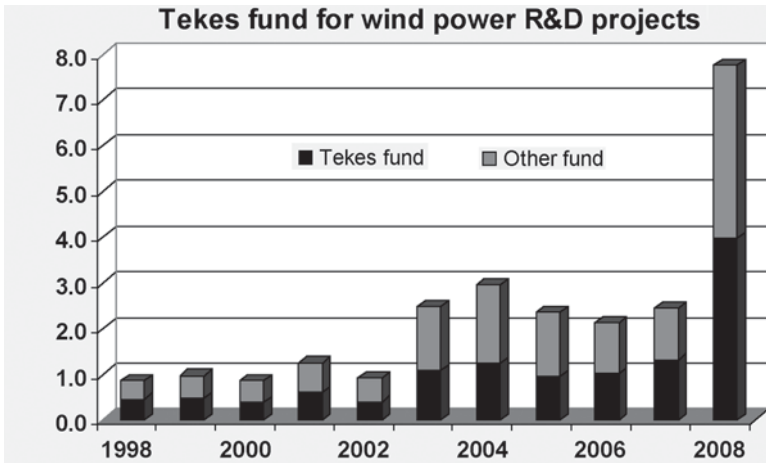


Figure 10 Development of R&D funding for wind power in Finland: Tekes funding and total funding.

wind turbine generator. The Switch company is developing multi-megawatt generators and a modular series-connected frequency converter. Moventas has several projects on gearbox load management. Pem-Energy Oy is developing small wind turbines. Hoxville has developed an embedded condition-monitoring system to be used in wind turbines.

5.2 Collaborative research

VTT has been active in several international collaborative projects in the EU, Nordic, and IEA frameworks. As part of the

EU project Tradewind (2006–2009), VTT estimated the impact of wind power on cross border flows in the European power system. As part of the EU project UP-WIND, technologies to control the shape of composite structures were developed at laboratory scale. In 2008, VTT implemented a phenomenological macroscopic SMA-material model iRLOOP, created at the Czech Academy of Science, into Matlab and ABAQUS. Development toward a plug-and-play type adaptive trailing edge which includes all needed sensors and actuators has started.

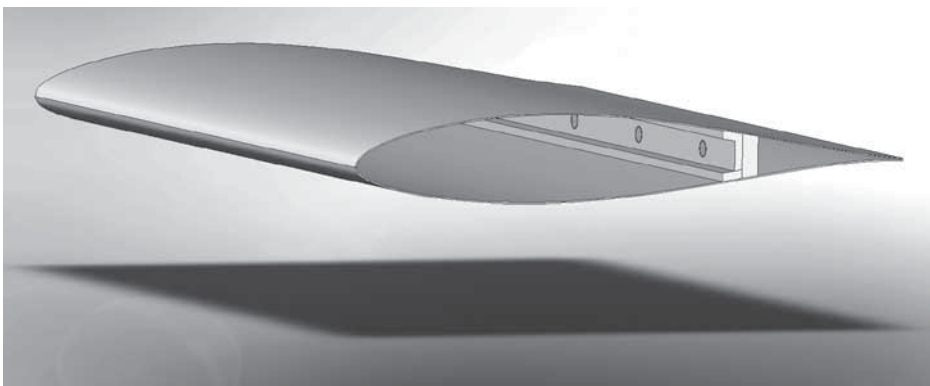


Figure 11 An airfoil section with a plug-and-play type adaptive trailing edge. (Photo VTT, Tomi Lindroos).

The Finnish Meteorological Institute (FMI) has been active in EU collaboration for wind and ice measurement technology. FMI is coordinating the COST collaboration “Measuring and Forecasting Atmospheric Icing of Structures,” in which VTT is also participating.

Nordic Energy Research has two projects related to wind energy: VTT is participating in a grid integration project, and VTT and FMI are participating in a project investigating how climate change affects renewable energies.

VTT is taking part in the following IEA Wind research tasks:

- Task 11 Base technology information exchange
- Task 19 Wind energy in cold climates (operating agent)
- Task 24 Integration of wind and hydropower systems
- Task 25 Design and operation of power systems with large amounts of wind power (operating agent).

Wpd Finland together with Motiva are participating in Task 28 Social acceptance of wind energy projects. Work on Task 19 wind energy in cold climates also has links

to cold climate technology development in some Finnish industrial projects.

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Up to 16 MW of new capacity will be added in 2009. In addition, projects totaling nearly 6,000 MW are in various planning phases in Finland. If the feed-in premium takes effect in 2010, a strong growth of the wind power market in Finland is anticipated.

A new wind atlas is currently under development by FMI with government budget funding and will be published at the end of 2009. This will help to reduce uncertainty when estimating the production potential of the taller multi-megawatt machines in the forested coastal areas of Finland.

A next-generation blade heating system is being developed in Finland, which will enable the use of the wind resource potential at arctic fell areas in Finland. Increasing global demand for ice-free turbines is foreseen.

Authors: Hannele Holttinen and Esa Peltola, VTT Technical Research Centre of Finland, Finland.

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1.0 Introduction

Wind power will remain the greatest contributor to the expansion of renewable energy in the electricity sector for the foreseeable future. In 2008, wind power generation accounted for some 6.5% of Germany's gross electricity consumption, and is therefore already one of the main producers of electricity in Germany, ranking alongside conventional technologies. At the end of 2008, Germany had a total of 20,301 wind turbines installed with an output of around 23,902 MW (compared with 22,250 MW at the end of 2007). Despite the huge increases in many countries, 22% of installed output worldwide is still concentrated in Germany. Germany retained its leading international position in the construction of new turbines with 1,665 MW, putting it in third place behind the United States and China (Table 1).

R&D supported by the Federal Ministry for the Environment (BMU) experienced a considerable increase in 2008. R&D projects with a total financial volume of 40.1 million € have been launched (Figure 1).

Current research and development priorities include helping to cut the cost of producing and operating wind turbines, and hence the cost of generating wind power, as well as continuously improving the technological requirements for the eco-friendly expansion of wind power. In 2008, BMU approved a total of 32 projects, including some funding top-ups, with a total volume of nearly 40.1 million €. A total of 29.9 million € was also allocated to ongoing research projects in 2008.

The aims and priorities of wind power research are determined at regular BMU strategy meetings with experts. The most recent strategy meeting took place on 3 and 4 November 2008 in Berlin. The outcome of this meeting was reflected in the new BMU funding announcement on 20 November 2008, which lists the following main research priorities for the next few years:

- Contributing toward cost-reduction, increasing yields, and improving the availability of wind turbines
- Technologies for the expansion of offshore wind power (including research at the alpha ventus test site)
- Accompanying ecological research and technological optimization of wind turbines to reduce ecological impacts.

2.0 Progress Toward National Objectives

The German government acknowledges the importance of renewable energy, and in this regard national policy was generally continued. The EU target for Germany of 12.5% contribution to energy consumption by all renewable energies in 2010 was already exceeded in 2007 with 14.2%. Therefore new targets were set in 2007. By 2020, the government aims to increase the proportion of primary energy consumption generated from renewable energy sources to 16%, as compared with 5.6% in 2006.

Total installed wind generation	23,902 MW
New wind generation installed	1,665 MW
Total electrical output from wind	40.4 TWh
Wind generation as % of national electric demand	6.5%
Target:	30% of national electricity demand from RES in 2020.

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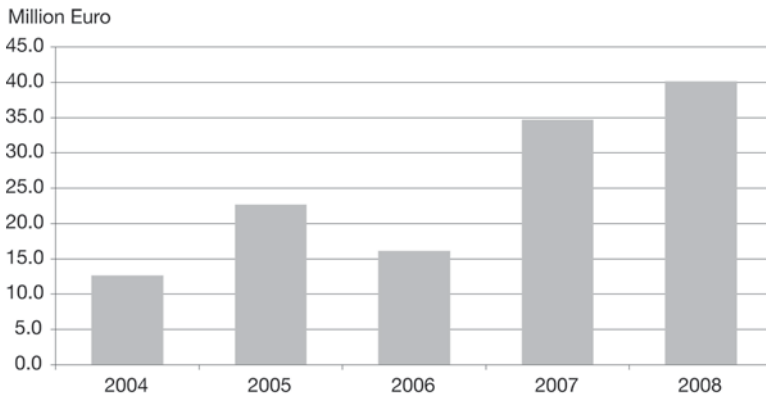


Figure 1 Development of funds for new R&D projects for wind energy re-research 2004 – 2008. Additional research into grid integration technologies related to wind energy has also been launched in 2008, with a financial volume of 14.6 million €.

The proportion of electricity consumption from renewable sources will be increased to at least 30%, and then will be continuously expanded (1).

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 with the Infrastructure Acceleration Act by improving the conditions for investors in offshore wind by obligating transmission system operators to pay for and install the grid connection from the onshore grid access point to the offshore wind farm toward meeting these targets. Another step is the revised Renewable Energy Sources Act (EEG) that was enacted by the parliament in July 2008. The beginning of the offshore construction of the first German offshore wind farm, alpha ventus, set a starting point for future offshore development.

3.0 Benefits to the National Economy

German wind turbine manufacturers and suppliers boast a global market share of more than one-third, thanks to sophisticated multi-megawatt turbines which have

become well-established on the German market over a period of many years. In 2007, the German wind power industry generated some 7.6 billion € from turbines and components alone (data of 2008 will be available in July 2009). According to the Verband deutscher Maschinen- und Anlagenbauer (VDMA/German Engineering Federation), the export share is 83%. In 2008, more than 90,000 people in Germany were employed in the wind power sector.

A recent forecast by the Deutsches Windenergie-Institut (DEWI/German Wind Energy Institute) predicts that around 210,000 MW of wind power will be installed worldwide by 2014, which translates into an investment volume of around 130 billion €, with offshore technology and repowering playing a key role. As soon as offshore expansion picks up pace, the maritime industry anticipates a new boom. Sea-ports such as Bremerhaven and Cuxhaven have already prepared for this by investing in infrastructure. The aim is to advance wind power generation through research and development, to reinforce German industry's position in this expanding market and safeguard its future viability.

Cost ranges for turbines onshore and offshore in 2008 are summarized in Table 2.

Table 2 Estimated average turbine cost and total project cost for 2008		
	Turbine cost €/kW	Total installed cost €/kW
ONSHORE		
Rated Power 1.3 - 1.9 MW	1,026 – 1,160	1,345 – 1,479
Rated Power 2.0 - 3.0 MW	941 – 1,199	1,260 – 1,518
Rated Power > 3.0 MW	1,155 – 1,340	1,474 – 1,659
OFFSHORE		
deep water, great coast distance	1,450 – 1,500	3,010 – 3,230
shallow water, low coast distance	1,350 – 1,450	2,625 – 2, 895
Data from Deutsche Windguard GmbH		

4.0 National Incentive Programs

An amendment of the Renewable Energy Sources Act was passed by the Parliament in July 2008 and came into force on 1 January 2009. The aim is to increase the share of renewable energy in the German electricity portfolio to at least 30% by 2020. This is intended to counteract the dramatic increase in energy and raw material prices (especially for steel and copper) and to promote the lagging offshore development in Germany.

4.1 Wind energy onshore

The amendment of the Renewable Energy Sources Act includes an initial remuneration of 0.092 €/kWh for at least 5 years and a maximum of 20 years, depending on the quality of the site according to the reference yield model. After the initial remuneration period, the tariff is 0.0502 €/kWh for a maximum of 20 years. Remuneration will be paid only for wind turbines with at least 60% yield of the defined reference. A reduction of 1% per year begins in 2010. For two cases there is a special extra payment of 0.005 €/kWh (until 2013) for repowering and for turbines fulfilling technical requirements for the improvement of

grid integration (voltage and frequency regulation) and for the lighting system.

4.2 Wind energy offshore

Turbines put into operation by 31 December 2015 receive an initial remuneration of 0.15 €/kWh for 12 years. After that period, the basic tariff is 0.035 €/kWh until the maximum remuneration period (20 years plus year of commissioning) is reached. The initial remuneration will be prolonged for wind farms more than 12 nautical miles away from the coast and in waters deeper than 20 m. For wind turbines installed after 31 December 2015, the initial tariff will be 0.13 €/kWh for a period of 12 years. A reduction of 5% per year will start for new wind turbines after 2015. A new principle is that operators can sell the electricity produced directly to third parties on a “calendar-monthly” basis (without EEG-remuneration).

5.0 R, D&D Activities

5.1 Structure of research

The study “On the structure of wind power research in Germany” was commissioned by BMU and conducted by the Internationales Wirtschaftsforum Regenerative Energien

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(IWR/International Economic Forum Renewable Energies). German wind power research is characterized by a large number of decentralized institutions, which makes it different from other areas of energy research such as photovoltaics, as well as from the research structures in other countries. The authors recommend the establishment of powerful, internationally visible players in wind research. To this end, they recommend the expansion of regional priority areas, and identified the region around Bremen and Bremerhaven in the North of Germany and the Rhine/Ruhr region in the West as regional clusters.

The study has helped to stir up the wind power research scene, and ensure the continuing evolution of structures in wind power research. Of central importance in this connection is the foundation of the Fraunhofer-Institut für Windenergie und Energiesystemtechnik (FhG-IWES/Fraunhofer Institute for Wind Energy and Energy Systems Technology) on 1 January 2009. At the heart of the institute is the Fraunhofer Center für Windenergie und Meerestechnik (CWMT/Fraunhofer Centre for Wind Power and Offshore Technology) in Bremerhaven, with the rotor blade competence center funded by the BMU and Bremen. When the Institut für Solare Energieversorgungstechnik (ISET) is incorporated during the course of 2009, the FhG-IWES will gain a second branch in Kassel, drawing on many years of experience in wind power research. There are also plans to forge close co-operation links between the FhG-IWES and the universities of Hanover, Oldenburg, and Bremen.

The latter have joined forces to form the university wind energy research center ForWind. The establishment of two Fraunhofer project groups at the universities of Hanover and Oldenburg will help to forge close co-operation. Kassel University will also be co-operating with the IWES. Together, IWES and the participating universities cover almost the entire spectrum of wind power research. This constellation

has created a top cluster for wind power research in Germany.

5.2 Projects

In 2008, BMU supported 123 on-going research projects in the wind power sector, with the development of offshore wind power a top priority. The 28 newly launched projects focus on the following priority areas:

- Completion of the RAVE research network in the test site alpha ventus with regard to foundations, grid integration, accompanying ecological research, and a central measurement project
- Developing new variants of foundations and supporting structures and new technologies for their production, including noise reduction in offshore expansion
- Improvement of the design of rotor blades using new materials
- Developing new multi-megawatt wind turbines and demonstrating them under near-shore conditions.

5.3. Offshore wind power

5.3.1 Alpha ventus test site

The first German offshore wind farm alpha ventus is under construction 45 km North of the North Sea island of Bochum. The company DOTI GmbH, owned by the power utilities EWE, E.ON, and Vattenfall, will construct and operate 12 wind turbines from Multibrid and REpower, with a total installed capacity of 60 MW. The first structure for alpha ventus was the transformer substation, completed in 2008 with a height of 60 m and weighing more than 1,300 tons. The transformer substation is located around two km from the BMU research platform FINO 1. The submarine cable was also laid in 2008. Unfortunately, construction of the 12 wind turbines, originally scheduled to begin in August 2008, had to be postponed until 2009 due to unfavorable weather conditions. As a test and demonstration project, alpha ventus will

mark the start of the use of offshore wind power in Germany.

The research initiative RAVE was launched in May 2008 with a kick-off event in Berlin. At the event, research projects at the alpha ventus test site were presented to a large expert audience for the first time. The main priorities of RAVE are to explore wind as a “raw material,” to investigate the technical requirements placed on wind turbines and their foundations, and to focus on grid integration and accompanying ecological research. The Bundesamt für Seeschifffahrt und Hydrographie (BSH/ Federal Maritime and Hydrographic Agency) and the Deutsches Windenergieinstitut (DEWI/German Wind Energy Institute) are involved in measurement and data collection, while the RAVE projects are being coordinated by ISET in Kassel. By the end of 2008, BMU had approved 20 projects with a total of 33.7 million € for research at the test site.

By signing a co-operation agreement, researchers and industry have set themselves the joint target of deriving maximum knowledge and experience from operation of the offshore test site which will benefit future wind power use on the high seas. Further information is available at: <http://rave.iset.uni-kassel.de/rave/pages/welcome>

The BSH, as the authority for the licensing of offshore wind farms, has drawn up a standard analysis concept to provide a framework for the ecological analyses required for the licensing, construction, and operation of an offshore wind farm. The analysis concept is being used for the first time in the construction phase of the alpha ventus wind farm. In order to investigate whether the defined methods and specified standards are adequate, appropriate, and effective, the StUKplus project will formulate broad-based ecological research activities in order to evaluate the analysis concept. The work is being coordinated by the BSH and is dedicated to determining the potential impacts of the wind farm on various protected species (marine mammals, resting

and migrating birds, fish, and biotic communities on the ocean floor). As such, they far exceed the requirements specified in the analysis concept. Based on the results, the BSH will optimize the analysis concept for the licensing of further wind farms. Evaluation of the analysis concept is the largest accompanying ecological research project to date. At the kick-off event in November 2008, some 70 experts from academia, research institutes, the wind industry, and policy and government authorities were told about the initial findings. (BMU funding total: 5 million €).

The BSH is managing and coordinating the measurement technology, as well as providing maintenance and support for measurements from all research projects. Installation of measuring equipment was completed on time in 2008. Over 200 sensors have been installed on the foundations of one of the wind turbines, and will provide information on power distribution, dynamics, position, water temperature patterns, and sediment deformations in the vicinity of the foundations. Once sited in the alpha ventus wind farm, the sensor-covered tripod foundation will be situated just 850 m from the FINO 1 research platform.

5.3.2 Technological development

In January 2008, the IWES/Fraunhofer-Institute for Wind Energy Research and Energy System Technology started work on construction of the rotor blade competence center in Bremerhaven. The first section of the test center to be completed has a hall for 70-m rotor blades. In the hall, measuring 17 m wide, 84 m long and 20 m high, these rotor blades can be subjected to in-depth analysis. To this end, they are screwed into a foundation made from 4,000 tons of steel-reinforced concrete, and subjected to months of vibrations, during the course of which the blade tips are deflected up to 17 m. The tests are accompanied by state-of-the-art measurements. The aim of the project is to ensure that the rotor blades are fit to withstand 20 years of offshore and

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onshore use. Phase two of the complex, for rotor blade lengths of up to 90 m, as used in future offshore wind farms, is currently in the final planning stages. The test rigs are part of the BMU-funded project InnoBladeTeC, in which Fraunhofer-IWES is collaborating with industry to develop new test methods designed to prepare rotor blades for the extreme loads at sea. Measurements are carried out on whole rotor blades, and supplemented by test rigs to allow much cheaper component testing, as well as a climate controlled chamber which allows the simulation of offshore conditions. In 2008, a project extension was approved. In the future, the rotor blades will be simultaneously deflected both vertically and horizontally during the load tests. (total BMU funding: 11.1 million €).

5.3.3 Foundations

Several companies and research institutes are participating in the OGOWIN project (optimization of jacket foundation structures for offshore wind farms with regard to material consumption, assembly sequence, and new production techniques) to develop a modular system for the foundation structures of offshore wind farms. In February 2008, early results from the OGOWIN project were incorporated into the world's first jacket foundation with cast junctions for offshore wind farms, which WeserWind GmbH has constructed onshore in Bremerhaven as a test foundation. It supports a 5M type 5-MW turbine from REpower. The particular feature of this jacket is its cast junctions, which produce a highly efficient and stable structure. The project is led by WeserWind GmbH Offshore Construction Georgsmarienhütte, with the involvement of HOCHTIEF Construction AG, and EUROPIPE GmbH. Participating research institutions include IWES, the Institut für Statik und Dynamik at Leibniz University Hanover, and the Bundesanstalt für Materialforschung und -prüfung. (BMU funding total: 2.3 million €).

Over the next few years, demand for foundations for offshore wind farms will grow. With this in mind, WeserWind GmbH Offshore Construction Georgsmarienhütte, in collaboration with other companies and IWES, is launching a joint project to pave the way for high-quality and cost-effective mass production of offshore foundations. There are currently no production facilities in the world that are suitable for mass production of this type of steel structure weighing several hundred tons. In this project, the principles of production automation and quality management already used in automotive engineering, for example, are to be adapted for the production of offshore wind turbine foundations. (BMU funding total: 2.8 million €).

On 28 October 2008, the commissioning of the BARD multi-megawatt nearshore wind turbine took place. The BARDVM installed at this site has a rated output of 5 MW with a total height of 152 m and a rotor diameter of around 120 m. BARDVM used the innovative BARD "Tripile Foundation" for the first time with this project. It is comprised of three piles, each weighing 210 tons, with a supporting cross-section on top weighing around 49 tons which carries the tower. The nearshore facility was installed around 400 m from the shore near Hooksiel outer harbor, in a water depth of 2-8 m depending on the tide. As part of the project, BARD will be testing the entire production, construction, and operation logistics at the nearshore site. (BMU funding total: 1.9 million €).

The aim of the joint project "Foundations of offshore wind farms from filigree concrete structures with a particular focus on the fatigue behavior of high-strength concrete" by the Institute of Concrete Construction at Leibniz University Hannover and Ed. Züblin AG is to develop the most lightweight possible filigree structure of high-strength concrete (HPC) for the foundations of offshore wind turbines. Development focuses on the dynamic interaction between the foundation structure and

the turbine, with the foundation initially being designed for a 5-MW turbine.

Parallel to the development of the foundation structure, the research team will also concentrate on manufacturing techniques, transportation and assembly devices, as well as the necessary logistics for subsequent mass-production and installation of the foundation structure. Finally, the research team will look at devising the most cost-effective overall solution possible. (BMU funding total: 350,700 €).

Herrenknecht AG, market leader in the production of tunnel-boring machines, is carrying out a feasibility study to determine whether the Herrenknecht Vertical Shaft Machine (VSM) is suitable for use in the construction of offshore wind farms. Unlike pile driving, boreholes are less dependent on the local geology and can therefore offer benefits, for example, with regard to noise emission levels in the construction of turbines. Other project partners include IMS Ingenieurgesellschaft mbH from Hamburg and the Institut für Geotechnik (Geotechnical Institute) at Hamburg-Harburg Technical University. (BMU funding total: 77,000 €).

5.3.4 Construction and logistics

Experience acquired during 2008 with the construction of the FINO 3 research platform and the alpha ventus wind farm have highlighted the decisive role of technologies for the construction and installation of offshore turbines (such as construction ships, jack-up platforms, cranes, etc.). Without adequate installation technology adapted to the specific requirements of offshore wind turbines, it will be impossible to continue expanding offshore wind power at the planned rate. Priorities here include the efficient handling of transportation and assembly, and minimizing the influence of waves, currents, and wind on the construction process. During the operational phase, logistics are also needed to give year-round access for the maintenance and repair teams, if possible.

A project by Deutsche WindGuard GmbH aimed to make the operation of offshore wind farms more cost-effective by identifying the optimum service vehicle. The alternatives considered were a Small Waterplane Area Twin Hull (SWATH), catamaran, crew boat, and helicopter. These vehicles are designed to transport maintenance staff safely to the wind farm even in heavy swell. A subsequent cost analysis revealed that a SWATH is the most cost-efficient alternative, particularly for large offshore wind farms. For optimum operation, the combination of a SWATH craft plus a helicopter was identified as the optimum solution for offshore wind farms. The project team also drafted technical recommendations to optimise the SWATH in terms of its suitability for offshore use in the servicing of wind farms. (BMU funding total: 46,500 €).

The project developer PTS GmbH has designed a system allowing assembly personnel and spare parts to be transported safely onto the platforms of offshore wind turbines in a wide range of weather conditions. The Personnel Transfer System (PTS) consists of a crane mounted on the platform of the wind farm. Personnel and equipment can be suspended from a hook and lifted onto the platform from the ship. An adaptive control system ensures that the distance between the hook and the ship always remains the same, even in rough seas. This system allows almost year-round safe access to offshore wind farms. This increases accessibility and safety, and also helps to cut assembly and maintenance costs. PTS GmbH is a joint venture between Teupen Maschinenbau GmbH and ep4 offshore GmbH. In 2008, Teupen constructed and tested a prototype of the system. (BMU funding total: 158,000 €).

The Institut für Seeverkehrswirtschaft und Logistik (ISL/Institute of Shipping Economics and Logistics) undertook a study to investigate the extent to which modern, coordinated logistics concepts

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and models from other industries may be transferred to the wind power sector. The study focuses on offshore logistics and the export market, and examines concrete case examples. The aim is to calculate logistics costs and illustrate potential cost-cutting measures. As logistics are estimated to account for between 15 and 20% of the costs in an offshore wind farm, this project could potentially make a decisive contribution toward improving the cost efficiency of offshore wind farms. (BMU funding total: 296,000 €).

Ed. Züblin AG is developing an innovative vertical lifting device for the final assembly of nacelles for offshore wind turbines weighing up to 500 tons. The proposed device lifts the nacelles from the transporter ship onto the tower. This will dispense with the use of expensive assembly units such as floating cranes and jack-up platforms, whose availability until now has been limited, at least for parts of the assembly process. The project is being carried out in collaboration with Berg-idl GmbH, Ofenburger University and Karlsruhe University. (BMU funding total: 475,000 €).

In a theoretical study, F+Z-Baugesellschaft mbH defined the application conditions and requirements for a jack-up platform for the construction of offshore wind farms. In the follow-up project, completed in 2008, the company developed a specific, certified technical design for this purpose. The new type of jack-up platform will be capable of withstanding wave heights of up to 2.5 m, making it usable in at least 75% of all weather situations throughout the year. (BMU funding total: 93,000 €).

5.4 Onshore technological research

Although offshore wind power is currently the greatest technological challenge for wind power development, onshore technology still offers the largest expansion potential in global terms. Here, older wind farms are increasingly being replaced by more powerful technology (repowering) in order to make optimum use of the energetic and economic potential of wind power.

In February 2008, Deutsche Wind-Guard GmbH began operation of a wind tunnel center in Bremerhaven, capable of creating wind speeds of up to 250 km/h. Over a working section of 14 m, experiments are conducted on models and original wind turbine parts. The acoustically optimized wind tunnel is used to improve the aerodynamic components of wind turbines. In collaboration with the wind farm industry, the center will address scientific and technical issues, with a particular emphasis on the optimization of rotor blade profiles to improve the efficiency of wind farms, the acoustic optimization of rotor blade profiles to minimize sound emission, and the identification and optimization of load profiles on rotor blades. (BMU funding total: 753,000 €).

A project to make wind farms more compatible with the requirements of civil and military airspace, monitoring was concluded by EADS Deutschland GmbH (European Aeronautic Defence and Space Company). The project included the development of technologies for radar engineering which enable the detection and suppression of signals from wind farms that can potentially interfere with airspace monitoring. Recommendations for minimizing radar reflections from the turbines were drawn up as well. (BMU funding total: 1 million €).

PN Rotor GmbH is working on the development and construction of a partially automated surface coating for rotor blades. It is hoped that this will reduce wear and tear on the rotor blades during operation and minimize the work involved in surface treatment. Coating systems are being selected and tested in collaboration with suppliers. In a subsequent stage, the team will develop suitable automated application techniques and the edges of the rotor blade will be given special edge protection. The partially automated finish is to be used in the new rotor blade production plant at PN Rotor for the construction of large offshore rotor blades. (BMU funding total: 846,600 €).

UpWind is currently the largest wind power project funded by the European Union. Since 2006, some 40 companies and research institutions across Europe have been working on this project to develop models for key components of large wind turbines with outputs of up to 10 MW. The recently established IWES (formerly CWMT) is collaborating closely with the UpWind network as an associated partner in a research project funded by BMU. IWES is also developing new test methods for rotor blades. It is hoped that, rather than testing the vibration resistance of entire rotor blades, it will be possible instead to perform static and dynamic load tests on rotor blade spars.

At the same time, IWES is contributing to the materials database "OptiDAT" within the framework of UpWind, and helping to define a certification methodology for rotor blade materials. (BMU funding total: 597,200 €).

5.5 Research platforms

Since summer 2003, the research platform FINO 1 in the North Sea has collected data on wind, waves, currents, and bird migration. It has also played host to other ecological research projects. To date, the BSH has recorded around 150 incidences of data use by industry and research. FINO 1 is acquiring still greater significance thanks to the offshore test site *alpha ventus*, which is located just a few hundred meters away. Back in early 2002, the planners deliberately sited FINO 1 in the main approach to this pilot wind farm so that measurement data could be evaluated in combination with data from the turbines. FINO 1 is an important research tool for the 20 research projects in the *alpha ventus* test site now approved under the RAVE research initiative. One turbine each from the companies Multibrid GmbH and REpower Systems AG will be equipped with extensive research technology as part of RAVE. FINO 1 wind measurement data will then be used to determine the

performance curves of the turbines and to perform load analyses.

The research platform FINO 2, located 45 km North of Rügen at the Baltic Sea, has been recording wind data and hosting ecological research projects since summer 2007. The wind measurements utilize the same regime as on FINO 1. Since 2008, the data has likewise been fed into the ODIN database of the BSH, where it is available for downloading alongside the FINO 1 data.

In late July 2008, offshore work began on construction of the FINO 3 research platform around 80 km North-West of the North Sea Island Sylt. To this end, a 55 m long steel pipe (monopile) was driven into the sea bed in water depths of 23 m. The surface of the monopile is fitted with a comprehensive array of sensors from Braunschweig University, which will later measure how the pile is embedded in the seabed. Researchers were anxious to discover how well the sensitive technology would survive the pile-driving process. Thanks to special protective covers, almost all sensor holders have remained fully functional, despite having been driven more than 20 m into the seabed.

In order to reduce noise emissions, the company Hydrotechnik Lübeck GmbH was commissioned by Forschungs- und Entwicklungszentrum FH Kiel GmbH to construct an air bubble curtain with a radius of 70 m around the construction site. Scientists at Hanover University and the Institut für technische und angewandte Physik GmbH (ITAP) investigated the effectiveness of this measure and recorded the sound pressure levels at various distances around the site. Initial data analysis suggests that the air bubble curtain achieved a total noise reduction of 12 decibels, with a 30 to 35 decibel reduction in the frequency range between 1 and 7 kilohertz. Biologists also spent several days studying the effectiveness of measures to protect porpoises. Initial results indicate that during construction, no porpoises entered the hazardous

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zone around the site. Two weeks later, the number of porpoises had returned to pre-construction level.

5.6 Environmental research and optimization

The expansion of offshore wind power use is accompanied by a wide range of projects on ecological issues. The effects on birds, marine mammals, fish, and benthic organisms are investigated, and legal aspects are taken into account.

The research project “Marine mammals in the North and Baltic Seas” (MINOS+) was successfully completed in early 2008. This was a joint project between the Leibniz-Institut für Meereswissenschaften (IFM-GEOMAR/Leibniz Institute for Marine Sciences at Kiel University), Forschungs- und Technologiezentrum Westküste (Büsum), the Deutsches Meeresmuseum Stralsund (German Oceanographic Museum) and the Nationalparkamt (National Parks Office) Schleswig-Holsteinisches Wattenmeer. The project represents a milestone in accompanying environmental research. Firstly, it examined the habitats, migration routes, and distribution patterns of porpoises, seals, and seabirds, and secondly, analyzed the hearing sensitivity of porpoises and seals. This unique data record provides the basis for numerous new findings on the distribution, behavior, seasonality, and sensitivity of such species. The methods developed will be used in future marine monitoring and accompanying studies in Germany. The study has broadened the ecological knowledge of Germany’s marine regions, and significantly improved our understanding of ecological correlations, creating a tenable scientific basis for the licensing of offshore wind farms. The data will be permanently stored in a database in the National Parks Office created specifically for this purpose. (BMU funding total: 3.4 million €).

The Institut für Vogelforschung “Vogelwarte Helgoland” (IfV/Institute for Bird Research) has already conducted numerous studies into potential impairments of migrating birds by offshore wind farms as

part of its “Finobird” project. In order to be able to track the flight paths of sea birds and migratory birds more accurately, the “Finorad” project will convert a decommissioned weather balloon tracking radar from the German army to enable it to be used for ecological research purposes. With the help of this system, it will be possible to monitor even small birds over distances of many kilometres, and to derive information regarding the spectrum of species. The new radar will therefore set a new state of the art in ornithological offshore radar technology, which will help to intensify our knowledge of bird migration. Scientists hope this study will enable them to quantify the potential impacts of wind farms on bird migration. If the project is successful, there are plans to use the new technology for the first time in the vicinity of the offshore test site alpha ventus. (BMU funding amount: 175,000 €).

In a joint project, Leibniz University Hanover, Erlangen University, Enercon GmbH, and the Forschungsinstitut für Optronik und Mustererkennung (FOM/Research Institute for Optronics and Pattern Recognition) are developing methods to analyze and reduce the risk of bat collision with onshore wind farms. Based on predictions, practical methods will be derived aimed at reducing and avoiding possible bat strikes. (BMU funding total: 1.1 million €).

The Michael-Otto-Institut within the Naturschutzbund Deutschland (NABU/ Nature and Biodiversity Conservation Union), BioConsult SH, and the Leibniz-Institut für Zoo- und Wildtierforschung (Leibniz Institute for Zoo and Wildlife Research) are exploring the reasons for possible collisions between birds of prey and wind turbines, with a special focus on red kites, sea eagles, and Montagu’s harriers. In order to be able to systematically investigate the behavior of birds in various parts of Germany, the birds of prey are fitted with small satellite receivers, rather like navigation systems, and terrestrial VHF transmitters. In this way, flight movements in the vicinity of wind farms are logged, and compared with standardized behavior

records. The observations provide insight into potential avoidance and minimization measures. (BMU funding total: 802,000 €).

6.0 The Next Term

Improving the conditions for investors in offshore wind should stimulate activity in 2009. The first German offshore wind farm alpha ventus will begin operation in 2009 and increased research funding will provide interesting results in the next years.

References

(1) Innovation through Research, Annual Report 2008 on Research

funding in the Renewable Energy Sector, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Germany.

Authors: Joachim Kutscher, Forschungszentrum Jülich GmbH, PtJ; Joachim Nick-Leptin and Ralf Christmann, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), et al.

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1.0 Introduction

The target established for Greece under the European Union's Renewable Energy Directive, Directive 2001/77/EC, is that at least 20% of electricity supply should come from renewable sources by 2010. Although this seemed an ambitious target, the approval of the Specific Framework of Planning Design and Sustainable Development for the Renewable Energy Sources (from the Ministry for the Environment, Physical Planning and Public Works) will enforce the development of renewable energy sources (RES) in Greece. The new framework aims at:

- The formation of planning policies for RES projects,
- The establishment of rules and standards for the development of efficient RES installations and their harmonious penetration into the environment, and
- The creation of sufficient mechanisms of RES planning.

Last, the Specific Framework of Planning Design and Sustainable Development for the Renewable Energy Sources is expected to decrease the difficulties of land selection and to lessen bureaucratic bottlenecks.

During 2008, four large wind farms were installed, having capacities in the range of 15 MW to 24 MW each. The total installed capacity of wind generators reached 990 MW.

The electricity sector operates within the framework set by Law 2773/1999 "Liberalisation of the electricity market—regulation of energy policy issues and other provisions" (Official Gazette A 286). This law was enacted for the transposition

of Directive 96/92/EC for the liberalization of the electricity market (OJ L27/30.1.1997). The basic law was revised by Law 3175/2003, "Exploitation of the geothermal potential, district heating and other provisions" (Official Gazette A 207) and Law 3426/2005, "Precipitation of the liberalisation process of the electricity market" (Official Gazette A 304).

Today, the RES deployment regime is governed primarily by Law 3468/2006, "Generation of electricity from renewable energy sources and through high-efficiency co-generation of electricity and heat and miscellaneous provisions" (Official Gazette A' 129). The text of the law and its circular D6/F1/oik.21691/30.10.2006 are posted on the Ministry of Development web site (<http://www.ypan.gr>).

Table 2 provides the feed-in tariff for wind energy. The list of prices is based on the price in euros per megawatt-hour (€/MWh) of electric energy absorbed by the grid, including the grid of non-interconnected islands.

2.0 Progress Toward National Objectives

Apart from the obvious environmental and social benefits of using renewable energy sources, the economic benefits from their development are huge, as they gradually promote Greece's independence from imported energy and finite fuel sources.

Directive 2001/77/EC, On the Promotion of Electricity Produced from Renewable Energy Sources in the Internal

Total installed wind generation	990 MW
New wind generation installed	115 MW
Total electrical output from wind	2.3 TWh
Wind generation as % of national electric demand	3.7%
Target:	3,370 MW

Electric energy production	Interconnected	Non-interconnected islands
Wind onshore	80.14	91.74
Wind offshore	97.14	

Electricity Market, sets an indicative target for Greece to cover a part of its gross national electricity consumption by 2010 from RES equal to 20.1%, with the contribution of large-scale hydroelectric plants included. This target is also compatible with the international commitments of Greece resulting from the Kyoto Protocol. Based on expected electricity consumption in 2010, production of electric power from RES on the order of 14.45 TWh (including large-scale hydroelectric plants) is set as the goal for 2010. To meet these goals, the installed capacity of wind farms should reach the level of 3,193 MW, and the corresponding energy generated should be on the order of 8.1 TWh.

In 2008, the installed capacity of the wind turbines reached 990 MW, showing an increase over the previous year of 13%. In 12 separate projects, a total of 72 wind energy conversion systems, with an installed capacity of approximately 115 MW, were connected to the electricity supply network. The current estimation of wind energy production in 2010 ranges between 2,040 MW (conservative scenario) and 3,193 MW (optimistic scenario) (1). The development of wind energy within the past 10 years is shown in Figure 1, which depicts total installed capacity per year.

The energy produced from wind turbines during 2008 was approximately 2,300 GWh. The energy produced in the previous five years was 1,873 GWh (2007), 1,683 GWh (2006), 1,270 GWh (2005), 1,130 GWh (2004), and 1,020 GWh (2003). Figure 2 shows the electricity produced from wind turbines during the past ten years.

3.0 Benefits to National Economy

3.1 Market characteristics

Wind energy represents an enormous opportunity to attract foreign investments into Greece and is also a challenge for the country’s business world. In the last decade, interest has increased among, mainly, construction companies and individual investors for wind energy-related projects. Wind energy deployment has become a challenging area for development all over the country—especially in areas having poor infrastructure, in which some of the most promising sites for wind energy development can be found. Although manufacturing of wind turbines has not been established in Greece, there is considerable domestic added value in connection with infrastructure works, for example, grid strengthening, tower manufacturing, road and foundation construction, civil engineering works, and so on. In addition, new jobs are created related to maintenance and operation of the wind farms in mainly underdeveloped areas. An expanding network of highly experienced engineering firms has been created and is currently working on all phases of the development of new wind energy projects. Thus, wind energy is gradually becoming a considerable player contributing in the development of the country. The distribution of installed wind farms throughout Greece is depicted in Figure 3.

3.2 Industrial development and operational experience

No significant manufacturing developments occurred in 2008 apart from the continuing involvement of the Greek steel industry

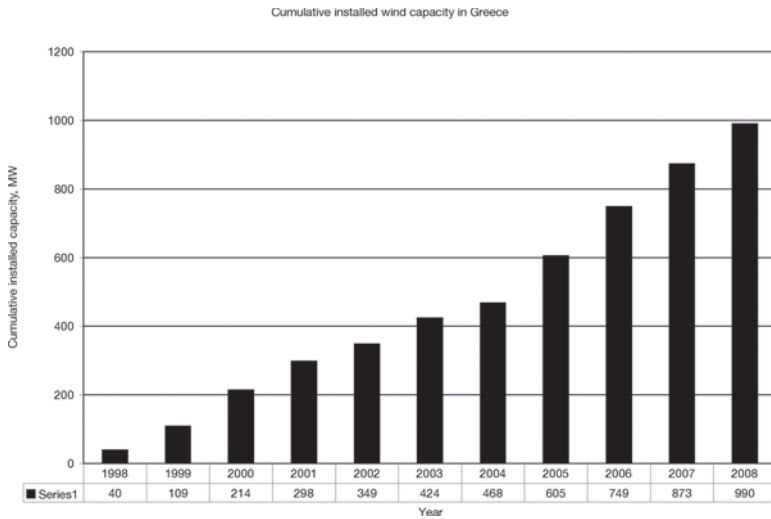


Figure 1 Cumulative installed wind capacity in Greece.

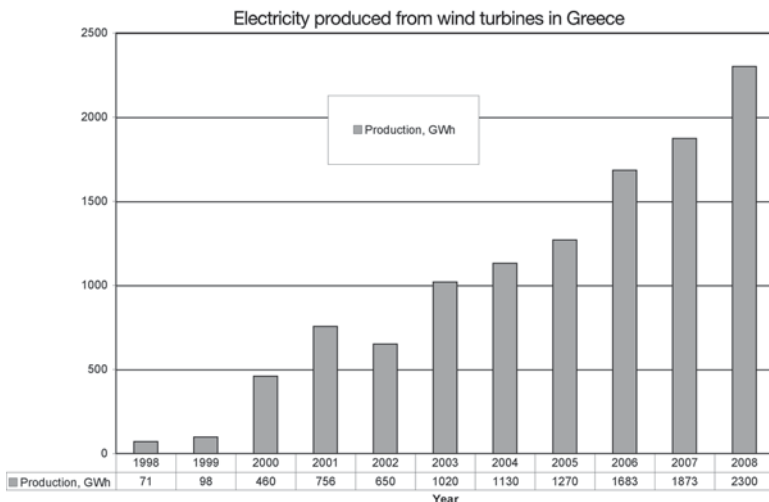


Figure 2 Electricity produced from wind turbines in Greece.

in wind turbine tower manufacturing. The average capacity of wind turbines installed in 2008 was 1,657 kW, while the average capacity of all the wind turbines operating in the country was 832 kW (Figure 4). The market share per manufacturer is depicted in Figures 5 and 6.

Wind farm malfunctions that have been reported up to now are mainly related to

gearbox failure and lightning strikes. No major events leading to extensive wind farm outages have been reported.

3.3 Economic details

The total cost of wind-power projects depends on the wind turbine type, size, and accessibility. This cost ranges from 1,000 to 1,200 €/kW and is mainly influenced by

National Activities



Figure 3 Distribution of installed wind farms in Greece.

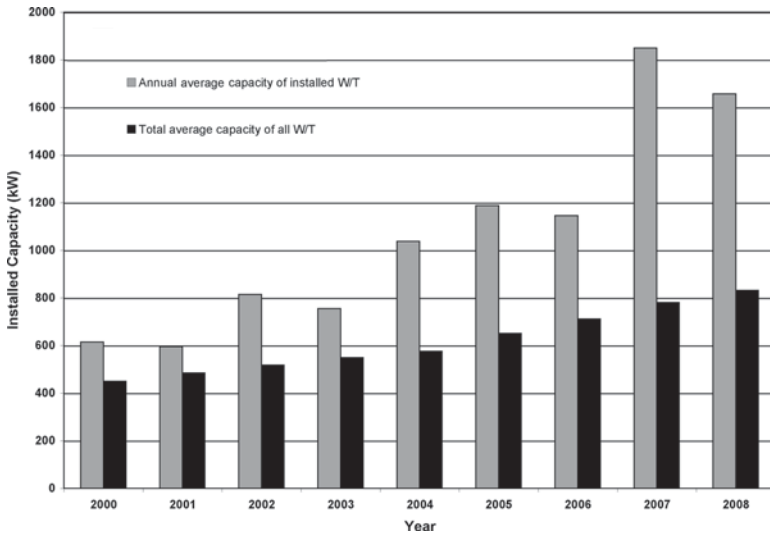


Figure 4 Average capacity of wind turbines installed in 2008 and operating in Greece.

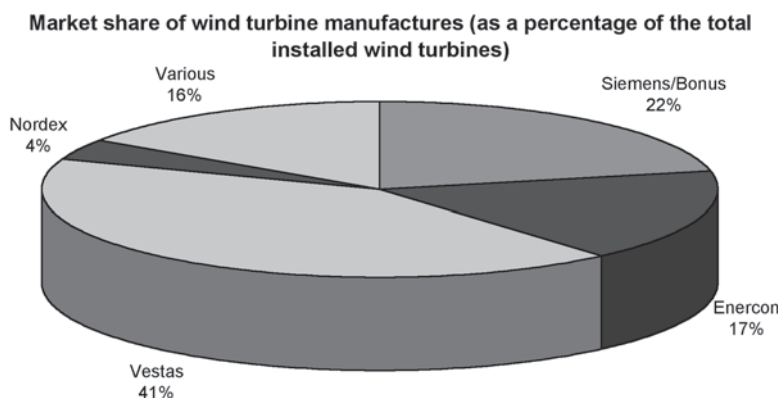


Figure 5 Market share of wind turbine manufacturers (as a percentage of total wind turbines installed).

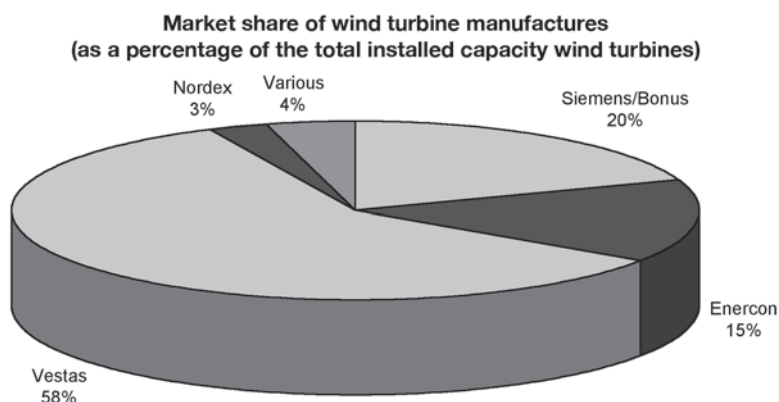


Figure 6 Market share of wind turbine manufacturers (as a percentage of total installed capacity).

international market prices and interconnection costs. The cost of generated wind power could be assumed to be between 0.026 and 0.047 €/kWh, depending on the site and project cost. The typical interest rate for financing wind energy projects is 7% to 8%.

In the liberalized electricity market, as well as before, a single price exists in the so-called interconnected system and in the autonomous systems, depending on the identity of the consumer and the voltage class. This price list concerns the tariffs of electricity purchased since August 2006 by the Hellenic Transmission System Operator according to Law 2244/94; the decision of the Minister of Industry,

Energy and Technology numbered Δ6Φ1/ OIK.8295/19.4.95 (ΦΕΚ 385/10.5.95); and Law 2773/99. This electricity either is produced by independent producers or is the surplus of auto-producers and comes from either RES or CHP. There is no capacity charge on purchases from producers in non-interconnected islands.

4.0 National Incentive Programs

Until 2008, financial support for wind energy projects was provided by the state within the framework of the Operational Program for Competitiveness (OPC), 2000–2006, and the Law for Development 3299/2004. The OPC raises resources from the Third Community Support Framework

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to provide public aid to renewable energy sources and energy saving, substitution, and other energy-related actions. As 2008 was the ending year of the Third Community Support Framework, most of the projects financed by the OPC have been finalized. Within the OPC, 29 wind energy projects of 468 MW total installed capacity have been approved. Twenty of them (295 MW total installed capacity) were successfully finalized, providing approximately 700 GWh/year to the national grid.

In January 2008, the Greek Ministry of Economy and Finance announced a new program entitled National Strategic Development Plan (NSDP), 2007–2013. The NSDP raises resources from the Fourth Framework Programme to reinforce the investment activities of the private sector and strengthen the productive potential of the country. Additionally, financial support for wind energy investments is foreseen through the Law for Development 3299/2004, which provides grants of up to 40% of the total investment.

5.0 RD&D Activities

The Ministry for Development promotes all R&D activities in the country, including applied and basic R&D as well as demonstration projects. Key areas of R&D in the field of wind energy in the country are wind assessment and characterization, standards and certification, wind turbine development, aerodynamics, structural loads, blade development, noise, power quality, wind desalination, and autonomous power system integration. There is limited activity in Greece concerning offshore deployment.

5.1 Activities of CRES

CRES (Center for Renewable Energy Sources) is the national organization for the promotion of renewable energy in Greece. It is mainly involved in applied R&D in the fields of aerodynamics, structural loads, noise, power quality, variable speed, wind desalination, standards and certification, wind assessment, and integration. CRES

has developed and operates its Laboratory for Wind Turbine Testing, which has been accredited under the terms of ISO/IEC 17025:2000.

Several research projects were running at CRES during 2008, co-funded by the European Commission and the Greek Secretariat for Research and Technology. These research projects had the following goals:

- Characterizing the main features of complex or mountainous sites and identifying the crucial parameters affecting both the power performance and the loading of different types of wind turbines operating in such environments
- Developing wind turbines for installation in hostile environments
- Improving the damping characteristics of wind turbine blades
- Developing new techniques for power quality measurement and assessment
- Increasing understanding of wind turbine standardization procedures
- Developing blade material testing techniques in the in-house experimental facility
- Understanding generic aerodynamic performance of wind turbine blades through computational fluid dynamics (CFD) techniques
- Developing cost-effective micro-siting techniques for complex terrain topographies.

In the Laboratory for Wind Turbine Testing of CRES, the project titled “Development of Infrastructures and Laboratory Support of CRES” (Measure 4.2, Action 4.2.2, of the operational program “Competitiveness”) ensures the update of its equipment and services. The project involves the optimization and integration of equipment and services related to power quality measurements, load measurements, wind speed measurements, and so on. Two of the most significant purchases by the CRES Wind Turbine lab under this project were the continuous-wave light detection and ranging system (LIDAR) Zephyr from Qinetiq

and the pulsed-wave LIDAR (windcube mode) from Leosphere, for wind speed measurements up to 150 m and higher. The project was completed in September 2008.

CRES is responsible for the development of the New Wind Map of Greece, which aims at the exploitation of country's wind potential and at the promotion of wind energy technology through new investments. The work involves the installation of 40 new masts. The Regulatory Authority for Energy (RAE) assigned the development of the map to CRES. The project was completed at the end of 2008.

5.2 University research

Basic R&D on wind energy is mainly performed at Greece's technical universities. The Fluids Department of the Mechanical Engineering school of the National Technical University of Athens (NTUA) is active in the fields of wind modeling, rotor aerodynamics and aeroelasticity, load calculation, fatigue analysis, noise, and wind farm design.

Since 2007, NTUA, in collaboration with CRES, developed a new eigenvalue stability tool for the analysis of the complete wind turbine in closed-loop operation (i.e., including the control loop). Also, NTUA participated in the EC-funded project UPWIND, which is aimed at developing the computational framework for the design of future large-scale wind turbine applications (beyond the current 5-MW scale). Within this project, NTUA developed and tested new aeroelastic tools capable of treating the large deflections anticipated in future large-scale highly flexible blades. New load control techniques such as a trailing edge flap have also been tested in the context of advanced 3-D aerodynamic modeling using the in-house free wake code GENUVP.

In 2008, the Electric Power Division of NTUA continued its research activities on renewable and distributed energy resources, focusing on several aspects of their technologies and grid integration issues. Specific research areas include the following:

- Microgrids with high penetration from distributed energy resources, concentrating on simulation algorithms and on control and communication technologies
- Investigation of wind power integration potential to the Greek interconnected power system and development of grid code recommendations
- Application of pumped storage to increase wind penetration levels in isolated island grids
- Investigation of PV penetration potential in isolated island grids
- Technical issues and feasibility studies for the interconnection of isolated island grids to the mainland power system
- Advanced short-term wind power forecasting functions for operational planning, using numerical weather predictions and advanced artificial intelligence techniques
- Power quality analysis of wind turbines and wind farms, with a particular emphasis on harmonic emissions
- Design of electrical generators and converters for small wind turbine applications, with a particular focus on permanent magnet synchronous generators
- Research on small stand-alone systems fed by renewable energy sources, including the design of the electrical and control systems for completely autonomous wind-driven desalination systems
- Development of laboratory infrastructure for renewable and distributed energy systems and participation in relevant laboratory and pre-standardization activity networks.

Since 1990, the Applied Mechanics Section of the Department of Mechanical Engineering and Aeronautics, University of Patras (UP), has focused on educational and R&D activities involving composite materials and structures. Emphasis is given

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to anisotropic material property characterization, structural design, and dynamics of composite rotor blades of wind turbines. Experience has been acquired by participating in several national and EC-funded research projects. UP is the Task Group leader in the EC-funded research project OPTI-MAT BLADES, an investigation of blade material behavior under complex stress states that assesses the effect of multi-axial static and cyclic loading on strength and life of composite laminates. Results are available in the form of design guidelines for rotor blade manufacturers, among others.

Other research activities of the Applied Mechanics Section include: (a) development of finite element formulations and dedicated code accounting for selective nonlinear lamina behavior (e.g. in shear, in the laminate) to model property degradation due to damage accumulation and predict the life of large rotor blades under spectrum loading; (b) probabilistic methods in the design of composite structures; (c) residual strength and fatigue damage characterization of composite materials using wave propagation techniques; (d) smart composites and structures; and (e) structural damping and passive and active vibration control.

5.3 Participation in IEA Wind tasks

Greece participates in Tasks 11 and 20. Task 11, Base Technology Information Exchange, promotes wind turbine technology understanding through cooperative activities and information exchange on R&D topics of common interest among member countries. Extra emphasis has been given through the years, especially at NTUA and CRES, to the development of aerodynamic models of

wind turbines, an activity that is supported by the involvement in the activities of Task 20, HAWT Aerodynamics and Models from Wind Tunnel Measurements.

6.0 The Next Term

In 2005, the existing legal framework was reviewed, and in mid-2006 a new law for the promotion of renewable energy sources and especially wind energy took effect. The new law aims to accelerate licensing procedures and alleviate major bureaucratic bottlenecks. A critical point for the achievement of the targets is completion of the extensive projects destined to boost transmission capacity of the grids in the areas of great interest for wind energy deployment (Eastern Macedonia–Thrace, Southeastern Peloponnese, and Euboea). The promotion of national land planning currently under way is expected to further facilitate investments in renewable energy systems. However, reaching the targets set for 2010 is still uncertain, unless additional measures and policies are undertaken, both institutional and technological. The institutional measures are expected to be implemented in the new legal framework, while technological actions such as the interconnection of the Northeastern Cyclades islands complex with the interconnected system are still to be decided and implemented.

References:

(1) 4th National Report Regarding the Penetration Level of Renewable Energy Sources Up to Year 2010 (October 2007).

Authors: Kyriakos Rossis and Eftihia Tzen; CRES, Greece.

1.0 Introduction

Wind energy's contribution to Ireland's electricity supply continues to rise (Figure 1). By December 2008, a total of 77 wind farms were connected, bringing the total installed capacity for wind to 1,002 MW or 13.7% of total installed capacity (1). Wind power displaced almost 1.28 million metric tonnes of CO₂ emissions and primary energy imports of 215,000 metric tonnes of oil equivalent to a nation that is more than 90% dependent on imported energy supplies. Wind farm connection rates have recovered to pre-2007 levels, with 207.7 MW connecting in 2008.

In 2008, wind generation produced approximately 2.3 TWh of electricity, increasing its share of electricity consumption from 6.8% in 2007 to approximately 8.7% in 2008 (2).

2.0 Progress Toward National Objectives

Ireland's target is to supply 15% of electricity demand from renewable sources by 2010. As large-scale hydroelectric development in Ireland is not a viable option, wind has contributed, and will continue to contribute, the vast majority of the additional renewable generation required (Figure 2). Added to other renewable generation stock, an estimated 1,350 MW of wind capacity is required to meet the target for 2010. At the end of 2006, 744 MW of wind capacity was connected. To meet the 2010 target from that point required the addition of 200 MW annually. In 2007, only 48.25

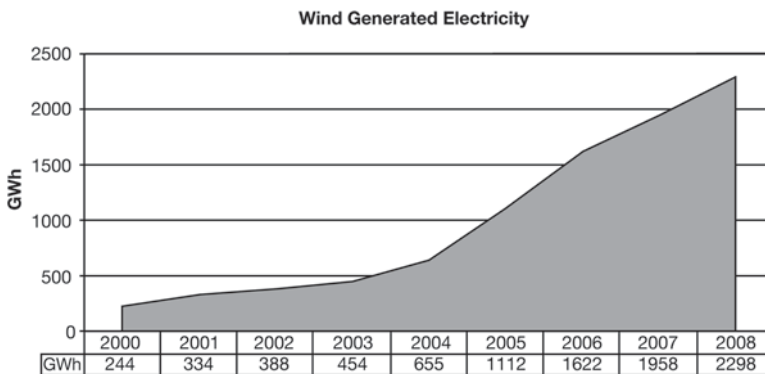


Figure 1 Wind-sourced electricity in Ireland, 2000–2008.
Source: EirGrid.

Table 1 Key Statistics 2008: Ireland	
Total installed wind generation	1,002 MW (MEC 986 MW*)
New wind generation installed	207.7 MW
Total electrical output from wind	2.298 TWh
Wind generation as % of national electric demand	8.7%
Target:	15% of electricity demand from renewables by 2010 40% of electricity demand from renewables by 2020
*maximum export capacity (MEC) see Section 2.0.	

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MW were added and this was a setback in efforts to meet the target. In 2008, wind farm connection rates were more in line with 2005 and 2006. However, it appears that meeting the target will hinge on the capacity additions in 2009 and the first half of 2010. The system operators have target connection dates within this time frame for more than 600 MW of contracts. These dates have been subject to slippage in the past, but if 60% to 70% of those contracted wind farms are connected within the period, the target may be achieved. Contracted wind farms totaled 1,412.3 MW at the end of 2008 (1). These successful applicants were taken from the applicant queue via a group processing approach, which is discussed later in this report.

A key national objective for renewable energy was revised during 2008. As outlined in the 2007 Energy White Paper (3), Ireland had aimed to supply 33% of its electricity demand from renewable sources by 2020. This target has been increased to 40% (4), and the government has emphasized that the target is to be seen as a minimum rather than a ceiling. Using current emission factors for Ireland's fuel mix,

a 33% penetration of renewable generation in 2020 would deliver a CO₂ saving alone of more than 7 million tonnes/yr. It can be seen from the figures for current connection applicants (11,000 MW) (5), sites contracted for connection (1,412.3 MW), and wind farms already connected (1,002 MW) that the wind industry is capable of providing the generation required as long as conducive conditions persist and the system operators have capacity to connect. Approximately 280 MW of new renewable capacity is required each year from 2009 to 2020 if the target is to be met. The peak connection rate to date was 231.85 MW in 2006, and the average connection rate over the past three years has been 162.6 MW. The capacity additions for each year since 2000 are shown in Figure 3.

Ireland's electricity regulator, the Commission for Energy Regulation, undertook a series of public consultations during 2008 that led to a direction to system operators as to how they should approach the connection of wind applicants in the next round of group processing (6). Those wishing to connect to the grid join an applicant queue once their application is "deemed



Figure 2 Kilgarvan, County Kerry 3-MW wind turbines. Courtesy of T. J. Hunter.

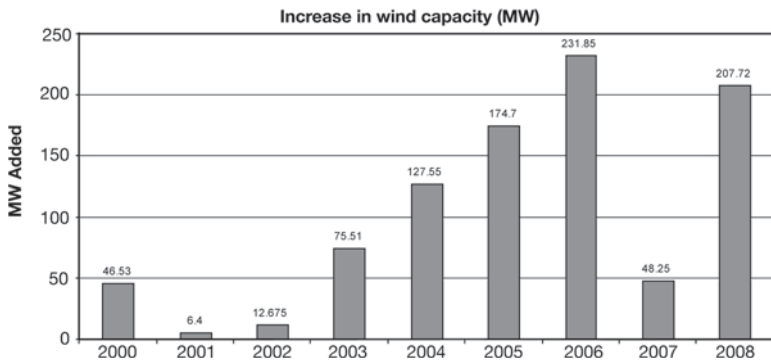


Figure 3 Annual increases in wind capacity 2000–2008. Source: EirGrid.

complete.” The options considered for accepting applicants into Gate 3 included a date-order approach (as per Gate 1), a mixed date-order/optimization approach (as per Gate 2), or a new approach proposed by the system operators known as the Grid Development Strategy (GDS) (6). The GDS will result in the issuance of offers to an amount of applicants in the connection queue at gate closure.

The aim of the GDS approach is to plan and develop the grid to meet its anticipated demand and generation needs up to 2025 in a cost-effective, optimal, and efficient way by assessing the system over a longer term than has been used in the past. According to the Commission for Energy Regulation, “the GDS allows for the optimal connection of a very significant capacity of renewable generation in Ireland over the coming years, facilitating the achievement of the 40% Government renewable target through a long term and strategic programme of transmission development, to the benefit of renewable generators and end-customers.”

During the next phase of the process up to 2011, 3,890 MW of renewable generation, including 3,877.5 MW of wind capacity, chosen by “deemed-complete” date order, will be offered. It is intended that this amount added to the grid by 2025 will provide the capacity needed to meet the 2020 targets, and it also takes into account some attrition of sites already holding connection offers. Where the local capacity of a node

on the grid is less than the firm capacity required by a group of generators, firm access to the network will be rationed on the basis of date order of applications received. Sites within Gate 3 will have the option to increase their maximum export capacity (MEC) by 20% up to a cap of 4 MW to account for changes in technology over the time scales the connection process may take.

The entire list of wind connection applicants, including those in Gate 3, amounts to over 11,000 MW at year’s end. To put this into context, Ireland’s peak demand was not expected to rise above 5,000 MW during the 2008/2009 winter season.

In 2008, just 200 MW of interconnection existed between the Republic of Ireland and Northern Ireland. As a result, the Irish Republic’s grid is relatively isolated. The East-West Interconnector project has progressed significantly in 2008 and is on course to be completed by 2012 (7). The East-West Interconnector will have a capacity of 500 MW and will be the first connection between the Republic of Ireland and Britain’s transmission systems. It is hoped that the interconnector will assist in the deployment of high levels of wind generation and provide generators with access to a larger market. Marine surveys have been completed, the proposed route chosen, authorizations granted, and connection points determined. Final permissions are currently being sought at either end of the two high-voltage direct-current cables. In January 2009, the European Commission

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announced a contribution of 100 million € toward the strategic infrastructure as part of its “Investing today for tomorrow’s energy” economic development plan.

Another 350-MW high-voltage direct-current interconnector between Ireland and Britain is planned by Imera Power, a private asset-investment company that will build and operate the interconnector on a merchant basis.

3.0 Benefits to National Economy

3.1 Market characteristics

The design, development, construction, equipping and connection of wind farm facilities in Ireland is estimated at 300 million €/yr of economic activity over the past three years. Up to 80% of the outlay is spent on imported equipment, including the turbine and associated electrical equipment. Therefore, the value to the local and national economy could be estimated to be worth approximately 60 million €/yr. The value of civil and construction costs to the local economies is approximately 30 million €/yr.

Development of wind farms in Ireland has been undertaken by a wide range of individuals and organizations—from farmers

and indigenous development companies to subsidiaries of semi-state bodies, utilities, and multinational developers. A landowner has the option of leasing land suitable for wind farm development without having to get personally involved in the development of the site. Typical costs for leasing such land are in the range of 6,000 €/MW installed.

Because the equipment is imported, the associated operation and maintenance (O&M) costs are with international suppliers. Therefore a large portion of the O&M expenditure, which is estimated to be 1.5% to 3% of the capital costs of a project, goes to equipment suppliers and manufacturers abroad. Current total capital costs are in the range of 1.7 million €/MW installed for wind developments in the 10-MW range. Five manufacturers’ turbines were installed during 2008; the market share of each (in terms of each) is shown in Figure 5.

A major development in the wind sector came during 2008 when Scottish and Southern Energy plc completed the acquisition of Airtricity Holdings Ltd, valued at the time at 1,455 million €. Airtricity has wind farm projects in Ireland, China, Europe, and the United States. Scottish and Southern Energy plc is the second-largest



Figure 4 Wind farming near Dunmanway in West Cork. Courtesy of Zane R. Llewellyn.

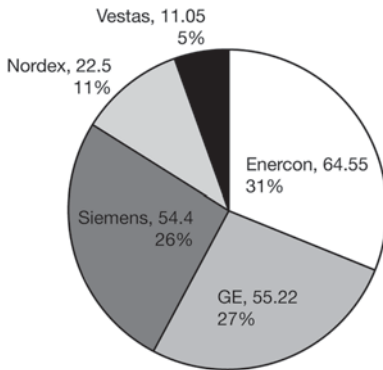


Figure 5 Turbines connected in 2008 (manufacturer, MW, %).

generator and supplier in neighboring United Kingdom, with operations in a range of other utilities and services.

3.2 Industrial development and operational experience

Although a burgeoning ocean energy industry is developing in Ireland, the country has no manufacturing industry of large-scale wind turbines. There is, however, a developing micro-scale turbine manufacturing industry, with a handful of companies developing their own units and masts. In addition, several companies are involved in manufacturing key mechanical and electrical components for both micro-scale and large-scale turbines and generators.

In 2007, the average size of a large-scale wind turbine grew to 1.9 MW; however, in 2008 the average size fell to 1.65 MW. During 2008, 128 turbines were installed in 12 wind farms, including extensions to two existing wind farms.

3.3 Economic details

Turbine costs currently range between 1.1 million € and 1.4 million €/MW, depending on the size of the turbine and the project. The trend in costs continues to be upward. A typical cost for connection would be in the range of 150,000 € to 300,000 €/MW. With the global economy facing recession, the demand for materials and hence costs

are expected to be reduced. Figure 6 shows how typical project costs can be apportioned in Ireland.

Current support mechanisms for renewable generation take the form of a Renewable Energy Feed-In Tariff (REFIT). REFIT is a public service obligation-backed power purchase agreement (8). Section 4.0 will provide details of the mechanism.

The single electricity market (SEM) has been live for more than a year. Northern Ireland and the Republic of Ireland trade almost all of their electricity through a gross pool operated by the SEM operator; a portion of electricity is still traded bilaterally with licensed suppliers outside of the pool. Generators with installed capacity of less than 10 MW can trade bilaterally if they choose, thus avoiding administrative burdens associated with market participation. All generators above the 10 MW minimum must trade in the mandatory pool, either directly or via an intermediary.

The SEM Committee continues to consult on the treatment of wind and other intermittent generation in the SEM (9). Membership of the SEM Committee includes both regulatory authorities and external members from Spain. The aim of the consultation is to promote discussion in a market of increasing wind penetration

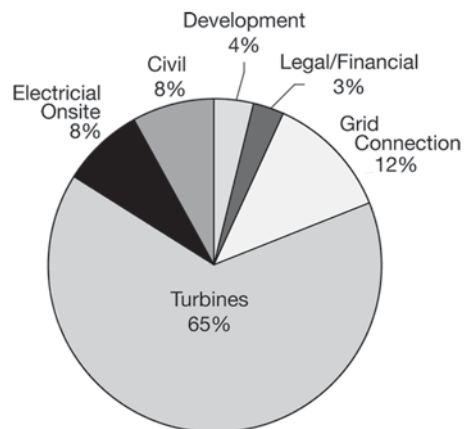


Figure 6 Breakdown of capital costs. Source: IWEA.

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with the goal of dealing with issues in a timely manner. Issues such as the process to secure economic dispatch, firm access, the calculation of the average system marginal price, constraint compensation, and capacity payments will be further developed in 2009 following several meetings held in February.

4.0 National Incentive Programs

REFIT is the form of support mechanism employed in Ireland, initially with the aim of meeting the 2010 targets for renewable energy (10). The indirect beneficiaries of this form of state aid are the renewable generators. Electricity suppliers receive payments accruing under REFIT in return for entering into 15-year power purchase agreements with approved generators. Different levels of REFIT exist for different renewable technologies to reflect the variation in their setup costs and to promote diversity in the generation portfolio. For wind generation, the values of the REFIT reference prices originally announced in 2006 were 57 €/MWh and 59 €/MWh for large-scale and small-scale wind, respectively. This value is inflated annually by the Consumer Price Index, which at present is low. At January 2009, the value of REFIT for large-scale wind was approximately 64 €/MWh. The average wholesale price of electricity for 2009 was forecasted to be between 90 €/MWh and 110 €/MWh; however, this is likely to reduce as gas prices fall (11).

Should suppliers become exposed to higher than average prices by contracting with REFIT-backed generators, they are compensated through the PSO for the opportunity cost occurring. Suppliers also receive 15% of the large-scale wind reference price on top of the energy payment. This 15% payment was originally designed to cover balancing costs (“top-up” and “spill”) in the old market and has been carried forward into the single electricity market.

Early in 2008, the Department of Communications, Energy, and Natural Resources announced a REFIT specific

to offshore wind at 140 €/MWh. The increased discrete tariff for offshore wind is designed to reflect the additional costs associated with offshore wind development and aims to stimulate activity in the area. Despite the fact that Ireland is an island, offshore development has been limited to date, with 97.5% of installed capacity onshore. Hundreds of megawatts of offshore wind capacity has been licensed, but progress toward construction is not yet evident. However, Gate 3 includes 785 MW of offshore connection applicants. The department responsible for foreshore leases has decided to temporarily postpone the assessment of further applicants until it has reviewed the process.

At the opposite end of the scale, a micro-generation field trial is planned for 2009 and 2010 (12). The study will offer a financial incentive for host sites to get involved. A proposal by the largest electricity supplier to buy exported electricity from domestic sites was welcomed as progress, although the industry would like to see a tariff or support mechanism that would provide a driver for technology adoption. The 90 €/MWh offering will be reviewed annually and is an interim tariff prior to the outcome of the micro-generation pilot study and smart-metering trials.

An indirect incentive for the deployment of micro-generation is provided by the Energy Performance in Buildings Directive being implemented in Ireland under the Building Energy Ratings scheme. Irish building regulations require that new dwellings have a portion of their energy demands met by renewable sources on-site. The designer has a choice between sourcing this energy through either renewable thermal or renewable electrical means (4 kWh/m²/yr electrical or 10 kWh/m²/yr thermal). The contribution of a wind turbine can be included in the Building Energy Ratings scheme once its performance over a year has been verified.

Sustainable Energy Ireland also administers a Low Carbon Homes Programme

which is in place to incentivize further efficiency in the design of dwellings (12). The program provides financial assistance for developments (5–15 dwellings) that offer a 70% improvement in energy efficiency when compared to 2005 building regulations. The program requires at least 10 kWh/m²/yr of electricity to be generated on-site for self supply or export. One-off demonstration buildings are considered if it can be shown that the design can be duplicated. Funding of 40%, up to a maximum of 15,000 €, is available per unit, and all scales of renewable electricity generation are eligible costs.

5.0 R, D&D Activities

Several key studies were published during 2008. January saw the publication of the All-Island Grid Study, which has since been of interest to industry participants all over the world and has provided a platform for further research in Ireland (13). A summary was provided in the 2007 IEA Wind Annual Report. The conclusions of the study were a key factor in the decision by government to increase to 40% Ireland's 2020 renewable electricity target.

5.1 Impact of high levels of wind penetration on the SEM

Following on from the technical grid study the regulators undertook a study to assess the possible impacts of high penetrations of wind on the SEM in 2020 (14). The study examines the impact of the five generation portfolios from the All-Island Grid Study on the unconstrained system marginal price and on the capacity payments to generators. Generators receive capacity payments proportional to their capacity and availability. The cost/benefit analysis was limited to analyzing the additional cost of the added renewable capacity and the displaced costs for carbon fuel and conventional plant. The study also analyzed the effect high wind penetration might have on the profitability of existing and new conventional generators. It should be noted that, among other

limitations, network costs were not included in the study.

At a high level, the study resulted in the following findings:

- Wholesale market prices are significantly lower for all but one portfolio of high wind penetration
- As expected, economic benefits are sensitive to fuel and carbon prices
- A mixed portfolio of plant including combined-cycle gas turbine, open-cycle gas turbine, and wind provides a greater carbon reduction
- Incentives may be required for all forms of new generation into the future
- The SEM design appears to be robust, but continued review will be required to facilitate the changes expected in the next decade.

It is worth noting that the modeling was carried out during a period of historically high oil and gas prices. Since then, prices have dropped to a level comparable with the low-price-fuel scenario, rather than those used in the central scenario.

5.2 Grid25

EirGrid, Ireland's transmission system operator, has published its strategy for the development of the grid up to 2025 (15). The study aims to identify how, on a national and regional level, the grid will need to be developed to accommodate projected demand growth and the move toward a high proportion of renewables. EirGrid estimates that the transmission system's capacity will have to double by 2025, and such an expansion is likely to cost in the region of 4 billion €. The potential of the existing grid to be upgraded will be maximized to minimize the construction of new lines, and no new 220-kV lines will be built. EirGrid will design the transmission network around 400-kV rather than 220-kV lines to minimize the footprint and length of new lines (a 400-kV circuit typically has the same

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capacity as three 220-kV circuits). The network will also have 110-kV lines.

Following on from Grid25, the transmission system operator has begun more detailed studies to identify specific reinforcement needs and their environmental, economic, and system impacts.

6.0 The Next Term

Ireland intends to take part in the new IEA Wind Task 28 (The Social Acceptance of Wind Energy Projects: Winning Hearts and Minds) and will contribute research beneficial to the international wind community. IEA Wind Task 25 (Design and Operation of Power Systems with Large Amounts of Wind Power) has been extended, and Ireland will continue its involvement.

While output from wind increases, provisional figures show that the capacity factor for the wind portfolio may have dropped just below 30% during 2008 (2). The reasons behind this apparent fall warrant further study (wind resource, site selection, turbine availability, etc.).

Several R, D&D projects will take place during 2009 and beyond. These—along with a national smart metering pilot, further work on Gate 3, and a review of the connection process for smaller generators greater than 11 kW—will assist the deployment of wind at all scales.

6.1 Micro-generation field trials

There is growing interest in the area of micro-generation from all sectors of the community for both economic and ecological reasons. Interest is expected to increase further, now that the largest electricity supplier intends to offer 0.09 €/kWh to its domestic customers for exported electricity.

The major wind R, D&D activity expected in 2009 will be at the smaller scales and will be undertaken by Sustainable Energy Ireland. Financial support to meet 40% of the start-up and short-term-maintenance costs will be available in approximately 50 trial locations with an overall budget for the study of 2 million € (12). Sustainable

Energy Ireland will fund data monitoring at all of the sites for the 18-month duration of the study. The monitoring will assess the performance of the technologies and inform future decisions on possible incentives, tariffs, or deployment programs.

To protect customers and prescribe best practices in the pilot study, turbine suppliers and manufacturers applying for inclusion in the pilot study will be required to supply equipment that conforms to the appropriate European standards (EN 61400-2/11/12), as will the associated inverters (EN50438). Installers will be required to undergo wind theory and practical manufacturer training. A robust site assessment and feasibility study will have to accompany an application. Best practices are prescribed in an effort to ensure high-quality and safe installations in a fledgling sector sensitive to the impact of bad customer experiences on future growth.

6.2 Smart network for island communities

Several offshore islands in Ireland support communities. Energy is provided by imports from the mainland or, in some cases, from distributed diesel generators. Wind has been used on the islands as far back as the 1980s and is still being harnessed on several islands on a small scale. The offshore islands have some of the best wind resources in Europe, and it is hoped that this, along with ocean energy, could be employed to increase the economic and environmental sustainability of island life by supplying the communities with reduced-cost electricity for power, heat, and transport. The Department of Community, Rural and Gaeltacht Affairs and Sustainable Energy Ireland have commissioned an economic and technical feasibility study focused on the Aran Islands with the possibility for duplication in other communities. The study will also assess the costs and benefits of storage technologies, both for transport end use and heating, thus improving security of supply of energy and reducing the need for conventional reserve.

6.3 Autoproduction

Autoproducers are generators with on-site generation installed with the aim of displacing imported electricity at retail rates. Wind autoproduction, large and small scale, will grow over the coming years as heavy energy users look for options to make their operations more competitive and sustainable. As autoproduction adds generation capacity downstream of the meter, it can be easier to facilitate than adding the same capacity directly to a congested grid, although grid access for the full capacity of the generator may be sought.

To date, autoproduction has been mainly employed through CHP generation. Following on from the success of the 850-kW turbine installed on campus in Dundalk Institute of Technology, some industrial customers are exploring their options. A number of energy services companies offer a risk-free model to industrial customers that have a suitable site. These companies take on all the risk in planning, designing, procuring, installing, and operating the megawatt-scale turbines. They then offer to the energy user on-site a tariff for the power produced that is guaranteed to be a percentage below the retail rate for the period of the long-term contract. With competitiveness becoming increasingly difficult for industry in Ireland, this arrangement is likely to be attractive to high energy users with suitable sites.

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Author: Martin McCarthy, Sustainable Energy Ireland.

1.0 Introduction

Italy, more than many other European countries, is very poor in indigenous resources, and so is highly dependent on foreign countries for its energy needs. The development of an energy policy for the exploitation of renewable sources has two main objectives: 1) having a significant contribution from RES to satisfy energy demand—even though in 2008, for the first time, domestic electricity demand was less (−0.7%) than in 2007—and 2) improving environmental indicators, by reducing air and water pollution through the replacement of older conventional generating plants.

In 2008, the electric energy generation from RES was quite good and much better than in previous years. This was mainly due to a strong increase of electricity production from hydropower and, to a much smaller extent, wind, taking into account the different relative weights of these two clean sources. In fact, the production from wind grew by 63% compared to 2007, according to 2008 provisional electricity statistics provided by Terna (Italian Transmission System Operator), while that from hydro increased by only 18%. However, in absolute terms production from hydro was 45,511 GWh (albeit including output of some pumped-storage plants). Production from wind was 6,637 GWh, with growth of approximately 2,500 GWh.

Hydro, with about the same installed capacity in 2008 as 2007, had a substantial production growth as a consequence of more rainfall and snow in the last months of the year. Wind energy also enjoyed a particularly windy year, but its substantial growth in energy contribution was mainly the result of a massive increase in power capacity. More than 1,000 MW was put into operation in 2008, establishing a new annual record (Table 1). Wind power capacity rose in 2008 by a surprising 37%, because many wind farms, totaling about 370 MW, were connected to the grid in December.

As to the whole electricity system, according to Terna's provisional data, the 2008 electrical demand on the domestic grid (including both customer loads and grid losses) was about 337 TWh. This is 0.7% less than 2007 and about the same as demand in 2006. The balance between imported and exported electricity improved to almost 40 TWh, 14.5% less than 2007. Italy's 2008 gross domestic electricity consumption (i.e., 318 TWh of gross domestic production plus the balance between import and export) can therefore be considered to be about 358 TWh.

Table 1 Key Statistics 2008: Italy

Total installed wind generation	3,736 MW
New wind generation installed	1,010 MW
Total electrical output from wind	6.637 TWh*
Wind generation as % of national electric demand	1.9%*
Formal wind target according to the 1999 RES White Paper:	2,500 MW or 5 TWh by 2008–2012
RES target according to Directive 2001/77/EC and Legislative Decree 387/2003:	22% (76 TWh) of gross electricity consumption from RES by 2010
Maximum wind potential according to the 2007 Position Paper of the Italian Government:	12,000 MW or 22.6 TWh by 2020
*Provisional data	

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Altogether, hydropower (less an estimated 5.5 TWh from pumped-storage plants, which cannot be considered as a RES output), wind energy, and geothermal energy (the last one with the same production as 2007), totaled some 52.1 TWh. According to GSE (Gestore dei Servizi Elettrici, the body in charge of running all RES support schemes), biomass contributed an estimated 7.2 TWh. Therefore, the total electricity contribution from RES in 2008 is estimated at nearly 60 TWh—10 TWh more than 2007 and an increase of 20%.

Wind-generated energy, as a percentage of national electricity demand, amounted to 1.9% in 2008, 63% more than in 2007. In spite of that, stronger involvement by central and local administrations and by the national transmission system operator Terna is still required for achieving, if not exceeding, the maximum wind potential of 12,000 MW. This is the estimate for 2020 according to the 2007 Renewable Energy Position Paper of the Italian government. Such wind development would contribute to reaching Italy's 17% quota of primary energy from RES by 2020, in accordance with the so-called European Directive 20/20/20. (This directive, before becoming operational, must be implemented at the national level.)

2.0 Progress Toward National Objectives

So far, the formal objective for wind energy is still 2,500 MW, which must be achieved in the 2008–2012 period, according to the national White Paper of 1999. This goal has by now been greatly exceeded. However, taking into account the aforementioned position paper issued by the Italian government in September 2007 (in response to the new 2020 RES targets set by the Plan of Action “An Energy Policy for Europe” of the European Council), the actual wind capacity objective for 2020 is now 12,000 MW, of which 2,000 MW is from offshore installations, corresponding to an annual production of 22.6 TWh.

Through new wind power capacity introduced into the electric system in

2008 equal to 1,010 MW, cumulative wind power in Italy was 3,736 MW at the end of December 2008 (Figure 1). This is well above the former official target and is in line with national commitments on a growing role for RES in accordance with the forthcoming European Directive. The total number of online turbines was 3,588, with an increase of 645 units in 2008.

2.1 Commercial Deployment

Wind energy, through excellent results achieved in 2008 both in terms of new power capacity and, according to provisional data, electricity generation, is confirming its important role in Italy's electricity system. It is now positioned as the third renewable source following hydro and biomass.

The average capacity factor of wind plants in 2008, according to figures computed by Garrad Hassan Italia S.r.l. from data acquired by Terna and ENEA, was as high as 0.24, appreciably higher than in 2007 (Figure 2).

Good wind conditions in 2008 and the increased power capacity online led to a share of wind generation of 1.9% as a percentage of domestic electricity demand. Italy is experiencing a growing but still low contribution from wind energy (in 2007 the share was 1.23%), but much more must be done to reach a possible but very ambitious share of 6% to 7% of electric demand. With 1,010 MW of new wind power capacity installed in 2008, the previous estimate of a maximum 3,500 MW of total capacity by 2008 (see the 2007 IEA Wind Annual Report) has actually been demonstrated to be low. Now the nearest target, which should be reached very shortly, is the threshold of 4,000 MW. By the end of 2009, taking into account works in progress, the cumulative installed capacity should be some 4,600 MW.

Despite the usual difficulties faced by developers—administrative bureaucracy, opposition from a minority of environmental associations, and lengthy procedures for connection to the grid (which

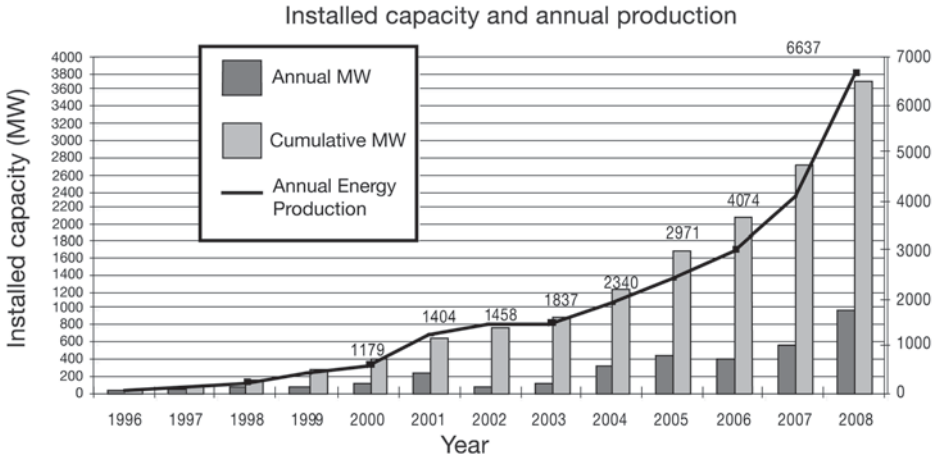


Figure 1 Trend of annual and cumulative wind turbine capacity and electricity production from wind in Italy.

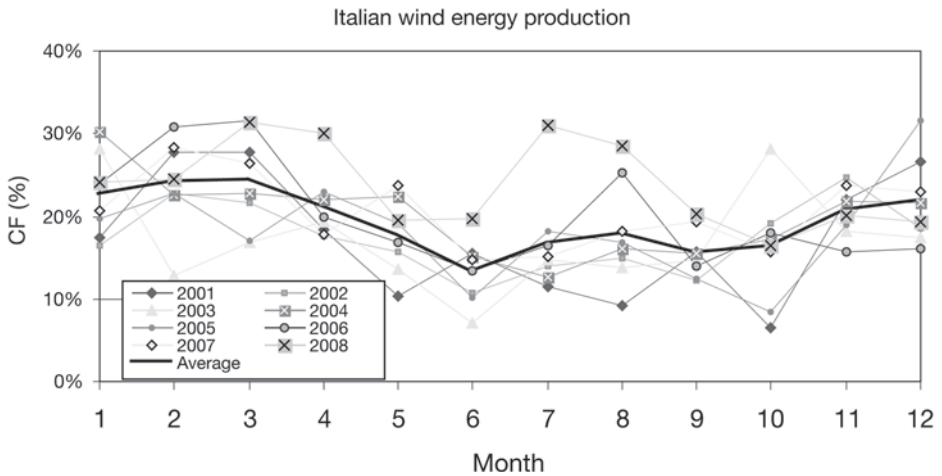


Figure 2 Capacity factor of Italian wind farms.

are becoming a real bottleneck)—wind energy deployment has been growing at a very brisk pace. Continued annual growth is anticipated of from 800 MW to 1,000 MW in the period 2009–2012. Moreover, this growth rate could be confirmed as an annual average until 2020 if a contribution were also to be made by offshore installations.

The Apulia (260 MW) and Sicily (211 MW) regions were the most active in 2008, followed by Campania, Sardinia, Calabria,

and Molise (Figure 3). Worthy of mention is the region Sardinia, where some 100 MW were installed last year despite the fact that wind energy had not been favored by the regional government.

In 2007, International Power plc, a leading independent electricity generating company with interests in more than 30,000 MW (gross) of power generating capacity located in 20 countries, entered the Italian wind market. It acquired some 550 MW and gained the position as the

Wind power capacity at the end of 2008 (MW)

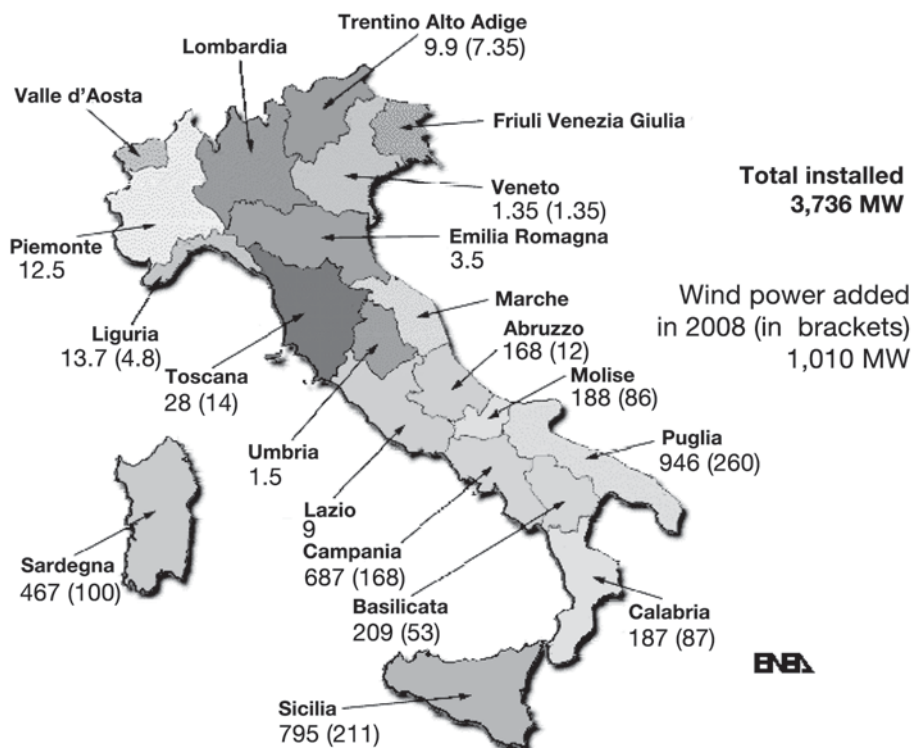


Figure 3 Wind power capacity at the regional level in Italy at the end of 2008 (wind capacity added in 2008 is indicated in brackets).

leading player in Italy in wind generation. International Power plc owns 1,199 MW of wind energy plants around the world, and its share in Italy of total wind power installed was almost 15% at the end of 2008.

Five other energy producers in the Italian wind market—two utilities (Enel and Edison) and the wind developers IVPC, Fri-EL, and E.ON Italia—have capacity shares ranging between 7.5% and 11.2%. They are followed by several minor investors with a share up to 3% (Figure 4).

The IVPC Group, Italian Vento Power Corporation, is one of the leading national operators in the production and sale of electricity from wind. Since 1993, when it was set up, the IVPC Group has expanded its range of services by offering them to third-party operators. IVPC has developed

and installed approximately 1,000 MW of wind capacity, which it manages, distributed over seven Italian regions. Of this capacity, it directly owns 324 MW. The IVPC Group currently has 166 MW under construction. Furthermore, through IVPC Gestione S.r.l. and its other service companies, it manages and maintains wind farms not only for itself but also for third parties.

With regard to the sourcing of financial resources, the IVPC Group is a lead player in obtaining bank loans (so-called project financing). From 2006 through 2008 alone, the IVPC Group negotiated and executed project financing bank loan agreements of approximately 696 million €. As regards intermediation in the sale of electricity and green certificates, the IVPC Group looks after the sale of electricity produced

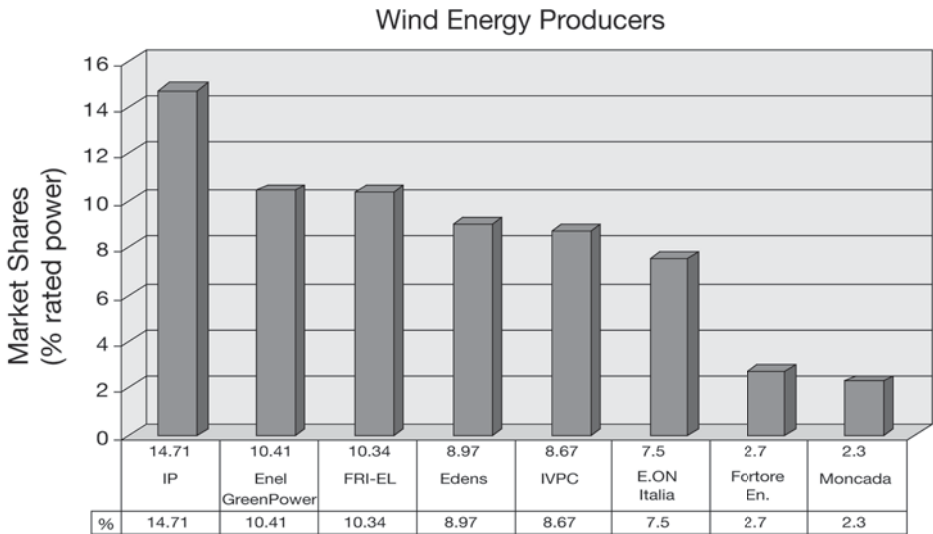


Figure 4 Contribution by electricity producers from wind at the end of 2008.

from the group's wind farms and wind farms belonging to third parties. It carries out the same activity for the sale of green certificates belonging to group companies. Intermediation activities for the sale of electricity and green certificates are carried out by its own organization based in Rome, which operates in the sector of electricity trading. Its aims are to maximize the objectives of the companies that own production plants, see to the care and fulfillment of all associated operations and activities (managing contracts, analyzing and checking data, monitoring stock markets, examining integrated commercial proposals, and so on), and act as interface in relations among institutions in the electricity sector.

Among wind manufacturers, Vestas still leads the Italian market with a share of total capacity close to 50% and more than 340 MW installed in 2008—one-third of the total capacity put into operation for the year. Gamesa maintains the second position, with a share of 20% and new installations totaling 164 MW. Enercon had quite a good result in 2008 with 125 MW installed, bringing its cumulative capacity to 473 MW or a 12.67% share of installed wind power.

Besides these three major manufacturers, others have entered the Italian market with shares ranging from 3.2% to 5.3%. REpower had the best result in 2008; 146 MW located in the Apulia and Sicily regions brought its total capacity to nearly 200 MW. It was followed by Nordex, which installed 109 MW, and Ecotecnia with 104 MW. GE Wind put into operation only 13.5 MW, but it should significantly increase its capacity in 2009 (Figure 5).

The average unit power of wind turbines installed in 2008 was 1,566 kW, slightly less than the previous year, but the average unit power of all online turbines at the cumulative level still increased from 926 to 1,041 kW. The increase is mainly thanks to a large contribution provided by 2-MW turbines and a number of other machines ranging from 1.35 MW to 3 MW (Figure 6).

So far, no electricity producers with a single wind turbine have entered Italy's market. However, the new incentive scheme of the 2008 Financial Law for wind plants up to 200 kW became fully operational (see Section 3.1) in the beginning of 2009. Also some new rules at the regional level, make it likely that small private investors, mainly

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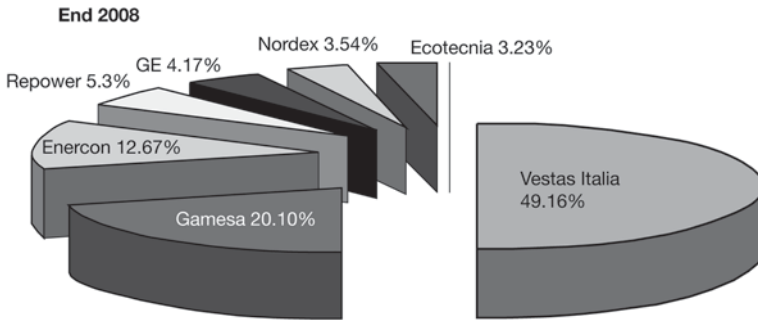


Figure 5 Market share of wind turbine manufacturers at the end of 2008 (percentages of total online capacity).

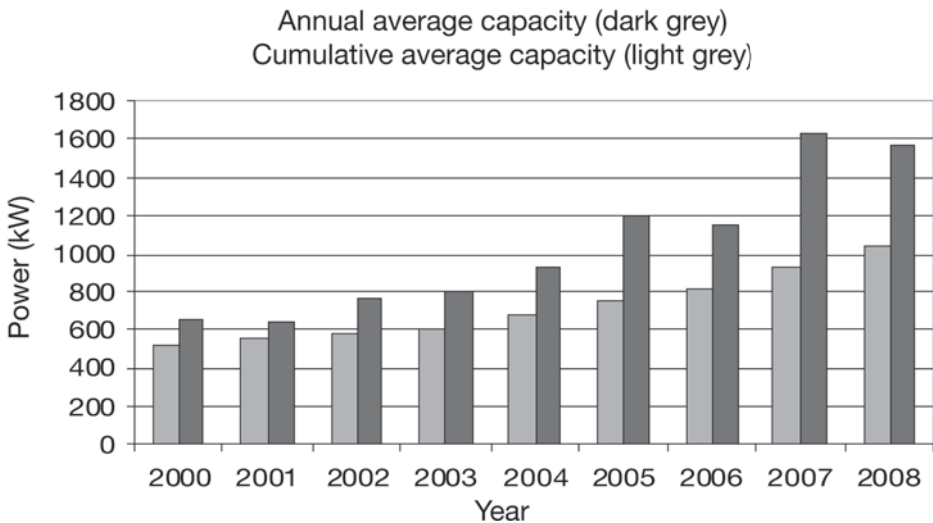


Figure 6 Average annual and cumulative online unit capacity.

farmers and landowners, will start to install single machines with capacity up to 1 MW.

3.0 Benefits to the National Economy

Because of the increasing annual growth of wind power capacity, the economic turnover of the wind sector in the past two years rose to more than 1 billion €, including turbines and components delivered to foreign countries. The most positive effect of this progress is the growing number of employees involved in the sector. At the end of 2008, according to ANEV (National Wind Energy Association), this amounted

to 18,309 positions, of which 5,353 are directly employed. The total personnel involved is subdivided as follows: feasibility studies, 2,240; manufacturing of turbines and related industry, 3,033; development and civil works, 5,246; installation, 1,421; and management O&M, 6,369.

Regarding future prospects, a study jointly carried out by ANEV and UIL (a national trade union) estimated that by 2020, assuming full exploitation of an Italian wind potential of 16,200 MW and energy production of 27.2 TWh, some 66,000 people would be employed (including indirect employment). In addition,

other economic and employment benefits are related to replacement of the main components of old medium-sized wind turbines, carried out by IVPC. Another positive aspect ensuing from the rising wind power capacity and its being scattered in rural areas is increased investment in upgrading electrical grid infrastructures, mainly planned and implemented by the TSO Terna.

3.1 Market characteristics

With awareness of the environmental and economic benefits from wind energy and the full knowledge of new opportunities offered by the changing incentive mechanism, local municipalities, entrepreneurs, investors (including foreign investors), and common citizens have shown steadily growing interest in being involved in new wind projects. Through the Ministerial Decree on 18 December 2008, the RES provisions in the 2008 Financial Law finally went into effect at the beginning of 2009. Among other measures, this law has introduced a favorable fixed feed-in tariff for electricity generated by RES plants up to 1 MW in capacity (for wind, this limit is only 200 kW) as an alternative to tradable green certificates (TGCs). This new incentive has prompted several entrepreneurs to build, commercialize, and invest in smaller wind turbines. This market, so far a niche market, now has the opportunity to grow significantly owing to the great interest shown by people living in medium-high windy areas.

Owners of wind farms are mostly private medium-large companies, utilities, and sometimes small local firms that have joined forces with larger ones. Neither single farmers nor citizens, including co-operatives, are yet owners of medium or large wind turbines. Only small turbines are currently owned (and to a lesser extent managed) by landowners. In the near future, this tendency should change, with a growing number of single wind turbines up to 1 MW in capacity being located and run on private properties.

3.2 Industrial development and operational experience

Vestas once again in 2008 was the leader both in annual and cumulative wind power capacity installed. The company is increasing its presence in Italy by setting up three subsidiary companies. Specifically:

- Vestas Italia S.r.l. is responsible for the sale, installation, commissioning, and maintenance of wind farms installed in Italy; Switzerland; eastern Mediterranean countries such as Turkey, Cyprus, Egypt, Tunisia, Libya, and Lebanon; South Balkan countries such as Bosnia, Macedonia, and Albania; and all the Middle East countries.
- Vestas Nacelle Italia S.r.l. specializes in the assembly of V52 850-kW and V90 3-MW turbines. So far, more than 2,600 nacelles have been sent worldwide.
- Vestas Blades S.r.l. is involved with the construction of blades for V52 units.

Vestas now has two commercial offices, in Taranto and Rome. Moreover, in 2008, the company inaugurated the new production line of the V90 3-MW turbine and increased the employees in its two factories in Taranto to almost 700 people.

In 2008, Leitwind was set up as a company belonging to the Leitner group. In December 2008, the company installed its first wind farm in Italy with four LTW 77 1.5-MW turbines (Figure 7). So far, Leitwind's commercial products are two turbines, LTW 70 and LTW 77, of 1.7 MW and 1.5 MW rated capacity, respectively, and with different rotor diameters, 70 m to 77 m, as a function of the wind class of the site. Previously, Leitwind installed a few wind turbines in Italy, Austria, Bulgaria, and India. A new prototype, the LTW 80, rated at 1.5 MW, is under development and is likely to be installed in 2009.

The very first wind farm in the Italian Alps was installed by Nordex at the end of December 2008. Four 2.5-MW NM 90



Figure 7 Leitwind LTW 77 1.5-MW turbines installed in Tuscany (courtesy of Leitwind).

turbines and one NM 80 turbine are located about 1,000 m above sea level close to the French border (Figure 8).

The Moncada Energy Group should soon begin producing the WPR 850/58 850-kW direct-drive turbine. In the near future, 2-MW, 20-kW, and 1.5-kW models are to be designed and built in its factory in Sicily. Moncada has received approval to build a 500-MW 400-kV merchant electrical line across the Adriatic Sea from Albania to Italy. The line is being developed as part of a wider plan for an integrated energy hub in southern Europe. This will enable Moncada to export power from its planned and already authorized 500-MW wind

farm in Albania. The interconnecting direct-current (DC) cable between the Italian transmission grid and the Albanian grid will be 154 km long. Of these, 14 km will run on Italian ground (Brindisi), 10 km will be on Albanian ground, and the remaining 130 km will be laid on the seabed in the Channel of Otranto down to a maximum depth of 825 m. The two ends of the cable will be connected to conversion stations (transforming AC to DC current and vice versa) which, in turn, will be connected to a 380-kV line at Brindisi Sud (Italy) and to a 220-kV line at Babica (Albania). This project has already been judged favorably by Terna and the Albanian TSO and was also approved (9 January 2008) by the Albanian government.

The company has also developed a project for an interconnecting DC cable between the Italian transmission grid and the Tunisian one, with a capacity of 600 MW and a voltage of 400 kV.

Regarding grid connection, mention should be made of Deliberation ARG/elt 99/08 issued by AEEG (the Regulatory Authority for Electricity and Gas) on 23 July 2008 to streamline further, and gather in a single document, the technical and economic conditions for connecting generating plants to electrical systems at all voltage levels. This deliberation, in effect from 1 January 2009, includes special provisions for RES plants, which should help clarify and speed up the procedures for connecting wind plants to the grid and better define the sharing of relevant costs between wind investors and the grid operator. On the other hand, a further AEEG Deliberation (ARG/elt 98/8 of July 2008) has allowed grid operators (for example, Terna) to require that new wind plants provide some ancillary services for the benefit of the electrical system. Such services include power output modulation, cut-in power ramp control, fault ride-through capability,

and regulation of active and reactive power.

Terna, with the aim of allowing the connection of growing energy production from wind into the national transmission grid, has developed the “collecting plants method” (metodo dei collettori di potenza). This method allows connection of considerable amounts of power in the safest way with environmental and economic benefits. Its main objective is to favor the connection of more than 200 MW of generation capacity to each collecting plant of the 380-kV system.

Terna plans to invest 550 million € in the national transmission grid to support the development of RES, and in particular wind energy, through the repowering of existing lines, construction of new lines, and construction of connecting plants, which represent the most significant part of planned investments. Terna’s plans for new connections include the 500-kV DC 1,000-MW submarine cable between Sardinia and the mainland (to be completed by the second quarter of 2010) and an enhanced connection to Sicily. They will guarantee an increase of some 3,700 MW of transmissible energy from wind.



Figure 8 Nordex 2.5-MW NM 90 turbines at Garessio (Cuneo) in the Italian Alps (courtesy of Nordex Italia).

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In September 2008, a small 80-kW wind turbine was installed by the company Blue H on a floating foundation about 20 km off the Apulian coast. This offshore turbine was installed on a 111-m depth of the seabed, where a counterweight was placed previously, and used a submerged deepwater platform. The temporary permit for the installation in the sea expired at the end of 2008, and the unit was subsequently decommissioned and brought safely back to shore. Blue H feels that it learned a tremendous amount from this experience and is confident that the know-how gained, along with its intellectual property already filed in the form of utility model and patents, will ensure its continued leadership in the field of floating wind turbines.

Blue H is currently building the first operational 2.5-MW unit in Brindisi, which it expects to deploy at the same site in the southern Adriatic Sea in 2009. This is the first turbine in the planned 90-MW Tricase offshore wind farm located more than 20 km from the beautiful coastline of Apulia.

Early in 2009, project GEOMA, a consortium led by Blue H, was selected as one of 30 recipients of Italian public funding under “Industria 2015,” a program announced by the Minister of Economic Development. The Blue H consortium is one of two wind energy projects selected by a panel of experts in Industria 2015. This Italy-based project will develop a hybrid concrete/steel 3.5-MW floating wind turbine ideal for the deep waters of the Mediterranean Sea. Consortium members are Ansaldo Sistemi Industriali, Blue H R&D, Blue H Sky Saver S.r.l., CESI RICERCA, EADS Astrium, Progeco, Società Gomma Antivibrante, TRE Tozzi Renewable Energy, and the University Federico II of Naples. The consortium aims to create an integrated solution for a floating wind turbine able to bring down the overall cost of electricity generation to be in line with the economics of onshore wind energy

generation, but without the problem of negative visual impact.

Other initiatives aimed at setting up offshore wind farms on fixed foundations in shallow waters are running along the coasts of southern Italy and Sicily. For the time being, the investors are dealing with difficult permitting procedures, increasing costs, and some adverse judgments expressed by local authorities.

3.3 Economic details

According to ANEV, the cost of installed wind turbines is at substantially the same level as it was in 2007. The average installed plant cost of a medium-sized wind farm (30 MW) at a site of medium complexity, with 15 km of paths/roads and 12 km of electric line for connection to the high-voltage grid, is approximately 1,800 €/kW. This cost is generally subdivided as follows:

- Turbines, installation, and commissioning, 1,270 €/kW: 70.6%
- Development, namely site qualification, design, administrative procedures, etc., 236 €/kW: 13.1%
- Interest on loans, 196 €/kW: 10.9%
- Connection to the grid, 73.8 €/kW: 4.1%
- Civil engineering work, 23.4 €/kW: 1.3%
- Annual cost of operation and maintenance has been estimated to be about 54 €/kW, which includes leasing of terrain, insurance, and guarantee
- Decommissioning cost has been estimated at approximately 5 €/kW.

The income of wind plant owners is currently derived from two sources:

- Income accrues from the electricity price obtained by selling the energy produced. Energy may be sold on the free wholesale market or directly to GSE through a special contract by which the whole production is purchased at prices set in accordance with those of the free market. Most wind plant owners choose the latter option.

In 2008, the purchase price was extremely variable depending on many factors; on average it could be put at approximately 90 €/MWh.

- Plant owners derive income from the price obtained from the sale of the TGCs assigned by GSE to electrical energy produced from RES. This price, too, was very variable in 2008; average value was estimated at about 75 €/MWh.

It is also worth recalling, for the sake of completeness, that a decreasing number of wind plants have still been entitled to sell energy to GSE at the premium feed-in tariffs granted by the old scheme (CIP Provision No. 6 of 29 April 1992). In 2008, the maximum CIP 6/92 tariff for wind plants was 151.8 €/MWh (preliminary price).

4.0 National Incentive Programs

As the old CIP 6/92 system based on feed-in tariffs gradually expires (incentives were granted for the first eight years of plant operation), more and more wind plants are benefiting from the current RES support schemes.

The main scheme (and the only one currently available to wind plants above 200 kW) is based on a RES quota obligation and the issuing of TGCs. Producers or importers of electricity generated from non-renewable sources must feed into the Italian grid a mandatory quota of RES electricity calculated as a percentage of the electricity produced from conventional sources in the previous year. At the beginning this percentage was 2%; in 2008, it rose to 3.8%. Operators subject to the RES requirement have to prove compliance by returning to GSE, after the end of the year, a corresponding number of TGCs. These can either come from one's own RES plants or be bought from other RES electricity producers. GSE grants TGCs to certified RES plants that began operating after 1 April 1999 (the so-called IAFR plants) for the first 12 years of operation (this term has

now become 15 years for plants that began operations on or after 1 January 2008). TGCs are valid for three years.

TGCs can also be bought from GSE at a price that is fixed every year in accordance with a given procedure. Unlike in previous years when GSE's TGCs were needed to meet demand, from 2006 onward the whole TGC demand has been covered by IAFR producers, mainly with hydro, wind, and geothermal plants. The ensuing competition pulled the TGC trading price well below that of GSE's TGCs, reportedly around 70–80 €/MWh in 2008 trading. These poor price conditions have been blamed on factors including that the RES obligation percentage rose at too slow a rate, which did not allow TGC demand to grow enough.

The rules of the RES quota/TGC scheme have recently been reshaped somewhat by the so-called 2008 Financial Law (Law 244 of 24 December 2007). It took quite some time for the RES provisions of this law to become effective as they required a further Ministerial Decree, which was issued only on 18 December 2008. However, the main changes brought in by these new provisions can be summarized as follows:

- The yearly increase of the mandatory quota of RES electricity has been raised from 0.35 to 0.75 percentage points in the period 2007–2012.
- The size of all TGCs has been reduced to 1 MWh.
- RES plants that have come online after 1 January 2008 will get TGCs for a period of 15 years (instead of 12 as older plants), in a number equal to the number of produced megawatt-hours multiplied by a coefficient. The coefficient is specific for each technology (e.g., 1 for onshore wind, 1.1 for offshore wind).
- From 2008 on, the price of TGCs bought from GSE will be calculated as the difference between 180 €/MWh and the annual average market price of electricity. (For example, the

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calculated price for 2008 was 112.88 €/MWh.)

- The reference values and coefficients may be updated every three years.
- Until Italy has reached its RES electricity target according to Directive 2001/77/EC, GSE must buy all unsold TGCs before their expiration date (three years from issue) at a price equal to the average TGC price of the previous year.

Another important feature is that these laws also set up or restructured other incentives available to RES plants of up to 1 MW capacity. Specifically, RES plant owners can choose a fixed comprehensive incentive price for the energy fed into the grid as an alternative to electricity market price plus TGCs. This option has been allowed for RES plants up to 1 MW, but it excludes solar plants (photovoltaics actually has its own special legislation and feed-in tariffs) and wind plants above 200 kW. The comprehensive price is available for 15 years to plants that have come into operation after 31 December 2007. For wind plants up to 200 kW capacity, it is currently 300 €/MWh.

Additional new provisions give RES plant owners the option to choose, as a trading mechanism, the on-the-spot exchange of their production with the energy they draw from the grid as customers. This possibility has now been extended to all RES plants up to 200 kW, provided they came into operation after 31 December 2007. (Formerly, this limit was 20 kW.) Both of these provisions, could well open new prospects for the deployment of small-sized wind turbines or plants with a single turbine up to an overall capacity of 200 kW.

5.0 R, D&D Activities

Since the introduction of a feed-in tariff for wind turbines up to 200 kW, several manufacturers of wind turbines up to 20 kW have begun scaling up projects. To date, however, only one of them, Terom Wind Energy, has developed a 55-kW turbine for

low-wind site applications. Blu Mini Power, through a venture with the French company Vergnet, is entering the Italian market with a 200-kW Vergnet turbine in addition to its own smaller turbines.

In addition to universities that have been working on wind energy for a long time (e.g., Genoa, Bologna, Trento, and the Polytechnic of Milan), other universities are now conducting R&D activities: offshore wind power (Catania), towers (Florence and Padua), and small turbines (Naples).

Among R&D activities of note are those carried out by the Aerospace Engineering Department of the Polytechnic of Milan. They are mainly focused on:

- Advanced control laws for wind turbines, namely development of control laws for variable-speed wind turbines for reducing fatigue damage and for gust load alleviation. Particular emphasis is placed on laws that include individual blade pitch control, account for aeroelastic effects (tower and blade flexibility), and can react to changes in the operating conditions (change in wind shear, presence of vertical and lateral wind components, operation in the wake of another turbine, and so on).
- Research activity has also led to the development of several supporting technologies, including monitoring of the wind turbine structural flexible states from strain gauges and accelerometers, and measurement of the spatial distribution of the wind over the rotor disk. The control laws are being tested both in the field on a megawatt-class wind turbine and in a high-fidelity simulation environment based on the multi-body finite-element aero-servo-elastic code named Cp-Lambda (Code for Performance, Loads, Aeroelasticity by Multi-Body Dynamics Analysis).
- In (WT)² (Wind Turbine in a Wind Tunnel project), aeroelastic wind tunnel models of a multi-megawatt wind turbine are designed for testing in the

large wind tunnel facility of the Polytechnic of Milan. Scope of the models is the development, verification, and comparison of control laws for wind turbines, as well as the testing of extreme operating conditions.

- Software for wind turbine design and optimization is being developed. This project aims at developing automated procedures for supporting all phases of the design process, including aero-servo-elastic analysis using the multi-body finite-element code Cp-Lambda, transfer of loads from aeroelastic simulations to detailed FEM models of sub-components for fatigue and ultimate analysis, and multi-objective optimization of the machine. The optimization procedures use the simulation capabilities provided by the Cp-Lambda code for performing: (a) aerodynamic optimization of the rotor (e.g., twist and chord distribution for maximum annual energy production (AEP), with noise constraints and maximum chord constraints); (b) structural optimization of the blades (e.g., minimum weight configuration for given design load cases [IEC-61400 DLCs], placement of frequencies, stress/strain allowables, and so on); and (c) combined aerodynamic-structural optimization (e.g., for maximum AEP over weight).

The University of Genoa is conducting several activities on wind assessment, including the development of new models. One of them has recently been developed to study the intermittent character of wind energy and its consequences for electrical power systems. Since wind energy is stochastic, a possible way to mitigate undesired fluctuations of energy output in the electrical system could be to identify the optimal allocation of wind power plants over an extended territory. This would allow lower temporal variability of the aggregate wind power output and, therefore, also guarantee a significant contribution to base load power supply. To date, this model has been

applied to the case of optimal allocation of wind plants over the island of Corsica. The model is based on the identification of anemological regions and wind regimes over the territory and on the calculation of the optimal spatial distribution of wind power plants under given requirements of minimal variability of overall wind energy input (i.e., the aggregate contribution of all anemological regions to the power supply system). By means of this optimization, wind energy fluctuation in the power supply system of Corsica has been reduced by about 58%, with an energy production loss of 23%.

CESI RICERCA has been working on wind power within the framework of its research program carried out under contract to the Italian government in the interest of Italy's electricity system. After completing its new Wind Atlas of Italy, CESI RICERCA is concentrating on better assessing Italy's offshore wind potential, taking into account all factors on which exploitation of this potential could depend (windiness, technology, costs, etc.). Since the most plentiful resources are found in waters too deep for the current offshore wind technology, CESI RICERCA has taken an interest in the feasibility of building plants on floating foundations. Consultants assist on more specific marine issues. The effort begins with a preliminary review of different concepts of floating platforms and their moorings. Next, a computational model analyzed, under normal and extreme wind and wave conditions, the dynamic behavior and stresses of a system comprising a large wind turbine mounted on floating structures of various types.

CESI RICERCA is also looking into the practical aspects of construction, installation, and operation of floating wind turbines, taking into account technical behavior and costs over the whole operating lifetime. A specific structure configuration has been selected and examined, and loads and stresses have been calculated both in normal operation and in other critical phases, including transportation and

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installation on site. At the same time, the costs of this structure have been estimated to get an idea of the overall investment and maintenance costs of a wind farm with floating wind turbines versus its expected energy performance.

CESI RICERCA has also undertaken to supplement the Wind Atlas of Italy with a full Atlas of Environmental Compatibility. This work provides, as far as possible, information about protected or restricted areas and other environmental constraints that could hamper the setting up of wind farms. CESI RICERCA has also developed a software application to simulate wind farms for preliminary assessment of their visual impact on a given area.

Wind-measuring masts have been set up, both offshore (on a very small island in the Adriatic Sea) and in Tuscany, to fine-tune the Wind Atlas in some areas of Italy.

6.0 The Next Term

In 2009 the growth of wind capacity is expected to be similar to that seen in 2008. Accompanying increasing industrial activity is expected and consequently the creation of new job opportunities. This forecast is confirmed by the civil engineering work in progress in several regions for setting up many more hundreds of megawatts and by

the Ministerial Decree of 18 December 2008 on incentives for electricity production from RES (implementing the 2008 Financial Law). Among other measures, the decree establishes a feed-in tariff for small wind turbines and helps to support the commercial value of TGCs.

Further development of R&D work can also be expected. Within the framework of Industry 2015, a new industrial policy law issued by the Italian government in 2006 and later implemented by the 2007 Financial Law, a call was published in 2008 by the Ministry of Economic Development to grant funds to R&D programs aimed at industrial innovation for energy efficiency. The announcement raised very strong interest, and many applications were submitted. Three wind power projects were approved: offshore floating wind plants, development of a large wind turbine prototype, and a system having a very small vertical-axis wind turbine and a PV device. The total eligible cost of these projects is some 50 million €, of which about 20 million € should be granted by the Ministry of Economic Development.

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1.0 Introduction

At the end of 2008, the total wind power capacity in Japan was 1,880 MW (1,508 turbines) with 342 MW of annual net increase. The national target is to reach 3,000 MW by 2010, so good progress toward the goal has been made (Table 1). However, the increase in wind power capacity each year has turned from an exponential curve to a linear curve. Therefore, the attainability of the national target is still under question. Some reasons for the deceleration in growth include legal reform of the Japanese Building Code in April 2007, the establishment of an extreme wind map as a guideline limiting development in some areas, and severe climactic events like typhoon and lightning strikes. Additionally, more than a few projects have been delayed or cancelled due to high-level requirements in getting legal permission and finding possible sites.

Another significant issue is grid connection. Compared with EU countries, Japan is very isolated, and so the influence of wind generation on grid stability is considered to be very large regardless of how small the penetration ratio is. Therefore, the electric power companies tend to limit new wind farm projects and often choose the small numbers of them allowed by random selection.

Moving to offshore installations has not yet begun due to deep-water conditions, however a national investigation was initiated in 2008.

2.0 Progress Toward National Objectives

2.1 Strategy

At the UN Climate Change Conference in Kyoto in December 1997, the Japanese government agreed to reduce the output of greenhouse gases by 6% (compared with the 1990 level) by 2010 (in the period 2008-12). To attain this target, the government decided to increase “new energy” (a term similar to renewable energy) to 3% of the primary energy supply by 2010 as outlined in the Primary Energy Supply Plan. Wind power generation contributes 7% of this new energy, which made the target for wind power 3,000 MW, or 2.1% of the primary energy supply by 2010.

In April 2003, the Japanese government passed legislation for a Renewables Portfolio Standard (RPS) in order to realize the national target for renewables by 2010. Under the original RPS, Japan’s utilities were obligated to use 12.2 TWh (1.35% of total electricity supply) from renewable sources by 2010. RPS targets are reviewed every four years. The new RPS target established in 2007 is 16.0 TWh (equivalent to 1.63% of total electricity supply) by 2014. During fiscal year 2008, wind plants supplied 2.856 TWh, which is one third of the total supply generated from renewable sources.

Table 1 Key Statistics 2008: Japan

Total installed wind generation	1,880 MW ¹
New wind generation installed	342 MW ²
Total electrical output from wind	2.856 TWh/yr ³
Wind generation as % of national electric demand	0.313% ⁴
Target:	3,000 MW by 2010 ⁵

1. Statistics at the end of December 2008, based on grid-connected wind plants; 2. New capacity (346 MW) minus decommissioned capacity (4 MW); 3. Estimated based on home page data, Japanese Renewables Portfolio Standard System, METI; 4. Electric power demand in 2008 was 913.2 TWh (Data: home page of the Federation of Electric Power Companies of Japan); 5. In the period of 2008-2012.

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However, judging from the 2008 year-end installation, it will be difficult to achieve the national wind target.

To counteract natural and social obstacles to wind power development, the government has been running the following investigations or research programs:

- Wind Energy Business Support Program
- R&D of Advanced Wind Energy Technology
- Investigation on Offshore Wind Technology
- Field Test Programme
- Demonstration of Grid Stabilization
- Demonstration of Battery-Backup Wind Farms
- Subsidies for Grid-Connected Systems
- Wind Technology Standards (Japanese Industrial Standards (JIS)/International Electrotechnical Commission (IEC))

2.2 Installed capacity

Japan's cumulative wind power capacity was 1,538 MW with 1,331 units at the end of December 2007, and 1,880 MW with 1,508 units at the end December 2008. The annual net increase was 342 MW (increase

ratio: 22.3%). Figure 1 shows the history of wind power development in Japan. Note that the period of statistics was changed from previous fiscal year to calendar year. Wind power generation in 2008 was 2.856 TWh and accounted for 0.313% of the national energy demand.

2.3 Rates and trends in deployment-

Most commercial wind farms have been developed with governmental promotional subsidy programs, which quickly accelerated developments. Figure 2 shows the history of annual increases in wind power capacity in percentages. The average increase rate in the past 17 years is 63%. The five-year average increases are 46.8% (1994-1998), 83.9% (1999-2003), and 26.7% (2004-2008). Looking at Figure 2 together with Figure 1, wind power development is apparently slowing down and the tendency of wind power development has turned from an exponential function to a linear function.

3.0 Benefits to National Economy

The wind turbine industry in Japan has been growing in recent years. Not only traditional Mitsubishi, but also several other manufacturers like Japan Steel Works, Ltd.

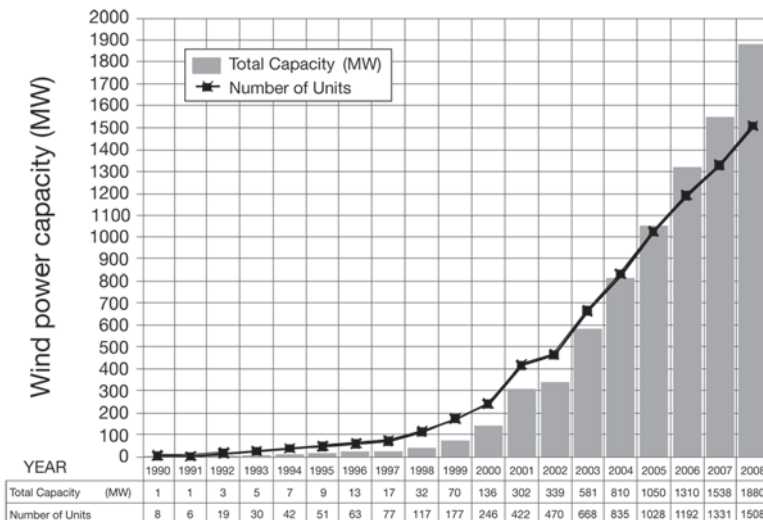


Figure 1 History of wind power development in Japan.

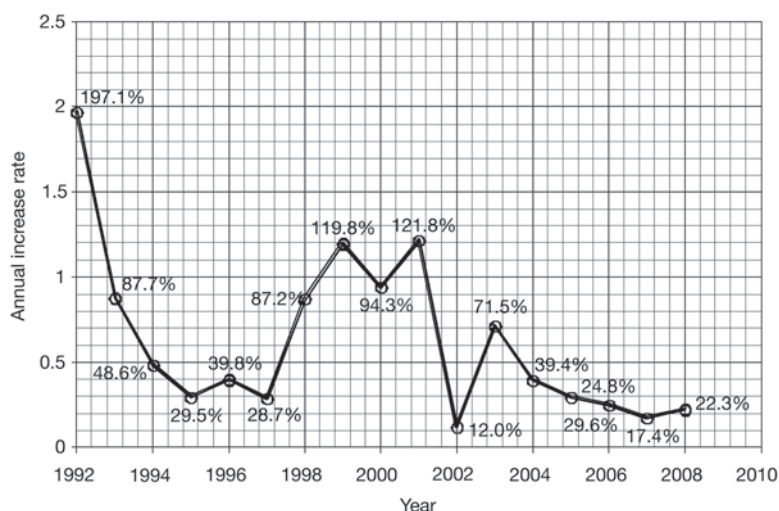


Figure 2 History of annual increase rate of wind power capacity (percent).

and Fuji Heavy Industries, Ltd. have started mass production of 2-MW-class wind turbines. Several bearing companies such as NTN, Ltd., JEKT Co., and NSK, Ltd., are also expanding their factories. Many electric companies like Hitachi, Ltd., Meidensha Co., and Fuji Electric Holdings (a) are exporting power devices corresponding for large numbers of orders from wind turbine manufactures around the world. The growth of the wind turbine industry brings so-called “green money” and “green jobs” for Japan. The production of wind turbines and their components has reached around 300 billion JPY/yr, according to data collected by the New Energy Foundation. More than 1,000 people are working directly in wind turbine mass production, and it is estimated that 4,000 to 15,000 jobs have been created among parts and devices companies.

3.1 Market characteristics

The wind power market in Japan has rapidly progressed in the past 15 years. As a result, large wind farms have been developed as shown in Figure 3. The largest wind plant was built in December 2008 in Izumo City in Shimane Prefecture. It has a total capacity of 78 MW from 26 3-MW Vestas turbines. Its operation is planned to

start in June 2009. Today there are five wind farms that exceed 50 MW. Many entities are developing wind power: citizen groups, NPOs, third-party sectors, local governments, and big private companies. Most of the large wind farms are owned by big wind energy developers.

Japan has four wind turbine manufacturers; Mitsubishi Heavy Industries, Ltd. (MHI, 2.4-MW), Fuji Heavy Industry, Ltd. (FHI, 2-MW), Japan Steel Works, Ltd. (JSW) (2-MW), and Komai Tekko Inc. (300-kW). However, foreign manufacturers such as Vestas, GE Energy, and Enercon dominate the Japanese market. Approximately 83% (by capacity) of wind turbines were supplied by foreign turbine manufacturers. As shown in Figure 4, the top supplier is Vestas (21.7%), following GE Energy (19.5%), Mitsubishi (16.4%), and Enercon (9.1%).

Nagashima Wind Hill, the third largest wind farm in Japan, began operation in June 2008 with 21 MHI 2.4-MW turbines.

Wind power capacity has increased very quickly in the past ten years; however, the sector has experienced a slowdown recently as detailed above. The four major reasons for this slowdown are natural external conditions, the legal system, grid systems, and

National Activities

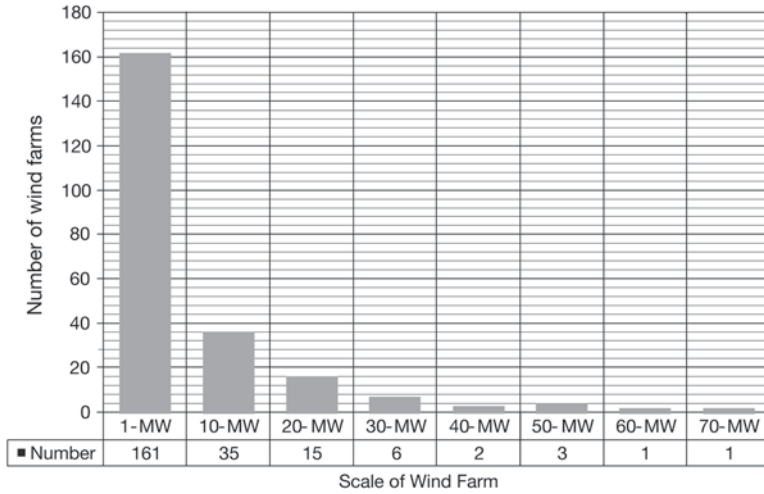


Figure 3 Scale distribution of wind farms larger than 10 MW.

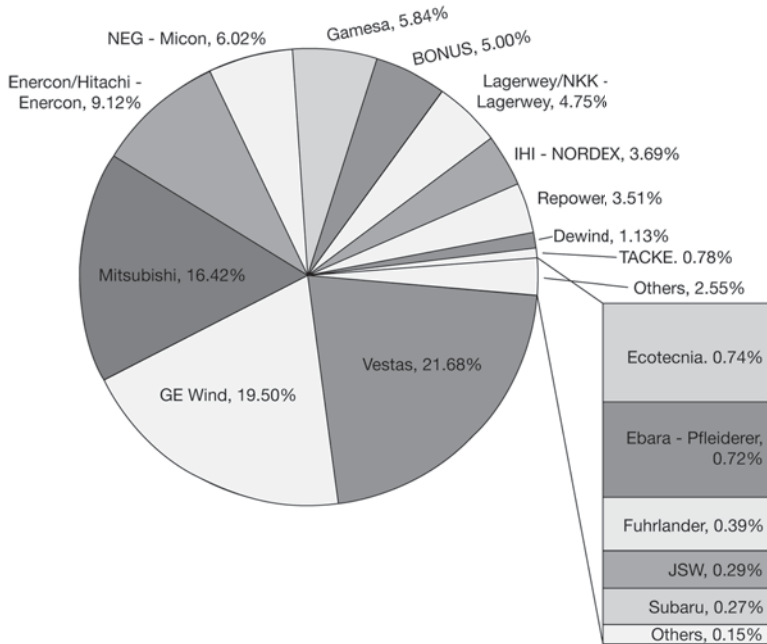


Figure 4 Share of the wind turbine manufacturers in capacity.

economics. The Japanese market is deeply influenced by external conditions, both natural and grid-related. Extreme wind conditions such as tropical storms and typhoons, high turbulence due to complex terrain, and heavy lightning storms are the most important technical issues. Isolated from

foreign countries by ocean, grid connection and stability is another severe barrier to wind power development.

The country has a history of typhoons that blow down turbines in the summer. Lightning strikes in winter and summer, strong gusts, and high turbulence in

complex terrains are also technical hazards. These challenges define the external conditions in Japan. Therefore in 2008, the New Energy and Industrial Technology Development Organization (NEDO) developed a safety guideline designed for Japanese meteorological and geographical conditions in order to provide technical measures against typhoons and lightning strikes and to help future wind turbine developments. As a result, some promising sites have to be carefully evaluated for safer development.

A new legal requirement has also limited development. According to the new Japanese Building Code, which became effective in June 2007, wind turbines over 60 m high shall be considered as a kind of building, and its height is defined as the top height of a blade from ground level. Under this revised code, the installation of wind turbines requires the minister's sanction. The application procedure for planning permission is very complicated, time consuming, and expensive. The first project authorized under the new code was in July 2008, which means absolutely no new projects started between June 2007 and July 2008. However, the permission process is rather standardized now and many projects are being authorized.

The grid system in Japan has also prevented new wind farm developments in order to keep the stability and security of electricity supply. Geographically, the leading regions for wind power development are Tohoku and Hokkaido in the north of the country and Kyushu in the south. Unfortunately, the greatest electricity demands are concentrated in the center of Japan such as Tokyo, Osaka, and Nagoya, while most of the potential wind power sites are located in remote areas where grid capacity is relatively small. Additionally, as a social system, this regional monopolistic grid system with very limited grid access forms a social barrier against challenging wind farm developments.

Another reason for the slowdown of wind turbine installations is the relatively high price of wind turbines due to the

depreciation of Japanese Yen against the Euro and the U.S. dollar. This has a significant impact on Japanese wind power capacity because more than 80% of new wind turbine installations were imported. This impact seems to be decreasing, however, because the price of wind turbines started decreasing due to appreciation of Japanese Yen against the Euro and the U.S. dollar from the latter half of 2008. Because of this, a number of developers have started trying to reopen projects that had been shelved. However, new installations in 2009 are not expected to be high due to long the lead-time for delivery of wind turbines.

3.2 Industrial development and operational experience

Several wind turbine manufacturers produce turbines in Japan. The main commercial turbines are listed in Table 2. These manufacturers have developed new turbines that are more suitable for Japanese external conditions, such as higher tolerances for 50-year extreme gusts (above 70 m/s).

A small but very stable wind farm development has been created by the local town government of Tomamae. It has developed a small wind farm since December 1998. The wind power plant consists of two 600-kW turbines and one 1,000-kW turbine. Nine years of operational data is available on the town's home page. Figure 8 shows monthly capacity factors vs. monthly mean average wind speeds with bin-averaged data plotted with black squares and a fitting curve. Tomamae, located in Hokkaido, has good winds and is one of the biggest wind farm regions in Japan (Figure 5). This steady effort to record and report the wind farm's operational data has encouraged many developers. From Figure 6, we may expect capacity factors above 30% if the mean wind speed is 7 m/s or 40% if 8 m/s.

3.3 Economic details

In general, the cost of a wind power plant in Japan is higher than in EU countries where wider grid systems are well

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Table 2 Main commercial wind turbines		
Manufacturer	Wind turbine	Technical characteristics P=Power; D=Rotor Diameter
Mitsubishi Heavy Industries, Ltd. (MHI)	MWT92/2.4	P=2.4 MW, D=92 m, 3 bladed, Upwind, Smart-Yaw control
	MWT-1000A	P=1.0 MW, D=61.4 m, 3 bladed, Upwind, SmartYaw control
Fuji Heavy Industries Ltd. (FHI)	SUBARU 80/2.0	P=2 MW, D=80 m, 3 bladed, Downwind
The Japan Steel Works, Ltd. (JSW)	J70/J82	P=2 MW, D=70.65/82.6 m, 3 bladed, Upwind
Komai Tekko Inc.	KWT300	P=300 kW, D=33 m, 3 bladed, Upwind Iref=20 %
Zephyr Corporation	Airdolphin	P=1 kW, D=1.8 m, 3 blades, Upwind Cut-in/Cut-out wind speed=2.5/50 m/s, Full carbon fiber blade

developed. In Japan, there are additional costs because of requirements for grid connection and stability including battery back-up plants.

A couple of years before 2007, it was reported at a national committee that the average cost of energy (COE) for a 25-MW wind farm was 10.2 JPY/kWh with subsidy. Generally COE was from 9.0 to 11.0 JPY/kWh for medium-sized wind turbines (unit capacities between 500 kW and 1,000 kW). For large-scale wind farms comprised of wind turbines with capacities of more than 1,000 kW, COE was in the range of 7.0 to 9.0 JPY/kWh.

The average wind turbine cost was

approximately 100,000 JPY/kW and the average initial cost was estimated at 190,000 JPY/kW in 2003. However, wind turbine costs increased approximately 80% in 2007. About 50% of this increase was caused by a worldwide trend and 30% was due to the currency exchange rate between the Euro, the U.S. Dollar, and the Yen. The impact was significant as more than 80% of wind turbines have been imported from Europe and the United States. As of mid-2008, the average initial plant costs were around 300,000 JPY/kW and the electricity purchase price was 10.4 JPY/kWh. The COE for 2008 is quite difficult to determine due to the social and natural obstacles described



Figure 5 A view of Tomamae wind farm region.

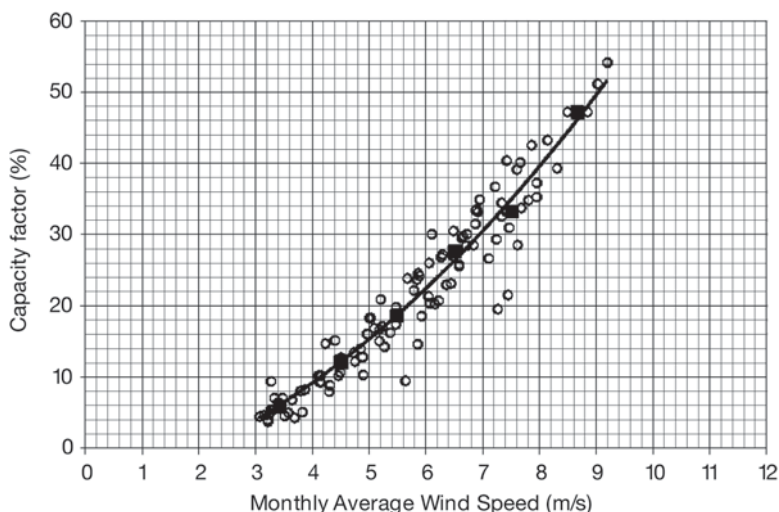


Figure 6 Operational data of Tomamae Yuhigaoka wind farm owned by the town of Tomamae.

in Section 3.1 as well as the global economic crisis.

4.0 National Incentive Programs

In fiscal year 2002, national wind energy R, D&D programs were closed and the main stream of governmental incentive programs on wind energy were switched to subsidies for wind plant developments and investigations on grid issues. However, the grid issues and external conditions such as extreme wind, high wind gusts, and lightning were found to be still technically important and investigations and demonstrations on these issues have been conducted for the past several years. NEDO reported J-Class (for Japanese conditions) Wind Turbine Guidelines in 2008 for the purpose of technical safety of wind turbines installed in Japan. An investigation program on offshore wind started as well.

The governmental incentive programs under the Ministry of Economy, Trade, and Industry (METI) are summarized in Table 3 with their time periods and budgets in fiscal year 2008. The total budget was 26,483 million JPY, which is 94.3% of the budget in fiscal year 2007. The main support and market stimulation incentives are subsidies

for Wind Project Support (Wind Business Support) and Subsidy Support for Grid Measures. The latter is a special incentive to encourage faster wind developments by solving the grid battery back-up system barrier.

5.0 National R, D&D efforts

Concerning wind technology R, D&D, three programs are running. It is also worth special mention that the basic research programs were revived, although the focuses are still in the field of applied technology.

5.1 Applied technology research

Advanced Wind Technology is a comprehensive program which includes both basic and applied research. Two key areas are remote sensing for advanced wind measurements and lightning measurements and J-class wind models for development of future safety standards. The projects aim to keep international co-operation with IEA Wind R, D&D and IEC standards.

Under the Offshore Wind Technology Project, several candidates for offshore wind sites were selected to start feasibility studies and project designs. Based on the feasibility studies; wind, wave, and soil measurements;

Table 3 Japanese National Incentive Programs. Data courtesy of METI and NEDO.

Programme	Category	Organization	Year									
			2006	2007	2008	2009	2010	2011	2012	2013		
New Energy Development Support (for wind))	Subsidy	METI			20,450							
Advanced Wind Technology	R,D&D	NEDO/METI			210							
Offshore Technology	R,D&D	NEDO/METI			200							
Field Test Programme	R&D	NEDO/METI			60							
Grid Stabilization	D&D	NEDO/METI			185							
Battery-Backup Technology	D&D	NEDO/METI			2,400							
Support for Grid Connection for Battery Back-up Plant	Subsidy	NEDO/METI			2,960							
IEA R&D WIND	R,D&D	NEDO/AIST			(Part of Advanced Wind Technology)							
Standardization (JIS, IEC)	Standard	NEDO/JEMA			18							
TOTAL					26,483							Million Japanese Yen (MJY)

and offshore wind performance predictions, detailed designs will be conducted in 2009.

Field Test Programme is a co-operative research project with NEDO that will take high-altitude wind measurements at several promising sites in order to develop useful wind databases.

Concerning demonstrations on grid issues, the Grid Stabilization Programme and Battery Back-up Demonstration Project were closed in 2008. One of the main technical targets of the Grid Stabilization Programme was to investigate the performance of wind generation prediction techniques using CFD (Computational Fluid Dynamics) models. Its availability was well appreciated but it has not been introduced as a common and powerful tool to help solve the grid issues. The Battery Back-up Demonstration Project contributed technical experience, and its database will contribute to future wind development with higher penetration.

Standardization of wind turbine technology is very important for reliability and safety since Japan has some very severe external conditions onshore as well as

offshore. Therefore, activities of the IEC and JIS are conducted by METI, NEDO, Japan Electrical Manufacturer's Association (JEMA), and the National Institute of Advanced Industrial Science and Technology (AIST).

5.2 Collaborative research

Since 1978, Japan has been the member of IEA Wind. In 2008, AIST expanded Japan's involvement in collaborative research through participation in IEA Wind Research Tasks. Since 1988, Japan has been involved in IEC activities aimed at establishing international standards for wind turbine technology. The Japanese Wind Energy Association (JWEA) and the Japanese Wind Power Association (JWPA), have been co-operating as a member of the Global Wind Energy Council (GWEC) since March 2005.

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National Activities

1.0 Introduction

In 2008, the first 750-kW turbine commercially produced by Unison was purchased by a Korean utility company (Figure 1), while the prototypes of both Unison's and Hyosung's 2-MW turbines were installed for type testing. Doosan's 3-MW turbine for offshore was still under development in 2008 and is scheduled for field testing in 2009. So far, progress in the Korean wind market remains a little behind schedule. At the end of 2008, the cumulative installed capacity was 236 MW (Table 1). The new installation of 43 MW, indicates the current difficulty caused by the increased price of imported wind turbines (due to currency exchange rate based on global economic crisis) and existing barriers of limited onshore sites and public acceptance issues (Figure 2).

In 2008, the Korean government set the Third National Basic Plan for New and Renewable Energy R&D and Deployment (Third Basic Plan for NRE). This is a revision of the Second National Basic Plan for NRE announced in 2003. According to the Third Basic Plan for NRE, the total installed capacity of wind turbines will be more than 7 GW in 2030. The data used in the following tables and this report are provided by the New and Renewable Energy Center under the Korea Energy Management Corporation (KEMCO).

2.0 Progress Toward National Objectives

At the end of 2008, 150 wind turbines were operating in Korea. According to the target in the Second Basic Plan for NRE,

an additional 2 GW of wind energy capacity is needed from 2009 to 2012 to reach the target. To achieve the goals of the plan, the Korean government set the Third Basic Plan for NRE. On 27 August 2008, the Third National Energy Basic Plan for Green Growth officially introduced green growth as "new national development paradigm" that creates new growth engines and jobs. Because Korea is the tenth largest energy consumer in the world, the economic feasibility of green energy has increased due to the high price of oil. The domestic market also has a good potential for greenhouse gas reduction. According to the new plan the capacity target for wind energy will be 4,336 MW by 2015 and 7,301 MW by 2030.

3.0 Benefits to National Economy

3.1 Market characteristics

The Third Basic Plan for NRE states that for primary energy consumption, the share of new and renewable energy will be 4.33% in 2015 and 11% in 2030. For the electricity supply target, wind generation is expected to provide the largest contribution (up to 42% or 16.6 TWh) of the total generation of 39.5 TWh by new and renewable sources in 2030. To achieve this goal, the government is providing attractive incentive programs such as the 15-year guaranteed feed-in tariff, tax incentives, and subsidies for the local wind market. Encouraged by strong government support of R&D

Table 1 Key Statistics 2008: Korea

Total installed wind generation	236 MW*
New wind generation installed	43 MW*
Total electrical output from wind	.421 TWh*
Wind generation as % of national electric demand	0.1%*
Target:	7,301 MW by 2030
* tentative	



Figure 1 Unison's first commercial product of 750-kW direct drive, U50, has been installed in Korea Hydro & Nuclear Power Co., Ltd.

programs, several big companies have been participating in wind turbine development projects, including local production of components. In 2007, as a result of government support in previous years, 750-kW and 1.5-MW wind turbines were successfully tested and certified by GL and DEWI Offshore and Certification Centre GmbH, respectively. In 2008, two different 2-MW wind

turbines were installed and will remain under field testing until mid-2009.

The Korean wind farm business has been slow so far for several reasons, including the complex system for approval of developments caused by conflict among existing laws, public acceptance issues, and difficulty getting permits for grid connection. Also, onshore sites are limited because of mountainous terrain.

The onshore wind map feasibility study performed by the Korea Institute of Energy Research (KIER) estimates the potential for wind farm development at up to 7.8 GW. In addition to this onshore possibility, the government is supporting an offshore wind map study that indicates an additional expansion potential of about 18 GW, reflecting the advantage of being a peninsula country. However, offshore wind construction might be challenging due to deep-sea foundation issues, concerns over coastal fishery rights, military radar issues, and environmental issues.

3.2 Industrial development and operational experience

The Korean wind industry is growing rapidly, especially in the development of wind turbines and components, while most installations related to wind farm development still depend on imports. Even though existing wind farms have been gaining experience in operation and maintenance, the repair or exchange of parts is still in the hands of foreign manufacturers. For this reason, several imported wind turbines had to be shut down for long periods due to delays in the delivery of re-imported parts. This kind of problem is one reason why local manufacturers and developers are accelerating their efforts to build up

Year	~2001	2002	2003	2004	2005	2006	2007	2008	Total
Capacity (MW)	7.9	4.7	5.4	50	30	77	18	43	236
Electrical Output (GWh)	32	15	21	48	130	239	399	421	1305



Figure 2 Taegi mountain's 40-MW wind part using VESTAS V80 turbines.

in-house technical expertise and supply the local market.

In 2008, three new big players—Hyundai Heavy Industries, Samsung Heavy Industries, and Hyundai-Rotem—entered the wind turbine manufacturing market in Korea with megawatt-scale wind turbines. In addition to the existing turbine manufacturers market initially formed by companies such as Unison, Hanjin, Doo-san Heavy Industries, and Hyosung Heavy Industries, all major shipbuilding heavy industries are finally ready to begin manufacture of wind turbines. Future business competition among these major heavy industries might open a new era accelerating technology development and the national wind industry as a core growth engine of green energy. The industrial value chain or supply chain had been formed with the existing infrastructure of utility companies, major shipbuilding heavy industries, and their components subcontractors. Taewong, Pyongsan metal, and Hyunjin Materials hold the biggest share of the world market for hot forging metal parts such as main shafts, tower flanges, and bearing rings. They are exporting major wind turbine components to Vestas, Enercon, Gamesa, GE Wind, and others. About half of the world's market for wind turbine towers is also covered by the Korean companies Unison and Dongkuk S&C.

4.0 National Incentive Programs

According to the Third Basic Plan for NRE, except for energy from wastes and biomass, wind energy will supply the biggest portion (12.6%) of the final target for new and renewable sources in 2030. To

achieve this goal, the feed-in tariff is an important element of the government's incentive policies. Wind generation is eligible for a 15-year feed-in tariff of 107.29 Won/kWh, which is scheduled to be reduced by 2% every year after October 2009. According to this plan, however, the Renewable Portfolio Standard is scheduled to take effect in 2012, and it will be the one of the most important policies.

For demonstration projects or stand-alone small wind installations of less than 50 kW, the government provides subsidies up to 70% to 80%. The government also provides subsidies to local governments of up to 60% for the installation of a new and renewable facility. This subsidy allows one-tenth of the installation cost to be deducted from income or corporation tax for the year. Also, an import tariff rate reduction is applied for stand-alone or grid-connected wind generators and blades. The government also compensates any loss by commercial banks up to a certain portion when long-term project financing to renewable energy construction is offered at lower than commercial rates. A single renewable construction facility can make a proposal to KEMCO for a maximum of 10 billion Won that is payable over ten years following an initial five-year grace period.

5.0 R, D&D Activities

Support of wind power is one way the Korean government can cost-effectively concentrate the R, D&D investment among new and renewable sources. The government's annual budget for wind R, D&D in 2008, 56.8 billion Won, has been aimed at localizing the manufacture of megawatt-size wind turbine systems and their components.

National Activities

Recent government research has been carried out to develop 2-MW onshore and 3-MW offshore domestic turbine models. The research program is also running a 4-MW offshore wind farm demonstration project that will be completed in 2009.

The important results of government-sponsored projects during 2008 were the development of 2-MW direct-drive permanent-magnet-generator wind turbines, 5-MW offshore wind turbines, and a planning study for a 300-MW offshore demonstration wind farm to be completed by 2012. Hyundai-Rotem, the high-speed-train manufacturer, signed a development contract with the government for 2-MW direct-drive wind turbines in the next three years, while Hyosung Heavy Industries is developing a 5-MW offshore turbine. Korea Electric Power Corporation (KEPCO), the key national utility company, signed on as a primary investigator for planning the 300-MW offshore wind farm project. This significant government funding has helped reduce business risk at the initial stage and speed up technology development by domestic turbine manufacturers to cope with global competition. The national demonstration projects for both onshore and offshore offer a test-bed of those domestic developments.

6.0 The Next Term

During the next few years, the government is willing to support the installation

of domestically manufactured wind generators as demonstration projects. This support should help Korean manufacturers to install their turbines in several places. Government R, D&D support will also be focused on speeding up the domestic manufacture of turbine components like gearboxes, pitch and yaw systems, and bearings. According to the national R&D roadmap, long-term research soon will be initiated on smart-blade concepts for large-rotor-diameter turbines and offshore floating foundation structures for deep water. In addition, there are increased requests from the wind industry for education and training of experts and for international collaborative research. Offshore wind farm developers are looking forward to a new feed-in tariff for offshore, while onshore wind farm developers are trying to set up a new policy for direct connection to the existing grid instead of to the utility company's transformer stations.

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1.0 Introduction

During 2008, three new wind power plants were under construction. All three are to be commissioned in 2009. On 28 November 2008, the government of Mexico issued the Law for the Use of Renewable Energy and Financing of Energy Transition (Ley para el Aprovechamiento de Energías Renovables y el Financiamiento de la Transición Energética). The new law will pave the way for a significant deployment of wind power within the next years and decades.

In August 2008, the government of Mexico, by means of the Federal Electricity Commission (CFE), awarded a contract for 209 million USD for the construction of a 300-km electrical transmission line for wind energy projects. The new line will be rated at 2,000 MW and will be shared by several wind project developers that also will share proportionally a long-term payment obligation for the line. The transmission line will be commissioned by the end of 2010.

CFE issued a second call for bid to construct a 100-MW wind power plant within the independent power producer (IPP) modality (La Venta III) after a first call for bid was declared void. Results of the bidding process will be known by May 2009. CFE issued another call for bid to construct another 100-MW wind power plant, also within the IPP modality (Oaxaca I).

According to plans of several wind power developers that already have obtained permits granted by the Energy

Regulatory Commission, about 2.2 GW of wind power capacity will be installed within the next three years.

The new Law for Renewable Energy instructs the Ministry of Energy to prepare and co-ordinate a Special Program for the Use of Renewable Energy. The program is to include specific goals established as minimum percentages in capacity (MW) and energy (MWh) and the strategies and actions for achieving them. By the end of May 2009, the program will be presented for consideration and approval by the president of Mexico.

Mexico's largest wind energy resource is found in the Isthmus of Tehuantepec in the state of Oaxaca (Figure 1). Average annual wind speeds in this region range from 7 m/s to 10 m/s, measured at 30 m above the ground. Given the favorable characteristics of this region, particularly its topography, it is estimated that more than 2,000 MW of wind power could be commercially tapped there. In fact, during 2008, La Venta II, the 83.3-MW wind power plant owned by CFE, operated at a capacity factor of around 34%. This compares favorably with capacity factors of wind power plants located in the best inland sites in the world.

National consumption of electricity is expected to grow from 209.7 TWh in 2008 to 281.5 TWh in 2017, representing an increase of 71.8 TWh of electricity

Table 1 Key Statistics 2006: Mexico

Total installed wind generation	84.6 MW
New wind generation installed	0 MW
Total electrical output from wind	.254 TWh
Wind generation as % of national electric demand	0.12
Target:	2.2 GW by 2010 to 2012* 6% of electric generation by 2030**
* From official projections **Shared vision from 2005 workshop	

National Activities



Figure 1 Location of wind turbines installed in Mexico as of December 2008.

generation equivalent to about 14 GW of additional generating capacity. Of this, 3.5 GW are already under construction or planned, the majority using combined-cycle gas-turbine technology. The remaining 10.5 GW will come from new projects. An opportunity therefore exists for supplying a reasonable portion of the uncommitted 10.5 GW of new capacity using Mexico's wind energy resource.

2.0 Progress Toward National Objectives

The Law for the Use of Renewable Energy and Financing of Energy Transition is a sound signal from the government of Mexico regarding both political will and commitment for energy diversification toward sustainable development. The regulatory instrument for this law will be issued by mid-2009.

2.1 Strategy

The main elements of strategy that are already included in the new law for renewable energy are:

Strategic goals; Special Program on Renewable Energy; Creation of a green fund;

Access to the grid; Recognition of external costs; Recognition of capacity credit; Technical standards for interconnection; Infrastructure for electricity transmission; Environmental standards; Support for industrial development; and Support for research and development.

2.2 Progress

By the end of 2006, CFE commissioned Mexico's first significant-capacity wind power plant (La Venta II) (Figure 2). It is rated at 83.3 MW and has 98 850-kW wind turbines from the Spanish manufacturer Gamesa Eólica (Table 2). The plant is owned by CFE and was constructed under the modality of financed public work. This means that a private contractor is responsible for the financing and construction of the wind power plant, and CFE pays the contractor the total amount of the contract when the plant is commissioned. After that, CFE owns and operates the plant. La Venta II is becoming an important project within CFE to increase knowledge about how to merge wind power technology into the national electrical system, to gain confidence on operation and maintenance issues, to

assess direct and indirect benefits, and to learn about all those technical issues that are not very transparent in the commercial arena.

La Venta II was constructed in one of the windier sites in the Isthmus of Tehuantepec. It is expected to operate at annual capacity factors above 40%. The estimated investment cost of this plant was 1,370 USD per installed kilowatt, not including the cost of the transmission line. The contract for construction was awarded to the Spanish consortium Iberdrola-Gamesa.

In mid-2007, Parques Ecológicos de México S.A., an association led by the

Spanish company Iberdrola, began construction of the first privately owned wind power plant for self-supply purposes. Rated at 79 MW, the plant is being built with 93 850-kW wind turbines from the Spanish manufacturer Gamesa Eólica. By the end of 2008, most of the wind turbines had already been installed; the plant is scheduled to be commissioned in February 2009 (Figure 3).

In mid-2008, Bii Nee Stipa S.A., an association led by the Spanish company Gamesa Energía, began construction of the second privately owned wind power plant for self-supply purposes. Rated at 22.9 MW, the plant is being built with 26 850-kW

Table 2 Wind Turbine Installations in Mexico at the End of 2008					
Location	Manufacturer	Wind turbines	Capacity (MW)	Commissioning date	Owner
La Venta, Oaxaca	Vestas	6 x 225 kW	1.35	1994	CFE
Guerrero Negro, Baja California Sur	Gamesa Eólica	1 x 600 kW	0.60	1998	CFE
La Venta, Oaxaca	Gamesa Eólica	98 x 850 kW	83.30	2006	CFE
Total		105	85.25		



Figure 2 La Venta II 83.3-MW windfarm on the Isthmus of Tehuantepec, Mexico.



Figure 3 Parques Ecológicos de México (93 MW under construction).

wind turbines from the Spanish manufacturer Gamesa Eólica. By the end of 2008, most of the wind turbines had already been installed; the plant will be commissioned by mid-2009.

In mid-2007, CFE launched a call for bid to construct a 100-MW wind power plant within the IPP modality. The bidding included a potential complement to the electricity buyback price of about 0.015 USD/kWh that would be granted by the Global Environmental Facility through the World Bank. Only two consortiums (both Spanish) participated in the bidding. Unfortunately, the bidding process was declared void. One of the companies was excluded during the evaluation of the technical offers while the other was excluded during the evaluation of its economic offer. In 2008, CFE issued a second call for bid for this project. Also during 2008, CFE issued another call for bid to construct another 100-MW wind power plant within the IPP modality (Oaxaca I). The results of both bidding processes will be made known in 2009.

In 2008, Eurus S.A., a consortium managed by the Spanish company Acciona and the Mexican company Cemex, started construction of a 250-MW wind power plant in the Isthmus of Tehuantepec. It will include 166 1.5-MW wind turbines manufactured by Acciona. By the end of 2008, about 25 wind turbines had been installed (but not commissioned yet). The project was suspended because of some disagreements with a group of local people; it is expected that a win-win agreement will be reached so construction of the project may continue as soon as possible.

3.0 Benefits to National Economy

3.1 Market characteristics

The wind power market in Mexico is still in its early stage, and negotiations between interested parties are still in progress. The major companies of the industrial sector are very interested in electricity self-supply projects based on wind power, and several companies are evaluating their economic feasibility. In addition, several municipal governments, as well as organizations of the trading and services sectors, are in similar

positions. Indeed, several important companies have already obtained permits to build wind power projects. Simultaneously, interest is growing in the installation of manufacturing facilities for wind turbines.

3.2 Industrial development and operational experience

During 2008, the combined electricity production from CFE's wind power plants La Venta I (1.3 MW) and La Venta II (83.3 MW) was around 254 GWh. The facilities operated at an annual capacity factor of 34%, according to Eng. Carlos Aguilar, the manager of the wind power plants. As mentioned previously, it was expected that the capacity factor of La Venta II would exceed 40%; however, there were some constraints regarding the availability of the transmission line and some of the wind turbines.

The Mexican company Fuerza Eólica is manufacturing permanent-magnet electric generators for the U.S. wind turbine manufacturer Clipper Windpower. This Mexican company is also manufacturing a 5-kW wind turbine, primarily for export markets. Several wind turbine components—including towers, generators, gears, conductors, and transformers—could all be manufactured in Mexico using existing infrastructure. Indeed, all the towers for the La Venta II wind power plant were manufactured in Mexico. A joint venture facility is manufacturing wind turbine blades in Mexico (exclusively for export). More than 200 Mexican companies have the capacity to manufacture the parts required for wind turbines and wind power plants. The country also has excellent technical expertise in civil, mechanical, and electrical engineering that could be tapped for plant design and construction. The new law for renewable energy instructs the Ministry of Energy and the Ministry of Economy to promote manufacturing of wind turbines in Mexico.

3.3 Economic details

Electricity prices to consumers vary depending on the region, time of day, voltage, and kind of user (sector). For electricity

billing purposes, the country is divided into eight regions. Each region has its own timetable for electric tariffs throughout the day. As an example, Table 3 shows the price for the HM tariff (general tariff for medium voltage—e.g., 115,000 V).

In 2008, a special buyback price for wind energy had not been set in Mexico. However, according to commitments made between private companies within the self-supply modality, it seems that some wind energy projects in the Isthmus of Tehuantepec are reaching economic feasibility. The main constraints on wind power market development in Mexico are as follows:

- Electricity for the industrial sector is subsidized.
- The methodology for computing the buyback price for wind energy that would come from IPPs (especially from small power producers) is not fully appropriate for reaching the point of financial feasibility for the projects (including those projected at the best windy regions).
- There is a critical need to generate a confident and stable business environment that can provide appropriate guarantees to international and national financial institutions on the viability and profitability of wind power projects.
- There is a critical need to include fitting and fair social benefits to wind landowners (especially to peasants) in the negotiation of wind power projects.

Table 3 Example of Electricity Price in Mexico*

Period	Price (Mexican Pesos/kWh)
Peak	1.93
Intermediate	1.29
Base	1.08

* Central Region, December 2008

National Activities

- Planning studies for deploying wind power at the national level have not yet been carried out.
- At the international level, the developers that have back-ordered wind turbines are controlling the wind development; wind turbines for new wind energy projects are becoming scarce or very expensive.

4.0 National Incentive Programs

In September 2001, the federal government through the Energy Regulatory Commission issued the first incentive for renewable energy. Embedded in existing legal and regulatory frameworks, this new incentive consists of a model agreement for the interconnection of renewable energy power plants to the national electrical grid. It allows self-supply generators to interchange electricity among various billing periods (e.g., base to peak). In this fashion, self-suppliers do not necessarily have to sell surplus electricity to CFE, because generation delivered to the grid during certain periods can be credited to compensate for the electricity extracted from the grid during other different periods. The interchange was allowed based on the ratio of the marginal costs among various billing periods; therefore, more than 1 kWh must be generated during a base period to match 1 kWh required in a peak period.

This administrative incentive was designed to improve the economic feasibility of some self-supply wind power projects, especially those for municipal public lighting, where the plants generate a considerable quantity of electricity during the daylight period when no electricity is required. Furthermore, before this incentive, electricity transmission charges for a renewable energy self-supply project were computed based on the project's rated capacity. Today, these charges are reduced to the power plant capacity factor level. However, this incentive was not effective since capacity charges were computed based on a five-minute period. This means that if a

specific wind power plant for self-supply purposes does not generate any power during just five minutes over one month, then full contracted capacity is used to compute billing charges.

During 2005, the Secretariat of Energy (Sener), Mexico's Energy Regulatory Commission (CRE), and the Mexican Association of Wind Power (AMDEE), with the technical support of the Instituto de Investigaciones Eléctricas (IIE), carried out an intensive negotiation with CFE to achieve the recognition of certain capacity credit for wind power. By the end of 2005, these participants agreed on a modification of the agreement. The modification includes the recognition of capacity credit of renewable energy technologies, based on the average capacity factor computed during the system's peak hour. The modification was issued in early 2006.

A tax incentive was issued in December 2004. The federal law for income tax (Ley de Impuesto Sobre la Renta) allows accelerated depreciation of investments in renewable technologies (wind energy is specifically included). Investors may deduct 100% of the investment in a year (one year of depreciation). Before, investors in equipment for electricity generation were allowed to deduct only 5% in one year (20 years of depreciation). The equipment must operate for at least five years following the tax deduction declaration; otherwise, complementary declarations are obligatory.

5.0 R, D&D Activities

The first demonstration project, La Venta I, a 1.6-MW wind power plant sponsored by the Mexican government, was built in 1994. In 1998, a 600-kW wind turbine was installed at Guerrero Negro. CFE operates both of these projects.

With the economic support of the Global Environmental Facility (GEF) and the United Nations Development Program (UNDP), the IIE is working to implement a Regional Wind Technology Center, which aims to offer the following provisions:

- Support to interested wind turbine manufacturers for the characterization of their products under the local conditions at the La Ventosa area
- A means to train local technicians in the operation and maintenance of wind turbines
- An easily accessible national technology display that facilitates interaction between wind turbine manufacturers and Mexican industries, thus promoting the identification of possible shared business ventures
- A modern and flexible installation that will enable researchers to obtain hard operational data on the interaction of specific types of wind turbines with the electrical system
- A means to understand international standards and certifications (issued abroad) in order to identify additional requirements to fit local conditions
- A means to increase the playing level of national research and technology development, including joint projects or specific collaboration activities with prestigious overseas R&D institutions.

Construction of the basic infrastructure of the Regional Wind Technology Center was completed in 2007. It is the first project to receive a permit to operate as a small power producer in Mexico. However, the installation of wind turbines has been delayed because of the long delivery times for machines in the wind energy market worldwide.

The wind energy resource in several promising areas of Mexico has not been evaluated in detail. Therefore, IIE's wind power action plan includes the exploration and assessment of the wind energy resource at both known and new regions. By the end of 2007, one full year of data had been collected for 20 promising new areas. Furthermore, through a contract with CFE, the IIE carried out a feasibility study for a wind power station in the state of Baja California Sur. Also, there is increasing interest by CFE in the short-term

prediction of wind power output at La Venta II. CFE is preparing a Grid Code for the interconnection of new wind power plants to the national electrical system.

6.0 The Next Term

Expectations for 2009 include the following. Several wind power projects already under construction that will be commissioned during 2009: Parques Ecológicos de México, 79 MW; Bii Nee Stipa, 28 MW; and Eurus (first phase), 150 MW. The results of the calls for bid for two CFE projects will be known. The regulatory instruments for the Law on Renewable Energy will be issued. A green fund for renewable energy will be available, and the rules for its application will be established. A Special Program on Renewable Energy will be established. Several studies, methods, standards, and other instruments aimed at fulfilling the objectives and instructions of the Law on Renewable Energy will be prepared and issued. Several private consortiums will start the construction of their projects, planning for commissioning dates at the end of 2010 or by early 2011.

In 2010 it is expected that a 2,000-MW transmission line for wind energy projects will be commissioned. A number of private consortiums will be ready to interconnect their wind turbines to the new transmission line.

For 2011 to 2012, it is expected that CFE's wind power installed capacity will reach 84.6 MW. IPPs' wind power installed capacity (for selling the electricity to CFE) will be around 505 MW. Privately owned wind power installed capacity (self-supply modality) should reach 2,000 MW. Total installed wind power capacity in Mexico would then reach about 2,600 MW.

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National Activities

1.0 Introduction

The Netherlands saw an all-time record of 490 MW of new wind capacity installed in 2008. The total installed wind capacity reached 2,214 MW. Wind power generated 4.3 TWh of electricity or 3.6% of the country's total electricity consumption of 119 TWh (Table 1). The Netherlands government confirmed its ambition to increase its target from 10% to 20% renewable energy in 2020. This implies an installed wind capacity of about 4 GW onshore and 6 GW offshore. The second offshore wind farm, Q7 of 120 MW, was completed and started operations.

2.0 Progress Toward National Objectives

2.1 Progress in 2008

The production of electricity from all renewables increased from 6.0% of the total electricity consumption in 2007 to 7.5% in 2008 (Table 2). This was due to the increased production of wind electricity and the co-firing of biomass in electricity plants. The contribution of wind electricity was 25% higher than in 2007 due to the additional 490 MW of installed capacity. The co-firing of biomass in electricity plants also increased 25% over 2007. In 2008, wind produced about half of the renewable electricity in the Netherlands (1).

In 2008, 221 wind turbines were installed with a total capacity of 490 MW and 63 turbines with a total capacity of 22 MW were decommissioned. The net added capacity in 2008 was therefore 469 MW, and the total installed capacity at the end

of 2008 was 2,214 MW (Figure 1). Of the turbines decommissioned in 2008, 37 (total capacity 14.6 MW) were replaced with 53 turbines (total capacity 126 MW). The net repowering effect was an increase of about 112 MW. The large repowering effect was mainly due to the decommissioning at Eemshaven in the province of Groningen of 20 Kenetech 33 turbines (total capacity 7.24 MW) and the installation at that site of a mix of Enercon E82 and Vestas V90 turbines (total capacity 114 MW) (2).

2.2 Government objectives

The national target is for 9% of the total electricity consumption to be supplied by renewable electricity in 2010. The government has the ambition to achieve energy savings of 2% per year, a share of renewable energy of 20% in 2020, and a reduction of greenhouse gas emissions of 30% compared to 1990.

Until 2011, the government expects the growth of renewable energy to come mainly from wind energy. The estimated growth for wind both onshore and offshore is given in Table 3. The government expects to stimulate the availability of necessary sites through various spatial planning activities and the production of renewable energy through the allocation of MEP and SDE subsidies of 900 million € from 2008 to 2011. For a more detailed explanation, see the 2007 IEA Wind Energy Annual Report

Total installed wind generation	2,214 MW
New wind generation installed	490 MW
Total electrical output from wind	4.3 TWh
Wind generation as % of national electric demand	3.6%
Target: Renewable Electricity in 2010	9%
Ambition: Renewable Energy in 2020	20%

National Activities

Table 2 Wind generated electricity, avoided fossil fuel, and national electricity consumption

	Wind generated electricity [GWh]	Primary energy savings [PJ]	National electricity consumption [GWh]
1985	6	0.05	
1986	7	0.06	
1987	14	0.12	
1988	32	0.26	
1989	40	0.33	
1990	56	0.50	78,582
1991	88	0.78	80,803
1992	147	1.30	83,173
1993	174	1.56	84,318
1994	238	2.12	87,067
1995	317	2.79	89,058
1996	437	3.76	92,259
1997	475	3.98	95,735
1998	640	5.32	99,292
1999	645	5.34	101,508
2000	829	6.86	104,718
2001	825	6.98	107,144
2002	946	7.98	108,452
2003	1,318	11.11	109,777
2004	1,867	15.59	112,930
2005	2,067	17.22	114,471
2006	2,737	22.46	116,085
2007	3,437	28.71	118,463
2008	4,259	35.57	119,300
CBS	Numbers CBS final		

2.2.1 Wind on land

Under the so-called Administrative Agreement National Development Wind Energy (Dutch acronym BLOW), the departments of economic affairs, spatial planning, water management, agriculture, defense, and the provincial and local authorities work together to create enough available sites. At the end of 2008, about 1,700 MW of projects were in the pipeline that fit in the provincial spatial policy.

The government's ambition to double the capacity for wind on land by 2011 (compared to 2007) and remove barriers to increasing the capacity after 2011 has been underlined by signed agreements with the provincial and local authorities. For the short term, a solution has been worked out for conflicts of interests concerning spatial planning issues (safety, noise), radar signal disturbance, and nature conservation on one hand and wind energy on the other. Active support of projects on a local level is also in place. For the long term, a spatial perspective has been worked out in cooperation with all government levels. For a more detailed explanation of BLOW see the 2007 IEA Wind Energy Annual Report.

2.2.2 Wind offshore toward 450 MW

To reach the ambition of committing 450 MW of offshore wind power within the present government 2008 to 2011 time-frame, the ministries of Economic Affairs, Water Management and Environment published a scenario in June 2008. The outline is as follows.

Step 1. The general part of the government's evaluation criteria of ecological effects is ready by 1 July 2008 and will be an integral part of all Environmental Impact Assessments (EIA).

Step 2. The main criteria for allocating the SDE subsidies through a tender are ready and published per 1 July 2008.

Step 3. Consultation of the wind industry about criteria for allocating the SDE subsidies and the evaluation criteria of ecological effects. In the autumn of 2008, the 11 initiators will be asked to indicate

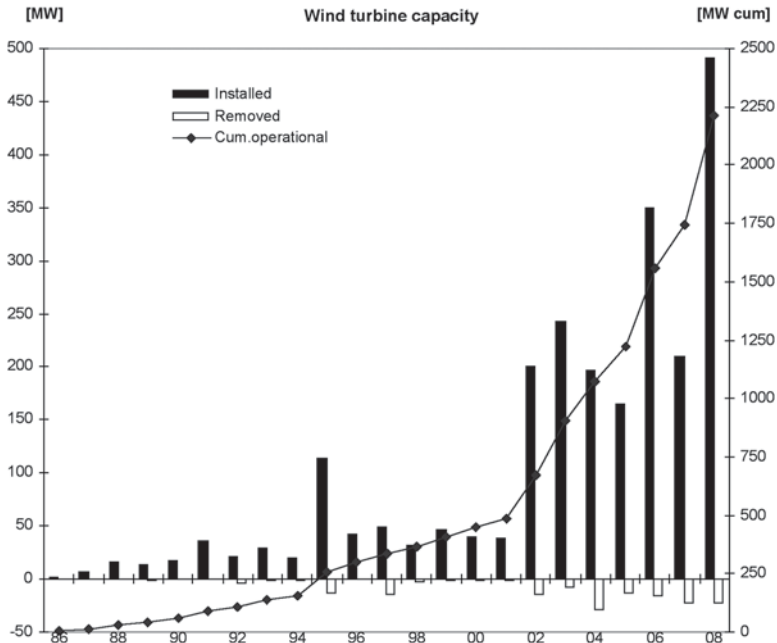


Figure 1 Installed, removed, and cumulative wind turbine capacity in the Netherlands.

how many of the 77 initiatives they will continue to pursue by supplying building permit applications (including EIA) before 1 March 1 2009.

Step 4. Evaluation of EIAs by the Ministry of Water Management before 1 February 2009. During this period, various (small) adjustments can be made due to nautical and air traffic safety, and environmental impact. The completed building permit application including a completed EIA needs to be supplied by 1 March 2009 at the latest. After this date new applications will not be accepted.

In the first half of 2009 the SDE subsidy criteria for wind offshore will be detailed and published.

Step 5. Applications for the SDE subsidy have to be submitted to the Ministry of Economic Affairs before 1 December 2009. A maximum of 450 MW offshore capacity will be allocated in this first SDE tender. An applicant needs to have a valid building permit, supply a solid business

Table 3 Necessary growth of wind energy up to 2011		
Necessary growth of wind energy		Capacity [MW]
Wind on land	MEP 2007 to 2008	2,100
Growth	SDE 2008 to 2011	2,000
Total on land	2011	4,100
Wind off-shore	MEP 2007 to 2008	230
Growth	SDE 2008 to 2011	450
Total off-shore	2011	680
Total wind	2011	4,780

National Activities

plan and project finance, and have enough experience.

Step 6. Evaluation of subsidy application by the Ministry of Economic Affairs according to the published criteria up to 1 April 2010.

Step 7. 1 April 2010. Decision to allocate SDE subsidies up to a capacity of 450 MW by the Ministry of Economic Affairs.

Step 8. Check building activities by the Ministry of Water Management. The building activities have to be started within three years after the date the building permit was issued. All issued building permits in 2009 automatically expire after three years. This automatic expiration includes building permits that were not awarded an SDE subsidy. The timeline and deadlines are given in Table 4.

2.2.3 Wind offshore toward 6,000 MW

To reach the Netherlands' ambition of 20% renewable energy in 2020, the government is aiming at 6 GW of offshore wind capacity. Preparations for the issue of locations were announced with the above-mentioned scenario in June 2008. They were given in a so-called "contour for a new policy (for wind offshore)" and consist of three main elements.

The government (initiative sub-secretary of state of Ministry of Water Management) designates "wind areas" in the National Water Plan 2009:

- Wind areas offshore are areas where, according to the vision of the government, wind farms could be realised while taking into account other functions in the North Sea (ecological conditions, ship and air traffic, oil and gas exploration, etc.). Point of departure is an area large enough for about 6,000 MW

- The total surface area of the wind areas will be about 1,000 to 1,500 km²
- Weighing of interests to designate the wind areas takes place via the process of a Strategic Environmental Assessment and the structural vision of the National Water Plan

- The status of these wind areas is that they will be reserved for the function wind and that the government commits itself to only give SDE subsidies in these areas

- Periodically the government (initiative minister of Ministry of Economic Affairs) opens "wind lots/licence areas" to tender a subsidy allocation and obtain "licence"

- Wind lot is the area, determined in coordinates, within the wind area

- The government determines the size of the wind lot in advance and it is (periodically) dependent on available subsidy

- Market parties can submit proposals for a wind farm in the wind lot at

Table 4 Scenario time line for 450 MW of offshore wind development	
Action	Deadline
Completed building permit application	1 March 2009
Final decisions building permits	1 November 2009
Application SDE subsidy	1 December 2009
SDE allocation	1 April 2010
Start building activities	1 November 2012

disposal in which they have to specify the intended installed capacity, energy production, and the financial support

- The government selects one party from the submitted applications (main criteria are highest energy production for the lowest subsidy, reliability of business plan, technical reliability of the proposal)
- The selected party gets a preliminary/ conditional subsidy allocation including licence, with the obligation to further develop the wind farm at that location within a certain period (with fixed phased milestones), to submit a building permit application including EIS, obtain a building permit, and build and exploit the wind farm
- The concerned licensee submits a building permit application (including EIS) and the government (initiative sub-secretary of state of Ministry of Water Management) supplies the building permit
- The building permit is based on an EIS and concerns “fine tuning.” The suitability of the location has been globally evaluated (taking into account cumulative effects) when it is designated a wind area in the National Water Plan.

3.0 Benefits to National Economy

3.1 Market characteristics

Total investment in wind energy installations in the Netherlands for 2008 can be estimated at 850 million €, assuming an average investment cost of 1,250 €/kW for the 370 MW installed onshore and an investment cost for the Q7 offshore wind farm of 3,192 €/kW for the 120 MW installed. The total investments in wind energy installations from 1989 to 2008, not corrected for inflation, is estimated at some 3 billion €. Figure 2 shows the investments per year over the period 1989 to 2008.

According to the European Wind Energy Association (3), 15.1 jobs are created in the EU for every MW installed. In addition,

0.4 jobs are created per MW of cumulative capacity in operations, maintenance, and other activities. About half of these jobs are associated with wind turbine and component manufacturing. For offshore the numbers are higher.

So for the 490 MW installed in 2008 we estimate that about 8,000 jobs were involved in the EU, of which about 4,000 were in the Netherlands. Further, for the 2,214 MW of total installed capacity, about 1,000 jobs are created permanently in operations, maintenance, and other activities.

The types of ownership have not changed much from 2007 to 2008. There seems to be a slight increase in ownership from private enterprises toward energy companies (Table 5). For a more detailed explanation of the types of owners, see the 2007 IEA Wind Energy Annual Report.

In 2008, a new developer RWE Offshore Wind Nederland B.V. started the process of obtaining building permits for offshore wind farms through the submission of five inception memoranda for environmental impact statements as required by the Public Works and Water Management

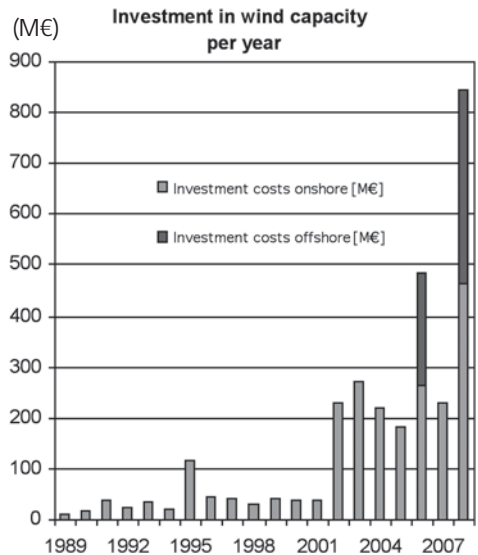


Figure 2 Investments per year over the period 1989 to 2008. Netherlands.

Table 5 Ownership of capacity in 2007 and 2008				
	2007		2008	
	MW	%	MW	%
Private Enterprises	1,354	72	1,523	68
Energy companies	516	28	702	32
Total	1,870	100	2,225	100

Act. Together with the earlier applicants, at the end of 2008, 11 initiators had supplied 77 initiatives for offshore wind farms.

At the end of 2008, the completed environmental impact statements and building permit applications for six offshore wind farms had been open for public inspection. This implies that the Ministry will not deal with other existing or future claims of other developers for the same site. The status of progress in applications for offshore wind farms with these site rights is given in Table 6. The prospective total installed capacity lies between 1,900 MW and 2,700 MW.

3.2 Industrial development and operational experience

The average generation capacity per installed turbine after a sharp decrease to 1,787 kW in 2007 increased again sharply to 2,219 kW in 2008. This is mainly due to the large number of 3 MW turbines from Enercon and Vestas installed in the Groningen Eemshaven area in 2008. From the total of 221 turbines installed, 97 have a capacity of 3 MW.

The average hub-height is rising again to nearly 80 m in 2008. From the total of 221 turbines installed, 91 have a hub-height of 100 m. These are also mainly in the Groningen Eemshaven area.

The installed swept area per unit of power decreased from 2.5 m²/kW in 2007 to around 2.1 m²/kW, because of the 64 Enercon turbines with 82 m diameter rotors and 3 MW generators installed in 2008 (Figure 3).

Of the wind turbines installed in 2008, the Vestas share was 52%. Enercon's share

of 9% in 2007 went up steeply to 47% in 2008. Nordex's share was 2%. For the first time ever the market was dominated by two wind turbine manufacturers with an almost equal share of the market (Table 7).

Seven wind farms with an installed capacity of 10 MW or higher were installed in 2008. The largest is the wind farm at Eemshaven and Emmapolder with 192 MW, equipped with 3-MW Enercon turbines. The second largest is the 120 MW offshore wind farm Q7 with 2-MW Vestas V80 turbines installed 24 km off the coast of IJmuiden. The third largest is the wind farm Eemshaven-Growind with 63 MW, equipped with 3-MW Vestas turbines. The cluster of wind farms at Eemshaven with

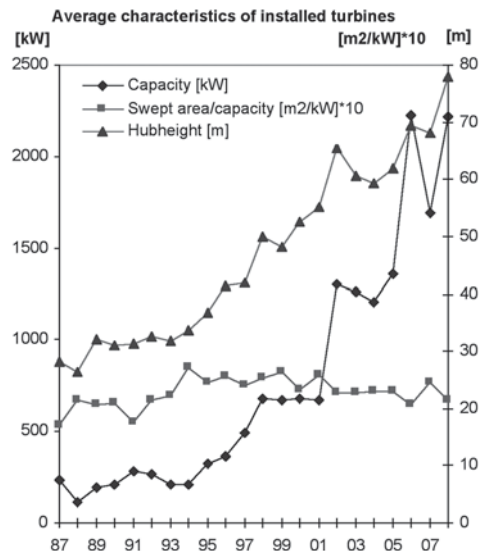


Figure 3 Annual average characteristics of installed turbines in the Netherlands.

Table 6 Building permit applications for offshore wind farms with site rights per 31-12-2008

Offshore wind farm	Area [km ²]	Pmin [MW]	Pmax [MW]	Inspection procedure	Draft decision	Final decision	Status 01 December 2008
IJmuiden	17	140	246	29 November 2006	18 February 2008		Application withdrawn
Katwijk	50	400	705	29 November 2006	18 February 2008		Draft declined
Den Haag II	43	270	480	24 January 2007	18 February 2008		Application withdrawn
Scheveningen Buiten	39	369	369	8 May 2007	22 May 2008	21 December 2008	Application declined
West Rijn	45	250	353	29 November 2006			Application complete
Breeveertien II	42	300	403	12 November 2007			Application complete
Rijnveld Noord	10	60	60	15 August 2008			Application complete
Rijnveld Oost	17	102	102	15 August 2008			Application complete
Total	263	1,891	2,718				

Table 7 New wind turbines by manufacturer in 2008

Manufacturer	Turbines	Installed capacity		Rotor swept area
		[MW]	[%]	[m ²]
Vestas	128	254.5	52	596,184
Enercon	90	228.4	47	433,336
Nordex	3	7.5	2	19,085
Total	221	490.4	100	1,048,605

around 260 MW is one of the largest concentrations of wind farms in The Netherlands (Table 8).

The company Advanced Tower Systems, a joint venture of Dutch MECAL, Hurks Group BV, and German Juwi Holding AG, designed and developed a new product. It is a hybrid concrete/steel tower, for wind turbines on land with hub-heights of 100 to 150 m (Figure 4). The tower is a combination of a prefabricated segmented

concrete tower with a conventional tubular steel tower part on top. The concrete part is built with pre-cast concrete segments that are long and slender and therefore easy to transport with ordinary trucks. The expected reduction in the costs of energy is up to 10%. At the end of 2008, the construction of the demonstration project with the 100 m high ATS tower and a Siemens Wind Power SWT2.3-93 wind turbine started at Windtest Grevenbroich in Germany.

National Activities

Table 8 Size of wind plants installed in 2008						
Wind farms > 5MW	Manufacturer	Turbines	Height [m]	Diameter [m]	Capacity [MW]	Swept area [m ²]
Eemshaven and Emmapolder	Enercon	64	100	82	192.0	337,985
North Sea Q7	Vestas	60	57	80	120.0	301,593
Eemshaven-Growind	Vestas	21	100	90	63.0	133,596
Amsterdam-Afrikahaven	Vestas	9	77.5	90	27.0	57,256
Aalten	Enercon	8	98	82	16.0	42,248
Middelburg-Borssele	Vestas	12	70	52	10.8	25,485
Stampersgat	Vestas	5	80	80	10.0	25,133
Eemshaven - Emmapolder	Vestas	3	100	90	9.0	19,085
Echteld - A 15	Enercon	4	78	82	8.0	21,124
Oosterhout	Nordex	3	100	90	7.5	19,085
Tuitjenhorn	Enercon	8	60	53	6.4	17,649
Marrum	Vestas	7	40	44	5.3	10,644
Midlum	Vestas	6	60	52	5.1	12,742
Various < 5MW	Others	-	-	-	10.4	24,980
Total					490.4	1,048,605

The wind turbine manufacturer DarwinD developed another new product. It is a 5-MW direct drive wind turbine with a rotor diameter of 115 m at 18 rotations per minute dedicated for offshore applications. Its unique features include a 5.3-m diameter, 3-kV direct-drive generator with permanent magnets, a single main bearing, innovative blades, a modern fully sealed over-pressured tower and nacelle, external air generator cooling, and an integrated management control system. The turbine is lightweight (tower head mass 265 tons), yet boasts high operational availability and a minimum of maintenance due to fewer components. The first prototype will be

erected late in 2009 on a 100 m tower at the ECN test field in Wieringermeer in the province of Noord Holland.

The construction of the second offshore wind farm Q7 in the Netherlands' part of the North Sea was completed in stages in the first quarter of 2008. This offshore wind farm is built just outside the 12-mile zone Southwest of the Offshore Wind Farm Egmond aan Zee (OWEZ) and has a surface area of 14 km². The 120-MW farm Q7 consists of 60 Vestas 2-MW 80-m-diameter turbines, with a hub height of 59 m. The investment costs are 383 million €. Q7 is non-recourse financed. The Q7 offshore wind farm was renamed at the



Figure 4 ATS Hybrid tower. Photo: ATS.

inauguration in June as the Princess Amalia offshore wind farm. For a more detailed explanation of the construction of the Q7 wind farm, its ownership and financing, see the 2007 IEA Wind Energy Annual Report.

3.3 Economic details

The Ministry of Economic Affairs contracts ECN and KEMA each year to assess the financial viability of the different renewable electricity production technologies in succeeding years. The Ministry uses these assessments, along with other statistics, to decide on the level of the SDE base tariffs required to bridge the difference between cost and market prices (unprofitable top) for each renewable electricity source and technology in succeeding years. The assessment by ECN and KEMA on the costs for projects in the Netherlands aimed at realization in 2009 and 2010 was published in December 2008. The costs for offshore wind projects were not assessed; this will be done separately in 2009.

The general financial and economic assumptions for the calculation for wind on land are: an equity share of 20%; interest rate of 5%; return on equity of 15%; project



Figure 5 Impression of DarwinD turbine. Picture: DarwinD BV.



Figure 6 Offshore wind farm Princess Amalia during opening ceremony. Photo: Jaap 't Hooft, SenterNovem.

return (WACC) of 6%; a 15 year loan period; a 15 year economic lifetime; indexation of variable costs of 2%; and a company tax of 25.5%. Two assumptions changed in the assessment from 2008-2009 to 2009-2010. Due to the credit crises, the equity share for project finance rises from 10% to 20%. The cap on energy investment deduction (EIA) changed from 80% of 1,100 €/kW to 600 €/kW.

Investment costs in the assessment are based on a reference case of orders for a 15-MW wind farm with 3-MW wind turbines. The O&M costs are seen as representative for 3-MW turbines. The calculation then led to a base subsidy tariff of 88 €/MWh for the period 2008 to 2009 and 94 €/MWh for the period 2009 to 2010. The values are summarized in Table 9.

4.0 National Incentive Programs

The feed-in support scheme SDE is the successor of the MEP scheme and has been in force since October 2007. It supports the production of all kinds of renewable energy with the ability to determine different support levels for different production technologies, e.g. wind onshore, wind offshore. The SDE scheme will make it possible to tender wind projects for a requested level of production subsidy and to evaluate projects on innovative aspects and learning effects.

In the SDE scheme, a base subsidy tariff is determined on the basis of average

production costs. The amount of support per kWh that a producer receives varies yearly by decreasing the base subsidy tariff with the average market price of electricity. For a more extensive description of the basic SDE mechanism, see the 2007 IEA Wind Energy Annual Report.

At the end of 2008, about a 100 MW of wind capacity were allocated a subsidy under the SDE scheme. This is lower than expected and probably because market parties still have to get used to the details of the new scheme and the financial consequences for their projects.

5.0 R&D Activities

For a complete description of the Netherlands research priorities refer to the 2007 IEA Wind Energy Annual Report.

5.1 *Interesting new research efforts*

At the end of January 2008, ECN completed a so-called 'Scaled Wind Farm' research facility. This wind farm is a miniature version of a full-scale commercial wind farm. The project is an integral part of ECN's test field for multi-megawatt class wind turbines. The setup is physically comprised of ten 10-kW AIRCON 10 turbines and 14 carefully placed wind metering masts at two distinct heights, 7.5 m and 18.9 m. The AIRCON 10 is a three-blade horizontal-axis wind turbine, fitted with a 7.6 m rotor

Table 9 Technical and financial parameters for wind onshore			
Wind onshore		Advice ECN-KEMA 2008-2009	Advice ECN-KEMA 2009-2010
Investment costs	[€/kW]	1250	1325
Full load hours	[hr/yr]	2200	2200
Fixed O&M costs	[€/kW]	24	25
Variable O&M costs	[€/MWh]	10	11
Base subsidy tariff	[€/MWh]	88	94

and an axial-flux type direct drive permanent magnet generator. At a wind velocity of 11 m/s the turbine reaches 10 kW rated, and output is kept at this constant level up to 37 m/s. This is ensured by a combination of electrical load regulation and active pitch control. The German made turbines have been put on short tubular steel towers with a 7.5 m hub height.

The advantages of a scaled wind farm are: costs of wind metering masts for a real farm are very high; switching off several real turbines for wake effect measurements is unacceptable for a commercial wind farm; introducing changes into the wind turbine control system is given by the AIRCON 10 turbine supplier for scaled wind farm research purposes.

ECN will use the scaled wind farm mainly for research projects concerning wind turbine wake modelling and verification. Other research projects at this site include: the validation of the code ECN Wakefarm; further testing in the scaled wind farm of the patented Heat&Flux concept to change the turbine performance in the first rows of the wind farm in order to increase the total wind farm output; and the quantification of the Controlling Wind concept in the scaled farm.

5.2 Interesting completed research

5.2.1 Study large-scale storage

On the order of the Transition Platform Renewable Electricity Supply, the added value of large scale electricity storage was studied. The results of the study were published in January (4) and also in a paper (5). The five different technologies studied were: low head (40 m) pumped hydro storage basin (60 km²) in the North sea; underground (1,400 m) pumped hydro storage; compressed air energy storage; using Norwegian hydro storage via NorNed cable; and more flexibility using electricity from combined heat and power units.

Analyses were performed on the operational effects, cost/benefits, costs of grid integration, and market effects. The main conclusion concerning wind energy was that integration of 4 to 10 GW of wind power in the Dutch Electricity generation system is possible without large scale electricity storage. This is mainly because of the increasing flexibility of the system and the expansion and better utilisation of interconnectors.

Even with more than 10 GW of offshore wind power after 2020, large-scale electricity storage would not be necessary in following years. This is under the condition that in 2020 the Western European



Figure 7 Scaled wind farm at ECN test site. Photo: Jaap 't Hooft, Senter-Novem.

electricity market is functioning well and the planned growth of interconnection capacity is realized.

5.2.2 Results of OWEZ

Further results of the Monitoring and Evaluation program of the offshore wind farm OWEZ, formerly known as NSW, became available in 2008. Reports and data are freely available (6).

Results from the OWEZ include wind climate characteristics. These are half-year reports with analyses of the meteorological measurements at the 116-m-high meteorological mast at the wind farm. They give amongst others graphical and tabular presentations of wind speed frequency distributions, turbulence intensity, vertical profile of turbulence intensity, and wind speed profiles. The associated 10-min average wind measurements of the site at three heights of the meteorological mast from July 2005 to December 2008 are also available. Wave and current data are integrated in the files of the 10-min average wind measurements of the site. A report with a description of the relation of wind, wave, and current characteristics is available.

The General Report covers the period from June 2005 until commissioning at the end of 2006. The report describes: the partners and contractual basis; project organisation; permits; technical description of the design, support structure, wind turbines, and electrical design; assembly and installation; planning versus execution; budget; health, safety, security, and environment management; risk management; financing, insurance, and power purchase agreements; quality assurance management; requirements and qualifications; monitoring and evaluation program; and lessons learned.

In the Operations Report 2007, NoordzeeWind gives an account of the first year of operation of the wind farm. It contains monthly statistics and figures about the availability of the wind farm and its energy production. Moreover, calculated losses and downtime per subsystem affecting this energy yield are also presented. It also contains a complete overview of all data and reports delivered by NoordzeeWind on behalf of the MEP-NSW in 2007. NoordzeeWind's general conclusion in this Operations Report 2007 is that the wind farm, having generated 330 GWh, has performed

satisfactorily. The Operations Report 2008 will be available in mid 2009.

Commercially sensitive data that has been collected during 2008 is on the subjects: corrosion and lightning; dynamics of turbines; aero-elastic stability; scour protection; electricity production, disruptions, failure data, availability, maintenance, and reliability; power quality, grid stability, and power forecasts; and wind turbine P-V curve and wake effects. ECN and Delft Technical University have started several projects with some of this data under an NDA agreement with NoordzeeWind.

5.2.3 Results of the We@Sea program

The results of the We@Sea program for the research lines: Scenario's and Integration; Offshore Wind Energy Technology; Spatial Planning and Environmental Aspects; Energy Transport and Distribution; Energy Market and Financing; Installation, Operations and Maintenance can be found on their website (7).

5.3 Collaborative research

Various Netherlands organisations participate in IEA Wind Tasks 11 Base Technology Information Exchange, 23 Offshore Wind Technology Deployment, 25 Design and Operation of Power Systems with Large Amounts of Wind Power, 26 Cost of Wind Energy, and 29 MexNext Improvement of Aerodynamic Models. The participation benefits the Netherlands R&D in various ways.

As of 2008, the Netherlands research institute ECN acts as Operating Agent in Task 29 Analysis of wind tunnel measurements and improvement of aerodynamic models (MexNext). Delft Technical University and AERotortechneek are also participating in this Task. The Netherlands' participation in this task is important to further strengthen the knowledge that ECN and Delft Technical University have in this research area.

Participation in the IEA Wind Tasks is a cost-effective way to conduct research. On average, each euro spent in the

country on research gives access to five euros value of research spent in the other participating countries.

Netherlands research institutes also participated in various EC projects. Among others, is the EC project Upwind, which is closely interlinked with the Netherlands INNWIND project.

6.0 The Next Term

The following policy developments in 2009 are expected: the issue of building permits for offshore wind farms; the detailing of the conditions and subsidy levels and opening of the offshore SDE tender; and the outline of the planning for the development of offshore locations, grid at sea, and support levels after 2011.

The expected installed capacity in 2009 is between 100 MW and 200 MW.

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- (4) Download from (in Dutch) http://www.senternovem.nl/energietransitiedev/onderwerpen/centrale_elektrische_infrastructuur.asp
- (5) Paper in English http://www.we-at-sea.org/publications/r3_03.pdf
- (6) See http://www.senternovem.nl/offshorewindenergy/technology_nsw/monitoring_mep-nsw/index.asp
- (7) <http://www.we-at-sea.org/index.php?keuze=r0>

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National Activities

1.0 Introduction

Electric energy in Norway is generated using a very high share of renewables. The dominating energy resource is hydropower, but there is also a keen interest in wind power as a commercial source of energy. Most of the remaining economical renewable resources are wind power, but there is also a potential for about 20 TWh of hydropower, mostly small-scale hydropower.

The wind energy potential is located mostly on West coastal areas. Norway has a long coastline and the offshore potential is also huge even though most of the offshore areas are deep water or protected marine zones. More than 50,000 MW of wind power potential has been identified.

In 2008, the installed wind power capacity in Norway increased from 385 MW to 430 MW (Table 1). By the end of 2008, there were project plans for over 15,000 MW in Norway. However, financing and public acceptance remain substantial hurdles to overcome for the installation of wind turbines. Although the price for long-term future electricity has risen during past years, it is still not a strong enough incentive to spur new investments in wind energy.

2.0 Progress Toward National Objectives

2.1 Strategy

Norway's national goal for renewable energy production and energy savings in 2010 is 12 TWh above the 2001 level. At least 3 TWh of this production will be achieved from wind power and 4 TWh from water-based central heating systems. For the longer term (2016), the government has

established a target of 30 TWh above the 2001 level of production from renewable energy sources and energy efficiency. To help achieve this goal, the Energy Fund, administered by the state-owned agency Enova, gives grants to energy saving and renewable energy production projects. The Energy Fund is partly financed by a levy on the transmission tariff, and the yield from a new fund (Basic Fund for Renewable Energy and Energy Efficiency). The Energy Fund contained approximately 190 million € in 2008.

In 2008, renewable sources of electricity contributed 110% of national electrical demand. About 0.6% of the renewable supply comes from wind power. Since electricity production in Norway mainly comes from hydropower, the share of renewable energy varies considerably from one year to the next. It turns out that 2008 was a rather wet year resulting in excess power production available for export. For 2010, the target set by the government for the renewable share of electricity consumption is 90%. According to a government statement, this target corresponds approximately with the 6 to 7 TWh of new renewable electricity production capacity being introduced from 1997 to 2010.

2.2 Progress toward the wind target

Interest in wind power is high, and several projects have been submitted for approval. Projects totalling 6,400 MW have applied for concession (approval). More than 2,000

Total installed wind generation	430 MW
New wind generation installed	45 MW
Total electrical output from wind	0.921 TWh
Wind generation as % of national electric demand	0.7 %
Target	3 TWh in 2010

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MW have received approval; however, very few projects are under way. This indicates that the economic incentives are not yet sufficient. There is an expectation, however, that the economic conditions will be improved in the future. In addition, projects totalling an annual production of 45 TWh have been proposed, including offshore wind power projects totalling 8,200 MW (23 TWh/yr).

All the projects cannot be developed due to the limitations of the existing grid capacity. In 2008 Enova and The Norwegian Water Resources and Energy Directorate estimated the potential for onshore wind power, based on the official Norwegian grid plan. The study concludes that it is possible to feed in approximately 5,000 MW onshore wind power by 2020. The total investment costs are estimated to be approximately 80 billion NOK (10 billion €), and will require support (state aid) of approximately 30 billion NOK (3.75 billion €).

Enova provided a grant to two wind power projects in 2008. Jæren Energi AS received 352 million NOK (44 million €) for a new wind park in Rogaland, with an annual production of 260 GWh. Additionally, Kvalheim Kraft AS received 93 million NOK (11 million €) for a new wind farm in Sogn og Fjordane, with an annual production of 50 GWh.

The target for wind power of 3 TWh of generation by 2010 represents

approximately 1,000 MW of installed capacity at the most favorable sites. Since 2001, Enova has signed contracts with energy utilities for 11 wind power projects. The projects represent an estimated 1.4 TWh/yr of energy production. There is no indication that the 3 TWh target can be reached by 2010 (Figure 1).

3.0 Benefits to National Economy

3.1 Market characteristics

Production of wind power is dispersed among seven energy companies, some of which are small local utilities. The largest wind power projects are operated by big national energy companies that also own power stations in foreign countries. So far there is no significant wind turbine manufacturing industry in Norway.

3.2 Industrial development and operational experience

3.2.1 Manufacturing

ScanWind Group AS is a new Norwegian-based manufacturer of large wind turbines (3.5 MW) for use in Class 1 wind areas. The design consists of a directly-driven, variable-speed turbine with a permanent-magnet generator. The company is ready for serial production in 2009. An installation of a prototype offshore turbine is expected in 2011.

Some of the Norwegian industry takes part in component production for wind energy systems, e.g. wind turbine blades

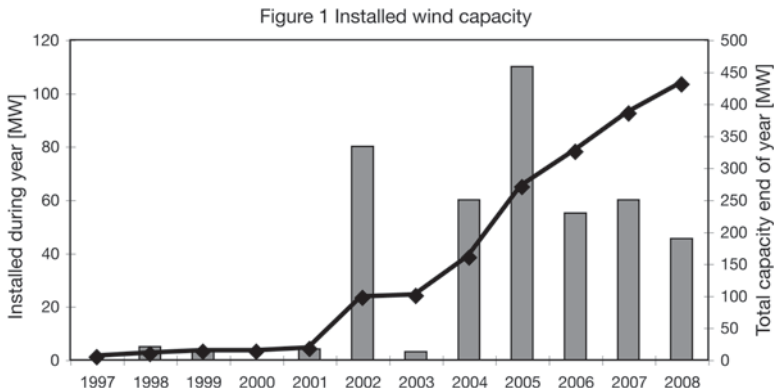


Figure 1 Installed wind power capacity in Norway.

and nacelles. Companies with experience from the offshore oil industry (OEW Tower and Aker Solutions) have widened their scope of interest and have also been engaged in the offshore wind industry. The companies offer offshore wind turbine sub-structure solutions like Jacket Quattropod and Tripod.

ChapDrive AS is a newly established company with the aim to develop a system for hydraulic transmission of wind power. The object of the system is to move the gearbox and the generator down to ground level in order to reduce the weight at the top of the tower. A pilot project has been in successful operation on a 225-kW wind turbine at VIVA AS test facility. An upgraded version will be connected on a 900-kW wind turbine by spring 2009. A 5-MW version is planned.

Another system for locating the generator at ground level is being developed by Anglewind. The system is comprised of an "angle" concept and a new drive train system for mechanical transmission of power. Installation of a prototype (225 kW) is expected by the end of 2009.

Another company, Smartmotor, has developed a new weight-reduced generator design for wind power applications. The main objective of this project is to develop a new radial flux permanent-magnet generation system that reduces the generator mass by at least 25%.

3.2.2 Operational experience

The technical availability of new wind turbines in Norway is usually in the range of 97% to 99%. Some wind farms are exposed to very harsh and turbulent wind. In those areas the availability is considerable lower, in some places even less than 80%. The mechanical impact of turbulent wind has apparently been underestimated.

The average capacity factor of wind turbines has varied between 24% and 29%. Based on calculations made on average wind speed through the year, the capacity factor should have varied between 30% and 33%. In 2008 the capacity factor was 24.4%.

All turbines, even those with very low availability, have been included in this figure.

3.3 Economic details

In some remote areas having favorable wind conditions, the cost of grid-connection is too high to make the development of wind energy economical. In addition, the capacity of the existing grid is a limiting factor in many places and restricts the size of the wind farms being constructed. Most new wind farms are designed taking into account the limitation of the capacity of the grid. An increase of the grid-capacity can be an option in some areas. Generally, areas with the best wind conditions are located in the northern part of the country, but these areas are too far from the consumer. Constructing new transmission lines has been considered, but so far the lower cost for generating in the North, where wind conditions are more favorable, does not make up for the additional cost of building new lines (Figure 2).

Estimates of production costs from sites with good wind conditions suggest a production cost of about 650 NOK/MWh (66 €/MWh), including capital costs (discount rate 8.0%, 20-year period), operation, and maintenance. During 2008, the spot market electricity price on the Nord Pool (Nordic electricity market place) increased until autumn 2008, followed by a noticeable drop. The forward price by the end of December 2008 was 375 NOK/MWh (38 €/MWh). So far wind energy is not competitive with the price of many new hydropower projects, which still is an option for new green power.

4.0 National Incentive Programs

For renewable power production, the support system is administrated through the state-owned Enova. The support is given as a grant (investment subsidy). There are no support systems for hydropower. Wind power is supported through Enova's Wind Power Program. The program will continue to 2010, where the target is to support at least 3 TWh of wind power.

National Activities



Figure 2 Location of wind installations in Norway.

The calculated grant (support) for each wind power project is based on a cash flow analysis, where the grant shall give the investment an Investment Rate of Return (IRR) of 8% before taxes. The wind power companies are in competition with each other and are being ranked by cost efficiency (kWh/support level). The most cost efficient projects are being supported in every round. The Wind Power program is being announced annually.

Parallel with the ongoing Wind Power Program, The Norwegian government has decided, as an option, to reopen negotiation with the Swedish government in a new

attempt to come to an agreement of a common scheme for a green electricity market. The result from the negotiations is expected to be announced in September 2009.

5.0 R, D&D Activities

In accordance with a broad-based political agreement on climate achieved in the Storting (the Norwegian parliament) and the national R&D strategy for energy (Energi21), the Research Council of Norway has selected eight new Centers for Environment-friendly Energy Research (CEER). The goal of the centers is to become international leaders in their respective areas of

energy research and to make environmentally friendly energy profitable. Each CEER will receive up to 20 million NOK (2.4 million €) annually over a five-year period with the possibility to receive an extension of funding up to eight years. Two of the CEERs are focusing on offshore wind energy: the Research Centre for Offshore Wind Technology at SINTEF Energy Research and the Norwegian Centre for Offshore Wind Energy (NORCOWE) at Christian Michelsen Research.

The governmental research program for sustainable energy is called RENERGI. Its budget for wind energy R&D in 2008 was 12.5 million NOK (1.5 million €). Norway will increase its research in offshore wind substantially in 2009. The following wind energy R&D projects have been approved for funding in 2008:

- A pilot project demonstrating hydraulic transmission of wind power
- Pre- and post-construction studies of conflicts between birds and wind turbines in coastal Norway. The main focus of this project is to obtain biological and ecological knowledge on wind turbines and bird behaviors, mortality and mitigating measures, and tool development to facilitate data collection. The project results will significantly increase knowledge about how wind power can affect birds adversely in coastal areas of Norway
- Development of maintenance strategies on the component and system levels. Methods will focus on availability in a life cycle cost perspective.
- Two concepts for floating wind turbines are under development. The systems are designed to operate in areas of deep water (200 m to 800 m). One of the concepts, Hywind, is a demonstration project in which StatoilHydro will use floating constructions familiar from the offshore industry as foundations for the offshore wind turbines. A full-scale (2.3-MW) prototype is expected to be in operation during 2009. Hywind received a 59 million NOK

(7.08 million €) investment grant from Enova in 2007. The other concept, Sway, is a tilting downwind solution to offshore turbines, but its demonstration project has been postponed until 2011.

- A new concept for a floating platform with three wind turbines (two upwind and one downwind) and tilted towers is under development. Construction will be completed on a dockyard, and then, the platform ready for operation, will be towed to the offshore site.
- Several projects dealing with wind resource mapping and micrositing in complex terrain have been approved.

In 2001, in order to assist the development of wind energy in Norway, SINTEF Energy Research, the Institute for Energy Technology (IFE), and the University of Trondheim (NTNU) formed a joint initiative to develop a test station for wind turbines on the midwestern coast of Norway. The test site (VIVA AS) was opened in the summer of 2005 and is now operating. A new 900-kW test turbine has been erected in order to try out the new hydraulic concept of ChapDrive AS. A hydraulic pump is installed in the nacelle and a corresponding hydraulic motor and the generator at the ground level. For more information: www.vivawind.no

The wind/hydrogen demonstration project at Utsira has now been in successful operation for more than four years. The purpose of the project is to demonstrate how renewable energy can provide a safe and efficient energy supply to isolated areas. The system is based on wind energy as the only energy source. Excess power is used to produce hydrogen which is to be used later in a fuel cell. The system was developed and is operated by StatoilHydro ASA. The company has decided to continue the project and improve the system to provide a basis for commercialization.

The Norwegian Water Resources and Energy Directorate (NVE) and Enova SF have conducted studies on the resource

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potential for offshore wind off the coast of Norway. The studies show a total theoretical potential annual wind resource of 14,000 TWh along the Norwegian coast. Only sea areas from the shoreline up to water depth less than 300 m are included in this potential. The studies document resource variation geographically along the coastline as well as seasonal variation of the wind speed over the year.

A computer based dataset representing the wind regime during the past 30 years has been developed. The data will be compared with the hydrologic data to study integration of wind power and hydropower. The Norwegian energy supply system is largely dependent on hydropower, however, this 122 TWh/yr system is vulnerable to annual variations in precipitation and to prolonged droughts despite its 87 TWh reservoir capacity. An increasing share of wind power promotes interest in the integration of wind power and hydropower, because both resources are naturally intermittent. The question is whether the two can be complementary and improve overall performance, or whether, they tend to increase the problems of energy supply when combined. The latter eventuality can be the case if drought years generally coincide with periods of low mean wind speed. Wind power

development has been slow in Norway recently due to low electricity prices, low support system, and increasing construction costs. As a result, pressure for large-scale integration of wind and hydropower has been low. With a new strategy for large-scale wind development, the wind-hydro integration study will be more important to implement. We therefore expect the activities to grow in 2009.

6.0 The Next Term

At the end of 2008, no wind development projects were under construction. Two projects have received grants and new wind capacity of 100 MW is expected to come into operation within one or two years.

During 2009, a complete Norwegian Wind Atlas (Onshore and Offshore) will be further developed and updated. So far the wind resources along the coastline have been mapped where most of the resources are located, but it now turns out that there are also large wind resources in the inland areas. The country's wind resources estimate figures will be revised after the new investigation.

Author: Knut Hofstad, Norwegian Water Resources and Energy Directorate, Norway.

1.0 Introduction

Due to its location, Portugal has several valuable renewable resources for electricity production. It has a high level of solar radiation, moderate wind resource, and considerable vegetable and animal biomass potential. Ocean and hydro resources are also present, mainly the latter—although its major development took place in 2006 with the construction of large hydraulic power stations. Wave energy systems are now under development; the PELAMIS project, the first of its kind, is installed and has been functioning since the beginning of 2008.

Nevertheless, Portugal still depends greatly on foreign countries for oil, gas, and coal resources, but it is taking large steps toward sustainable renewables-based electricity generation. Government and competent authorities established several measures in recent years that created incentives to install renewable energy systems and created the conditions for economic development in the energy sector.

Regarding renewable energy systems, at the end of 2008 Portugal had about 8,151 MW capacity (1), corresponding to an estimated energy production of about 23,179 GWh. This production constitutes 43.3% of national electricity demand. However, this represents a 9% decrease in production compared with 2007, largely due to the decrease hydropower production. The goals defined for 2010 and 2013—that 39% and 45%, respectively, of the national electricity demand be generated from RES—are within reach. Wind generation at the end

of 2008 was about 11% of the total national electrical demand—50.6 TWh (2).

Also, use of renewable sources for micro generation of electricity is growing and as a result of legislation published at the end of 2007 (Dec. Law 363-2007, 2 November). The public in general has responded in large numbers to the initiatives and the programs that followed. By the end of 2008, 5,768 license requests had already been granted and registered on the web site of CERTIEL (3), the governing agency, corresponding to 19,772 kW of capacity. Of these registered systems, 7,137 kW are ready for inspection and about to start production (4).

2.0 Progress Toward National Objectives

During 2008, moderate steps toward accomplishment of national objectives took place. At the end of the year, renewable energy generation capacity was 8,151 MW. Hydro systems experienced a decrease in output of about 15% compared with the previous year (Figure 1). Biomass decreased slightly, whereas wind and photovoltaic (PV) systems have increased somewhat compared with the previous year. In 2008, the first PV park was connected to the electric grid. Although total PV installed capacity has grown about 60% since 2001, it is still a small part of total renewable sources (0.3% of production compared with other renewables technologies).

Table 1 Key Statistics 2008: Portugal

Total installed wind generation	2,819 MW
New wind generation installed	694 MW
Total electrical output from wind	5.737 TWh
Wind generation as % of national electric demand	11%
Target:	3,750 MW by 2010 5,100 MW by 2013

National Activities

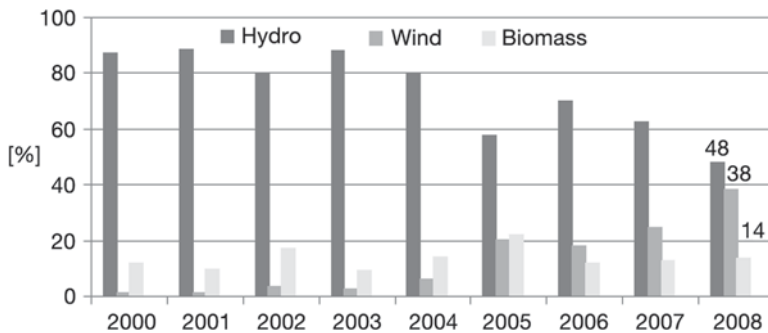


Figure 1 Evolution of the production from each renewable technology, in comparison with the overall production of renewable energy systems.

At the end of 2008, about 2,819 MW of wind energy capacity was installed, an increase of 625 MW over 2007 (Figure 2). This is a 33% increase from 2007 to 2008 (Figure 3).

Wind energy production in 2008 was 5,695 MWh in the mainland territory plus 47 MWh in the Madeira and Azores archipelagos, which together could meet about 11% of total national demand (Figure 4).

Most of the installed wind parks have capacity greater than 50 MW (Figure 5a). Figure 5b classifies wind parks in terms of production hours at full capacity.

As shown in Figure 6, the projected increase in capacity through 2010 assumes the complete fulfillment of Portugal's wind power goals under the 77/2001/EC Directive for Renewable Energies.

During 2008, the mean wind speed was above the average of the previous 10 years, representing a wind index of 1.05 for the coastal region and 1.03 for the mountainous region of mainland Portugal (Figure 7). For the Azores and Madeira archipelagos, this value is not yet available.

The increase in wind capacity occurred mostly in the northern region of the country and also in the Azores (4.5 MW). Figure 8 shows the capacity distribution by district in mainland territory.

The north of Portugal is characterized by higher values of wind energy potential. Consequently, and also due to the availability of transmission lines to collect the generated electricity, wind parks are concentrated in this region. Distribution of installed capacity is shown in Figure 9.

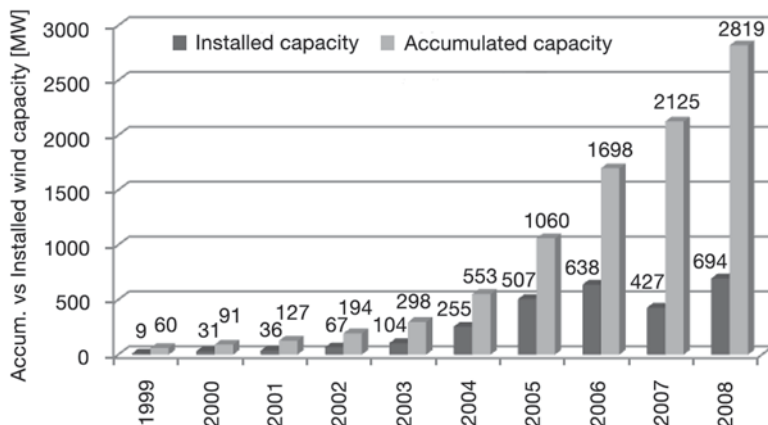


Figure 2 Installed capacity versus accumulated capacity.

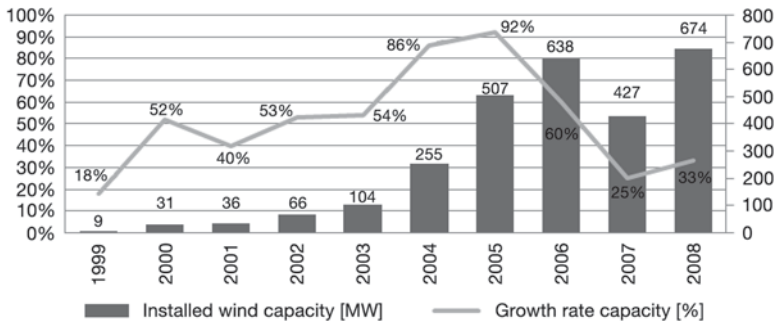


Figure 3 Installed capacity growth rate.

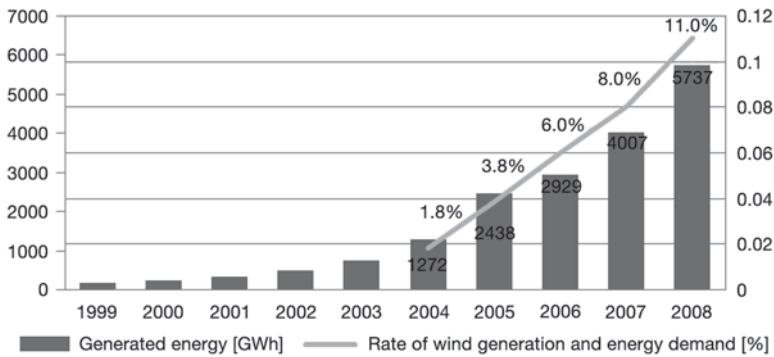


Figure 4 Wind energy generation in 2008.

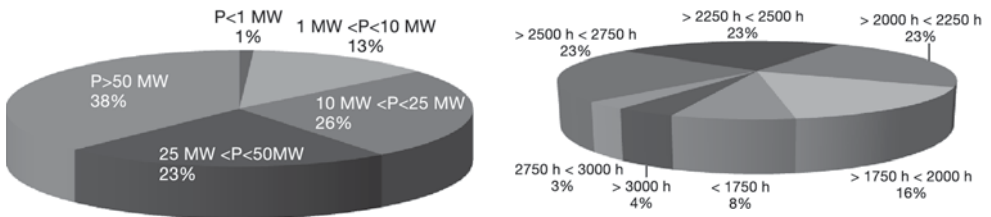


Figure 5 Wind park capacity classification (a) and classification in production hours at full capacity (b).

3.0 Benefits to National Economy

3.1 Market Characteristics

During 2008, the unit cost of wind turbines was estimated to be in the range of 950 to 1,110 €/kW. Cost depends on the turbines' characteristics and/or the country of manufacturer. Contracted O&M is estimated to have averaged approximately 13% or 15% of the investment cost for the past decade of wind power plant operation.

Interest in the renewable energy sector is still increasing in Portugal. Several companies in this sector have been created, some of them focused on implementing microgeneration systems for domestic use. This growth has led to considerable job creation in the sector and formation of multiple opportunities to expand the sector.

During 2008, to cooperate in reaching European objectives to reduce greenhouse

National Activities

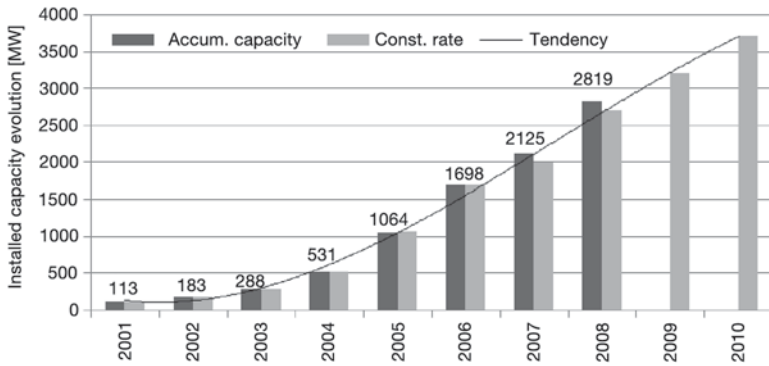


Figure 6 Installed wind capacity evolution from 2001 to 2010.

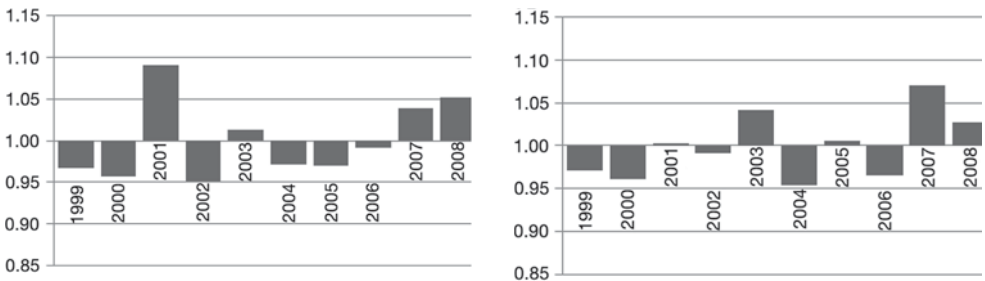


Figure 7 Wind index for (a) coastal and (b) mountainous regions of mainland Portugal.

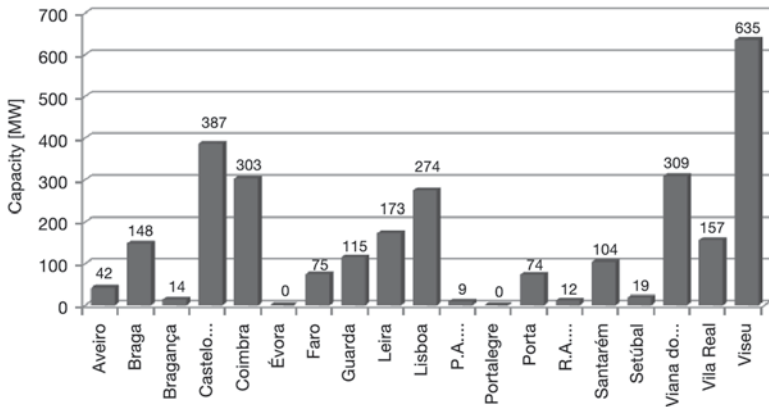


Figure 8 Installed capacity distribution by district.

gas emissions and move toward renewable energy use, the new microgeneration legislation published in 2007 (Dec. Law 363-2007, 2 November) was applied. This legislation's main objective is to simplify the licensing process for potential

microproducers/consumers through Internet registration and licensing.

Application of the law began in April 2008 with the first call to register microgeneration systems. By the end of February, of the 25 MW registered, 5 MW

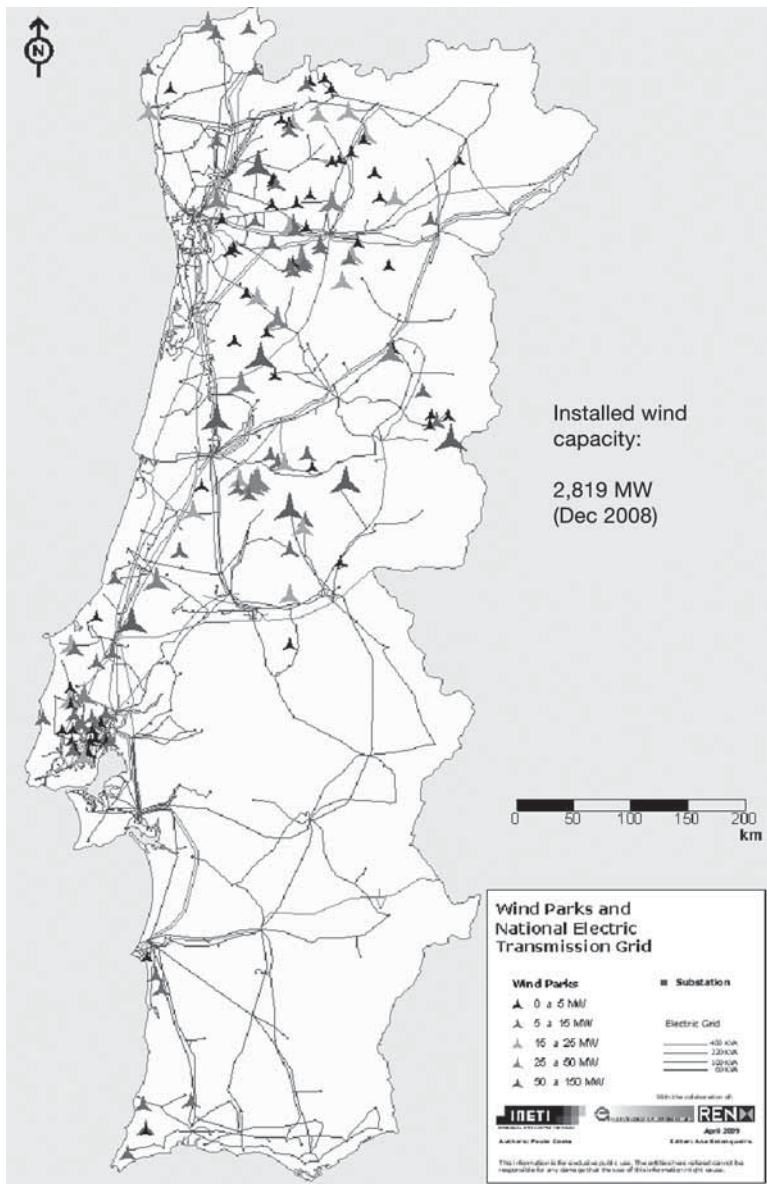


Figure 9 Wind capacity installed in mainland Portugal, showing location of wind parks and transmission network.

were already awaiting inspection. The Portuguese government's goal for 2010 is to have at least 165 MW of these small systems installed, assuming a growth rate of 20% per year.

Although application of the new legislation has been a success so far, more

homeowners that have become energy producers are choosing PV over small wind turbines. This is somewhat surprising considering that the financial incentives are similar (or even better for wind) and the wind resource is quite good in some urban areas.

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In the offshore wind sector in 2008, some companies examined more areas, looking for high-potential zones where offshore turbines could be used. Some companies are now conducting experiments to study the project's viability (energetic and economic).

3.2 Industrial development and operational experience

During 2008, more than 363 wind turbines were installed with an average nominal power of 1.9 MW (1). ENERCON remains the manufacturer with the largest market share in the Portuguese wind power industry. This wind turbine manufacturer, as well as Repower, produces relevant components for wind turbines in the Portuguese territory. The distribution of installed capacity by manufacturer is shown in Figure 10.

The wind power sector already plays an important role in job creation in Portugal and promises to continue to do so in coming years. This job creation has been particularly relevant in the interior regions (remote areas), since, as with most other European countries with large wind development, specialized workers for new developments, such as engineers, are becoming hard to find.

3.3 Economic details

In Portugal, environmental regulators are very rigid about wind energy and prefer large wind turbines (>1,500 MW) over the smaller ones. Also, the very complex orography that characterizes mainland Portugal

and the fact that most of the suitable sites for wind energy exploitation are already taken and/or under contract leads to the installation of turbines with high rated capacity.

The total wind farm installation costs are estimated between 1,200 and 1,400 €/kW, and annual maintenance is estimated to be between 17 and 19 million €/MW/year.

Concerning tariffs for renewable energies, in 2007 no new legislation was published regarding conventional wind parks. Dec. Law 33-A/05 is used to define which tariffs to apply in the operating projects. Also the price for energy remains unchanged since 2006 (Figure 11) for wind parks with connection permits granted before 2005.

For micro generation, and considering the new legislation being implemented there are two types of regime: general and special. In the general regime, 5.75 kW is the maximum capacity possible to install, and the tariff is equal to the cost of electricity sold under the purchasing contract. In the special regime ("additional benefits"), microproducers can install a maximum capacity of only 3.68 kW. However, to have access to these benefits, single houses must have a 2-m² installation of solar collectors, and condominiums must have an energetic certification. The reference tariff is guaranteed for the first five years following the installation. It is defined as 650 €/MWh for the first 10 MW installed, and it decreases 5% for each additional 10 MW registered in the Registration System of Microproducers (SRM) per year (Figure 12). The amount of the reference tariff depends on the renewable energy technology used. It is

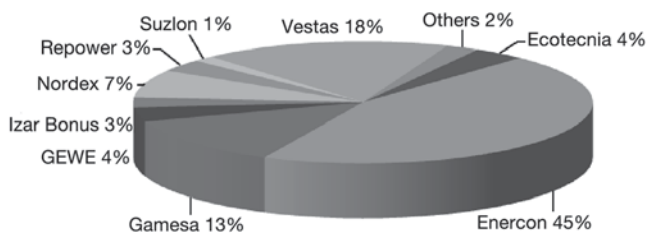


Figure 10 Distribution of installed wind capacity by manufacturer.

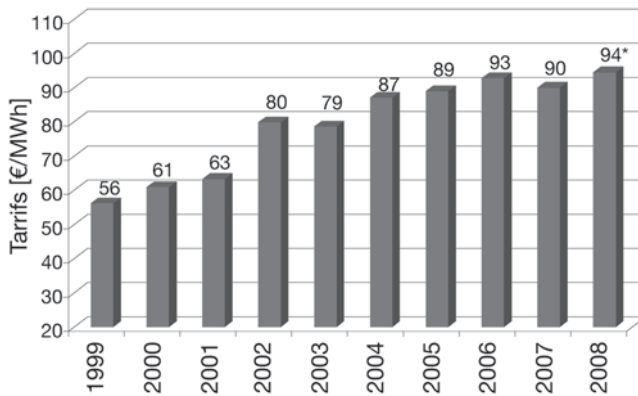


Figure 11 Tariff evolution for wind parks 199-2008.

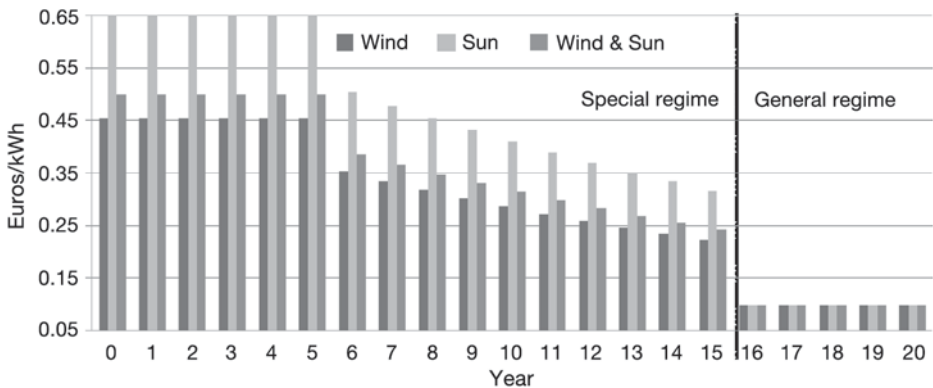


Figure 12 Tariff evolution in the project lifetime for microgeneration systems.

100% for solar, 70% for wind, and 30% for hydro, cogeneration, biomass, and others.

4.0 National Incentive Programs

During 2008, small changes in national incentive calls took place. The QREN financing program was opened in November 2008, in which several scientific and technological areas were under evaluation, including energy renewable systems. A financing call for R, D&D projects was also opened at the end of 2008 by the Portuguese Science and Technology Foundation (FCT), covering a huge variety of areas.

Several projects financed by the European Union Seventh Framework Programme (FP7) kicked off during the

summer of 2008. Portuguese institutions, including Instituto Nacional de Engenharia, Tecnologia e Inovação (INETI), are participating in the five-year project NORSEWInD (Northern Seas Wind Index Database, EC FP7-2008) to run from 2008 to 2013. Another relevant governmental financing program, PRIME/MAPE, was released in 2008 with funds covering 1,533 MW of wind park capacity.

5.0 R, D&D Activities

5.1 National R, D&D Efforts

In Portugal, many R, D&D groups are housed in academic and/or research institutes and financed by research projects included in international, European, and

National Activities

national programs. The R, D&D development is growing slowly with the continuing participation of wind energy developers and consultancy entities in academic projects, especially those related to doctoral and postdoctoral projects.

Wind energy R, D&D activities are mainly being developed in the regions of Oporto and Lisbon. In the north region of Portugal, the main institutes are the Faculty of Engineering of the University of Porto (FEUP) through the Research Centre for Wind Energy and Atmospheric Flows (RCWEAF) and the associated laboratory INESC-Porto (Computers and Systems Engineering Institute of Porto), which is part of the research network established by the Portuguese Foundation for Science and Technology (FCT).

The most active public R, D&D organizations in wind energy research and technology is INETI, a part of the Ministry of Economy and Innovation, located in Lisbon's region and financed partially by the national government and wind energy companies (consultancy contracts).

The main R, D&D projects under way in Portugal include the following:

- ANEMOS plus (EC) – INESC Porto;
- Cup anemometer correlation with wind satellite data for offshore purposes (input to NORSEWInd, EC FP7-2008) – INETI;
- Applying research on the use of hydro storage as regulation for excess wind production – INESC Porto;
- Remote control of wind park clusters using DSO by TSO request – Several wind energy developers;
- Using wind turbine as FACTS – INESC Porto;
- TURBan 2.5-kW small wind turbine project (national project financed by DEMTEC (70/0201) that consists of the development of two prototypes of small and low-cost turbines for urban use) – INETI.

In 2008, Portugal achieved some milestones. It became the first country with a wave farm (the Aguçadoura Wave Farm), had several multi-megawatt photovoltaic plants installed, and had its highest increase in wind power capacity to date.

The Aguçadoura Wave Farm, the first commercial-scale farm in the world to take advantage of wave energy, is located 5 km off the coast near Póvoa de Varzim in the north of Portugal. It is composed of three PELAMIS wave energy converters. The farm was commissioned and operated during the summer and autumn of 2008, producing power and transferring it to the Portuguese national grid. This project was conceived by the Portuguese renewable energy company Enersis, which developed and financed it. In 2008, the Aguçadoura Wave Farm had an installed capacity of 2.25 MW, enough to meet the average electricity demand of more than 1,500 Portuguese homes. In its second phase the installed capacity will be increased from 2.25 MW to 21 MW using an additional 25 PELAMIS machines (Figure 13).

During 2008, Portugal also inaugurated several solar PV power plants (Figure 14). The world's third largest PV plant is near Moura, a southern Portuguese town, with an installed capacity of 46.41 MW, distributed by 2,520 azimuthal trackers, each one equipped with



Figure 13 The front of the PELAMIS machine at the Aguçadoura Wave Park with the city of Póvoa de Varzim in the background (5).

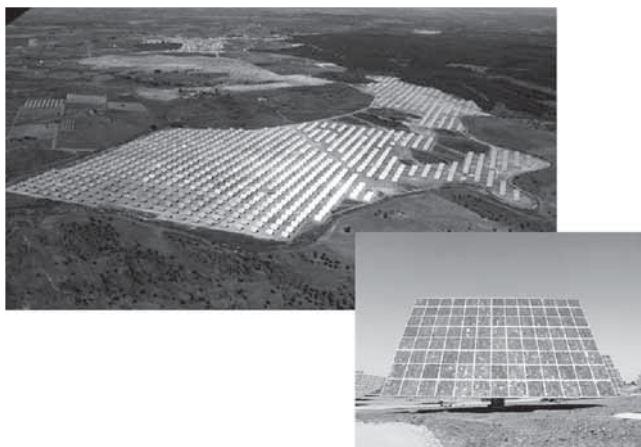


Figure 14 Solar photovoltaic central in Moura, south interior of Portugal (6).

104 solar panels. This plant will also include a research center.

In 2008, several wind parks were installed in Portugal, among them Europe's biggest onshore wind park, installed in the northern region of Viana do Castelo. This wind farm has 120 wind turbines (Figure 15).

5.2 Collaborative research

In 2008, the TURBan project, carried out by the INETI, continued. The small wind turbine prototype with horizontal axis

completed the testing phase, and industrial manufacturing for commercial launch was about to start. Portuguese manufacturers will contribute most of the components. Another small wind turbine was developed according to the second phase of the TURBan project with a vertical rotation axis (VAWT) (Figure 16). This turbine, with 2 kW of rated power, has very high performance unique in its class and is currently undergoing testing.

NORSEWInD was created to address the shortage of offshore data for the wind



Figure 15 Europe's biggest onshore wind park in the northern region of Viana do Castelo, Portugal. Photograph: Estela Silva/EPA.

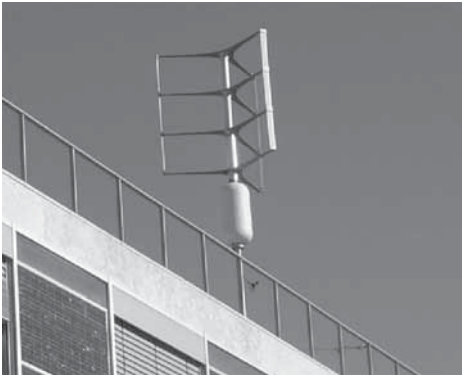


Figure 16 The TURBan 2-kW vertical-axis prototype, developed by INETI. Photograph: INETI.

industry. Offshore wind is an expensive business, with a real problem in obtaining easily available high-quality datasets suitable for project decision making. This project will use new techniques to acquire physical data offshore for the wind industry. In early August 2008, the NORSEWInD project, with which INETI is involved, officially kicked off. NORSEWInD is made up of 15 organizations and is financed by the European Community under the Seventh Framework Programme. The project will develop high-quality wind atlases to the North, Irish, and Baltic seas. It will use, among other data sources, the anemometer station of Berlenga Island, operated by INETI, to validate methodologies for its atlas. This project will create one of the biggest dedicated instrumentation networks to acquire wind speed data offshore.

Also, new sites for offshore measurements are already under study along the Portuguese coast using contracts with Portuguese wind energy companies.

6.0 The Next Term

During 2008, the Portuguese Wind Atlases (onshore and offshore) will be further

developed and updated. The onshore atlas will incorporate detailed data at the municipality scale and apply methodologies that will be useful in several foreign countries, especially those in Africa and Eastern Europe. The offshore wind atlas project will also be continued. It will include the data obtained in the measurements campaign of 2007 and will study new methodologies for offshore resource assessment.

The urban wind energy sector is now a high priority, representing a new business opportunity for the wind energy sector. This opportunity demands new methodologies for urban wind resource assessment. It also requires continued development of simple methods to reliably estimate wind energy production in very complex terrain. These are good prospects for R, D&D during 2009.

It is expected that in 2009, offshore wind feasibility studies will begin with measurements in the sea along the Portuguese Atlantic Coast.

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

1.0 Introduction

Installed wind capacity in Spain reached 16,740 MW in 2008 with the addition of 1,609 MW, according to the Spanish Wind Energy Association's Wind Observatory. The wind sector expected this growth after the 3,500-MW increase in 2007, a special year in which companies made an effort to start up the greatest number of wind farms so they could benefit from the previous support system. The total of 16,740 MW establishes Spain as the third country in the world in terms of installed capacity and will allow the 2010 objective (20,155 MW set by the Renewable Energies Plan 2005–2010) to be reached.

The addition of 1,609 MW in 2008 is an increase of 10.63%, the third highest increase in absolute terms in the short history of wind energy in Spain. The only higher annual increases were in 2007 (3,505 MW or 30%) and 2004 (2,297.51 MW or 37%).

Electrical energy demand in 2008 was 266,485 GWh, a growth of 1.21% over 2007. Wind energy met 11% of this demand and was the fourth largest contributing technology in the generation system, besting hydropower (7% of demand). The other contributors to the system were gas combined-cycle power plants (32% of total demand), nuclear power plants (20%), and coal power plants (16%). Figure 1 shows how electricity was generated in Spain during 2008.

On several occasions in 2008, wind energy covered more than 40% of hourly

demand, and for several days it supplied more than 30% of daily electricity demand.

For instance, on November 24, wind energy supplied more than 35% of the total electricity demand (Figure 2). And on several occasions, production of wind energy reached more than 40% of hourly demand.

Wind energy in Spain has also emerged as a driving force for industrial development. In 2008, investment was more than 2,250 million €, and about 50% of Spanish wind energy equipment production is dedicated to the export market. According to the "Macroeconomic Study on the Impact of the Wind Energy Sector in Spain," the number of jobs related to wind power reached more than 40,000 in 2008. Of this total, the number of direct jobs in operation and maintenance of wind farms, manufacturing, assembly, research, and development is estimated at more than 21,800. The number of indirect jobs (linked mainly to components) is estimated to be more than 17,000.

Finally, it is important to point out the significant efforts of the industrial sector and the system operators to implement the new Grid Code (P.O.12.3). Due to their coordinated efforts, the impact of wind energy on system operation is smaller than expected. The regulatory systems have been able to regulate and optimize system management at very low cost.

Total installed wind generation	16,740 MW
New wind generation installed	1,609 MW
Total electrical output from wind	31.1 TWh
Wind generation as % of national electric demand	11.5%
Target:	20,155 MW by 2010
Source: AEE (Spanish Wind Energy Association) and REE (Spanish Transmission System Operator)	

National Activities

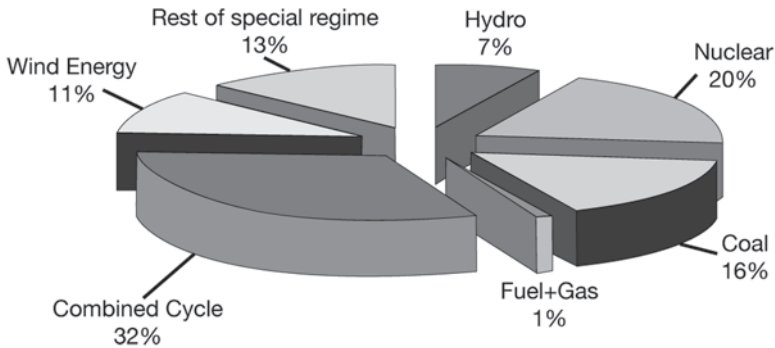


Figure 1 Electricity generation system in Spain, 2008. Source: REE

2.0 Progress Toward National Objectives

The present objectives for 2010 for the promotion of renewable energies are contained in the Spanish Renewable Energy Plan 2005–2010 (PER) (1). This plan is a revision of the previous version completed in 2002. The aim of this revision was to maintain the commitment to meet at least 12% of total energy use from renewable sources by 2010. It also incorporates other indicative targets (29.4% of electricity generated from renewable sources and 5.75% of transport fuel from biofuels).

For the wind energy sector, the PER objective implies reaching a capacity of

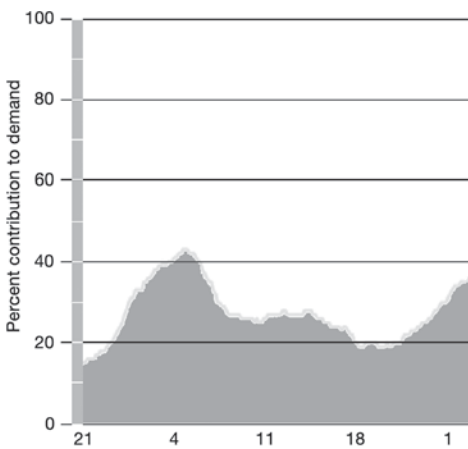


Figure 2 Coverage of electricity demand by wind power production on November 24, 2008. Source: REE

20,155 MW by the end of 2010. The 1,609 MW installed in 2008 confirms that the sector is strong and that this growth will be maintained or will increase in the next two years, reaching the total of 20,155 MW fixed as the objective according to PER.

Figure 3 shows the annual cumulative wind capacity and the PER objectives for 2005 to 2010.

The strength of the wind energy sector and its continuous growth have created the expectation of new targets for the next term. There is consensus for fixing a new target of 40,000 MW by 2020. The installed wind power in Spain during 2008 implies a growth rate of 10.63%, as shown in Figure 4.

The majority of the Autonomous Regions (that are responsible for regulating wind installations) have their own specific objectives, which reached a total value of 41,000 MW between 2010 and 2020. Local governments see the need for this on the basis of energy planning, local resource use, industrial development, and job creation in their zones (Table 3).

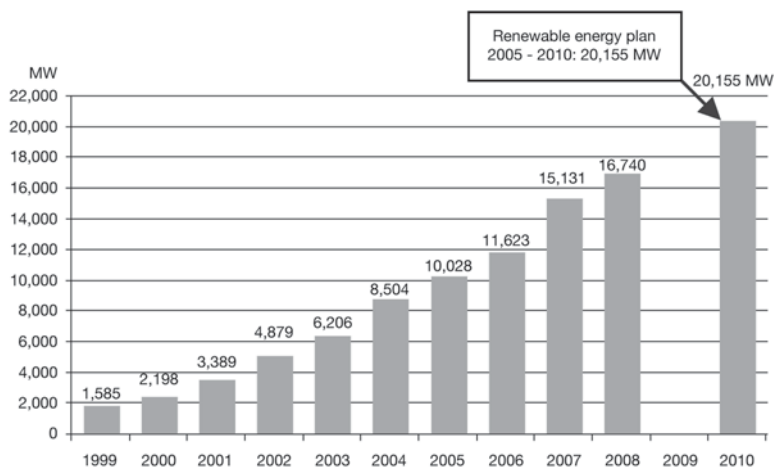
The industrial sector participating in the Asociación Empresarial Eólica, or (Spanish Wind Energy Association) has established a new objective for onshore of 40,000 MW for 2020 (2). It is conducting studies and developing strategies to reach that goal.

Finally, the management and planning of the new Spanish target is designed to fulfill the new European Union objectives

Table 2 Current and expected employment created by the wind sector in Spain.

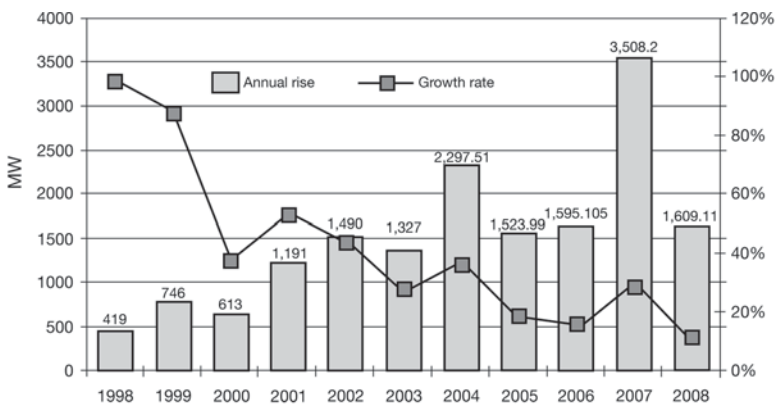
	2008	2010	2012
Direct employment	21,824	26,950	31,184
Indirect employment	17,307	21,371	24,728
Total employment	39,131	48,321	55,912

Source: AEE



Source: IDAE, CNE, AEE

Figure 3 Cumulative wind power and objectives for 2010.



Source: AEE

Figure 4 Annual growth of installed wind power.

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Table 3 Wind power capacity by Autonomous Regions

CCAA	Potencia Instalada a 01/01/2009	Limites Estudios zonales (MW)	Puesta en servicio + autorizada CCAA (MW)	Planes Regionales (MW) (1)	Concursos en Marcha
Andalucía	1,795	3,754	3,487	6,284	500
Aragón (2)	1,749	2,400	1,951	4,000	
Asturias	304	918	819	1,100	
Baleares (2)	4	50	210	210	
Canarias (3)	134	344	440	1,025	440
Cantabria	18	400	32	300	1,100
Castilla León	3,334	4,375	6,488	6,625	
Castilla La Mancha	3,416	3,990	3,324	4,100	
Cataluña	420	1,460	1,248	3,500	
Extremadura (2)	0	225	501	400	
Galicia	3,145	3,438	2,950	6,500	2,325
Madrid (2)	0	50	0	200	
Murcia	152	538	411	850	
Navarra (2)	959	1,400	922	1,536	
La Rioja (2)	447	500	448	665	
C. Valenciana (2)	710	1,600	2,300	3,500	250
Pais Vasco (2)	153	250	145	624	256
TOTAL	16,740	25,692	25,676	41,419	4,871

(1) Potencia eólica instalada prevista por las CCAA, cada comunidad tiene un objetivo temporal distinto
(2) Al no disponer de estudios zonales, se aplica el criterio PER
(3) Puesta en servicio + autorizada: Concurso eólico de Canarias
Fuente: AEE, Estudios zonales, Planes regionales

established during 2007—to supply 20% of the primary energy with renewable sources by 2020. Due to the solidity of the wind sector, it is likely that an important amount of the renewable objective will be covered by wind energy.

The installed electrical power capacity in the mainland generation system increased more than 4,200 MW during 2008

and reached a total of 89,944 MW according to the data of Red Eléctrica de España (the Spanish Transport System Operator [TSO]) (3). Wind power, solar technology, and combined cycle are the technologies that contributed to this growth.

With more than 16,740 MW of wind power installed, there are nowadays more than 16,800 turbines operating in Spain.

They are grouped among 733 wind farms. The average size of an installed wind farm in 2008 was 24 MW. Wind energy is present in fifteen of the seventeen Spanish Autonomous Community (SAC). The SAC Castilla-La Mancha has the most installed power among them. The region's capacity breakdown shows that Castilla-La Mancha keeps its leadership with 3,415.61 MW (273.25 MW added in 2008), but the biggest growth in absolute terms is in Castilla y León, with 518.69 MW; that amount put this SAC in second place with 3,334.04 MW, ahead of Galicia (which ranked first two years ago), which had 3,145.24 MW.

In percentages, Comunidad Valenciana has experienced the biggest growth, with 27.66%. With the 154 MW installed in 2008, it has reached 710 MW. Comunidad Valenciana is followed by Andalusia, which

grew 24%, adding 349 MW to reach a total of 1,795 MW. This places Andalusia ahead of Aragón, which is fourth with 1,749 MW. Only two SACs, Extremadura and Madrid, have not yet installed any wind power capacity. However, they have advanced projects and regulation to start wind energy activities. It should be noted that unlike many other countries with significant wind development, Spain has increased its distribution throughout the country. Table 4 and Figure 5 show wind energy development and annual growth by SAC.

Use of wind power has lowered CO₂ emissions by about 18 million tons just during 2008. Furthermore, wind generation has saved up to 6 million tons of conventional fuels. Wind production has supplied the electrical consumption of more than 10 million households.



Figure 5 Wind capacity distribution in Spanish Autonomous Communities, January 2009. Source: AEE.

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Table 4 Wind Power Growth by Spanish Autonomous Communities				
CCAA	Accumulated at 01/01/08	In 2008	Accumulated at 01/01/09	Growth 2008/2007 %
Castilla-La Mancha	3,142	274	3,415.61	8.70%
Castilla y León	2,815	519	3,334.04	18.40%
Galicia	2,973	172.45	3,145.24	5.80%
Andalucía	1,446	349.45	1,794.99	24.17%
Aragón	1,719	30	1,749.31	1.73%
Navarra	952	7	985.77	.69%
Comunidad Valenciana	556	154	710.34	27.66%
La Rioja	447	0	446.62	0%
Cataluña	343	77	420.444	22.42%
Asturias	276	28	304.30	10.13%
País Vasco	153	0	152.77	0%
Murcia	152	0	152.31	0%
Canarias	134	0	134.09	0%
Cantabria	18	0	17.85	0%
Baleares	4	0	3.65	0%
Extremadura	0	0	0	0
Madrid	0	0	0	0
TOTAL	15,131	1,609	16,740	11%
Source: AEE				

3.0 Benefits to National Economy

3.1 Market characteristics

The number of installations during 2008 demonstrates the maturity of the wind industry, which has been able to increase despite worldwide difficulties with the supply of wind turbines and components. Installing and operating wind plants to cover 11% of the Spanish electrical demand implies a huge accomplishment by the developers and manufacturers.

In 2007, there was a tendency to consolidate big wind energy holdings. The largest Spanish developers had accumulated most of the wind farms

connected to the grid during 2008 and some medium size companies were being acquired by the big ones.

In the ranking of wind farm owners, Iberdrola Renewables, the largest Spanish utility, has the largest accumulated capacity (4,602.35 MW) thanks to the addition in 2008 of 305.10 MW. Acciona is still in second place with an accumulated capacity of 2,698.84 MW. The most new capacity (321.50 MW) was added by ECYR (ENDESA), the company that owns a total accumulated capacity of 1,640.94 MW. Several other organizations have installed wind power capacity during 2008. For instance,

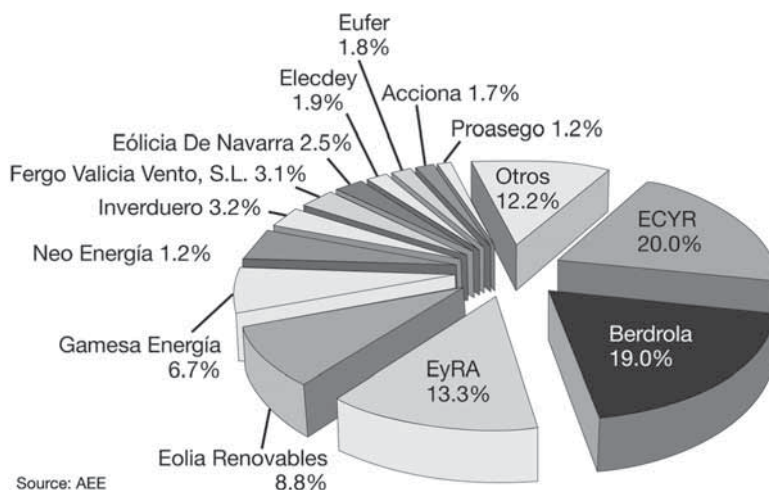


Figure 6 Installed wind capacity in 2008 by developer.

Energías y Recursos Ambientales (EyRA) installed 213.68 MW and reached the sixth position with 495.68 MW. Eolia Renovables installed more than 141 MW, supplying 8.8% of installed capacity.

Figure 6 shows the percentage of new capacity supplied by each developer.

3.2 Industrial development and operational experience

Gamesa installed more than 50% of new capacity (Figure 7), according to the Spanish Wind Energy Association's Wind Observatory, with more than 9,480 MW (including the subsidiary company MADE) in Spain,

which consolidates its leadership among manufacturers. VESTAS, the second largest manufacturer, installed more than 15% of new capacity in 2008, adding 242.2 MW. Figure 8 shows the distribution of accumulated wind capacity by manufacturer.

The number of wind turbines in Spain increased by more than 890 in 2008, and the total number of turbines is more than 16,000 units. The average size of a wind turbine installed in 2008 was 1.6 MW.

Wind turbines operating in Spain show important seasonal behavior, as shown in Figure 9. Total electricity generated by wind farms was more than 31,100 GWh, and the

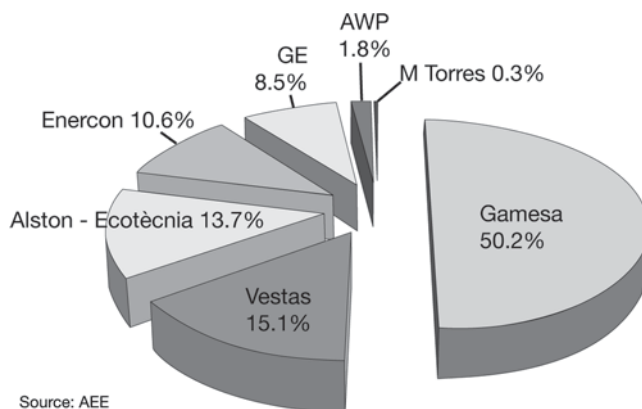


Figure 7 Installed wind capacity in 2008 by manufacturer.

National Activities

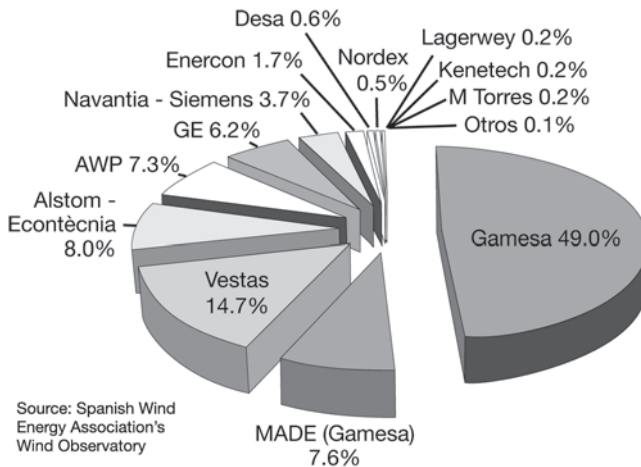


Figure 8 Accumulated wind capacity by manufacturer at the end of 2008.

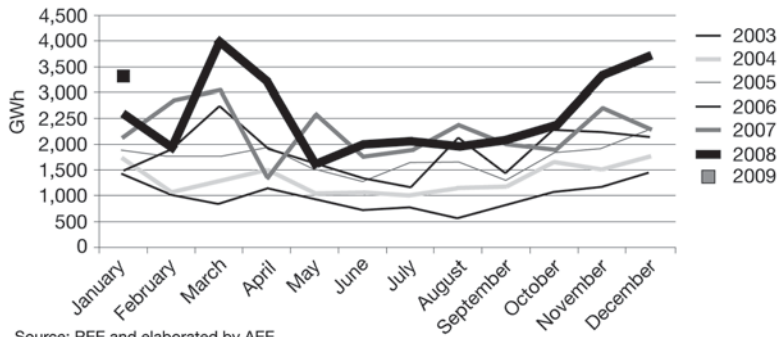


Figure 9 Electricity generated by wind, 2003 to 2008, monthly distribution.

equivalent hours at rated power were slightly higher than 2,000 hours for most of the wind farms. On 18 April 2008, new historic highs in wind power were recorded: 10,879 MW of instantaneous power, 10,727 MWh of hourly wind power, and 213,169 MWh of daily wind power (28.2% of the electrical demand for that day). On 24 November, instantaneous wind power production supplied 43% of total demand.

3.3. Economic details

The increasing use of large wind turbines (2 MW of nominal power), the increasing prices of raw materials, the shortage of main components, and the excess demand for wind turbines have increased prices

for wind generators. The average cost per kilowatt installed during 2008 in Spain was about 1,400 €/kW.

4.0 National Incentive Programs

The promotion of renewable energies has been a stable national policy for several years. All political parties have similar policies regarding support of renewable energies. The main tools within this policy at a national level are:

- A payment and support mechanism enacted by the Parliament through Electric Act 54/1997: Producers of renewable energy sources are entitled to connect their facilities and transfer the power to the system through the

distribution or transmission grid and receive remuneration in return.

- The Renewable Energy Plan, including midterm objectives for each technology (PER 2005–2010), and the tariff scheme are guaranteed until the fulfillment of targets.

- Royal Decree (RD) 661/2007 regulates the price of electricity from renewable sources in Spain. The new regulation has been in force since June 2007. Wind farm installations governed by previous regulations (RD 436/2004) had until January 2009 to decide whether they would continue to follow RD 436 or choose the new RD 661/2007.

To facilitate the integration of wind energy into the grid, supplemental incentives are based on technical considerations (reactive power and voltage dips). These incentives apply only for the existing wind farms; after January 2008 it is mandatory to satisfy Grid Code P.O.12.3).

Payment for electricity generated by wind farms in Spain is based on a feed-in tariff. The owners of wind farms have two options:

- A regulated tariff scheme: payment for electricity generated by a wind

farm is independent of the size of the installation and the year of start-up. For 2009, the value is 78.183 €/MWh; the update is based on the Retail Price Index minus an adjustment factor.

- A market option: payment is calculated as the market price of electricity plus a premium, plus a supplement, and minus the cost of deviations from energy forecasting. There is a lower limit to guarantee the economic viability of the installations and an upper limit (floor and cap). For instance, the values for 2009 are: reference premium 31.2 €/MWh, lower limit 76.98 €/MWh, and upper limit 90.7 €/MWh. The price of wind electricity versus the market price is shown in Figure 10.

The feed-in scheme will be valid until fulfillment of the PER objective (20,155 MW) in 2010. An additional 2,000 MW are considered for repowering wind farms built before December 2001, and an extra bonus of 70 €/MWh is considered.

The market price of electricity in Spain during the past several years is shown in Figure 11. In 2008, the electricity price reached 64.4 €/MWh.

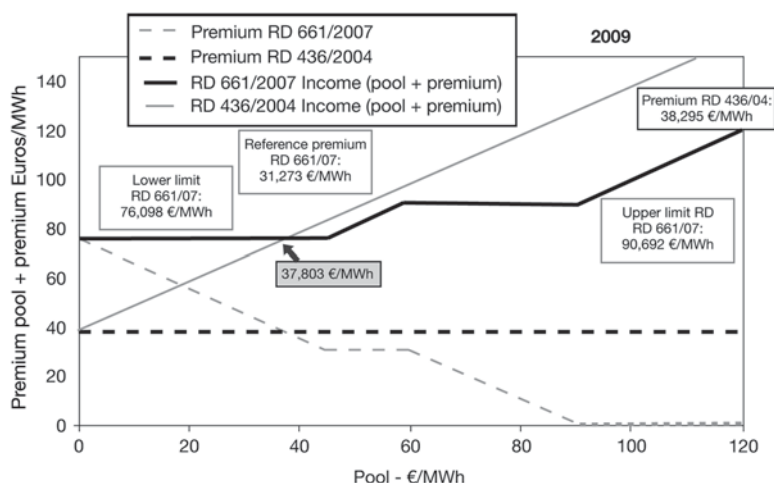


Figure 10 New regulations for payment of electricity from wind plants, values for 2009.

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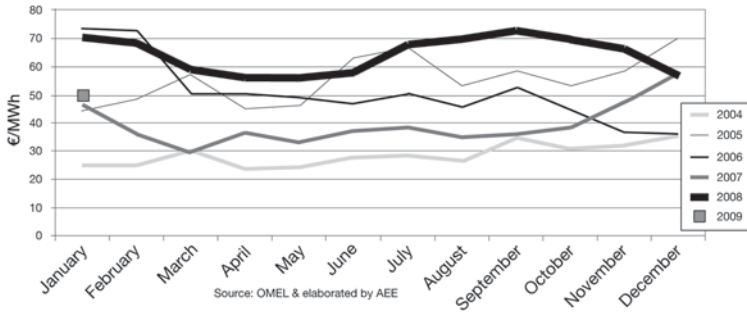


Figure 11 Evolution of electricity prices in Spain, 2004 to 2008.

5.0 R, D&D Activities

A new R&D plan was developed in 2008. This plan covers 2008 to 2011 for the R&D and technological program prepared by the Spanish national government. It is based on the national science and technology strategy instead of thematic areas as in previous calls.

The ongoing PER 2005–2010 is making an exhaustive analysis of the technological innovation required to achieve its objectives. In the case of wind energy, the Spanish priorities are to make efforts leading toward the following goals:

- Develop advanced systems to control the quality of the power fed into the grid,
- Develop wind turbines with unit power outputs of more than 2 MW,
- Adapt high-capacity wind turbines to the more demanding technical requirements of offshore applications, and
- Implement demonstrations of offshore wind farms.

Within the basic research activity drive by the General Sub-direction for Research projects of the Science and Innovation Ministry, many projects have been proposed for the different Subprograms of the National R&D Plan:

- Subprogram of fundamental research projects (not oriented).
- Subprogram of fundamental research projects oriented to knowledge transfer.

- Subprogram of complementary actions for non-oriented fundamental research projects.
- Assistance for development and reinforcement to Results Research Transfer Offices.

It is important to highlight that most of the projects presented to this solicitation were focused on grid integration and control issues. During 2008 the following projects were approved:

- Study of the effect of grid voltage sags on the operation of wind turbines. Leader: Polytechnic University of Catalonia.
- Wind farm with synchronous wind turbines connected in unity generation. Leader: University of Malaga.
- Stabilization of wind farms by the implementation of biomass plants. Modeling, simulation, and analysis of the techno-economic viability of this kind of hybrid system. Leader: Polytechnic University of Valencia.
- Development of advanced control techniques to improve the integration of wind energy converters into electrical distribution networks. Leader: University of Alcalá de Henares, Madrid.
- Maximization of wind energy penetration in the electrical system by the participation of auxiliary services of the grid and the contribution to dynamic stability. Leader: University Carlos III, Madrid.

- Improving the stability of the electrical grid by the application of FACTS based on wind energy generators.

Leader: Polytechnic University of Catalonia.

- Development of distributed measuring solutions for industrial monitoring based on the use of smart-sensor networks. Leader: University of Valencia.

The CENIT program carried out by the Center for Industrial Technological Development (CDTI) from the Ministry of Industry and Energy is another effort to increase R&D activities. It is a Spanish-government project aimed at increasing investment in R&D for both public and private initiatives over the next few years, with the objective of reaching 2% of GDP. The program started in 2006 and so far two projects have been approved: Windlifter 2015 and Eolia.

Windlifter 2015 is an industrial research project led by Spanish turbine manufacturers Gamesa and Ecotecnia. Its objective is to keep Spain at the cutting edge of wind power technology. Specifically, the project involves the design of new high-power machinery. Windlifter 2015 has received a grant of 13 million €, almost half of the 28.5 million € estimated total investment required. The project's objectives are the following:

- Improve the design process of future turbines, reducing time to market and increasing maturity of the first series, considered vital to leading the market as of 2012;
- Boost Spanish-owned enabling technologies;
- Create a holistic simulation model that reproduces as faithfully as possible the behavior of future turbines and determines the effect of new configurations, new enabling technologies, and other factors on turbine performance;
- Deploy several midsize technological-scientific infrastructures in Spain that permit experimentation at scales up to 5 MW with complete turbine

prototypes and critical components (generators, gearboxes, converter, chassis yaw, etc.).

Another R&D project financed by CENIT is Eolia, carried out by a consortium of 16 companies led by Acciona Energia. The project has been approved by the CDTI for a grant of 16.7 million €, not quite half the overall 33.9 million € estimated total investment required. Eolia includes 25 research centers and seven private companies subcontracted by the consortium. Its objective is to develop technologies enabling deployment of offshore wind plants in deep waters (over 40 m). The project's research activities integrate a series of technologies, including energy (wind power and other electricity technologies) aquaculture, desalination, construction, naval and marine grid connections, and O&M technologies.

In the Program for the Promotion of Technical Research (PROFIT) the government makes calls for proposals for publicly funded projects aimed at encouraging private companies and other entities to adopt research and technology development activities. The program is in line with the objective established in the National Plan of Scientific Research, Development and Technological Innovation (National R&D and Innovation Plan) 2004–2007, in part dedicated to the promotion of technological research. The National R&D and Innovation Plan 2004–2007 set a series of objectives aimed at contributing to the general development of good relations among science and technology companies. The energy objectives of PROFIT in the energy field are:

- To use R&D to guarantee economically viable and environmentally friendly energy supply, based on efficiency and quality criteria, employing conventional energy sources and introducing technologies to optimize their use, and
- To facilitate scientific and technological resources contributing to the

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efficient and competitive deployment of renewable and emerging energy technologies, together with their improved integration within the electricity system.

During the 2007–2008 period, the following projects were approved:

- R&D project on an innovative foundations solution for deep-sea offshore wind turbines (from 30 to 60 m depth). Leader: Construcciones Especiales y Dragados S.A.
- Development of a pitch rotor control based on hydrostatic transmission. Leader: Hydra-Power S.L.
- R&D on the capacity to use tall buildings as wind energy production sites. Leader: Vallehermoso Promoción.
- Application of nanotechnology to improve the efficiency of wind farms. Leader: Maeco Eólica S.L.
- GAVEGE Project: R&D on a new, improved, and flexible mechanical system for different sizes and types of wind technology components. Leader: Etxe-Tar S.A.
- Development of a new automatic process for manufacturing flanges for the wind sector. Leader: Industrial Barraquesa S.A.
- New line of machines for high precision manufacturing of large-diameter cylindrical components for use in the aeronautical, wind, naval, and energy generation sectors. Leader: Danobat Scoop.

Finally, the Strategic Singular (PSE) Projects are carried out by strategic national consortiums for technological research led by the industrial sector. In the field of wind energy, a project called Minieólica is developing to promote the Spanish small wind energy sector (new developments of turbines up to 100 kW). This project involves more than six manufacturers of small wind turbines and components, three engineering companies, five public and private research centers, three universities,

and three end users. The 16 projects are organized in three main areas:

- Product development supporting manufacturers to develop new products. New designs will cover the needs of the market in the power range between 1 and 5 kW for urban and residential applications (innovative horizontal- and vertical-axis wind turbines) and from 20-kW and 100-kW very reliable, robust, and efficient newly designed small wind turbines for residential, industrial, and agricultural applications.
- Technical development breaking technological barriers and advancing technological development in key areas for small wind turbines.
- Infrastructure development activating and supporting the small wind turbine sector. The objectives of this area are promotion, dissemination, sensitization, and information collection for the small wind turbine sector.

The Spanish Wind Power Technologies Platform REOLTEC has an important role in the coordination and definition of research priorities for the Spanish Ministry of Education and Science. REOLTEC is the platform for exchange of ideas among all Spanish R&D entities to define research and development priorities. Those priorities are identified by several working groups focused on wind technology, wind resources and site assessment, grid integration, certification and standardization, offshore wind farms, applications, environmental issues, and social acceptance aspects.

The CENER Wind Turbine Test Laboratory (www.cener.com) was inaugurated on 22 September, 2008. Located in the town of Sangüesa, Navarra, it is comprised of a series of cutting-edge technology wind turbine test infrastructures, of international reference, which include:

- Blade Test Plant, to perform tests on characterization of physical properties, static and fatigue test. It has two test positions for blades of up to 85 m. long.

- Power train test bench, to perform mechanical durability tests on the power train (low speed shaft, multiplier, high speed shaft and generator) of wind turbines of up to 5 MW
- Electrical test bench, to perform tests on generators and power electronics equipment.
- Nacelle test bench, to perform functional tests on the complete nacelle, and tooling trials as well as to train personnel in assembly and maintenance.
- Composite material laboratory, to optimize the manufacturing processes of components with composite materials, characterization of process control variables and characterization of material physical, chemical and mechanical properties.

6.0 The Next Term

Expectations for the Spanish wind energy industry for 2009 are optimistic. It is likely that by the end of the year, 18,500 MW of total capacity will be installed. This amount represents more than 90% of the objectives defined in PER 2005–2010, which established a target of 20,155 MW by the end of 2010. Only funding problems related to the financial crisis could affect reaching the target. However, when the target is reached, a revision of the tariff scheme will be in order.

Electricity prices seem likely to be flat in 2009 and may not exceed 80 €/MWh (especially if the contribution of hydropower to the system continues increasing and oil prices do not increase too much).

During 2009, installation costs are expected to be as in 2008. No important shortage of components and materials is expected that could influence the continuation of the stable Spanish wind energy market.

One of the main challenges for the industry in 2009 is to complete the regulations for the Grid Code. Grid management has been reformed, and every wind farm is assigned to a control center, which makes the feed-in more transparent.

With a joint effort of the transport system operator, utilities, and the wind energy sector, wind parks will continue to increase their contribution to meeting electrical demand.

Among new technological developments are two 3-MW-rated power wind turbines under test by Alston-Ecotécnia and Acciona Wind Power, another being designed by MTorres, and a brand-new 5-MW wind turbine from Gamesa.

In relation to small wind, several new manufacturers are developing wind turbines from 3 kW to 100 kW for grid-connected applications, and two manufacturers are working on new wind turbine prototypes in the range from 150 kW to 300 kW. New feed-in tariff for small wind is under discussion.

A new Renewable Energy Plan is being studied by the authorities to include the objectives of the European Union for 2020. A realistic estimate for wind energy in Spain is that 40,000 MW of onshore and 5,000 MW of offshore wind capacity could be operating by 2020, providing close to 30% of Spain's electricity.

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1.0 Introduction

The new wind energy installations in 2008 had a capacity of 216 MW (Table 1), which is less than the 236 MW that were installed in 2007. However, the installation rate in the two last years has been about four times higher than in previous years. Figure 1 shows the evolution of installed wind power capacity in Sweden from 2003 to 2008. This rate must be increased even more if the new proposed planning goal of 30 TWh/yr can be met by 2020.

2.0 Progress Toward National Objectives

2.1 Swedish energy and electricity mix

The Swedish energy end use in 2007 (numbers for 2007 are used since general statistics for 2008 are not yet available) was 404 TWh. The energy use is divided into industrial energy use 157 TWh; transport 105 TWh; and residential, services, etc. 143 TWh. The total energy supplied was 624 TWh. The difference between energy supply and use consists of losses and use for non-energy purposes. The largest losses were in nuclear power production with 124 TWh. The electricity production was 144.9 TWh in 2007.

Preliminary figures for 2008 indicate a 0.5% increase in electricity production compared to 2007. At the same time, electricity use decreased by nearly 2%, which resulted in net export of electricity from Sweden of about 2 TWh in 2008. The production mix is shown in Figure 2.

2.2 Goals for wind power

In recent political negotiations about energy, the government agreed to suggest a new

planning goal for wind power generation of 30 TWh/yr until 2020. The purpose of the planning goal is to create land area for wind in the general public planning (e.g. spatial planning and grid planning) for possible production by 2020. Previously, the Swedish Energy Agency had suggested that planning be divided between 20 TWh onshore and 10 TWh offshore.

With current quotas in the electricity certificate system it is estimated that wind energy will contribute approximately 7 to 8 TWh by 2015. Without a change in quotas in the electricity certificate system, further expansion by 2020 will be marginal. The Swedish Energy Agency, however, notes that increased quotas can work as an effective way to increase the contribution of renewable electricity, and that wind energy likely will contribute to a major increase in renewable electricity production. The Swedish Energy Agency further notes that even though the electricity certificate system likely will work to increase wind energy onshore, nothing will happen in the near future offshore unless additional support is given. The Swedish Energy Agency will therefore look at suggestions for dedicated support for offshore wind.

2.3. Need for changes to the legislation

A change in quotas in the electricity certificate system or other economic support systems will be needed to reach a level substantially larger than 8 TWh by 2020.

Total installed wind generation	1,047 MW
New wind generation installed	216 MW
Total electrical output from wind	1.974 TWh
Wind generation as % of national electric demand	1.4%
Planning Target	30 TWh in 2020 (suggested planning target)

National Activities

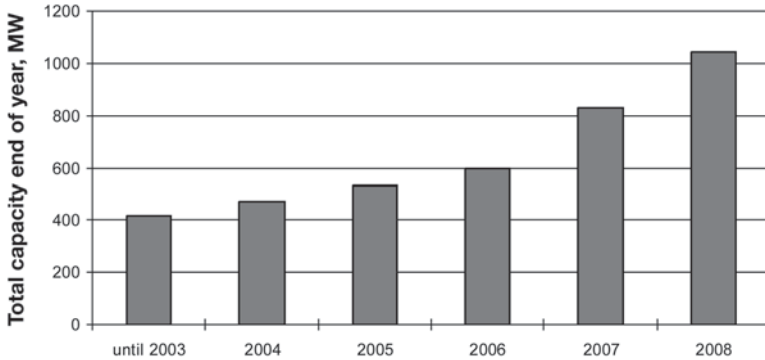


Figure 1 Installed wind power capacity in Sweden 2003 to 2008.

In addition to such changes, there is also a need to make the permit procedure run smoother and a need for changes in the electricity act. Today, several permits are required for a single project according to the Environmental Code, the Planning and Building Act, the Electricity Act, and sometimes other regulations as well. This results in several different reviews with possible multiple appeals, even though it essentially is the same assessment that is made. This results in long wait times from first application until permits are obtained. The government has therefore appointed an inquiry to look over the legislative process and make suggestions for changes. Results from this and other inquiries were recently included in a set of suggestions from the government:

- The Certificate System shall be further developed. For the year 2020, 25 TWh is mentioned as a goal with even further increases thereafter. The Swedish Energy Agency will be given tasks to analyze and develop methods to meet the new goals as well as expanding the market for the Certificate System to other countries
- A new target for wind power of 30 TWh is settled for the year 2020, with 20 TWh onshore and 10 TWh offshore
- The planning process for wind power will be simplified by removing the so-called doubled permissions. In the future, planning should be

sufficiently permitted with one of these permissions

- The preconditions for offshore wind power should be investigated in more detail.

Another inquiry into the grid-connection for renewables recently put forward its suggestions for changes to the legislation and procedures coupled to the Electricity Act. The inquiry found that there is a need to solve certain bottlenecks in the electricity network to make it easier to expand the network in an economically sound way (e.g. step-costs occur in the financing for upgrading networks). The inquiry therefore proposes the creation of a grid investment fund to finance investments in the electricity grid for future renewable energy connections. The fund is suggested

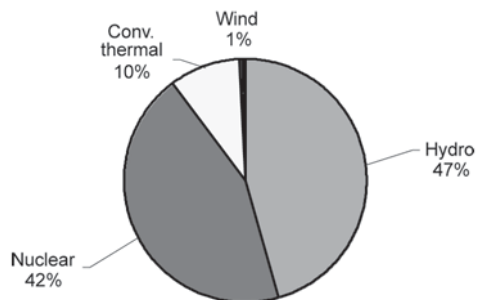


Figure 2 Electricity production mix in Sweden during 2008.

to be financed via network companies and to be shared according to each company's underlying electricity consumption by end customers.

3.0 Benefits to National Economy

3.1 Market characteristics

The consortium Vindpark Vänern is currently constructing a 30-MW park in Lake Vänern. A number of other offshore sites have already obtained permits or are in the permitting process. However, there is no further construction going on since onshore investments are currently more economical.

The expansion onshore is driven partly by the large utilities like Vattenfall and E.ON but also by other actors. Much of project development currently takes place in forested areas with developers continuing to establish land lease contracts with forest owners. The Norwegian power utility Statkraft, for example, has applied for final permitting consent to develop and build 1,140 MW to produce about 2.4 TWh of wind energy. RES Skandinavien together with Hg Capital of the UK are currently building the 95.4-MW wind farm Havsnäs in the northern part of Sweden. The independent developer O2 Vindkompaniet finalized several onshore wind farms during 2008, and a Danish consortium built the 35-MW Bondön project near the city of Piteå.

Apart from the companies mentioned above there are a number of utilities, developers, real estate companies, and private persons developing smaller and larger projects that are still in the planning phase. The current financial crisis will slow the construction of some projects during 2009. Of the erected wind power in 2008, Vestas obtained a market share of 45%, Enercon and Nordex each had a share of 25% and Dynavind (WinWinD) had a share of around 5%.

3.2 Industrial development and operational experience

There are a few manufacturers of small wind turbines in Sweden. The large, international manufacturers of large turbines,

Vestas, Enercon, Nordex, and others, have sales offices in Sweden.

On the component side (supply chain), however, the value of manufactured goods is large. The market consists of subcontractors such as SKF (roller bearings and monitoring systems), ABB (electrical components and cable), Vestas Castings (former Guldsmedshytte Bruk AB), Dynavind (tower production), and EWP Windtower Production. Other companies worth mentioning are Oiltech (hydraulic systems and coolers), Nexans (cables), and ESAB (welding equipment). The subcontractors are mainly multinational companies, but smaller entities that find the wind power market relevant to their know-how are also established in Sweden.

World record holder Näsudden II was decommissioned during 2008 (Figure 3). The reason was a major failure of the gearbox. The 3-MW machine began operation on 1 June 1993 and produced 61.4 GWh during 61,469 hours of operation (a world record).

The decommissioning was done by blasting the lower part of the tower, which resulted in collapse of the whole machine. The site will be reused for erection of a 2.5-MW prototype machine from the Indian-German company Kenersys. This project is part of the Market Stimulation Program run by Vattenfall.

3.3 Offshore construction

Three offshore projects, Utgrunden II, Kriegers Flak, and Lillgrund projects have been partly funded with support from the market introduction program as described in Section 4. The Vindpark Vänern project in the largest lake in Sweden is also being built with support from the market introduction program.

For Utgrunden II, all necessary permits are ready and construction was planned to start in 2007. However, the developer E.ON in early 2007 decided to postpone building the wind farm. Having received all tenders for the construction, the financial return did not meet internal minimum



Figure 3 The decommissioning of wind power aggregate Näsudden II.

levels and the project has been put on hold for the time being.

Support for the Kriegers Flak project has been granted for development studies. The project consists of studies of different foundation types, risk assessment for ship safety, and studies of how the wind farm will influence marine currents. The result of the studies will be reported in 2009.

The Lillgrund 110-MW offshore wind farm was put in operation in 2007. The project consists of 48 Siemens 2.3-MW turbines and a main transformer on a separate platform. They are erected on 49 gravity foundations that were built in Poland by a Danish-German Joint Venture, Pihl-Hochtief, and transported on barges to the Lillgrund site. The turbines have a hub height of 68.5 meters and a rotor diameter of 93 meters. Construction of the foundations started in 2006 and was finished during spring 2007. The internal offshore cables within the wind farm and the export cable were laid during summer 2007. The first wind turbine was erected on 3 August

2007. The last turbine was erected in October 2007. The first wind turbine was connected to the grid and started to generate electricity on 4 October 2007. All wind turbines were in operation on 28 November 2007. The availability of Lillgrund in 2008 was 94% and the production was 326 GWh (calculated normal year generation of 330 GWh).

Vindpark Vänern is being built in Lake Vänern, the largest lake in Sweden with a total area of 5,600 km². The park is given 40 million SEK (3.7 million €) of financial support from the Swedish Energy Agency, which is 9.5% of the total estimated investment of around 450 million SEK (41.6 million €). The foundations are currently under construction. The water depth on the site is around 5 to 7 meters. The foundations consist of concrete foundations that are secured in the rock by approximately 16 20-meter-long pre-stressed anchors. This makes it possible to have rather small foundations with a minor influence on the lake bottom and the ecosystem.

3.4 Economic Details

The average price of electricity certificates in 2008 was 247.21 SEK/MWh, which is higher than in 2007 when the average certificate price was 195.4 SEK/MWh. Prior to the introduction of the electricity certificate system, Sweden had a subsidy for wind power called the Environmental Bonus. This system is being phased out and will be removed after 2009. During 2008, the value of the Environmental Bonus was 20 SEK/MWh onshore and 130 SEK/MWh. During 2007, the Environmental Bonus was 40 SEK/MWh onshore and 140 SEK/MWh offshore.

Figure 4 shows the average value of the total revenue for wind-generated electricity onshore in Sweden during 2007 (the price paid to a wind turbine owner can be slightly reduced to cover the balancing cost on electricity price for the grid company). The sum is around 56 €/MWh. During 2006 the same number was 76 €/MWh.

4.0 National Incentive Programs

There are three main incentive programs for the promotion of wind power: electricity certificates; production support, the so-called Environmental Bonus; and support for technical development in coordination with market introduction for large-scale plants offshore and in arctic areas. The work

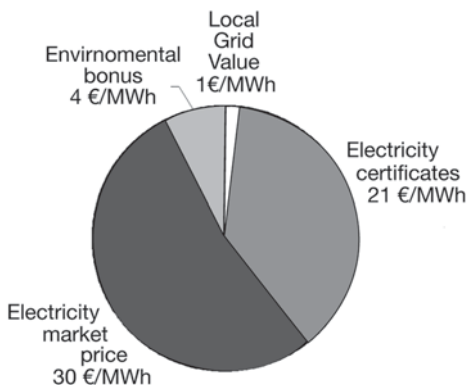


Figure 4 Breakdown of total revenue (56 €/MWh average) for a wind power plant during 2007.

done in assessing areas of national interest for wind power can also be considered a sort of “soft incentive.”

4.1 Electricity certificates

The national production target for renewable energy sources as a result of the EU directive 2001/77, implies an increase in the annual use of renewables in Sweden of 10 TWh from 2002 to 2010. The tool to meet the target is a quota-based system with electricity certificates. The system came into force on 1 May 2003, and is intended to increase the production of renewable electricity in the most cost-efficient way. The increased deployment of renewables, and particularly wind power, will be driven by stipulated quotas that are increased annually, as well as by a quota obligation fee. The system replaces earlier public grants and subsidy systems. The principle is that there should be sellers and purchasers of certificates, and a market to bring them together. There are no specific quotas for wind power. Electricity producers receive from the state a certificate for each MWh of renewable electricity that they produce. This certificate can be sold, to provide additional revenue above the sale of the electricity, improving the economics of electricity production from renewable energy sources and encouraging the construction of new plants for the purpose. The demand for certificates is created by a requirement under the Act that all electricity suppliers and certain electricity users purchase certificates equivalent to a certain proportion of their electricity sales or use, known as their quota obligation. The size of this obligation is increased from year to year, increasing the demand for renewable electricity. The price of certificates is determined by supply and demand, and can vary from one transaction to another.

The current aim of the system is to increase the level of renewable electricity to 17 TWh by 2016 relative to the 2002 level. A new production unit can receive certificates only for a period of 15 years.

National Activities

Old units therefore leave the system after 15 years. Around 2010 there is a “notch” in the quotas due to the fact that a number of older production units are phased out of the system after 2012. Figure 5 shows the quotas and expected production. The quota-based electricity production in 2007 was about 13.25 TWh (9.6 TWh bioenergy, 2.2 TWh hydropower, and 1.4 TWh wind power). The increase in production from wind and hydro was about equal in 2007 with wind increasing by 0.44 TWh.

4.2 Production support (the Environmental Bonus)

The level of the “Environmental Bonus” is declining for each year until 2009. It will be zero after 2008 for onshore and after 2009 for offshore wind power.

4.3 Support for technical development

In 2003, the Swedish Energy Agency launched a program to support technical development in coordination with market introduction, for large-scale plants offshore and plants in arctic areas. The aim is to stimulate the market, achieve cost reduction, and gain knowledge about environmental

effects from wind power offshore and in the arctic areas. For the years 2003 to 2007, the budget was 350 million SEK (38 million €). The market introduction has been prolonged another five years with an additional 350 million SEK for the period 2008 to 2012. The projects funded to date are shown in Table 2.

4.4 Areas of national interest

According to the environmental code, land and water areas shall be used for the purposes for which the areas are best suited in view of their nature, the situation, and the existing needs. Priority shall be given to the use that promotes good management from the point of view of public interest. In the environmental code, different areas of Sweden are designated as areas of national interest for different kinds of land use. These are areas of national interest for fishery, mining, nature preservation, outdoor recreation, etc. The idea is to protect specific areas such that the specific national interest not is jeopardized. An area can be of national interest for several kinds of land use. In order to guard the interest of wind energy, 49 geographical areas in

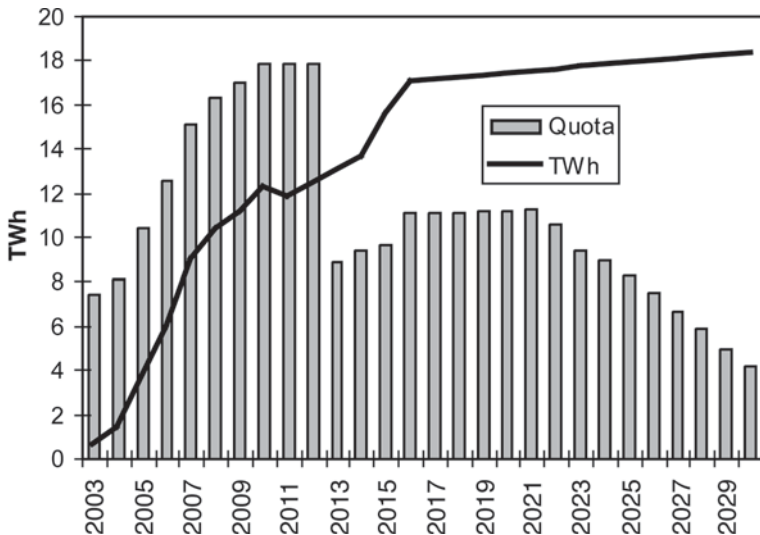


Figure 5 Quotas and production goal of the electricity certificate system. [units on left axis should be TWh]

Table 2 Projects with support from the market introduction program

Project	Recipient company	Support	Location	Estimated production and estimated year of operation
Lillgrund	Örestads vindkraft-park AB (owned by Vattenfall)	213 MSEK (23 M€)	Offshore	330 GWh; operating since late 2007.
Utgrunden II	E.ON Vind Sverige AB	70 MSEK (7.6 M€)	Offshore	285 GWh; planned for 2008 but recently postponed.
Vindpark Vänern	Vindpark Vänern Kraft AB	40 MSEK (4.3 M€)	Largest Swedish lake	89 GWh; planned for full operation in 2009.
Uljabouoda	Skellefteå Kraft AB	35 MSEK (3.8 M€)	Onshore artic	100 GWh (2008)
Kriegers Flak	Sweden Offshore Wind AB (Vattenfall AB)	9.45 MSEK (1 M€)	Offshore	No production. Only development program.
Vindval		35 MSEK (3.8 M€)		No production. Only research program.

13 counties were pointed out as areas of national interest for electricity production from wind energy in 2004.

The Swedish Energy Agency has started a network to promote the use of wind power. Project financing decisions totaling about 13 million SEK were made in autumn 2008. Most of the projects are designed to strengthen local activities and knowledge of wind power. One project, for example, will develop informational handbooks about regional/local ownership of wind power. Other projects are aimed at stimulating local wind power development, such as support for industry wind power development projects. Projects for strengthening the competence of key people involved in wind power planning and in helping municipalities with contacts between actors related to wind power establishment were also supported. Support was also given to projects that enhance school education and increase the quality of education for wind power technicians.

5.0 R, D&D Activities

Publicly funded wind energy research is mainly carried out within the Vindforsk and Vindval research programs.

5.1 National R, D&D efforts

The Vindforsk II program ran between 2006 and 2008 with a total budget of 45 million SEK. The goal of the program was to generate knowledge in order to facilitate the deployment of wind energy and its integration with the power grid. Vindforsk was focused on research related to the technological development of wind turbines and their interplay with the technical environment in which they operate. Studies have been carried out in the following areas:

- Large amounts of wind power from a market and technical perspective. One study showed that the opportunities for wind power expansion are not limited by its physical potential but will instead largely depend on whether

National Activities

or not barriers are created by the permitting process, opportunities for grid connection, and technical problems.

- Sound propagation around offshore wind turbines. This was investigated by one project, and the results provided a basis for modification of the Swedish Environmental Protection Agency's model "Sound propagation around offshore wind turbines."
- Wind energy in cold climates. One project focused on development of methods to de-ice or prevent icing on rotor blades, and two projects focused on ice measurement and detection.
- Wind turbine design. Studies were carried out ranging from how wind farms can be optimized with regard to wind turbine wakes, to new splicing methods for steel wind turbine towers.
- Electrical systems in wind turbines. Investigations into the problem of high frequency transients in wind farms have been carried out, amongst others, and are resulting in models for electrical systems with more detailed modeling of circuit breakers in the system.
- Grid connection. Projects have focused on ways during the planning and design stages to ensure that wind farms meet the code requirements of Svenska Kraftnät (the Swedish National Grid) regarding their behavior in the grid.
- Operation and maintenance. Studies have shown that wind turbines have lower availability than previously thought. Review of the statistical data has uncovered errors and misleading information in the reporting system.

A decision for the next stage in Sweden's national R, D&D efforts, Vindforsk III, was made in December 2008. Vindforsk III will run from 2009 to 2012 with a total budget of 20 million SEK/yr. Elforsk, the Swedish Electricity Utilities' R&D company administers the program. The program is financed 50% by the Swedish Energy Agency and 50% by Elforsk. Vindforsk III

will be organized in four project packages: the wind resource and establishment, cost effective wind power plant and design, optimal running and maintenance, and wind power in the power system.

The Vindval program is financed by the Swedish Energy Agency and is administered by the Swedish Environmental Protection Agency. Vindval is a small part of a program called "Market introduction and technology development program" which has run since 2003. Vindval's objective is to facilitate an increase in the expansion of wind power by compiling basic data for environmental impact assessments and permit application processes. Research within Vindval helps compile knowledge about how wind power affects animals, the environment, people, and the landscape. Vindval will also contribute to the increase of competence in and knowledge about the environmental effects of wind power at Swedish universities, colleges, institutes, and companies. Three studies have been finished during the year:

- Environmental optimization of foundations for offshore wind power and studies of small fish at Lillgrund wind farm
- A study about how sea-based fauna is affected by noise from offshore wind power
- Experience from wind power building – support, acceptance, and resistance.

During 2008, the program was extended through 2012 with a new budget of 35 million SEK. Within this time period the program will include new environmental studies in important fields such as social studies; animals in the forests; and effects on economic areas like reindeer farming, nature tourism, and outdoor recreation. Other important areas will be to synthesize and spread information to important actors in the industry about the effects from wind power.

Apart from projects in these programs, other R&D projects are also funded.

- A study on how to decrease disturbances to defense radar systems from offshore wind power have shown that the handling of wind power permitting can be simplified.
- A group at the University of Uppsala is working on direct driven conversion systems for renewable energy. The work is on implementations for wind power, wave power, and power from streaming water. For wind they are working on direct driven vertical axis H-rotors. The generators are built with windings with high voltage cables.

5.2 Collaborative research

Research groups in Sweden participate in all currently operating IEA Wind Research Tasks. During 2008, Sweden re-joined Task 19. Vattenfall AB served as Operating Agent for Task 11, Base Technology Information Exchange in 2008. Participation in the IEA Wind Tasks boosts work in the national programs by allowing the invaluable sharing of expensive data from experiments and measurements.

During late 2007, Sweden also signed a Joint Declaration on Co-operation in the Field of Research on Offshore Wind Energy Deployment with Denmark and Germany. The aim is to co-operate on common research areas and share experience. No firm collaboration projects involving

Sweden have started yet. The Kriegers Flak area has projects being planned both on the Swedish and German part of the Flak, and is currently under consideration for the Danish part. It has been identified as a good start for collaboration.

6.0 The Next Term

The two research programs Vindval and Vindforsk will start new research projects in 2009. A lot of the expected growth in wind generation capacity will be in forest areas and also in the northern parts of Sweden in the "low-fjelds." The interest in those regions is prompted by the rather good wind potential as estimated by Swedish wind mapping. Substantial uncertainty, however, exists in the energy capture and loads of turbines in forested areas. The character of wind shear and turbulence is less explored in these areas and projects in the coming research program will be set up to increase the knowledge in this area.

References:

(1) Decommission of Näsudden II,
See youtube: <http://www.youtube.com/watch?v=Ddr8VwFMJ4I>

Author: Maria Danestig, Swedish Energy Agency, Sweden.

National Activities

1.0 Introduction

Electricity consumption in Switzerland declined by 0.6% in 2007 to 57.4 billion kWh. The last time a decrease in consumption was recorded was in 1997. Domestic power plants generated 65.9 billion kWh, or 6.1% more electricity than in 2006. This constitutes the third highest electricity output ever achieved in the country. After consecutive years of electricity import surpluses in 2005 and 2006, an export surplus was achieved once again in 2007.

In February 2007, the Federal Council decided to focus its energy policy on four main areas: energy efficiency, renewable energy, replacement of existing large-scale power plants and construction of new ones, and foreign energy policy. In order to implement this strategy, the Federal Department of the Environment, Transport, Energy and Communications (DETEC) prepared draft action plans for energy efficiency and the use of renewable energy, which were approved by the Federal Council on 20 February 2008.

These action plans set out to reduce the consumption of fossil fuels by 20% by 2020 (in line with the declared climate objectives), to increase the proportion of renewable energy to overall energy consumption by 50%, and to limit the increase in electricity consumption to a maximum of 5% between 2010 and 2020. From 2020 onwards, the objective is to stabilize electricity consumption.

Although Switzerland has pursued a consistent energy policy since 1990

through the Energy 2000 and SwissEnergy programs (1), it is still a long way from achieving its goal of securing a sustainable energy supply, quoted as a “2000 Watt Society” (2). In view of the diminishing fossil fuel reserves, the challenges associated with climate change, and the high degree of dependence of Switzerland’s energy supply on imports, the focus is increasingly shifting toward renewable forms of energy (Figure 1).

For the SwissEnergy program, renewable energy is a clear priority. Despite this priority, the proportion of wind power to Switzerland’s overall energy consumption is still very modest (Table 1). However, the growth prospects for renewable energy are excellent – both in the near future and over the long term, thanks to technological progress, increasing economic competitiveness in the context with “Cost-covering remuneration for feed-in to the electricity grid (CRF),” and the positive image of renewable energy.

SwissEnergy will only be able to achieve its objectives relating to renewable energy by working closely with strong partners from the country’s economy, which possess detailed knowledge about the general environment and the energy market. These include the Swiss Wind Energy Association “Suisse Eole,” as well as the cantons (states). SwissEnergy also

Table 1 Key Statistics 2008: Switzerland

Total installed wind generation	13.8 MW
New wind generation installed	2.3 MW
Total electrical output from wind	.0185 TWh
Wind generation as % of national electric demand	0.03%
Target:	100 GWh/yr in 2010 600 GWh/yr in 2025

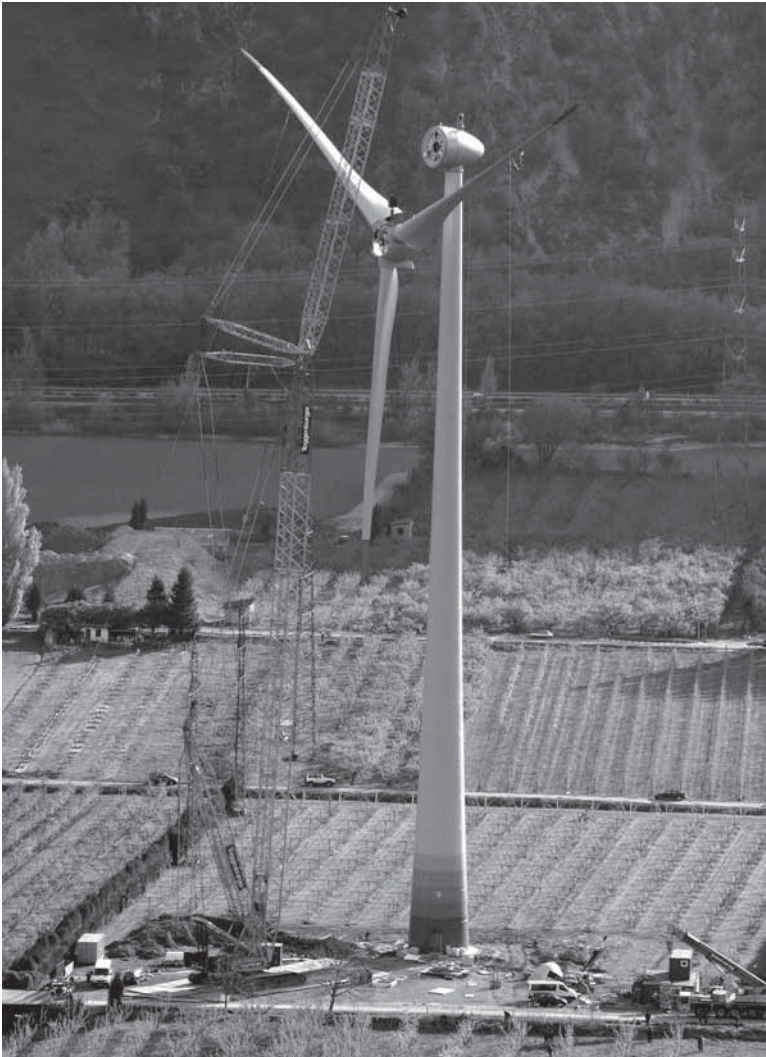


Figure 1 Award winning project of “Eolienne Mont d’Ottan” in the inner alpine valley of Wallis (photo courtesy of RhônEole).

promotes the transfer of new technologies from research to practical implementation (Section 4).

2.0 Progress Toward National Objectives

The targets of the SwissEnergy program are based on the Energy Act, the Kyoto agreement on the climate, and the CO₂ Act. Such aims are as follows:

- Climate: Reducing carbon dioxide emissions by 10% by 2010 (compared to the 1990 level) according to CO₂ legislation.
- Electricity: Limiting the increase in electricity consumption to a maximum of 5% compared to the 2000 level.
- Renewable forms of energy: Increasing the proportion of renewable forms of energy used in electricity

production by 500 thousand MWh and in heat production by 3 million MWh.

2.1 Impacts on energy consumption in 2007

The additional impacts achieved in 2007 – based on voluntary measures encouraged by the SwissEnergy program – lie at about 3.5 PJ. These impacts are about 16% lower than in the previous year and constitute about 0.4% of Switzerland's final energy consumption. The clearly weaker rise in impacts is a result of a reduction in the budget to approximately 39 million CHF – 7% less than 2006. In the fifth year of the SwissEnergy program, a total of 2.7 PJ of combustibles, 0.3 PJ of vehicle fuels, and about 0.5 PJ of electricity could either be saved or substituted with renewable forms of energy as a result of voluntary measures and promotional measures at the cantonal level.

Both electricity production and heat production from renewable forms of energy further increased in 2007. SwissEnergy is well on the way to reaching its targets. The heat sector has already attained 80% of its target for 2010, with a further 551 GWh of heat (corrected for variations in the climate) produced in 2007. Wood and waste (renewable proportions) still make the greatest overall contribution in this sector. The greatest percentage growth was recorded in the heat pump sector with 11.5% compared to 2006. The number of solar panels increased strongly over 2006. The number of biogas plants remained roughly the same as in the preceding year. Further progress was made in the building renovation sector. Heat pumps and wood-pellet burners are gaining a greater share of the market because of the steep increase in the price of oil.

The increase in production of electricity from renewable forms of energy was more modest. In 2007, an additional 52.9 GWh of electricity were produced from renewable sources of energy. In this sector 75% of the agreed target for 2010 has

already been attained. The greatest absolute gain was noted in the wood sector; electricity production from wood increased to 92.4 GWh, more than double the quantity for 2006. By contrast, waste incineration plants produced less electricity, however such plants still make the greatest contribution to achieving energy targets. Above average growth was recorded in the photovoltaic sector, although in contrast to 2006 some larger facilities were installed.

2.2 Wind energy

The Swiss wind energy concept also identifies the calculated wind energy potential for Switzerland based on the real wind conditions on the sites and on the possible number of plants to be installed (3):

- Time horizon 2010: 100 GWh
- Time horizon 2025: 600 GWh
- Time horizon 2050: 4,000 GWh.

In 2008, wind energy in Switzerland produced 18.54 GWh representing 18% of the 2010 objective. By 1 January 2009 there is a “Cost-covering remuneration for feed-in to the electricity grid (CRF)” for renewable energy in Switzerland. This change of politics in promoting wind energy did lead to a boost of new projects (Section 4).

3.0 Benefits to National Economy

3.1 Market characteristics

The installed capacity of wind energy in Switzerland did increase during 2008 by 2.3 MW. The total capacity of all 38 installed turbines is 13.8 MW, and the energy yield in 2008 increased to 18.54 GWh (Figure 2). This brings the average capacity factor up to 16%.

In 2008, 94% of the electricity from wind energy was produced by utility companies. Driven by the new regulation for the remuneration of green electricity, various companies (utility owned and private) are developing activities to get a share of finances at disposition for renewable energies.

National Activities

3.2 Industrial development and operational experience

The Swiss industry is active in the following fields of wind energy:

- Development and production of chemical products for rotor blades, like resins, adhesives, etc. (Gurit Heberlein, Huntsman, Clariant)
- Development and production of power electronics like inverters, etc. (Integral Drive Systems AG, Vivatec, VonRoll Isola)
- Services in the field of site assessments and project development (Meteotest, Interwind, NEK, Kohle/Nussbaumer)
- Niche products like ice detectors (Boschung, Markasub AG).

The total turnover in the above mentioned areas is about 200 million €/yr, which represents about 600 employees. The chemical products and power electronics industries account for 95% of this turnover and 85% is covered by the four largest companies. Some companies are mayor players in the world market despite the nearly non-existent home market.

3.3 Economic details

The specific costs of existing larger wind power plants (including installation) amounted to about 2,000 to 2,200 CHF/kW (1,345 to 1,480 €/kW). Today's prices for new installation are more like 2,800 CHF/kW (1,885 €/kW). These prices will result in cost-covering tariffs in the range of 0.25 CHF/kWh (0.17 €/kWh) at windy locations. Unfortunately, the regulation for the compensatory feed-in remuneration scheme provides only 0.17 to 0.20 CHF/kWh (0.11 to 0.13 €) for wind energy – based on the same mechanism as the German model. At the moment, there are negotiations between the wind energy industry and the Swiss Federal Office of Energy (SFOE) to raise this value.

4.0 National Incentive Programs

4.1 Cost-covering remuneration

Producers of renewable electricity from hydropower (up to 10 MW), photovoltaic energy, wind power, geothermal power and biomass energy as well as biomass waste have been able to register their plants for the cost-covering remuneration for feed-in to the electricity grid (CRF) since 1 May 2008. An annual sum of around 320 million CHF (215 million €) is to be earmarked for the new promotion measures called for in the Federal Energy Act. It has been decided that a maximum share of 30% would go into wind energy.

The scheme will go into operation on 1 January 2009. From this date, plants that qualify for the new incentive scheme and have submitted their notification of commissioning to swissgrid AG correctly and on time will receive the compensatory feed-in remuneration for the electricity they feed into the grid. By the end of October 2008, the national grid company swissgrid AG, which is handling the registration and decision process on behalf of SFOE, had received 5,426 applications, 3,500 of which were received on 1 and 2 May 2008 alone.

A total of 365 wind energy projects, with an overall installed capacity of 675 MW, did receive a notification of registration of their application. This means, that developers found sites in Switzerland which could produce up to 1,200 GWh - despite the fact, that the foreseen tariffs are not cost covering (Figure 3).

Yet this figure must be analyzed rather critically, since for registration, only a contract with the land owner and the installed capacity had to be presented. So it is quite possible that during the future developments, various projects will be abandoned due to insufficient economics, spatial planning issues, landscape protection, etc. Developers now have two years to produce the necessary documents for the building permits, otherwise they must re-apply and

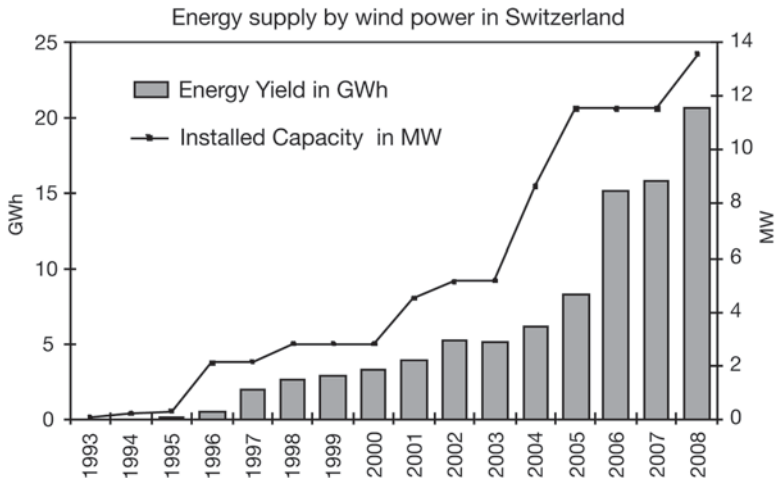


Figure 2 Installed capacity and energy yield of wind turbines in Switzerland through 2008.

are on the waiting list. However, for the further growth of the wind energy industry in Switzerland it is very important to see that once the financial aspects are regulated (CRF), the number of planned wind projects just sky rocketed! (Figure 4)

The high number of registrations in all technologies meant that the full cap for all technologies laid down by Parliament in the Energy Act has since been reached. The SFOE is therefore declaring a moratorium from 1 February 2009 for all technologies. In practical terms, this means that swissgrid AG will put all new applications from any type of plant on a waiting list if they are postmarked 1 February 2009 or later.

Further expansion of green electricity production in Switzerland on the basis of the current CRF incentive system is no longer possible. Only by amending the legislative framework can the economic potential of renewable power continue to be exploited. The main focus must be on raising the CRF cost limits (full cap). A further possibility would be to speed up the introduction of obligatory production quotas from renewable energies for the individual energy supply companies.

4.2 Swiss Wind Energy Association "suisse Eole"

Wind energy is an important element within the SwissEnergy program. Suisse Eole, the Swiss Wind Energy Association, is the leading authority on the use of wind energy in Switzerland and co-ordinates all activities in collaboration with the cantonal institutes of energy, energy suppliers, and energy planners. Under the title "Implementation of the concept Wind Energy Switzerland," suisse Eole can offer certain operational and financial support for site assessments and communication measures.

Based on the important changes in the energy policy framework of Switzerland (CRF), the number of players on the Swiss market has increased dramatically (Figure 4). To establish a high quality reference standard for future projects will be a major challenge of the Swiss Wind Energy Association.

5.0 R, D&D Activities

5.1 National R, D&D efforts

The wind energy research program 2008 to 2011 focuses on (4):

- Developing innovative turbine components for specific application in

National Activities

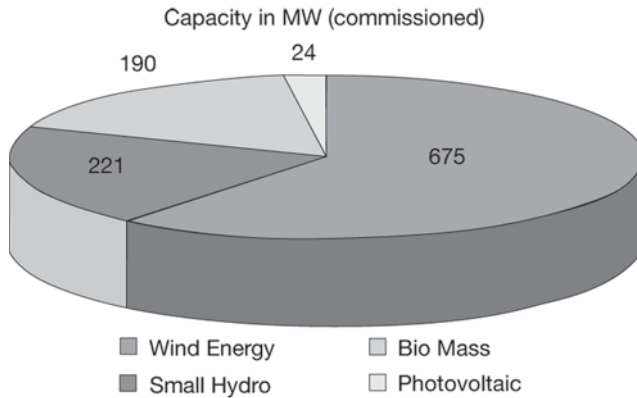


Figure 3 Capacity of registered projects under cost-covering remuneration for feed-in to the electricity grid (CRF) scheme.

Switzerland's harsh climatic conditions:

- Reducing loads with new materials
- Increasing the energy yield at low wind speeds
- Employing Nano-technology against icing and fouling.
- Increasing availability and energy yield at extreme sites:
 - Developing planning expertise for applications in complex terrain
 - Testing and demonstration plants at extreme sites
 - Evaluating operational experiences, and making recommendations.
- Increasing the "value" of the wind energy, and optimizing the integration of wind energy into the grid:
 - Fore and nowcasting the power production from wind
 - Grid regulation with a high amount of wind energy
 - Optimizing the conditions for intermittent production plants in the grid
- Increasing the acceptance of wind energy, and integrating social and environmental authority:
 - Defining success factors and strategies
 - Improving local planning processes, social acceptance

- Implementing public participation models.

Implementing pilot and demonstration projects leads to stronger market penetration by wind energy and closes the gap between research activities and application in practice.

In 2008, the budget for wind energy related R&D projects was 729,000 CHF (490,740 €). This is an increase from 2007 by more than 50%. An amount of 677,000 CHF (455,740 €) is spent on promoting activities.

5.2 Collaborative research

Within this framework, the following projects were realized:

- Development of innovative turbine components such as antifreeze coatings for rotor blades
- Increased availability:
 - Alpine test site Gütsch, handbook and seminar within COST 727
 - Measuring and forecasting icing on structures
 - Development of wind turbines for safe operation in alpine environments
- Increased "value" of the wind energy using fore and nowcasting of energy

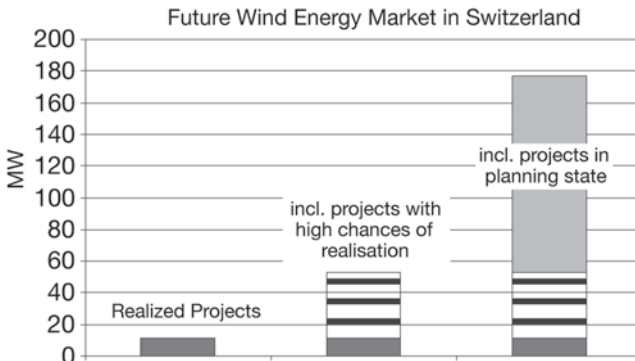


Figure 4 Possible development of future wind energy market in Switzerland.

yield from wind turbines in complex terrain

- Increased acceptance for wind energy
 - Effect of wind power installation in Switzerland
 - IEA Topical Expert Meeting “Social Acceptance”
 - Social Acceptance of Wind Energy in Switzerland – To Invest or Not to Invest
 - “Code of Conduct” for the development of wind energy projects in Switzerland
- Under the title “Pilot and Demonstration Project,” the following activities were realized:
 - Support of spatial planning activities for the implementation of wind energy projects
 - Financial support for site assessment
 - Purchase of a Lidar, which can be rented out by the Swiss Wind Energy Association.

Switzerland participates in the IEA Wind Implementing Agreement Task 11 Base Technology Information Exchange, and Task 19 Wind Energy in Cold Climates. Since 2008, the new Task 28 on Social Acceptance of Wind Energy Projects: Winning Hearts and Minds is managed by Switzerland.

6.0 The Next Term

Based on operating experience and the possible optimization potential, the research activities should have results on the following key factors:

- Quantifying the production losses and the downtimes due to icing; implementing and evaluation of relevant measures
- Reducing the production cost by increasing the full-load hours and the reliability of turbines in harsh conditions
- Increasing the accuracy of energy yield estimates
- Reducing planning and installation costs by speeding up planning procedures and considering important acceptance issues.

The following research projects are in discussion:

- Product development in the area of antifreeze coatings
- Development of a reliable ice detector
- Providing a freezing up map of Switzerland
- Evaluating the effects of the icing up on the operational behavior and the energy yield of wind turbines in the Jura mountains
- Developing a product for “Fore and Nowcasting”
- Further development of a “Code of the of Conduct,” accepted procedure

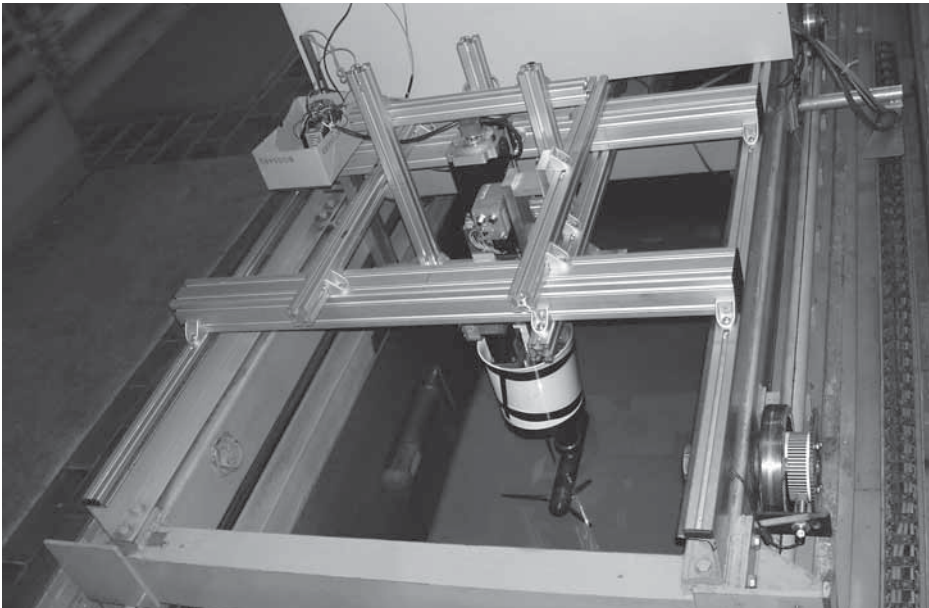


Figure 5 Sub-scale model wind turbine test facility at the ETH Zürich (Photo ETHZ).

for wind energy development in Switzerland

- Project “Before/After” for the determination of the effects of the implementation of wind turbines.

Thanks to the new CRF legislation the results in new project development are astonishing. Future research activities have to concentrate on issues that lead to the realization of a substantial amount of these planned projects.

The experiences in cold climates will be continuously shared in international seminars and in the project group of the IEA Wind Task 19 Wind Energy in Cold Climates. Having more experiences in difficult site development and sophisticated planning procedures than in large-scale wind energy development, Switzerland is running the new IEA Wind Task 28 Social Acceptance of Wind Energy Projects.

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Author: Robert Horbaty, Swiss Wind Energy Program, Switzerland.

1.0 Introduction

The United Kingdom (UK) has one of the best wind resources in Europe and has significant potential for development of both onshore and offshore wind. The UK government has put in place a range of measures to enable the successful development of that potential resource, and it is committed to ensuring the further growth of wind generation. The proposed EU target of 15% of the UK's energy to come from renewable sources, whilst still subject to agreement, is likely to mean a very significant increase in the contribution from wind energy—both onshore and offshore—to the UK's overall energy mix.

From the time the first commercial turbine was installed in the UK, it took fourteen years for the UK to reach the 1-GW mark but less than two years to double that capacity to 2 GW. By the close of 2008, more than 3.3 GW of wind energy capacity was operational in the UK. The UK is now the world leader in offshore wind energy, with 598 MW installed capacity.

Since the publication of the 2007 IEA Wind Annual Report, the UK government has strengthened the regulatory framework to deliver its renewable energy targets by setting in law three key pieces of legislation:

- The Climate Change Act
- The Energy Act
- The Planning Act

In addition to these legislative measures, the government has conducted a Strategic Environmental Assessment (SEA)

to investigate the potential impacts of further leasing for offshore wind farms and licensing for offshore oil and gas, including natural gas storage. These measures are detailed in Section 4.

In the UK, primary energy supply comes from a range of sources: natural gas (39%), oil and petrol products (36%), coal (17%), electricity (7%), and renewables and waste (2%) (1). Electricity generation stations use a mixture of energy sources: coal (39%), gas (36%), nuclear (17%), and renewables (5%). The remaining 4% comes from other fuels, oil, and electricity imports (2). Renewable energy sources accounted for 5.17 million tonnes of oil equivalent, with 4.08 million tonnes used to generate electricity, 0.73 million tonnes to generate heat, and 0.36 million tonnes for transport fuel (3). Use of renewable energy grew by 8.4% between 2006 and 2007 (4). Total primary energy demand was 2.7% lower in 2007 than in 2006 at 226 million tonnes of oil equivalent (5).

UK gas production is declining as UK continental shelf reserves deplete. The UK continues to be a net importer of gas. In the fourth quarter of 2008, imports of gas were 16.6% higher than the same period in 2007. Exports also increased by 21.3% (8). Reliance on imports will increase over the coming years as output from the UK declines.

Table 1 Key Statistics 2008: United Kingdom

Total installed wind generation (9)	3,331 MW
New wind generation installed (10)	912 MW)
Total electrical output from wind (11)	5.274 TWh (2007)
Wind generation as % of national electric demand (12)	1.32% (2007)
Targets:	10% of electricity from renewables by 2010 and proposed 15% of total energy from renewables by 2020



Figure 1 The final blade is fitted to the first turbine on Whitelee wind farm. Image courtesy of Scottish Power Renewables.

The wind energy industry in the UK continues to grow rapidly. A total of 912 MW of new wind generation capacity was commissioned in 2008 (450 MW in 2007), bringing the UK well over the 3-GW mark in terms of installed capacity. Total installed capacity stood at 3,331 MW in February 2009, an increase of 38% above the 2007 level. This includes 598 MW of offshore wind energy capacity. Further key statistics are shown in Table 1.

One of the main contributors to this increase in capacity was the Whitelee wind farm in Scotland, now one of the largest in Europe (Figure 1). When the first phase is complete, it will have a generating capacity of 322 MW. If plans for extensions are approved, Whitelee will increase its capacity further to 614 MW. Clyde, another wind farm in Scotland, has been approved by

the Scottish government. This wind farm will have a generating capacity of 548 MW when fully commissioned.

The overall electricity contribution from wind energy increased from 1.04% (2006) to 1.32% (2007) of the total electricity demand for the UK. This contribution from wind is set to rise dramatically. Wind energy will be the single biggest contributor to the government's target of 10% of electricity from renewables by 2010. Wind is expected to deliver more than half of the 10% electricity target.

There were 1,665 MW of projects under construction at the end of 2008, and a further 7,093 MW were approved but had not yet begun construction. Figure 2 shows the installation of wind turbines on the Lynn and Inner Dowsing wind farms, which came online in 2008.

2.0 Progress Toward National Objectives

2.1 Policy background

The UK government has four long-term goals for its energy policy:

1. Put the country on the path to reducing carbon dioxide emissions by 80% by 2050, with real progress by 2020.
2. Maintain the reliability of energy supplies.
3. Promote competitive markets in the UK and beyond, helping to raise the rate of sustainable economic growth and to improve our productivity.
4. Ensure that every home is adequately and affordably heated.

The Department of Energy and Climate Change (DECC) was established on 3 October 2008. DECC joins much of the Climate Change Group that was previously part of the Department for Environment, Food and Rural Affairs (Defra) with the Energy Group from the Department for Business, Enterprise and Regulatory Reform (BERR). The DECC has three principal objectives (13):

- Ensure that the UK has energy that is affordable, secure, and sustainable.
- Bring about the transition to a low-carbon economy.
- Achieve an international agreement on climate change at Copenhagen in December 2009.



Figure 2 Lynn and Inner Dowsing wind farms under construction. Image courtesy of Centrica.

Renewable energy is an integral part of the government's longer-term aim of reducing CO₂ emissions by 80% by 2050. In 2000, the government set a target of 10% of electricity supply from renewable energy by 2010. In 2007, 5% of the UK's electricity supply came from renewable sources, with 4.9% from Renewables Obligation (RO)-eligible sources (14). There are no specific targets for installed capacity or electricity generation from wind energy.

The UK has agreed with other member states to an EU-wide target of 20% of energy from renewables by 2020, including a binding 10% target for the transport sector. The European Commission (EC) has proposed that the UK share of this target would be to achieve 15% of the UK's energy from renewables by 2020. The mechanisms to help achieve these targets are detailed in Section 4.

2.2 Progress toward national targets

British Wind Energy Association (BWEA) figures (15) show a total of 34 new projects, including two offshore projects, came on stream in 2008, representing 912 MW of new capacity. Figure 3 shows the new capacity by country.

Projects commissioned in 2008 (Table 2) raised the total installed capacity to 3,331 MW, an increase of 38% over capacity installed at the end of 2007 (Figure 4). Figure 5 shows the distribution of installed capacity by country in the UK. Figure 6 shows projects under construction at the end of 2008.

Offshore wind projects completed through the end of 2008 brought the total installed offshore capacity in the UK to 598 MW (Table 3).

In 2008, 56 new projects were approved through the planning system totaling 3,980 MW. These projects brought the total UK capacity approved but not yet under construction to almost 7,100 MW (Figure 7)

The total capacity of approved projects is 12,089 MW, which includes operating projects, projects being constructed, and projects that are approved but have not yet

National Activities

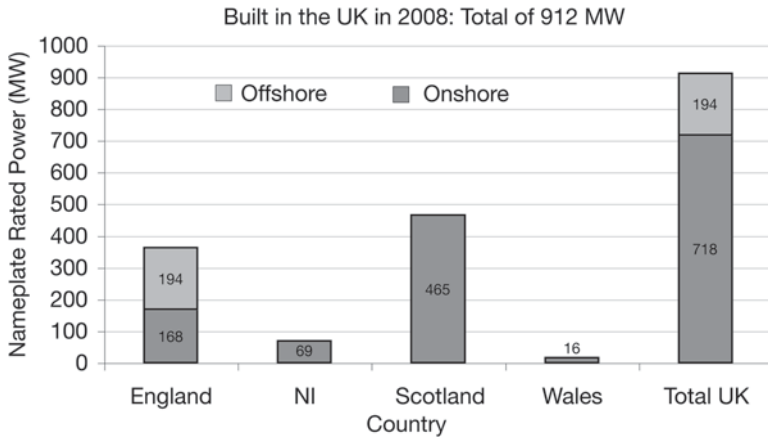


Figure 3 Wind capacity built in the UK in 2008 (912 MW total).

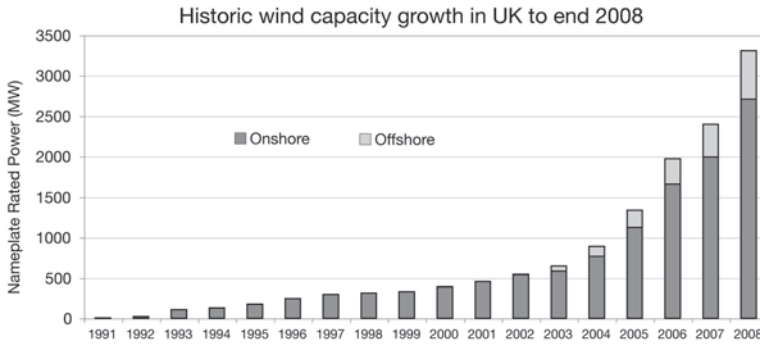


Figure 4 History of wind capacity growth in the UK through end of 2008.

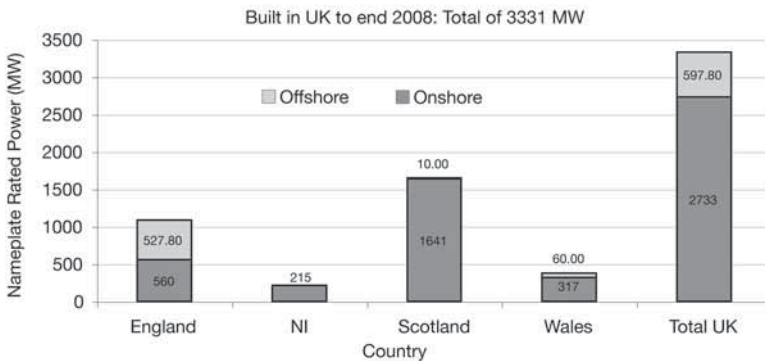


Figure 5 UK wind capacity built through end of 2008.

Table 2 Wind Projects Commissioned in the UK in 2008					
Wind farm	Region	Turbines	Power*	MW	Online
Bessy Bell extension	Northern Ireland	6	1.30	9.0	May 2008
Bicker Fen	England	13	2.00	26.0	November 2008
Braich Ddu farm	Wales	3	1.30	3.9	January 2008
Conisholme Fen re-submission	England	20	0.80	16.0	May 2008
Dalswinton, Pennyland Moor	Scotland	15	2.00	30.0	October 2008
Drumderg	Scotland	16	2.30	36.8	October 2008
Green Knowes	Scotland	18	1.50	27.0	September 2008
Hagshaw Hill extension	Scotland	20	1.30	26.0	October 2008
High Hedley Hope 2	England	4	1.30	5.2	October 2008
Inner Dowsing	England (off-shore)	30	3.60	97.0	November 2008
Kilbraur (Strathbrora)	Scotland	19	2.50	47.5	August 2008
Knabs Ridge, Felliscliffe	England	8	2.00	16.0	September 2008
Liniclate wind farm	Scotland	1	0.90	0.9	December 2008
Lynn	England (off-shore)	30	3.00	97.0	November 2008
Millennium (Glenmoriston) extension	Scotland	4	2.50	10.0	December 2008
Millennium (Glenmoriston)	Scotland	16	2.50	40.0	October 2008
Minsca farm	Scotland	16	2.30	36.8	May 2008
Moel Maelogen extension	Wales	8	1.30	11.7	October 2008
North Redbog	Scotland	2	0.80	1.6	July 2008
Owenreagh extension	Northern Ireland	6	0.85	5.1	August 2008
Ramsey repowering	England	1	1.80	1.8	September 2008
Ransonmoor Phase II	England	2	2.00	4.0	April 2008
Scout Moor	England	26	2.50	65.0	September 2008
Shooters Bottom farm	England	1	2.00	2.0	June 2008
Slieve Rushen repowering	Northern Ireland	18	3.00	54.0	April 2008
The Hollies wind farm	England	2	1.30	2.6	July 2008
Trimdon Grange	England	4	1.30	5.2	October 2008
Ulster University	Northern Ireland	1	0.80	0.8	August 2008

Table 2 continued on page 276

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Continued from page 275					
Walkway, High Swainston	England	7	2.00	14.0	May 2008
Watten (Bilbster)	Scotland	3	1.30	3.9	September 2008
Westmill	England	5	1.30	6.5	March 2008
Whitelee, Eaglesham Moor (part)	Scotland	89	2.30	204.7	November 2008
Whittlesey	England	1	1.80	1.8	September 2008
WWF Roskrow Barton	England	2	0.85	1.7	February 2008
*Average turbine size: 2.18 MW		414		911.5	

been constructed (Figure 8). The greatest proportion of capacity in this figure (3,255 MW) is made up of English offshore projects that have been approved but have not yet been built. Onshore wind projects in Scotland also contribute significantly to this total, with over 2 GW of capacity approved but not yet under construction.

The approval rate for new wind energy projects in 2007 was 70.1%. This was significantly greater than the rates of 54.7% and 59.6% observed in 2006 and 2005, respectively. In 2008, the approval rate dropped to 61%. Although this rate is considerably worse than the 2007 rate, more capacity was approved in 2008 (almost 4 GW) than in 2007 (2,300 MW).

In both 2007 and 2008, refusals had the biggest impact in Scotland. In 2007, 17 projects and 575 MW of capacity were refused planning permission or were withdrawn. In 2008, only six Scottish projects were refused permission or were withdrawn; however, this amounted to over 1 GW of capacity.

3.0 Benefits to National Economy

3.1 Market characteristics

The consistently high level of project development undertaken over the past three years, together with the large number of projects that have gained planning consent and are on the drawing board, underlines the fact that wind energy remains one of

the fastest-growing energy sectors in the UK. It is estimated that companies working in the renewables sector currently sustain about 16,000 (16) jobs in the UK, and this number is projected to increase as the wind industry grows. If the UK is to meet its proposed 2020 RE target, it is estimated that this will require 122,000 to 133,000 jobs (16), although not all of these will necessarily be in the UK.

The supply chain that supports the UK wind energy industry includes developers; professional services providers such as accountants, solicitors; and insurers; and technical consultants in the areas of wind resource assessment, planning, civil engineering, environmental impact assessment, and electrical engineering. Also included are supply chain manufacturers that provide all major components of a wind turbine, including blades, foundations, seabed survey, logistics and port storage, installation, cable laying, connections, standards/certification, and O&M services. With the exception of Clipper Windpower, major turbine manufacturers are located outside of the UK, which poses challenges for the UK supply chain.

3.2 Economic details

Financing for wind farms is obtained largely from the balance sheets of corporate investors and banks, although there is a small amount of private investment. There

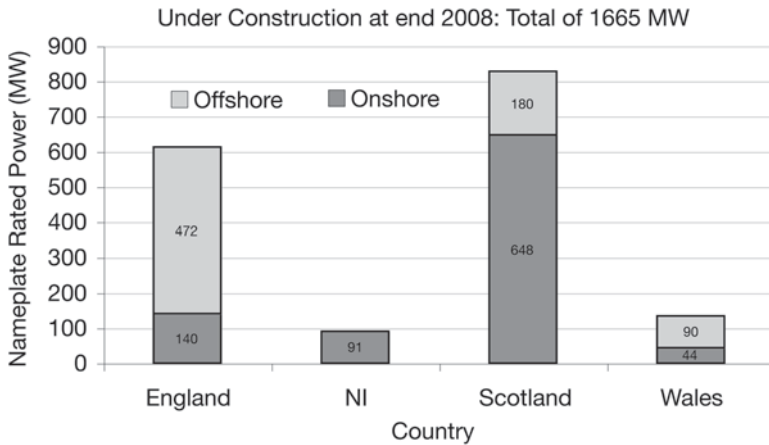


Figure 6 UK wind capacity under construction at end of 2008.

Table 3 Completed Offshore Wind Projects in the UK (through 2008)				
Wind farm	Turbine/manufacture	Turbine no.	Capacity (MW)	Online
Inner Dowsing	3.6 MW/Siemens	30	97	November 2008
Lynn	3.6 MW/Siemens	30	97	November 2008
Burbo Bank	3.6 MW/Siemens	25	90	October 2007
Beatrice	5 MW/RE Power	2	10	July 2007
Barrow	3 MW/Vestas V90	30	90	July 2006
Kentish Flats	3 MW/Vestas	30	90	October 2005
Scroby Sands	2 MW/Vestas	30	60	March 2004
North Hoyle	2 MW/Vestas	30	60	December 2003
Blyth Offshore	2 MW/Vestas	2	3.8	December 2000

are also some community wind farms in the UK. One of these was completed in 2008—the five-turbine Westmill wind farm (Figure 9). Westmill is the first onshore wind farm to be built in the southeast of England and is 100% community owned.

The Renewables Obligation has greatly increased the development of wind projects, with utilities, generators of conventional power, and new developers active in the market. Because of the high value the RO places on renewables, corporate investment

will yield good returns through an expansion of the core business while reducing exposure to penalty payments. Onshore wind energy has found particular favor because of its economics, maturity, and ability to deliver relatively quickly. In the future, offshore wind, biomass generation, and technologies further from commercial deployment (for example, wave and tidal) will be advantaged by the introduction of banding.

During the current financial recession, project financing has generally been very

National Activities

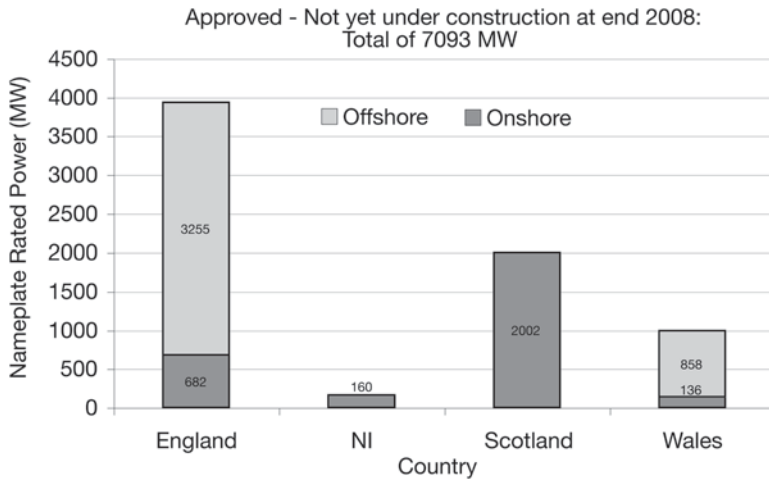


Figure 7 UK capacity approved but not yet under construction at end of 2008.

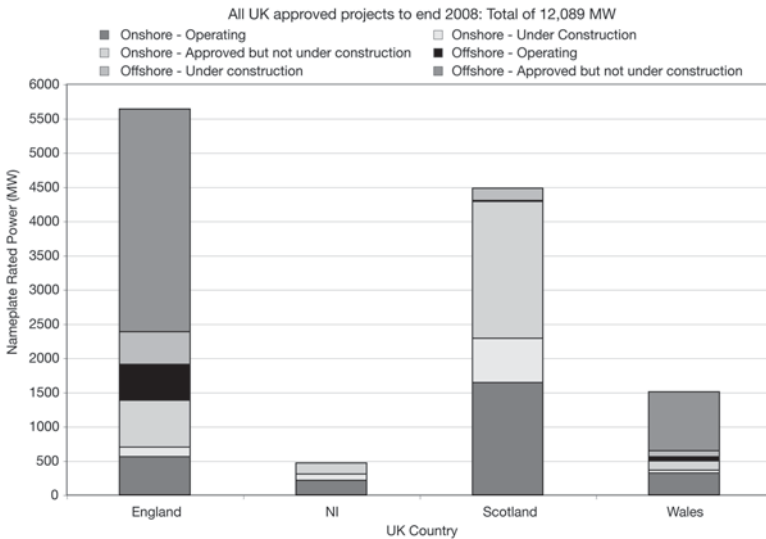


Figure 8 All UK-approved projects to end 2008.

difficult. In some cases, particularly in the offshore market, this has led to companies withdrawing from projects. This has often resulted from changes in ownership rather than the project not being taken forward.

The present-day costs of installing wind energy in the UK are between 1000 £/kW and 1,500 £/kW onshore, rising to between 2,000 £/kW and 3,000 £/kW

offshore. The higher capital expenditure costs of offshore are due to the increase in size of structures and the logistics of installing the turbines at sea. The costs of foundations, construction, installations, and grid connection are significantly higher offshore than onshore. Typically, for example, offshore turbines are 20% more expensive, and towers and foundations offshore can cost

more than 2.5 times the price for a project of similar size onshore.

Indications of power purchase prices come from published auction prices and trading prices from renewable energy certificates. Currently, the Non-Fossil Fuel Purchasing Agency Ltd. (NFPA) conducts biannual green power auctions. These auctions are for electrical output that will be produced by NFFO (Non-Fossil Fuel Obligation) generators during a six-month period (starting 1 April or 1 October) following the end of the auction. These auction prices are for electrical output, together with (depending on the generation technology) Climate Change Levy Exemption Certificates (LECs) and Renewables Obligation Certificates (ROCs). In the NFFO power auction in February 2009, the price for wind was 92 £/MWh. This is a significant decrease from the peak of 136.9 £/MWh in August 2008. In February 2008, the price was 106 £/MWh. In January 2009, ROCs cost 51.81 £/MWh. This is a decrease from the peak of 53.27 £/MWh in July 2008. In January 2008, the price was 49.95 £/MWh.

4.0 National Incentive Programs

The government is eager to encourage the development of wind generation in the UK and has created several incentives, either through legislation or other means. The measures introduced and some of the key issues faced are detailed in this section.

4.1 Energy Act

The Energy Act 2008 received Royal Assent on 26 November 2008. It implements the legislative aspects of the Energy White Paper published in May 2007; its principal objective is to make the legislative framework more appropriate for today's energy markets. Aspects of the Energy Act that are expected to affect UK wind energy projects include the following:

- A reform of the Renewables Obligation, the principal fiscal incentive for renewable electricity generation in the UK. The act aims to increase the effectiveness of the RO by allowing different levels of support to different renewable technologies under the RO



Figure 9 Construction of the Westmill wind farm, Oxfordshire, England. Photo by Martin Phelps of Westmill Wind Farm Co-operative.

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scheme through banding (see Section 4.4 for more detail on this).

- The provision for a system of feed-in tariffs to be introduced for small-scale renewable generators (e.g., small-scale wind turbines) up to a maximum total capacity of 5 MW, to incentivize households, businesses, and community groups to generate low-carbon electricity. The government intends to consult in summer 2009 on the detail of a feed-in tariff mechanism and is aiming to introduce the new mechanism in 2010.
- Additional powers to enable the Office of Gas and Electricity Markets (Ofgem) to run effective competitive offshore transmission tenders and recover their costs. This is designed to ensure that the most economic and efficient transmission solution is encouraged to facilitate the expansion of offshore renewables.
- Strengthening of the statutory decommissioning scheme for offshore energy installations, including offshore wind turbines, as part of the offshore licensing regime.

4.2 Climate Change Act

The Climate Change Act 2008 received Royal Assent on 26 November 2008, making the UK government the first in the world to introduce legally binding long-term objectives to tackle climate change. The act includes the following elements:

- The creation of the Climate Change Committee (CCC), an independent advisory body on climate change consisting of experts in the field. The CCC will advise the UK government on reducing emissions across the economy, adaptation strategies, and setting targets for emissions reductions over time. CCC members will also report independently on progress made toward targets.
- A formal system for setting medium- and long-term emissions reduction

targets and carbon budgets for all areas of the UK economy, including electricity generation. The act requires the UK government to reduce the net UK carbon account for the year 2050 to at least 80% below the level of net UK emissions of targeted greenhouse gases in 1990. Since currently two-thirds of UK emissions originate from the use of energy, this will act as a driver for large-scale adoption of low-carbon energy sources, such as wind generation, over the next forty years.

4.3 Planning Act (England and Wales)

The Planning Act 2008 received Royal Assent on 26 November 2008. The act introduces several reforms to the town and country planning system in England along with a new integrated planning system for major infrastructure—including large-scale renewable energy generation projects in England and Wales. The new system is designed to improve and streamline the planning process to reduce uncertainty, time, and cost while retaining public involvement and accountability.

The act establishes the Infrastructure Planning Commission (IPC), an independent body responsible for applications for development consent for nationally significant infrastructure projects. (For electricity generation, this means schemes with an installed capacity of greater than 50 MW onshore and greater than 100 MW offshore.) The IPC will be guided by National Policy Statements (NPSs). These will be prepared for each category of infrastructure that the Planning Act defines as nationally significant. It is expected that there will be an overarching NPS for energy infrastructure and a specific NPS for renewable energy. By rationalizing the planning regime for major infrastructure projects in this way, the UK government aims to reduce the time between application and decision to less than a year in most cases.

The UK government launched a consultation on the list of statutory consultees

for NPSs in January 2009 which closes in April 2009. The government has also published its “Route Map to IPC Implementation” which establishes a timetable that requires the IPC to begin making decisions in 2010.

4.4 Planning in Scotland

The planning system in Scotland differs from that of England and Wales. In Scotland, the planning system for large renewable energy projects is also being reformed (17, 18). The Scottish government recognizes that steps are urgently needed to streamline the consenting process. The Scottish government now has the objective of determining new applications within nine months where there is no public inquiry.

In December 2008, a draft of Scotland’s second National Planning Framework (NPF) was laid before Scottish Parliament for consideration. The NPF is concerned with Scotland’s development over the next 25 years and the actions needed to bring about that development. The draft NPF sets out the following issues:

- The Scottish government’s commitment to develop Scotland’s renewable energy potential.
- A different planning process for projects deemed to be of national significance.
- The potential for development of a subsea transmission grid.

The Scottish Parliament is currently reviewing the draft, with the aim of publishing the final document in spring 2009.

4.5 The Renewables Obligation

The Renewables Obligation (19) is the government’s chief incentive mechanism for renewable electricity generation in the UK. Also, working in support of other policy measures such as the EU Emissions Trading System, it is an important part of the government’s program for securing reductions in carbon dioxide emissions. It requires electricity suppliers to source an increasing

proportion of their electricity from renewable sources or pay a buyout price.

To make the RO more efficient and effective, the government is introducing several reforms. The RO Order is expected to get EU approval for state aids such that it can be implemented on 1 April 2009. The new RO Order will accomplish the following:

- Band the RO to provide more support to technologies that are currently further from commercial deployment.
- Introduce mechanisms to protect investments made in renewables generation.
- Change the RO to make it easier for microgenerators to access it.

These proposals are now set out in the draft Renewables Obligation Order, which went before parliament in March 2009.

The UK government and the Devolved Administrations understand the benefits of a consistent approach across the UK and the importance of this matter to many within industry. Separate Renewables Obligation Orders were made for Scotland and Northern Ireland so that the changes came into effect on 1 April on a UK-wide basis.

Under a banded RO, onshore wind will continue to receive 1 ROC/MWh, and offshore wind will receive 1.5 ROC/MWh. This change acknowledges the extra difficulties, risks, and costs involved in offshore wind development as compared with onshore wind development. Since its introduction in 2002, the RO has succeeded in almost tripling the level of renewable electricity (from 1.8% of total UK supply to 4.9% in 2007). The changes being introduced are designed to make the RO more successful still. A banded RO is expected to deliver approximately 13.4% of electricity from renewable sources by 2015/2016.

The Chancellor’s Pre-Budget Report announced on 24 November 2008 that the Renewables Obligation was to be extended from its current end date of 2027 to at least 2037. The announcement has been widely

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welcomed and will allow investors to plan for the short to medium term. Indeed, this extension means that almost all renewables projects going through planning will benefit from the RO support mechanism throughout the entirety of their proposed life spans.

4.6 The Renewable Energy Strategy consultation

In the Renewable Energy Strategy consultation, the government consulted on a range of possible measures to deliver the proposed UK share of the EU's renewable energy target (of 20% of energy by 2020). The consultation (20) ran from 26 June to 26 September 2008 and sought views on how to increase the use of renewable energy in the UK as part of the overall strategy for tackling climate change. Responses to this consultation helped to shape the UK Renewable Energy Strategy, which was published in late spring 2009 after the final shares of the EU target had been agreed by member states. Renewable Energy Strategy consultation proposals relevant to wind power generation included the following:

- Creating additional financial incentives for electricity by extending and raising the level of the RO for large-scale electricity and using either feed-in tariffs or enhanced RO for micro generation.
- Removing grid barriers to renewables by providing new incentives for National Grid to build grid infrastructure and by reforming access arrangements.
- Reducing planning consent barriers by providing strong guidance and training to local decision makers through a National Policy Statement, creating an expert body to advise planners and setting regional renewables targets that shape local economic strategies.
- Stimulating innovation and the supply chain by setting a clear, long-term framework and considering how efforts to meet the 2020 target will affect

incentives to develop emerging renewables technologies.

It is expected that the key growth area will be wind power, both onshore and offshore. One scenario in the consultation was that by 2020, offshore wind capacity could be ~14 GW, compared with less than 1 GW today. This would require the installation of a further 3,000 offshore turbines, rated at 5 MW. Initial government models indicate that ~13 GW of onshore wind generation capacity will be required by 2020, as compared with 2.7 GW in February 2009. This equates to approximately 4,300 onshore turbines rated at 3 MW. It is expected that a large proportion of this onshore wind development will take place in Scotland.

4.7 Addressing aviation issues

Current-generation wind turbines have very large radar signatures, and can have significant impacts on civilian and military aviation radar systems. Therefore, wind energy developments must take into account national air defense and air safety. To investigate the issue and improve understanding between the aviation and wind energy industries, BERR (now DECC) set up the Wind Energy, Defence and Civil Aviation Interests Working Group. The Working Group, includes representatives from UK military and civilian aviation authorities, the BWEA, and the UK government.

In 2008, the Working Group produced the Aviation Plan, which coordinates activities to identify, develop, and deliver mitigation solutions. The plan allows stakeholders to monitor progress of the delivery of solutions by presenting details of the key programs, including studies on air defense radar, air traffic control, radar interference reduction, and stakeholder consultations. To ensure the success of the plan, several stakeholder groups signed a Memorandum of Understanding, published in June 2008, to commit to fully implementing the Aviation Plan and its approach.

To ensure the delivery of the Aviation Plan, an Aviation Management Board

(AMB) has been established with overall responsibility for the success of the plan. This is supported by a panel of experts, the Aviation Advisory Panel (AAP). The role of the AAP is to provide the AMB with information and advice on the progress of the Aviation Plan and its associated work streams. Both of these groups had their inaugural meetings in July 2008.

In addition, a financial management board has also been established to ensure that the work streams will have appropriate financial support. Their inaugural meeting was planned for March 2009. Full details of the Working Group's activities, meeting minutes, and documentation can be found at <http://www.berr.gov.uk/whatwedo/energy/sources/renewables/planning/on-shore-wind/aeronautical/page18755.html>.

4.8 Grid connection issues

The Transmission Access Review (TAR), led jointly by DECC and Ofgem, has examined the technical, commercial, and regulatory frameworks for the National Grid to ensure that they remain fit for purpose as the proportion of renewable generation on the system grows. The final report of the TAR was published on 26 June 2008 (21). Taken together, the measures set out in the TAR final report will remove or significantly reduce grid-related access barriers to renewable generation. The report recommends actions that will allow faster connection of some renewable generation to the grid in the short term; introduce new, enduring grid access arrangements that will allow faster connection and expansion of grid capacity; and identify the new transmission infrastructure necessary to meet the UK share of the 2020 EU renewable energy targets and new financial incentives on transmission companies to deliver that infrastructure.

To facilitate faster connection to the grid, National Grid is proposing changes to the contractual system for transmission access. The Connection and Use of System Code (CUSC) is the legal document that

constitutes the contractual framework for connection to and use of National Grid's high-voltage transmission system. National Grid leads a series of CUSC Working Groups, which are developing CUSC Amendment Proposals (CAPs). These amendments are intended to improve access arrangements that facilitate the anticipated connection of large volumes of generation whilst maintaining an efficient and reliable network. CAPs relating to short-term access modifications aim to facilitate more short-term connection to the transmission system through changes to how access rights are granted. CAPs that address long-term transmission access involve changing the framework for agreeing and terminating long-term connection agreements.

The CAPs require approval by Ofgem before they take effect; several were approved and implemented in 2008, and others will be considered in 2009. Ofgem delivered a progress report to the Secretary of State at the end of December 2008 stating that it was satisfied with progress and would continue to work with National Grid to agree on further amendments. The UK government views the development of offshore wind generation as a major contributor to meeting the 2020 renewable generation target. At present, there is little electricity network infrastructure installed offshore; DECC and Ofgem are working together to develop a new regulatory regime for offshore electricity transmission so that significant amounts of renewable offshore generation can be connected to the onshore grid in a cost-effective way.

DECC and Ofgem have been consulting on the design and implementation of the new regime. Several consultations and stakeholder communication events took place in 2008 (22). The final consultation on the full package of proposals for the offshore transmission regulatory regime will be published in 2009.

The UK government has decided that offshore transmission owner (OFTO) licenses will be granted via competitive tenders run by Ofgem. Companies will bid a

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20-year revenue stream to design and build (where appropriate), finance, and maintain the transmission assets connecting each offshore generation project to the onshore grid. The government believes this competitive approach will deliver significant efficiencies and attract new players and innovation to the market. The first tenders are expected in the summer of 2009 so that existing projects will have an OFTO in place when the new regime comes into force in June 2010.

4.9 Offshore wind

Of the marine renewable energy generation technologies, only offshore wind is presently commercially viable, although other marine renewables technologies will eventually also contribute to the attainment renewable energy goals. Under The Crown Estate Act 1961, The Crown Estate is landowner of the UK seabed out to the limit of the territorial sea and areas of offshore (www.thecrownestate.co.uk). The Crown Estate's permission in the form of a site option agreement and lease or license is required for the placement of structures or cables on the seabed. This includes offshore wind farms and their ancillary cables and other marine facilities. The Energy Act 2004 gave The Crown Estate rights to issue licenses within Renewable Energy Zones from 12 nautical miles (nm) out to 200 nm for development.

Round 1 of offshore wind farm leasing was supported by the government using the Capital Grants Programme, which covered approximately 10% of project capital costs. The first phase of the development of offshore wind projects in the UK was launched in December 2000 and has resulted in 14 projects, of which 7 are now operational.

During Round 2, 15 projects, with a combined capacity of up to 7.2 GW, received leases to operate offshore wind farms. These projects are all at varying stages of development, either progressing through the planning system or under construction.

None of the Round 2 projects are yet operational, although work on the 64-MW Gunfleet Sands II wind farm has started and should be fully operational in 2010.

Proposals for Round 3 of offshore wind farm leasing were announced on 4 June 2008 by The Crown Estate (23). In Round 3, The Crown Estate is taking a more prominent role and will coinvest with developers, combining the technical experience of the offshore wind industry with efficiencies generated by The Crown Estate's access to resources and stakeholders. The key principle underlying the first two rounds of offshore wind farm development was a robust process for selecting parties to develop, construct, finance, and operate designated offshore wind projects. This is being carried forward into Round 3.

The Crown Estate's role in Round 3 will revolve around program delivery and zonal contract management; the partners will work with The Crown Estate to identify suitable wind farm sites in each zone and thereafter address delivery of specific sites. The Crown Estate will not be involved in building or operating wind farm sites. During 2008, significant progress was made toward agreeing Round 3 leases. The Crown Estate has mapped potential zones suitable for wind farm development against other activities that are undertaken on its Marine Estate. In August 2008, organizations were invited to submit expressions of interest. Ninety-six UK and international companies registered their interest during Round 3, greatly exceeding expectations. In September 2008, The Crown Estate issued an invitation to negotiate to parties selected following their submission of an expression of interest. Potential developers that registered interest were invited to bid for one or more of nine development zones identified by The Crown Estate. The timetable for Round 3 is as follows:

- 2009 (Q1)—Submission of bids
- 2009 (Q4)—Completion of awards to zone partners
- 2010 to 2013—Phase 3 (consents and contracts)

- 2014—Phase 4 (construction)
- 2018—Phase 5 (operation)

In 2007, The Crown Estate undertook a feasibility assessment of transmitting electricity through offshore transmission systems. The study concluded that the activity was technically feasible and offered commercial possibilities. As a result, a more detailed investigative study has been undertaken to examine the potential requirements for offshore transmission connections for Round 3 wind farms. In April 2008, The Crown Estate commissioned a study (24) into the potential requirement for offshore transmission connections for Round 3 wind farms and connecting up to 25 GW of additional wind generation. The report's observations and recommendations included the following:

- The extent of constraints on the supply chain may affect delivery of the Round 3 connections.
- The power transfer capacity of HVAC and high-voltage direct-current (HVDC) technologies should be raised to improve economies of scale.
- “No regret” onshore reinforcement options should and can be progressed immediately to provide the necessary transmission capacity in a timely manner.

The Crown Estate believes there is a case for commencing onshore reinforcements ahead of connection applications. It understands that a coordinated plan and commitment are needed to give the supply chain the confidence it needs to invest in infrastructure to support transmission development.

On 5 January 2009, BERR (now DECC) published its Offshore Energy Strategic Environmental Assessment (SEA) Environmental Report for public consultation, closing on 22 April 2009 (25). This SEA was intended to accomplish the following:

- Consider the environmental implications of a draft plan/program

for licensing for offshore oil and gas, including gas storage, and leasing for offshore wind. This includes consideration of the implications of alternatives to the plan/program and the potential spatial interactions with other users of the sea.

- Inform the UK government's decisions on the draft plan/program.
- Provide routes for public and stakeholder participation in the process.

The SEA considered the alternatives to the draft plan/program and the potential environmental implications of the resultant activities in the following contexts:

- Objectives of the draft plan/program
- SEA objectives
- Existing regulatory and other control mechanisms
- Wider policy and environmental protection objectives
- Current state of the environment and its likely evolution over time
- Existing environmental problems.

To attain the 25-GW objective of the draft plan/program, several thousand wind turbines would be needed which, depending on turbine spacing and wind farm separation, may occupy up to 10,000 km². Development on this scale may result in significant environmental effects on areas or landscapes of recognized national, European Community, or international protection status, as well as on other uses of the sea. The conclusion of the SEA Environmental Report is that restricting the areas offered spatially through the exclusion of certain areas is the preferred option. The report concludes that no overriding environmental considerations will prevent achievement of the offshore oil and gas, gas storage, and wind elements of the plan/program—assuming implementation of several mitigation measures to prevent, reduce, and offset significant adverse impacts on the environment and other users of the sea.

On 16 February 2009, The Crown Estate announced it would be offering

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exclusivity agreements to companies and consortia for 10 sites for development of offshore wind farms in Scottish territorial waters (26).

5.0 R, D&D Activities

To accelerate development of both onshore and offshore wind energy, the UK government provides funding for research and development projects in partnership with industry. It does this through two bodies:

- The Technology Strategy Board (TSB)
- The Energy Technologies Institute (ETI).

5.1 Technology Strategy Board (TSB)

The TSB (27), sponsored by the Department for Innovation, Universities and Skills, was established as an executive body at arm's length from government in 2007. It supports businesses conducting research and development in certain technology areas in the form of match-funded grants. As well as investing in programs and projects, much of its work is in spreading knowledge, understanding policy, spotting opportunities, and bringing people together to solve problems or make new advances. The TSB's vision is for the UK to be seen as a global leader in innovation and a magnet for technology-intensive companies, where new technology is applied rapidly and effectively to create wealth. The TSB's priorities for R, D&D in wind energy include the following:

- Projects that seek to reduce cost of the turbines themselves or of offshore foundations, installation, or operations and maintenance.
- Projects that seek to mitigate the interaction between wind turbines and radar, which is at present a key barrier to wind development both onshore and offshore.

The TSB had no new calls for wind-related projects in 2008, as this area of R&D is now supported under the Energy Technologies Institute. However, the TSB continues to support existing projects in

wind R&D. In 2008, TSB spent approximately 650,000 £ on the wind program to support R, D&D projects (Table 4). These projects are at various stages of the project cycle from inception to completion.

During 2008, one new project joined the TSB wind program. The in-situ wireless monitoring of offshore wind towers and blades project aims to develop a system to monitor blades and support structures for offshore wind generators. The data will be transmitted and the system controlled by wireless communication with the shore base. This system could drastically reduce the cost of offshore wind turbine inspection whilst increasing reliability.

5.2 Energy Technologies Institute

The ETI (28) is a 50:50 partnership between government and industry, with some of the world's largest energy and engineering firms involved. The institute will spearhead the collaborative development of new commercially viable, sustainable low-carbon energy technologies to provide a secure, sustainable, and affordable energy supply for this and future generations. BERL (now DECC) has announced that it is prepared to authorize matched public funding of up to 550 million £, creating the potential for a 1.1-billion-£ institute over 10 years.

The ETI sees offshore wind in particular as a strategic priority. To support increasing levels of deployment in line with the government's ambition, the initiative has the following goals for 2020:

- Reduced costs: cost of energy to be reduced to the prevailing least-cost wholesale price of electricity, or lower.
- Increased yields: annual farm availability to be increased to 97% to 98% or better, equivalent to onshore wind today.
- Reduced risks: reduction in technical uncertainties to allow farms to be financed in a manner, and at costs, equivalent to onshore wind today.

The ETI issued a call for projects to form part of its Offshore Wind and Marine

Table 4 Wind Research Projects with TSB Support

Project name	Start date	Initial end date*
Stealth technology for wind turbines	November 2005	December 2007
Deepwater offshore wind farm demonstrator project	September 2004	March 2009
A low-cost safety-critical radar-absorbing material for wind turbine nacelles and towers	November 2006	March 2009
Stealthy wind turbines—addressing the radar issue	November 2005	August 2009
Development of an innovative radar absorbing composite structure for wind turbine blades	March 2008	January 2010
Cost-effective manufacture of offshore wind turbine foundations	June 2008	May 2010
Affordable innovative rapid production of offshore wind energy rotor blades	February 2007	September 2010
Innovative high-power direct-drive superconducting generator for offshore wind	December 2005	October 2010
In-situ wireless monitoring of offshore wind towers and blades	June 2008	May 2011

* Due to the nature of these projects, it is likely that the project end dates will change.

Energy Programmes in December 2007. More than 130 expressions of interest were received for the Offshore Wind Programme for a range of projects involving research, development, and demonstration activities. On 13 January 2009, the ETI announced funding for its first four projects. Three are related to offshore wind turbine technology, and one is related to tidal stream turbine technology. The three projects in the Wind Energy Programme will receive ETI funding totaling approximately 10 million £. The project consortiums have begun to mobilize with the aim of completion by April 2010.

Project Nova is a UK-based consortium led by Guildford energy specialists OTM Consulting that includes representatives from three universities—Cranfield, Strathclyde, and Sheffield; the Centre for Environment, Fisheries and Aquaculture (CEFAS); and SME Wind Power. Key subcontractors include James Ingram Associates and QinetiQ. The project will assess the feasibility of a unique wind turbine with a pair of giant vertical wings, which has the benefit of ruggedness, stability, and simpler maintenance access when compared with the horizontal-axis concept of conventional turbines.

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Project Helm Wind is a UK-based consortium led by E.ON Engineering that includes representatives from Rolls-Royce, BP Alternative Energy, and the University of Strathclyde. The project aims to deliver a concept design and feasibility study for a new offshore-specific wind farm and seeks to overcome the issues facing today's systems including turbine reliability and accessing equipment for maintenance.

Project Deepwater Turbine is led by Blue H Technologies with representatives from UK groups including BAE Systems, CEFAS, EDF Energy, Romax, and SLP Energy. The project aims to design and determine the feasibility and potential of an integrated solution for a 5-MW floating offshore wind turbine for deep-water deployments between 30 and 300 meters.

Further support for wind is expected via several new mechanisms in 2009. The Environmental Transformation Fund for Low Carbon Technologies (29) formally began operation on 1 April 2008. On 26 June 2008, John Hutton announced his intention to launch an Offshore Wind Technology capital grants competition, supporting the demonstration of next-generation technology for offshore wind. The UK Energy Research Council is expected to announce that it will develop a technology road map for offshore wind in 2009. The Carbon Trust has announced that it will launch an Offshore Wind Accelerator program, with the aim of reducing offshore wind costs, in 2009.

6.0 The Next Term

The UK Renewable Energy Strategy is scheduled to be published in late spring 2009 following agreement in March 2009 about the UK's share of the EU renewable energy target. The UK RE national action plan, which will set out how the UK will meet its target, will be published later in 2009.

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UK renewable energy statistics can be found at the web site for Department for Business, Enterprise and Regulatory Reform (BERR), which is now part of DECC, the Department for Energy and Climate Change:

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1.0 Introduction

During 2008, the United States added more than 8,500 MW of wind energy capacity, becoming the world's largest wind energy generator (Table 1). The total U.S. wind generation capacity increased by 50% to 25,369 MW (1), which will produce enough electricity to power approximately seven million U.S. households. Wind energy projects completed in 2008 accounted for approximately 42% of the nation's new generating capacity for the year and an investment of 16.4 billion USD, according to the American Wind Energy Association (AWEA). Generation from these projects over their lifetime will avoid nearly 44 million tons of carbon emissions—the equivalent of taking more than seven million cars off the road.

More than 100 new wind projects larger than 2 MW were installed in 25 states and resulted in nearly 5,000 turbines being commissioned in 2008. The average size of the turbines installed in 2008 was 1.67 MW, a slight increase from the 1.65 MW in 2007. More than half of the turbines were 1.5 MW and the largest turbines were 3 MW. The average project size was about 70 MW. The world's largest operating wind plant is the 735-MW Horse Hollow facility that covers 47,000 acres (190 km²) in Texas.

More than 5,000 MW of new capacity could be commissioned in 2009, according to industry predictions. However, due to the economic climate and especially difficulties with financing, the level of activity in 2009 is uncertain. Provisions of the American Recovery and Reinvestment Act economic

stimulus bill signed in early 2009 could help the industry.

The industry for small wind turbines (defined as having a capacity rating of 100 kW or less) also experienced record-breaking growth in 2008. According to AWEA, the small wind turbine industry grew by 78% in 2008, adding 17.3 MW of new capacity, which brought the total small wind capacity up to more than 80 MW. More than 10,000 units were sold. The United States claimed about 50% of the global market share and is home to about one-third of the 219 identified manufacturers worldwide.

2.0 Progress Toward National Objectives

Renewable energy in general and wind energy in particular have been an integral part of economic legislation and policy in late 2008 and early 2009. In October 2008, the Emergency Economic Stabilization Act of 2008 (P.L. 110-343) renewed the production tax credit (PTC) for wind energy (2). In February 2009, the American Recovery and Reinvestment Act of 2009 further extended the PTC for wind energy to 31 December 2012 (3 and 4). Specific provisions are discussed in Section 4.0. The New Energy for America plan put forth by President Obama (5) contains policies that support investment in alternative and renewable energy technologies that are intended to end U.S. dependence on foreign oil, address the global

Table 1 Key Statistics 2008: United States

Total installed wind generation	25,369 MW
New wind generation installed	8,558 MW
Total electrical output from wind	71 TWh
Wind generation as % of national electric demand	1.9%
Target:	10% of U.S. electricity from renewables by 2012, and 25% by 2025

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climate crisis, and create millions of new jobs in the green energy sector. One goal of the plan is to ensure that 10% of U.S. electricity comes from renewable sources by 2012 and 25% by 2025.

A report published by the U.S. Department of Energy (DOE) in 2008, examined the potential for wind energy to provide 20% of U.S. electricity by 2030. Wind energy currently provides 1.9% of U.S. electricity (6). Wind capacity contributing 20% would support 500,000 jobs, reduce green house gas emissions equivalent to taking 140 million vehicles off the road, and save 4 trillion gallons of water. The report concluded that reaching such capacity will require an increase from the current 25.5 GW to more than 300 GW. To achieve this increase by 2030, annual increases in wind capacity will need to exceed 16 GW after an initial 10-year ramp-up period. The 8.5-GW increase in 2008 is a significant step toward meeting this goal.

However, as the 20% Report outlined, there are many challenges to taking full advantage of this opportunity. The research activities of the DOE Wind Program (Section 5) are designed to meet these challenges with efforts aimed at technology, resource assessment, and social acceptance issues.

In the near term, a goal of the DOE Wind Program is for 30 of the 50 states to have more than 100 MW of generating capacity by 2010. Industry records show that by the close of 2008, 22 states had 100 MW or more of wind generation operating, and 35 states had some wind plants operating within their borders (Figure 1). The Midwestern state of Iowa now has more installed capacity than California, and seven states have more than 1,000 MW of generating capacity:

- Texas: 7,118 MW
- Iowa: 2,791 MW
- California: 2,517 MW
- Minnesota: 1,754 MW
- Washington: 1,447 MW
- Colorado: 1,068 MW
- Oregon: 1,067 MW

Many states have renewable energy targets and made efforts in 2008 to promote wind energy development. For example, the California governor issued executive orders streamlining the state's approval process for renewable energy projects and increased the proportion of renewable generation required of utilities to 33% by 2020. The governor of New Jersey called for 30% of the state's electricity to come from renewables by 2020, with 3,000 MW to come from offshore wind power. He projected that this energy development would create 20,000 new jobs in the state.

Other supporters of wind energy are entering the public arena with proposals to increase installations. Oil developer T. Boone Pickens launched the Pickens Plan (7) that proposes increases in wind-generated electricity to save natural gas, which can then be used as a transportation fuel. This, he argues, would allow the United States to cut imported oil by one-third. Another voice, Nobel Peace Prize recipient and former Vice President Al Gore, argues that it is necessary and possible to obtain 100% of U.S. electricity from renewable energy within 10 years.

3.0 Benefits to the National Economy

The new wind generating capacity installed in 2008 represents an investment of about 17 billion USD, according to the AWEA. About 85,000 people were employed in the wind industry, up from 50,000 in 2007. The share of components for wind systems made domestically has increased from less than one-third in 2005 to about half in 2008. In 2007 and 2008, manufacturers of turbines and components announced additions to or expansions of 70 facilities, which created an estimated 8,400 new jobs in 2008 alone.

3.1 Market characteristics

Independent power producers still owned the bulk of U.S. wind energy generation at the end of 2008, and six companies owned more than 1,000 MW of wind energy assets each: NexEra Energy Resources (formerly

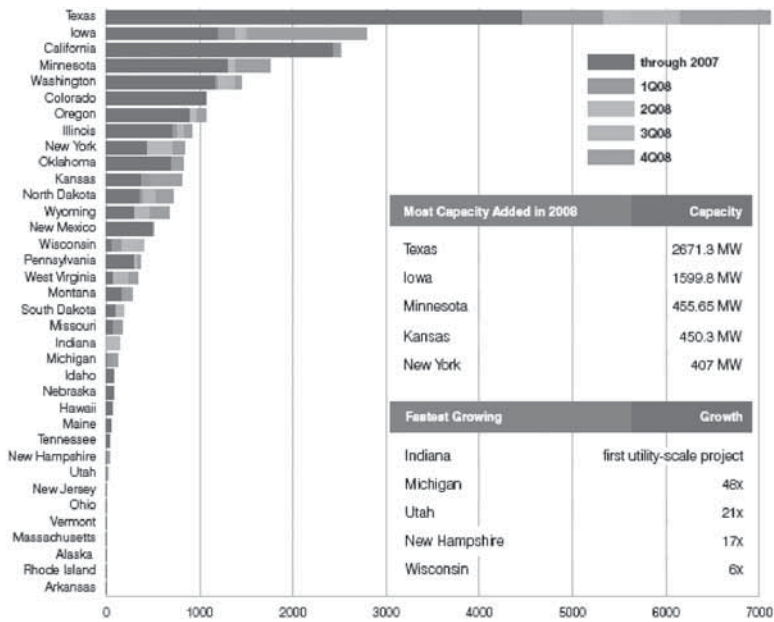


Figure 1 Wind power capacity installations by state (Source: AWEA Annual Wind Industry Report, 2008).

FPL Energy) owns 6,290 MW (approximately 25% of the total U.S. capacity); Iberdrola Renewables owns 2,063 MW; MidAmerican Energy owns 1,939 MW; Horizon-EDP Renewables owns 1,872 MW; Invenergy owns 1,276 MW; and Babcock & Brown Wind owns 1,118 MW (8). Utilities owned approximately 15% of the wind energy projects in 2008.

Ownership patterns include the tendency for dominant developers to buy projects developed by others and bring them under central operation, maintenance, and marketing structures. For example, Duke Energy purchased the holdings of wind developer Catamount Energy Corp. with projects in both the United States and the United Kingdom. With this acquisition, Duke Energy Generation Services had more than 500 MW of operating assets and 5,000 MW of wind energy under development in 12 states.

The number of community-owned projects is on the rise, according to Windustry, a nonprofit organization that supports community ownership of wind projects.

By July 2008, the total capacity for community owned projects was 736 MW. These projects use turbines over 50 kW in capacity and are completely or partly owned by towns, schools, commercial customers, or farmers.

3.2 Industrial development

General Electric Energy supplied the majority of the turbines, 3,657 MW, purchased in the U.S. in 2008, followed by Vestas with 1,120 MW, Siemens with 791 MW, and Suzlon with 738 MW (Figure 2). New companies entering the U.S. market included Acciona, AWE, Fuhrlander, and REPower.

The manufacture of wind turbines in the United States is increasing with the establishment of factories by major international suppliers. Seven of the ten largest suppliers of wind equipment—Acciona, Clipper, Gamesa, GE, Siemens, Suzlon, and Vestas—have manufacturing facilities in the United States. Acciona, based in Madrid, completed a wind turbine manufacturing facility in Iowa that employs more than 100 people. When the plant reaches full capacity,

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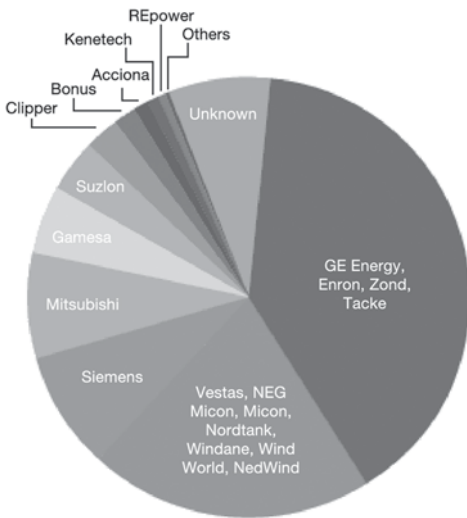


Figure 2 Top manufacturers contributing to the U.S. market for large-scale wind turbines.

it will supply approximately 2,610 MW of capacity per year. While wind power development brought some foreign manufacturing to the United States, some licensing of U.S. technology also took place. American Superconductor Corporation licensed its 1.65-MW and 2-MW wind turbine designs to South Korea-based Hyundai Heavy Industries Co., Ltd. for sale in the U.S. market beginning in 2009.

More than 100 companies now produce components for wind turbines, including towers, composite blades, bearings, and gears. Reflecting industry growth, AWEA membership grew to more than 1,800 companies in 2008 from 600 in 2005. Most of the new members are companies in the wind power supply chain. Figure 3 shows the distribution of wind energy manufacturing facilities across the country.

Production of small wind turbines is also a significant economic activity according to AWEA's 2008 Small Wind Turbine Global Market Report (8). With the increasing number of small turbines entering the market, consumers are questioning product safety and quality. Consumers buying small wind turbines have no

third-party information to help them compare products or estimate performance. To address this issue, the DOE Wind Program is funding and providing technical support for the formation of a Small Wind Certification Council (SWCC), an independent certification body for North America. The SWCC will certify small wind turbines that meet or exceed performance, durability, and safety requirements. The SWCC elected a board of directors in 2008 and will begin to certify turbines in late 2009. Some turbines submitted by manufacturers for certification will be tested in the United States at DOE's National Renewable Energy Laboratory (NREL) National Wind Technology Center (NWTC) in Golden, Colorado; others may be tested in Canada at the Wind Energy Institute of Canada's North Cape facility. The SWCC is currently developing protocols for certifying small wind turbine systems, including those not tested at accredited facilities. Certified turbines will be labeled for rated power, rated annual energy production, and rated sound level.

Gaining local acceptance for wind energy projects is key to increasing generation capacity. A decision in Washington State affirmed a contested permit for a large wind energy project. The successful developers conducted wildlife and habitat surveys, committed to post-construction monitoring, established a conservation reserve program to mitigate unavoidable impacts to habitat, and altered project layout in response to local concerns. Such activities earned the support of local citizens and state and regional environmental organizations. Nationally, wind energy companies and environmental groups created the American Wind Wildlife Institute to facilitate timely and responsible development of wind energy while protecting wildlife and wildlife habitats.

3.3 Economic details

Although wind energy project costs are influenced by many factors, turbine costs are the largest contributor. According to DOE's Annual Report on U.S. Wind Energy

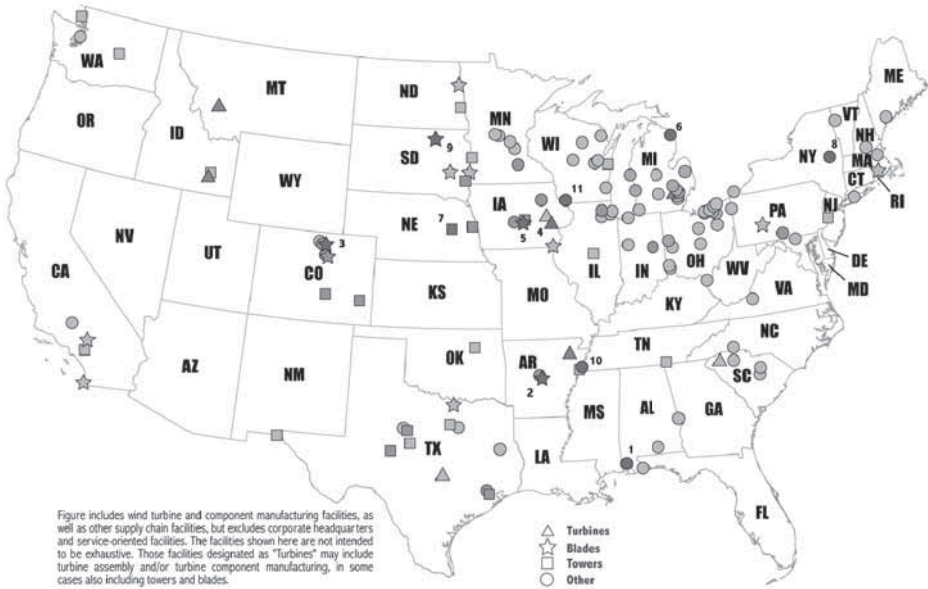


Figure 3 Manufacturing for wind energy development is distributed across the United States. Source: National Renewable Energy Laboratory.

Markets (9), between 2006 and 2008, capacity-weighted average turbine prices increased by roughly 210 USD/kW—from 1,150 USD/kW to 1,360 USD/kW—and project costs have increased on average by roughly 350 USD/kW during the past several years (Figure 4). This cost increase is driven by increasing commodities prices, unfavorable exchange rates, and fully committed production capacities.

Despite rising turbine costs, the cost of electricity from wind energy is still competitive with that generated by conventional sources in many areas. A database of wind power sales prices maintained by DOE contains price data for 158 wind projects installed since 1998 (9). The capacity-weighted average (projects are weighted by nameplate capacity to represent actual market prices) sales price for projects built

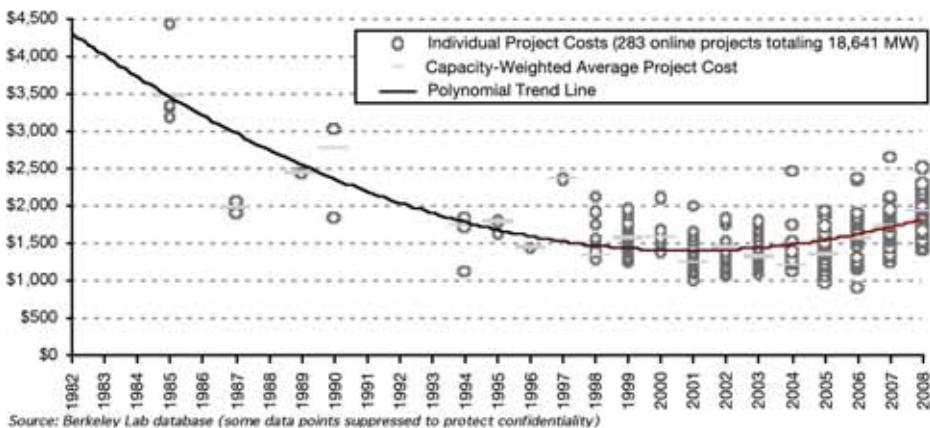


Figure 4 Wind project capital costs, 1982–2008.

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in 2008 was roughly 51.5 USD/MWh, up from a low of 30.9 USD/MWh for projects built in 2002 to 2003. This price is what the utility pays to the wind plant operator and includes the benefit of the federal production tax credit and state incentives.

4.0 National Incentive Programs

Federal tax incentives and state renewable portfolio standards (RPS) played important roles in the record growth of 2007 and 2008. In most of 2008, uncertainty about the extension of federal tax credits prompted completion of planned projects but may also have caused delays in starting new projects. In October 2008, Congress approved a one-year extension of federal tax credits and added other provisions beneficial to wind energy development. Then in February 2009, the federal incentives were expanded and extended to 2012, providing a predictable and transparent support framework to attract investment.

4.1 Federal incentive programs

The U.S. government provides research and development funding (see Section 5.0) and tax incentives for energy sector development because of its importance to society. The Emergency Economic Stabilization Act of 2008 (P.L. 110-343) and the American Recovery and Reinvestment Act of 2009 included important incentives for wind energy. The production tax credit (PTC) encourages investment in new wind plant construction by providing an income tax credit based on electricity production from wind projects. The investment tax credit (ITC) allows 30% of the investment to be refunded in the form of reduced income taxes. ITC may also be taken in the form of an upfront grant equivalent to 30% of total project value. These tax incentives were extended to 31 December 2012.

With the 2009 legislation, wind facility owners can claim the 30% ITC instead of the PTC if they choose. This provision will allow facilities to be leased or subject to a sale and leaseback without a loss of the credit, treating wind projects the way

solar projects have been treated in the U.S. tax code. Businesses and home owners are also allowed to claim the full 30% ITC for qualified small wind energy property with no dollar cap on the credit. To further stimulate industrial development, the law also includes a new 30% credit for investment in new or re-equipped manufacturing for wind energy equipment. Several grant programs were also included that will be funded depending on the evolving economic priorities of the government. The legislation also authorized extension of the Loan Guarantee Program for eligible “commercial” technologies such as wind.

The inflation-adjusted value of the PTC in 2008, was 0.021 USD/kWh for wind energy. To be eligible for a PTC, projects had to be in service by the close of 2008. The PTC goes to the owner(s) of the eligible renewable generating project, and is reduced if projects also receive certain types of government grants, tax-exempt bonds, subsidized energy financing, or other federal tax credits. Only projects located in the United States that sell their output to an “unrelated person” may qualify for the PTC. The record-breaking increases in capacity in 2006, 2007, and 2008 are evidence of the PTC’s effectiveness.

4.2 State incentive programs

The voluntary purchase of wind-generated electricity through green power or green pricing programs has significantly influenced wind industry growth. According to an analysis conducted by the U.S. Department of Energy, more than 850 utilities across the United States now offer green power programs. Green power sales in 2008 increased by about 20% over 2007, and they represent more than 5% of total electricity sales for some of the most popular programs. By the end of 2008, more than 600,000 utility customers participated in green power programs, which supported approximately 5,000 MW of new renewable power capacity. Wind is the primary source of electricity generated for green energy programs nationwide.

State-mandated RPS programs that require utilities to purchase a percentage of their overall generating capacity from renewable resources also have a significant effect on the wind industry. By the end of 2008, 28 states had adopted RPS approaches (10). In Missouri, voters approved a renewable electricity standard that requires 15% of the state's electricity to come from renewables by 2021. Hawaii increased its renewable electricity standard from 20% to 40% by 2030. Wind energy is expected to contribute significantly to achieving these goals. In 2008, state RPS policies collectively called for utilities to procure about 23 billion kWh of new renewable energy generation. By 2010, RPS policies call for utilities to obtain around 58 billion kWh of new renewables, rising to 99 billion kWh in 2012 (11).

Green pricing above the standard electricity rate is one way utilities support their purchases of electricity from wind and solar. The end-user price of green power for residential customers in utility programs in 2008 ranged from 0.0101 USD/kWh to 0.055 USD/kWh above standard electricity rates, with an average premium of 0.014 USD/kWh and a median of 0.015 USD/kWh. Generally, consumers spend about 5.10 USD per month above standard electricity rates for green power through utility programs (12).

Other state programs that provide stimulus for market growth include: grant programs, loan programs, production incentives, and utility resource planning.

4.3 Transmission policies

The need for increased grid access has been proposed in a study by the investor-owned utility American Electric Power and AWEA. The study, which was referenced in the DOE report *20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply*, concluded that a transmission superhighway will be needed for the United States to obtain 20% of its electricity from wind. More than 19,000 miles of new 765-kV (high

efficiency) transmission lines are proposed, costing 60 billion USD.

To improve grid access, planning and construction of multi-state, extra-high-voltage transmission lines is underway. One of these is the Wyoming–Colorado Intertie Project, which will connect the Front Range of Colorado with the windy areas of eastern Wyoming starting in 2013. Project sponsors auctioned 850 MW of capacity, and wind developers subscribed for nearly 70% of the transmission. In another effort, two utilities announced plans to construct a 150-mile, 345-kV transmission line to connect central Maine with future wind projects estimated to be worth 1.6 billion USD. Another project approved by the Texas Public Utility Commission will use 4.9 billion USD to build 2,300 miles of new 345-kV lines to link potential wind development areas with load centers. This line will make it possible to add 11,550 MW of wind to the more than 5,500 MW already operating in Texas.

4.4 Incentives for small wind

Many states also have policies and incentives for small wind electric systems. These incentives include rebates and buy-downs, production incentives, tax incentives, and net metering. Several states have adopted buy-down programs that levy a small charge on every kilowatt-hour of electricity sold. The money raised is used to buy down or subsidize the purchase of small renewable energy systems. The subsidy or rebate may be as much as 50% of the cost of a small wind turbine. The rebates become even more effective when combined with low-interest loans and net metering programs.

Under net metering policies, electricity customers who install their own grid-connected wind turbines are allowed to interconnect their turbines on a reverse-the-meter basis with a periodic load offset. The customer is billed only for the net electricity consumed over the entire billing period. In most states, generation beyond what the customer uses during the billing period is sold to the utility at avoided cost or granted

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back to the utility without payment to the customer. In 2008, 40 states and the District of Columbia offered some form of net metering policy (10).

5.0 R, D&D Activities

Although some states support research activities, most public research and development on wind energy in the United States is sponsored by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Wind and Hydropower Technologies Program (Wind Program). The mission of the Wind Program is to increase the development and deployment of reliable, affordable, and environmentally responsible wind and water power technologies in order to realize the benefits of domestic renewable energy production. The total budget for the DOE Wind Program was close to 50 million USD for fiscal year (FY) 2008 (1 October 2007 through 1 October 2008). The budget approved for FY 2009 was 55 million USD. And the administration has requested 75 million USD for FY 2010.

5.1 Large wind turbine technology

The DOE Wind Program works to reduce the cost of electricity from large wind systems through in-house research at national laboratories and research contracts to universities and industry. Technology development partnerships make program staff and testing facilities available to help improve the reliability and performance of utility-scale wind energy technology.

5.1.1 Manufacturing

A new advanced manufacturing initiative by DOE's Sandia National Laboratories (Sandia), TPI Composites, Iowa State University, and the Iowa Power Fund will work to expand U.S.-based manufacturing and domestic suppliers to the wind industry. The work will target components that are difficult or expensive to inventory, result in downtime when waiting for replacements, or have high transportation costs, such as

gearboxes, generators, blades, and towers. For blades, the partnership with the Iowa Power Fund will work to speed up wind turbine blade manufacturing by exploring technology innovation, such as automation.

5.1.2 Gearboxes

The industry has identified improving gearbox reliability as an important way to reduce costs of large wind turbines. Gearbox replacement and lubrication account for 30% of the parts cost for the entire turbine system. The DOE Wind Program initiated the wind turbine Gearbox Reliability Collaborative (GRC) in 2006 to validate the design process, including everything from calculating system loads, to rating bearings, to testing full-size gearboxes. Instrumented gearboxes will undergo dynamometer tests and full-scale field tests with support from facilities and expertise at NREL, Sandia, universities, and industry. In 2007, experts shared information on gearbox design and performance at an international workshop sponsored by DOE. In 2008, an international team of analysts compared their predictions of gear tooth loads and bearing loads. Next they will compare these predictions with test data, improve design codes, and improve gearbox designs. The GRC drivetrain and gearbox will be tested by Wind Program researchers in NREL's 2.5-MW dynamometer test facility.

In 2008, a new positioning system for the dynamometer table was installed to allow quick alignment of the drive shaft with the drivetrain being tested, and researchers successfully tested several drivetrains. Tests conducted on the DeWind 2.2-MW drivetrain for Composite Technology Corporation's D8.2 wind turbine demonstrated stable and satisfactory operation at power levels ranging from 250 kW to 2 MW. The company worked with the Wind Program to test the machine before it was installed on the company's prototype turbine in Sweetwater, Texas. Another prototype drivetrain was tested for Global Energy Concepts. The 1.5-MW single-stage permanent-magnet drivetrain was developed

under the DOE Wind PACT project and is available for new utility-scale wind turbine system designs.

5.1.3 Blades

Research on wind turbine blades aims to improve their efficiency and durability while reducing manufacturing costs. Work supported by the Wind Program is demonstrating the advantages of advanced materials (carbon and carbon/glass hybrids) and is exploring resin transfer molding (RTM) and vacuum-assisted RTM manufacturing processes for utility-scale wind turbine blades. This work also includes designing and fabricating advanced blades that incorporate innovations such as carbon/e-glass hybrid materials and aeroelastic tailoring methodologies. To validate process developments and design modeling tools, the Wind Program is working with the U.S. Department of Agriculture to test substructures and small blades in Bushland, Texas.

To verify the performance of new blade designs and materials, the Wind Program worked with several industry and academic partners in 2008 to conduct structural tests on a variety of blades. Knight & Carver's 27-m STAR blade developed with Sandia and a 46.2-m blade developed by TPI composites were among those tested (Figure 5). The NREL structural testing group also worked with Sandia researchers to test the 9-m TX-100 wind turbine blade developed by Sandia.

In response to increased industrial activity across North America and larger blades being deployed on wind turbines, the Wind Program is working with consortiums in Massachusetts and Texas to develop two new blade test facilities. The new facilities will give industry an unbiased, technical environment in which to ensure that the new larger blades, up to 80-m long, meet design and certification standards.

The DOE Wind Program is also working with Spain's Centro Nacional de Energías Renovables (CENER) to test blades manufactured in Spain. Information

obtained from CENER will be used to accelerate the development of the program's new blade test facilities in the United States.

5.1.4 Design codes and control systems

The AeroDyn code was developed by engineers at NREL and its subcontractors to analyze wind turbine performance, loads, and stability. In 2008, 50 participants in an AeroDyn workshop agreed that improvements to design codes could speed the advancement of wind power. The group discussed ways to pool resources to expedite the future development of AeroDyn.

International collaboration is especially useful to address issues with design codes and systems analysis. The DOE Wind Program hosted an international workshop on the widely used TurbSim Code in 2008. TurbSim is a stochastic, full-field, turbulent wind simulator that is used with the

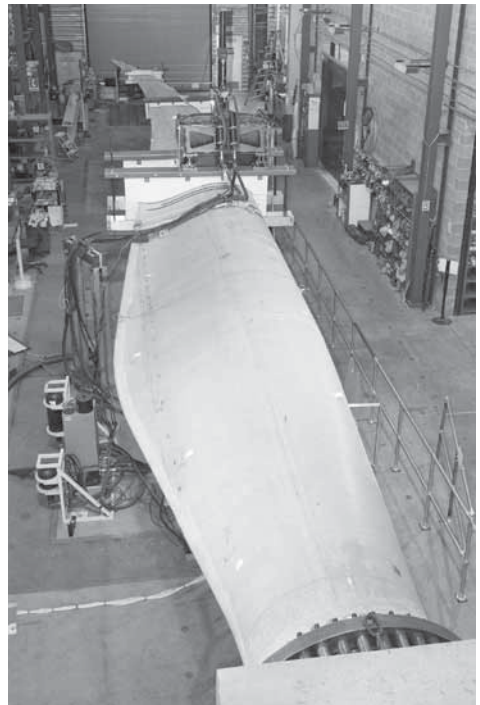


Figure 5 Knight and Carver's STAR blade during fatigue testing at NREL.

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AeroDyn-based design codes. The workshop's 49 participants represented Denmark, Germany, Japan, Spain, the U.S. wind industry, Sandia, Los Alamos National Laboratory, NREL, and the University of Colorado. Other design experts from Argentina, Canada, China, Germany, India, Turkey, and the United States, participated via Internet connection.

New control approaches could mitigate loads and deflections and enhance energy capture of wind turbines. NREL is working with the University of Colorado and the Colorado School of Mines to develop and evaluate combined feedforward and feedback controls to mitigate turbulence-induced fatigue loads. Feedforward controllers will use Doppler LIDAR measurements of turbulence statistics to demonstrate that new controls reduce turbine loading. The effort will field-test advanced controls on the three-bladed Controls Advanced Research Turbine (CART3) at the NWTC. The Wind Program is also collaborating with the University of Auckland (New Zealand), the University of Wyoming, and the European Union UPWIND Project on issues of adaptive controls for very large wind turbines.

The United States experiences extreme wind conditions in many prime wind development areas. To help industry better match turbine capabilities to site requirements and assess the risks to wind plants from local atmospheric conditions, the Wind Program is working with the University of Texas and Texas Tech University to develop a hazard framework. The framework uses extrapolations from 50-year extremes of wind (see Figure 6) to compare design criteria (based on objective standards) with the loadings at specific sites where plant layout or atmospheric conditions may cause significantly different loading.

To help improve wind system reliability, the Wind Program is working in partnership with utilities, reliability tracking experts, operating companies, and turbine manufacturers to assemble a database

containing data on plant operations, plant development, turbines, components, and materials. The effort will provide field data on the effectiveness and reliability of turbines to the manufacturers and suppliers of components who can take actions to improve reliability. Feedback is also given directly to wind plant operators providing benchmark information needed to optimize operations and reduce overall operation and maintenance costs. Reliability workshops discussing these issues were held in 2006 and 2007, and another is scheduled for June 2009.

5.1.5 Wind forecasting and resource assessment

The ability to accurately predict wind farm performance and revenues is of great interest to the industry. Current methods based on models developed for upper atmospheric weather forecasting need to be tuned for lower boundary layer physics where wind turbines operate. The Wind Program is teaming up with the National Center for Atmospheric Research (NCAR) and the National Oceanic and Atmospheric Administration (NOAA) to refine analytical tools to improve wind resources estimation, siting, forecasting, and grid management.

Improving the accuracy and reducing the cost of resource assessment is the goal of a project begun in 2008. Advanced resource assessment measurement methods are being tested by NREL, Clipper Windpower Project Development, and equipment providers Sintec and Second Wind. They are comparing inflow measured via new SODAR systems with reference 80-m meteorological tower data. Program researchers are also working with wind project developers to calibrate and test their resource assessment equipment at NREL.

5.1.6 Turbine testing

Testing large wind turbines will help researchers improve the performance and reliability of existing turbines and future designs. The Wind Program will install two multi-megawatt turbines at the NWTC in

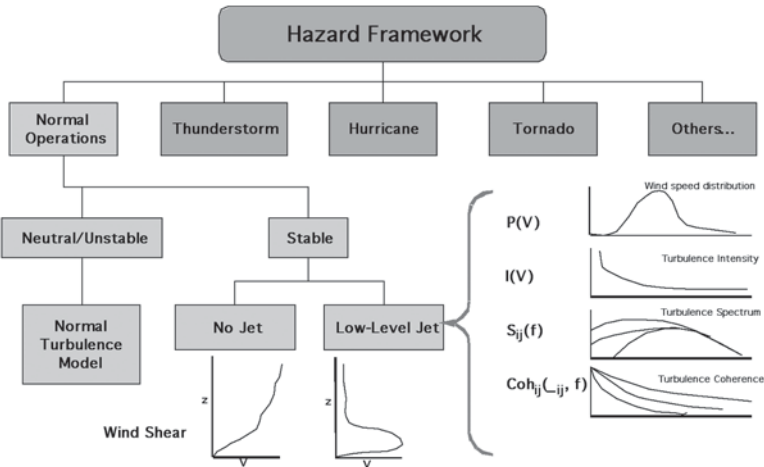


Figure 6 Hazard framework that will help match turbine capabilities to site requirements.

2009, a GE 1.5-MW and a Siemens 2.3-MW wind turbine. The turbines will be instrumented to collect data on aerodynamics, power characteristics, vibrations, system fatigue, acoustics, and other key measurements. The 1.5-MW turbine will mainly be used as a tool for long-term testing and R&D. It will help researchers address wind farm performance and component reliability issues. The turbine will also be used for educational and outreach purposes. The Siemens 2.3-MW turbine is a late-stage prototype. It features a novel blade design that captures more of the wind's energy with little or no load penalties.

5.2 Distributed wind technology

A market study for mid-sized turbines conducted by the DOE Wind Program in 2008 (13) identified a market for 100 GW of currently available commercial turbines and an additional 100 GW of market potential for a new generation of more efficient turbines. The report concluded that improvements in the technology, reductions in cost, and greater policy support are needed to increase the use of smaller wind turbines.

To help industry offer consumers more small wind turbine systems that are certified for safety and performance, the Wind

Program at NREL launched an independent small wind turbine test project in 2007 and the first four turbines to undergo testing were installed at the NWTC in 2008. The turbines include: Mariah Power's Windspire Giromill machine, a 1.2-kW vertical-axis wind turbine; Abundant Renewable Energy's 442 10-kW turbine; Gaia-Wind's 11-kW two-bladed turbine; and Integrity Wind System's EW50 50-kW turbine. These commercially available turbines are being tested to standards adopted by the IEC and in compliance with the draft AWEA standards for small wind turbine systems. The tests include power performance, power quality, acoustics, safety and function, and duration.

The Wind Program is also considering a project to develop regional test centers and defining how these test centers would operate. As part of this effort, the program hosted a small wind testing workshop in 2008. More than 50 people attended the workshop, including representatives of existing and proposed test centers. The workshop provided an opportunity for researchers to coordinate with small wind testing organizations and identify wind turbine test experts across North America that are involved with qualifying or

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certifying the performance of commercial small wind turbines.

Interest in combining wind energy and diesel generators to lower energy costs is expanding in Alaska, Hawaii, and other isolated communities worldwide. More than 170 participants from more than 10 countries shared the technical details of combining wind power with diesel generators at the 17th Wind-Diesel Workshop, held in Girdwood, Alaska, in April 2008.

5.3 Increasing deployment

The Wind Program's activities to increase deployment involve providing information and technical support to wind energy projects. One important goal is to increase deployment of renewable energy at government facilities. For example, the DOE Transformational Energy Action Management (TEAM) initiative goal is to "maximize installation of secure, on-site renewable energy projects at all DOE sites." As part of this initiative, Wind Program researchers at Sandia are evaluating a wind project at Kirtland Air Force Base in New Mexico. If feasible, a 30-MW wind farm could be designed, built, and operated by a private company and could provide up to 40% of the energy for the site. The DOE/National Nuclear Security Administration, Sandia, and Kirtland would purchase the electricity. The wind potential is also being evaluated at Army, Navy, Coast Guard, and Border Patrol facilities, at universities, and at Argonne, Fermi, Idaho, and Sandia National Laboratories using wind measurement equipment on towers and mini-SODAR devices.

Plans are also being made to assess electrical demand by military housing at bases. Pacific Northwest National Laboratory (PNNL) hosted an Army Energy Summit in Richland, Washington, for energy managers from 20 Army bases. PNNL, NREL, and Idaho National Laboratory presented papers on wind energy and worked directly with energy managers to formulate wind development plans for their bases. Training and support have been provided for projects

at NASA facilities, National Forest Service areas, and National Park Service sites.

The United States is home to more than 700 Native American tribes located on 96 million acres. Much of this land has excellent wind resource that could provide electricity and revenue to the communities. The Wind Program provides a wide range of technical assistance and outreach activities to more than 20 tribes from 13 states. This work includes an anemometer loan program and training sessions in site selection, land agreements, environmental reviews, permitting, interconnection and transmission, and grid integration. In June 2008, the Lakota Nation celebrated the installation of a 65-kW Nordtank turbine that supplies 120 MWh of electricity per year to the Pine Ridge Reservation radio station.

5.3.1 Systems integration and transmission

With the rapid growth of wind energy development, system operators are concerned that the higher penetration levels of wind energy may affect frequency regulation, load following, scheduling, line voltage, reliability, and reserves. DOE's Renewable Systems Interconnection (RSI) team has researchers from seven of the DOE national laboratories working with many independent system operators (ISOs), regional transmission operators (RTOs), the Federal Energy Regulatory Commission, industry partners, and DOE's Office of Electricity Delivery and Energy Reliability. The goal is to ensure that grid reform measures include provisions for variable generation resources such as wind energy. Studies have been performed with wind-integration penetrations of up to 25% energy from wind in Minnesota, 33% renewables in California, and 20% wind energy capacity in Colorado. At these moderately high penetration levels, these studies projected that wind power's variability and uncertainty would impose ancillary costs below 0.005 USD/kWh.

The RSI team is also examining the major areas of the U.S. grid known as the

Western Interconnection and the Eastern Interconnection. The Western Interconnection stretches from western Canada south to Baja California in Mexico, reaching east over the Rockies to the Great Plains. The Eastern Interconnection reaches from central Canada east to the Atlantic Coast (excluding Québec), south to Florida, and back west to the foot of the Rockies (excluding most of Texas, which has its own interconnection grid). The RSI team is working with GE Energy and 3TIER to investigate the impacts of large penetrations of wind and solar on the grid in the Western Interconnection. This effort examines issues such as geographical diversity of wind, mega-projects (1,000 MW or larger), and balancing area co-operation. The study includes mesoscale modeling to create the wind power time series and power system modeling and analysis. The mesoscale wind speed and wind power dataset will cover a three-year period. Up to 30,000 synthetic time-series data sets of wind energy output will be generated, representing unique 30-MW plants, totaling 600 GW of potential energy capacity. Study results will be publicly available online at www.nrel.gov/wind/systemsintegration/. The Eastern Wind Integration and Transmission Study (the largest integration study to date) encompasses the ISOs and RTOs in the eastern United States. Mesoscale modeling, power system modeling, and analysis will support the feasibility study for a 765-kV transmission system that could enhance the interconnections between the Midwest ISO and Pennsylvania-Jersey-Maryland RTO and may expand to include the Southwest Power Pool.

The North American Electric Reliability Corporation is reviewing the role of wind energy in system reliability through its Integrating Variable Generation Task Force. The RSI team began working with the task force in 2008 to ensure its members have accurate information about the impacts of wind energy on the operation of the nation's energy infrastructure to ensure fair consideration during rule making.

5.3.2 Technology acceptance

To increase public understanding of wind technology, the Wind Program provides objective information to regional organizations, federal agencies, state and local energy offices, Native American agencies, rural agencies, electrical co-operatives, and utilities. An important activity in 2008 was the publication of a series of reports on the economic benefits, reduction of carbon dioxide, and water conservation benefits of developing 1,000 MW of wind energy in each of 10 states. For example, the economic benefits from 1,000 MW of wind energy development in Indiana (Figure 7) were calculated to be 1.3 billion USD, annual CO₂ reductions were estimated at 3.1 million tons, and annual water savings were estimated to be 1,684 million gallons (14).

The Wind Program also provided support for six new wind application centers that opened in 2008. The centers, located at universities, provide training for engineers in wind applications and also support the Wind for Schools Project. The objectives of the Wind for Schools Project are to engage rural school teachers and students in wind energy education, equip college students with the skills and knowledge they need to become wind energy professionals, and introduce distributed wind energy systems to rural communities. To accomplish these objectives, project members assist schools with the installation of a small wind turbine through a coordinated community effort. Five small wind turbines have been installed so far. The university students analyze the wind resources, energy usage, siting, permitting, land use, and financials, and they oversee installation of the power and data acquisition systems.

The Wind Program is working to develop Regional Wind Energy Institutes (RWEIs) because many of the most challenging wind energy issues are regional in nature. The goal of the RWEIs is to provide accurate and current information to members of state wind outreach teams that are actively engaged in furthering wind power development by educating key constituents

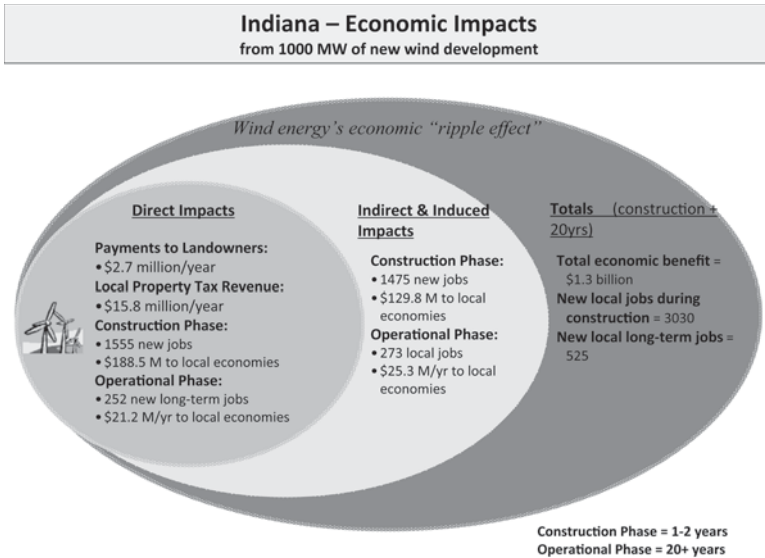


Figure 7 Graphic illustrating the benefits of wind energy development in Indiana from a series of reports completed for 10 states in 2008.

in their respective states. In 2008, the program managed three RWEIs in the MidAtlantic/Southeast, the Southwest, and the Great Lakes regions.

To help understand and resolve wind-wildlife interactions, the Wind Program is working with several groups, including the U.S. Fish and Wildlife Service’s (FWS) Wind Turbine Guidelines Advisory Committee, the Bats and Wind Energy Cooperative, the Grassland Shrub Steppe Species Collaborative, and the American Wind Wildlife Institute (AWWI). The FWS’s Wind Turbines Guidelines Advisory Committee has 22 members representing the varied interests associated with wind energy development and wildlife management, including federal and states agencies, conservation groups, Native Americans, wind energy developers, and utilities. The objective of this committee is to provide the Secretary of the Interior with recommendations for developing effective measures to avoid or minimize impacts to wildlife and their habitats related to land-based wind energy facilities.

Members of the Bats and Wind Energy Cooperative (BWEC) include the Wind

Program, Bat Conservation International, AWEA, and the U.S. Fish and Wildlife Service. In January 2008, 50 experts attended a workshop in Texas to find solutions that support the continued growth of wind energy production while preserving bats and their habitats. As a result, BWEC began a project to validate and refine methods to predict wind plant impacts on bats based on preconstruction assessments. An acoustic system to discourage bats from entering wind facilities will also be field-tested. In another development, changes to operations during low wind conditions at a plant in rural Pennsylvania, owned and operated by Iberdrola Renewables, demonstrated nightly reductions in bat fatality ranging from 53–87% with marginal annual power loss (15).

Members of the Grassland Shrub Steppe Species Collaborative include the DOE, the National Wind Coordinating Collaborative, and representatives from state and federal agencies, academic institutions, nongovernment organizations, and the wind industry. The goal of this 4-year project is to identify the impact, if any, of wind installations on grassland and shrub

steppe avian species such as the lesser prairie chicken (16).

The American Wind Energy Association provided support for the formation of the American Wind Wildlife Institute (AWWI). AWWI focuses its efforts on facilitating timely and responsible development of wind energy while protecting wildlife and wildlife habitat. The institute will do this through research, mapping, mitigation, and public education on best practices in wind plant siting and wildlife habitat protection.

In another study, Wind Program researchers are investigating whether artificial intelligence can be used to detect the presence of birds using Next-Generation Radar (NEXRAD) data. NEXRAD is a network of 158 high-resolution Doppler weather radars operated by the National Weather Service. The program is working with the U.S. Geological Survey and Montana State University to develop algorithms to differentiate biological (bird) echoes in the NEXRAD data to help identify migratory flyways.

Wind power-radar interaction issues gained national attention when wind projects were delayed over fears that radar operations would be affected by wind turbines. The National Wind Coordinating Collaborative convened a forum of more than 100 experts, including representatives from AWEA, DOE, the Department of Defense, and the Federal Aviation Administration to discuss the influence of wind energy on aviation radar and possible mitigation strategies. In 2008, a study funded by the Office of Homeland Security concluded that wind farms can interfere with radar tracking of aircraft and weather but that no fundamental physical constraint prohibits the accurate detection of aircraft and weather patterns around wind farms (17). Interference occurs when radar signals are reflected back by wind turbines, causing clutter on the radar screens. The report also concluded that it is difficult to distinguish wind farm signatures from airplanes and weather, and that quantitative

evaluation tools and metrics are needed to determine when a wind farm poses a sufficient threat to a radar installation.

5.4 International collaborative research

International co-operation multiplies the effect of government and industry research dollars. In 2008, the Wind Program at NREL joined the UpWind Project funded by the European Union to conduct R&D activities on the design of very large turbines (8 MW–10 MW) for both land-based and offshore wind plants. Project participants include representatives from universities, laboratories, and industries in a dozen countries.

The Wind Program also benefits from participation in the IEA Wind international agreement. Program representatives gain information by attending executive committee meetings and U.S. researchers serve as operating agents (managers) for four IEA Wind research tasks:

- Task 20 Horizontal-Axis Wind Turbine Aerodynamics and Models from Wind Tunnel Measurements works to increase the understanding of the aerodynamics of horizontal-axis wind turbines through the analysis of the data collected from a full-scale wind tunnel experiment
- Task 23 Offshore Wind Energy Technology and Deployment. The United States supports this task in joint leadership with Denmark and participates in offshore technology R&D by sharing much of its offshore modeling work
- Task 24 Integration of Wind and Hydropower Systems. In addition to being the operating agent for this task and gaining results from the six participating countries, the United States is sharing three wind and hydropower case studies. This task will complete its work in 2009 with the publication of a final report
- Task 26 Cost of Wind Energy. This task will develop a common,

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transparent methodology for estimating the cost of wind energy and identifying the primary differences among countries. The work should help efforts to compare the cost of energy for various technologies.

In addition to managing four tasks, participation on other IEA Wind Tasks makes it possible for U.S. researchers to contribute to and benefit from cutting-edge analyses of the most pressing issues facing wind energy development worldwide.

- Task 11 Base Technology Information Exchange promotes information exchange among experts on R&D topics of common interest at four meetings per year. Experts from the United States benefit from attending these meetings and contribute to the world dialogue on important issues
- Task 19 Wind Energy in Cold Climates develops guidelines for applying wind energy by gathering and sharing information on cold climate operational experience and modeling. Participants established a preliminary site classification formula for wind turbine designers, manufacturers, project developers, and wind energy producers. The U.S. representatives share their experiences with rural wind projects in Alaska
- Task 25 Power System Operation with Large Amounts of Wind Power provides information to facilitate the highest economically feasible wind energy penetration into electricity power systems worldwide. The U.S. representatives will contribute to seven national projects and share the results of all thirteen projects planned by the Task
- Task 27 Labeling of Small Wind Systems is organizing to establish appropriate international testing and labeling standards for small wind systems. The United States is working with the Operating Agent to define this work

- Task 28 Social Acceptance of Wind Energy Projects is collecting experiences of successful wind energy development projects to determine the best strategies to deliver information and gain public acceptance
- Task 29 MexNex(t): Analysis of Wind Tunnel Measurements and Improvement of Aerodynamic Models continues the work of Task 20 using NASA and EU wind tunnel data to improve aerodynamic models used in wind turbine design.

In addition, DOE's Office of Electricity Delivery and Energy Reliability is working with the IEA Implementing Agreement on Distributed Generation on integration of demand-side management, distributed generation, and renewable energy sources and energy storage.

The Wind Program also supports experts who contribute to standards work such as that of the IEC. Program experts participate in 11 active IEC/TC88 Wind Standards Working Groups.

6.0 The Next Term

Thanks to the extension and expansion of federal and state incentives, utilities and developers are expected to move forward with many wind energy projects in 2009. However, the contraction of the global economy has cast uncertainty on the effect of the ITC and other incentives in a time of tight lending and limited tax equity. The President's New Energy for America plan aims to ensure that 10% of U.S. electricity comes from renewable sources by 2012, and 25% by 2025. Although achieving 20% wind energy by 2030 is technically feasible, it will require comprehensive R&D to address a broad spectrum of challenges facing industry today. The nation's transmission infrastructure needs to be expanded and upgraded, and manufacturing facilities need to increase and improve their production processes to keep pace with demand.

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Appendix C

Currency conversion rates IEA wind annual report 2008			
Country	Currency	1 €	1 USD
Australia	AUD	0.502	0.698
Austria	Euro	1.000	1.392
Canada	CAD	0.587	0.817
Denmark	DKK	0.134	0.187
Finland	Euro	1.000	1.392
Germany	Euro	1.000	1.392
Greece	Euro	1.000	1.392
Ireland	Euro	1.000	1.392
Italy	Euro	1.000	1.392
Japan	JPY	0.008	0.011
Republic of Korea	KRW	0.00057	0.00079
Mexico	MXP	0.052	0.072
Netherlands	Euro	1.000	1.392
Norway	NOK	0.103	0.143
Portugal	Euro	1.000	1.392
Spain	Euro	1.000	1.392
Sweden	SEK	0.091	0.127
Switzerland	CHF	0.673	0.937
United Kingdom	GBP	1.050	1.462
United States	USD	0.718	1.000
"Source: Federal Reserve Bank of New York (www.x-rates.com) 31 December 2008"			

Appendix D

Glossary of terms and abbreviations.

CCGT	Combined cycle gas turbine	ExCo	Executive Committee of IEA Wind
CEN/ CENELEC	European Committee for Standardization/ European Committee for Electrotechnical Standardization (the original language is French); similar to ISO/IEC	FY	fiscal year
		GB	giga bytes
		GEF	Global Environment Facility
		GHG	greenhouse gas
CHP	combined heating and power or cogeneration of heat and power	GL	Germanischer Lloyd Certification body
		GW	gigawatts 1,000,000,000 Watts
CIGRE	International Council on Large Electric Systems	GWh	gigawatt hour
CO ₂ e	carbon dioxide equivalent	HAWT	horizontal axis wind turbine
COE	cost of energy	hydro	hydroelectric power
DFIG	doubly fed induction generator	IEA	International Energy Agency
DG	distributed generation	IEC	International Electro-Technical Commission
DNV	certifying organization (Danish)	IEEE	Institute of Electrical and Electronics Engineers
DSM	Demand-side management	IPP	independent power producer
EC	European Commission	ISO	international standards organization
EEZ	Exclusive Economic Zone	IT	information technology; Italy
EIA	Environmental impact assessment	kW	kilowatt 1,000 Watts
ENARD	Electricity Networks Analysis Research and Development	kWh	kilowatt hour
EU	European Union	£	United Kingdom pound

m	meter	repowering	taking down old turbines at a site and installing newer ones with more generating capacity
m a.g.	meters above ground		
m.a.s.l.	meters above sea level		
Mtoe	million tonnes of oil equivalent	RETD	Renewable Energy Technology Deployment
MW	megawatt 1,000,000 Watts	RPS	renewables portfolio standard
MWh	megawatt hour	S.A.	Sociedad Anonyma
m/s	meters per second	tCO ₂ -e per capita	tonnes of carbon dioxide emissions per person
NA	not applicable	TNO	transmission network operator
NDA	no data available		
NGO	non-governmental organizations	TSO	transmission system operators
O&M	operations and maintenance	TW	terawatt 1,000,000,000,000 Watts
pdf	portable document format	TWh	terawatt hour
PJ	peta joule	UK	United Kingdom
PSO	Public Service Obligation	UN	United Nations
PV	photovoltaics or solar cells	UNDP	United Nations Development Programme
R&D	research and development	U.S.	United States
R, D&D	research, development, and deployment	VAWT	vertical axis wind turbine
RE	renewable energy	wind index	describes the energy in the wind for the year, compared with a normal year
RES	renewable energy systems	WT	wind turbine
		yr	year

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