



# IEA Wind Energy Annual Report 2004 ...



International Energy Agency  
Executive Committee for the

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

April 2005



**Front cover: WinWinD 1-MW turbines near Oulunsalo, Finland. Photo courtesy of WinWinD.**

**Back cover: The 60-MW North Hoyle offshore wind farm operated by National Windpower, near Chester, England. Photo credit: Georgina Web, AEA Technology.**

# FOREWORD

The twenty-seventh IEA Wind Energy Annual Report reviews the progress during 2004 of the activities in the Implementing Agreement for Co-operation in the Research, Development, and Deployment of Wind Energy Systems under the auspices of the International Energy Agency (IEA). The agreement and its program, which is known as IEA Wind, is a collaborative venture among 21 contracting parties from 18 IEA member countries and the European Commission.

The IEA, founded in 1974 within the framework of the Organization for Economic Co-operation and Development (OECD) to collaborate on international energy programs, carries out a comprehensive program about energy among 26 member countries. IEA Wind was one of more than 40 implementing agreements of IEA in 2004.

This report 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, Canada, Denmark, Finland, Germany, Greece, Ireland, Italy (two contracting parties), Japan, Mexico, the Netherlands, Norway (two contracting parties), New Zealand, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States. While Germany and New Zealand were not active members in 2004, these countries rejoined IEA Wind in 2005.

Peter Goldman  
Chair of the Executive Committee  
(2004-2005)

Patricia WEIS-TAYLOR  
Secretary to the Executive Committee

Web site for additional information on IEA Wind  
[www.ieawind.org](http://www.ieawind.org)



# CONTENTS

Message from the Chair .....	7
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## The IEA R&D Wind Program

1. Executive Summary .....	9
2. Implementing Agreement and Active Annexes .....	15
Task XI Base technology information exchange .....	20
Task XIX Wind energy in cold climates .....	26
Task XX HAWT Aerodynamics and models from wind tunnel measurements .....	29
Task XXI Dynamic models of wind farms for power system studies .....	32
Task XXIII Offshore Wind Energy Technology Deployment .....	34
Task XXIV Integration of Wind and Hydropower Systems .....	38

## National Activities

3. Overview of National Activities, 2004 .....	43
4. Australia .....	67
5. Canada .....	79
6. Denmark .....	83
7. European Commission .....	99
8. Finland .....	103
9. Germany .....	109
10. Greece .....	115
11. Ireland .....	125
12. Italy .....	133
13. Japan .....	147
14. Mexico .....	155
15. The Netherlands .....	161
16. New Zealand .....	179
17. Norway .....	185
18. Portugal .....	189
19. Spain .....	199
20. Sweden .....	213
21. Switzerland .....	221
22. United Kingdom .....	227
23. United States .....	239

## Appendices

A. The 54th Executive Committee (photo) Oulu, Finland .....	253
B. List of Executive Committee Members, Alternate Members, and Operating Agents .....	255
C. Currency Exchange Rates .....	259
D. Glossary of Terms and Abbreviations .....	261



# MESSAGE FROM THE CHAIR

This has been a year of continued growth for the wind industry. The world's wind energy generation capacity is now more than 47 gigawatts, and in some countries the contribution of wind generation to the national electrical supply has reached 20%. We expect the global market for wind energy to continue its rapid growth of nearly 28% per year. A number of countries have stepped up their pace of installation, such as Australia, Canada, and Spain, helping to expand the industry. When we take into account installation and operation of wind generation worldwide, the industry now turns over more than 7 billion euro annually.

Because we now have significant generation capacity and expect continued growth of the industry, we face a new set of challenges and opportunities. When these are addressed through international cooperative research, we accelerate our learning within each country. For example, our research in dynamic models of wind farms for power system studies (Annex XXI) has been working on some of the challenges of electrical system operation. This year we began to address issues of installing wind turbines offshore to allow greatly increased capacity (Annex XXIII). On land, participants in the new Annex XXIV began exploring issues around the integration of wind and hydropower systems.

Our experts meetings have shown that in many of the countries with high expectations from wind energy, large-scale integration into the electricity distribution system can be a challenge. Continuing our efforts in 2005, we will look at opportunities to address how electric networks can economically accept high levels of wind energy.



**Peter Goldman, Chair of the Executive Committee, 2004 to 2005.**

This IEA Wind Energy Annual Report describes the work of our cooperative research (Annexes) and the progress within each of our Member Countries. For additional information about our activities or to send us comments about this report, please visit our Web site at [www.ieawind.org](http://www.ieawind.org).





## CHAPTER 1

# EXECUTIVE SUMMARY

The continuous progress of wind energy brings with it many new challenges and this has generated a wide spectrum of activities within the IEA Wind Implementing Agreement. Topics are covered either through the very successful format of Annex XI, Base Technology Information Exchange, which brings experts together or through dedicated Annexes tackling issues in greater depth. These are fully described within this annual report with some of the highlights from 2004 summarized below.

## People Like Wind Turbines

Surveys in many countries have shown that the majority of people both see the need for wind turbines and want more of them. However, wind power project realization does depend on local acceptance. Cultivating positive attitudes is not always easy but it is always important. This was the basis of an expert discussion held in Sweden this year under Annex XI, called 'Wind Turbines in Social Landscapes.' The recurrent theme was the need to collaborate with the local community early in the planning of the project. By the time the planning application has been made, the battle has already been won or lost.

## What Are the Offshore Challenges?

Another meeting arranged within Annex XI brought together experts with a strong interest in developing offshore wind technology in order to identify the areas most in need of R&D. The meeting began with

a stirring presentation of the difficulties encountered with the groundbreaking Horns Rev offshore project in Denmark. The very strong message was, do everything you can onshore before going offshore.

The meeting developed a foundation for a new IEA Wind annex called Offshore Wind Energy Technology Development. The new Annex XXIII was approved at the Executive Committee meeting in May 2004 with two distinct activity areas. The first of these is 'Experience with Critical Deployment Issues' to be lead by Risø National Laboratory in Denmark and the second 'Research for Deeper Water' to be lead by NREL in the United States.

The goal for the first year of running the annex is to generate work programs and budgets. The Offshore Annex held its first meeting in October 2004 in Washington, D.C. to discuss Coupled Turbine/Substructure Dynamic Modeling.

## Database Available on Offshore Environment Studies

A representative from the IEA Wind implementing agreement sits on the advisory board of the EU project called Concerted action on Offshore Deployment (COD). The COD project compares and shares information on non-technical aspects of offshore wind farms and has identified more than 180 studies in the area of environment. A database with descriptions of all these studies is available on the website at <http://www.offshorewindenergy.org/>.

## High Wind Penetration

The wide topic of the grid integration of wind energy has been identified by IEA Wind as one of the critical issues to the deployment of wind, affecting many countries either now or in the near future. A need is seen for a new activity dedicated to the integration of large amounts of wind energy, tackling both planning and operational aspects.

To that end, a very well attended meeting was held in Dublin, Ireland in November 2004. In order to contain the scope of a new annex, it was suggested that work should focus on integration at a 'system' rather than a local level. Although theoretical technical limits on the level of wind energy penetration into a power system cannot be objectively defined, the grid integration costs rise with increasing wind power penetration. Hence, a reasonable objective is to maximize the level of wind penetration that can be achieved at acceptable cost. It is expected that a new annex proposal will result. The work will be linked to and complement work under Annex XXI 'Dynamic models of wind farms for power system studies,' concerned with modeling the components of a wind farm. A new annex on integrating large amounts of wind energy will also be linked to Annex XXIII 'Offshore wind energy technology development' on concerns of the grid aspects of offshore wind and to Annex XXIV 'Integration of wind and hydropower systems' concerning the benefits that can be accrued from combining wind and hydropower stations.

### Special Standards for Cold Climates?

There has been a perceptible increase in interest in turbines operating in cold climates since work began on this issue in 2001. This increased interest has come with improving technology and a realization that some elevated cold sites could offer better economics than less windy lowland sites. Annex XIX 'Wind energy in cold climates' has so far defined the state of the art of the technology and defined the measurement of icing. There is now an enthusiasm for discussing the creation of standards specifically for cold climate wind power. The classification of sites and appropriate technology will help manufacturers, developers, and investors in project planning and assessment. Preparation for an extension to the cold climate work is underway and will be decided in 2005.

### Aerodynamic Modeling Needs More R&D

Unexpectedly large variations have been found in the output from a selection of contemporary aerodynamics codes. Perhaps more surprising is that the discrepancies between predictions and measurements

show no consistent trends in either magnitude or direction. This has been the finding of the Annex XX 'HAWT aerodynamics and models from wind tunnel measurements.' In this work, a number of codes have undergone a blind comparison using identical sets of data representing diverse aerodynamic regimes. The Annex will now go on to formulate and validate new wind turbine aerodynamics models. Like the blind comparison, Annex XX model development exploits the high quality aerodynamics data acquired under controlled conditions in the NASA Ames 80 foot by 120-ft wind tunnel.

### Work Starts on Integrating Wind and Hydropower

The IEA Wind member countries contain about 450 GW of hydropower capacity and more than 40 GW of wind generation. Integrating these two renewable resources for the benefit of consumers is an idea being pursued in several countries. At least seven countries have now grasped the opportunity to participate in an Annex dedicated to combining wind and hydropower. They will share information and conduct cooperative research concerning the generation, transmission, and economics of integrating wind and hydropower systems.

Annex XXIV 'Integration of wind and hydropower systems' was formed this year and will initially run for four years to May 2008. It aims to identify practical combined systems and to develop an understanding of the parameters that will determine the appropriate mix of wind, hydro, and pumped storage. These will of course also be dependent upon the market structure prevailing. The potential benefits are in the control of power delivery and the management of water flows to improve the overall economics.

## NATIONAL ACTIVITIES

### Installed Capacity and Growth

Within the IEA Wind member countries, wind energy has now seen an average growth rate of 28% over the last 9 years, and, once again, more wind energy was installed globally in 2004 than in any previous year.

At the end of 2004, the global wind capacity reached 47.9 GW. New Zealand topped the growth charts nearly quadrupling its installed capacity. Exceptional growth was also seen in Australia, Finland, Ireland, Japan, Portugal, and Switzerland. In terms of generating capacity, Spain and Germany again put in more wind power than any other country.

While the wind community cannot be complacent against a slightly falling growth rate in the last two years, the outlook does continue to look positive. Top of the league next year may be the United States, where wind industry experts are predicting installation

of over 2,000 MW of new capacity. If a global growth rate of 25% is seen in the next few years, global capacity would reach 182 GW by the end of 2010.

## Electricity Generated

Globally, it is estimated that approximately 92 TWh of electricity were generated from wind in 2004, based on an average capacity factor of 24%. As a means of comparison, this is almost as much electricity as that used by Portugal and Greece combined. In Denmark, contribution to electricity generation from wind energy has now reached 20%.

Country	Total installed capacity (MW)	Offshore installed capacity (MW)	Capacity installed in 2003 (MW)	Total No. of Turbines	Average new turbine size kW	Wind generated electricity GWhrs/yr
Australia	380.0	-	182.0	288	1,780	-
Canada	444.0	-	127.0	535	1,280	<i>1,361</i>
Denmark	3,118.0	406.0	3.0	5,389	817	6,580
Finland	82.0	-	35.0	-	-	120
Germany	16,629.0	-	2,020.0	16,543	1,696	-
Greece	468.0	-	43.6	812	-	990
Ireland	260.2	25.2	71.2	321	1,000	-
Italy	1,265.0	-	357.0	1,880	918	1,837
Japan	940.0	-	434.0	-	-	988
Mexico	2.2	-	-	-	-	-
Netherlands	1,072.0	-	167.0	1,686	1,203	<i>1,853</i>
New Zealand	168.0	-	132.1	175	1,100	155
Norway	160.0	-	60.0	-	-	-
Portugal	562.0	-	264.0	513	1,780	<i>1,292</i>
Spain	8,263.0	-	2,061.0	-	1,060	<i>14,178</i>
Sweden	442.0	22.5	38.0	719	971	772
Switzerland	8.9	-	3.5	23	1,750	6
United Kingdom	900.8	123.8	253.2	1,191	1,710	1,286
United States	6,740.0	-	359.0	-	1,200	<i>19,600</i>
<b>TOTALS</b>	<b>41,905.1</b>	<b>577.5</b>	<b>6,610.6</b>			

**Table 1 National statistics of the IEA R&D Wind member countries. Figures in italics are estimates. None or no data available are indicated by -.**

Offshore Development Plays a Leading Role for Some For Denmark, the Netherlands, and the UK, offshore wind is expected to provide the majority of future wind growth. In Denmark, the basis for the construction of two more offshore wind farms was agreed to this year, each with a capacity of 200 MW. This will be complemented by a further re-powering program. The Netherlands see the construction of 6 GW of offshore wind as both possible and necessary in meeting long-term expectations. The UK has recognized that current rates of development are not on-track to meet targets and that offshore wind is likely to be required at large scale.

### Meeting Government Targets

As the wind sector and policies mature, expectations and targets are becoming better founded and, as a consequence, more realistic. Denmark had a target of 20% generation from renewables by 2003, which is now fully satisfied by wind energy alone. Spain and Italy are expecting to meet their current targets early and the Netherlands is optimistic about achieving an interim target to reach 6% of electricity consumption from renewables in 2005.

A number of countries are less optimistic in spite of great efforts to put in place favorable market conditions and measures to address constraints. This is the case for Greece, Portugal, Sweden, and the UK.

### Support Mechanisms

Stability in the market conditions for wind is an essential element of encouraging the investment needed for development. The high dependence of markets on government policies is an ever-present concern and one that continues to constrain wind. Sweden changed to a green certificate based system in May 2003 with the aim of increasing wind development. However, no major new investments resulted in the first year, attributed to uncertainty about the system's survival after 2010. While the Australian MRET (Mandatory Renewable Energy Target) has been very successful in generating recent growth, there is now great insecurity looking forward. This is because the Federal Government's new approach does not include an extension to the MRET. At current growth rates, the

MRET will be fully met during 2007, removing further demand. The rate of growth in the United States for 2004 was considerably lower than in previous years due to a delay in the extension of the Federal Production Tax Credit (PTC). This is a cycle that repeats itself, and the PTC has now only been extended to the end of 2005.

### Other Measures to Encourage Wind Energy

In an effort to increase the rate of wind development in Sweden, 49 areas were designated as of national interest for wind power in October 2004. Switzerland has adopted a similar approach with all projects in the medium term focusing on specific sites identified because of their wind resource, accessibility, and low landscape sensitivity. In Finland, sites for wind power capable of realizing up to 4,000 MW, mostly offshore, have been added to regional plans by the authorities.

The Dutch national railway manager ProRail has permitted a demonstration project using wind turbines directly over a freight railway line. ProRail wants to gather a year of experience with wind energy. If it is satisfied, then there is the potential for several hundred megawatts of similar projects.

Community or locally owned wind farms bring several benefits, and interest in them is spreading. They increase the money flowing into the area, provide a positive interest to the people that are living with the turbines, and can reduce the resistance to gaining a building permit. Denmark has built its industry on local ownership, and the Netherlands has a history of locally and especially farmer owned turbines. To increase their selling power, many Dutch turbine owners have now formed co-operatives. One Dutch co-operative with some 300 MW of capacity allows consumers to buy wind-generated electricity and choose the generation source down to an individual turbine.

### Turbine Development

German manufacturers have produced the three largest turbines to date: the Enercon E-112, 4.5-MW turbine; the Repower M5, 5-MW turbine with a

126 m rotor; and the Multibrid M5000, 5-MW turbine. The Enercon E-112 has been under evaluation since October 2002. Most leading manufacturers are catching up with turbines of 3 to 5 MW capacity either available or under development. While these will be initially installed onshore, many are also targeting the offshore market, requiring adaptation, which has been the focus of the Danish manufacturers this year.

The U.S. company Clipper Windpower is taking an unorthodox approach for its 2.5-MW turbine. The company will use four generators mounted radially to the gearbox, with the goal of producing a drive-train that is much lighter than conventional drive-trains.

In 2004, the average new turbine size exceeded 1 MW for all countries except Italy, Sweden, and Denmark. The average new turbine deployed by the IEA countries was approximately 1,290 kW.

## WIDER IEA ACTIVITIES

### Electricity Network R&D

Recurring blackouts and disruptions in power quality highlight reliability and security issues in electricity transmission and distribution networks. Nevertheless, managing these power systems and applying remedies are not simple matters in the context of steady growth in electricity trading, in network congestion, and in use of distributed and intermittent power generation. The IEA has proposed a new international collaboration for addressing widely encountered R&D and grid issues, for monitoring national and other programs, and for circulating know-how. Participants would fix the work program and priorities. Possible topics might include: architecture, technology and management of networks; status and impact of distributed power generation technology and systems; intermittency of energy sources together with mitigating options such as demand-side measures and storage; and hierarchies of trans-boundary control. The future of this proposed activity will depend upon the level of interest in IEA countries.

## Publications

*Renewable Energy – Market and Policy Trends in IEA Countries* reviews the experience of IEA countries. It examines policies and measures that have been introduced, the objectives behind them, and an evaluation of the results. The stated aim is to identify best practices in order to assist governments in making future policy decisions. [ISBN 92-64-10791-6]

Some important signposts are provided in a recently published free downloadable IEA Technology Brief *Sustainable Transport Systems – How to Get There Faster*. This handbook identifies the technologies that can contribute short-term to significantly reducing greenhouse gases in transport. It also indicates the most promising paths for the longer-term. It is the first in a new series of IEA Technology Briefs. Topics planned for the future include electricity transmission and distribution.

A joint IEA/NEA study *Projected Costs of Generating Electricity -- 2005 Update* provides generation cost estimates for over a hundred power plants. These include coal-fired, gas-fired, nuclear, hydro, solar, and wind plants. The study shows that the competitiveness of alternative generation sources and technologies ultimately depends on many parameters with no clear-cut “winner.” It reports that the lowest levelized costs of generation from the traditional generation technologies are within the range of 25 to 45 USD/MWh in most countries. At a 5% discount rate, levelized costs for wind power plants considered in the study are calculated to range between 35 and 95 USD/MWh, but for a large number of plants the costs are below 60 USD/MWh. [ISBN 92-64-00826-8]

IEA publications are available via the IEA web-site at <http://www.iea.org/>. This includes the annual publication *Renewables Information*; which provides statistics about deployment and seeks to increase the understanding of the current market and trends.



## CHAPTER 2

# THE IMPLEMENTING AGREEMENT

## 1.0 THE IMPLEMENTING AGREEMENT

IEA's commitment to wind energy dates back to 1977, when the Implementing Agreement for Co-operation in the Research and Development of Wind Turbine Systems (IEA Wind) began. The past 27 years have seen the development and maturing of wind energy technology. This process has been possible through vigorous national programs of research, development, demonstration, and financial incentives. In this process, IEA Wind has played a role by providing a flexible framework for cost-effective joint research projects and information exchange. In 2004, the participants changed the name of the agreement to include deployment, an acknowledgement of the increasing importance of research into issues surrounding large-scale deployment of wind energy systems.

The mission of the IEA Wind Agreement continues to be to encourage and support the technological development and global deployment of wind energy technology. To do this, the contracting parties exchange information on their continuing and planned activities and participate in IEA Wind tasks regarding cooperative research, development, and deployment of wind energy systems. The tasks are listed as numbered Annexes to the Implementing Agreement.

In 2004, 21 contracting parties from 18 countries and the European Commission participate in IEA Wind. Australia, Austria, Canada, Denmark, European Commission, Finland, Germany (membership renewed for 2005), Greece, Ireland, Italy (two contracting parties), Japan, Mexico, the Netherlands, New Zealand

(membership to be renewed in 2005), Norway (two contracting parties), Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States were members. (See Table 1). The Republic of Korea and the European Wind Energy Association will join in 2005.

Recently there has been increasing interest in IEA participation from both the Organization for Economic Cooperation and Development (OECD) and non-OECD countries. This interest is being encouraged, and prospective members attend IEA Wind Executive Committee (ExCo) meetings to observe first-hand the benefits of participation.

### 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 of national program activities in 2004 is presented in Chapter 3 of this Annual Report. Individual country activities are presented in Chapters 4 through 23.

### Collaborative Research

Participants in the IEA Wind Agreement are currently working on six cooperative research tasks, which are approved by the ExCo as Annexes to the original Implementing Agreement. (See Table 2) Progress in cooperative research is described later in this chapter. Tasks are sometimes referred to by their annex number. Some annexes have been completed

Country	Contracting Party to Agreement
Australia	Australian Wind Energy Association
Austria	The Republic of Austria
Canada	Natural Resources Canada
Denmark	Danish Energy Authority
European Commission	The Commission of the European Communities
Finland	The Technical Research Centre of Finland (VTT Energy)
Greece	The Ministry of Industry/Energy and Technology (CRES)
Ireland	Sustainable Energy Ireland
Italy	CESI S.p.A. and ENEA Cassaccia
Japan	National Institute of Advanced Industrial Science and Technology (AIST)
Mexico	Instituto de Investigaciones Electricas (IIE)
Netherlands	The Netherlands Agency for Energy and the Environment (SenterNovem)
Norway	The 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	Energimyndigheten
Switzerland	The Swiss Federal Office of Energy
United Kingdom	Department of Trade and Industry
United States	The U.S. Department of Energy

**Table 1 Contracting parties in 2004 to the Implementing Agreement for Co-operation in the Research, Development, and Deployment of Wind Energy Systems (IEA Wind).**

or put on hold and so do not appear as active projects in this report. To date, 16 tasks have been successfully completed and two tasks have been deferred indefinitely. (See Table 3) This is why the numbers of active annexes may not be sequential. Countries choose to participate in tasks that are relevant to their current national research and development programs. Additional tasks are planned when new areas for co-operative research are identified by Members.

The level of effort on a task is typically the equivalent of several people working for a period of three years. Some tasks have been extended to continue the work. The projects may be 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 program coordinated by an Operating Agent. Table 4 lists participants in tasks during 2004.



Task XI	Base technology information exchange OA: FOI, Sweden (1987 to present)
Task XIX	Wind energy in cold climates OA: Technical Research Centre of Finland – VTT Energy. (2000 to 2005)
Task XX	HAWT Aerodynamics and models from wind tunnel tests and measurements OA: NREL, the United States (2003 to 2005)
Task XXI	Dynamic models of wind farms for power system studies OA: Sintef Energy Research, Norway (2003 to 2005)
Task XXIII	Offshore Wind Energy Technology Development OA: Risø National Laboratory, Denmark and the National Renewable Energy Laboratory (NREL), United States (2004 to 2006)
Task XXIV	Integration of Wind and Hydropower Systems, OA: NREL, United States (2004 to 2006)

**Table 2 Active cooperative research tasks defined in Annexes to the IEA Wind Implementing Agreement.**

To obtain more information about the cooperative research activities, contact the Operating Agent representative for each task listed in Appendix B or at [www.ieawind.org](http://www.ieawind.org).

### 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 from each contracting party that has signed the Implementing Agreement. Most countries are represented by one contracting party that is usually a government department or agency. Some countries have more than one contracting party within the country.

The ExCo meets twice each year to exchange information on the R&D programs of the member countries, to discuss work progress on the various tasks, and to plan future activities. Decisions are reached by majority vote. Member countries 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 approved by the ExCo in the annual budget.

### OFFICERS

In 2004, Mr. Peter Goldman (United States) served as Chair and Mr. Sven-Erik Thor (Sweden) served as Vice-Chair. At the 53rd ExCo meeting, Prof. Ana Estanquero (Portugal) was elected as additional Vice-Chair.

### PARTICIPANTS

In 2004, Germany was invited and accepted to rejoin the IEA Wind Implementing Agreement effective 2005. (See Appendix B for an updated list of Members, Alternate Members, and Operating Agent representatives.) During the year, the ExCo also invited the Republic of Korea and the European Wind Energy Association to join and details of participation are expected to be completed in 2005.

### MEETINGS

The ExCo normally meets twice a year for Members to review ongoing tasks; plan and manage cooperative actions under the Agreement; and report on national wind energy research, development, and deployment activities (R,D&D). The first meeting of the year is devoted to reports on R&D activities in the member countries, and the second meeting is devoted to reports about deployment activities.

The 53rd ExCo meeting was hosted by the Department of Trade and Industry of the United

Task I	Environmental and meteorological aspects of wind energy conversion systems OA: The National Swedish Board for Energy Source Development. (1978 to 1981)
Task II	Evaluation of wind models for wind energy siting OA: U.S. Department of Energy – Battelle Pacific Northwest Laboratories. (1978 to 1983)
Task III	Integration of wind power into national electricity supply systems OA: Kernforschungsanlage Jülich GmbH, Germany. (1978 to 1983)
Task IV	Investigation of rotor stressing and smoothness of operation of large-scale wind energy conversion systems OA: Kernforschungsanlage Jülich GmbH, Germany. (1978 to 1980)
Task V	Study of wake effects behind single turbines and in wind turbine parks OA: Netherlands Energy Research Foundation. (1980 to 1984)
Task VI	Study of local flow at potential WECS hill sites OA: National Research Council of Canada. (1982 to 1985)
Task VII	Study of offshore WECS OA: UK Central Electricity Generating Board. (1982 to 1988)
Task VIII	Study of decentralized applications for wind energy OA: UK National Engineering Laboratory. (1984 to 1994)
Task IX	Intensified study of wind turbine wake effects OA: UK National Power plc. (1984 to 1992)
Task X	Systems interaction. Deferred indefinitely.
Task XII	Universal wind turbine for experiments (UNIWEX) OA: Institute for Computer Applications, University of Stuttgart, Germany. (1988 to 1995)
Task XIII	Cooperation in the development of large-scale wind systems OA: National Renewable Energy Laboratory (NREL), USA. (1990 to 1995)
Task XIV	Field rotor aerodynamics OA: Stichting Energieonderzoek Centrum Nederland (ECN), the Netherlands. (1992 to 1997)
Task XV	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 XVI	Wind turbine round robin test program OA: the National Renewable Energy Laboratory (NREL), the United States. (1995 to 2003)
Task XVII	Database on wind characteristics OA: RISØ National Laboratory, Denmark. (1999 to 2003)
Task XVIII	Enhanced field rotor aerodynamics database OA: Netherlands Energy Research Foundation – ECN, the Netherlands Extend the database developed in Task XIV and disseminate the results. (1998 to 2001)
Task XXII	Market development for wind turbines. On hold.

**Table 3 Completed or inactive research tasks.**

Country	XI Base Technology Information Exchange	XIX Wind Energy in Cold Climates	XX HAWT Aero- dynamics and Models from Wind Tunnel Tests	XXI Dymanic Models for Wind Farm Power Systems	XXIII Offshore Wind Energy Technology and Deployment	XXIV Integration of Wind Hydropower Systems
Australia						x
Austria						
Canada	x	x	x			x
Denmark	x		x	x	OA	
European Commission	x					
Finland	x	OA		x	(in progress)	x
Greece	x		x			
Ireland	x			x		
Italy	x					
Japan	x				(in progress)	
Mexico	x					
Netherlands	x		x	x	(in progress)	
Norway	x	x	x	OA	x	x
Portugal				x		
Spain	x		x			
Sweden	OA	x	x	x	(in progress)	x
Switzerland		x				x
United Kingdom	x			x	x	
United States	x	x	OA	x	OA	x
Start Date	1987	2001	2003	2003	2004	2004
End Date	Ongoing	2004	2005	2005	2008	2008

**Table 4 Participation of member countries in Annexes during 2004. (OA indicates operating agent organization that manages the task.)**

Kingdom, at Chester, UK on 18 to 20 May 2004. There were 26 participants from 14 of the contracting parties, three operating agent representatives of tasks, and several observers. The ExCo reviewed and approved technical progress reports of ongoing tasks XI, XIX, XX, and XXI; and approved the final report of Annex XVI Round Robin Test Program. Task XXII, Wind Energy Market Acceleration remained on hold pending decisions at IEA. Two new annexes were approved contingent on several steps being completed within one year: Annex XXIII, Offshore Wind Energy Technology and Deployment and Annex XXIV, Integration of Wind and Hydropower Systems. The

ExCo approved the audit report of 2003 accounts of the Common Fund. On 20 May 2004, the ExCo visited the 60-MW North Hoyle offshore wind park operated by National Windpower.

The 54th ExCo meeting was hosted by VTT Processes, Systems, and Models of Finland at Oulu, Finland on 5 to 7 October 2004. There were 24 participants from 14 contracting parties, two operating agent representatives, and four observers. The ExCo invited the European Wind Energy Association to join as Sponsor members, pending amendments to the Implementing Agreement to add such a mem-

bership category. The ExCo reviewed and approved progress and budgets of the ongoing tasks: Annex XI, XIX (which was extended through May 2005), XX, XXI, XXIII, and XXIV. The ExCo approved the budgets for the ongoing tasks and for the Common Fund for 2005. On 7 October 2004, the ExCo visited the factory of WinWinD where a 3-MW turbine was being assembled.

## 2.0 TASK XI – BASE TECHNOLOGY INFORMATION EXCHANGE

The objective of this Task is to promote wind turbine technology by co-operative activities and information exchange on R&D topics of common interest. These particular activities have been part of the Agreement since 1978. The Annex was extended in 2003 for the years 2004 and 2005.

The task includes activities in two sub-tasks. The first sub-task is to develop recommended practices for wind turbine testing and evaluation by assembling an Experts Group for each topic needing recommended practices. In the series of Recommended Practices, 11 documents have been published. Five of these have appeared in revised editions (Table 5). The documents on Noise Emission and Cup Anemometry have been reprinted during 2003, due to the large demand. Many of the documents have served as the basis for both national and International Standards.

The second sub-task is to conduct joint actions in specific research areas designated by the IEA Wind Executive Committee. So far, Joint Action Symposia have been initiated in aerodynamics of wind turbines, wind turbine fatigue, wind characteristics, offshore wind systems, and wind forecasting techniques. In each of these topic areas, symposia and conferences have been held. In addition to Joint Action Symposia, Topical Expert Meetings are arranged on topics decided by the IEA Wind Executive Committee.

Over the 25 years since these activities were initiated, 45 volumes of proceedings from Topical Expert Meetings (Table 6) and 26 volumes of proceedings from Joint Action Symposia (Table 7) have been published.

### Topical Expert Meeting 42 on Acceptability in Implementation of Wind Turbines in Social Landscapes

The meeting gathered 15 participants from research and government organizations as well as consultant companies from Denmark, Ireland, Italy, Sweden, the Netherlands, and the United Kingdom. The goal of the meeting was to review and evaluate the status of research and activities concerning socio cultural aspects and environmental impact assessment (EIA) procedures in relation to wind energy development.

Participants concluded that wind power project realization depends on a good local acceptance. This requires a participative process during project development. In the formal planning and permitting stage, this is guaranteed by legal procedures. However, once this stage starts, local acceptability likely has already been won or lost. Good governance at the initial, informal stage of site selection and project definition can make the difference and be decisive on local acceptance. Various instruments, communicative and financial, can be applied in participative governance. However, the effect of the interventions depends on the local target group and the type of negative impact. Good governance is crucial but not a guarantee for local acceptance. Whatever is done, some group may not accept the project in some specific respect. Then in the end, this non-acceptance should be judged in the legal procedures during the formal stage.

“Words of wisdom” from the meeting follow.

- Hierarchical planning is destructive
- Collaborative planning is crucial

### Topical Expert Meeting 43 on Critical Issues Regarding Offshore Technology and Deployment

A primary goal of the meeting was to give the participants a good overview of the challenges encountered in offshore applications and to identify areas needing more R&D attention, to “identify white spots.”

The meeting gathered 18 participants, representing Denmark, Finland, the Netherlands, Sweden, the

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

**Table 5 List of Recommended Practices developed by IEA Wind.**

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
34	Noise immission	Boulder, Colorado	2000
33	Wind forecasting techniques	Stockholm, Sweden	2000
32	Wind energy under cold climate conditions	Helsinki, Finland	1999
31	State of the art on wind resource estimation	Lynby, Denmark	1998
30	Power performance assessments	Athens, Greece	1997
29	Aero-acoustic noise of wind turbines	Milano, Italy	1997
28	State of the art of aeroelastic codes for wind turbines	Lynby, Denmark	1996
27	Current R&D needs in wind energy technology	Utrecht, Netherlands	1995
26	Lightning protection of wind turbine generator systems and EMC problems in the associated control systems	Milan, Italy	1994
25	Increased loads in wind power stations	Gothenburg, Sweden	1993
24	Wind conditions for wind turbine design	Risø, Denmark	1993
23	Fatigue of wind turbines, full-scale blade testing	Golden, Colorado	1992
22	Effects of environment on wind turbine safety and performance	Wilhelmshaven, Germany	1992
21	Electrical systems for wind turbines with constant or variable speed	Gothenburg, Sweden	1991
20	Wind characteristics of relevance for wind turbine design	Stockholm, Sweden	1991
19	Wind turbine control systems–strategy and problems	London, England	1990

**Table 6 Topical Expert Meetings held since 1990. For a complete list of meetings, see [www.ieawind.org](http://www.ieawind.org).**

No	Year	Host	Place	Country
<b>Aerodynamics of wind turbines</b>				
16	2003	NREL	Boulder, CO	USA
15	2001	NTUA	Athens	Greece
14	2000	NREL	Boulder	USA
13	1999	FFA	Stockholm	Sweden
12	1998	DTU	Lyngby	Denmark
11	1997	ECN	Petten	Holland
10	1996		Edinburgh	United Kingdom
9*	1995	FFA	Stockholm	Sweden
<b>Fatigue of wind turbine blades</b>				
5	1999	Uni. Delft	Delft	Holland
4	1996	DLR	Stuttgart	Germany
3*	1994	ECN	Petten	Holland
<b>Wind</b>				
3	2003	Risø	Roskilde	Denmark
2	1999	Risø	Roskilde	Denmark
1	1994	GL	Hamburg	Germany
<b>Wind forecasting techniques</b>				
2	2004	DTU	Lyngby	Denmark
1	2002	SMHI	Norrköping	Sweden

**Table 7 Joint Action Symposia since 1994.**

United Kingdom, and the United States. Presentations included both detailed research presentations and general descriptions of the current situation in Denmark, Finland, the Netherlands, the UK, and the United States.

As a part of the introduction to the meeting, an inspiring presentation was given on experiences from the Horns Rev wind farm. Lessons learned were summarized as follows.

- Test and try anything that can be tested or tried before leaving shore
- Train the technicians onshore in stead of offshore
- The weather is “flexible,” requiring flexible plans or all work.

At the end of the meeting, a proposal was presented for creating an annex dealing with critical issues regarding offshore technology and deployment. The proposal served as the basis for discussion on making a prioritized inventory of challenges going offshore. The discussion resulted in an Annex proposal for IEA Wind being prepared after the meeting. Table 8 lists the first and second priority challenges.

## Topical Expert Meeting 44 on System Integration of Wind Turbines

### BACKGROUND

Wind power penetration is increasing rapidly in many countries worldwide. In the leading countries, wind power capacity penetrations of up to 30% have been attained. The interaction of wind energy and the power system has emerged as a potentially significant obstacle to increased penetration. Issues range from operating reserves and frequency control, to the ability of the current grid system to accommodate additional generation. Individual countries with high wind power penetration may currently rely upon interconnection with neighboring countries for provision of ancillary services that support the high local penetration. As power systems and markets are not necessarily delineated by political boundaries, the technical assessment of the effects of high wind penetration upon these may better be carried out on a system-wide, rather than individual country, basis. In some cases, the cost (both direct and external) of providing required ancillary services (including various classes of reserve) exhibits an exponentially increasing relationship with wind penetration. Thus, the availability of system ancillary services may be a limiting factor on the rate of deployment of wind power.

In addition to creating environmental benefits, it has been suggested that wind generation may impact the operation of electricity systems in such a way as to increase the requirement for reserve. This is because wind generation has a number of physical and technical characteristics that are very different from the conventional generation it displaces.

### SUMMARY

The meeting gathered 28 participants, representing Denmark, Finland, Ireland, Italy, the Netherlands, North Ireland, Norway, Portugal, Sweden, the United Kingdom, and the United States. The meeting started with a presentation of the related IEA Wind Annex XXI, Dynamic models of wind farms for power system

studies. Then, presentations covered national activities, impacts of large scale on system operation, and dynamic simulation. Additional topics included smoothing effects over large geographic areas, how to calculate reserve requirements, ride-through standards and their feasibility, cost of integration for all energy sources including wind, and the need for reliable and validated models of wind turbines for power system analysis.

### Discussion of a new annex

After a short presentation by Hannele Holttinen of VTT Finland, listing possible ideas for the new annex, a lively discussion ensued. System integration of wind power is a large area of research, so participants agreed that the scope should be reduced. This could be done for example by taking only the impacts that require system-wide analyses, which would leave out impacts that are dealt with locally (distribution efficiency, voltage management). The goals of such an annex could include:

- State-of-the art of research made so far
- Guidelines for the study methods and data used
- Quantifying the impacts of wind power on power system
- Information exchange between the participating countries and institutions.

Guidelines could include study methods for stability analyses and reserve needs as well as how to incorporate wind power in grid analysis and energy system models. Rules of thumb that could be used as a first step when considering large penetration of wind power in power systems would be useful. The annex should try to come up with quantification of the range of impacts and costs for different power systems (relative to system size, wind power dispersion, and amount of flexibility).

Links to other ongoing work were considered very important to take into account in the proposed annex. An ad hoc group was formed to work further on the scope of the annex and make a draft proposal to the IEA Wind ExCo. The group is led by Hannele Holttinen/VTT ([hannele.holttinen@vtt.fi](mailto:hannele.holttinen@vtt.fi)) Finland.



Topic/subtask	Priority	Information Exchange	R&D action	Potential country participation
1. Operating offshore wind facilities and technology applications – joint action symposium – exchange of experience	1	1		All
2. Alternative support structures for wind energy in deep water (30 m). Deepwater offshore issues moorings, floating platform design, stability, power cabling, dynamic stability.	2	2	1	US, JP
3. Ecological issues and regulations LCA, decommissioning, consent agreement (permitting) and public involvement	1	1	2	All
Layout and array effects (energy production, mutual shadow effect of large, closely-spaced wind farms)	2	1	1	DK, NL, S, UK
Specific loads and load combinations for standardization (e.g. extreme wind/ wave load combinations, wake loads)	2	1		All
External conditions (e.g. instrumentation for site assessment, siting, and energy prediction)	1	1	2	S, US, DK
Safe operation offshore (personnel safety requirements, increased personnel access)	2	1		All
Reliability and statistical design procedures – calibration of safety, Risk assessment (see Annex XI)	2	1	1	All – NL
Condition monitoring, inspection, reliability, operation and maintenance, forecasting of conditions	1	1	1	All
Cost development, economic risks, financing, and insurance	2	1	2	All
Electric system integration (dynamic behavior, controllability and stability, power balance, reserves, see Annex XXI)	1	1	1	All
Ship collision	2	2		S, NL
Technology, project, operation and decommissioning uncertainties – effect on costs (TEM)	2	1		All
Integrated dynamic modeling of WT/ support structure	2		1	DK, NL, UK

**Table 8 Challenges facing development and deployment of offshore wind technology.**

TSO participation in this annex was considered highly important and that would also help create a working link between CIGRE and annex work.

### Topical Expert Meeting on Operation and Maintenance of Wind Power Stations

This meeting was planned for the fall in Mexico. Unfortunately, the meeting had to be canceled due to too few participants being available at that time.

### Second Joint Action Symposium on Wind Forecasting Techniques

The meeting gathered 22 participants from Denmark, Greece, Ireland, Italy, Norway, Spain, Sweden, the UK, the US, and an observer from France. Participants came mainly from research and government organizations as well as consultant companies and utilities. The presentations addressed general aspects of forecasting, tools for forecasting, and uncertainties. The final discussion dealt with a number of different issues, some of them suitable for further research.

Participants agreed that progress had been made since the previous meeting. The trend is now towards more probabilistic research. There are better methods for up-scaling (from wind farm level to regional level). Methods for ensemble forecasts are getting more attention. A number of commercial companies are offering forecasting services, especially in the United States. Areas where more research is needed included the following.

- More accurate predictions, verification, down-scaling, and real time adoption
- Estimating uncertainties of the predictions
- Upscaling
- Long range forecasting, two-weeks to a few months
- Challenging areas (i.e. complex terrain, offshore, tunnelling, etc).
- Climate change – Long-term assessment.
- Implementation issues and errors, something for next meeting?

### Next meeting

The participants recommended arranging the next meeting in the fall of 2005, preferably in the United States. Examples of proposed topics are how to present forecasts, point figure, uncertainty, correlation and ways to incorporate other energy sources, e.g. hydro, into forecasts.

All documents produced under Task XI are available to citizens of participating countries from the Operating Agent representative, listed in Appendix B. More information can be found on the Internet at [www.ieawind.org](http://www.ieawind.org).

Author: Sven-Erik Thor, FOI, Sweden.

## 3.0 TASK XIX – WIND ENERGY IN COLD CLIMATES

### Introduction/Objective

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.

In order to supply needed information on the operation of wind turbines in cold climates, Task XIX to the IEA Wind implementing agreement was officially approved in 2001. The resulting task began in May 2001 and has now continued for three years. A plan for continuation of the Annex has been prepared and is subject to approval in spring 2005. The wind turbine sites that either have icing events or low temperatures outside the standard operational limits of wind turbines has been agreed on as the scope of project.

The objectives of the work are to:

- Gather and share information on wind turbines operating in cold climates
- Establish a site-classification formula, combining meteorological conditions and local needs

- Monitor the reliability and availability of standard and adapted wind turbine technology that has been applied
- Establish and present guidelines for applying wind energy in cold climates.

Participants in the task include Canada, Finland (Operating Agent), Norway, Sweden, Switzerland, and the United States.

## Means

The participants have agreed to a cost-shared and task-shared arrangement to carry out specific activities necessary to achieve the objectives. In addition to financial support for the Operating Agent, participants will supply information and attend task meetings. The main activities are divided to five subtasks, which follow.

## OPERATIONAL AND PERFORMANCE EXPERIENCE

The project gathers operational and performance experience mainly through national wind turbine statistics and information available to the participants. For more widely spread information, project Internet pages have a form that can be used to report events.

The goal is to determine how much production loss and failure by icing and low-temperature events is caused to turbines at different sites. With the help of national statistics and reported information, the need and the scale of the need for adapted technology, as well as functionality and reliability of the cold climate modifications that are employed so far, is defined. Technical availability will provide information on reliability of turbines in cold climates.

In addition to this, construction experience and operation and maintenance experience in cold climates are gathered. The reliability and power performance



**Figure 1** Foundation work in connection with site measurement campaign. Photo: Kjeller Vindteknikk, Norway.

of wind turbines are often overestimated because the harsh conditions are not taken into account with appropriate seriousness, and not enough is known of the expected icing time and the persistency of icing.

The reliability of anemometers, ice detectors, and other sensors is also an issue for wind power utilization in cold climates. In addition to expected technical availability, the reliability of wind measurements plays an essential role at the time of investment decision. With unheated anemometers, wind resources may easily be underestimated in an icing climate.

#### EXTRAORDINARY OPERATIONAL EVENTS

In addition to general information gathered from several cold climate sites, the participants monitor in detail extraordinary events such as icing, storms, lightning strikes, and voltage losses on selected sites.

#### SITE ASSESSMENT AND CLASSIFICATION

Classification is needed due to different site requirements. In addition to the standard site assessment, low temperature and icing-related issues should also be considered. A site classification procedure will be formulated on the basis of existing information on ice induced loading of wind turbines and effects of ice on energy production in different winter climates.

#### TECHNOLOGY CLASSIFICATION

Technology that has been developed to meet the requirements of demanding winter conditions is new. The suitability and capability of different cold climate technologies are evaluated on the basis of collected information. Finally, the classification of sites and technology will result in guidelines for turbine investors, manufacturers, and developers to be used during project planning. With this categorization, an estimate of the size of the markets of adapted wind turbine technology can also be formed.

#### DISSEMINATION OF RESULTS

Internet pages have been created for the project to disseminate general information and operational experiences, as well as to gather information (located

at [arcticwind.vtt.fi](http://arcticwind.vtt.fi)). The operational experience and the final result, guidelines for cold climate wind energy production, will be disseminated to developers and turbine manufacturers. One important dimension of this work will be to consider if cold climate issues should be recognized in future standards that set the limits for turbine design.

#### Status

The State-of-the-Art of Wind Energy in Cold Climate report was finished and published in spring 2003. This report summarizes available wind turbine technologies intended for use in low temperatures and icing climate. The report can be downloaded in a PDF format from the project Internet pages (located at [arcticwind.vtt.fi](http://arcticwind.vtt.fi)).

First steps have been taken to establish a site-classification formula. The further development and verification are still underway. The first recommended method for ice measurements in connection to site assessment and turbine operation has been established.

The final report including guidelines regarding cold climate issues of wind energy, is in draft phase. Final report will be delivered to ExCo during the Spring 2005. Once approved, the report will be available on the project Internet page in a PDF format for downloading.

A poster of the Annex XIX was on view in European Wind Energy Conference in London in November 2004.

Interest in cold climate specific issues has increased and one of the driving forces for that is the improving cold climate wind turbine technology. This technology has improved competitiveness of cold climate sites compared to lowland and offshore sites. Preparation of the continuation of the Annex XIX has been started. A proposal for the continuation has been sent to current participants as well as to three countries that has shown interest.

Authors: Timo Laakso and Esa Peltola, VTT Processes, Finland



Figure 2 Wind turbine at a walking distance from a ski lift in Gütsch. Turbine is equipped with a de-icing system. Photo: ENCO AG, Switzerland.

#### 4.0 TASK XX – HAWT AERODYNAMICS AND MODELS FROM WIND TUNNEL MEASUREMENTS

##### Introduction

As wind energy expands worldwide and turbines grow ever larger, sustained technological innovation will require aerodynamics models of greater accuracy and reliability. To achieve these goals, theoretical and computational models must evolve alongside high quality experimental measurements. Over the past decade, turbine aerodynamics instrumentation and data quality have improved substantially as a result of efforts like IEA Cooperative Research Task XIV, "Field Rotor Aerodynamics", and Task XVIII, "Enhanced Field Rotor Aerodynamics Database."

In these efforts, turbine sizes and configurations were comparable to state-of-the-art turbines, and

recorded aerodynamic phenomena that were representative of operational machines. Although of high quality, these measurements contained atmospheric inflow fluctuations and anomalies, which precluded clear discernment of complex turbine aerodynamics. Alternatively, wind tunnel experiments offered steady, uniform inflows capable of revealing turbine aerodynamic structures and interactions. However, wind tunnel dimensions generally restricted turbine size, and left doubt as to whether data thus acquired were typical of full-scale turbine aerodynamics.

To acquire aerodynamics data representative of full-scale turbines, under conditions of steady uniform inflow, the NREL (National Renewable Energy Laboratory) UAE (Unsteady Aerodynamics Experiment) wind turbine was tested in the NASA Ames 80 foot by 120 foot (24.4 m by 36.6 m) wind tunnel. (See Figure 3) This test was designed to provide accurate and reliable experimental measurements, having high spatial and temporal resolution,

for a realistic rotating blade geometry, under closely matched Reynolds number conditions, and in the presence of strictly controlled inflows. Completed in 2000, the test included 22 turbine configurations, and produced over 2100 data files containing nearly 100 GB (gigabytes) of high-quality data.

Shortly after test completion, select data were employed as a reference standard in a blind comparison designed to evaluate wind turbine aerodynamics code fidelity and robustness. In this exercise, participants were given the UAE geometry and structural properties, and then attempted to predict aerodynamic response for a modest number of test cases representing diverse aerodynamic regimes. Code comparison participants did not have access to the experimental aerodynamics data until well after their model predictions were completed and submitted to NREL. Represented in the field of models were blade element momentum models, prescribed wake models, free wake models, and Navier-Stokes codes. Results generally showed unexpectedly large margins of disagreement between the predicted and measured data. Notably, no consistent trends were apparent regarding the magnitudes or the directions of these deviations.

The need for improved wind turbine aerodynamics models is clear, and the potential benefits are readily apparent. This research task is being established to capitalize on high quality experimental aerodynamics data from the NREL UAE wind tunnel test, as well as comparable data from other sources. Appropriately analyzed, these data will yield unique and unprecedented findings regarding turbine aerodynamics. This information can be exploited to formulate and validate new wind turbine aerodynamics models. Improved models will improve wind energy machine design, and continue the trend toward lower cost wind energy.

## Task Organization

**Objectives:** Task XX research objectives and work areas are mutually consistent, and structured to transition aerodynamics data to accurate, robust wind turbine aerodynamics models for machine design and analysis.

- Acquire accurate, reliable, high-resolution experimental aerodynamic and structural loads data for horizontal axis wind turbines representative of full-scale machines.
- Analyze these data using methodologies designed to reveal the flow physics responsible for phenomena observed on horizontal axis turbines.
- Formalize this understanding in hierarchically structured, physics based model subcomponents, with appropriate consideration for computational efficiency.
- Integrate model subcomponents into comprehensive models in incremental fashion, as a basis for accurate, robust prediction of horizontal axis wind turbine aerodynamics and structural loads.

**Participants:** At present, twelve organizations representing eight IEA member countries are participating in Task XX, and are listed below.

Canada: University of Quebec

Denmark: Risø National Laboratory

Greece: National Technical University of Athens and the Center for Renewable Energy Systems (CRES)

The Netherlands: Energieonderzoek Centrum

Nederland (ECN) and the Technical University of Delft

Norway: Agder University College and the Institutt for Energiteknikk

Spain: National Center for Renewable Energy (CENER)

Sweden: Swedish Defence Research Agency

Aeronautics Division (FFA) and Gotland University

United States: the National Renewable Energy Laboratory (NREL)

## Task Status

During 2004, participants continued research activities previously proposed and initiated under Task XX. Research results were presented and discussed at the Task XX Annual Progress Meeting, which was held on 17 June 2004 at the École de Technologie Supérieure, in Montreal, Canada. As in previous years, the Task XX meeting was held in conjunction with the Task XI Aerodynamics of Wind Turbines meeting.

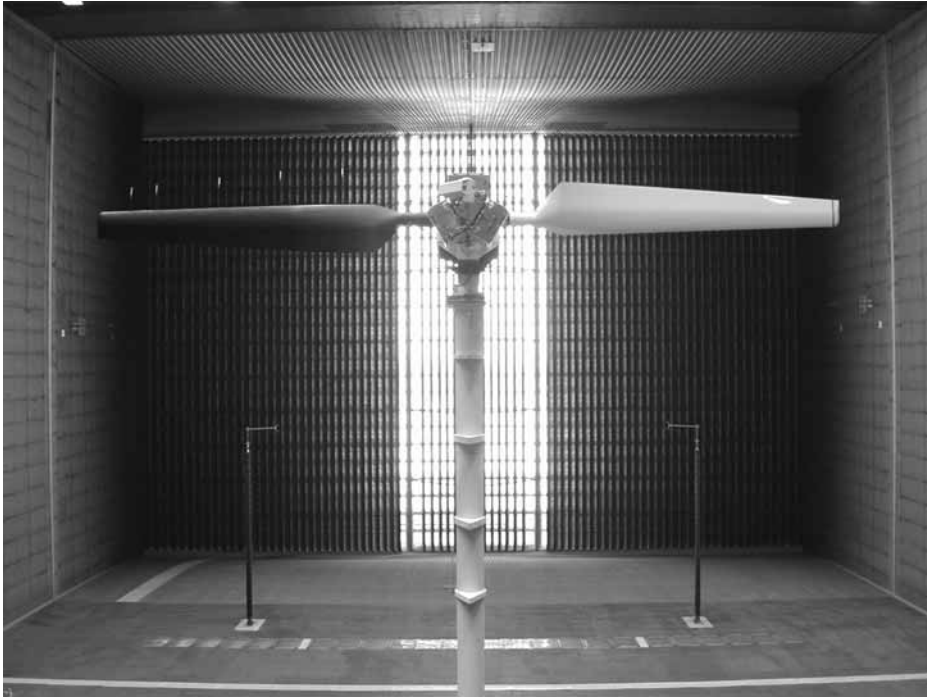


Figure 3 NREL UAE in NASA Ames 80 foot by 120 foot wind tunnel, looking upstream toward tunnel inlet.

At the June 2004 Annex XX annual meeting, researchers representing their respective participating countries reported on work carried out during the preceding year. Brief encapsulations of these status reports are included below.

“Actuator-Lifting Disk Modeling: Validation with NREL UAE Measurements” – Conventional actuator disk model coupled with vortex wake containing discrete trailed and shed vorticity elements, allowing more rigorous representation of aerodynamics while minimizing resource intensiveness. (C. Masson and C. Leclerc, École de Technologie Supérieure, Canada)

“Unsteady Aerodynamics in 2D and 3D Using Indicial Function Concepts” – Unsteady aerodynamics models for wind turbine blades under yawed operating conditions, based on indicial formulations and modifications to near wake models to achieve improved accuracy without drastically increased computational requirements. (M. Gaunaa, Risø National Laboratory, Denmark)

“The Effect of Test Set-Up on Turbine Blade Segment Performance” – Comparative analyses of aerodynamic force and surface pressure data for differing configurations to isolate effects due to wind tunnel, turbine, or instrumentation. (R. van Rooij, Delft University of Technology, The Netherlands)

“Annexlyse: Validation of Models Using IEA Annex XVIII Aerodynamic Field Measurements” – Analyse the full-scale aerodynamic field measurements which have been taken in IEA Annexes XVIII and XIV, and to develop and validate aerodynamic models using these field data and wind tunnel data. (G. Schepers and A. van Garrel, Energieonderzoek Centrum Nederland; R. van Rooij and A. Bruining, Delft University of Technology, The Netherlands)

“Cylindrical Green’s Function Approach For Wind Turbines and Related Applications” – Novel theoretical formulation for axisymmetric and sheared wakes renders analytical integration feasible for operating

conditions represented by previously intractable equation sets. (J. Conway, Agder University College, Norway)

“Wind Turbine Blade Stall Investigations” – Time and frequency domain characterizations of surface pressure data are being carried out, for axisymmetric and yawed operating conditions, to deduce flow field structure for comprehension and modeling. (A. Knauer, Institutt for Energiteknikk, Norway)

“Aerodynamic Analysis from Three-Dimensional Wind Turbine Blade Measurements at Zero Yaw Angle” – Analyze surface pressure and aerodynamic force data for parked and rotating blade conditions to understand evolution and structure of blade flow fields for rotors at zero yaw. (X. Munduate and A. Gonzalez, Centro Nacional de Energias Renovables, Spain)

“Numerical Evaluation of Tip Vortex Circulation from a Wind Turbine” – Create a CFD based aeroelastic simulation of a wind turbine, which will provide improved understanding of the wake physics and more reliable modelling capability for future turbines of significantly greater size. (S. Ivanell, Gotland University, Sweden)

“Peak and Post-Peak Power Aerodynamics from NASA Ames Phase VI Wind Turbine” – Analyze NASA Ames wind tunnel aerodynamic force and power data for unyawed rotor to provide guidelines for developing a stall delay/post stall aerodynamics model compatible with observed flow physics. (J. Tangler and B. Gerber, National Renewable Energy Laboratory, United States)

“Competing Local And Global Influences on Rotationally Augmented HAWT Blade Aerodynamics” – This project is examining NREL UAE Phase VI mean and time varying surface pressure and aerodynamic coefficient data for axisymmetric operation, to understand flow field as a precursor to model formulation. (S. Schreck, National Renewable Energy Laboratory, United States)

The 2005 Task XX Annual Progress Meeting will be held on May 25-26, at the Centro Nacional de Energias Renovables (CENER), in Pamplona, Spain.

As in previous years, the meeting will be held in collaboration with the Annex XI Aerodynamics of Wind Turbines meeting.

Author: Scott Schreck, NREL’s National Wind Technology Center, United States

## 5.0 TASK XXI – DYNAMIC MODELS OF WIND FARMS FOR POWER SYSTEM STUDIES

### Introduction

The worldwide development of wind power installations now includes planning of large-scale wind farms ranging in magnitudes of 100 MW, as well as application of wind power to cover a large fraction of the demand in isolated systems. As part of the planning and design of such systems, it is well established that the stability of the electrical power system needs to be studied. The studies are commonly conducted using commercial available software packages for simulation and analysis of power systems. These packages normally facilitate a set of well-developed models of conventional components, such as fossil fuel fired power stations and transmission network components; whereas models for wind turbines or wind farms are not standard features. Hence, users are left to build their own wind farm models. This is not trivial and certainly not efficient. Rather, a coordinated effort is expected to enhance progress, and consequently, Task XXI under the IEA Wind agreement was proposed and approved in April 2002 with SINTEF Energy Research of Norway as the Operating Agent.

### Means and Objectives

This task is carried out on a cost- and task-shared basis. The participants contribute with financial support to the Operating Agent and carry out activities, supply information, and join meetings as required to meet the task objectives.

The overall objective is to assist the planning and design of wind farms by facilitating a coordinated effort to develop wind farm models suitable for use in combination with software packages for simulation and analysis of power system stability. The effort



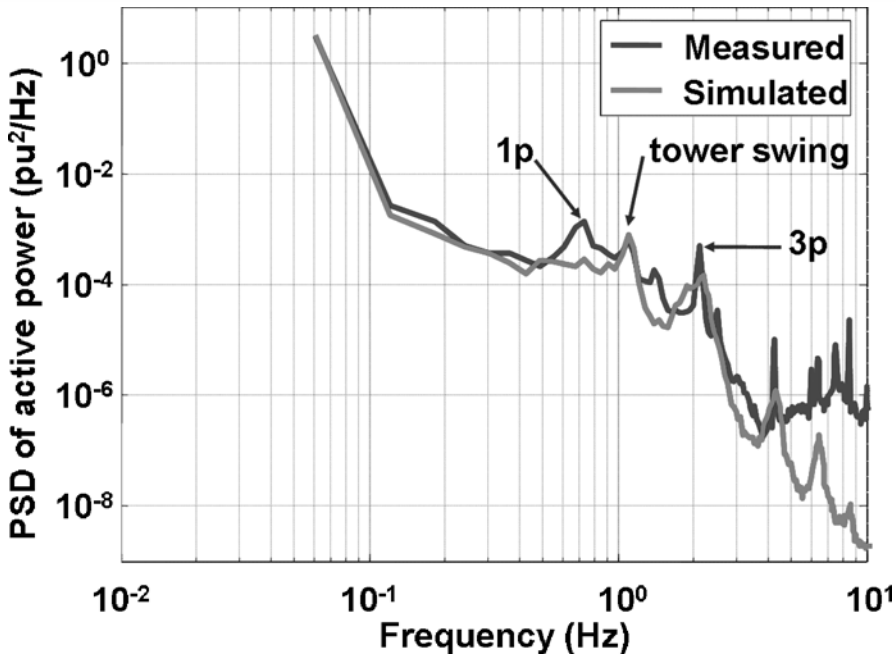


Figure 4 Power spectral density (PSD) of measured and simulated active power output from fixed speed, stall controlled wind turbine during normal operation.

comprises the following immediate objectives and activities.

- Establish an international forum for exchanging knowledge and experience within the field of wind farm modeling for power system studies
- Develop, describe, and validate wind farm models. (The wind farm models are expected to be developed by individual participants of the task, whereas the description and validation will be coordinated by the task, which helps provide state-of-the-art models and pinpoint key issues for further development.)
- Set-up and operate a common database for benchmark testing of wind turbine and wind farm models as an aid for securing good-quality models.

## Status

The task now has participants from nine countries (Denmark, Finland, Ireland, the Netherlands, Norway, Portugal, Sweden, the United Kingdom, and the United States) with research institutes and universi-

ties carrying out work to develop and test wind farm models, as well as doing grid studies in cooperation with wind turbine manufacturers and electric utilities. In total, participants of the task during its three and a half years of operation are expected to contribute with more than 20 person-years of work effort.

Cooperation within the task is through sharing measurement data, model descriptions, and discussions at meetings. A total of five task meetings have been arranged. The last meeting in 2004 was hosted by Sustainable Energy Ireland and UCD in Ireland. It was combined with a Topical Expert Meeting on System Integration of Wind Turbines with invited industry actors.

Model developments are ongoing among participants, including both fixed- and variable-speed technologies and by using various software tools (Matlab/Simulink, PSSE, SIMPOW, DlgSILENT and EMTDC).

An Internet "e-room" has been established for sharing documents and measurement data among the participants of the task. The database part of the e-

room contains measurements mainly from fixed-speed wind turbines, but also a small collection of measurements from variable speed wind turbines.

Benchmark testing of models is ongoing. Such tests include both validation against measurements and model-to-model comparisons, and they consider dynamic operation during normal, fault-free conditions and response to grid fault. See Figure 4 and Figure 5 for examples.

The importance and relevance of Task XXI is highlighted by a current situation that has a varying level of confidence in, and knowledge about, wind farm grid-interaction modeling with larger wind farm projects planned. Therefore, a key issue is dissemination of task results, which is performed by individual participants and through joint actions, such as arranging open workshops and maintaining public Internet information about the annex.

A topic of high interest is the ability of wind turbines to ride through temporary grid faults, hence, contributing to grid stability. Detailed models may be used to assess such abilities, but an actual performance test may be required to provide confidence. A pro-

posal emerging as a spin-off from this task work is to update IEC 61400-21 to specify requirements for such testing. This work is now ongoing, so that in the future, wind turbine manufacturers may refer to standard test certificates for demonstrating performance under grid transients, and also these same data sheets may be used for verifying dynamic models of wind farms for power system studies.

Additional information about Task XXI can be found on the Internet at <http://www.energy.sintef.no/wind/IEA.asp>.

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## 6.0 TASK XXIII OFFSHORE WIND ENERGY TECHNOLOGY AND DEPLOYMENT

### Introduction

Installing wind turbines offshore has a number of advantages compared to onshore development. Onshore, difficulties in transporting large components and opposition due to various siting issues, such

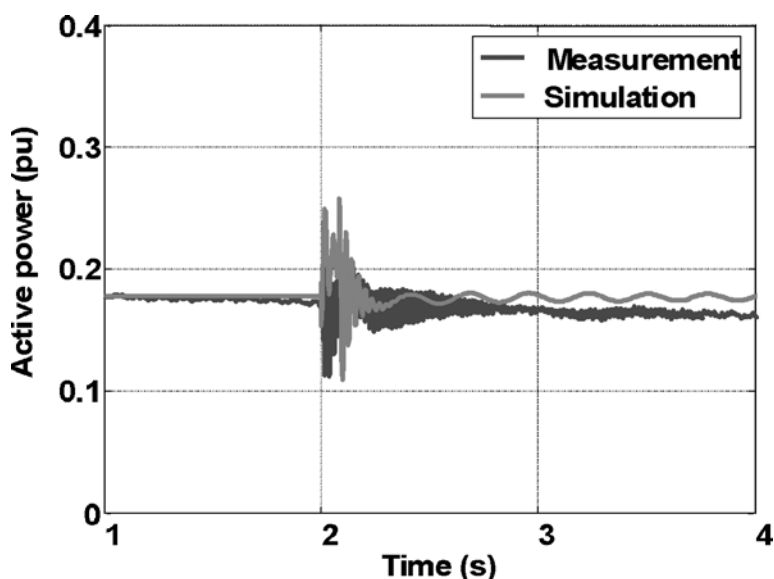


Figure 5 Time-series of measured and simulated active power output from variable speed wind turbine subject to a voltage dip.

as visual and noise impacts, can limit the number of acceptable locations for wind parks. Offshore locations are usually far enough away from populations to reduce objections from residents and 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 tend to blow faster and smoother at sea than on land yielding more electricity generation per square meter of swept rotor area. Especially larger onshore 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 simplifying some transmission issues, yet far enough away to reduce visual and noise impacts.

Good wind resource, proximity to load centers, and expansion of development areas are some of the reasons why development of offshore wind energy is moving forward. By the close of 2004, offshore wind power plants were operating in Denmark, the Netherlands, Sweden, and United Kingdom.

Challenges for offshore development include higher initial investment costs for large machines and sea cables for the connection to land; more difficult access to the turbines resulting in higher maintenance costs; and more severe environmental conditions at sea due to salt water and additional loads from waves and ice.

Despite the difficulties of offshore development, it holds great promise for expanding wind generation capacity. In Europe, the space available for offshore wind turbines in many countries is larger than onshore. For example, in the Netherlands roughly 3 GW of wind power could be installed in areas available outside the 12-mile zone (about 22 km) with a water depth of less than 20 m. The Netherlands shares this advantage of shallow water with countries such as Belgium, Denmark, Germany, and the United Kingdom. Figure 6 shows the cumulative installed offshore capacity to by the end of 2003.

## Need to Collaborate Identified

IEA Wind Annex XI sponsored a Topical Experts Meeting (#43) on Critical Issues Regarding Offshore Technology and Deployment in March 2004 in Denmark. The meeting gathered 18 participants, representing Denmark, Finland, the Netherlands, Sweden, the United Kingdom, and the United States. Presentations covered both detailed research presentations and more general descriptions of current situations in Denmark, Finland, the Netherlands, UK, and the US.

Some nations with long coastlines but without shallow seas within their continental shelf are interested in exploring technology relating to installing wind turbines in deeper water. EU countries such as Ireland, Spain, Italy, and Portugal have a relatively small sea area with water depths less than 30 m. Figure 7 shows that outside the EU, China and the U.S. have the highest potential for wind power development in deeper waters, followed by Brazil and Japan.

In October 2003 and again in October 2004, workshops on deep-water technologies were held in Washington, D.C. with participants from the US and Europe, see:  
[http://www.nrel.gov/wind\\_meetings/offshore\\_wind/](http://www.nrel.gov/wind_meetings/offshore_wind/).

It was clear from these workshops that opening vast windy areas of deep-water ocean for electric power generation will require development of new technologies and strategies. Work is underway in many countries to address issues surrounding wind development offshore. Both of these meetings on aspects of offshore development recommended the IEA Wind Implementing Agreement as a framework for sharing information on these activities.

## Annex XXIII Approved

In May 2004, the executive committee approved a proposed research Annex to sponsor focused workshops and develop research tasks directed at understanding issues and developing technologies to advance the development of wind energy systems offshore.

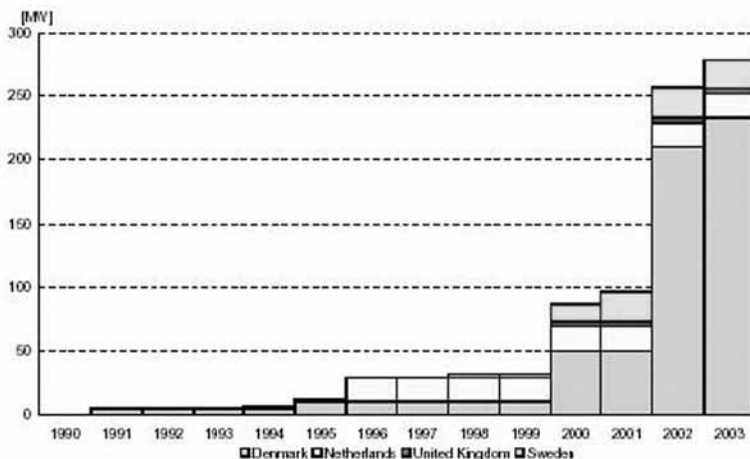


Figure 6 Realized offshore wind power through February 2003

OBJECTIVES OF ANNEX XXIII

The objectives of this annex are to do the following related to offshore development of wind energy systems:

- Conduct R&D activities of common interest to participants to reduce costs and uncertainties
- Identify joint research tasks among interested countries based on the issues identified at the Topical Expert Meeting #43 on Critical Issues Regarding Offshore Technology and Deployment
- 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 define joint research activities for the Annex participants.

During the first year of the Annex, (May 2004 to May 2005) the goal is to identify interested participants, project leaders for each research area, and prepare Work Programs and Budgets for each collaborative research activity.

MEANS TO ACHIEVE OBJECTIVES WITH PROPOSED SUBTASKS

This annex begins with two subtasks. Risø National Laboratory in Denmark and the National Renewable Energy Laboratory in the United States will serve as

joint operating agents. The joint operating agents are responsible for the following subtasks, with Risø leading Subtask One and NREL leading Subtask Two.

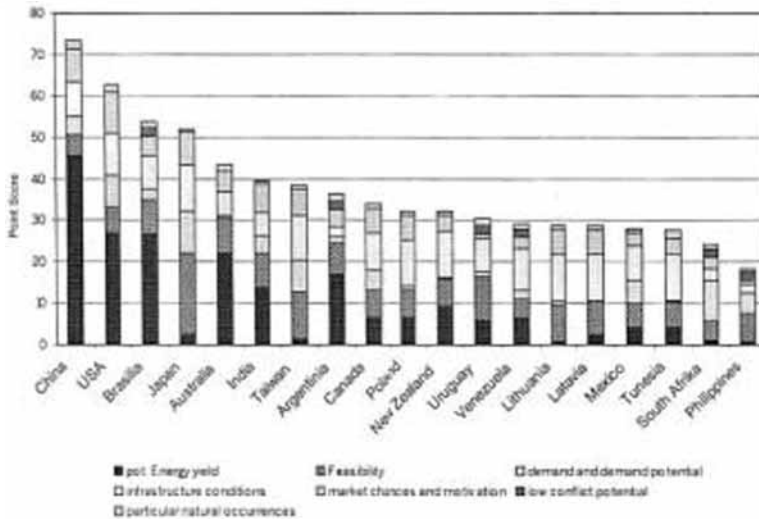
SUBTASK ONE: EXPERIENCE WITH CRITICAL DEPLOYMENT ISSUES

The Operating Agent and/or a host country will organize workshops to define collaborative research areas. The first one on Ecological Issues and Regulations will be hosted by the Netherlands in May or June 2005. A second workshop on Electrical System Integration of Offshore Wind will be held in the United Kingdom in September 2005, and a third one on External Conditions and Facility Technology and Design is planned in Denmark for October 2005.

SUBTASK TWO: RESEARCH FOR DEEPER WATER

The second subtask will address issues pertaining to deployment of wind turbines in water depths greater than 30 m. Primarily, this will include support structures that deviate from the present monopile technology. The procedure for identifying specific R&D collaborative tasks for Subtask Two will follow the workshop process discussed above and this process is already underway.

Coupled turbine/substructure dynamic modeling  
- A Kick-off meeting was held in October 2004 in



**Figure 7 Offshore Potential for Non-EU Countries.** Source: Siegfriedsen, Lehnhoff, & Prehn aerodyn Engineering, GmbH, Conference Proceedings of Offshore Wind Energy in the Mediterranean and other European Seas, Naples, Italy April 10-12, 2003.

Washington D.C. United States. Representatives from Denmark, Japan, Norway, the United Kingdom, and the United States attended. The October meeting attracted 32 participants from 8 countries. To maximize the benefit to the research community and to take advantage of experience with current turbine modeling effort in shallow water, it was decided to include both shallow and deep-water modeling. Uncertainties associated with load prediction increase the risk for offshore machines, and the development of accurate dynamic models for load prediction is the best way to reduce these uncertainties. Participants will share their codes among the other participants and compare assumptions, model fidelity, and the results of model outputs for controlled cases determined by the group. Through this type of rigorous sharing and subsequent validation efforts, offshore researchers will accelerate the development of codes for modeling a wide range of offshore wind turbines systems. A research topic “Coupled turbine/substructure dynamic modeling” was discussed and targeted for detailed collaborations and planning at a follow up meeting held at Risø National Laboratory in Denmark in January 2005.

## Results Expected

The results of the Subtasks One and Two in the first year are expected to be the following. Technical Proceedings will be published from the workshops on critical research areas from the two Subtasks. In addition, the results will be presented by the operating agents or their representatives to various conferences and to the IEA ExCo. Collaborative research activities under each Subtask will be defined with participating members, work program, and budget. A project leader will be designated who reports to one of the Operating Agents.

## Time Schedule

The Annex shall continue for a period of four years beginning May 2004, when it was approved in-principle in Chester, UK. The Annex may be extended for such additional periods as may be determined by two or more participants, acting in the Executive Committee and taking into account any recommendation of the Agency’s Committee on Energy Research and Technology (CERT) concerning the term of the

Annex. Extensions shall thereafter only apply to those Participants who agree to the extension. A preliminary time schedule is provided below.

## Participation

Participation is open to any organization within a country belonging to the IEA Wind Implementing Agreement. No fees are required through May 2005. The United States and Denmark have agreed to bear the cost of shared operating agents through 2005 and the participants in the planned workshops bear their own costs. Fees for the coming years of operation will depend on the research tasks identified and approved by participants.

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## 7.0 ANNEX XXIV – INTEGRATION OF WIND AND HYDROPOWER SYSTEMS

### Introduction

The IEA Wind member countries contain about 450 GW of hydropower capacity and more than 31 GW of wind generation. Integrating these two renewable resources for the benefit of consumers is an idea being pursued in several countries. Attendees at an IEA Wind Topical Experts Meeting in 2003 expressed the need for research activities to be conducted under the auspices of the IEA Wind agreement. In response, a proposal for Annex XXIV Integration of Wind and Hydropower Systems was approved by the ExCo in May 2004. This cooperative research effort will operate for four years, ending in May 2008. It offers participating organizations a way to multiply the experience and knowledge gained from individual efforts. In addition, the IEA Wind Annex XXIV works in cooperation with the IEA Hydropower Implementing Agreement, which is investigating integration of hydropower and wind through a complementary set of investigations. (see Figure 8)

The annex has two primary purposes.

1) To conduct cooperative research concerning the generation, transmission, and economics of inte-

grating wind and hydropower systems, and  
2) To provide a forum for information exchange.

The following are specific objectives of the Annex:

- Establish an international forum for exchange of knowledge, ideas, and experiences related to the integration of wind and hydropower technologies within electricity supply systems
- Share information among participating members concerning grid integration; transmission issues; hydrological and hydropower impacts; markets and economics; and simplified modeling techniques
- Identify technically and economically feasible system configurations for integrating wind and hydropower. Include the effects of market structure on wind-hydro system economics with the intention of identifying the most effective market structures
- Document case studies pertaining to wind and hydropower integration, and create an on-line library of reports.

The objective of the Annex will be achieved through at least four activities: Grid Integration Case Studies; Hydrologic Impact Case Studies; Market and Economic Case Studies; and Simplified Modeling of Wind-Hydro Integration Potential. While many case studies may involve all four of these topics, some countries that participate in this Annex may only address and share information related to one. In addressing each case study topic, information exchange amongst the collaborators will address problem formulation and assumptions, analysis techniques, and results.

The following are expected outcomes of the annex:

- Identifying feasible wind/hydro system configurations
- Identifying and developing techniques to analyze grid integration of wind energy, especially as pertains to grids that include hydropower
- Understanding the capacity of wind energy that can be supported by hydropower in terms of the ancillary services
- Understanding the potential for energy storage
- Understanding the technical constraints and limiting parameters in wind and hydropower integration.

# Conceptual View

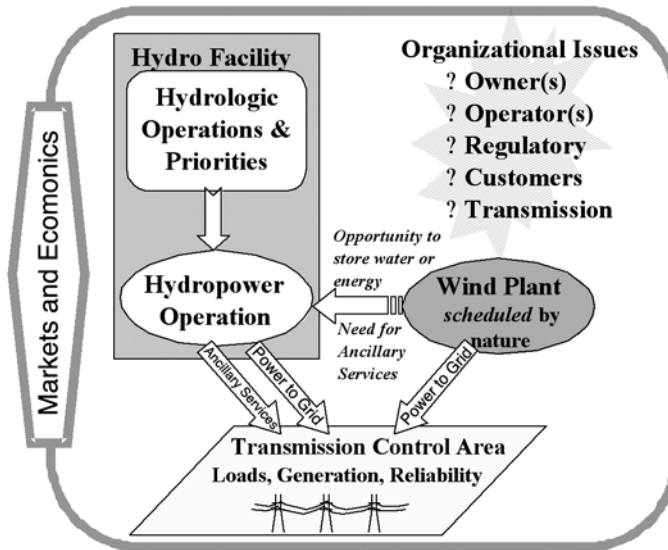


Figure 8 A conceptual view of the issues surrounding integration of wind and hydropower systems.

## Research Activities

### GRID INTEGRATION CASE STUDIES

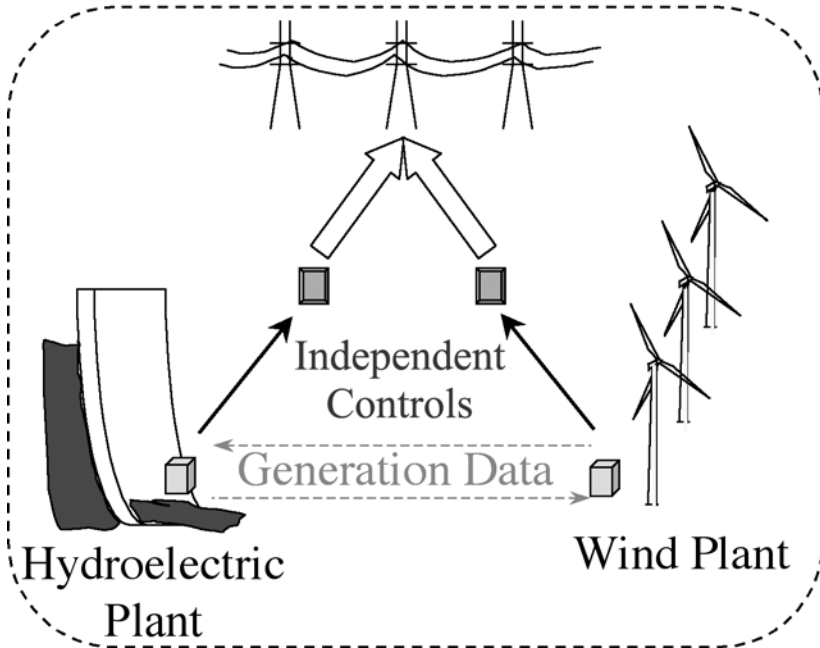
Given the wide variety of hydropower installations, reservoirs, operating constraints, and hydrologic conditions, combined with the diverse characteristics of the numerous electrical grids (control areas), there are many possible wind/hydro integration combinations and many possible solutions to issues that arise. Figure 9 illustrates two of the many potential configurations for wind and hydropower integration within a transmission control area. Hydro generators typically have very quick start-up and response times and may have flexibility in water release timing. Therefore, hydro generators may be ideal for balancing wind energy fluctuations or for energy storage and redelivery. Studying the grid integration of wind energy, particularly on grids with hydropower resources, lies at the heart of understanding the potential for integrating wind and hydropower resources.

Since this type of case study is fundamental, it is expected that all countries participating in the annex will contribute with at least one case study.

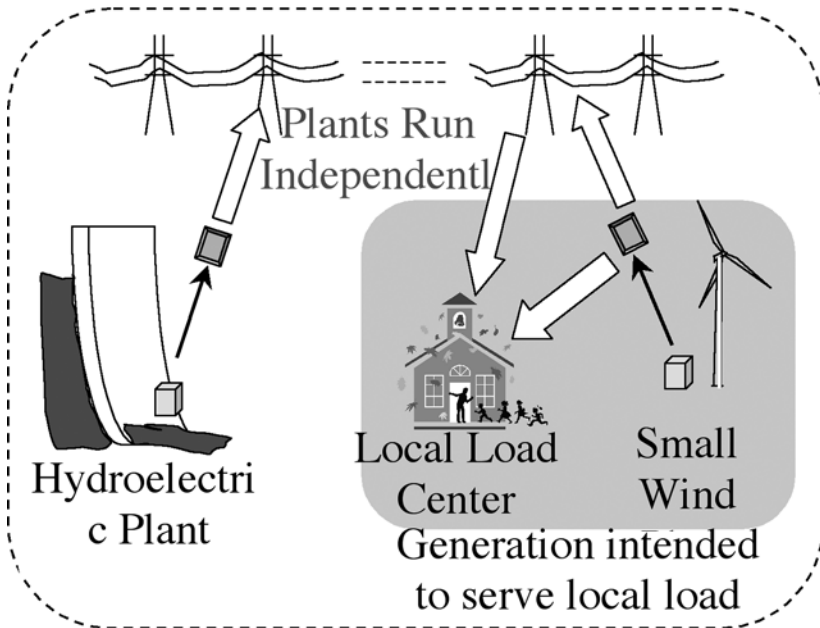
### HYDROLOGIC IMPACT CASE STUDIES

Depending on the relative capacities of the wind and hydropower facilities, integration may necessitate changes in the way hydropower facilities operate. These changes may affect operation, maintenance, revenue, water storage, and the ability 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 these and other impacts and benefits, it is unlikely that many hydro facility operators will be interested in integrating with wind power. Thus, study of these impacts on hydropower facilities and hydrological operations to determine the benefits and costs could help pave the way for implementation of wind-hydro projects.

### Transmission Control Area



### Transmission Control Area



Figures 9a and 9b Two possible configurations for wind and hydropower integration within a transmission control area.



## MARKET AND ECONOMIC CASE STUDIES

While grid integration and hydrologic impact studies may demonstrate the technical feasibility to integrate wind and hydropower systems, implementation will depend upon the economic feasibility of a given project. Such economic feasibility will depend on the type of electricity market in which the wind-hydro integration project is 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. Using this understanding, there may be opportunities to devise new methods of scheduling and pricing that will be advantageous to wind-hydro integration and permit better utilization 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 to the electricity customer during low-hydro years and extended droughts may also be investigated.

## SIMPLIFIED MODELING OF WIND-HYDRO INTEGRATION POTENTIAL

Simplified methods for approximating the amount of wind power that can be physically or economically integrated with existing hydropower generation should be devised based on the characteristics of the local transmission control area loads, hydropower facilities, and the wind power resource. 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 in a large interconnected grid that includes significant hydropower resources, but not to consider specific hydropower resources it is expected that one-quarter to one-third of the participating countries will contribute to the simplified modeling.

A major accomplishment of this Annex will be a database of case studies conducted through cooperative research of the Annex participants.

## Status and Plans

The following countries had committed to participating in the annex by the close of 2004: Australia, Canada, Finland, Norway, Sweden, Switzerland, and the United States. A kick-off meeting was planned for February 2005 at Hoover Dam, Boulder City, Nevada, United States to initiate the collaborative work of the annex participants.

Author: Thomas L. Acker, NREL, United States.



## CHAPTER 3

# OVERVIEW OF NATIONAL ACTIVITIES, 2004

## 1.0 INTRODUCTION

The basis of this overview chapter is the national reviews of the IEA Wind Implementing Agreement Member countries presented in Chapters 4 through 23. The following overview provides a compressed analysis, focusing on the most significant and interesting developments that have occurred during 2004, together with a brief policy description and update across all the countries.

Countries are increasingly appreciating that wind energy offers important economic and social benefits in addition to the established environmental benefits. Within the reporting IEA member countries, the following benefits have all been cited as key in the drive to develop wind energy.

- Very low lifetime emissions of harmful gases (especially CO<sub>2</sub>) per unit of electricity generated
- Employment opportunities, through turbine and component supply and assembly, the development and installation of turbines, operation, and servicing
- Increased diversity and security of electricity supply
- Cost of energy competing with that of current thermal plant
- Removal of cost uncertainties caused by fuel supply price fluctuations
- Support of rural economies.

Most countries with strong incentive and support schemes for wind are seeking to realize a competitive national manufacturing industry in parallel with the growth of installed capacity. This is being achieved by several countries. The countries with the highest deployment of wind energy, such as Denmark, Germany, Spain, and the United States, have developed strong national industries and have become exporters as well as importers of equipment.

Denmark turbine manufacturers continue to top the manufacturers' league tables, but other countries are developing increasingly strong capabilities, with Spain making large inroads in recent years and Germany making strong progress in developing multi-megawatt turbines. The advent of offshore wind is also now beginning to generate new employment for docks and shipyards. The employment benefit has become the primary driver for Spain. It is estimated that the Spanish wind industry accounts for approximately 7,000 direct jobs and nearly 20,000 indirect jobs. It is hoped that the number of wind-related jobs will grow to around 51,000 by 2011.

Both the Portuguese and Greek governments are aiming to reduce national dependence on expensive imported fuels. In some American states, recent increases in the price of fossil fuels have led to strong interest in wind, both to increase security of supply and to reduce costs. With the benefit of the Federal production tax credit, 12 major utilities in the western United States are now planning over 3 GW of new

wind by 2014, on a least-cost basis. In Canada, too, wind is beginning to look economically attractive, particularly where provincial governments provide additional support. The previous surplus of generation is rapidly declining as a result of increasing demand and reduced generation from thermal and nuclear plant.

The value of new wind installations worldwide is estimated at 8.3 billion USD for 2004. This figure is based on an average total project cost of 1,000 USD/kW installed. This excludes the operational costs of all the installed capacity, which is estimated at around a further 1.4 billion USD.

Country	National target for renewables	National target for wind energy
Australia	Additional 2% of electricity from renewables by 2010, meeting target of 9,500 GWh/year at the start of 2010.	No specific target but expect up to 900 MW of wind turbines by 2010
Canada	None	None
Denmark	Supply 20% of electricity consumption by the end of 2003.	None
Finland	Increase generation from renewables by 50% over 1995 levels, by 2010 (3 Mtoe/yr; up to 8.4 TWh).	Anticipate 3% of new renewables to be wind energy, giving 500 MW by 2010.
Germany	Meet at least 4.2% of primary energy supply from renewables by 2010. Generate 12.5% of electricity supply from renewables by 2010, increasing to 20% by 2020.	No national targets. Lower Saxony target of 1,000 MW by 2000; Schleswig-Holstein target of 1,200 MW by 2010.
Greece	None	More than 1,500 MW by 2010
Ireland	Installed capacity of 500 MW by 2005; renewables generate 13.2% of electricity by 2010.	None
Italy	Double the renewables contribution to the energy balance by 2010.	Wind power provides 3.4 million tons per year of avoided CO <sub>2</sub> emissions. This equates to about 2,500 MW by 2010, or growth of 200 MW per year.
Japan	Reduce the output of greenhouse gases by 6% compared with 1990 levels by 2012; Renewables to increase the contribution to energy supply from 1.15% to 3.1%.	300 MW by 2012
Mexico	None	None
Netherlands	By 2010, 5% of energy from renewables (9% of electricity), rising to 10% of energy in 2020.	The government creates conditions for the installation of 1,500 MW by 2010 and 7,500 MW by 2020, of which 6,000 MW is offshore.
New Zealand	Additional 30 PJ of renewable energy against the supply of consumer renewable energy in 2000.	None
Norway	By 2010 to have 3 TWh/yr of electricity from wind energy plus 4 TWh/yr of energy from other renewables (and industrial waste heat), including fired central and district heating systems.	Wind energy is to supply 3 TWh/yr in 2010 (approximately 1,000 MW).

Portugal	Renewables supply 4,951 MW by 2012 (excluding large hydro) to achieve 39% of electricity consumption by 2010.	Target: 3,750 MW by 2010.
Spain	Achieve 12% of primary energy demand from renewables by 2010.	Target: 13,000 MW installed capacity by 2011, yielding 28.6 TWh/year.
Sweden	Increase electricity production from renewables by 10 TWh by 2010, relative to 1990 levels.	Wind energy is to supply 10 TWh/yr by 2015.
Switzerland	To increase the electricity supplied from new renewables (without hydropower) by 0.5 TWh by 2010.	Target: 50 to 100 GWh by 2010
United Kingdom	To increase the electricity supplied from renewables to 5% by 2003 and 10% by 2010, subject to the cost to the consumer being acceptable.	None
United States	None	None. Industry goal: generate 6% of the nation's electricity from wind by 2020 (approximately 100,000 MW).

**Table 1 National targets for wind and renewables among the members countries of IEA Wind. No targets changed in 2004.**

## 2.0 POLICY UPDATE

National targets for wind and renewables among the member countries of IEA Wind are summarized in Table 1. No targets changed in 2004.

### Australia

The Mandatory Renewable Energy Target (MRET) is the cornerstone of the Australian renewable energy industry. Introduced in 2003, it stipulates that electricity suppliers must source an additional 2% of generation (now interpreted as 9,500 GWh) from renewable energy by 2010. Implemented through a system of tradable certificates and capping penalties, it necessitates the installation of up to 900 MW of wind turbines.

A review of the MRTE scheme was released in January 2004, recommending increasing the target from 9,500 GWh in 2010 to 20,000 GWh by 2020, and holding the target at this level until 2035. However, last year the government announced its intention to retain the existing target, causing much concern within the burgeoning commercial wind sector. Australia's Renewable Energy Action Agenda, a partnership between government and industry supporting

the renewable energy industry, now anticipates a winding back of renewable energy investment over the next few years as the MRET is met. Several of the state governments have responded this year with their own state-based renewable energy targets. However, none of their growth targets are set beyond 2010, and so there remains no established longer-term market for wind energy.

Although the government did not establish increased renewables targets beyond 2010 in its white paper, it did include a renewable energy development initiative providing 100 million AUD over seven years and a budget of 14 million AUD to develop wind forecasting capabilities.

### Canada

The principal driver for wind energy development in Canada remains the government's Wind Power Production Incentive (WPPI) program introduced in 2002. It is proving to be very effective. A funding level of 260 million CAD was provided to facilitate the installation of 1,000 MW by 2007. By December 2004, the program had applications totaling 192 projects and 11,000 MW of capacity.

Additional deployment support comes from accelerated capital write-off schemes and government contracts, under the Green Power Purchase (GPP) program, for purchasing green electricity for its buildings. The GPP program allows developers to sell electricity generated by wind and other forms of renewable energy to the government at premiums negotiated through a competitive process. As a by-product of this federal program, wind power producers have built additional wind plants and green energy is being sold to private, provincial, and municipal consumers.

There now also seems to be some interest in offshore, with the government conducting studies of the environmental impacts and regulation of offshore wind farms for large projects off the coast of British Columbia in the Pacific and in the Great Lakes of Ontario.

## Denmark

Denmark continues to expect that a rising share of electricity consumption will be covered by renewables, though no new targets have yet been set. The old target of 20% generation from renewables by 2003 is now fully satisfied by wind energy alone in a year of average wind speeds. Future development is expected to come almost entirely from either offshore wind or onshore repowering. From the beginning of 2003, the price paid to private generators fell by between 16% and 38%, which has brought other investment to a complete stop.

In March this year, the government formed an agreement with six of the coalition parties concerning onshore and offshore wind and its support mechanism. The new electricity bill was subsequently introduced in June. Onshore repowering will be supported through free market prices supplemented by environmental bonuses. Offshore development will be conducted through a tendering process. The obligation to purchase wind-produced energy has been replaced with financial support for each kilowatt-hour of electricity generated.

An action plan for wind, produced in 1997, shows how a total capacity of 4,000 MW of offshore wind could be installed in Denmark by 2030. To date, two large offshore wind farms have been installed—one at Horns Rev in 2002 and one at Nysted in 2003. The basis for the construction of two more offshore wind farms was agreed to this year; each will have a capacity of 200 MW.

New repowering regulations aim to replace poorly sited turbines with new turbines on more appropriate sites. Approximately 900 older wind turbines with capacities up to 450 kW will be replaced, to yield an additional capacity of up to 350 MW within the next five years. Repowering will be subsidized at a rate of 0.12 DKK/kWh (0.022 USD/kWh).

The introduction of renewable energy certificates, agreed to in March 2000, has been postponed. The new electricity bill specifies the cost for grid connection and the premium paid on top of the market price for brown electricity. It will not change the net price paid to wind turbine owners, but it will simplify the structure of the payments they receive. The premium payment is set at 0.10 DKK/kWh (0.018 USD/kWh). The market price for the electricity is now fixed at a monthly average and is no longer based on the spot price for each hour. In 2004, the market price plus premium varied between 0.28 DKK/kWh and 0.34 DKK/kWh (0.051 USD/kWh to 0.062 USD/kWh).

## Finland

Finland has a limited wind resource, which is predominantly offshore. It recognizes the role of all the renewables and has the greatest expectations from bioenergy. The action plan from 1999 strives to increase the share of renewables to 3 Mtoe/yr by 2010 and to 6 Mtoe/yr by 2025. The corresponding targets for wind energy are 500 MW by 2010 and 2 GW by 2025.

In 2004, a report titled “The Views for Realising the Targets for Wind Power in Finland” was published as a follow-up to the Action Plan. It estimated that the increase in support for wind power needed to reach the target was 10 euro/MWh (14 USD/MWh), in addition

to the existing investment subsidy (about 30%) and tax refund (6.9 euro/MWh). The investment subsidy alone was not thought adequate to achieve the 2010 goal.

The same report also promised an investigation into alternative subsidy systems. The investment subsidy is expected to remain as the primary support mechanism, but it will be supplemented with additional support, perhaps in the form of a premium price corresponding to the tax levied on household consumers.

## Germany

The goal of the federal government is to double the share of renewables in the energy supply by 2010. Renewable energy sources will cover 4.2% of primary energy consumption and 12.5% of electricity consumption. The medium-term objective is to increase the share of renewables in provision of electricity to at least 20% by 2020.

In Germany, the instrument for renewables market stimulation is the Renewable Energy Sources Act (EEG). It contains a minimum price regulation and obligates the nearest grid operators to accept and pay for electricity from renewable energies. The minimum fee paid by the grid operator is dependent on the branch of renewable energy, the size of the installation, and, in the case of wind energy, the location. Planning and investment security are ensured by the fixed rates per kilowatt-hour fed into the grid over a maximum duration of 20 years. This has created a very powerful incentive for long-term investment. The EEG was revised in 2004. It now guarantees a basic payment of 0.055 to 0.087 euro/kWh (0.075 to 0.118 USD/kWh) for onshore wind and 0.0619 to 0.091 euro/kWh (0.084 to 0.123 USD/kWh) for offshore. Payments will decrease by 2% annually from 2005 for onshore wind and again by 2% for offshore wind, but from 2008.

The next step for wind energy use in Germany focuses on the large offshore potential. In the framework of its strategy for the use of wind energy, the federal government has set itself the goal of achieving about 2,000 to 3,000 MW by 2010, with a long-term target

of between 20,000 and 25,000 MW. It is expected that the revised EEG will strongly encourage offshore development.

## Greece

Greece recognizes a high potential for wind energy, and the government wishes to exploit wind energy to replace expensive imported fuel and to actively involve Greek industry in creating new jobs. In spite of major institutional, regulatory, engineering, and funding changes, the deployment of wind energy technology remains below that needed to meet the indicative targets set by the 2001 European directive. This corresponded to 2,000 MW by 2010. Creating a vital renewables market is made more difficult by the still fluid state of the liberalization of the utility sector, which was dominated for more than a half century by a single national utility company. The new law 2773/99 brought about the liberalization of the electricity market while maintaining support for renewable energy, yet the effect on the development of wind energy remains to be seen.

The Operational Program Competitiveness (OPC) supports the development of wind energy projects. Public funding of 30% of capital costs is available, rising to 50% in the case of transmission lines constructed for grid connection. The eligible cost for financing a wind farm is up to 900 euro/kW (1,218 USD/kW), excluding the cost of grid connection.

## Ireland

The final round of the principal renewables support mechanism, the Alternative Energy Requirement (AER), took place in 2003, and a government consultation exercise started to find its replacement. Responses to the consultation were received early in 2004, and the government convened a Renewable Energy Development Group to consider the options in detail. The group reported to the government late in 2004, and an announcement on the nature of the future support mechanism is expected.

The AER started in 1996 and has had six rounds of competitive bidding for fixed-price contracts of 15 years. Support for an additional 235 MW of wind

projects under the 2003 AER VI was announced in December 2004, after EU state aid approval for support for this additional capacity was received. Although it is very effective in letting renewables contracts, it has been less effective at building projects; only 13% (197 MW out of 807 MW) has been realized to date, but this will increase with time.

Current targets are for an additional 500 MW of installed renewable electricity generating capacity between 2000 and 2005, with a further indicative target of increasing electricity consumption from renewable sources to 13.2% of total demand by 2010. Wind power is expected to contribute in excess of 90% toward these targets. The current consultation aims to set further targets for the period between 2010 and 2020. The moratorium on wind connection offers has compromised achievement of the 2005 wind target, but with projected build rates, the target should be reached by 2006.

## Italy

Italy has followed up its pro-renewables white paper of 1999 by approving the law (no. 387 of 29 December 2003) implementing the principles and goals of EU Directive 2001/77/EC. This directive stipulates that Italy should increase its contribution from renewables from the current level of 16% up to 22% of electricity demand by 2010. The Italian law (387) came into force early in 2004, with the first deadline in 2005. The obligation, set at 2% of electricity sales in 2004, is placed on producers and importers of electricity and is set to increase by 0.35% each year until 2006. Nonetheless, the law remains only partly operational, as it calls for some additional provisions that are still to be issued, thus causing a series of problems for all private investors in a large part of southern Italy.

It is, however, expected that the white paper target for wind energy of 1,400 MW by 2006 will be achieved as soon as spring next year. The final target of 2,500 MW by 2008 through 2012 could also be accomplished early if law 387 becomes fully effective. Attempts to make the law universally effective are being made through an active dialogue between the regional and local authorities.

## Japan

The situation in Japan has not changed in the last year. The target for wind energy of 3,000 MW still stands, increased from just 300 MW in 2001. In April 2002, the Japanese government passed legislation for a Renewables Portfolio Standard (RPS), in order to realize the national target for renewables by 2010. The required contribution of renewables to total primary energy is 3% in 2010, and Japan's utilities are obliged to source 1.35% of their total electricity supply from renewables. Grid limitations pose the greatest threat to reaching the 2010 target, with some capacity limitations already in force in some areas. Very positive national policy and capital subsidies from NEDO have been supported by the utilities offering private long-term electricity purchase contracts.

## Mexico

Estimates have indicated that Mexico's most important wind resource would be sufficient for the installation of at least 5 GW of wind power. This figure is based on rough regional estimates, as detailed resource studies have yet to be conducted.

The Mexican energy policy is aimed at securing an electricity supply sufficient to enable the expected economic development. This implies an average increase in electricity demand of 5.6% between 2002 and 2011. This will require a projected 30 GW of new capacity, 15.6 GW of which will need to come from projects not yet under construction. Wind energy has an opportunity to supply a portion of this, although there is no specific target for wind.

Mexico's Action Plan for Removing Barriers to the Full-Scale Implementation of Wind Power in Mexico got under way at the beginning of the year. The first phase of the program, which was approved by the Global Environmental Fund through the United Nations Development Programme, will address legal and regulatory barriers and improve estimations of the wind resource. A Regional Wind Technology Center will also be implemented to address educational barriers, wind turbine testing, and technology transfer issues.



At the end of the year, wind and other renewables were given an important tax break. Investors are now able to write off 100% of capital in the first year, provided the equipment remains operational for at least five years. Previously they were only allowed to deduct 5%, giving a 20-year depreciation.

## The Netherlands

The government policy for renewable energy was revised in 2001. Wind and biomass are expected to give the greatest contributions to the 2020 target of 10% of primary energy demand by 2020, with an interim target of 5% by 2010. A further interim target is to reach 6% of electricity consumption from renewables in 2005 and 9% in 2010. This year, 4.5% of total electricity consumption came from renewables, and the 2005 target is now considered achievable. It is seen as both possible and necessary to build 6 GW of offshore wind in meeting long-term expectations.

Measures for the support of renewables in the Netherlands remain dynamic. From July 2003, the production incentive was replaced by the Environmental Quality Electricity Production (known as the MEP). This introduced a set of stepwise measures coming into force progressively up to the beginning of 2005. The measures aim to increase national generation from renewables and so decrease green energy imports and the associated leaking of taxpayers' money abroad. This is to be achieved by a change from end-user demand stimulation to production stimulation.

End-user demand has been created by electricity retailers that offer green electricity for the same price as conventional electricity. This has been possible because of an exemption from ecotax placed on fossil energy consumption. Under the MEP, green electricity attracts a progressively reduced level of ecotax exemption, reducing to zero in 2005. Even with this lower energy taxation rate, the cost of green energy to end users in 2004 was the same as for conventional power.

The production stimulation comes from a fixed premium price for producers of green electricity in the Netherlands, but no longer from abroad. The premium

price will be paid for ten years, up to a maximum of 18,000 full load hours in the case of onshore wind. The MEP support levels are adapted in line with the phasing out of the renewable ecotax exemption. With the introduction of the MEP, energy investments were no longer eligible for full depreciation in their first year.

## New Zealand

In New Zealand, renewable sources already provide 29% of total consumer energy and about 70% of the electricity supply, mostly from hydro (62% of electricity supply). The electricity industry has undergone major structural reform in the past six years, which kept the promotion of renewable energy at bay until July 2000, when the Energy Efficiency and Conservation Act came into force. In April 2002, the government released a target for an increase of 30 PJ of renewable energy by 2012. However, no quantifiable targets have been set for the electricity sector or for wind energy.

Further reform was imposed on the industry in 2003. An electricity industry and market-wide regulator, the Electricity Commission, was formed in 2003 after the industry failed to agree on arrangements for self-regulation. New rules came into effect in March 2004.

## Norway

Wind energy has been supported through the combination of an investment grant of up to 10% and a small production subsidy. The production subsidy ceased at the end of 2003. In the future, it is expected that the subsidies will be replaced by a green certificate market, which is currently under governmental deliberation. In the meantime, a transition scheme for wind power development will come into force, and various options for it are now being considered.

In a year with above-average rainfall, Norway could be self-sufficient with electricity from renewables, almost all of which is hydro. More typically now, with the increase in energy demand, Norway depends on importing some electricity, mainly from Sweden and Denmark. There are limited opportunities for new

hydro projects, and in 1998 the Norwegian government stated an overall goal of reaching 3 TWh/yr of electricity from wind energy by 2010. This equates to approximately 1,000 MW of installed capacity operating with a capacity factor of at least 34%.

## Portugal

In 2003, the government reaffirmed the national objective of promoting the installation of 3,750 MW of wind capacity by 2010. It also stated a key policy aim to reduce Portugal's dependency on external energy sources and to establish new objectives for renewable energy. The supporting measures include financial incentives and feed-in tariffs, and there is also personal tax relief for private individuals investing in renewables.

However, with installed wind capacity only reaching 15% of the 2010 goal by the end of the year, it is now considered unlikely that these objectives will be met. This would require annual installation to just exceed 500 MW. It is technically feasible, provided no delays occur in the reinforcement of the transmission network.

Most projects currently under way are oriented toward the development of combined wind and hydro, with the wind used for pumped storage under high wind penetration conditions. This interest stems from the high hydro capacity installed and the high correlation between availability (and sometimes excess) of hydro resource and high wind during the winter months.

## Spain

Spain is notable for its success both in building wind farms and developing an indigenous wind turbine manufacturing industry. Spain has adopted the European target of 12% of primary energy demand derived from renewables. To achieve this, in 1999 the Spanish government set a target contribution of 21.5 TWh/yr from wind by 2010, corresponding to an installed capacity of about 9,000 MW. However, following the success in developing wind energy, in 2002 this target was increased to 13,000 MW by 2011. There is now an expectation that the target

will be further increased in an update of the Spanish Energy Plan being conducted late in 2005. Wind already contributes nearly 6% to the total electricity demand. This high level of growth has been possible because of a stable legal framework providing guaranteed access to the grid and a premium price for the electricity generated.

The regulations were modified this year in the royal decree 436/2004. The changes, introduced in March, sought to bring about stability and transparency, together with a long-term guarantee for payments. The owners of new renewable facilities have a choice of either selling their electricity to the distribution company at a regulated premium tariff or selling it in the open market and receiving several supplements. In both cases, generators will receive supplements for reactive power and for maintaining the supply during voltage dips, but both cases are also subject to penalties in deviating from forecast production. Generators are encouraged to participate in the free-market option, which has additional participation payments and capacity payments as well as the premium related to the average price of electricity.

## Sweden

The decision to phase out nuclear power and limitations on further hydro-power make wind energy a vital component of the future power supply. A new market-based system was introduced in May last year, with tradable electricity certificates (Elcertifikat) for renewable electricity generation replacing an investment subsidy. The system is driven by a compulsory renewables quota on electricity consumers that starts at 7.4% and increases annually to about 17% in 2010. Heavy industry is exempt in the first two years. Those who do not meet their quota will pay a penalty of 150% of the average certificate price up to a cap, which for 2004 has been set at 0.240 SEK/kWh (0.033 USD/kWh). In parallel with the introduction of Elcertifikat, the current "environmental bonus" will be ramped down from 0.181 SEK/kWh in 2003 (0.025 USD/kWh) to zero in 2009. During this time, the bonus for wind turbines offshore will be slightly higher than for onshore. The electricity and the certificates can be sold separately.

In the initial period, after the introduction of electricity certificates, wind generators have received an average total price of 0.721 SEK/kWh (0.10 USD/kWh); however, the success of the new system and its impact on the development of the wind energy market cannot be judged at this early stage. Evaluation during 2004 of the new system and its impact on the development of the wind energy market resulted in a suggestion to make the system permanent, with quotas set far into the future to stimulate new investments. The possibility of developing a common certificate market with Norway is now being investigated and, if favorable, may be introduced in 2007.

In an effort to increase the rate of wind development, 49 areas were designated as being of national interest for wind power in October of this year. They have been selected on the basis of wind speed, landscape character, water depth in the case of offshore, proximity to dwellings, and a minimum wind farm size of 10 MW. Planning will now take this into account. Areas may be designated as of national interest for more than one reason, and in these cases the drive for wind energy will be judged against other interests, such as protection of the environment.

## Switzerland

The new Swiss Energy ten-year program set an objective to reduce the consumption of fossil fuels and the associated CO<sub>2</sub> emissions by 10% in the period 2000 to 2010. Additionally, the growth of electricity demand must not exceed 5%, hydro-power's contribution must not be reduced, and the contribution made by other forms of renewable energy must increase to 0.5 TWh. The Federal Department of the Environment, Transport, Energy and Communications (DETEC) has published a media report with a clearly positive statement concerning wind power generation in Switzerland aiming at an annual production of 50 to 100 GWh from wind power by 2010. This equals 10% of the goal for all renewables set by the federal Swiss Energy program.

All activities and projects in the medium term will focus on installing wind at specific sites that have already been identified because of their wind resource, accessibility, and landscape sensitivity characteristics.

There are currently plans for 64 turbines on ten designated sites, with some turbines already in planning.

The Swiss energy law obliges electricity suppliers to purchase electricity from independent producers at the premium price of 0.15 CHF/kWh (0.13 USD/kWh). From the beginning of 2005, these costs have to be paid by operators of the high-voltage grid.

## United Kingdom

In 2003, an Energy White Paper set out goals to work toward cutting the United Kingdom's carbon dioxide emissions by some 60% against 1990 levels by about 2050. It also stated an ambition to double the share of electricity from renewables by 2020.

The key support mechanism remains the Renewable Obligation (RO). The RO and associated Renewables (Scotland) Obligation came into force in April 2002. It requires power suppliers to derive a steadily increasing proportion of the electricity they supply from renewables and is guaranteed in law until 2027. The RO is based on the free-market trading of RO certificates, or ROCs. Suppliers can either present enough certificates to cover their own obligation, or they can pay a "buyout" price of 30 £/MWh for any shortfall. All proceeds from buyout payments are recycled to suppliers in proportion to the number of ROCs they present. Currently ROCs have a higher value than the electricity, which is also sold on the free market independently of the ROCs.

The RO percentage target is set to increase each year from its current level of 4.9% in 2004–2005 to reach 10.4% by 2010–2011. In December 2003, the government announced its intention for the RO percentages to continue to rise beyond 2010–2011 to reach 15.4% by 2015–2016.

Other policy elements include exemption of electricity generated from renewables from the climate change levy (a tax on the business use of energy) and development of a proactive strategic approach to regional planning through targets and capital grants for early offshore wind and energy crops projects.

In Wales, too, there is new optimism for wind energy as the Welsh Assembly finally published its long-awaited draft of Technical Advice Note 8. Imposing a strategic approach to meet its aims, the assembly has set a dedicated onshore wind target of 800 MW by 2010. This is to be developed within several identified strategic areas, but it is still subject to many of the normal planning considerations.

In 2003–2004, eligible renewables accounted for 2.4% of Great Britain's electricity generation, significantly lower than the RO level of 4.3%. Achieving the 10% target will therefore require a step change in the level of generation from renewables. Offshore wind is likely to be required at large scale to achieve the government's targets, but there is currently no funding beyond the RO to cover the higher costs of developing offshore projects.

## United States

The National Energy Policy, published in May 2001, contains recommendations to diversify the national energy supply, move toward clean and affordable energy sources, and modernize the electricity grid and infrastructure. Wind energy and other renewable sources play a key role in this policy. The policy includes expansion of goal-oriented R&D focused on advanced technologies adapted to sites with lower wind speeds. There are no national targets for wind energy deployment. However, the goal of the U.S. wind industry is to generate 6% of the nation's electricity from 100 GW of wind by 2020.

The federal production tax credit (PTC) was extended in October 2004, now running up to the end of 2005. It provides a credit of 0.018 USD/kWh (adjusted periodically for inflation) for electricity produced from a wind farm during the first ten years of its operation. With the PTC back in place, experts are predicting a record-breaking year in 2005.

In addition to the PTC, many states have additional incentives for renewables. Of all the state incentives, renewable energy purchase mandates—often called Renewables Portfolio Standards (RPS)—will probably have the largest impact on wind development. In 2004, 5 states added RPS policies, bringing

the total number of states with RPS or mandates to 18. Approximately 2 GW of wind power has been supported by these policies to date, with greater expectations for the coming years.

In 2003, the Department of Energy released ambitious wind energy cost targets as a part of a multiyear technical plan for 2004 to 2010 and beyond. These goals are to reduce the cost of electricity from large wind systems in class 4 (5.8 m/s at 10 m) wind resources to 0.03 USD/kWh for onshore systems or 0.05 USD/kWh for offshore systems by 2012. For distributed wind systems, the goal is to reduce the cost of electricity to 0.10 USD/kWh to 0.15 US USD/kWh in class 3 (low-wind) wind resources by 2007, the same level that is currently achievable in class 5 wind resources.

## 3.0 IMPLEMENTATION PROGRESS

### High Sector Growth Sustained

In 2004, the rate of growth in global wind energy deployment fell a little to 21.5% with a very positive outlook for the next few years. The global growth rate was just under that achieved within the IEA Wind countries at 22.2%, which have sustained a rate of between 20% and 45% over the last decade. At the end of 2004, the global wind capacity reached 47.9 GW. The total installed capacity in the IEA Wind countries reached 25.3 GW. Offshore capacity reached 578 MW, which is a 2.3% share. (See Figure 1) If the annual global growth rate were 25%, capacity would reach 60 GW by the end of next year and 182 GW by the end of 2010.

*New Zealand* topped the growth charts this year, nearly quadrupling its installed capacity with an expansion of two sites and one new 90-MW wind farm. Exceptional growth was also seen in Australia, Finland, Ireland, Japan, Portugal, and Switzerland. In terms of capacity, *Spain* and *Germany* again put in more wind power than any other country.

Wind energy capacity in *Australia* and *Portugal* almost doubled in the past year with the installation of 380 MW and 264 MW, respectively. Record years were also had by the United Kingdom, Italy, Canada,

and Ireland. The *UK's* additional 250 MW of capacity included the only offshore project commissioned this year, at Scroby Sands off the east coast of England. Alberta is currently the leading *Canadian* province with installed capacity totaling 275 MW. However, the provinces of Quebec and Ontario have now awarded contracts for 990 MW and 355 MW, respectively, to be built during the next few years. Although *Ireland* can only register 71 MW of new installed capacity, marginally exceeding its previous record of 2003, an additional 100 MW plus capacity was constructed, but is awaiting grid connection. *The Netherlands* saw a net gain of 196 MW, with 163 turbines installed and 80 removed, achieving its second-best year. *Finland* achieved a 75% expansion of wind with the installation of 15 more turbines, bringing its total capacity to 82 MW. *Italy* managed to install 389 new turbines with a combined capacity of 357 MW in spite of difficulties in energy regulation and planning. Although *Japan* did achieve a growth of 86%, it regarded this as insufficient in working toward its target.

*Spain* continues to consolidate its position; it improved on last year's growth rate by six points, up to 33%, which required the installation of just over 2 GW of new turbines. *Germany* also installed just over 2 GW of new capacity, but this represented just 14%

growth, down from last year's 22%.

*The United States* did not manage to maintain the momentum of 2003 because of the delayed extension of the principal support mechanism, the PTC. It increased installed capacity by 359 MW, a growth of just 6%. However, 2005 may be very different now that the PTC is in place until the end of next year.

Growth was steadier and continued the pattern set in 2003 for *Greece* and *Sweden*. *Mexico* installed no new capacity, and *Denmark* managed just 3 MW.

### Great Expectations

Total global installed wind capacity was estimated at 47,864.1 (MW) at the close of 2004. (See Table 2)

Overall, the picture is for wind energy to continue to show the very strong growth it has now experienced for many years. The wind energy marketplace is global in scope, and while some well-established markets like Germany are slowing, others such as Australia, Canada, Portugal, Spain, and the United States are stepping in to maintain a very positive picture. Top of the league next year may be the United States. Wind industry experts are predicting that the

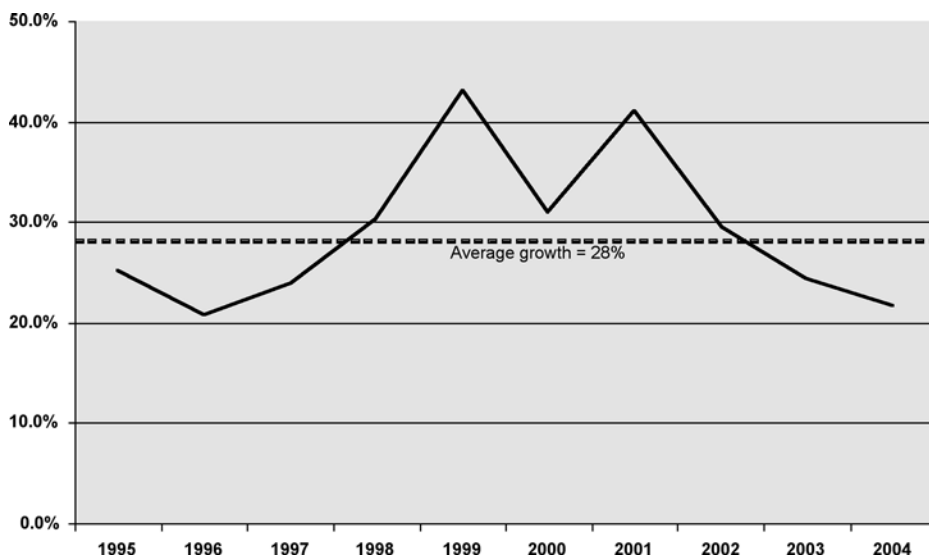


Figure 1 Annual growth rate across the IEA Wind countries.

renewal of the US Federal production tax credit in October 2004 will give rise to over 2,000 MW of new capacity in 2005.

With a huge area and a good wind resource, Australia has vast potential. Growth during the past three years was exceptional, and it is expected to continue for the next couple of years. However, there remains great uncertainty beyond this without an extension to the Mandatory Renewable Energy Target past 2010. At the end of 2004, more than 355 MW were under construction, with a further 363 MW under bid and 926 MW having received planning approval.

The United Kingdom has recently seen a greater success rate in the planning system for onshore wind, and there is a strong political drive to develop the large offshore resource. Currently 18 projects are under construction, totaling more than 500 MW of new capacity scheduled to be commissioned in 2005, which should produce a record year. Over 700 MW gained planning approval during 2004. Against this, in 2004 less capacity was installed than had been predicted, as has been the case for the past several years.

For Canada, 2004 was a record year, with 127 MW going in, although expectation had been for higher capacity. Much of this expectation has now been deferred to 2005, which should be a very good year. Quebec and Ontario provinces have awarded contracts for 990 MW and 355 MW, respectively, to be built during the next few years. A further 99 MW should come online in Quebec by the spring.

In 2004, Portugal almost doubled its installed wind capacity with an additional 264 MW. Expectations are high for the next couple of years. Grid connection permits totaling over 3,000 MW have been granted, and more than 700 MW are under construction. Portugal is expected to exceed 1,000 MW of wind capacity by the end of 2005.

Ireland had in excess of 100 MW of constructed wind capacity awaiting grid connection at the end of 2004. This, combined with the volume of new grid connection agreements for wind—one of the best indicators

of near-term growth—points to continued growth in deployment rates for 2006 and 2007.

The government of Mexico has launched a bidding process to construct a 100-MW wind farm (La Venta II), although it is unlikely to be completed in 2005.

The New Zealand company Meridian has gained consent for another 70-MW wind farm in the South Island. Meridian has stated that it has identified sites for 700 MW of capacity at less than 0.06 NZD/kWh (0.043 USD/kWh).

Denmark is expecting much of its wind expansion to come from offshore wind. This year, the Danish Energy Authority issued two bids, each for 200 MW, for wind farms at Horns Rev in the North Sea and at Rødsand.

The Dutch 100-MW Near Shore wind farm was given its final building permit this year. Comprising 36 Vestas 3-MW 90 m-turbines, it is expected to be built in 2006.

## Turbine Size

The average new turbine size increased again this year, continuing a trend. The market was dominated by megawatt-class machines and the average new turbine size exceeded 1 MW for all countries except Denmark, Italy, and Sweden. Denmark's average turbine should have been over 1 MW, but this year just 12 new turbines went in, which happened to be smaller than usual. Italy continues to use smaller turbines than is typical across Europe because of terrain constraints, although it uses larger turbines where possible. In Germany, which typically deploys the largest onshore turbines, the average size in 2004 reached 1,696 kW.

The average new turbine deployed by the IEA Wind member countries was approximately 1,290 kW (based on data from Australia, Canada, Denmark, Germany, Italy, Netherlands, New Zealand, Portugal, Spain, Sweden, Switzerland, United Kingdom, and United States), which is an increase of 6% from last year. In 1995, the average new turbine had a capacity of just 440 kW.

Country/region	Capacity at year-end 2003 (MW)	New capacity (MW)	Offshore capacity at year-end 2004 (MW)	Total capacity at year-end 2004 (MW)
Australia	198.0	182.0		380.0
Austria*	414.0	193.0		607.0
Canada	317.0	127.0		444.0
Denmark	3,115.0	3.0	406.0	3,118.0
Finland	47.0	35.0		82.0
Germany	14,609.0	2,020.0		16,629.0
Greece	424.4	43.6		468.0
Ireland	189.0	71.2	25.2	260.2
Italy	908.0	357.0		1,265.0
Japan*	506.0	434.0		940.0
Mexico	2.2			2.2
Netherlands	905.0	167.0		1,072.0
New Zealand	35.9	132.1		168.0
Norway	100.0	60.0		160.0
Portugal	298.0	264.0		562.0
Spain	6,202.0	2,061.0		8,263.0
Sweden	404.0	38.0	22.5	442.0
Switzerland	5.4	3.5		8.9
United Kingdom	647.6	253.2	123.8	900.8
United States	6,381.0	359.0		6,740.0
India*	2,120.0	863.0		2,983.0
China*	566.0	198.0		764.0
France*	198.0	192.0		390.0
Egypt*	69.0	76.0		145.0
Belgium	67.6	29.4		97.0
Costa Rica	71.0			71.0
Poland*	58.0			58.0
Ukraine	51.0	6.0		57.0
Morocco*	54.0			54.0
Rest of world*	241.0	112.0		353.0
Grand total	39,402.4	8,461.7	577.5	47,864.1

**Table 2 Global installed wind capacity. (Source: representatives of IEA Wind member countries and \* indicates data from Windpower Monthly.)**

## Electricity Generated by Wind

Globally, it is estimated that approximately 92 TWh of electricity were generated from wind in 2004, based on an average capacity factor of 24%. This is almost as much electricity as is used by Portugal and Greece combined. Denmark has the highest percentage contribution from wind energy, reaching 18.5% of total electricity consumption in 2004. In a year of average wind speeds, this would increase to 20%.

### How Windy Was It?

In 2004, for the third year running, European wind speeds were reported as below average. The annual mean wind speed is often compared with the long-term mean wind speed by a wind index, which expresses the annual wind speed as a percentage of the expected long-term speed. For example, Denmark reported a wind index of 90%, up from last year's figure of 84%.

## 4.0 MARKET DEVELOPMENT

### Green Electricity

To attract environmentally conscious individuals and businesses, many utilities are now offering "green electricity" generated from renewable sources. Generally, such green electricity is sold at a slight premium, and in some cases the uptake has been low. Typical of this is Finland, where several companies offer "green" or even "wind" energy certified by the Association for Nature Conservation. The modest uptake is not helped by the fact that only a few percent of households have changed electricity supplier at all since market liberalization.

There has been greater success with green electricity in the Australia, the Netherlands, and the United States. In the United States, voluntary purchase of renewable energy at higher prices by end-use customers has provided supplemental revenue to support the installation of more than 1,500 MW of new wind projects. Approximately 1.3 billion kWh of green power was sold in 2004. Currently, about 15% of the U.S. utilities offer green power in 34 states. In

Australia, more than 100,000 customers across the country have opted for green power, which is managed through a national accreditation program that sets stringent environmental and reporting standards. The Netherlands is an interesting case; there, green electricity has been available for a few years at the same price as conventional electricity. More than 1.4 million households have become customers.

As well as the domestic and business sectors, governments are also buying green power to lead by example. The federal government of Canada buys green electricity at premiums negotiated through a competitive process. This has proven to be very effective and has led to wind power producers building additional turbines to sell to private, provincial, and municipal consumers.

### Community-Owned Projects

Community or locally owned wind farms bring several benefits. They increase the money flowing into the area, provide a positive interest to the people who are living with the turbines, and can reduce the local resistance to providing a building permit.

Denmark has built its wind industry on local ownership, with the vast majority of early projects owned by the local community and landowners. This continues to be the case with the repowering program, but utilities are the principal owners of the large offshore projects. The Netherlands, too, has a history of locally-owned, especially farmer-owned, turbines. To strengthen their position in selling their power in the liberalized market, many of these turbine owners in the Netherlands have formed co-operatives. The Dutch association of wind turbine owners, PAWEX, represents the owners of several hundred megawatts of wind generating capacity. The organization enables them to lobby government on rules affecting the value of their power. The Dutch co-operative Windunie, with some 300 MW of capacity, has an ultimate goal of becoming an energy company in its own right. A consumer can already buy electricity from Windunie and choose a generating source, down to the individual turbine.



The interest in community ownership has spread to other countries. In Spain, several regional governments are preparing new regulations to encourage the involvement of small investors and municipalities in the ownership of wind turbines. Galicia, Navarra, and other regions have a special procedure to promote small wind farms (less than 5 MW). In the United States, a group of farmers in Minnesota has formed two limited-liability companies to invest in wind.

## New Growth through Re-powering

Repowering is the word used by the wind sector to describe the process of replacing old turbines with new (usually larger) ones. Because the size of wind turbines has increased so much, repowering a wind farm can increase the farm's capacity by several times. So repowering is now becoming a common element of development for countries where wind energy has been established a long time, particularly where there is also a scarcity of good, acceptable wind sites on land.

Denmark is the only country to date to specifically target repowering with its 2002 repowering scheme. This scheme was very effective, resulting in the replacement of 1,200 old turbines with 300 new ones. There was little activity in 2004, but new repowering regulations came in toward the end of the year, aiming to replace 900 old turbines; see Policy Update section above.

Repowering continued in the Netherlands in 2004. The replacement of 49 old turbines with 41 new turbines produced a net increase in capacity of 36 MW. On average, the new turbines were 942 kW (4.4 times) larger than the old turbines.

## Turbines over Railway Lines

The Dutch national railway manager ProRail has permitted a demonstration project using wind turbines directly over a freight railway line. ProRail wants to gain a year's experience before it considers changing its rules, to allow more projects. If it is satisfied, there is the potential for several hundred megawatts of similar projects.

## Connecting Offshore

Large components of the cost of offshore wind are the "shallow" connection to the main grid and the "deep connection" costs of integrating large offshore plant into the complete electricity network.

The Dutch project Connect 6000, conducted by KEMA (an engineering services and testing laboratory) and funded by the government, was completed in May this year. Its objective was to develop a vision of the integration of 6,000 MW of offshore wind power. It concluded that an investment of around 300 million euro (400 million USD) is required over a timescale of 9 to 14.5 years. In principle, the first wind farms can make individual connections to the transmission system. After that, government intervention is needed to ensure that future connections are bundled at two key points, to enable the integration of the full 6 GW. The national grid operator TenneT is best placed to manage the process.

In the United States, the development of offshore wind has a pronounced benefit in supplying electricity to coastal cities, where onshore wind would impose a large burden on the inland transmission system.

### Small/Autonomous Wind

The level of interest and support for small turbines is increasing in many of the reporting countries. There are two principal applications.

First, small wind can be effective and economic in providing a power supply to remote areas. This has driven the Australian interest, and it is a market also growing in Spain. Such autonomous systems are not connected to the grid and are generally supported with diesel generation, often including energy storage in the form of lead/acid cells. Just over 55 MW of new capacity in Australia this year was wind diesel. The Renewable Remote Power Generation Program (RRPGP) provides financial support to increase the use of renewable energy generation in remote areas presently relying on diesel. More than 200 million AUD (156 million USD) is expected to be available through the RRPGP, which provides up to 50% of the capital costs.

The other key market for small turbines is to supply electricity to grid-connected domestic and business users. The economics of small grid-connected turbines are currently poor without some level of support.

One favored mechanism for support is net metering, currently being used in many states in the United States and planned for Italy. Net metering effectively enables the electricity meter to go backwards when the turbine is producing more power than is being used. The resulting electricity that is spilled back into the grid has the same value as that supplied from the grid, which is much higher than the price paid to commercial-scale renewables generators. As of September 2004, 41 of the states offered some form of net metering policy.

Investment support is the other principal incentive mechanism. In the United States, investment support in 10 states offers direct rebates or grants to owners of small wind systems, sometimes covering more than half of the installed cost.

Not surprisingly, manufacture of small turbines is growing with significant export opportunities. Turbines that cater to these markets generally fall in the range of 60 W to 20,000 W. However, much larger turbines have been installed in autonomous systems, and the companies that started with small turbines are developing increasingly large turbines. In Spain, Solener is developing 25-kW and 40-kW turbines, and Bornay is developing turbines of up to 50 kW. Wenvor Technology of Canada is developing turbines of up to 30 kW. In the United States, Bergey Windpower has developed a 50-kW turbine, and Northern Power Systems is developing a 100-kW turbine. The Italian company Jonica Impianti has developed a 20-kW turbine.

The Spanish research center CIEMAT is focusing much of its research and testing activity on small wind energy for autonomous wind systems. It is testing several small turbines, components, and complete systems including flywheel storage and control management units.

It should be noted that in strict energy terms, the contribution of small wind is very low compared with that made by large grid-connected wind farms, but the value of the electricity can be very high in remote locations. It is also often argued that bringing small wind energy into the community educates residents and increases acceptance of larger wind farms.

## 5.0 ISSUES AFFECTING IMPLEMENTATION

### Promoting Wind Energy

The wind energy debate has intensified over the past year in the United Kingdom. The media portrayal of the debate can be misleading, often focusing on the interests of protest groups and continuing to repeat old myths and misinformation. This gives a biased impression that wind energy is neither progressing nor popular. The British Wind Energy Association has responded with its own publicity campaign, "Embrace the Revolution," aiming to make people think about wind energy in a different way and providing a vehicle for the largely silent majority to show their support.

Concerns about the impact of wind energy on the landscape are being addressed in Australia by AusWEA and the Australian Council of National Trusts, the country's foremost landscape conservation body. They have started a joint project this year aiming to develop mutually agreed methodologies for assessing landscape values to assist in the siting of wind farms.

### Economics

Demand for wind has been created through a spectrum of capital grants, tax incentives, and production support mechanisms. There are now many instances of encouraging investment in wind (and other renewables) by providing a higher value for the electricity generated. This enables wind to compete with conventional generation in the prevailing economic environment. It should be noted that the relative costs of the various generation sources are very hard to disentangle from historical policies and that the real cost of impacts on the environment is not always fully passed on to the generators.

The level of support required to make wind energy competitive varies with the base cost of electricity. In several IEA Wind member countries, the base cost of electricity is low, and in some cases the situation is compounded by an excess of capacity. New Zealand and Norway are dominated by low-cost, long-established hydroelectricity, and in Norway competition is exacerbated by the import of low-cost electricity generated from coal and gas. Australia is dominated by very-low-cost, coal-fired electricity. In Finland, despite quite substantial support, wind cannot compete with the low spot prices in this fully liberalized market.

### Political and Market Stability

The high dependence of markets on government policies is an ever-present concern. The commercial and financial sectors need to have confidence that a market will remain favorable long enough to warrant investment. Overall, the wind sector does have a degree of insulation from single market policy changes, because of the smoothing effect over the global marketplace.

In May 2003, with the aim of increasing wind development, Sweden changed to a system based on green certificates. However, no major new investments resulted in the first year, prompting an early review by the Swedish Energy Agency this year. The lack of investment has been attributed to uncertainty about the system's survival after 2010. To address this, the agency has now proposed that the electricity certificate scheme be made permanent and that long-term quota levels should be set.

Although the Australian Mandatory Renewable Energy Target has been very successful in generating recent growth, there is now great insecurity looking forward. This is because the federal government's new approach does not include an extension to the MRET, which at current growth rates will be fully met during 2007, removing further demand.

The rate of growth in the United States for 2004 was considerably lower than in previous years due to a delay in the extension of the federal production tax credit. The year 2005 is now expected to be a record-

breaking year, but this is a cycle that is repeating itself, and the PTC is even now only extended to the end of 2005.

### Planning Policy

For several countries where the existing market stimuli make wind power attractive, the main constraint on the rate of development is the difficulty of obtaining building consent. This can be through either a high level of refusal or a very demanding and lengthy bureaucratic processes. Such delays also increase development costs.

Progress in Spain and Portugal is constrained by lengthy bureaucracy and authorization procedures, which may mean a project takes four to five years from inception to the start of installation. In July, the British Wind Energy Association completed a planning study showing that the average time to planning consent is up to 30 months in England, but lower in Scotland. In the same month, the English government published Planning Policy Statement 22, which mirrors the guidance in Scotland and aims to improve the planning success rate.

Italy has suffered similarly, but it has changed policies to emphasize that renewables are in the public interest and not deferrable. Complete plant construction should now be authorized within six months by a single permitting act. The development of wind in Italy has become very regionally dependent. Although central government sets overarching policy, the planning approval is made at regional and local levels. This has given rise to strong regional variations in terms of targets, guidelines, incentives and views on environmental impact. In Sicily, a pro-wind attitude has been adopted, and projects have even been approved ahead of the approval of the regional plan. In Sardinia, however, the new government in power from the middle of the year has stopped any wind initiative until the approval of a regional landscape plan, which will be no sooner than the end of 2005. Projects stopped include those authorized previously by the former administration; as much as 1,000 MW are now in jeopardy, with economic damage to investors and municipalities.

## Grid Limitations

Technically, the integration of large-scale wind energy into electricity networks can be done with existing technology, so long as there is the political will to make the investment in infrastructure. Denmark has already achieved a contribution of almost 20% from wind energy nationally, with no major technical problems. However, in most of the countries with high expectations from wind energy, large-scale integration into the electricity distribution system is seen as a potential—if not an immediate—constraint (Australia, Denmark, Germany, Greece, Ireland, Italy, Japan, the Netherlands, Portugal, Spain, the United Kingdom, and the United States). Transmission constraints, operational policies, and a lack of understanding of the impacts of wind energy on utility grids are three of the toughest barriers facing future deployment. For many of these countries, the problems arise because wind farms are located in relatively unpopulated areas away from the main load centers. Consequently, the local grids are weak and require reinforcement and improvement to enable significant power export. In the United States, the distances, and so the potential electrical losses, are large.

Grid capacity and power quality have already become real constraints in Japan. In the areas of Hokkaido and Tohoku, wind capacity has been limited to 250 MW and 150 MW, respectively. If this issue is not resolved shortly, the national target for 2010 may well not be attained. The situation may be helped by NEDO demonstrations of power stabilization using battery backup. In Ireland, a moratorium on processing new grid connection applications for wind was in place until mid-2004. Following this, developers still had to wait while the electricity distribution network code was revised. A mechanism to deal with the backlog of applications was devised and instituted in the closing days of 2004.

Spain has already instigated some practical measures to maintain the stability of the system. At certain times, for example during the Christmas holidays, the production of wind farms has been voluntarily reduced, corresponding with low consumption periods and strong winds.

There is great concern in the United States about future transmission system tariff structures. The transmission providers have made submissions to the regulator that threaten to make wind uneconomic in some areas through limiting services, inflicting high use-of-system charges, and imposing heavy penalties. In response to this, a conference was held in December to identify measures to prevent such discrimination against wind in electric power markets.

## Environmental Effects

Wind energy has, of course, been driven by the benefit of low greenhouse gas emissions, an issue that continues to increase in importance as governments seek to limit climate change. In terms of the environmental benefits of wind energy, the mantra “think globally, act locally” applies very well. Nonetheless, there is often conflict with local environmental interests, and the approval of wind projects must be based on a balance between these sometimes conflicting needs.

Addressing the interests of environmental groups can form a major element of the planning approval process. In Portugal, the approval process for the more problematic sites has slowed considerably, and it takes up to five years to gain a decision. Part of the problem of assessing the environmental impacts of a wind farm can be the lack of reliable data. This was a factor in the rejection this year of a 300-MW Swedish offshore project proposed off of Sweden’s west coast. This situation can be self-perpetuating.

A conflict with some bat species has been established in a few cases in the United States. This year, a workshop was held in Juno, Florida, drawing several of the world’s leading bat scientists. The workshop’s objectives included discussions on state-of-the-art methods and technologies for understanding bat behaviors to prevent future interaction between wind turbines and bats.

## Defense and Aviation

A conflict with the interests of defense and aviation has placed a sizeable constraint on wind development

in Sweden and the United Kingdom, and it now also threatens the Netherlands. The issue affecting the majority of rejected schemes is the effect wind farms may have on primary radar, with consequent operational impacts on air defense and air traffic control services.

A working group has been established in the United Kingdom with an assignment to produce guidelines and direct research toward alleviation of the critical problems. During 2004, several initiatives were under development to find workable solutions to the radar problem that were acceptable to aviation regulators. One initiative concerns the development of an advanced digital tracker (ADT) developed by AMS. It is now proposed to modify the tracker, which originally was applied to naval radar, and to test the technology on wind turbines in an air traffic control environment. An initial study was also conducted to evaluate the potential costs and benefits of radar-absorbent wind turbine blades. This work also may move on to a testing phase during 2005.

The Dutch Ministry of Transport, Public Works, and Water Management now intends to introduce legislation on the height of objects and their influence on radar and radio around regional airports. The present interpretation of these rules would block planned wind projects with a capacity of a few hundred megawatts, especially in Brabant and south Holland.

## Finance

There does not appear to be a problem with the availability of financing for wind development. Established markets have an advantage in greater competition in the marketplace, leading to keener interest rates. Typically wind farms are financed on a 20/80 equity basis. For example, in the Netherlands, Green Funds from banks like ING, Rabo, Fortis, and Triodos provide an abundant source of capital at low interest rates. Almost all Dutch wind farms are financed this way. Typical projects are financed over ten years in Denmark. Greece reports interest rates of the order of 7% to 8%.

Last year, a new wind investment trend surfaced in the United States. Traditional strategic investors are being partly displaced by institutional investors. Strategic investors are companies like Florida Power and Light and American Electric Power. Institutional investors are mainly passive and motivated by tax benefits and overall returns, and they may have previous experience in other tax-advantaged industries. If the production tax credit is extended beyond 2005, this largely untapped market will become critical for the future of the industry, as it will unleash substantial new capital.

## 6.0 TECHNOLOGY AND INDUSTRY

### Turbine Development

German manufacturers Repower, Multibrid, and Enercon continue to lead in the development of the largest turbines. The largest turbine in the world is now the Repower 5M; its capacity is 5 MW, and it has a rotor diameter of 126 m at a hub height of 120 m. The prototype was erected in September 2004 in Schleswig-Holstein. Multibrid completed installation of its 5-MW turbine in December 2004. This machine has a 116-m rotor diameter on a 102-m tower. Three examples of the 4.5-MW Enercon E-112 are now operational; the prototype has been running since October 2002. Most leading manufacturers are catching up and have turbines of 3 MW to 5 MW capacity either available or under development. Although these will be initially installed onshore, many manufacturers are also targeting the offshore market, and their products will have to be adapted to operate in that environment. This has been the focus of the Danish manufacturers this year.

Testing of the two Scanwind 3-MW turbines has produced promising results so far. The Norwegian/Swedish Company Scanwind Group AS has taken the unusual step of developing both a geared and gearless 3-MW turbine. The directly driven version (no gearbox) was erected in Norway last year. The more conventional geared turbine was erected in December this year. ScanWind started the delivery of the 3,000-DL gearless turbine to the home market this year, and it will introduce the geared version late in 2005. The

Spanish company Ecotecnia is also developing a 3-MW turbine, in this case with a 100-m-diameter rotor. This is a big step from its current production models of 1.67 MW and 74 m rotor diameter.

The Finnish manufacturer WinWinD erected a 3-MW prototype in November 2004. This is a development of its 1-MW machine with variable speed, a one-stage planetary gearbox, and a permanent magnet generator. The 1-MW turbine has been operational since the spring of 2001. The company has now built 13 MW, all in Finland, but has started to export this year, selling turbines to France, Portugal, and Sweden.

In the United States, GE Wind Energy completed a design conceptualization for a 3-MW-to-5-MW prototype turbine that includes advanced controls and diagnostic systems and blade load alleviation. It also built a prototype 2.5-MW turbine for testing at ECN's test site in the Wieringermeer. Also undergoing testing at the ECN test site is NEG Micon's 2.75-MW, 92-m turbine.

Another U.S. company, Clipper Windpower completed the fabrication of most of the components for its 2.5-MW Liberty prototype turbine. The prototype incorporates a distributed drive train, blades with truncated root section airfoils, and advanced controls. The U.S. National Renewable Energy Laboratory completed dynamometer testing on the new drive train, with field trials anticipated next year. Clipper's goal is to produce a drive train that is 30% lighter than conventional drive trains.

Mitsubishi Heavy Industries Ltd. (MHI) is the only Japanese manufacturer supplying medium to large wind turbines. Last year, MHI started development of a new 2.4-MW turbine.

The Italian company Leitner is progressing well with its Leitwind 1.2-MW prototype erected last year. The three-bladed, gearless turbine has now been certified for class 1 sites, and production of one or more 1.5-MW turbines with larger 70-m or 77-m rotors for wind class 2 sites is also planned.

The prototype Lagerwey turbine installed near Andermatt in Switzerland in very harsh conditions has been replaced. It had problems with the inverter and developed deep cracks in the blades. The bankruptcy of Lagerwey exacerbated the problems in terms of technical support. It has now been replaced with an Enercon E-40, which has operated without problems since its installation in November of this year.

Windflow Technology Ltd. is the sole prospective New Zealand wind turbine manufacturer. It has developed a 500-kW two-bladed teetered-rotor wind turbine employing a torque-limiting gearbox. One turbine was built in 2003 and has been undergoing tests since then. The company is now seeking consent for its first commercial wind farm of some 50 MW.

### National Test Sites

After several years, the new Danish test site for multi-megawatt wind turbines has now been completed. The site, at Høvsøre on the northwest coast of Jutland, was selected to capture high wind response; average annual wind speed there is 9.1 m/s at 78 m. It consists of five test stands with dedicated meteorological masts able to accommodate turbines of 5 MW capacity and heights of up to 165 m to blade tip. Vestas, Siemens Windpower (previously Bonus), and Nordex have already leased test stands.

Construction also continues on a Norwegian test site, the product of a joint venture between the Institute for Energy Technology and Trondheim University. The coastal wind turbine test site is in central Norway and will be in operation in the summer of 2005.

ECN has installed five identical Nordex 2.5-MW turbines on its test site. The turbines will be used to take measurements validating the modeling of turbulence, wakes, and extreme fatigue loads. They are also expected to be used in a field experiment to develop the acoustic/optic registration of bird collisions. This year, ECN completed the implementation of a computer code to analyze offshore wind turbines in the frequency domain. The code is particularly suited to aeroelastic stability analysis, control design, and the rapid computation of loads.

## Grid Integration

Many countries are necessarily conducting research to tackle the immediate or looming problem of grid limitations (see grid limitations). The new IEA Annex XXI “Dynamic Models of Wind Farms for Power System Studies” is coordinating modeling activities that will accelerate learning in this area.

In Portugal this year, several studies have been conducted to identify how, through online continuous control of reactive power from wind parks, it is possible to reduce losses and improve voltage profiles in high-voltage distribution grids. Also concluded during 2004 was the Portuguese power system stability study, examining the scenario of the high wind energy penetration intended by 2010. It showed no technical limitations within the Iberian Interconnected Transmission System and Market (MIBEL).

The future grid integration requirements in Germany were the subject of a major investigation in 2004. The results show that the technical problems resulting from the expected expansion of wind energy could be solved, but with a price tag of 1.1 billion euro. The study identified a need to upgrade 400 km of the existing grid and install an additional 850 km. According to the study, the requirement for increased balancing and reserve capacity could be covered by a combination of the existing fossil fuel and pumped-storage plant, together with the replacement of old plant with new gas turbines.

Spain and Portugal have programs that provide direct support for grid reinforcements. The Portuguese POE/PRIME program provides partial support, and the Greek OPC program provides up to 50% of the cost of transmission lines for the connection of renewables.

There is a new source of funding for grid integration studies in Denmark. The transmission system operators are being re-nationalized into one government-owned company in 2005. A subsidized R&D program will focus on development of renewable technologies and emphasize the interaction between turbines and the power system, including wind power's ability to contribute to regulation and stability.

## Resource Assessment and Forecasting

Resource studies continue to be an important activity for many countries and regions. This year, Portugal published a wind atlas together with a national database of wind characteristics drawn from about 50 anemometric stations. A major exercise has just come to fruition in Canada with the completion of a wind energy atlas across its entire territory. It benefits the commercial wind sector by improving the site selection process and by reducing the need for extensive field studies to verify wind conditions.

The Tall Towers Research Project in the United States is seeking to validate meso-scale weather modeling and to examine the interaction between “nocturnal jets” and tall turbines. The Department of Energy is collaborating with five states to measure wind resources at levels above normal measurements (50 m above ground level).

## Operational Experience

Contemporary turbines have become very reliable and perform with few operational difficulties. Average availabilities are generally over 98%. National statistics produced in Sweden give an average availability of 99.1% in 2003, 98.1% in 2002, and 98.3% over the previous five-year period from 1996 to 2001. Finland reports slightly lower availabilities (95% in 2004), largely as a result of the extreme operating conditions.

Capacity factors are typically between 0.20 and 0.35, depending on the wind speed and the turbines used. Spain reported an average capacity factor of 0.21 for 2003, with the UK onshore capacity factor reported as 0.241 for the same year. The United States estimates an average capacity factor of 0.29. In Ireland, which has very high wind speeds, capacity factors to date have generally exceeded 0.35, and capacity factors exceeding 0.40 are not uncommon.

Wind turbines are designed with a life of 20 years or more. Danish studies have found that consumables such as gearbox oil and brake pads are often replaced at intervals of one to three years. Parts of the yaw

system might be replaced every five years, and vital components exposed to fatigue loading, such as main bearings and gearbox bearings, might be replaced once in the design life. A cost model also developed in Denmark and based on statistics from 1991, 1994, and 1997, includes a reinvestment of 20% of the turbine cost in the tenth year, financed over the following ten years.

Overall reliability can be considered high, reflected in the availabilities achieved. Occasional component faults affect many operating machines. Several such cases over the years have involved gearboxes and blades. These require large retrofit programs conducted at the expense of the component or turbine manufacturer. The most recent example was the retrofit program conducted by Vestas on its 2.0-MW offshore turbines at Horns Rev in Denmark. In this case, the nacelles were returned to the factory, where the generators and transformers were replaced and several smaller modifications were made.

In Finland during 2004, downtime on three 1.3-MW machines was caused by partial blade loss under storm conditions. A fire destroyed another 1.3-MW turbine.

Japan, too, has an unusual climate, but rather than low temperatures, it experiences regular typhoons and frequent and high-energy lightning strikes. This year, several new government activities have been initiated to promote the development of standards and consequently of turbines that will be able to cope with these extreme conditions.

## Standards

All wind turbines installed in Denmark have to comply with the Danish Certification Scheme. In December of this year, a new scheme was introduced based on the IEC WT01 System for Conformity Testing and Certification. This replaces the old Type Approval Scheme. The implementation of the IEC brings a more uniform and consistent approach to certification and with it the prospect of easier access to enable manufacturers to sell their products internationally.

## Costs

Cost of energy is the correct economic performance measure for wind energy system. The cost of wind-generated electricity continues to fall steadily. This is driven by technological development and increased production levels, together with the use of larger machines. For the recent megawatt-plus machines, the installed costs per unit capacity might not be lower, but the overall economics continue to improve. This is because the turbines are on taller towers, which give rise to higher wind speeds and improved energy yields.

The Australian Wind Energy Association (AusWEA) completed a study in 2004 that found that the production cost of both wind turbines and the electricity they produce has decreased by 75% over three decades. The report estimated that Australian wind power prices would converge with the cost of coal and gas within 15 to 20 years.

In many areas of the United States, the projected cost of energy for utility-scale production can be as low as 0.04 to 0.06 USD/kWh, given an excellent resource and megawatt-plus-scale turbines. In the UK, projects have been developed for under 0.03 £/kWh under long-term fixed-price power purchase contracts where wind speeds are high (over 9.0 m/s at hub height).

The costs are a little higher in Japan because of the additional cost of transporting imported turbines from Europe and the United States and higher than average installation and grid connection costs. Here the costs are 7 to 9 JPY/kWh (0.065 to 0.084 USD/kWh) for large wind farms using megawatt-plus-sized turbines.

Because of the commercial nature of wind farms, very little firm cost data is available, although most countries provide estimates. For complete wind farms, the estimates of average cost vary according to country, between about 1,000 to 1,400 USD (800 to 1,100 euro) per kilowatt of installed capacity, with 1,250 USD (1,000 euro) as the round average. In reality, system costs have a range that depends on location, project size, and other factors. The cost of the turbine and tower alone varies between about 800 and 1,150 USD (630 and 900 euro), with 950 USD (750 euro) being



typical. These costs show a split of roughly 75% for the turbine (including tower) and 25% for the balance of plant (foundations, electrical infrastructure, and roads).

Operating costs include servicing, repairs, site rental, insurance, and administration. A thorough study was conducted in Denmark, tracking operating costs for turbines in the size range 150 kW through 600 kW. The work shows near contemporary turbines (500 to 600 kW) having annual operating costs steadily increasing from 1% of the investment cost in the first year to 4.5% after 15 years. These figures are consistent with Portuguese estimates of 2% to 4% and Dutch estimates of 3.4% for smaller projects. The maintenance and repair costs account for roughly one third of the total operating costs.

## Manufacturing

Spain and Australia report a strong growth in the wind manufacturing sector this year. In Spain, new component factories have been inaugurated. The Spanish Manufacturers and Promoters Association reports that Spanish manufacturing investment in R&D amounts to 11% of gross value added, well above the industrial average of 1% and higher even than the electronic equipment industry at 5.4%. Australia's manufacturing industry experienced significant growth, particularly in Tasmania, where a new Vestas assembly plant opened last year and which also has nacelle and tower manufacturing.

During 2004, the Portuguese government announced its intention to use future calls for wind capacity as a means to promote and provide incentives for new turbine manufacturing and assembly facilities. This comes close on the heels of an announcement last year that two new assembly factories and a new blade factory will be built soon.

In well-established markets such as Denmark, wind energy has created opportunities for non-wind-based businesses to expand their client base by becoming specialists in the provision of transport, insurance, cranes for installation, and development services. Offshore oil and gas companies are now also applying their expertise to the offshore wind sector.

## Acquisitions and Mergers

The German turbine manufacturer DeWind was acquired by the UK company FKI in 2002 and employed about 400 people manufacturing complete wind turbines at its plant in Loughborough. Unfortunately, in November 2004 FKI announced its intention to exit the DeWind turbine business. The UK's second turbine manufacturer, NOI Scotland, also ceased trading in 2004.

The technology from Lagerwey, which entered administration in 2003, has now found new homes. Zephyros B.V., owned by the Triodos bank and the German wind farm developer BVT, purchased the rights to the 2-MW direct-drive turbine. At the end of 2004, Zephyros B.V. started work on a new assembly factory for that turbine. The 750-kW direct-drive turbine developed by Lagerwey is being assembled and marketed by Emergia Wind Technology, run by former Lagerwey employees.

## Employment

The Spanish wind sector association Plataforma Eólica Empresarial has estimated that wind energy has to date generated about 7,000 direct jobs and nearly 20,000 indirect jobs (2003). Projections are for this to rise to 51,000 jobs when an installed capacity of 13 GW is reached.

Wind energy is the fastest-growing energy sector in the UK. To date, about 4,000 jobs are sustained by companies working in the wind sector. The Department of Trade and Industry has estimated that the second round of offshore wind developments alone could bring a further 20,000 jobs for Britain. The manufacturing of turbines and components in Australia is currently employing more than 250 people, and the number is growing rapidly. This figure excludes non-manufacturing and indirect jobs.

## 7.0 NATIONAL STATISTICS

Statistics reported by member countries are listed in Table 3. Blank entries indicate no reported data.

Author: Ian Fletcher, Wind Business Support, UK.

Country	Total installed capacity (MW)	Offshore installed capacity (MW)	Capacity installed in 2003 (MW)	Total No. of Turbines	Average new turbine size kW	Wind generated electricity GWhrs/yr
Australia	380.0	-	182.0	288	1,780	-
Canada	444.0	-	127.0	535	1,280	<i>1,361</i>
Denmark	3,118.0	406.0	3.0	5,389	817	6,580
Finland	82.0	-	35.0	-	-	120
Germany	16,629.0	-	2,020.0	16,543	1,696	-
Greece	468.0	-	43.6	812	-	990
Ireland	260.2	25.2	71.2	321	1,000	-
Italy	1,265.0	-	357.0	1,880	918	1,837
Japan	940.0	-	434.0	-	-	988
Mexico	2.2	-	-	-	-	-
Netherlands	1,072.0	-	167.0	1,686	1,203	<i>1,853</i>
New Zealand	168.0	-	132.1	175	1,100	155
Norway	160.0	-	60.0	-	-	-
Portugal	562.0	-	264.0	513	1,780	<i>1,292</i>
Spain	8,263.0	-	2,061.0	-	1,060	<i>14,178</i>
Sweden	442.0	22.5	38.0	719	971	<i>772</i>
Switzerland	8.9	-	3.5	23	1,750	6
United Kingdom	900.8	123.8	253.2	1,191	1,710	1,286
United States	6,740.0	-	359.0	-	1,200	<i>19,600</i>
<b>TOTALS</b>	<b>41,905.1</b>	<b>577.5</b>	<b>6,610.6</b>			

**Table 3 National statistics of the IEA Wind member countries. Figures in italics are estimates. None or no data available are indicated by -.**

## CHAPTER 4

# AUSTRALIA

### 1.0 INTRODUCTION

For the Australian wind industry, the past three years has resulted in both exceptional growth and great uncertainty. While Australia has 40 times less installed wind energy than Germany, the world wind energy leader, the potential for this continent enormous. Australia is 20 times larger geographically than Germany and has one of the strongest and most abundant wind resources on the planet.

Wind energy capacity in Australia almost doubled in the last year with 380 MW of wind energy capacity installed at the close of 2004. This is significantly higher than the 198 MW of installed capacity at the end of 2003 and represents another milestone for the emerging industry. Approximately 1,281 MW of additional wind energy projects are either approved or under construction with many more in various stages of development. Once installed, these projects will provide enough electricity to meet the demands of about 750,000 homes.

An important driver of the industry has been the development of local manufacturing industry. This local manufacturing capacity supports the Australian industry's goal of becoming a support hub for the Asia-Pacific region. Other Asia-Pacific outreach efforts have been achieved through strong advisory alliances and joint ventures with the Chinese and Fijian renewable energy sectors.

The future growth of the industry is now uncertain given that the Federal government's new approach to national energy strategy does not include an extension to the rapidly filling Mandatory Renewable Energy Target (MRET). This has led to great insecurity for the wind industry in Australia because the MRET market will essential by filled by 2007.

The Australian Wind Energy Association (AusWEA) has engaged a number of stakeholders to further address key issues in the region. These include developing protocols for noise abatement, bird and bat protection, landscape value assessment, aircraft safety and local government taxation in 2004.

A key focus for the industry in 2005 is to explore how the Australian economy will be affected by the global push toward renewable energy. A number of opportunities are being considered to expand the industry including mechanisms such as a state-based renewable energy target and increased voluntary uptake of green energy through green power programs.

### 2.0 NATIONAL POLICY

The development and growth of the renewable energy industry in Australia is primarily supported by the strategic initiatives that have flowed from the Federal government's 1998 National Greenhouse Strategy (NGS) – the strategic framework for advancing Australia's domestic greenhouse response. The Australian government, through the Australian Greenhouse Office, delivers the majority of these initiatives under the 1.8 billion AUD climate change strategy. The initiatives include a wide range of measures focusing on the energy, transport, and agricultural sectors. Those initiatives that offer support to the wind industry are as follows.



Figure 1 Turbine at the Woolnorth Wind Farm, Tasmania.

## Mandatory Renewable Energy Target (MRET)

MRET is the cornerstone for the Australian renewable energy industry. This was a “world first” in terms of creating a nationally legislated renewable energy market. The legislation mandated an initial target of an additional 2% (later converted to 9,500 GWh) of renewable energy by 2010, through to 2020. This target requires electricity wholesalers and retailers to source an annually increasing percentage of their supply from registered renewable generators or pay a shortfall penalty of 40 AUD/MWh. Since coming into effect in 2001, this market-based measure has delivered an increasing amount of renewable electricity to the country. MRET has also underpinned investment in a number of renewable energy manufacturing facilities for nacelle, blade, and tower manufacture and assembly.

A review of the MRET scheme in 2003 was required by legislation. The Review Panel’s (Tambling) Report, released in January 2004, recommended increasing

the target from 9,500 GWh in 2010 to 20,000 GWh by 2020 and holding the target at this level until 2035. The government’s response in June 2004, framed within the White Paper on Energy and the Environment, Securing Australia’s Energy Future, was to retain the existing target (9,500 GWh by 2020), while refining some of the processes associated with its administration and operation.

## White Paper on Energy and the Environment

The white paper included funding for the following support incentives.

- A renewable energy development initiative; 100 million AUD over seven years
- Low emissions technology and abatement; 27 million AUD over four years
- Advanced electricity storage technologies; 20 million AUD over four years
- Wind forecasting capability; 14 million AUD
- Improving grid accessibility through federal and state government relations.

The white paper also included a 500 million AUD Low Emissions Technology Demonstration Fund to support industry-led projects that can reduce the cost of large-scale, low emission technologies with significant long-term abatement potential. However, it is anticipated that this fund will be predominantly focused on the fossil-fuel industry.

## Renewable Energy Action Agenda (REAA)

The REAA, another NGS initiative, was developed in 2000 and remains the central guiding point for the renewable energy industry. This agenda established a partnership between government and industry to support and advance the domestic renewable energy industry. The intent of the agenda is to foster a competitive energy market, and, by providing clear investment signals, to achieve annual renewable energy sales of 4 billion AUD/yr by 2010. Prior to the release of the white paper, and with sales exceeding 1.5 billion AUD, this target was seen as achievable. However, the expected winding back of renewable en-



Figure 2 Starfish Hill Wind Farm, South Australia.

ergy investment over the next few years, as the MRET is met, will make the 4 billion AUD target extremely difficult to achieve.

### Other Programs of NGS

The NGS also provides direct support to the renewable energy industry through programs that include:

- The Renewable Remote Power Generation Program (RRPGP), which will provide approximately 200 million AUD by 2004 to increase the use of renewable energy in remote areas of Australia;
- The Renewable Energy Equity Fund, which provides venture capital to high-growth and emerging companies commercialising direct or enabling renewable energy technology services;
- The Renewable Energy Commercialisation Program (RECP) potential for strong commercial contribution to the renewable energy industry, with a focus on GHG emissions reduction;
- The Renewable Energy Showcase, which pro-

vides seed funding and/or promotion of leading edge technologies that are approaching commercialisation.

### Green Power National Accreditation Program

Renewable energy development is also encouraged by a Green Power program. Green Power is a national accreditation program that sets stringent environmental and reporting standards for renewable energy products offered by electricity suppliers to households and businesses across Australia. Over 100,000 customers across Australia have chosen Green Power products, including close to 5,000 businesses. As a result of the growing demand for Green Power, over 150 new approved renewable energy projects have been installed in Australia since 1997, including numerous wind farms. Growth of the renewable energy industry and the installation of new generators have made a positive contribution to employment and tourism in regional areas.

## State-Based Strategies

Several of the state governments moved in 2004 to initiate a state-based renewable energy target in response to federal decision not to increase the current MRET. State energy ministers from New South Wales (NSW), Victoria, South Australia, and Tasmania have agreed to (1) Accelerate the current work being done on emissions trading; (2) Establish an Inter-jurisdictional Working Group to recommend ways to increase the MRET from the current level and time frame; noting the recommendations of the Federal government commissioned Tambling report as a minimum outcome; and (3) Demand immediate action by the Federal government to offer incentives to promote energy efficiency and demand management. In addition, some Australian states have also established their own GHG abatement programs.

### NEW SOUTH WALES

From January 2003, NSW electricity retailers and other “benchmark participants” were required to meet mandatory targets for abating the emission of GHGs from electricity production and use for the period 2003 to 2012 under the Greenhouse Gas Benchmarks Scheme. The mandated target of 7.27 tCO<sub>2</sub> emissions per capita is to be achieved by 2007 and maintained until 2012. Failure to meet this target will incur a penalty of 10.50 AUD per tonne of emissions by which the target is exceeded.

The NSW government has also recently released an Energy Directions Green Paper, inviting public submissions on a range of energy policy issues. The government’s intent is to provide business and industry with a reliable, affordable, sustainable, and secure electricity supply.

### VICTORIA

The Victorian Government’s Greenhouse Strategy includes a target of 10% renewable energy consumption by 2010, with the goal of 1,000 MW of installed wind energy by 2006. One of the key initiatives of the strategy is the Renewable Energy Support Fund

(RESF). The objective of the RESF is to encourage innovative applications of medium-scale proven renewable energy technologies in Victoria.

### QUEENSLAND

Under the Queensland government’s Cleaner Energy Strategy, released in 2000, electricity retailers are required to source 15% of electricity sold in Queensland from gas-fired or renewable energy after 1 January 2005. The government will also significantly increase its funding for existing and new programs supporting renewable and innovative energy technologies, especially the Sustainable Energy Innovation Fund, which will be extended until 2005.

### WESTERN AUSTRALIA

The government of Western Australia (WA) announced in early 2005 its plans to establish a renewable energy target for WA’s main electricity grid and is investing in new renewable energy projects as part of its 59.75 million AUD package. The main element of the package is to increase the proportion of renewable energy in the South West Interconnected System from 1% to 6% by 2010. The target represents a 50% increase above what would be expected under the Federal government’s Mandatory Renewable Energy Target (MRET). The government aims to achieve the target by supporting the expansion of MRET or, if necessary, other mechanisms aimed at delivering renewable energy in a competitive market environment.

The government will also commit to establishing eight new renewable energy projects in remote towns during the next four years. Coral Bay on the Ningaloo Coast has already been identified as one of the eight towns to benefit with a commitment to build a new 5.7 million AUD wind-diesel power system, subject to support from the Federal government.

## Progress Toward National Targets

The MRET scheme, introduced in 2001, has performed well in supporting the construction of renewable energy infrastructure and the development

of the renewable energy industry in Australia. The expected annual growth of wind generating capacity is 20%.

Australia's agreed Kyoto target is 108% of 1990 emissions over the period 2008 to 2012. Current projections indicate that Australia's greenhouse emissions will be 586 million tonnes (Mt CO<sub>2</sub>-e) averaged over 2008 to 2012 – exactly meeting the 108% Kyoto target. This latest projection is lower than the projection of 110% released in 2003, and represents a 12 Mt CO<sub>2</sub>-e decrease in emissions. However, at the Kyoto negotiations, Australia made sure that the massive 1990 emissions from land clearing were counted in its emissions baseline. Thus, Australia's 'status quo' emissions appeared very high. A high baseline emissions figure means that Australia can largely meet its Kyoto target by simply ensuring that not as much land is cleared in the period 2008 to 2012. As a result, Australia's emissions are predicted to jump substantially after 2012 when these land-clearing credits will no longer be available.

This situation is illustrated by Australia's rising stationary emissions, which are predicted to be 146% of 1990 emissions by 2008 to 2012. This increase is primarily a result of a declining proportion of renewable energy in the total energy mix across the past 20 years. This mix has been reduced from approximately 20%, due to Australia's early investment in hydro-electricity, to currently less than 10%.

### 3.0 COMMERCIAL IMPLEMENTATION

#### Installed Capacity

The total installed capacity of commercial wind turbines (10-kW size or greater) reached more than 380 MW at the end of 2004 (Figure 3). This equated to an increase of just under 182 MW in 2004 (Figure 4). Seventeen companies or authorities own and operate these projects in Australia. Just over 55 MW of the wind energy capacity installed in 2004 was wind/diesel with 60 MW connected to the grid.

The outlook for further installations of large grid-connected wind is very positive. At the end of 2004, more than 355 MW were under construction with a further 926 MW receiving planning approval and another 363 MW under tender. The projects are spread over the five states of New South Wales, South Australia, Tasmania, Victoria, and West Australia, which all have large tracts of cleared farmland suitable for wind farm development.

A further 4,202 MW of projects have been identified in the public domain and are currently under the feasibility stages of development. In total, 6,221 MW of wind energy projects are in the pipeline for Australia. In addition, a large number of identified potential projects are not yet in the public domain.

Some of these projects may not proceed once they have been tested against the wind resource, local

Cummulative Installations

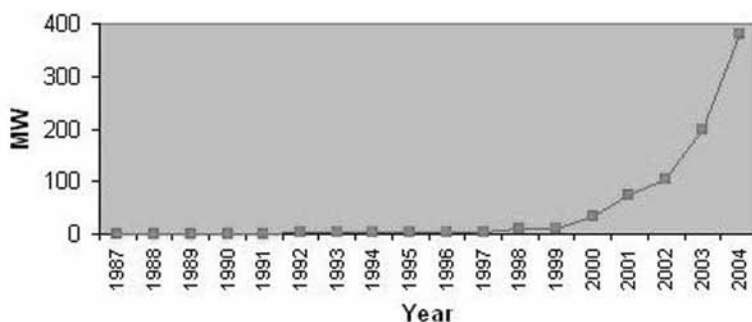
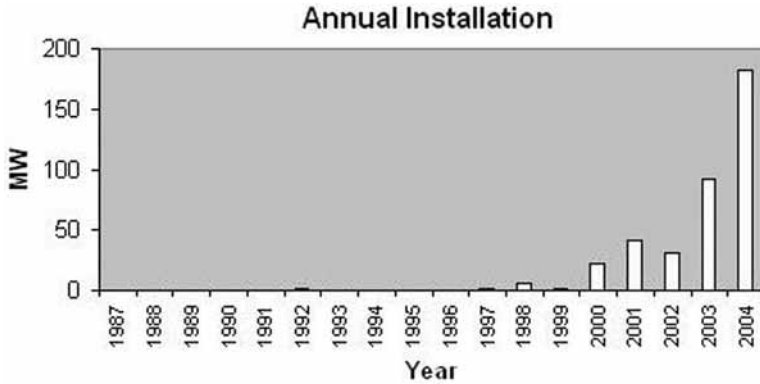


Figure 3 Total installed wind capacity in Australia.



**Figure 4 Annual installation of wind energy capacity.**

and state government planning approval criteria, availability of grid transmission infrastructure, and financing. However, market insecurity is the biggest issue facing future projects. Many of these projects are unlikely to have a viable guaranteed market to sell their power unless the level of demand for wind energy is increased, through either dramatic increases in Green Power programs, or raised renewable energy targets at the state and federal levels.

### Rates and Trends in Deployment

Over the past five years, Australia's wind capacity has undergone an averaged annual growth rate of over 100%. This rapid growth rate is expected to continue as requirements for electricity retailers to source more renewable energy ramp up towards the current legislated MRET of 9,500 GWh of renewable energy by 2010.

Wind energy projects in Australia have all been land-based so far. Australia is sparsely populated, and several states have extensive private coastal and inland farmlands that possess good wind regimes. In addition, there is a trend towards installing larger turbines for grid-connected projects. The largest turbines installed in 2003 were 1.75-MW Vestas equipment. Some upcoming wind developments are expected to use 2-MW turbines. Smaller wind turbines including Westwind and Enercon machines are being utilised for small remote wind/diesel projects.

Additional projects are still being identified, particularly in the inland regions of Victoria, NSW, and the Australian Capital Territory (ACT). In January 2004, the Victoria government released a detailed wind map of the state, which indicated viable inland areas. The NSW Government has also released its own wind atlas.

A focus of the wind industry has been to encourage local manufacture of wind turbines and towers, with a trend to award construction contracts based on commitments to local industry development. Grid-connected projects have so far been able to award approximately 50% of construction contracts to local Australian companies.

In 2004, Australia's manufacturing industry experienced significant growth, particularly in Tasmania. Australia now has a nacelle assembly plant (Vestas), nacelle and nose cone manufacturer (AusTech Composites), and a turbine tower manufacturer (Haywards Engineering) situated in Tasmania. The steel industry is also benefiting significantly from the turbine construction business. Air-Ride Technologies, which is in South Australia, is a major steel fabrication company supporting the industry. Plans are underway to establish local blade manufacturing in Victoria where a manufacturing plant currently builds wind towers and components (Keppel Prince). The manufacturing industry currently employs more than 250 Australians.



## Contribution to National Energy Demand

The installed capacity of wind farms in Australia during 2004 is estimated to have produced 780 GWh of electricity. This is less than 1% of Australia's total electricity production. In 2003, the installed capacity of 198 MW was estimated to have produced more than 520 GWh of electricity with over 442 GWh provided to state transmission systems and 78 GWh to remote power systems. Caution should be applied in the use of these estimates as actual production figures are not reported in Australia.

## 4.0 MARKET DEVELOPMENT AND STIMULATION

### Support Initiatives and Market Stimulation Instruments

The most influential market stimulant for wind power in Australia continues to be the MRET, which requires

an additional 9,500 GWh of new electricity generated per year from renewable and specified waste sources by 2010. As stated earlier, the federal government decided not to increase MRET in its White Paper on the Energy and Environment, released in 2004.

Apart from the MRET, several other support initiatives exist for the wind industry in Australia. One federal government strategy is the Renewable Energy Action Agenda, described earlier. This government and industry partnership is on track toward achieving annual renewable sales of 4 billion AUD by 2010, with 2002 to 2003 sales estimated at 1.8 billion AUD. The Renewable Energy Technology Roadmap, which has followed on from the agenda, provides strategic long-term direction to the industry.

Other Federal government support for renewable energy includes the following initiatives:

- A 500 million AUD Low Emissions Technology Demonstration Fund
- The Renewable Remote Power Generation Program



Figure 5 Construction at Woolnorth Wind Farm, Tasmania.

funded to 264 million AUD available over four years commencing in 2000 (see section 8)

- The 54 million AUD Renewable Energy Commercialisation Program, launched in 1999 and continuing for five years (see Section 8)
- The 26.5 million AUD Renewable Energy Equity Fund
- An R&D Tax Concession administered by the Federal Department of Industry, Science and Resources and the Australian Taxation Office, which fosters renewable energy innovation with a 1.25 AUD deduction for every dollar spent on eligible R&D activities.

The Australian Greenhouse Office (AGO), established in 1998, remains the principal Federal government agency on greenhouse matters. The AGO is providing up to 6 million AUD over four years to foster the industry and guide standards development. It granted an 88,000 AUD award to AusWEA to develop the Best Practice Guidelines for the Implementation of Wind Energy Projects in Australia in 2001. These guidelines are intended to be a live document to ensure that they represent the very best in development practice in the light of ongoing knowledge and experience.

The AGO gave a further grant to AusWEA of 170,000 AUD in 2003 for the Wind Industry Development Project. This project has developed a set of 12 fact sheets for the industry and is in the process of developing Bird Dataset Protocols as an enhancement of the Best Practice Guidelines.

### State Support

The state governments have taken a more active role in promoting the uptake of renewable energy sources in recent years, largely in response to the Federal government's decision not to increase the current MRET. Most states have also established authorities to promote and support the uptake of renewable energy technologies. In Western Australia, the Sustainable Energy Development Office, created in 2001, continues to deliver state sustainable energy policy. In NSW, sustainable energy development is supported through the Department of Environment, Utilities and Services (DEUS). The Sustainable Energy Authority of Victoria (SEAV) works to accelerate prog-

ress toward a sustainable energy future for the state, by facilitating investment in demonstration of innovative renewable energy technologies.

The NSW and Victorian agencies have each produced state-based wind atlases, DEUS (formally known as the Sustainable Energy Development Authority (SEDA)) in 2002, and SEAV in 2004. During 2002 and 2003, SEDA's WindBusiness unit produced data to assist the NSW industry to choose favorable sites and to harness the maximum available energy at any site. In Victoria, the 8.45 million AUD Renewable Energy Support Fund, administered by SEAV, provides up to 20% of the capital cost of medium-scale renewable energy projects.

## 5.0 DEPLOYMENT AND CONSTRAINTS

Market development constraints are mainly caused by low market price for electricity from renewable sources, restricted access to the grid for export of power and grid integration issues, and difficult planning approval processes.

### Market Price

Renewable energy development in Australia faces a serious competitive challenge in the form of some of the lowest electricity prices in the world, largely due to the generation sector's reliance on comparatively cheap and abundant coal for approximately 90% of electricity. The market price for electricity from wind farms is set by a number of sources, including market spot price, value of renewable energy certificates, green power component, and emission reduction rights.

### Access to Grid

Issues associated with the connection of wind farms to Australia's transmission and distribution grids, now and in the future, are of high importance to the wind energy industry. These issues have the potential to make or break the development of new wind farms, depending on the location of the project within the transmission and distribution systems.



Figure 6 Toora Wind Farm, Victoria.

## Planning Approval

In Australia, wind farms come under the jurisdiction of state or local authorities. Most states are now moving toward state government approval for the larger wind energy projects while involving local governments in the consultation process. Victoria and South Australia have developed extensive planning guidelines for wind farm developments. NSW is currently preparing its planning guidelines, which will assess all projects over 30 MW in the state.

All wind farms in Australia are also accountable under federal legislation known as the Environment Protection and Biodiversity Conservation (EPBC) Act. Under the assessment and approval provisions of the EPBC Act, actions that are likely to have a significant impact on a matter of national environmental significance are subject to a rigorous assessment and approval process. An action includes a project, devel-

opment, undertaking, activity, or series of activities. In Australia, the Bald Hills Wind Farm in Victoria is the only wind energy development that has been called in under the Act. The outcome of the assessment has not yet been announced.

In response to calls from community leaders, AusWEA and the country's foremost landscape conservation body, the Australian Council of National Trusts, launched a joint project to address landscape concerns. The project aims to develop mutually agreed methodologies for assessing landscape values to assist siting wind farms. Stage 1 of the project, funded by the Federal government through the Department of Environment and Heritage and the Australian Greenhouse Office, involves developing an issues paper and canvassing solutions to landscape issues, is complete. Stage 2 involves the development of methodologies for landscape assessment, and Stage 3 involves testing and demonstrating those methodologies. AusWEA intends to secure additional funding from federal and state governments to proceed through the remaining stages of the project.

Defining the perceived loss of visual amenity against considerable economic and environmental benefits, both to local communities and to the whole nation, is crucial. Other issues include the potential impact of wind farms on rare and endangered species such as migratory orange-bellied parrots (protected under the EPBC Act), neighbors potentially affected by noise, and changes in land values.

AusWEA's comprehensive Best Practice Guidelines for the Implementation of Wind Energy Projects in Australia aids in appropriate installation of wind farms. The guidelines were prepared by consulting with diverse stakeholder groups including developers, local councils, consultants, environmental groups, state agencies, network operators, and retailers. AusWEA plans to update the guidelines in 2005 and establish a system that demonstrates compliance with them, with a particular emphasis on the importance of community consultation.

Standards Australia has also established a Wind Turbine Noise Committee to address the lack of an Australian standard in this area. Their Australian

Standard for the Prediction, Measurement and Assessment of Noise from Wind Turbines will provide a detailed methodology and examples, but no recommendations for criteria or limits as these are the responsibility of the relevant regulatory authorities.

## 6.0 ECONOMICS

The Australian Wind Energy Association (AusWEA) commissioned a study on the cost of wind energy in 2004, which found that the cost of wind is declining at a rapid rate (Figure 7). The production cost of both wind turbines and the electricity they produce has declined by 75% over three decades. The report estimated that Australian wind power prices would converge with the cost of coal and gas within 15 to 20 years time, provided that the Australian wind industry keeps up with international growth (Figure 8).

Growth of capital expenditure on wind farms has been rapid over the last two years and is forecast to continue at an extraordinary rate. Total expenditure of approximately 1.62 billion AUD is expected by 2007 under the current MRET. In 2004, AusWEA prepared a wind energy investment map, which calculated the potential investment from all proposed wind farm projects in Australia. The 4,850 MW of projects under

consideration in May 2004 were estimated to hold the potential to create total capital investment of 8.7 billion AUD for the nation.

## 7.0 INDUSTRY

### Manufacturing

Australia has a small but viable manufacturing industry for wind turbines. The manufacture of 5-kW to 20-kW turbines for export is another growing Australian industry. Demand for large wind turbine generator components has developed a vibrant domestic industry for steel tower manufacture. Currently, the Australian content of new wind farms is estimated at about 50% of total requirement, with the balance largely coming from Danish and German manufacturers.

The emerging Australian wind industry is beginning to deliver real manufacturing jobs in regional Australia with over 250 new direct jobs currently being created in Victorian, Tasmanian, and South Australian manufacturing facilities and many more direct and indirect jobs in transport, installation, operations, and management.

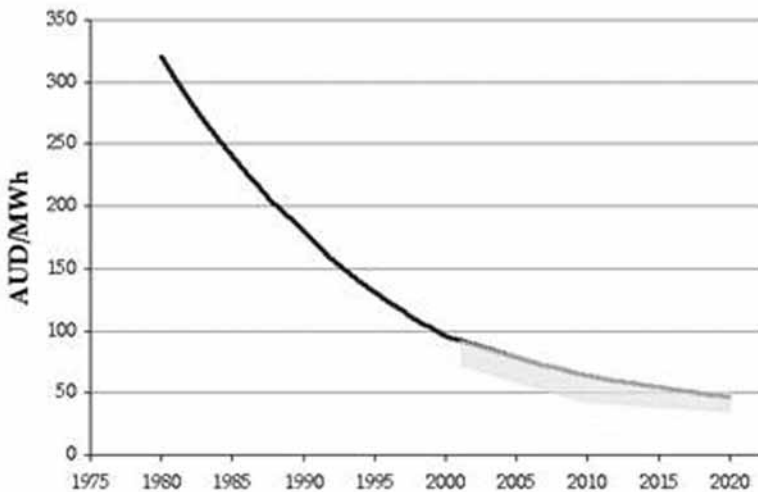


Figure 7 The declining cost of wind power.

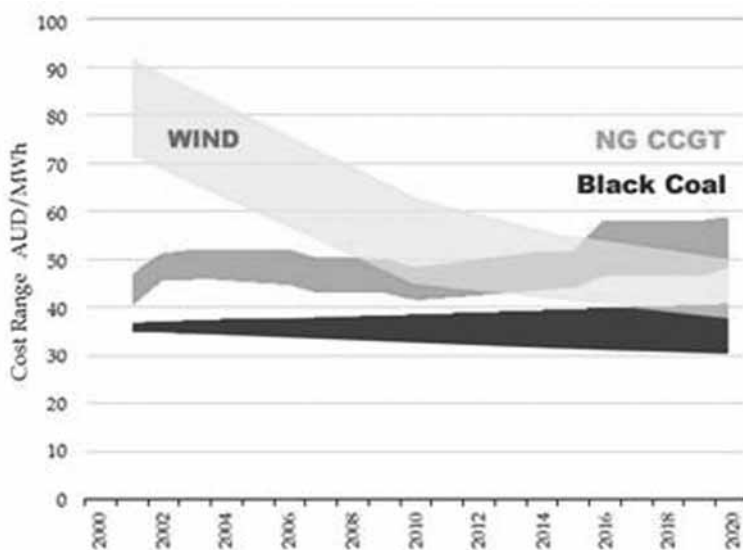


Figure 8 Cost convergence of wind and fossil fuels

Manufacturing in Australia of turbine blades has been the subject of feasibility studies by some of the world's largest manufacturers since the MRET was announced. The key impediment has been guaranteeing demand for sufficient numbers of machines to justify the start-up costs for such facilities. The states of Victoria and Tasmania are the most likely locations for proposed blade plants. International manufacturers state that they are attracted to Australia as a location because it is well situated to export throughout the Asia-Pacific region, and because it possesses political stability, well-developed infrastructure, and an array of other positive social, economic, and financial factors.

### Industry Development and Structure

The wind industry in Australia consists of a range of different types of companies. Wind farm developers and owners include private equity investors, public companies, government-owned generators, and utilities both from within Australia and offshore. The industry is also serviced by a wide range of companies both public and private providing materials, specialist expertise, labor, and ancillary services including finance.

### 8.0 GOVERNMENT SPONSORED R&D

New government R&D sponsorship came through the Federal government's White Paper on Energy and the Environment in the form of the Low Emissions Technology Fund and funding programs from the Australian Greenhouse Office (AGO), state government sustainable energy organisations, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and universities.

#### Australian Greenhouse Office Initiatives

The key AGO programs of benefit to wind energy projects are the Renewable Energy Commercialisation Program (RECP), Renewable Energy Industry Development Program (REID), and Renewable Remote Power Generation Program (RRPGP).

RECP has conducted six rounds of project thus far. Under the last round of the Commercialisation component and the Industry Development component, the following three projects were funded.

- Powercorp Pty Ltd has received a 1 million AUD grant for the commercialisation of its Intelligent

Power Systems Wind/Diesel/Energy Storage technology to enable successful marketing and installation of this innovation in Australia and overseas.

- Wind Corporation Australia Limited received a 238,400 AUD award to produce Comprehensive Guidelines for the Development of Embedded Wind Farms Connected in Rural Australia.
- Wind Energy Research Institute of CSIRO Land and Water received a 38,600 AUD award to produce a Planners Guide for Wind Resource Assessment in Australia.

REID supports the growth of the Australian renewable energy industry, mainly through grants to Australian companies, which demonstrate that their projects would assist the wider development of the Australian renewable energy industry. Under the most recent REID round in March 2003, AusWEA received 170,000 AUD to develop assessment protocols and dataset standards with regard to wind turbine impacts on birds and bats, and to develop and disseminate a range of educational material on Australian wind farms.

RRPGP provides financial support to increase the use of renewable energy generation in remote parts of Australia that presently rely on diesel for electricity generation. The objectives are to (1) Help provide an effective electricity supply to remote users; (2) Assist the development of the Australian renewable energy industry; (3) Help meet the energy infrastructure needs of indigenous communities; and (4) Lead to long-term greenhouse gas reductions. More than 200 million AUD is expected to be available over the life of the RRPGP supporting up to 50% of the capital costs of renewable generation equipment.

### Other Initiatives

In 2003, the Sustainable Energy Authority of Victoria (SEAV) funded the development of a Victorian Wind Atlas and Map, which was released in January 2004.

This product seeks to increase the quality of publicly available information about the state's wind resource. Average annual wind speeds were modeled using the WindScape wind resource mapping tool developed by the Wind Energy Research Unit of CSIRO Land and Water. WindScape uses atmospheric data and regional topography to model wind resource. The wind speeds have been modeled at 65 m a.g. to a resolution of three kilometers.

Commonwealth Scientific and Industrial Research Organisation (CSIRO) is Australia's premier scientific organisation. It makes its major contribution to wind energy research through its Wind Energy Research Unit (WERU). The WERU has primarily focused on developing capabilities for regional wind assessment tools and modeling wind flow over complex topography.

RESLab is a testing laboratory for renewable energy components and systems. Formerly a project of ACRE at which time it was known as ACRESLab, the lab was shifted to a new center within Murdoch University called the Australian Sustainable Energy Centre (ASEC) near the end of ACRE's term. Continuing under the name RESLab, the laboratory provides testing, design, certification, and training services for the renewable energy industry. It also conducts standards development, product development, research, and commercial consultancies.

The University of Newcastle Wind Energy Group's research focuses on small wind turbines. As a consequence of past research, three turbines have been designed for remote area power systems (RAPS): a 0.6kW machine being marketed by Australian Wind Power, a 5-kW turbine being manufactured in China, and a 20-kW prototype. Aerodynamics and structural dynamics are the two main areas of the current research program.

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## CHAPTER 5

# CANADA

### 1.0 INTRODUCTION

Canada ratified the Kyoto Protocol in 2002 and is pursuing the implementation of wind energy as part of its response to the Climate Change Challenge. In addition, the country supports the development of this renewable resource to achieve the goals of energy diversification, technology development, job creation, and increased trade. Canada has tremendous wind energy potential, and federal and provincial governments support its deployment through an increasing number of incentive programs. The main vehicle of technical support at the national level is the Wind Energy Research and Development (WERD) Program, at Natural Resources Canada, a department of the federal government of Canada. In 2002, Canada introduced the Wind Power Production Incentive, a 260 million Canadian Dollar (CAD) program to accelerate the introduction of wind energy in Canada. This program is currently almost all committed, and Canada has recently announced its intention to quadruple its scope.

### 2.0 NATIONAL POLICY

The main elements of the Wind Energy R&D program are: Technology Development, Resource Assessment, Test Facilities, and Information/Technology Transfer. Field trial projects are selected to evaluate the performance of the new technology under special environmental conditions or for specific applications.

Although there are no national wind energy deployment targets, the federal government's Wind Power Production Incentive (WPPI) program ensures the provision of economic incentives for up to 1,000 MW of new installed capacity by 2007. Under the new commitment, the program aims to have installed capacity of 4,000 MW by 2010. This program is presently the main driver for wind energy deployment in Canada. Other levels of government support the development and expansion of the wind energy industry to varying degrees, and installed capacity is set to grow quickly (see following sections).

### 3.0 COMMERCIAL IMPLEMENTATION

#### Installed Wind Capacity

By December 2004, a total of 444 MW of wind power had been installed in Canada. This is an increase of 127 MW from last year's 317 MW or a 40% increase. Alberta currently has the highest installed capacity, totaling 275 MW; however, both the provinces of Quebec and Ontario have awarded contracts for 990 MW and 355 MW respectively to be built during the next few years. New installations in 2004 include Vision Quest's Summerview Wind Farm Phase 1 (68 MW) and Suncor-Magrath Wind Farm (30 MW) both in Alberta. Other provinces have seen small phases of wind farms installed, as preludes to larger installations that will be done in 2005. For example, a first phase of 9 MW was installed in 2004 in Quebec province that is part of two projects totaling 108 MW which will be coming online by end of March 2005.

Installed wind power capacity in Canada has experienced an average annual growth rate of 44% over the past five years. Though average growth is high, it has varied widely from year to year. Large capacity additions occurred in 1999 (100 MW) and 2001 (77 MW) but it was only 18 MW in 2002 and 90 MW in 2003. For Canada, 2005 is expected to be a very good year, even though the wind farm developers will have to compete for equipment with projects in the United

States that will be increasing due to the renewal of the production tax credit incentive there.

## Contribution to National Energy Demand

The national electrical energy demand in Canada in 2004 was 602 TWh. Total installed generation capacity at the end of 2003, the most recent year for which statistics are available, was projected at 112 GW, which includes hydro power, coal, nuclear, natural gas, oil-fired, wood-fired, tidal, and wind plants. The installed wind capacity was 317 MW by the end of 2003, and an estimated 765 GWh of wind energy was produced that year.

## 4.0 MARKET DEVELOPMENT AND STIMULATION INSTRUMENTS

Currently, Class 43.1 of the federal Income Tax Act provides 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. Recently, the tax write off has been increased from 30% to 50% per year, on a declining balance basis.

The government has also extended the use of flow-through share financing for intangible expenses in certain renewable projects, through the Canadian Renewable and Conservation Expense (CRCE) category in the income tax system. With CRCE, the Income Tax Act allows the first, exploratory wind turbine of each section of a wind farm to be fully deducted in the year of its installation, in a manner similar to the one in which the first, exploratory well of a new oil field can be written off.

The federal government has established a Green Power Purchase program. This program allows developers to sell electricity, generated by wind and other forms of renewable energy, to the government at premiums negotiated through a competitive process. As a byproduct of the federal program, wind power producers have built additional wind plants, and green energy is being sold to private, provincial, and municipal consumers.

The most influential market stimulation instrument so far is the federal government's Wind Power Production Incentive (WPPI) program for wind energy developers. Qualifying wind energy facilities receive an incentive payment of 0.01 CAD per kWh of production. The incentive is available for the first 10 years of production and helps to provide a long-term stable revenue source. The program is intended to help address climate change and improve air quality. Originally slated for 1,000 MW to be built by 2007, the program has recently been expanded to 4,000 MW to be built by 2010.

Interest in WPPI has been high. By December 2004, the program had registered Letters of Interest applications totaling 192 projects and 11,000 MW of capacity. Based on the quantity and quality of the applicants, it is expected that 2005 will be a watershed year for wind power development in Canada. Provincial and territorial governments are being encouraged to provide additional support, and a number of provinces have begun to develop their own complementary programs. For example, Quebec has awarded contracts for 990 MW and is expected to launch another Request for Proposals (RPS) for 1,000 MW to be built between 2006 and 2012. Ontario has also recently awarded contracts for 355 MW to be built by 2007 and is expected to launch another RPS for 2,500 MW of clean energy production. Both of these provinces and Nova Scotia intend to provide net-metering for small wind projects. Other provinces have set goals and/or RPS for wind energy.

The just-completed Wind Energy Atlas is a massive database of high-resolution wind statistics for all of Canada, making Canada one of the largest countries in the world to have a comprehensive Wind Energy Atlas across its entire territory.

The Wind Energy Atlas was created with WEST, the Wind Energy Simulation Toolkit, a sophisticated computer modelling program developed by scientists with Meteorological Service of Canada (MSC), in partnership with their colleagues at Natural Resources Canada. WEST allows planners of wind energy projects to look both backward and forward in time to generate a detailed picture of wind patterns for any location in Canada. This means wind farms can be situated



with greater precision, and, by reducing the need for extensive field studies to verify wind conditions in a given area, development of new projects can move much more quickly. The Atlas can be found on the internet at:  
<http://www.windatlas.ca>.

## 5.0 DEPLOYMENT AND CONSTRAINTS

The following wind turbines are deployed and operational in Canada: 66 US Windpower (Kenetec) 360-kW and 375-kW wind turbines; one NEG-Micon 900-kW and 136 NEG-Micon 750-kW machines; 20 Nordex 1.3-MW wind turbines; 232 Vestas V47 660-kW and 53 Vestas V80 1.8-MW wind turbines, 2 Vestas 3-MW machines; 4 Lagerway 600-kW machines, one 750-kW Lagerway machine, one Enercon E 40 600-kW machine, one Turbowinds 600 kW wind turbine, one Tacke 600-kW unit, and a handful of turbines with capacities of 150 kW and less. Most of the wind turbines presently operating in Canada are privately owned, which makes it very difficult to obtain their operating performance data.

The main constraints for wind energy development in Canada are the lower cost of conventional energy and a surplus of generation capacity in many areas. However, in a few jurisdictions these factors are changing. In some provinces, such as Alberta and Ontario, surplus generation is rapidly declining. In addition, the production incentive allows wind-based electricity generation to be more competitive with conventional forms, particularly in those regions where the provincial governments choose to contribute.

## 6.0 ECONOMICS

### Trends in Investment

The budgets for the Wind Energy R&D (WERD) program, for the Fiscal Years 2004/05 and 2005/06 are about 1.5 million and 1.75 million CAD respectively. All the partners in the projects (contractors, research institutions, and provinces) will collectively match the WERD contributions, doubling the budgets for the R&D projects.

The Canadian government's Technology Early Action Measures (TEAM) program provides funds for activities falling under the Climate Change initiative, which include renewable energy deployments. The funds from this program can be accessed for wind energy projects that involve nearly developed technologies ready for field trial in the short term.

The WPPI program is an incentive on production given directly to the developers of wind farms. It represents about 0.01 CAD/kWh for a ten-year period. Slated originally for 1,000 MW to be built by 2007, it has recently been expanded to 4,000 MW to be built by 2010.

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

Electricity deregulation in Alberta resulted in the restructuring of government-owned utilities into a free-market system. Full retail competition between power generators began on 1 January 2000. This process has allowed wind generators freer access to the electrical grid. In Ontario, a similarly deregulated system commenced on 1 May 2002. However, a few short months later, the provincial government, under political pressure for rising electricity prices, capped the generation component of the cost to small consumers, effectively freezing the rates for four years. This is viewed as a setback to private generators, some of which have been considering wind power projects. Nevertheless, incentives for renewables, now being finalized, are expected to offset the impacts of the rate cap. In all other Canadian jurisdictions, the buy-back price is generally set by the local utility and based on avoided costs.

## 7.0 INDUSTRY

Industries that are related to wind energy include manufacturers of rotor blades, control systems, inverters, towers, and small wind turbines as well as wind resource assessment firms and wind farm developers.

The following manufacturers are operating in Canada. Wenvor Technology of Guelph, Ontario and Plastique Gagnon of Quebec are developing small wind turbines

in the 20-30 kW size. Novelek Technology of New Brunswick has developed 10- and 25-kW inverters for the commercial wind turbine market. Composotech Structures of Goderich, Ontario is manufacturing blades for 10-kW to 1.5-MW wind turbines. The company produces rotor blades on speculation for wind turbine manufacturers and also has a generic blade design, suitable for turbines in the 750 to 900 kW range.

## 8.0 GOVERNMENT SPONSORED R, D&D

The focus of the Canadian national wind energy program continues to be on R&D to develop safe, reliable, and economic wind turbine technology to exploit Canada's large wind potential, as well as supporting Field Trials. The program also supports a national test site: The Atlantic Wind Test Site (AWTS) at North Cape, Prince Edward Island for testing electricity generating wind turbines and wind/diesel systems.

The program supports new technology development activities related to:

- components for wind turbines in the 600 kW to 2 MW range;
- small to medium size wind turbines (10 kW to 275 kW) for use in agro-business, and to supplement diesel-electricity generation in remote communities;
- wind/diesel control systems for wind/diesel hybrids in remote communities.

The government is studying the impacts and regulation of offshore wind farms in the context of large projects off the coast of British Columbia in the Pacific and in the Great Lakes of Ontario.

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## CHAPTER 6

## DENMARK

## 1.0 INTRODUCTION

The utilization of renewable energy has played an important role in Danish energy policy over the last decades. The main objective of Danish energy policy has varied since the energy crisis in 1973, but renewable energy has continuously been one of the key focus areas. As a result, the development and practical application of renewable energy technologies already has contributed to enhancing security of supply and reduction of the environmental impact from energy production. At the same time, the promotion of renewable energy has meant economic growth by means of exports and new jobs.

The development of wind energy has been a commercial success story. Since the first commercial wind turbines were constructed around 1980, there has been tremendous growth in technological development and turnover. Modern Danish wind turbines produce about 100 times as much electricity as the first commercial wind turbines of 1980; over the last decade, the annual global sales of Danish wind turbine manufacturers have grown from about 200 MW a year to more than 3,000 MW a year. The global market share of the Danish wind turbine industry over the last few years has been around 40%.

In Denmark, more than 300 MW of wind capacity have been installed per year over the last eight years. The exception has been 2004, when only a few new turbines were installed. The total wind power capacity

by the end of 2004 was 3,118 MW. Out of this capacity, 2,700 MW was operating onshore and 418 MW offshore. In 2004, the electricity produced from wind energy covered 18.5% of the country's electricity demand (35,500 GWh).

## 2.0 NATIONAL POLICY

## Latest Strategy

On 29 March 2004, the Minister for Economic and Business Affairs entered an agreement with six of the coalition parties (V, K, S, SF, RV, KD) on the construction of new offshore wind farms and the replacement of wind turbines in unfavorable locations with erection of new wind turbines in other places. This agreement also calls for increased R&D and demonstration of advanced energy technologies. The objective is, above all, to ensure that electricity is sold under market conditions. The main points of relevance for wind energy are given below.

Offshore wind farms are seen as a way to enhance the long-term reliability of energy supply and continue diversification of power supply to a wide range of energy sources. To support continued development of wind-energy technology, the parties agreed to ensure the basis for construction of two offshore wind-farms, each with a capacity of 200 MW. This process will begin with a call for bids. The locations proposed will be Horns Rev and Rødsand.

The consumer obligation to purchase electricity produced from wind energy is being fully replaced with financial support in accordance with the transition regulations in force. Also, the low rate of interest could make it advantageous for wind turbine owners to convert previous loans to new obligation loans with land collateral. For existing wind turbines that are no longer covered by the transition regulations, a simplified calculation of the market price will be offered, as well as a subsidy of up to 0.36 Danish Kroner (DKK)/kWh. As part of the changes, the market price is fixed

as a monthly average and is no longer based on the spot price for each individual hour of production.

New re-powering regulations include the removal of approximately 900 older wind turbines with capacities up to 450 kW. The aim is to establish a new overall capacity of up to 350 MW within the next five years. Re-powering will be subsidised at a rate of 0.12 DKK/kWh, paid in connection with production of new wind turbines during 12,000 full-load hours, for twice the installed effect of the scrapped wind turbine. If the average monthly discount price for wind turbine producers exceeds 0.48 DKK/kWh in any month, re-powering credits will be reduced accordingly.

The system operators of the national transmission grid conduct a public service obligation (PSO) program for research, demonstration, and development projects for the expansion of an environmentally friendly and reliable electricity supply system in Denmark. The PSO program run by the system authority will be increased by 30 million DKK to 130 million DKK per year over four years.

### Progress Toward National Targets

The electricity from wind energy alone covered 18.5% of the total electricity consumption in 2004. This fulfilled the major part of the target of 2003, which was 20%. No new targets have been set, but, according to the energy policy agreement, a national action plan will be prepared for the infrastructure through

2010 as part of a long-term action plan. The goals are to secure a greater degree of security of supply, to establish well-functioning competitive markets, and to accommodate renewable energy. The action plan will also describe the future energy supply, the interplay and integration of different energy technologies, and the perspectives for future energy supply up to 2025, including use of new energy technologies.

The action plan covers the larger transmission cable links in Denmark and improvement and new construction of foreign links. Experience with an open electricity market shows that if production capacity is to be fully exploited, both a well-functioning electricity market and a comprehensive transmission grid that can ensure free movement of energy both domestically and across national borders are necessary. In addition, there is a need to enhance certain foreign links and parts of the grid in Denmark. On the basis of the action plan, the Danish government will prepare relevant proposals for parliamentary decisions. The action plan will be presented for the Parliament in 2005.

### 3.0 MARKET DEVELOPMENT AND STIMULATION INSTRUMENTS

#### Main Support and Incentives

The electricity bill adopted by the Parliament on 9 June 2004 specifies the cost for access and connection of wind turbines to the grid and the premium paid on top of the market price. According to the original bill

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Notes for Table 1 (next page):

1. Scrap certificates are given for the production from new turbines installed in the period from 1 January 2005 to 31 December 2009 for a capacity equivalent to 2 times the capacity of dismantled turbines up to 450 kW within a total of 175 MW of dismantled turbines.

2 Scrap certificates are given for the production from new turbines installed in the period from 3 March 1999 to 31 December 2003 for a capacity equivalent to 3 times a capacity of the dismantled turbines of up to 100 kW and to 2 times the capacity of the dismantled turbines between 100 and 150 kW (if within a distance of 2.5 km from a dismantled 100-kW turbine).

3. Until it has been decided to implement green certificates, a premium of 0.10 DKK/kWh is paid.

4. Wind turbine owners must pay for trade- and balancing cost and are compensated for that with 0.023 DKK.

5. The system operator is responsible for selling the electricity on the spot market.

Turbine category	Production category	Transition time from origin	Special premium paid [DKK/kWh]	Certificates or premium paid for 20 years <sup>3</sup> + net balancing <sup>4</sup> [DKK/kWh]	Total (example based on a market price at 0.20 DKK/kWh) [DKK/kWh]
A) Turbines installed from 2005				+ 0.10 + 0.023	0.323
	Production from capacity installed with Scrap Certificates (2005–2009) <sup>1</sup>	12,000 full load hours	+ 0.12	+ 0.10 DKK/kWh Cap 0.48 for market + premiums + 0.023	0.443
B) Turbines installed 2003–2004				+ 0.10 Cap of 0.36 for market+ premiums + 0.023	0.323
	Production from capacity with Scrap Certificates (2003–2004) <sup>2</sup>	12,000 full load hours	+ 0.17	+ 0.10 Cap 0.60 for market + premiums + 0.023	0.493
C) Turbines installed 2000 –2002	Production from turbines installed on land	22,000 full load hours	+ Difference between market price and 0.33	+ 0.10	0.430
	Production capacity with Scrap Certificates (2001–2002) <sup>2</sup>	12,000 full load hours	+ Difference between market price and 0.33 + 0.17	+ 0.10 Cap 0.60 for market + premiums	0.600
	Production from turbines installed offshore	10 years	+ Difference between market price and 0.33	+ 0.10	0.430
D) Turbines owned by electricity companies	Production from turbines installed on land from 2000	10 years	+ Difference between market price and 0.33	+ 0.10	0.430
	Production from turbines installed offshore from 2000	42,000 full load hours	+ Difference between market price and 0.353	+ 0.10	0.453
E) Turbines < 25 kW	Production from turbines installed on land in own grid installation		+ Difference between market price and 0.60	No <sup>5</sup>	0.600

**Table 1 Purchase prices for electricity by the end of 2004 (1 euro is 7.46 DKK).**

from December 2003, renewable energy certificates should be issued for electricity produced from renewable energy, but the introduction of these certificates has been postponed and the certificates have been temporarily replaced by a premium of 0.10 DKK/kWh. All wind turbines except those installed by the utility sector before 2000 can obtain certificates or the premium for 20 years. In 2004, the market price plus premium varied between 0.28 and 0.34 DKK/kWh.

However, a large number of the existing turbines are still in the transition period according to the rules introduced in 1999, which depend on size and age. The average purchase price for electricity from these private wind turbines could vary between 0.43 DKK/kWh and 0.58 DKK/kWh. The detailed rules are specified in Table 1.

Present deployment activities on land are mainly due to the schemes for re-powering of old wind turbines. The first scheme was valid through 2003 and resulted in the dismantling of nearly 1,500 turbines (approximately 150 MW). As earlier mentioned, a second re-powering scheme has been introduced late in 2004 giving owners of wind turbines up to 450 kW within a lump of 175 MW an extra premium of 0.12 DKK/kWh on top of the 0.10 DKK/kWh premium. The scheme runs for five years. Details of both re-powering schemes are included in Table 1.

No changes have been introduced regarding taxation, and today income from wind turbines, by and large, is taxed as any other income.

### Offshore Wind Farm Concession

Based on the Danish energy policy agreement regarding wind energy and decentralized combined heat and power of 29 March 2004, the Danish Energy Authority in July 2004 offered for tender an offshore area for the establishment of the second offshore wind farm at Horns Rev in the North Sea. The tender concerns a concession including a license to carry out preliminary surveys and the right to exploit the wind energy from an offshore wind farm of 200 MW. The award criteria, which will be used in the selection of the concession owner, include the kWh price, the location and design of the project, and the timetable

for implementation of the project. Candidates interested submitted a request to participate in order to be considered for prequalification by 1 September 2004. The Danish Energy Authority received four applications from Energi E2 A/S, Elsam Kraft A/S, DONG VIND A/S, and the Consortium Horns Rev II (comprises seven developers and investment companies). Late in 2004 DONG VIND A/S withdraw their application.

A second tender for the other 200-MW wind farm was offered in December 2004 at the site of Rødsand. In order to form the basis for that decision, the Danish Energy Authority had completed a screening of the sea areas at Rødsand, Gedser Rev, south of Læsø in Kattegat, Lysegrund north of Zealand in Kattegat, Kriegers Flak the Baltic and Omø Staalgrunde.

### Wind Turbine Certification

Wind turbines installed in Denmark have to fulfill the Danish Certification Scheme. In December 2004, a new scheme was introduced in place of the former Type Approval Scheme. The new scheme is based on the IEC WT01 System for Conformity Testing and Certification of Wind Turbines. The Implementation of the IEC system means a higher degree of mutual recognition of certificates between countries and therefore easier access for all manufactures to sell their products internationally. The certification bodies providing services according to the new scheme now can operate based on an accreditation given by any internationally recognized accreditation body. Those bodies authorized by the Danish Energy Authority in 2004 under the old scheme are listed in Table 2. The Danish Energy Authority is responsible for administration of the scheme. Risø National Laboratory acts as secretariat and information center for the scheme. All documents related to the certification scheme can be found on the web site: [www.wt-certification.dk](http://www.wt-certification.dk).

## 4.0 DEPLOYMENT

The total capacity of wind power in Denmark increased to 3,118 MW by the end of 2004, with 2,375 MW in western Denmark and 743 MW in eastern Denmark. The total number of turbines was 5,398. During 2004, the number of new wind turbines was only 12 and 6

Service	Authorized body
Type approvals of wind turbines	Det Norske Veritas Germanischer Lloyd Tüv Nord
Production and installation certification	Germanischer Lloyds Certification GmbH Det Norske Veritas Certification of Mgt. Systems Bureau Veritas Quality Assurance
Basic tests	Risø, Test & Measurements Tripod Consult Aps Wind Test GmbH Ingenieurbüro für Windenergie
Power curve measurement	Risø, Test & Measurements DEWI, Wilhemshafen Tripod Consult Aps Wind Test GmbH Windconsult GmbH Ingenieurbüro für Windenergie
Testing of systems and concepts	Risø, Test & Measurements
Blade testing	Risø, Sparkær blade test centre
Noise measurement	DEWI, Wilhemshafen Wind Consult GmbH Wind Test GmbH DELTA Akustik & Vibration + bodies approved by DELTA

**Table 2 Companies authorized by the Danish Energy Authority to provide services under the Danish scheme for certification for wind turbines in 2004.**

were dismantled. The average capacity of the turbines installed in 2004 was 0.817 MW.

The deployment rate in Denmark in numbers and accumulated capacity are shown in Figure 1. The deployment has been almost constant from 1996 to 1999, adding approximately 300 MW of wind power capacity onshore annually. In 2000 and 2003, the installed capacity varied including nearly 400 MW offshore. In 2004, few new turbines were installed.

In the same period, more than 1,600 old wind turbines amounting to a capacity of 160 MW were removed.

The average size of new wind turbines has grown gradually from 750 kW in 1999 to 2 MW in 2003. In 2004, the average size was smaller because no new offshore turbines were installed. The development in wind turbine size is illustrated in Figure 2.

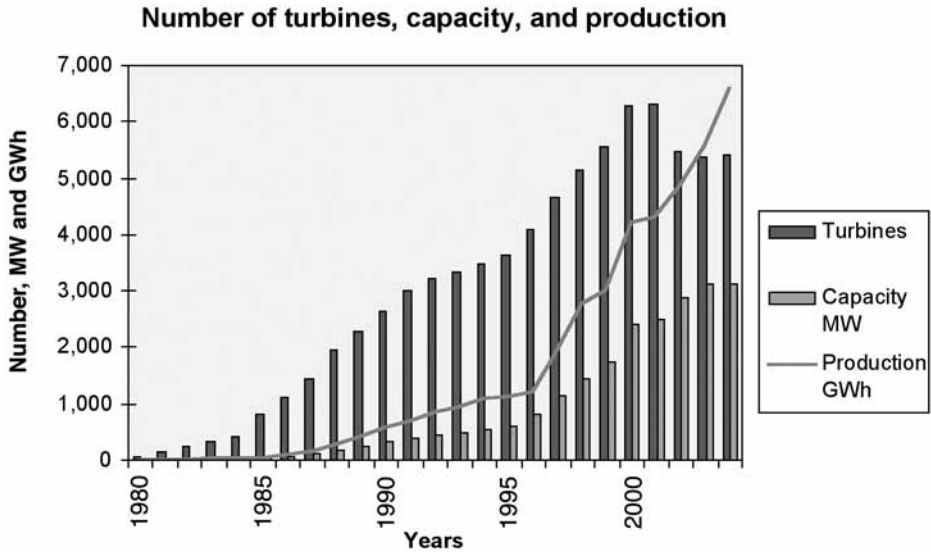


Figure 1 Development in number of wind turbines and accumulated electrical capacity and production in Denmark.

### Contribution to National Energy Demand

The total electricity production from wind energy in 2004 was 6,580 GWh, corresponding to about 18.5% of the total electricity demand in Denmark. The wind index describes the energy in the wind for the year, compared to a normal year. In 2004, the wind index was similar to those of the previous five years, relatively low at approximately 90%. Wind energy production with a wind index 100% would correspond to about 20% of the electricity demand. The development in the wind energy index is shown in Figure 3.

### Wind Turbines Deployed

Several different groups own wind turbines: private individuals, private co-operatives, private industrial enterprises, municipalities, and power utilities.

Wind turbines on land in Denmark have typically been installed in clusters of three to seven machines. Clusters of wind turbines are preferred in the spatial planning by local and regional planning authorities. In a few places, larger wind farms are allowed.

Denmark's largest wind farm on land (in capacity) is still Rejsby Hede from 1995 with 39 600 kW-turbines (21.4 MW). The largest turbines on land are five 3.0-MW turbines and five 2.75-MW turbines installed in 2002 at special sites. At the Risø testsite at Høvsøre a 3.6-MW and a 4.2-MW turbine are being tested.

The two largest wind farms are offshore. The 160-MW wind farm at Horns Rev consists of 80 Vestas 2-MW wind turbines placed in the North Sea, 14 to 20 km offshore at Blaavands Huk (Figure 4). The Nysted wind farm south of Lolland is located in inland waters and consists of 72 Bonus 2.3-MW wind turbines (Figure 5) (Table 3). Both are owned by large energy companies, whereas the 40-MW Middelgrunden offshore wind farm is a 50/50 shared ownership between a private cooperation and a utility.

A smaller 23-MW offshore wind farm is located about 4 km south of Samsø. It consists of ten Bonus 2.3-MW wind turbines and was completed in 2003. It is owned jointly by utility and private investors. The turbines are 100 m high and are erected on monopiles.

In Nissum Bredning close to a chemical factory in Northwest Jutland, the Rønland offshore wind farm



Turbines installed per year and average capacity

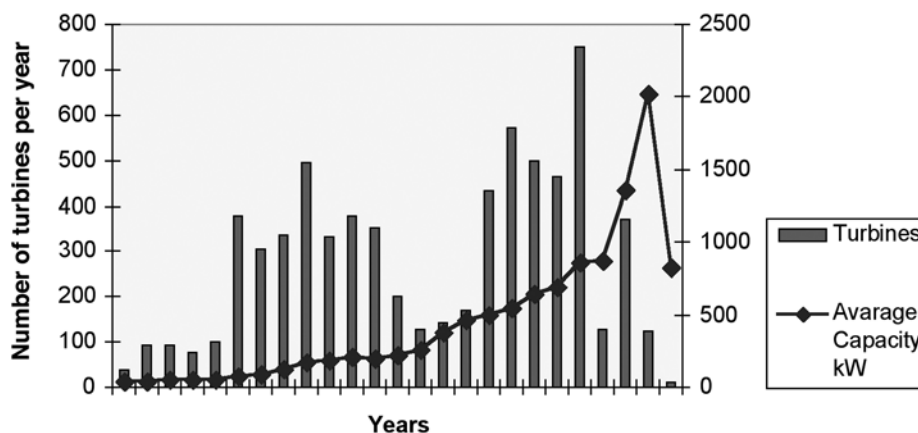


Figure 2 Development of the average capacity of wind turbines installed in Denmark.

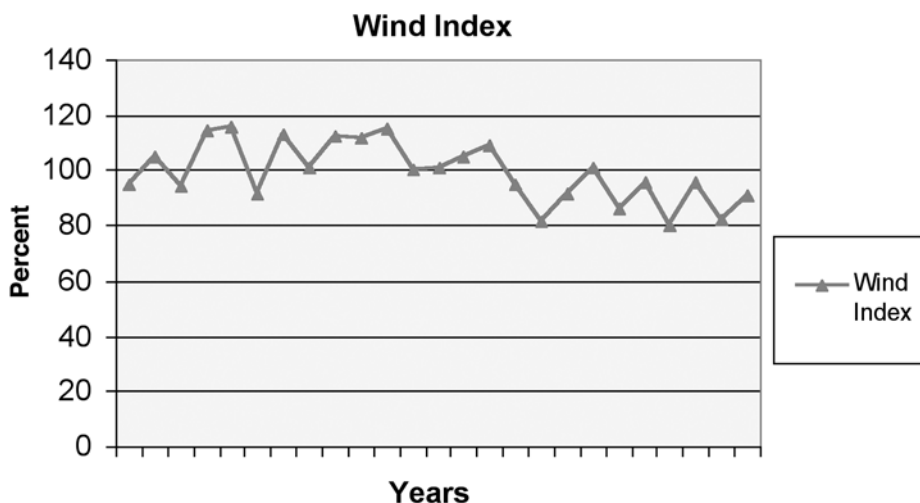


Figure 3 Annual energy in the wind in Denmark, illustrated by the wind energy index.

was put into operation early in 2003. It consists of four Bonus 2.3-MW turbines and four Vestas 2-MW turbines.

Finally, an experimental offshore wind cluster of four wind turbines was established by Elsam on a harbour site in Frederikshavn. It consists of two 3-MW Vestas turbines, one 2.3-MW Bonus turbine, and one 2.3-MW Nordex turbine.

## Operational Experience

Technical availability of new wind turbines in Denmark is usually in the range of 98% to 100%. Operation and maintenance costs including service, consumables, repair, insurance, administration, lease of site, etc. for turbines between 55 kW and 600 kW



**Figure 4 Offshore wind farm at Horns Rev, 160 MW. Published with the permission of ELSAM.**

have been previously analysed by the Danish Energy Authority, E&M-Data, and Risø National Laboratory and reported in earlier IEA wind annual reports. (See [www.ieawind.org](http://www.ieawind.org))

Based on a new study carried out by the Danish Wind Turbine Owners Association, some preliminary results on the operational experience of turbines between 600 kW and 1300 kW are shown in Figure 6.

## 5.0 DEPLOYMENT AND CONSTRAINTS

### Main Constraints on Market Development

For nearly a decade, the Danish market for wind turbines has been large and remarkably constant. It has been expected that the market would slow down eventually due to limitations in future electricity purchase prices.

In certain regions of Denmark, the deployment of wind energy has now reached a point of saturation with respect to spatial planning. The development of the inland market will therefore mainly be tied to re-powering of smaller wind turbines with new megawatt-scale machines.

In 2002, the re-powering program and the offshore development kept the market up. However, in early 2003, the new liberal market-based price system went into effect with a cap of 0.36 DKK/kWh including CO<sub>2</sub> compensation. As a result, private investment in new wind turbines on land came to a complete stop except for the re-powering scheme.

Wind farm characteristics	Horns Rev wind farm	Nysted wind farm
Installed capacity [MW]	160.0	158.4
Number of turbines	80	72
Wind turbine type	Vestas 2-MW	Bonus 2.2-MW
Expected annual production [GWh]	600	595
Hub height [m]	70	70
Wind farm area [km <sup>2</sup> ]	20	24
Water depth [m]	6.5–13.5	6–9.5
Distance to shore [km]	14–20	10
Distance between rows [m]	560	850
Distance between turbines in rows [m]	560	480
Internal grid voltage [kV]	34	33
Transmission to shore voltage [kV]	150	132

**Table 3 Main data of the two large Danish wind farms at Horns Rev and Nysted.**



Figure 5 Offshore wind farm at Nysted, 158 MW. Published with the permission of Energi E2.

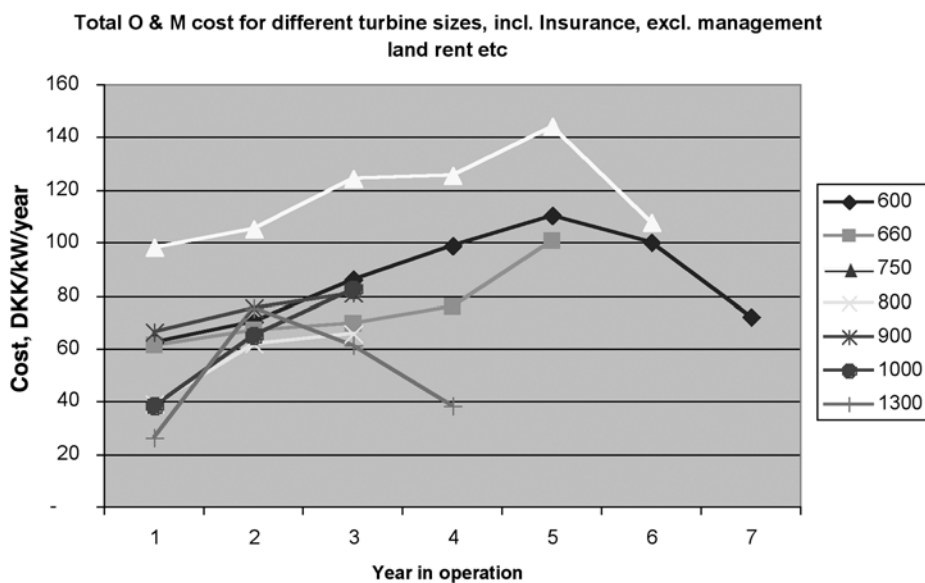


Figure 6 Total O&M cost for different turbine sizes, including insurance, excluding management, land rent, etc.

According to law, the right to exploit energy from water and wind within the territorial waters and the economic zone (up to 200 nautical miles) around Denmark belongs to the Danish government.

Representing the government, the Danish Energy Authority handles approval of electricity production from water and wind and pre-investigation of such within the national territorial waters and within the economic zone belonging to Denmark.

The experiences so far are that many interests have to be accounted for before permission can be given. The government has therefore decided that permission only will be given according to a tendering procedure for specific areas. In addition, the impact on the environment must be documented by an environmental impact assessment for each project.

### Electricity Surplus

A possible constraint to the future deployment of wind energy into the Danish energy system is maintaining the power balance or dealing with the electricity surplus. Due to the high share (~50%) of electricity from combined heat and power (CHP) and the high share (~25%) from renewable electricity (mainly wind power), a substantial part of the Danish electricity production is influenced by weather conditions (outdoor temperature and wind speed). This limits the system's ability to adapt to quickly changing electricity prices on the market. On cold, windy nights, an electricity surplus may arise. On one hand, this is a successful demonstration of how far CHP and electricity from renewable energy can be developed. On the other hand, it poses a new challenge to the electricity system in general and the system operators in particular to handle the fluctuating electricity production.

Electricity surplus is generally exported. If it is not physically possible to export the entire surplus, a critical situation arises which can require the wind capacity to be reduced. This happens already today in the western part of Denmark with increasing frequency.

The economic benefit of utilizing the surplus (rather than exporting it) depends on the price on the power

market and on the environmental value of electricity export from Denmark. In general, more flexibility in the power production and demand will be appropriate to be able to respond to market conditions.

## 6.0 ECONOMICS

### Trends in Investment

New information on investment costs is not available for 2004, because the onshore Danish market was very small and the new large offshore projects were only in the planning process. For the recent megawatt-sized machines, the ex-works cost might be slightly higher per kilowatt of capacity. However, for these large machines, the wind resource at rotor height is larger and the harvest of wind energy therefore better. This means that the total economy of the megawatt-scale projects should be better.

Availability of capital for wind power projects is not a problem in Denmark. Financial institutions compete efficiently on this market, and different financial packages have been developed. Typical projects are financed over 10 years.

Additional costs depend on local circumstances, such as soil conditions, road conditions, proximity to electrical grid sub-stations, etc. Additional costs on typical sites can be estimated to approximately 20% of total project costs. Only the cost of land has increased during recent years.

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

The production cost for wind-generated electricity per kilowatt-hour has decreased rapidly over the last 18 years, and today this cost can compete with the cost of electricity produced from a new coal-fired power station based on condensation.

For the average consumer (4,000 kWh/year), the net electricity price from power distribution utilities was 0.67 DKK/kWh (before tax and VAT) in 2004. This figure comprises subscription, grid and PSO tariff, commercial and prioritized power costs. For private low-voltage consumers, a tax of 0.67 DKK/kWh and

25% VAT is added. In 2004, the total consumer price for Danish low-voltage customers was about 1.67 DKK/kWh. Table 1 gives an overview of the buy back prices.

## 7.0 INDUSTRY

### Manufacturing

Today the major Danish based manufacturers of large commercial wind turbines up to 3 MW size are Siemens Wind Power (former Bonus Energy A/S) and Vestas Wind Systems A/S. Vestas and NEG-Micon merged in 2003. Gaia Wind Energy A/S makes 11-kW machines for electricity to households. Calorius-Weststrup A/S makes a 5-kW heat producing turbine.

A number of industrial enterprises have developed important businesses as suppliers of major components for wind turbines. LM Glasfiber A/S is a world-leading producer of composite blades for wind turbines. Mita Teknik A/S produces controller and communication systems. Svendborg Brakes A/S is a leading vendor of mechanical braking systems. Also, Danish subsidiaries of large international industries such as Siemens, ABB, SKF, FAG, etc. have developed businesses in the wind power industry.

### Industry Development and Structure

Industrial development in 2004 focused on a new generation of 3- to 5-MW turbines as a way to adapt to the emerging offshore wind farms. The largest prototype is the 4.2-MW wind turbine from Vestas (NEG-Micon), which was erected in late 2003 at the Høvsøre test site.

The estimated sales by the Danish wind turbine manufacturers (Vestas and Siemens Wind Power) were 3,219 MW in 2003, which is only slightly higher than the figure for 2002 (3,147 MW). The sales for 2004 are not published yet. The Danish home market in 2004 only amounted to 9.8 MW, considerably less than previous years.

Service and maintenance of the wind turbines in Denmark is carried out by the manufacturers' own service departments. In addition, a handful of inde-

pendent service companies have been established. These are companies such as DWP Mølleservice A/S and DanService A/S. Some of the electricity companies service their own turbines.

Other industrial service enterprises have created important businesses in servicing the wind power industry. For example, companies are specialized in providing cranes for installations of wind turbines; providing transport of turbines, towers, and blades domestically and for export; providing insurance, etc. Companies with expertise in offshore construction and operations in the field of oil and gas activities are now offering their assistance to the wind energy business for offshore wind farms. The major Danish consultancies in wind energy utilization are BTM Consult ApS, E&M Data, Elsam Engineering, WEA ApS, and Tripod ApS. A number of experienced engineering consulting companies such as Carl Bro, Rambøll, Cowi, and others have shown increasing interest and are taking part in wind energy development.

The power production companies Elsam, Energi E2 as well as DONG have entered the wind energy business as developers, owners, and operators of wind farms in Denmark and internationally.

The two major organisations that represent the owners and the manufacturers are: The Danish Wind Turbine Owners' Association ([www.dkvind.dk](http://www.dkvind.dk)) and the Danish Wind Industry Association ([www.windpower.org](http://www.windpower.org)).

## 8.0 GOVERNMENT SPONSORED R, D&D

### Funds

Based on the political agreements of 9 May 2003 and 29 March 2004, the public funds in 2004 amounted to approximately 273 million DKK (app. 200 million DKK in 2003). This includes funds for energy research, development, and demonstration financed by grid system operators (the consumers). In addition, the National Research Councils can and may provide additional funds for energy research. The available funds are shown Table 4.

## The Energy Research Programme EFP

The Danish Energy Authority - in 2004 part of the Ministry of Economic and Business Affairs - is responsible for administration of the Energy Research Programme (EFP), which covers both conventional energy and renewable energy. The EFP works to establish the technological opportunities required for the practical implementation of Danish energy policy. The EFP is also intended to contribute to reinforcing exports of Danish energy technology and know-how. Descriptions (in Danish) of EFP and the projects supported are available on the Danish Energy Authority's www-pages ([www.ens.dk](http://www.ens.dk)).

The budget for the EFP in 2004 was higher than in the previous two years due to the political agreement of 9 May 2003. The budget was increased from 40 million DKK to 72 million DKK. In 2004, a number of

wind energy projects were funded (Table 5). In addition, EFP supported international R&D cooperation through IEA.

Out of the budget, 7 million DKK was reserved for quality assurance of renewable energy devices including wind turbines. Two million DKK for quality assurance of wind turbines was allocated to the Secretariat of Danish Wind Turbine Certification Scheme to manage the scheme. The actual certification of turbines and installations are carried out by private certification companies like DnV and GL.

Denmark has been active in international standardization in IEC and CEN/CENELEC for several years and standardization work has a high priority and is supported through R&D funds.

	2003	2004	2005
	Million DKK	Million DKK	Million DKK
Energy Research Programme (EFP)	41	72	73
PSO-electricity production	100	130	130
PSO-electricity utilization	25	25	25
Renewable energy R&D - Danish Research Agency	35	45	45
Total	201	242	273

**Table 4 Programs and available funds for renewable energy R&D projects including wind energy.**

Title	Applicant	Total budget (million DKK)	Support (million DKK)
Electrical Design and Optimisation of Wind Turbines	AAU	5,438	3,250
Dynamic Wake Model for Detailed Aero-elastic Simulation of Turbines in Wind Farms	Risoe	6,144	2,855
Program for Research in Applied Aero-elasticity	Risoe	5,768	3,495

**Table 5 Wind energy projects funded by the Energy Research Programme in 2004.**

## The PSO Program of the Transmission System Operators

In addition to the government R&D programs, the transmission system operators – which from 2005 are merged into one government-owned company - have PSO-subsidized R&D programs for non-commercial projects concerning new and environmentally friendly energy technologies. The programs focus on development of RES technologies including wind power. The final approval rests with the Danish Energy Agency. The responsible minister determines the budget.

The PSO program emphasizes the interaction between turbines and the power system, including the wind power plants' abilities to contribute to regulation and stability. Furthermore, the PSO program supports the utilization of measurements and experiences from ongoing offshore wind farm projects. The wind energy projects funded in 2004 are shown in Table 6.

For the environmental demonstration program, 84 million DKK has been allocated as a PSO in the period 2001 to 2006. Baseline studies have been undertaken in the projected areas so that the original environmental conditions relating to birds, mammals, fish, benthic invertebrates and plants, hydrology,

geomorphology and noise can be compared to conditions after the introduction of a wind-farm. In order to concentrate the investigations, it was decided to conduct a monitoring program for prioritised subjects and to make effect-studies in areas where the presence of species to investigate can be expected to be high.

Out of the total annual budget of 100 million DKK in 2004, approximately 20% was used on wind energy. Prioritized issues are efficiency, costs, and reliability of the wind turbines; regulation and forecasting of production; environmental impact; and monitoring the offshore demonstration program.

## The Danish Research Agency – the National Research Councils

According to an agreement reached in 2002 between the government and the opposition, 110 million DKK (20 million DKK in 2003 and 45 million DKK in 2004 and 2005) will be devoted to strategic renewable energy research projects. The funds will be administered by the Danish Research Agency – The Danish Strategic Research Council. The wind energy projects and amounts funded in 2004 are shown in Table 7.

Title	Applicants	Support (million DKK)
Intelligent Wind Power Prognosis Systems	DTU-IMM	2.1
Lifetime and Load Calculation for Gears	Elsam	3.0
Follow-up Project on Horns Rev Wind Farm	Elsam	3.5
Integration and Control of Wind Power in the Danish Power System	AAU-IET, Risø, Elsam	3.5
Power Fluctuations from Large Offshore Wind Farms	Risø, DTU-IMM, Elsam, E2	3.5
Wake Effects in Large Offshore Wind Farms	Risø, Elsam, E2	3.5

**Table 6 Wind energy projects funded by the electricity consumer financed (PSO) program in 2004.**

Title	Applicant	Support (million DKK)
Offshore wind power research related bottlenecks	Risøe	10,000
Simulation and control of Wind Turbine flows using Vortex Generators	DTU	2,373
Nonlinear Multi body Dynamics of Wind Turbines	AAU	3,700

**Table 7 Wind energy projects funded by the Danish Research Agency in 2004.**

### Risø National Laboratory

In order to strengthen its competence to cover all sides of off-shore development and in order to strengthen the education of PhDs and engineering candidates, Risø in May 2002 formed a consortium with the Technical University of Denmark in Lyngby, Aalborg University and DHI (Danish Hydraulic Institute). This consortium builds on the existing close cooperation with TUD on Aeroelastic Design and with AaU on Electrical Design. The cross-disciplinary consortium is intended to improve the network and coordination between research, education, and industry. The research is planned and implemented around the following themes: a) climatic conditions, b) wind turbine design, c) electrical systems, control and integration, and d) society, markets, and energy systems. Many of the R&D projects listed in Tables 5 through 7 are carried out by partners in the consortium.

In addition to project cooperation between the consortium partners, a grant was given by the Council of Researchers Education to a national research school, the Danish Academy in Wind Energy, with the purpose

to strengthen the education of PhDs and attract visiting students, researchers, and professors.

During the last several years, large efforts have been spent on establishing a new test site for multi-MW wind turbines. The test site was selected at Høvsøre, a site at the north-west coast of Jutland in order to have a reasonable number of high wind situations during a limited test period, the annual average wind speed at 78 m height 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 5 MW each. West of each test stand, a meteorological mast and two 165-m masts with light markings have been installed. Three manufacturers have leased test stands: Vestas, Siemens Windpower, and Nordex. The first wind turbine at the test site, a 3-MW turbine with rotor diameter of 90 m and hub height of 80 m, was put in operation on 7 November 2002. At present five wind turbines are installed. The test site is shown in Figure 7.

Authors: Jørgen Lemming and Peter Hauge Madsen, Wind Energy Department, Risø National Laboratory, Denmark; and Lene Nielsen, the Danish Energy Authority, Danish Ministry of Transport and Energy.





Figure 7 The test site for MW-sized wind turbines at Høvsøre.



## CHAPTER 7

EUROPEAN  
COMMISSION

## DG RTD AND DG TREN ACTIVITIES

## INTRODUCTION

The European Commission (EC) R&D Framework Programme funds research projects with medium- to long-term impact managed by the Directorate-General for Research (DG RTD). The EC also funds demonstration projects with short- to medium-term market impact managed by the Directorate-General for Transport and Energy (DG TREN).

In 2004, research projects, which have been running under the 5<sup>th</sup> Framework Programme (FP5 ENERGIE) (1999-2003) can be divided into the following categories:

- A. Wind turbines
- B. Blades and rotors
- C. Wind resources forecasting and mapping
- D. Wind farm development and management
- E. Integration of wind power
- F. Demonstration

The progress in these sub-areas was presented on 23 November 2004 during a research session organised in collaboration with the 2004 European Wind Energy Conference.

The 6<sup>th</sup> Framework Programme (FP6 Sustainable Energy Systems) (2003 – 2006) launched its first calls for proposals in 2003, and three projects started

in 2004. Another call for proposals, which includes various wind energy-related topics, was published in September 2004. New projects are likely to start in 2005.

Below is the list of 2004 funded projects including a short justification for the funding of the specific project(s):

## A – TURBINES

Improved economics from wind energy can be obtained through:

- Larger wind turbines to offer economies of scale and to make better use of good sites;
- Use of high wind speed sites in complex terrains with robust, easy-to-transport and easy-to-install wind turbines;
- Development of small and medium-sized, stand-alone wind turbines with high efficiency, low cost, and positive environmental impact.

## A1. RESEARCH AND DEVELOPMENT OF A 5-MW WIND TURBINE

Project Acronym: 5 MW WIND TURBINE  
COORDINATOR: Vestas Wind Systems (DK)

## A2. DEVELOPMENT OF A MW-SCALE WIND TURBINE FOR HIGH-WIND COMPLEX TERRAIN SITES

Project Acronym: MEGAWIND  
COORDINATOR: CRES (GR)

## A3. RECOMMENDATIONS FOR DESIGN OF OFFSHORE WIND TURBINES

Project Acronym: RECOFF  
COORDINATOR: RISØ Nat. Labs. (DK)

## A4. EXPLORING NEW CONCEPTS FOR SMALL AND MEDIUM-SIZED WIND MILLS WITH IMPROVED PERFORMANCE

Project Acronym: EXPLOREWIND  
COORDINATOR: Ideutvikling AS (NO)

## B – BLADES AND ROTORS

The blades are the most critical components of wind turbines:

- The aerodynamic properties of the blades can still be improved using experimental data from operating wind turbines and from wind tunnel measurements or e.g. by knowledge transferred from aeronautics; this does lead to higher efficiency and to lower noise;
- The dynamic behavior of blades can be improved with skilful combinations of new materials, especially to reduce overall weight;
- The hub, too, can be made lighter and more resistant to dynamic loads with the use of new materials.

### B1. WIND TURBINE ROTOR BLADES FOR ENHANCED AEROELASTIC STABILITY AND FATIGUE LIFE USING PASSIVELY DAMPED COMPOSITES

Project Acronym: DAMPBLADE  
COORDINATOR: CRES (GR)

### B2. WIND TURBINE BLADE AERODYNAMICS AND AEROELASTICS: CLOSING KNOWLEDGE GAPS PROJECT

Acronym: KNOW-BLADE  
COORDINATOR: RISØ Nat. Labs. (DK)

### B3. MODEL ROTOR EXPERIMENTS UNDER CONTROLLED CONDITIONS

Project Acronym: MEXICO  
COORDINATOR: ECN (NL)

### B4. RELIABLE OPTIMAL USE OF MATERIALS FOR WIND TURBINE ROTOR BLADES

Project Acronym: OPTIMAT BLADES  
COORDINATOR: WMC (NL)

### B5. SILENT ROTORS BY ACOUSTIC OPTIMISATION

Project Acronym: SIROCCO  
COORDINATOR: ECN (NL)

### B6. AEROELASTIC STABILITY AND CONTROL OF LARGE WIND TURBINES

Project Acronym: STABCON  
COORDINATOR: RISØ Nat. Labs. (DK)

## C – WIND RESOURCES FORECASTING AND MAPPING

Better knowledge of wind resources significantly reduces the cost of wind energy production by:

- Selection of the most appropriate sites with high wind and more steady conditions;
- Better forecasting of power production (increasing reliability of supply);
- Preventive action to protect wind turbines from excessive wind loads.

### C1. DEVELOPMENT OF A NEXT-GENERATION WIND RESOURCE FORECASTING SYSTEM FOR THE LARGE-SCALE INTEGRATION OF ONSHORE AND OFFSHORE WIND FARMS

Project Acronym: ANEMOS  
COORDINATOR: Ecole des Mines (FR)

### C2. A HIGH-RESOLUTION NUMERICAL WIND ENERGY MODEL FOR ON- AND OFFSHORE FORECASTING USING ENSEMBLE PREDICTIONS

Project Acronym: HONEYMOON  
COORDINATOR: University College Cork (IRL)

## D – WIND FARMS

Wind farms, i.e. groups of wind turbines installed at given sites, offer economies of scale and make better use of the sites. The funded projects aim to improve the management, monitoring, and surveillance of such wind farms and to provide recommendations on how best to set up such wind farms.

### D1. ADVANCED MANAGEMENT AND SURVEILLANCE OF WIND FARMS

Project Acronym: CLEVERFARM  
COORDINATOR: RISØ Nat. Labs. (DK)

### D3. CONDITION MONITORING FOR OFFSHORE WIND FARMS

Project Acronym: CONMOW  
COORDINATOR: ECN (NL)

## E – INTEGRATION OF WIND POWER

Wind is a source of electrical power, which varies in time and is produced in a decentralised way (though modern offshore wind parks will soon have generation capacities comparable to conventional power plants). This creates special problems, especially if wind is to provide a high share of overall electric power supply. These problems can be solved or at least alleviated by dedicated research efforts on the integration of wind power into the local and/or (inter-) national grid.

### E1. WIND ENERGY NETWORK

Project Acronym: WIND ENERGY NETWORK  
COORDINATOR: EWEA (BE)

### E2. TOWARDS HIGH PENETRATION AND FIRM POWER FROM WIND ENERGY

Project Acronym: FIRMWIND  
COORDINATOR: Renewable Energy Systems (UK)

### E4. WIND POWER INTEGRATION IN A LIBERALISED ELECTRICITY MARKET

Project Acronym: WILMAR  
COORDINATOR: RISØ Nat. Labs. (DK)

### E5. CLUSTER PILOT PROJECT FOR THE INTEGRATION OF RES INTO EUROPEAN ENERGY SECTORS USING HYDROGEN

Project Acronym: RES2H2  
COORDINATOR: Instalaciones Inabensa S.A.

### E6. SOLAR AND WIND TECHNOLOGY EXCELLENCE, KNOWLEDGE EXCHANGE AND TWINNING ACTIONS ROMANIAN CENTRE

Project Acronym: RO-SWEET  
COORDINATOR: ICPE (RO)

how innovative technological solutions can be integrated under realistic operating conditions and reduce the costs associated with implementation of new technologies. In particular, projects in the context of growing markets (larger machines) and emerging markets (off-shore) have been supported. Twenty-seven Demonstration projects (corresponding to a total budget of 40 million euro) have been supported through the 5<sup>th</sup> Framework Programme. Three projects, including an Integrated Project, have been selected in the first call of the 6<sup>th</sup> Framework Programme (total EC support: 8 million euro).

## EUROPEAN COMMISSION CONTACTS

More details on the projects can be obtained through the following contact persons:

### DG RESEARCH

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## F – DEMONSTRATION PART – DG TREN

The short-medium term RTD actions of the FP5 ENERGIE and FP6 Sustainable Energy Systems programmes are managed by DG TREN. The projects which have been supported aim at demonstrating



## CHAPTER 8

# FINLAND

### 1.0 INTRODUCTION

The energy production of Finland has a high share of renewables, mainly hydropower and biomass. The gross electricity demand is about 85 TWh, of which 12% is produced by biofuels and 15% by hydropower. Commissioning of new wind energy capacity showed growth in 2004. New installations were 30 MW in 2004, for a total capacity of 82 MW by the end of the year. The total wind energy production in 2004 was 120 GWh, which corresponded to 0.1% of the annual gross electricity consumption of Finland.

### 2.0 NATIONAL POLICY

#### Strategy

Targets for wind power deployment in Finland are set in the Action Plan for Renewable Energy Sources (1999). This Action Plan became a part of National Climate Strategy in 2001. It recognises the EU RES-E-Directive on national objectives concerning electricity produced from renewable energy sources, which for Finland is 31% of the total electricity consumption in 2010. The electricity production with renewable energies would increase by 8.3 TWh from the level in 1995. The major part, 75%, would be generated from biofuels. The target for wind energy deployment is set to 500 MW in 2010 and a goal of 2,000 MW in

2025. Under this plan, wind energy production would reach 5 TWh/yr in 2025, which is about 5% of the projected gross power consumption.

For total energy production, the target is to increase the use of renewable energy sources at least by 50% by the year 2010 from the level of the year 1995. Of this increase about 90% is expected to originate from bioenergy, 3% from wind power, 3% from hydropower, 4% from heat pumps, and less than 0.5% from solar power. Achieving the targets would reduce greenhouse gas emissions by about 7.7 million tonnes of CO<sub>2</sub> equivalent.

The Action Plan was updated in 2002, keeping the same targets, but recognising that reaching the target for wind power would demand more effective actions than the existing ones. Emission trading is expected to have an impact on electricity market price, and thus improve the cost-competitiveness of wind power. However, the impact is estimated to be minor during the first round of emission permit allocations from 2005 to 2007, due to the large amount of permits distributed free of charge.

#### Progress Toward National Targets

During the review of the Action Plan for Renewable Energy, the progress toward the goals was assessed. It was recognised that the progress has been slow compared to the goals, especially for wind and solar energy. In addition, the funds available for an investment subsidy are not adequate to achieve the goals set for 2010. The factors behind the slow progress in wind energy have been the low cost of electric energy in the market together with the lower investment subsidy, the long lead time for planning of wind projects, and the differing practices in grid connection policies for distributed generation. In the updated Action Plan for Renewable Energy, it is proposed that alternative subsidy systems for wind energy will be considered. A working group selected by the Ministry

of Environment has set up a framework for the planning and building permission procedures.

A special area, the Åland islands between Finland and Sweden, constitutes an autonomous region with its own legislation, budget, and energy policy. Wind energy deployment is steady and considering the small population, the targets are ambitious. Wind energy is expected to cover 10% of electricity consumption in the region by 2006 (this was 6% in 2003).

### 3.0 MARKET DEVELOPMENT AND STIMULATION

The Action Plan for Renewable Energy Sources states that the investment subsidy will remain the primary support mechanism although new support mechanisms are to be investigated. For wind energy installation, an investment subsidy of up to 40% can be awarded, depending on the rate of novelty in the project. Projects that have applied for subsidy in 2002-2003 have received an investment subsidy of about 30%. In addition to the investment subsidy, a price premium of 6.9 euro/MWh is awarded. This corresponds to the tax on electricity that is paid by household consumers.

In 2004, a report "The views for realising the targets for wind power in Finland" was published as a follow-up to the Action Plan. The increase in support for wind power necessary to reach the target was estimated to be 10 euro/MWh, in addition to the existing investment subsidy (about 30%) and tax refund (6.9 euro/MWh). With the existing support, a realised wind power capacity of 300 MW is foreseen for 2010. The national energy and climate strategy will be updated during spring 2005. Possible changes in wind power targets and measures to achieve the targets will be discussed during the preparation process.

The Information Centre for Energy Efficiency (Motiva) is promoting wind energy by publishing best practice guides and handbooks. The Finnish Wind Energy Association is also promoting wind energy through seminars and political lobbying. Both the Energy Industries and Technology Industries in Finland have

formed a branch group for wind power to promote wind power technology and deployment.

### 4.0 DEPLOYMENT

Sixteen wind turbines were commissioned in 2004 bringing the total wind energy capacity to 82 MW by the end of the year. The total wind energy production was 120 GWh in 2004. The development in capacity and gross production is presented in Figure 1. The gross electricity consumption in 2004 was 86.8 TWh. Wind energy represents about 0.1% of the national consumption.

There were 92 wind turbines in operation in Finland at the end of 2004. In all, 62% of the capacity originates from Denmark, 22% from Germany, and 16% from Finland. The size of the installed capacity ranged from 200 kW to 3 MW. Average wind turbine size was 900 kW at the end of 2004.

The turbines installed in the harsh climate at elevated sites of northern Finland are protected with ice-preventive equipment. Proximity of large open waters is found to increase the possibility of wind turbine icing at lower latitudes and coastal areas in Finland as well. The same solution that has been tested in northern Finland has been tested at sites in southern Finland where public safety is a concern due to occasional icing.

There are currently about 100 MW of projects in various planning phases in Finland; some are, however, uncertain. In 2005, less than 30 MW of new wind power capacity is foreseen. The short-term potential on the coastal areas of Finland, taking into account both economical and land use restrictions, is more than 300 MW. Offshore, nearly 10,000 MW of wind power potential has been identified in the process of renewing regional plans in Finland. About 200 MW could be realised before 2010.

### Operational Experience

According to the production statistics, an improved performance of wind power production can be seen in Figure 1. The average full-load hours have been



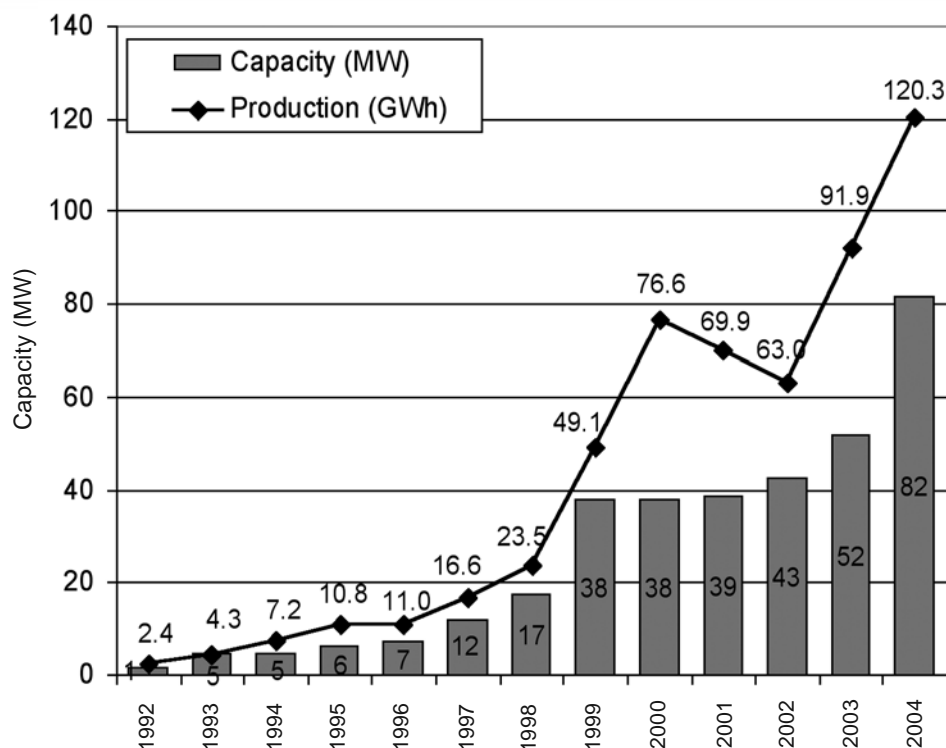


Figure 1 Development of wind energy production and installed capacity in Finland 1992–2004.

higher since 2000 than in the 1990s even though the production index has been lower. This is mainly due to more MW-scale machines reaching higher wind resource.

Overall availability of the wind turbines operating in Finland was 95% in 2004, like in 2003. The largest downtimes in 2004 were due to three 1.3-MW machines losing one blade tip in stormy weather and due to a fire destroying one 1.3-MW turbine totally in July.

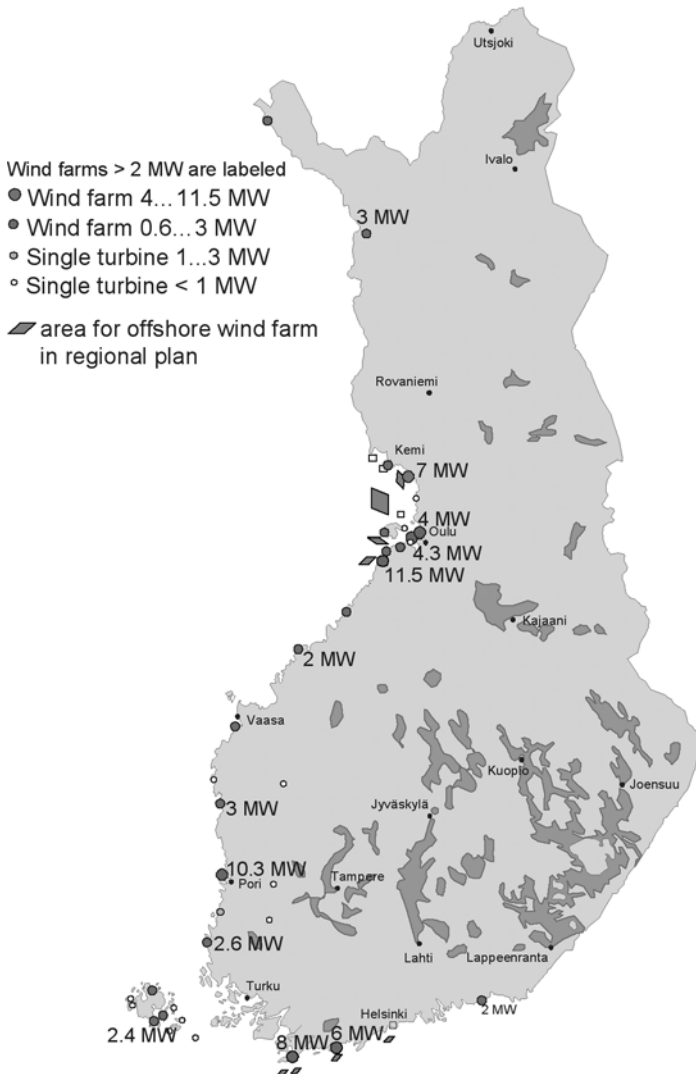
## 5.0 DEPLOYMENT AND CONSTRAINTS

The electricity market has been fully liberalised, down to household consumers, since 1997. Thus all wind energy installations are “merchant” producers that have to find their customers in a competitive market. Current market prices are low and, despite the quite substantial support, wind energy cannot yet

compete with spot prices for electricity. Most turbines are owned by or operated in co-operation with a local utility to facilitate energy market access. The transmission and distribution charges for distributed generation vary greatly across the country and are so high in some areas that they prevent local generation.

Wind energy deployment is slow but there is still a continuous discussion on 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. In order to overcome these problems, the Ministry of Environment published guidelines for planning and building permission procedures of 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 been added to plans for the Gulf of Bothnia, North (about 4,000 MW) and the Gulf

Finland year 2004: 82 MW, 92 turbines



**Figure 2 Installed wind power in Finland at the end of 2004. Large offshore sites added to regional plans are marked with diamonds.**

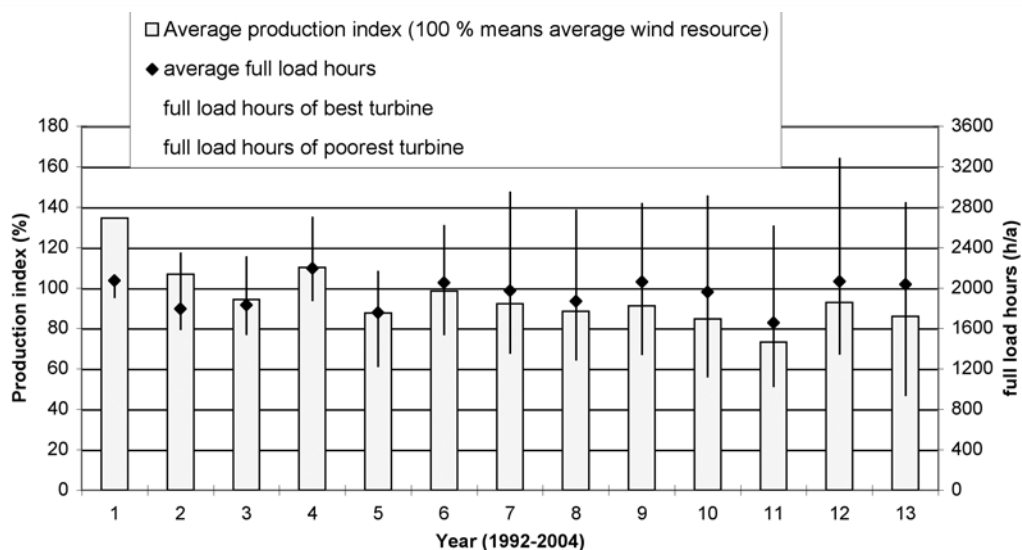
of Finland, West (about 500 MW), and the planning process is ongoing for Gulf of Bothnia, South and Gulf of Finland, East.

**6.0 ECONOMICS**

At a good site on coastal Finland, the cost of wind energy production could be about 30–40 euro/MWh,

including an investment subsidy (15 years, 7% internal rate of return). The average spot price in the electricity market of Nordpool has been 27–37 euro/MWh in 2002 through 2004, but considerably lower in years with good hydropower resource.

As stated above, all wind energy installations are commercial power plants and have to find their customers on a free power market. In most cases, an



**Figure 3 Power performance of wind turbines in Finland 1992-2003. Production on-line as full load hours, compared with production index (100% means annual production corresponds to average production over 1987-2001). Includes only turbines operating the full year and with availability > 90%.**

agreement with a local utility is made, giving market access and financial stability. Some utilities have offered to buy wind energy production at a price higher than avoided costs in general.

There are several companies offering “green” or specifically “wind” electricity, certified by the association for nature conservation, at a price higher than the average for households. The market success for these initiatives, however, has been modest. Only a few percent of the household consumers have changed electricity supplier at all since the liberalisation.

If the impacts of emission trading raise electricity market prices, this will affect the cost competitiveness of wind power and also make sites with less favorable wind resources realisable. In this way, the wind power market in Finland may increase.

## 7.0 INDUSTRY

The Finnish manufacturer WinWinD presented its first 1-MW prototype in spring 2001, and erected the 3-MW prototype in November, 2004 in Oulu. The turbines operate at variable speed and have a one-

stage planetary gearbox and a permanent magnet generator. WinWinD has manufactured 16% of all turbines in Finland (13 MW). WinWinD also started their export activities in 2004, with turbines sold to France, Portugal, and Sweden.

For some time, Finnish industry has produced main components such as gearboxes and induction generators as well as materials like cast-iron products, tower materials, and glass-fibre products for the main wind turbine manufacturers. The total turnover was about 200 million euro in 2003.

A blade heating system for wind turbines operating under icing conditions was released as a commercial product in 1998. It has been developed mainly for the domestic market but also for export; the first delivery to Sweden was made in 1998.

The manufacturing industry has formed a branch group under the Association of Metal Industries, now called Technology Industries in Finland, to promote technology development and export in wind technology.

## 8.0 GOVERNMENT SPONSORED R, D&D

Since 1999, there has not been 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. Priority is given to product development and the introduction of new products.

There is a drive towards offshore locations of turbines. The installation of turbines in icing waters requires careful design of the foundation and support structure. Projects to develop foundation and installation technologies suitable for Finnish offshore conditions have been made in a co-operation between research bodies and industry.

The technology program DENSY (Distributed Energy Systems), launched in 2003, contains some wind-

related research projects. Ongoing research projects within the DENSY technology program have been divided into five project groups:

- IT and automation
- Business models
- Heat and CHP systems
- Electrical systems
- Industrial manufacturing.

The project group on electrical systems includes some projects related to the grid connection and energy storage of distributed energy systems, including wind, and technology development projects.

A new technology program CLIMBUS (Business Opportunities in Mitigating Climate Change) was launched in 2004. This five-year technology program aims to develop technology and business concepts related to reduction of greenhouse gas emissions.

The focus areas of the program are:

- Clean energy production and fuels
- Business services
- Technologies for energy efficiency and non-CO<sub>2</sub> greenhouse gases.

Authors: Hannele Holttinen and Esa Peltola, VTT Technical Research Centre of Finland.



**Figure 4** Erection of 3-MW pilot turbine by WinWinD, November 2004, Oulu, Finland.

## CHAPTER 9

## GERMANY

## 1.0 INTRODUCTION

During 2004, wind energy deployment expressed as accumulated installed capacity increased in Germany nearly as rapidly as it has grown since 1998. At this stage, wind energy is able to produce about 6% of the German annual net electrical energy consumption and has become a powerful factor of the national energy mix. Most of the data presented in this report were collected and analyzed by the Deutsche Windenergie Institut (DEWI) or the Bundesverband WindEnergie e.V.

## 2.0 NATIONAL POLICY

The goal the Federal government set itself is to double the share of renewables in the energy supply by 2010. The goal is for 4.2% of primary energy consumption to be covered by renewable energy sources. The share in gross electricity consumption is to be increased to 12.5%. The medium-term objective for the Federal government is to increase the share of renewable energy in the electricity provision to at least 20% by 2020. In the long run, i.e. by 2050, at least half of the energy supply is to be met by renewable energy.

The Act on granting priority to renewable energy sources (Erneuerbare-Energien-Gesetz, EEG) of 21 July 2004 makes it compulsory for operators of power grids to give priority to feeding electricity from renew-

able energy into the grid and to pay fixed prices for this. The entry into force of the Renewable Energy Sources Act in 2000 triggered the desired boom in the construction of new installations. The Renewable Energy Sources Act was revised in 2004. For onshore wind turbines, it guarantees a basic payment of 0.055 euro/kWh and, depending on local wind conditions, a maximum payment of 0.087 euro/kWh with a decline of the payment by 2% for new installed WEA beginning in 2005.

For offshore wind turbines, the basic payment is 0.0619 euro/kWh and the maximum payment amounts 0.091 euro/kWh depending on distance from shore and water depth. The decline by 2% begins in 2008 to stimulate the wind industry to reduce costs stepwise and to invest in R&D.

## Strategy

The Strategy of the German Government on the Use of Off-Shore Wind Energy sets the goal to install 2,000 MW of offshore wind energy capacity by 2010. Other defaults formulated in the Offshore-Strategy are:

- Expansion of offshore wind energy deployment shall be compatible with nature and the environment and be economically viable
- Implementation of wind farms will proceed by a step-by-step approach taking into consideration technical, economic, and legal uncertainties
- Clarification of the legal situation within the 12-nautical miles zone and in the Exclusive Economic Zone (EEZ) (environment/ nature protection, investment security) will take place. The Federal Nature Conservation Act and Offshore Installations Ordinance have been revised accordingly
- Technical and ecological research shall accompany the expansion
- Suitable areas shall be identified (inter-ministerial approach), taking into account competing

forms of use in the EEZ such as fisheries, extraction of mineral resources, navigation, military uses, and environment protection.

### 3.0 MARKET DEVELOPMENT AND STIMULATION

The main stimulating effect on the German market is caused by the Renewable Energy Sources Act. Market trends clearly show that in 2004, turbines of the rotor class 60 to 90 m account for almost 92% of the market. In the statistically relevant electrical capacity range, only three-bladed turbines are available on the German market. Two German manufacturers offer turbines in different classes without gearboxes. All other manufacturers offer turbines with gearboxes. With increasing size, turbines tend to be equipped with variable-speed systems. The reasons for one or the other technology are to be found in material saving aspects, grid connection issues, power quality requirements, and finally, in economic reasons.

According to WindEnergy–Studie 2004, the annual new installed capacity on shore will drop down to nearly zero by 2012. This process started in 2003 (see also Section 4.0). Beginning in 2006, it is expected that onshore repowering and offshore development will dominate market growth. According to this prognosis, the 2002 level of new installed capacity will be reached again in 2014 and exceed that level of growth after 2014.

### 4.0 DEPLOYMENT

As of 31 December 2004, 16,543 wind turbines with a rated power of 16,628.75 MW were in operation in Germany. During 2004 alone, 1,201 turbines with total rated power of 2,036.9 MW were installed. Compared to the previous year, there was a decrease in the number of newly installed turbines of approximately 29.5% and the newly installed power went down by 607.63 MW or approx. 23%. This development was expected because suitable onshore locations have become more and more saturated for reasons of landscape protection and unfavorable wind conditions in the areas with low density of wind turbines.

The density of wind turbines and hence the contribution of wind energy generation is very differentiated among the German Federal States. For example, the potential annual energy yield in the state Schleswig-Holstein, located between the Baltic- and North Sea, of 4,465 GWh is equivalent to 33% of the energy consumption in this state. Mecklenburg-Vorpommern provides 29%, Saxonia-Anhalt provides 27%, and Brandenburg provides 20%. Whereas the annual energy yield from wind is less than 600 GWh or less than 2% of the electrical energy consumption in seven other states.

Compared with the previous year, the average rated power per new installed wind turbine went up by approximately 9% and reached 1,696.0 kW in 2004. Also in 2004, 45 wind turbines with a total rated power of 17 MW were removed and replaced with 33 wind turbines with a total installed power of 54 MW. This is called repowering.

### 5.0 DEPLOYMENT AND CONSTRAINTS

It is expected that the Renewable Energy Sources Act, revised in 2004, will stimulate offshore development. By the end of 2004, eight pilot projects had been approved by the Federal Maritime and Hydrographic Agency (BSH) with a total capacity of about 2,000 MW. Another 37 projects are in the planning phase or will be decided on by BSH (total 69,000 MW) in the future. At present, a main constraint for the offshore pilot wind farms is the licensing of the cable. The responsibility for licensing the cable is divided between BSH as a Federal Agency for the EEZ area and the authorities of the coastal German State. Political efforts are being made to simplify the licensing procedure.

In 2004, aspects of grid integration of offshore wind farms were investigated in a survey of the Deutsche Energie Agentur (dena) together with industry especially power supplying companies. The results show that the technical problems of grid integration anticipated from the expansion of wind energy deployment could be solved. According to the dena survey, by 2015 the existing length of power lines in the German grid needs to be extended by about 5%. About 400 km of the existing grid needs to be upgraded, and about 850 km have to be newly installed. The costs

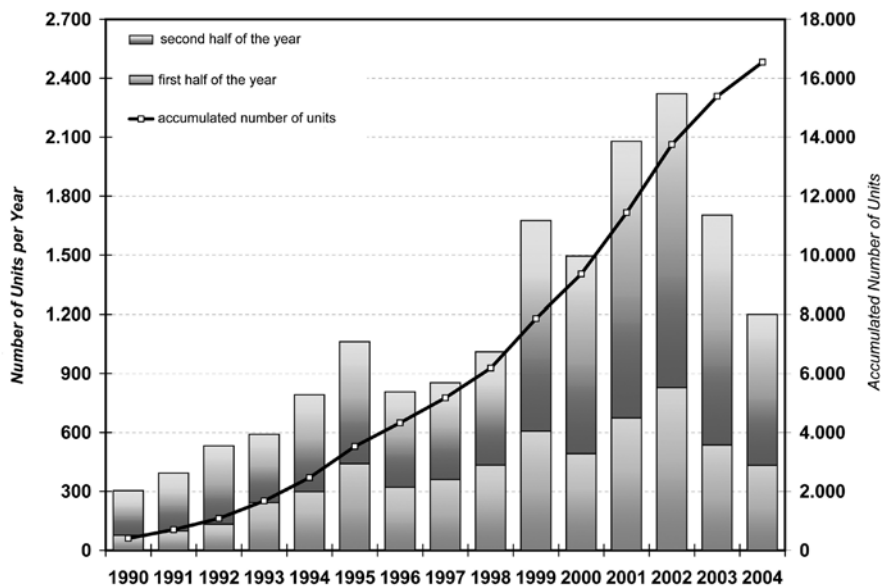


Figure 1 Development of the yearly installed and accumulated number of wind turbines. Source: DEWI.

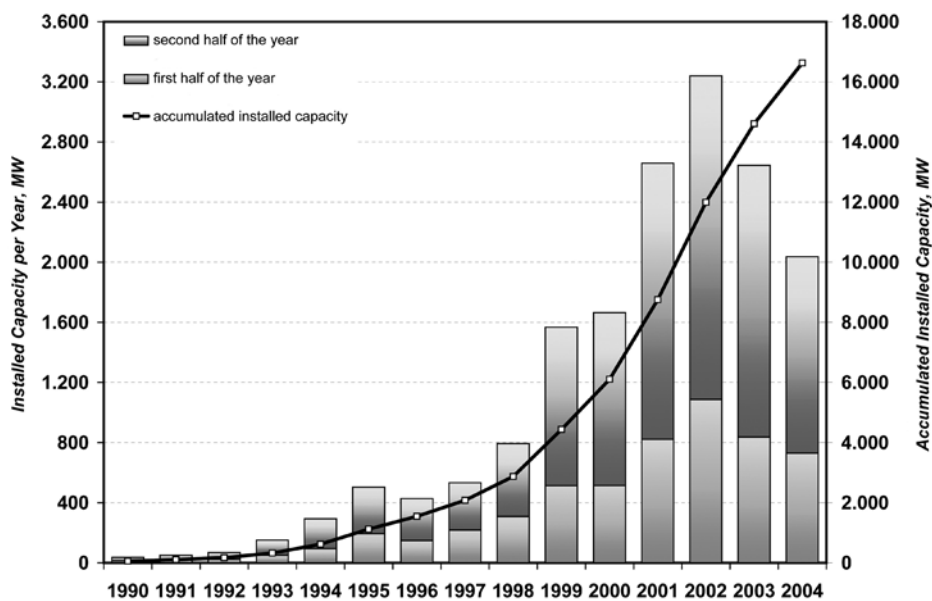


Figure 2 Development of the yearly and accumulated installed power of wind turbines. Source: DEWI.

for this expansion of the grid come to a total of 1.1 billion euro. Further expansion of wind energy leads to higher demands for the provision of balancing and reserve capacity. This could be covered by existing fossil fuel plants and by pumped-storage power plants and new gas turbine power plants in the course of replacement of older plants.

**6.0 ECONOMICS**

Because of the anticipated trend to offshore development, (Section 3.0) the German wind industry is looking with hope on the beginning of the off-shore process. The industry is developing and testing leading technology for offshore conditions. According to statistics published by Bundesverband WindEnergie, in 2004, using conservative assumptions, 45,400 people were directly employed in the wind energy industry in Germany by 31 December 2003. This is about double the number of employees in 2000.

**7.0 INDUSTRY**

Three German manufacturers developed wind turbines in the capacity class of 4.5 to 5 MW. Two of

them erected prototypes on shore or near shore by the end of 2004. These wind turbines are designed for early offshore development and differ in technological conceptions as the range of total masses of the housing and rotor from 310 t to 535 t shows. The development of the ENERCON E-112 (4.5 MW) and the development of the Multibrid M 5000 (5 MW) have been supported by the Federal government. The development of REpower 5M (5 MW) was supported by the European Union and the State Government of Schleswig-Holstein. All prototypes are running in test programs to ensure that technically mature wind turbines will be erected at offshore sites.

**8.0 GOVERNMENT-SPONSORED R&D**

**Research Program**

In November 2004, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety published the new support measure for wind energy research. The main goals are as follows:

- 1) Contributions to reduce the costs and to increase the yield of electricity from wind energy by

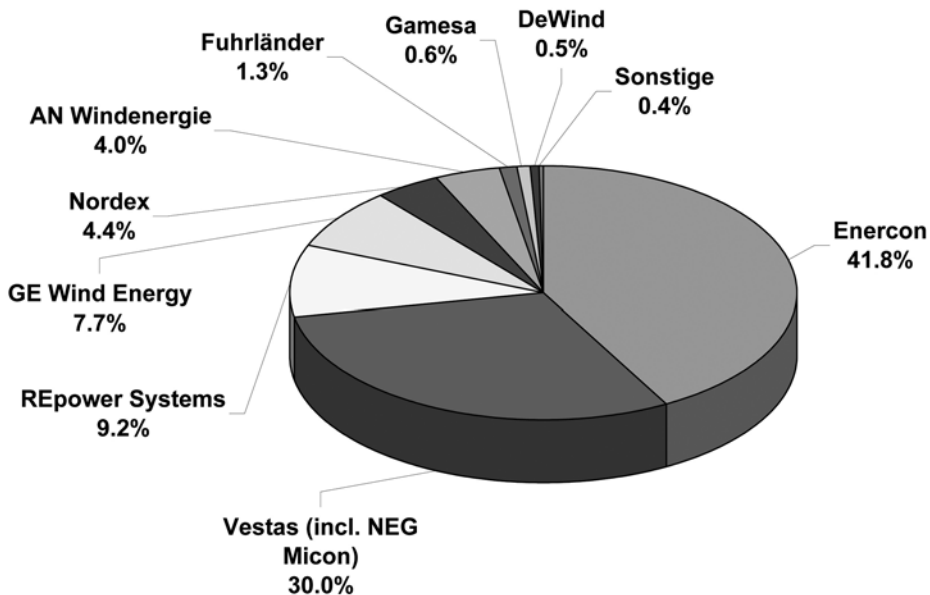


Figure 3 Shares of the suppliers on the German market as % of total installed rated power in 2004. Source: DEWI.



- Improving adjustment and monitoring technology
- Using new materials
- Optimizing offshore foundations
- Reducing mass of wind turbines
- Reducing mechanical loads on wind turbine structures and on foundations
- Upgrading automation in the production process of wind turbines
- Improving measuring and testing technologies.

2) Contributions to the integration of large amounts of electrical energy produced from wind i.e.

- Conceptions for grid integration of offshore wind farms
- Technologies for power management in the grid
- Improvement of yield prognosis
- Specific aspects of energy storage with respect to wind energy.

3) Conducting ecological research along with offshore wind energy deployment.

- Investigation of possible effects on marine mammals, birds, fishes, and benthic organisms
- Determination of cumulative effects from navigation, fishery, wind farms, and exploration of mineral resources
- Development of technologies for the prevention or reduction of negative effects on the environment
- Integration of marine environmental data and information with respect to offshore wind energy.

4) Further topics of research are listed here.

- Interactions with other technologies such as wave energy exploitation
- Research on measuring platforms in the North- and Baltic Sea
- Further development of wind turbines with low capacity for local applications.

Highlights of research finished in 2004 are:

- The development of the above mentioned 5-MW wind turbine by Multibrid
- In the field of accompanying ecological re-

search the report of the MINOS project, which gives new information and data on resting sea birds, harbor porpoises, and seals in the German EEZ, and on the hearing ability of marine mammals.

Further ecological projects finished in 2004 dealt with the environmental risks after a possible ship collision with a wind turbine; migratory birds in the North- and Baltic Sea; sound emissions of offshore wind turbines and emissions during ramming of piles; legal and administrative aspects of offshore wind energy deployment and protection of the marine environment.

The research on most of these problems was extended in 2004 for another three years, for example, the research network MINOS plus. Additionally, a research network investigating the possible influence of offshore wind farms on the water exchange and streaming processes in the Baltic Sea was established in co-operation with researchers in Sweden, Denmark, and Poland.

The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety supported 25 new research projects in the field of wind energy research in 2004 with a total amount of 12.0 million euro, 13 of them deal with environmental aspects of offshore wind energy deployment supported with 5.8 million euro.

During the Renewables 2004 Conference held in June in Bonn, the Danish Minister for the Environment, the Danish Minister of Economics and Business, and the German Minister for the Environment signed a Letter of Intent for Danish-German Co-operation in Research for Off Shore Wind Energy Utilisation. At the end of 2004, the co-operation agreement was in the final stage of discussion between the two sites.

### Offshore Measuring Platform FINO 1

The first German Offshore Measuring Platform, FINO 1, was erected in July 2003 in the North Sea, about 45 km north of the coast of the island Borkum (at a water depth of 28 m), adjacent to the location of planned wind farms. Hydrological, meteorological, oceanographic, and physical data relevant for the

construction of offshore wind plants and their foundations are being recorded. Environmental, especially biological, parameters are being monitored for the next few years and basic data and information will be gathered about the environmental impact of offshore wind farms (See IEA Wind Energy Annual Report 2003, Germany: [www.ieawind.org](http://www.ieawind.org)). In 2004, the measuring equipment of FINO 1 worked with high reliability. Data are stored in a permanent data bank of the BSH and the first data sets have been delivered to interested institutions abroad. Further information and examples of deliverable data sets could be accessed at [www.fino-offshore.de](http://www.fino-offshore.de).

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## CHAPTER 10

# GREECE

### 1.0 INTRODUCTION

Greece is making profound institutional, regulatory, engineering, and funding efforts in order to meet the indicative target set by Directive 2001/77/EC. This is difficult because of the yet fluid state of liberalization of the utility market that was dominated for more than a half century by the single utility company in the nation. One of the aims of the Greek government is to substitute expensive imported fuel, currently used for electricity production in a large part of the Greek territory, by exploiting the country's wind potential.

The government has already made considerable movements such as the new Law 3299/2004, which provides financing support of up to 50% of the total investment. A decision was made to develop a National Council for Energy Policy, which will secure long duration energy planning. A new Legal Framework of Licensing new enterprises was established in order to reduce the time and the cost required for their development. The promotion of national land planning is underway to facilitate investment in renewable energy systems. Government support for wind energy exploitation is part of its policy concerning renewable energy sources.

### 2.0 NATIONAL POLICY

#### Strategy

In Greece, the Law 2773/99 "Liberalization of the Electricity Market – Regulation of Energy Policy Issues and other Provisions," constitutes the basic legal background. According to this law, two companies - the Regulatory Authority of Energy (RAE) and the Hellenic Transmission System Operator (HTSO S.A. or "the Operator") - have been created. These two companies are the basic factors of the free electricity market.

RAE is an independent, public authority that manages, suggests and promotes the existence of equal opportunities and fair competition. It gives operation licenses to producers, providers, and all others related to the market. In addition, RAE formulates suggestions to the Minister of Development with regard to the issue of power generation authorizations. Thereafter, RAE monitors the implementation progress of the renewable energy sources (RES) projects through quarterly reports and recommendations, which can recommend that investors remove from the sector due to unjustifiable slowness. RAE also recommends legislative measures for further deregulation of the electricity market within which critical RES issues can be addressed (as is the case of hybrid plants). On a more long-term basis, RAE considers the introduction of green certificates and the establishment of a network of large-scale dispersed energy production.

HTSO is the company that handles the Hellenic Transmission System of Electric Energy. HTSO S.A. has a double role. The first role is the one being played by Public Power Corporation in respect to the transmission system: it always looks for a balance between production and consumption, and it ensures that quality electric energy is provided reli-

ably and safely. The second role of HTSO is to settle the market - in other words, to act like an energy "stock market" that arranges on a daily basis who owes to whom, according to Law 3175/2003. HTSO does not provide electric energy, and whatever basic exchanging relations exist are bilateral ones between producers/providers and their customers.

Until December 2004, RAE approved an important number of applications for power production from wind energy, equivalent to 4,330 MW total installed capacity. An optimistic estimation of wind energy penetration up to 2010 is 2,170 MW. This estimate takes into account the 30% restriction on penetration of wind energy power into the electric network. More specifically, 700 MW for Evia (Andros, Tinos islands); 350 MW for Thraki; 280 MW for Lakonia, East Arkadia; 240 MW for Crete, Rhodes, and other non-interconnected islands; and 600 MW for the rest of the country.

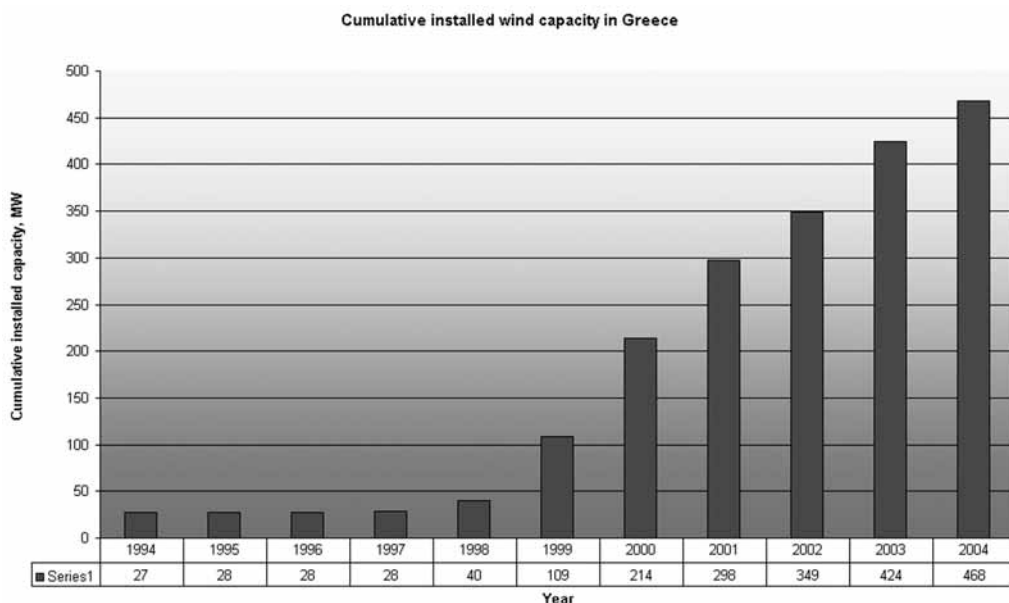
According to the Law 2773/99, HTSO uses the wind energy as first priority during generation unit dispatching. The price paid to the producer is a percentage of the tariff paid by the medium- and low-voltage consumers, the same power use as defined by the older Law 2244/94 until the Law 2773/99 came in effect. The difference is that the Minister of Development is allowed to ask the producers of renewable sources for a discount on price.

### Progress Toward National Targets

In 2004, the installed capacity of wind turbines reached 468 MW (from 812 wind turbines). The current national target for wind energy is now 2,000 MW for 2010, following EU directives. The new Law 2773/99, introducing electricity market liberalization, maintains energy support from renewable sources in the framework of the competitive market, yet the effect of liberalization on the development of the wind energy is not obvious.



Figure 1 The 2.64-MW wind park at Syros Island. Photo courtesy International Technological Applications SA (ITA), Greece.



**Figure 2 Cumulative installed wind capacity in Greece, 1994 to 2004.**

### 3.0 COMMERCIAL IMPLEMENTATION

#### Installed Capacity

In seven separate projects, a total of 59 wind energy conversion systems with an installed capacity of approximately 62 MW were connected to the electricity supply network during 2004. This brings the total installed wind energy capacity to 468 MW (812 wind turbines).

#### Rates and Trends in Deployment

The development of the wind energy within the last 10 years is shown in Figure 2, which depicts the total installed capacity per year.

#### Contribution to National Energy Demand

The energy produced from wind turbines during 2004 was approximately 990 GWh, while the energy produced in 2003, 2002, 2001 and 2000 was 850 GWh, 650 GWh, 756 GWh, and 460 GWh, respectively. The total energy consumption in the country is about 50 TWh, so the energy produced from wind turbines ac-

counts for about 1.5% of the energy demand. Figure 3 shows the electricity produced from wind turbines for the last ten years. By 2010, the total energy consumption in the country is expected to reach 72 TWh.

### 4.0 MARKET DEVELOPMENT AND STIMULATION

#### Main Support Initiatives and Market Stimulation Incentives

The Operational Program Competitiveness (OPC) supports the development of wind energy projects. OPC raises resources from the 3<sup>rd</sup> Community Support Framework, which provides public aid to RES and energy saving, substitution, and other energy-related actions up to 1.02 billion euro. The public aid accounts for 30% of the eligible cost of the projects and goes up to 50% in the case of transmission lines that will be constructed for the connection of RES plant with the grids. The Center for Renewable Energy Sources (CRES) acts as an intermediate agent in charge of the administration and management of projects included in Measure 2.1, Action 2.1.3 of the OPC. More specifically, CRES is the thematic intermediate agent responsible for the administration and man-

Electricity produced by wind turbines in Greece

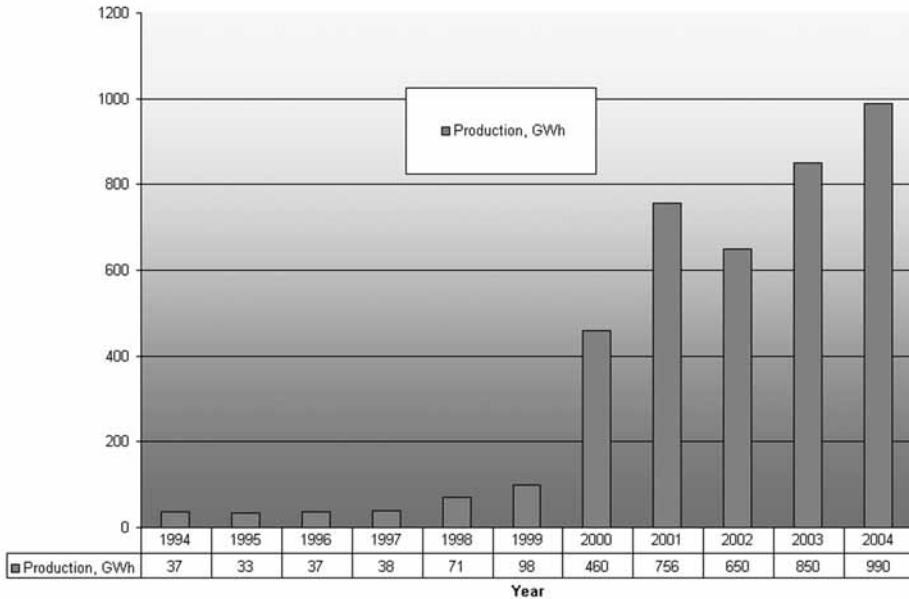


Figure 3 Electricity produced from wind turbines in Greece, 1994 to 2004.

agement of all wind energy projects on the mainland and those with nominal capacity greater than 5 MW on the islands of Greece. The relevant budget is up to 650 million euro. An installation permit is necessary in order to finance a project. The eligible cost for financing a wind farm is up to 900 euro/kW, without including the cost for the electrical grid connection.

## 5.0 DEPLOYMENT AND CONSTRAINTS

### Wind Turbines Deployed

The average capacity of the wind turbines installed in 2004 was 1,038 kW; while the average capacity of all the wind turbines operating in the country was 576 kW (Figure 4). The market share per manufacturer is depicted in Figures 5 and 6.

### Operational Experience

Due to the relatively short operation periods of most wind energy projects, limited malfunctions have been reported since their commissioning, and these were

mainly related to gearbox failure and lightning strike events. However, CRES has developed and continuously updated a database with information about the operation and performance of all the wind parks around Greece.

### Main Constraints on Market Development

The two main constrains for the installation of new wind farms remain (1) the complicated procedures for the acquisition of generation authorization, and (2) the inadequate electrical network to absorb the energy produced.

## 6.0 ECONOMICS

### Trends in Investment

The total cost of wind power projects depends on the wind turbine type, size, and accessibility. This cost varies between 970 and 1,170 euro/kW. The generated wind power cost could be assumed to be between 0.026 and 0.047 euro/kWh, depending on

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

## Trends in Unit Costs of Generation

The power generation system in Greece is divided into two categories: the so-called interconnected system of mainland and the autonomous power plants of the islands. In the liberalized electricity market, as well as before, a single price exists in both systems, depending on the identity of the consumer and the voltage class. This price list concerns the tariffs of electricity purchased since 1 November 2004 by HTSO according to the Law 2244/9; 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

cogeneration of heat and power (CHP). There is no capacity charge on purchases from producers in non-interconnected islands.

## 7.0 INDUSTRY

### Manufacturing

No significant manufacturing developments occurred in 2004 except for two manufacturers of small wind turbines in the range of 1 kW to 5 kW. However, the manufacturing of tubular towers of the wind turbines by the Greek steel industry has been considered. One Greek company that has been involved in blade manufacturing has not yet managed to commercialize its products.

### Certification

Greece requires installation permission for wind turbines with more than 20 kW of capacity. With the new

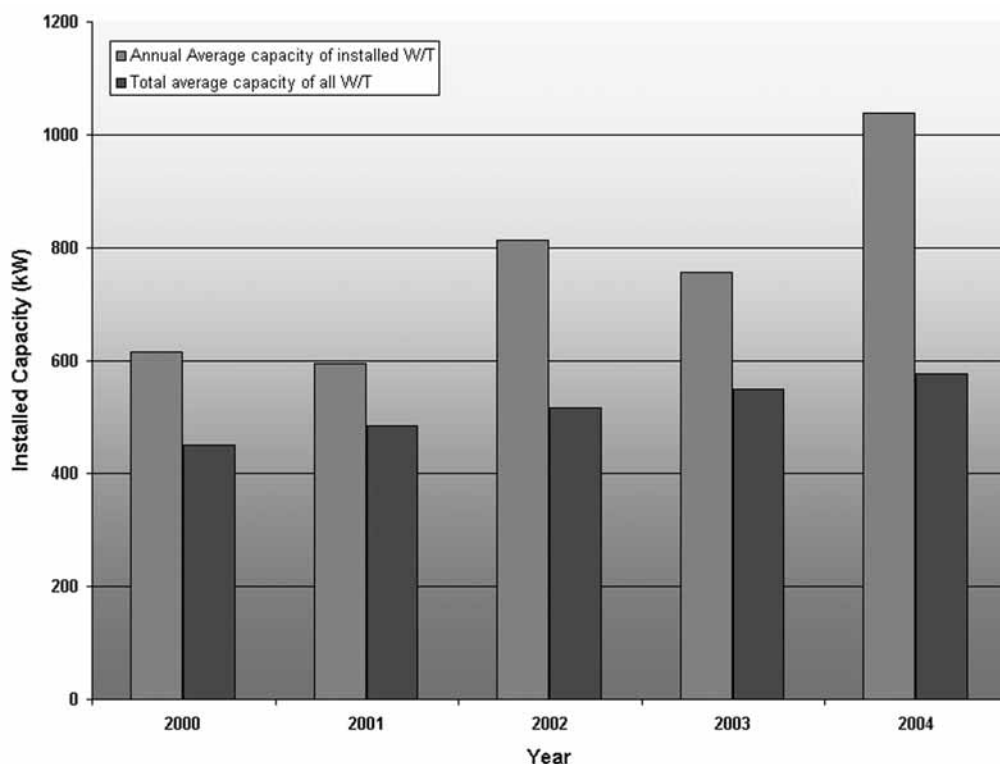


Figure 4 Average capacity of the wind turbines installed in 2004 and operating in Greece.

Market share of wind turbine manufactures (as a percentage of the total installed wind turbines)

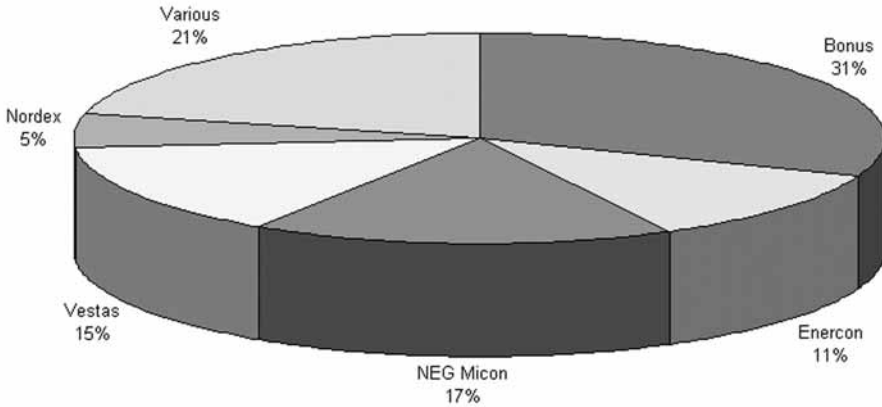


Figure 5 Market-share of wind turbine manufacturers (percent of turbines installed).

Market share of wind turbine manufactures (as a percentage of the total installed capacity wind turbines)

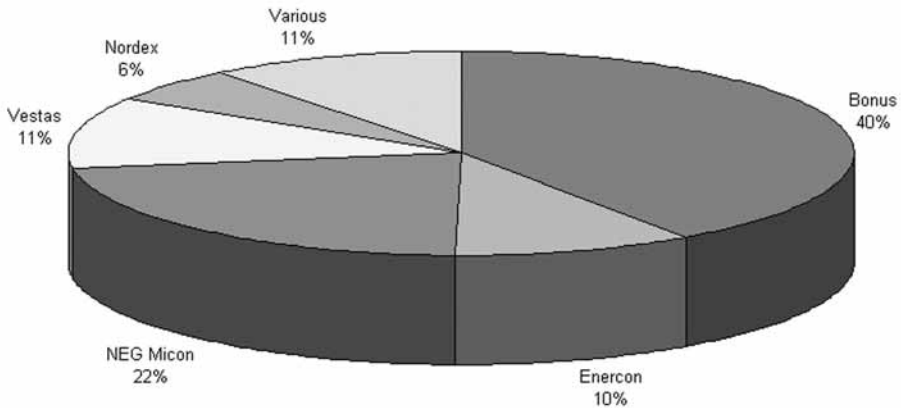


Figure 6 Market-share of wind turbine manufacturers (percent of installed capacity).

Law "Procedures for the Installation and Production Permits," a type approval certificate along with a power quality certificate is required for each type of wind turbine and each wind park. CRES is, by law, the certifying authority for wind turbines in Greece and is responsible for issuing the certificates. CRES accepts type certificates and reports of power quality measurements issued by authorized institutions - such as Germanischer Lloyds, TUV and DNV or any other organization accredited according to

EN45011 for certifying wind turbines - according to the following standards and criteria:  
 Germanischer Lloyds Regulations  
 Danish standards and criteria  
 Dutch standards and criteria  
 International Electrotechnical Commission (IEC) 61400-1 standard

Additionally, CRES's Wind Energy Department participates in the standardization work carried out by the



Hellenic Organization for Standardization (ELOT), in the framework of European and International organizations working on certification procedures, and in standards to be followed nationwide, taking into account the climate characteristics of Greece. In 2004, active involvement in the activities of IEC TC-88, CLC/BTTF83-2 and their working groups continued.

## 8.0 GOVERNMENT SPONSORED R&D

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 testing, noise, power

quality, wind desalination, and autonomous power system integration. There is limited activity in Greece concerning megawatt-size wind turbines or offshore deployment.

## Activities of CRES

CRES is the national organization promoting renewable energy in Greece 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.

Connection voltage	Magnitude with tariffs	Independent production a) from RES b) from CHP through RES	Auto-producers surplus	
			a) from RES	b) from CHP through RES
High	Energy	0.06611	Peak	0.03357
			Interim load	0.02326
			Low load	0.01726
Medium	Capacity	1.69705		-
	Energy	0.06611		0.05142
	Capacity	1.69705		-
Low	Energy	-		0.06356
	Capacity	-		-

**Table 1 Interconnected systems and interconnected islands. Prices in euro/kWh for energy and in euro/kW per month for capacity.**

Connection voltage	Magnitude with tariffs	Independent production a) from RES b) from CHP through RES	Auto-producers surplus
			a) from RES b) from CHP through RES
ALL	Energy	0.08172	0.0636

**Table 2 Islands not interconnected. Prices in euro/kWh.**

CRES, in co-operation with a Greek company, designed and developed a pilot autonomous hybrid (wind turbine/photovoltaic) reverse osmosis system for seawater desalination, within the National Programme PAVET, of the Greek Ministry for Development, for further research on technologies coupling. The system has been installed and is under testing at the CRES Test Site.

Several research projects were running at CRES during 2004, 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 (most sites favorable for wind energy development in Greece are of such topography) and identifying the crucial parameters affecting both the power performance and the loading of different types of wind turbines operating in such environments (new techniques are under development for power-curve measurement of wind turbines operating in complex terrain)
- 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-testing techniques within 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.

## University Research

Basic R&D on wind energy is mainly performed at the country's technical universities. The National Technical University of Athens (NTUA) is actively involved in two research areas concerning wind energy: (1) rotor aerodynamics and (2) wind energy

integration in the electrical grid. The fluids section of the Mechanical Engineering Department of NTUA is active in wind modeling, rotor aerodynamics, load calculation, fatigue analysis, noise issues, and wind farm design.

The work conducted during 2004 included applied research on wind turbine aeroelastic stability.

NTUA participated in an EC-funded project for the aeroelastic stability of large wind turbines. Within this project, NTUA developed a linearized version of the in-house code, GAST, for the purpose of stability analysis of the complete wind turbine system. The stability tool was successfully validated against measurements on a full-scale large wind turbine. The damping characteristics predicted by the stability tool were also compared to those extracted from non-linear aeroelastic simulations with the in-house free wake aeroelastic code GENUVP. The GENUVP code was upgraded to include a second order beam model for the analysis of large deflection problems.

The Electrical Engineering Department of NTUA has been actively involved in the field of wind energy since 1980, participating in R&D projects sponsored by the EU and other institutions and co-operating with universities and research centers from many European countries.

In 2004, the Electric Power Division of NTUA continued its research activities on issues related to the technical constraints and problems in the integration of wind power into the electrical grids, the management and control of isolated power systems with increased wind power penetration, power quality of wind turbines and wind parks, and the design of electrical components for wind turbines. Specific research areas include the following:

- The technical constraints and problems in the integration of wind power into the electrical grids have been investigated in various regions of Greece, where the transmission system is weak and there is high interest in wind projects because of favorable wind conditions.
- Steady state voltages, voltage variations, and power quality issues have been investigated.

- The effect of large wind power penetration on the security of the mainland and also on island systems has been studied.
- Various control systems of variable speed wind turbines have been studied.
- A specialized code for the simulation of the effect of most common wind turbine types on the steady state and dynamic performance of weak grids has been developed. This tool allows the convenient study of relevant power quality problems.
- Distributed renewable generation is gaining considerable attention, and research in this area has continued, focusing mostly on technical issues related with the grid integration and control of such units. Particular emphasis is placed on the development of microgrids, comprising low voltage grids with increased distributed generation.
- Design of electrical generators and converters for wind turbine applications is in progress, including permanent magnet synchronous generators with state-of-the-art electronic converters, suitable for small wind turbines.
- Integration of wind turbines in small stand-alone systems is being researched, with specific application in water desalination for remote areas.
- Increasing wind power penetration in isolated island systems, with proper application of pumped storage via reversible hydro-power stations, has been studied in detail regarding its steady state and transient stability performance. This is crucial for the exploitation of the wind potential in many non-interconnected Greek islands.
- The development of advanced control centers for the management of conventional and renewable generation in isolated island systems is an on-going research area. Within this framework, algorithms and techniques are elaborated for short-term wind power forecasting for operational planning using numerical weather predictions and applying advanced artificial intelligence techniques (Radial Base Functions).

The Applied Mechanics Section of the Department of Mechanical Engineering and Aeronautics, University of

Patras (UP), has since 1990 focused on educational and R&D activities involving composite materials and structures. Emphasis is on 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.

During 2004, UP contributed to three research projects, funded by the EC, namely: "DAMPBLADE-Wind Turbine Rotor Blades for Enhanced Aeroelastic Stability and Fatigue Life Using Passively Damped Composites," "MEGAWIND-Development of a MW Scale Wind Turbine for High Wind Complex Terrain Sites," and "OPTIMAT BLADES-Reliable Optimal Use of Materials for Wind Turbine Rotor Blades." In DAMPBLADE, UP is contributing with experimental characterization of anisotropic damping properties, development of a dedicated FEM code for efficient damping modeling of composite structures, and finally, design of a 20-m GRP rotor blade optimally damped. In the MEGAWIND project, UP has accomplished the structural design of a modular (split) 30-m blade, which will be verified by full-scale testing of a prototype manufactured by Geobiologiki SA. In the OPTIMAT BLADES project, UP is Task Group leader in investigating blade material behavior under complex stress states in which the effect of multi-axial static and cyclic loading on strength and life of composite laminates is to be assessed, and results will be available in the form of design guidelines for rotor blade manufacturers.

Other research activities of the Applied Mechanics Section are: (a) development of finite element formulations and dedicated code accounting for selective non-linear lamina behavior, e.g. in shear, in the laminate, modeling of property degradation due to damage accumulation so as to predict 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, passive, and active vibration control.

## Demonstrations

No new demonstration projects were initiated in 2004. Performance results on the previously reported demonstration project titled “CRES 3.1 Megawatt Wind Farm in Complex Terrain” can be found at <http://www.cres.gr/windfarm>. The monitoring software has

the ability to periodically update the contents of the Internet site, presenting the latest operational data of the wind farm.

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## CHAPTER 11

# IRELAND

### 1.0 INTRODUCTION

There was continued growth in the annual addition to wind generation capacity in 2004, indicating that the industry is in a strong growth phase. The total commissioned wind generation capacity at the end of 2004 was 260 MW, an increase of 70 MW over 2003. In addition, there was more than 100 MW of constructed wind capacity awaiting grid connection at the end of 2004. The volume of new grid connection agreements for wind generation capacity, which is one of the best indicators of near-term growth in the sector, also points to continued growth in deployment rates for 2005 and 2006.

This increased rate of deployment was maintained despite the moratorium on processing new grid-connection applications for wind generation that was in place until mid-2004. After this moratorium ended, wind connection applicants had a further wait while the electricity distribution network code was revised and while a mechanism to deal with the backlog of connection applications was devised and instituted in the closing days of 2004.

### 2.0 NATIONAL POLICY

Progress towards achieving the national renewable electricity capacity target for 2005, though improved, was, in 2004 still below the rate required to deliver the required additional 500 MW of renewable generating capacity. The moratorium on wind connection

offers has compromised the possibility of this target being achieved by the end of 2005, but, given current projected build rates, it should be reached within a year of that date.

Ireland also has a target of obtaining 13.2% of its national electricity consumption from renewable sources by 2010, committed to under the EU RES-E directive. This has been estimated to require a deployment of 1,100 MW of wind capacity. All parties involved with enabling this deployment recently re-affirmed their commitment to achieving this target in meetings held in 2004.

### 3.0 COMMERCIAL IMPLEMENTATION

#### Installed Capacity

The installed and commissioned wind generating capacity in the republic of Ireland at the end of 2004 was 260 MW. Wind generation capacity totalling 70 MW was connected to the electricity grid during 2004 and marginally exceeds the 2003 record of 52 MW. Construction has been completed on additional projects totalling more than 100 MW, including the 72 MW Meentycat cluster of wind farms, but these awaited grid connection at the end of 2004.

#### Rates and Trends in Deployment

While the growth of the wind energy sector in Ireland is rising, the rate of increase in deployment is low. To date, increases have not exhibited the year to year doubling of capacity additions which is typical in other countries when the industry enters its high growth phase. It has become apparent, in analysis subsequent to the moratorium mentioned above, that the availability of grid connections will, in coming years, become the primary limiting factor on the growth of the wind power sector in Ireland. As noted in the 2003 IEA Wind report, 326 MW of wind generation capacity was authorized to be connected in 2004. However, the actual volume connected fell far

short of this. The shortfall can in part be attributed to delays in the provision of connection infrastructure, as mentioned, and 100 MW of capacity was completed and awaited connection at the end of 2004. Work on the 60-MW Derrybrien project, due for grid connection in 2004, was halted due to a peat-slide at the site late in 2003. Work recommenced in 2004 after the adoption of recommendations in a geotechnical consultants report.

In the offshore wind sector, while commissioning on Phase 1 of the Arklow Bank project was completed in 2004, there were no other significant developments in the sector. Airtricity the company that is developing the 500-MW Arklow bank offshore site, entered in to partnership with EHN of Spain to execute the 60-MW Phase 2 of the project.

### Contribution to National Energy Demand

The estimated contribution from wind power to national electricity demand in 2004 was 655 GWh. This represents a 44% increase over 2003 production. A preliminary estimate for the total electricity demand in Ireland in 2004 is 26,013 GWh, an increase of 5.4% over 2003. The percentage contribution of grid-connected wind power to gross national electricity demand was 2.52%.

## 4.0 MARKET DEVELOPMENT AND STIMULATION

The primary market support mechanism for renewable electricity in Ireland has been the Alternative Energy Requirement (AER) scheme through which price support contracts with a 15-year term are awarded to renewable electricity generators in regular competitive tender rounds. The scheme has been in place since 1996, and the results of the last round, AER VI, in which contracts for 334 MW of wind projects were awarded, were announced in July 2003. Support for an additional 235 MW of wind projects under AER VI was announced in December 2004, after EU state aid approval for support for this additional capacity was received.

Under the AER program, a total of 807 MW wind power capacity announced in the tender rounds since 1996. As of the end of 2004, 197 MW has been commissioned<sup>1</sup>.

In December 2003, the government released a consultation paper titled "Options for Future Energy Policy, Targets and Programmes"<sup>2</sup> outlining possible choices for renewable energy policy in Ireland up to 2020. Responses to the consultation were received early in 2004, and the government convened a Renewable Energy Development Group to consider the options in detail. The group reported to the government late in 2004, and an announcement on the nature of the future support mechanism is expected. Pending this announcement, there is no current government scheme to which new renewable energy projects can apply to for support.

In Ireland, the electricity market is fully open to competition, in accordance with the requirements of the EU Directives 96/92/EC and 98/30/EC, as of 19 February 2005. During the staged opening of the electricity retail market, special consideration was given to renewable electricity suppliers in granting them access to all consumers in advance of full market opening. With full market opening, this commercial advantage has been eliminated. Wind generation capacity totaling 85 MW, or 33% of the installed capacity in Ireland, trades electricity within these trading arrangements without the benefit of government price support or green credits.

The main fiscal incentives, from which investors in wind farm projects can benefit, are; a) the Business Expansion Scheme (BES) and b) tax relief under Section 486b of the 1998 Finance Act, on capital directly invested in wind farm assets. Under a), those investing in approved qualifying businesses can claim a tax refund on income invested. Electricity generation is a qualifying business activity. The scheme has an investment cap of 750,000 euro and is thus of limited value to larger wind energy projects. Under b), corporate investors in renewable energy projects can claim tax relief on equity investment in capital assets. As the corporate tax rate has been reduced to 12.5%, this fiscal incentive will have limited future attraction. A 2002 amendment to the Finance Act also

restricted eligibility for tax relief on capital assets to active participants in projects. This measure effectively eliminated a commonly used investment vehicle for private investment in wind farms.

## 5.0 DEPLOYMENT AND CONSTRAINTS

### Wind Turbines Deployed

The number of operational grid-connected wind turbines in Ireland at the end of 2004 was 321. Of these, 314 were onshore and 7 were offshore. The size of operational wind turbines ranges from 225 kW to 2.5 MW onshore and the single offshore wind farm uses 3.6-MW turbines. In 2004, 45 onshore wind turbines with an average size of 1 MW were commissioned. This average size is smaller than the 2003 average size of 1.34 MW and lags world wide averages. Possible reasons for this are: (i) turbine size is more or less fixed at the planning stage and project development periods are protracted and (ii) road access limits turbine size on many sites in Ireland. The largest wind farm operational at the end of 2004 was 25 MW. At the time of writing, the largest windfarm constructed, but not yet grid connected, was the 72-MW Meentycat cluster of wind farms, which comprises twenty-three 2.3-MW wind turbines and fifteen 1.3-MW wind turbines. The largest wind turbines deployed in Ireland to date have been 2.5-MW Nordex turbines onshore and 3.6-MW G.E. wind turbines offshore.

### Operational Experience

Capacity factors for wind turbines installed in Ireland to date generally exceed 35% and capacity factors exceeding 40% are not uncommon. While turbine availability will typically exceed 97%, there has been mixed experience on the reliability of turbines supplied in the early years of the development of the industry in Ireland. A wind turbine users group was formed in Ireland in 2003 to provide a forum where experiences on turbine performance could be exchanged and concerted representations could be made to manufacturers. A study to develop the scope of a monitoring program was funded by Sustainable Energy Ireland (SEI) in 2004. SEI expects to part-fund the implementation of such a program in 2005.

The commissioning and first year of operation of the Arklow Bank offshore wind farm, Ireland's first offshore wind-farm, has been relatively trouble free. The grid connection to shore was damaged early in 2005 by a ship anchoring in an unauthorized area and the associated outage while the cable was repaired lasted several weeks. Precautions have been taken to ensure that there will be no recurrence.

### Main Constraints on Market Development

As indicated in the 2003 and 2004 reports, permitting of wind farm sites has diminished as a near-term constraint on market development and electricity system issues have emerged as the primary constraint on growth.

The moratorium imposed on processing grid connection applications at the end of 2003 was requested by the TSO for two key reasons:

- Most wind farms installed to date are not grid code compliant
- Dynamic models of wind turbines were not provided by turbine suppliers as required in their conditions of connection.

As Ireland's electricity system is an isolated island system with very limited interconnection, it must deal with contingencies from within its own resources. Because of the small size of the system, substantial frequency excursions are not uncommon and it is important that an increasing penetration of wind power does not exacerbate these excursions. In particular, it is important that wind farms are able to "ride through" transmission system faults, that cause severe voltage depression, and remain connected to maintain system frequency. Prior to 2004, the transmission system grid code did not give consideration to the special characteristics of wind turbines. A draft grid code section<sup>3</sup> dealing specifically with wind generators was produced in April 2004 and adopted in June 2004.

The unusual sensitivity of Ireland's electricity system to generator interruptions also makes it more critical that the TSO can accurately model the performance of wind turbine generators during system faults to

anticipate and address any adverse effects that may arise when large numbers of these are connected to the electricity system. In order to do this, computational models of the wind turbine generators are required for use within the TSO's power system simulation software. Only the wind turbine manufacturer will have the proprietary information necessary to generate such models. Prior to December 2003, no turbine manufacturer had provided models which met the requirements specified in connection agreements. During the moratorium, significant progress was made in obtaining such models for all operational wind turbines and those that are specified in current connection agreements and connection applications. Work is ongoing to validate the models that have been provided.

While the moratorium on connection offers to wind generators officially ended in June 2004, when the Commission for Energy Regulation (CER) issued an instruction<sup>4</sup> to the TSO, it did not, in effect, end until October 2004, when a modification to the distribution system grid code was approved. It had become apparent during the moratorium that a backlog of connection applications had amassed which would be difficult to deal with within the one-at-a-time application processing system that was in place. The transmission and distribution system operators developed a proposal<sup>5</sup> for a group processing scheme to address this. The CER gave a direction to implement this scheme on 23 December 2004<sup>6</sup>. Under this scheme, wind farm connection applications which meet pre-defined qualifying criteria will, at appropriate intervals, be assessed and made offers en bloc. This will significantly reduce the work required to process applications and, on average, result in applicants receiving connection offers earlier. It should also result in more efficient provision of new electricity network assets, as sharing of connection infrastructure by generators will become more common.

While this arrangement will more efficiently deliver connection agreements to wind farm applicants, a point will soon be reached where the rate of growth of the wind energy sector will be limited by the rate of provision of new electricity infrastructure. A report commissioned by the CER in 2003,<sup>7</sup> provided indication of the amounts of wind power generation that

could be accommodated in the Irish electricity transmission system, within various time horizons, before deep reinforcements are required. The cumulative capacity in connected wind farms, connection offers, and connection applications currently far exceeds limits identified within that report. The lead-time for the provision of major electricity system infrastructure upgrades is longer than the construction period for the wind farms whose connection applications require its provision. The rate of wind power deployment will therefore soon be determined by the rate of new transmission system infrastructure provision.

## 6.0 ECONOMICS

### Trends in Investment

Estimated average costs for onshore wind farm development in Ireland in 2004 are 1,150 euro/kW of capacity installed (including an estimated 100 euro/kW for grid connection), with wind turbine costs making up 750 euro/kW of installed capacity. Annual operation and maintenance costs average 0.012 euro/kWh.

As only one offshore wind energy project has yet been built, there is limited cost data for this sector of the industry. Estimated costs for developments in Irish coastal waters range from 1,270 to 2,050 euro/kW installed<sup>8</sup>, the lower cost probably is not including grid connection. Information relating to offshore projects under development, albeit of a small scale, indicate costs at the higher end of this range. The costs for such developments are highly sensitive to project scale.

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

The price caps in the 6th and final tender round of the AER prices support scheme were announced in July 2003. They were 0.05742 euro/kWh for projects smaller than 5 MW; 0.05216 euro/kWh for those larger; and an indicative price cap of 0.084 euro/kWh for offshore wind farms (to a total capacity limit of 50 MW and 25 MW per site). Contracts awarded under this support scheme have a 15-year duration and in-



clude full indexation. An accelerated capital recovery mechanism was included in this tender round whereby projects could obtain increased payments in the first seven years of the contract period, with rates reduced commensurately in the final eight years. The actual prices bid by winning projects are confidential and weighted average prices were not published for this tendering round.

As the majority of wholesale electricity in Ireland is traded through bilateral contracts, average wholesale prices for comparison to wind power are unobtainable. However, the Commission for Energy Regulation does calculate annually a benchmark “Best New Entrant” (BNE) electricity price to be used in setting prices in the secondary balancing market including the “top-up” price for electricity. This price, based on CCGT generating plant, was 0.0479 euro/kWh from January to September 2004 and increased to 0.0521 euro/kWh from October to December 2004 and wind-power, with generating costs in Ireland ranging from 0.003 to 0.006 euro/kWh<sup>9</sup>, compares favorably to it. The average price paid to wind generators under the AER price support mechanism in 2004 was 0.0583 euro/kWh.

## 7.0 INDUSTRY

There is no significant wind turbine manufacturing industry in Ireland. There have been several initiatives to set up manufacture of specific wind turbine components and to manufacture micro-scale turbines. SEI has funded several R & D projects in these areas and these are detailed below. SEI has funded a study on offshore wind energy potential and associated industry development in Ireland. When completed, this study will serve to inform government policy on the development of this industry sector.

## 8.0 GOVERNMENT-SPONSORED R, D&D

### Priorities

The 1999 Irish Government Green Paper on Sustainable Energy, along with setting renewable energy targets for Ireland, set out a program of Sustainable Energy R, D&D with a budget of 50 million

euro for the years 2000 to 2006. SEI was charged with administering this budget. Of this budget, 16 million euro was specifically allocated to renewable energy research, while other parts of the program also contain renewable energy elements. Priorities identified within the Green Paper were techniques for assessing the wind regime on land-based sites and their adaptation to Irish conditions and site evaluation techniques for offshore wind farms.

The government-convened Renewable Energy Strategy Group completed a report specific to wind energy development, titled “Strategy for Intensifying Wind Energy in Ireland” in 2001<sup>10</sup>. This report identified key areas where development is required, and work was initiated in these areas. As the majority of the requirements initially identified have now been addressed and the wind industry in Ireland has moved from the initial deployments phase to the threshold of large scale deployment, the priorities for facilitation of future wind energy development have also changed. In 2004, the Minister for Communications, Marine and Natural Resources, whose brief includes energy policy, formed a Renewables Development Group, chaired by his Department. Here the Renewables Industry, the Commission for Energy Regulation, SEI, and the Network Operators met to share expertise and to advise the Minister on the policy requirements for the future development of the renewable energy sector. Future R&D requirements for the sector formed part of the discussion and the group reported to the Minister on these.

In August 2002, SEI launched the Renewable Energy R, D&D program outlined above. The focus of the program is to stimulate the application and further deployment of renewable energies, particularly those close to market viability. That could include measures to stimulate the development of the technologies and produce implementation plans for those with economic potential. The primary objectives are to remove barriers to the deployment of renewable energy technologies and help stimulate the development of an Irish renewable energy industry.

The Renewable Energy Research, Development and Deployment program, with an indicative budget of 16

million euro, will give priority to supporting the following:

- Research aimed at developing policy options for enhanced deployment
- Research to define the market structure for renewable energy technologies with high penetration potential
- Research aimed at cost reduction, improved reliability and/or opening new markets
- Demonstration of non-technical innovation
- Feasibility studies for renewable energy projects
- Demonstration aimed at high-risk, high-reward projects
- Investigation into core areas common to many renewable technologies, such as the electricity system, regulation, technical standards, fiscal and support measures, finance, markets, planning, and policy.

For onshore wind energy, specific priorities identified for the program are measures to address the creation of the correct electrical network, market, and social conditions for the wider acceptance of the expanding deployment of wind energy.

### New R, D&D Developments

The program outlined above has had significant numbers of applications to it since its launch. Among the wind energy R&D, projects which have been approved for funding to date include:

- Development of a short-range ensemble prediction system for wind energy forecasting in Ireland
- Participation in IEA R&D Wind Agreement Annex 21- Dynamic Models of Wind Farms for Power System Studies
- A study on Offshore Wind Energy Potential and Associated Industry Development in Ireland
- A study on the deployment of a Wind Turbine Design and Method of Implementation which is Ideally Suitable for Use at Small Irish Wind Farms
- A Study to Define of a Monitoring Programme for Irish Wind Farms

- Study of Electricity Storage Technologies and Their Potential to Address Wind Energy Intermittency in Ireland
- Marketing/technical feasibility study to determine the possibility of developing a viable small VAWT
- An investigation of the effects of wind turbines on MSSR radar tracking in Ireland
- A project to develop Wind Turbine Blade Manufacture with New Materials
- An evaluation of wind turbine foundation behavior
- A study on the Influence of Mounting Booms and Towers on Wind Speed Measured by Anemometers
- Development of a Demonstration 1.2-kW Domestic Wind Turbine
- A Study of Ownership Models and Financing of Community Renewable Energy Initiatives.

Commissioned studies on specific prioritized topics affecting wind energy integration which have been funded under the Renewable Energy R, D&D include:

- An updated wind atlas for Ireland with 200-m resolution, providing wind data at 50 m, 75 m and 100 m for both onshore and offshore areas of the Republic of Ireland<sup>11</sup>
- A public attitudes survey “Attitudes to the Development of Wind Farms in Ireland”<sup>12</sup>
- A Study on Renewable Energy in the New Electricity Market<sup>13</sup>
- A study titled “Costs & Benefits of Embedded Generation in Ireland”
- A study titled “Impacts on operating (and load following) reserves of increased wind penetration in Ireland”<sup>14</sup>
- A study titled “Economic Analysis of Policy Mechanisms.”

### Offshore Siting

The mechanism for permitting offshore wind farms is an adaptation, introduced in 2000, of the offshore exploration licensing system. It comprises a “foreshore license,” which allocates exclusive rights to a single developer to allow in-depth site assessment, and a “foreshore lease,” which assigns exclusive site

development rights to a developer. To date, eleven foreshore licenses have been issued and one foreshore lease, the latter being for the Arklow bank. Two projects with foreshore licenses were winning tenders, for 25-MW capacity each, in the AER VI competitive tendering round. The lack of applications for grid connection from the sector indicates that, apart from the Arklow bank project, there will be little near-term activity in the sector.

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## CHAPTER 12

# ITALY

### 1.0 INTRODUCTION

In the energy sector, Italy is strongly dependent on fuel imported from foreign countries. An analysis of the Italian primary energy balance in 2003 confirms this trend, which started some decades ago. In fact, domestic primary energy production was only 29.5 Mtoe, while total imports corresponded to 184.9 Mtoe, of which the majority were oil products (107.4 Mtoe), followed by natural gas (51.4 Mtoe), and coal (14.5 Mtoe). Total exports were some 22.3 Mtoe, of which 22.1 Mtoe were oil products.

In 2004, domestic electrical energy demand was about 322 TWh, with a slight increase of 0.4% from 2003. Domestic gross electricity production was 300.4 TWh in 2004, with an increase of 2.3% from 2003. The total amount of electricity imported, corresponding to 45.6 TWh, was 10% less than in the previous year. Hydropower production was 48.7 TWh (including some pumped-storage plants), with an increase of 10% from 2003. Thermal production from fossil fuels (natural gas, oil and, to a lesser extent, coal) totaled 244.4 TWh. The remainder came from other renewable sources, such as geothermal plants (5.4 TWh), wind farms (1.8 TWh), biomass plants, photovoltaic plants, etc.

With Law No. 239, issued in August 2004, on the reorganization of the energy sector, the activities and the general objectives of energy policy were established. Its main points are first to guarantee

the safety, flexibility and continuity of energy supply by diversifying primary energy sources and then to: promote the unitary functioning of the energy market; exploit domestic hydrocarbon resources in an environmentally-friendly way; favor research and new technology in the energy field; and increase efficiency in the end-use of energy. A specific objective is improving the environmental sustainability of energy through, among other things, increasing use of renewable sources.

Legislative Decree No. 387 was issued on 29 December 2003 for implementing EU Directive 2001/77/EC on the promotion of renewable energy sources (RES hereafter) in the electricity system. The decree is only partly operational, which has caused a series of problems for all private investors in a large part of the Southern Italian regions. Italy still displays a conflict between opportunities and constraints regarding a satisfactory renewable energy growth rate, with the highest controversy surrounding wind energy. In fact, although wind power capacity increased 357 MW in 2004, with a cumulative capacity of 1,265 MW, wind investors are facing other difficulties, particularly at a regional level, where the final decisions are taken. For example, in Sardinia, the new regional government is opposed to wind energy exploitation on the island and so a lot of conflicts have arisen between regional authorities and investors, as well as municipalities. A peculiar aspect of the wind energy approach in Italy is provided by the two largest islands. Sardinia is now against wind energy, while Sicily is supportive and is attracting some investors coming from Sardinia where, at least for the time being, they have been denied the possibility of continuing to develop their projects.

The wind market has naturally been influenced by these regulatory aspects; and setbacks ensuing from connection of wind power plants to the grid led to significant delays in several projects. Nevertheless, annual installed wind capacity increased in 2004 at a higher rate than in the previous record year of 2001.

Thus, market response is fairly positive and fully in line to reach the 2006 intermediate target.

New 1.5-MW and 2-MW turbines, manufactured by GE Wind, Gamesa, and REpower, brought the total of large machines installed in Italy to more than 70 at end 2004. This figure, according to some investors and taking into account works in progress and other planned projects, will significantly increase in 2005 and 2006. Enel GreenPower alone installed more than one third of Italian wind capacity in 2004. It developed some 125 MW in Sicily with five new wind farms composed of 850-kW Gamesa and Vestas turbines. In Sardinia, it is completing a wind farm built by GE Wind and made up of larger, 1.5-MW units.

The medium-sized turbine segment increased its production for the Italian market during 2004 with a significant benefit in terms of employment both at the factory in Taranto, where all the Vestas V52 turbines are produced, and at national firms, which supply several of the components for individual machines and wind farms. Moreover, Leitner is progressing well with its Leitwind 1.2-MW prototype, to be followed by production of one or more 1.5-MW turbines, depending on the market. In addition, the small company, Jonica Impianti, is now marketing its 20-kW turbine.

## 2.0 NATIONAL POLICY

In June 2002, the Italian parliament ratified the Kyoto Protocol on Climate Changes. In December 2002, the Interministerial Committee for Economic Planning (CIPE) approved a National Plan for Greenhouse Gas Reduction issued by the Ministry of the Environment, with the aim of complying with the objectives on gas emissions.

Italy has confirmed, through Legislative Decree No. 387 of 29 December 2003, the target of 76 TWh/yr from RES set for 2008 through 2012. The National White Paper for Exploitation of Renewable Energy Sources was approved by CIPE in 1999, in order to increase the contribution of RES to gross electricity consumption from 16% in 1997 to 22% in 2010. This target and other specific measures, should guarantee the achievement of Italy's Kyoto engagements (6.5% reduction of annual greenhouse emissions by

2008-2012 from the 1990 level). In this context, the estimated contribution coming from wind is 5 TWh, corresponding to capacity of approximately 2,500 MW. The main measures of Legislative Decree No. 387/03 that should have a positive impact on wind energy are:

- Increase of the 2% mandatory quota of electrical energy from new RES plants by 0.35% annually, from 2004 until 2006. This quota has therefore become 2.35% for 2004 electricity production;
- Exchange at the point of production of the electricity produced by small RES plants, of a maximum 20 kW in capacity (net-metering basis). Selling of the excess electricity produced is not allowed. This article of the law has to be supported by a regulation issued by the Regulatory Authority for Electricity and Gas;
  - Permit for renewable plant construction has to be released by the region concerned, through a single authorisation involving all parties concerned, within 180 days;
  - National targets are to be allocated among regions;
  - Work on construction of RES plants and related infrastructures is considered in the public interest, urgent, and not deferrable;
  - RES electricity is granted the right of priority in use and dispatching.

As a consequence of delays in issuing the regulations and applicative decrees necessary to make this law effective (except for the mandatory quota of RES, already in force since 2002), the expected results have not yet been achieved. The green certificate mechanism, connected to the mandatory quota of RES is going well after a difficult start-up lasting almost two years. Many wind investors are trying to obtain permits to build in all the Southern regions.

With Law No. 239 issued on 23 August 2004, the entire energy sector has been finally reorganized. In the context of the principles coming from the European system and international obligations, the principles of this law are considered fundamental in energy matters. The activities of the energy sector are regulated as follows:

- Production, import, export, storage, purchasing, and selling of energy to entitled customers, as well as transformation of energy source ma-

terials, can be carried out freely in the national territory.

- Transportation and dispatching of natural gas in the network, management of energy supply infrastructures connected to transportation, and dispatching of energy in the network are of public interest.
- Electricity and natural gas distribution; exploration, harvesting, and underground storage of hydrocarbons; and transmission and dispatching of electricity are attributed under concession in accordance with the relevant legislation.

To diversify energy sources for environmental protection and security of supplies, the Minister of Production Activities, in agreement with the Ministers of the Environment, Infrastructures and Transportation, is to promote one or more program agreements. These agreements will be made with interested operators, research institutes, and interested regions for research and exploitation of advanced and environmentally sustainable technologies for electricity production or fuel from coal. Pursuant to this law, electricity generated using hydrogen and energy produced in plants using hydrogen or fuel cells is now entitled to obtain green certificates, as is energy produced by CHP plants connected to district heating, (but only for the part of thermal energy used for district heating).

## Strategy

According to Legislative Decree No. 112/98 for the decentralization of administration, the decision on installing RES plants has to be taken at the regional and local level. Central and southern Italian regions, where wind potential is better, are completing their energy plans with different approaches to wind energy in terms of target, guidelines, incentives and environmental impact. Sardinia, Calabria, Basilicata, Umbria, Lazio, and Tuscany have approved their energy plans, including regional wind targets and sometimes their own guidelines, but in certain cases this is not a guarantee. In fact, since July 2004 in Sardinia a new administration has been in charge, which, through a regional law issued in November 2004, stopped any wind initiative, including those authorized previously by the former administration. This delay will last until

the approval of a regional landscape plan, perhaps at end 2005 or later. According to the National Wind Energy Association (ANEV), wind energy projects totaling some 1,000 MW are at risk in Sardinia, with economic damage to investors and municipalities where wind farms have been planned.

In Sicily however, wind projects are going ahead and public financial support for wind projects has been confirmed, even though the regional energy and environmental plan has not yet been approved. Wind projects of around 800 MW, of which more than 100 MW are completed, have obtained the approval of the regional environmental authorities.

## Progress Toward National Targets

With the new wind capacity added in 2004, the next target defined by the Italian white paper on renewables (1,400 MW by 2006 from wind) will be achieved soon, probably in the spring of 2005. The final target of 2,500 MW by 2008 through 2012 could be accomplished earlier if Law No. 387 becomes fully effective shortly, through an active co-operation with the regions and local authorities.

## 3.0 MARKET DEVELOPMENT AND STIMULATION

Historically, public support for RES deployment, in addition to state-funded research programs, started with Law No. 308, followed by the more effective Laws No. 9 and 10 issued in 1991. All these laws provided financial incentives, the last one for up to 30% of the investment cost (50% for demonstration plants).

In April 1992, Provision No. 6/92 issued by the Inter-ministerial Committee for Prices (CIP) dramatically changed the incentive scheme for renewables, establishing a premium price for eight years of plant operation on the basis of the type of renewable technology used for electricity production connected to the grid. This law increased the technologies allowed to get a premium price to include the so-called assimilated ones, like co-generation (CHP), which eventually obtained a larger amount of public incentive than truly renewable sources. Even so, this provision was the driving force of the market for new

renewables and particularly for wind energy. In 1996, the private investor IVPC, after a careful study of wind characteristics in the southern Apennines chain based on previous results obtained by ENEA, installed its first wind farms on the border between the Apulia and Campania regions. Since that time, wind power capacity has been growing in spite of the radical change to an incentive scheme based on green certificates and in spite of the local opposition forces to wind energy development, generally led by landscape committee representatives and also, recently, by the regional authorities in Sardinia.

In the process of privatising the Italian national power system, the Electricity Market Operator (GME) is responsible for managing transactions in the Electricity Market in accordance with neutrality, transparency and objectivity criteria. To achieve these targets, GME organises and manages the power exchange, a virtual marketplace where, every day, producers and buyers sell and purchase electricity. As part of the policies of development of renewable energies and energy efficiency, GME also organises and manages venues for trading Green Certificates and White Certificates (i.e. those linked to energy savings).

Green Certificates (CV) represent a new scheme to promote electricity generation from renewables. In accordance with Legislative Decree No. 79 of 16 March 1999 and the ensuing Ministerial Decree of 11 November 1999, the electricity generated by RES plants that have become operational or have been repowered after 1 April 1999, shall be certified as obtained from renewables and consequently shall be eligible for CVs for the first eight years of operation. CVs are issued by the Transmission System Operator (GRTN) on the basis of producers' reports of electricity generation from renewables in the previous year or expected generating capability in the current or following year. Moreover, art. 11 of Legislative Decree 79/99 stipulates that, beginning in 2002, producers and importers of electricity from non-renewable sources shall yearly feed a given share of electricity from renewables into the power system. This share shall be equal to 2% of the electricity from non-renewable sources generated or imported

in the previous year and exceeding 100 GWh/year. Producers and importers may also fulfill their RES obligation by purchasing Green Certificates which have been issued in respect of electricity from renewables generated by other producers. From 2004 through 2006, the minimum share of electricity from renewables to be fed into the power grid in the following year shall be increased by 0.35% per year. GRTN, in accordance with Law No. 239, has now lowered the amount of electricity corresponding to one CV issued on the basis of Law No. 79/99 from 0.1 GWh to 0.05 GWh. CVs related to RES plants that are also entitled to CIP 6/92 prices are retained by GRTN, which must sell them at a fixed price calculated every year according to a given procedure (0.09739 euro/kWh for the 2004 production).

The total price per kilowatt-hour that a wind energy investor can currently get is the sum of the CV value and the electricity selling price. Both these prices are determined by the market. The CV value is close to the reference price fixed by GRTN (0.09739 euro/kWh) for its own CVs, which actually works as a maximum price. This stems from the fact that in 2004, as in previous years, the certificates owned by GRTN were more than those of entitled RES producers and were even enough to cover the whole demand for certificates. The electricity selling price depends on a variable fuel price and other parameters. It could be given a 2004 weighted average value of about 0.056 euro/kWh.

GME organises and manages the Green Certificate Market. The following entities may participate in the Green Certificate Market as buyers or sellers: GRTN, domestic and foreign producers, electricity importers, wholesale customers, and associations (consumers' and users' groups, environmental associations, trade unions). These entities must have submitted an appropriate application to GME and have been qualified as Market Participants. Market sessions take place at least once a week in the period from January to March of each year and at least once a month in the remaining period. Trading is on a continuous basis.

RES plants also have access to other incentives through Law No. 488/92, which provides subsidies on



investments to enterprises in various sectors, including electricity. Moreover, some southern regions have granted financial support to wind projects. Sicily is the only region with different support measures for onshore and offshore projects. Onshore plants can obtain a maximum financial contribution of up to 25% of eligible cost, while for offshore plants the percentage is 42%. These percentages are only for medium and small enterprises, otherwise the figures for onshore and offshore wind farms are reduced to 17% and 29%, respectively.

**4.0 DEPLOYMENT**

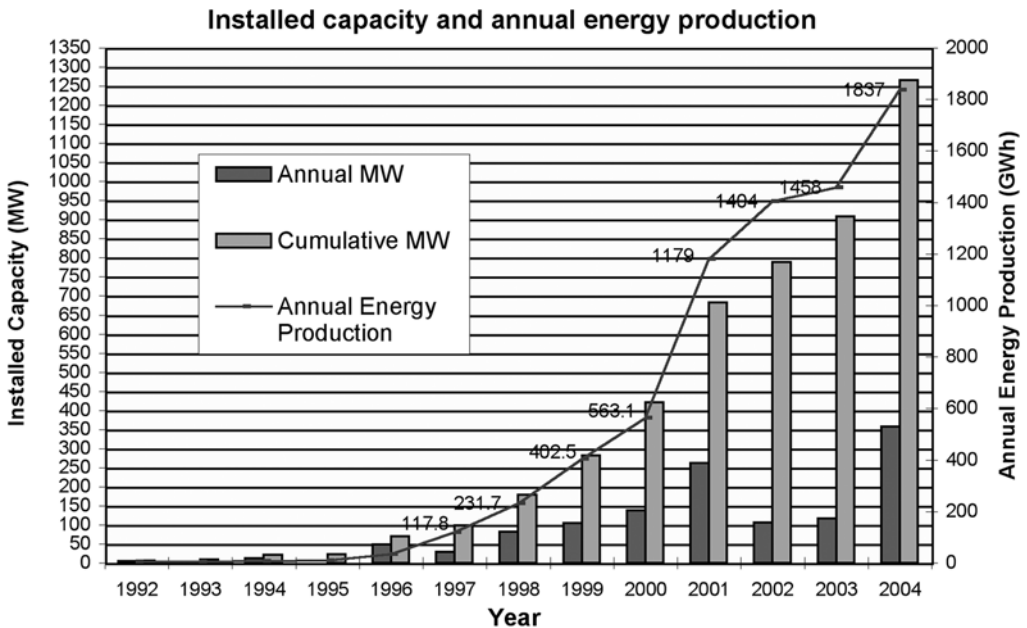
During 2004, new wind power capacity of 357 MW (389 turbines) was connected to the grid, bringing Italy's total to 1,265 MW with 1,880 units on line. Compared to the two previous years, there was a strong increase in installation rate, but owing to the usual uncertainties relating to wind energy development in Italy, it is still difficult to foresee what will happen in the near future after completion of the several wind farms currently under construction. Figure 1

shows the installed capacity (annual and cumulative) and annual energy production.

Sardinia and Sicily were the most active regions in 2004, with a slight difference between them; 120 MW were set up in Sardinia and 116 MW in Sicily. The Abruzzo region had 50 MW installed. Table 1 shows both the cumulative wind power capacity and the capacity installed in 2004 split among regions. In the same table, wind farms under construction or planned are also shown.

Enel GreenPower connected four wind farms with medium-sized (850 kW) machines to the grid. Another wind farm with 22 1.5-MW turbines installed should be completed soon. These wind farms are located in Sicily and Sardinia.

The IVPC group, through its companies IVPC Sardegna and IVPC 2000, installed 68 MW in Sardinia (43 MW) and Sicily (25 MW). In Sicily, IVPC 2000 is completing some wind farms composed of 850-kW turbines.



**Figure 1** Installed capacity (annual and cumulative) and the annual energy production in Italy.

Cumulative and 2004 installed capacity of wind farms in the Italian regions				
Regions	Cumulative wind power (MW)	2004 Wind power (MW)	Energy producers in 2004	Wind turbines installed in 2004
Sicily	178	116	Enel GreenPower, IVPC	Vestas V52, Gamesa G52
Sardinia	241	120	Enel GreenPower, IVPC, ENDESA, FRI-EL	Gamesa G80, Vestas V52, GE 1.5
Campania	286	24	Harpen eolica, SA.IN, STAR WIND	Vestas V52, Fuhrlander SL
Basilicata	85	9.35	Energia Sud	Vestas V52
Apulia	253	32	Edens, EnerTAD	Vestas V47, Repower RE MM82
Lazio	9	4.2	EnerTAD	Enercon E40
Molise	35			
Abruzzo	157	50	Edens, Gamesa	Enercon E40, Vestas V47, Gamesa G52-58
Planned and under construction capacity of wind farms in the Italian regions in 2005				
Regions	Planned wind power capacity (MW)		Energy producers	Wind turbines
Sicily		200	IVPC, Asja	Vestas V52
Sardegna		21	Enel GreenPower	GE 1.5
Calabria		50	Gamesa, Eolo 21	Gamesa G52, Vestas V52
Apulia		190	EnerTAD, SA.IN, IVPC, Eolo Puglia, Vento Energia, Sistemi Energetici, Bergamo Energia, Fortore Energia, Edens	Vestas V80, GE 1.5 Enercon E70, Enercon E40
Basilicata		90	Gamesa, FRI-EL	Gamesa G83, Vestas V52
Campania		150	FRI-EL, Gamesa	Vestas V80, Gamesa G83

**Table 1 Wind power in regions: cumulative, installed in 2004, and planned in 2005.**

Edison Energie Speciali (Edens) completed two wind farms in the Abruzzo and Apulia regions for a total power capacity of 30 MW.

The average capacity of the 1,880 wind turbines installed at the end of 2004 was 673 kW, 10% higher than the previous year (Figure 2), while the average capacity of the 389 units put into operation in 2004 was 918 kW. This significant increase was due to the installation of 42 large turbines (1.5 MW and 2 MW). Figure 3 shows the 2004 shares of total installed wind capacity held by electricity producers in Italy.

In 2004, Gamesa and Vestas-IWT, through their 850-kW products, were the main suppliers on the Italian market (Vestas has had a well-established footing in Italy for some years now). GE Wind and REpower entered the Italian wind market for the first time in 2004. They are now completing two wind farms, respectively, in the Sardinia and Apulia regions, where 36 1.5-MW and 19 2-MW units are planned to be built by the end of 2005. They had 33 MW and 20 MW already installed in these areas at end of 2004.

Gamesa has confirmed its presence in Italy as an energy producer as well, with its 20-MW wind farm located in Northern Sardinia composed of 10 G80 2-MW turbines. This plant has recently been sold to the Spanish utility ENDESA. Another 31.5-MW wind farm made up of 37 G52 and G58 850-kW turbines is located in a mountainous part of the Abruzzo region. Table 2 shows the market shares of wind turbine manufacturers at the end of 2004.

Therefore, despite the harsh topographical features of most Italian sites, some large turbines have already been connected to the grid and a greater number will be installed by 2005. Achieving such results has required several expensive infrastructures, in particular mountain roads.

### Contribution to National Energy Demand

Although wind power capacity increased significantly in 2004, this happened mostly toward the end of the year. As a result, total electrical energy produc-

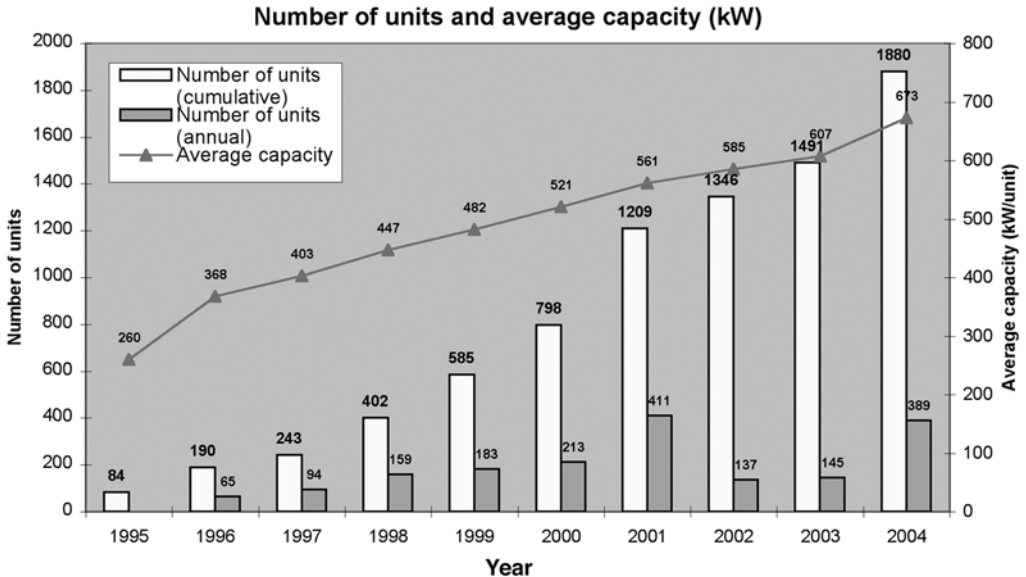


Figure 2 Number of units and their average capacity.

	2004 installed (MW)	2004 installed (percentage)	Cumulative capacity (MW)	Cumulative capacity (percentage)
Vestas	170.0	48	747	59.0
Enercon	6.6	2	201	16.0
Gamesa	125.0	35	151	12.0
Bonus			29	2.3
REpower	20.0	6	20	1.6
GE Energy	33.0	9	33	2.6
RWT			28	2.3
WEST			21	1.6

Table 2 Market shares of wind turbine manufacturers at the end of 2004.

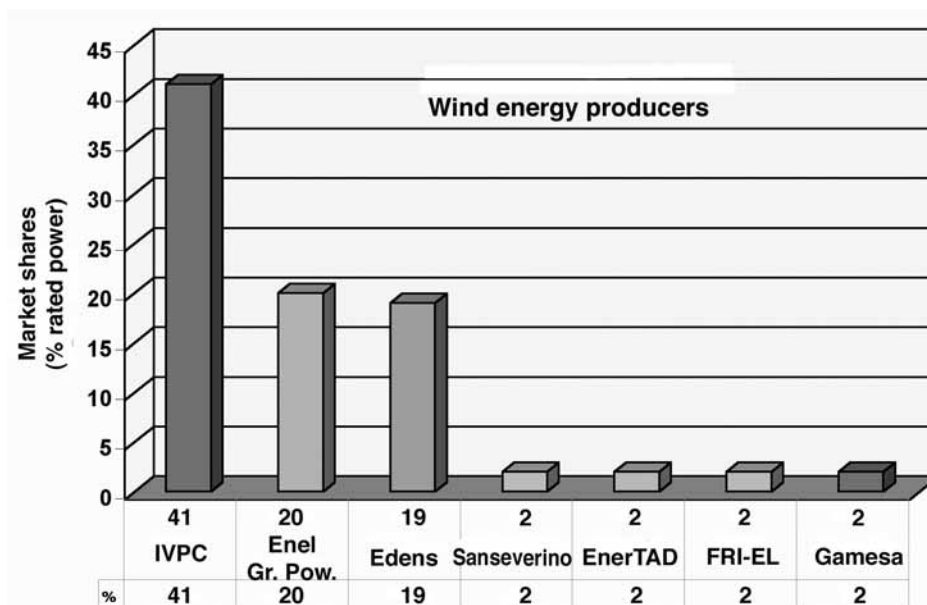


Figure 3 Contribution by electricity producers from wind at the end of 2004 (as a percentage of total on-line capacity).

tion from wind increased to only about 1.8 TWh (to be precise, 1,837 GWh according to GRTN). This is a 25.6% increase from 2003, so that wind's share in national energy demand remained very low, at about 0.6%. Domestic electrical energy demand was about 322 TWh (including transmission and distribution losses) in 2004, 0.4% more than in 2003. About 45.6 TWh were imported from abroad, with a significant (10.5%) reduction compared to the previous year. The gross electrical energy produced in Italy in 2004 was 300.4 TWh. Thermal plant production was roughly the same as in 2003, about 244.4 TWh, and the gross contribution of all renewable sources, including large and small hydro, was almost 53 TWh, 10% more than in 2003 (See Introduction).

## 5.0 DEPLOYMENT AND CONSTRAINTS

With an almost 40% increase in wind power capacity in 2004, 73 large turbines installed and some 80 under construction, it is strange but accurate to say that Italian wind developers faced more unexpected and adverse events than ever before. The most striking of these setbacks was the stopping of any wind project in Sardinia (at least until the approval of a new regional landscape plan), which was ordered in November 2004 by the new authority that entered office. Sardinia is one of the windiest Italian regions. In its regional energy and environment plan, approved in 2003 by the previous administration, the contribution of wind to electricity demand was significant, with a wind-energy limit of 2,000 MW. This energy plan also included specific guidelines for wind turbine installation, with the aim of achieving a good harmonization with the landscape. With the new authority in charge, several wind investors have left the island after having carried out expensive feasibility studies. Substantial investments have been lost and the remainder are at risk, while debate goes on and judgments on law-suits brought by Enel GreenPower and other operators are awaited.

In the Marche region too, problems must be solved before construction of wind farms, principally because many windy sites are also very sensitive in terms of avifauna and natural beauty. Regional and provincial authorities have so far been rather reluctant to accept renewable energy plants in their areas. Conversely,

some wind energy exploitation guidelines issued by the regions present technical requirements that do not agree with the main characteristics of wind energy nor with the conditions needed for projects to be profitable. For example, strong disagreements, of both a technical and a political nature, are creating difficulties for wind investors in the Basilicata region where some projects have been cancelled and others have been postponed. In all these cases, to some extent, both the press and a minority of local environmentalists have contributed to fomenting doubt, confusion, and opposition to wind energy.

Another constraint is the connection of wind generation to the grid, especially when this operation requires the construction of new high-voltage lines. For instance, in the Campania region, IVPC has been waiting three years for full connection to the grid for two wind farms, totaling almost 20 MW. Other operators have also been complaining of the time and bureaucracy taken for GRTN to comply with its duty to connect new wind farms to the grid.

The delay in issuing the regulations and decrees needed to implement Legislative Decree No. 387/03 is causing a further postponement in the application of this law on a regional basis. Although these problems caused the failure of important wind projects, a good number of other initiatives were completed in 2004, even in Sardinia before the regional decree stopping wind plants. The successes are thanks to the confidence of financial institutions and investors in the green certificate system and the positive attitude of Sicily, where civil engineering works for building new wind farms are still in progress. Figures 4 and 5 show two of these recent installations.

## 6.0 ECONOMICS

### Trends in Investment

Since more operators entered the wind sector in Italy during 2004, there was a significant increase in total investment. About three times as much investment was made as in 2003, corresponding to some



Figure 4 GE Wind 1.5-MW turbines at Enel GreenPower's site of Littigheddu (Sardinia).

300 million euros. This positive trend should be improved on or at least equaled in 2005 because a good number of projects are in progress. The trend of investments will depend on the attitude of some regions toward wind energy (see above). In this context, the decisions of Sardinia's authorities in 2005 could increase or decrease Italy's overall investments in wind to a very significant extent.

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

It is not easy to arrive at general unit generation cost figures because wind plant owners are not, as one can well understand, very prone to give out such confidential data. In addition, Italy features various sites with disparate windiness and terrain. Mountain sites

generally cause the cost of wind farm items other than wind turbines (roads, electrical lines, installation etc.) to be higher, and cause delays in permits. The extent of this extra cost can vary significantly from one site to another. As to energy yield, the annual number of equivalent hours of generation at full capacity can be estimated to be, in most cases, around 2,000. From these data, a generating cost range of 0.06 to 0.07 euro/kWh can be guessed, but this can only be a rough estimate.

Regarding the income of wind energy investors, in late 2004 GRTN fixed the selling price of its own green certificates for 2004 production at 0.09739 euro/kWh (GRTN's certificates are those that belong to RES plants that also get CIP 6/92 feed-in prices, so that they are retained by the issuing body for itself). There has thus been an increase from GRTN's 2003 price of 0.0824 euro/kWh. This trend will affect the



Figure 5 Vestas V80 2-MW turbines at FRI-EL's site in the Campania region.

selling price of certificates coming from entitled RES electricity producers, because all certificates will be traded together and offered to electricity producers required to comply with their 2004 RES quota obligation (2.35% of non-renewable energy production exceeding 100 GWh). By selling its own certificates on the same market, GRTN actually sets a price cap, because GRTN certificates currently outnumber those offered by RES investors (see also Section 3.0). The likely income from 2004 certificates can however be deemed as fairly rewarding for wind investors, considering that they get this income in addition to their proceeds from selling electrical energy.

On the other hand, the wind plants that still benefit from the former mechanism of CIP Provision No. 6/92 get premium prices for the energy they feed into the grid during the first eight years of operation. According to the authority concerned (Cassa Conguaglio per il Settore Elettrico), for 2004, the CIP 6/92 feed-in price for wind energy was set at 0.1276 euro/kWh.

## 7.0 INDUSTRY

The Italian market is characterised by the steady presence of Vestas, which last year again proved to be the leading company among wind industry players. In 2004, Vestas Wind System A/S, following the merging with NEG Micon and the consequent reorganisation, modified its structure, creating six Sales Business Units (SBUs) and four Production Business Units (PBUs). Its Italian subsidiary IWT, according to this strategy, now hosts the SBU Vestas Mediterranean East which, through Vestas Italia and Vestas Hellas, has Sales and Service responsibilities for Italy, Greece, and Eastern Mediterranean countries. IWT also has two PBUs, Vestas Nacelles Italy and Vestas Blades Italy.

The Vestas Group is confident about the Italian market. The company put one of its SBUs in Taranto and made the two PBUs located in Italy the sole agent of the only kW-class wind turbine still included in the new product range, the V52 850-kW machine. This

underlines the great experience and competence reached by the Italo-Danish Company IWT. Particularly in 2004, Vestas Italia achieved very good results in the Italian market, greatly contributing to the surpassing of the target of 1,000 MW connected to the grid. Orders received for V52 turbines to be installed in 2005/2006 are making a strong contribution to output in the Italian facility, which now employs more than 450 people, including both white and blue collar workers. Vestas Italia is now installing Italy's two biggest projects, totaling 70 MW each, using the V80 2-MW units, together with a series of projects with the smaller V52 machines.

### Prototypes

Two prototype turbines developed by Italian industry in 2003 have been running well. One of them, the Leitwind 1.2-MW machine by the Leitner company, has achieved certification, carried out by TÜV Süd (Munich). The construction of a few more Leitwind units is currently planned, even though this will depend on the availability of new mountain sites and confirmation of the orders.

The second prototype, the JIMP20 by Jonica Impianti, is a 20-kW turbine, which has completed its experi-

mental phase (See Figure 6). Jonica Impianti, a small company located in Southern Italy, has been involved since 2000 in manufacturing wind turbine prototypes in the 3.3-kW and 20-kW ranges. In the latter range, it has developed the innovative JIMP20 turbine, which is, inter alia, equipped with a synchronous axial-flux permanent-magnet generator. A first pre-series of 30 units has already been built and series production is currently being launched.

With the approval of Decree No. 387 of 29 December 2003, net metering will be extended to all new renewable sources up to 20 kW of unit capacity. This presents a good opportunity for a niche market in small wind turbines in Italy.

### Component suppliers

The following companies supply components for the wind industry in Italy.

- ABB for engines and generators
- Bonfiglioli, Coman for reduction gears
- Ring Mill for forging
- Elettromeccanica di Marnate (EDM)- SEA for transformers
- Pirelli for cables
- Monsud, Leucci, Pugliese for towers.



Figure 6 JIMP 20 small turbines (20 kW) developed by Jonica Impianti.



Moreover, the DAVI Wind Tower Division is very active in producing towers for most wind manufacturers.

## 8.0 GOVERNMENT SPONSORED R, D&D

Some Italian universities have lately been involved in R&D activities, particularly Bologna University for lightning protection, Trento University for cold climate applications and Milan University for supplying integrated aeroelasticity simulation software. In the latter project, the University of Milan is transferring the experience achieved in the aeroelasticity field in its work on helicopter rotors. Leitner SpA intends, through this aeroelasticity software, to overcome the limits of currently available commercial codes. The project includes a validation stage on an experimental basis, as well as a specific task for optimization of control logics. The Milan University Department of Aerospace Engineering is also carrying out research activity in the fields of control and supervision logics and wind models, as well as a preliminary project with non-conventional configurations.

In addition to lightning protection, the Bologna University Department of Electrical Engineering has been involved in developing a 10-kW small wind turbine prototype. The university is also doing some research on topics related to large wind turbines, particularly evaluating a direct-drive configuration and analysing the most suitable power converters.

In the past few years, the company CESI S.p.A. has developed and published the Wind Atlas of Italy and performed other research work on wind energy topics (e.g. assessment of high-altitude and offshore wind potential) with support since 2000 from the Fund for Research on the Electrical System established by the Italian Minister of Production Activities. Within this framework, a new research program was subsequently outlined and approved by the Regulatory Authority for

Electricity and Gas in March 2004. As to wind energy, however, the R&D work for 2004 and 2005 has been limited to monitoring the development of the wind sector worldwide and assessing the role of wind power in scenario studies concerning the development of Italy's electricity system from now until 2030.

## Offshore Wind Development

In Italy, there is not yet a strong interest in offshore applications. However, some universities, and in particular, that of Bologna, since 1997, have shown interest in marine wind potential and in offshore foundations and the possible use of oil platforms. ENEA, too, has been involved in offshore activities through its participation in three European projects: OWEE, WEMSAR and NOSTRUM (Net Offshore Technologies, Resources and Use in the Mediterranean sea). The latter was completed in 2004.

The NOSTRUM project was co-ordinated by Besel, a Spanish consultant and engineering firm. Its main objectives were to facilitate the deployment of offshore wind power in the Mediterranean Sea and to remove legal and administrative barriers that make the development of the sector difficult. The work was divided into the following items:

- Analysis and evaluation of the state of the art
- Drawing up of a Mediterranean wind map
- Characterization of sea-beds
- Legislative context
- Environmental aspects.

A Mediterranean wind map at 60 m above sea level has been created. As a result, considering the areas where wind speed is more than 6 m/s, depth is less than 50 m, and distance from the coast is more than 5 km, a total surface area of 9,000 km<sup>2</sup> has been identified for potential exploitation for wind energy.

Authors: L. Pirazzi (ENEA) and C. Casale (CESI)



## CHAPTER 13

# JAPAN

### 1.0 INTRODUCTION

At the end of Fiscal Year 2004 (March 2005), the total wind-power capacity in Japan was estimated to be 936 MW with 933 turbine units. This corresponds to one-third of the national target for wind-power capacity by 2010. After some wind turbines experienced severe damage from typhoons or lightning strikes, several activities have been organized to promote sound development of wind technology under governmental initiatives.

### 2.0 NATIONAL POLICY

#### Strategy

At the United Nations (UN) Climate Change Conference in Kyoto in December 1997, the Japanese government agreed to reduce the output of greenhouse gases by 6% by 2010, compared to the 1990 level. To attain this target, the government has changed the target of wind power in the latest Primary Energy Supply Plan for 2010 from 300 MW to 3,000 MW. The government also set another target to develop wind energy to supply as much as 6,020 MW by 2030.

#### Progress Toward National Targets

In April 2002, the Japanese government passed legislation for a Renewables Portfolio Standard (RPS) in order to realize the national target for renewables by

2010. The contribution of renewables to the total primary energy resources is expected to be 3% in 2010, up from 1.2% in 1999. Under the RPS, Japan's utilities are obligated to source 1.35% of total electricity supply from renewables by 2010.

### 3.0 COMMERCIAL IMPLEMENTATION

#### Installed Capacity

Japan's cumulative wind-power capacity was 684 MW in September 2004 (data source: New Energy and Industrial Technology Development Organization (NEDO)) and will be 936 MW at the end of fiscal year 2004 (March 2005). Figure 1 shows the history of wind turbine development in Japan. Every value of capacity was taken at the end of each fiscal year (March).

#### Rates and Trends in Deployment

The average annual increase late in the period of latest five years is 170% as shown in Figure 2. Most commercial wind farms have been developed with governmental promotional subsidy programs.

#### Contribution to National Energy Demand

Wind power generation from April 2003 to March 2004 was 987.8 GWh. The national energy demand in the same period was 834.3 TWh, so the contribution of wind power counts for 0.118%.

### 4.0 MARKET DEVELOPMENT AND STIMULATION

#### Main Support Initiatives and Market Stimulation Incentives

The Ministry of Economic, Trade, and Industry's (METI's) and the New Energy and Industrial Technology Development Organization (NEDO) have

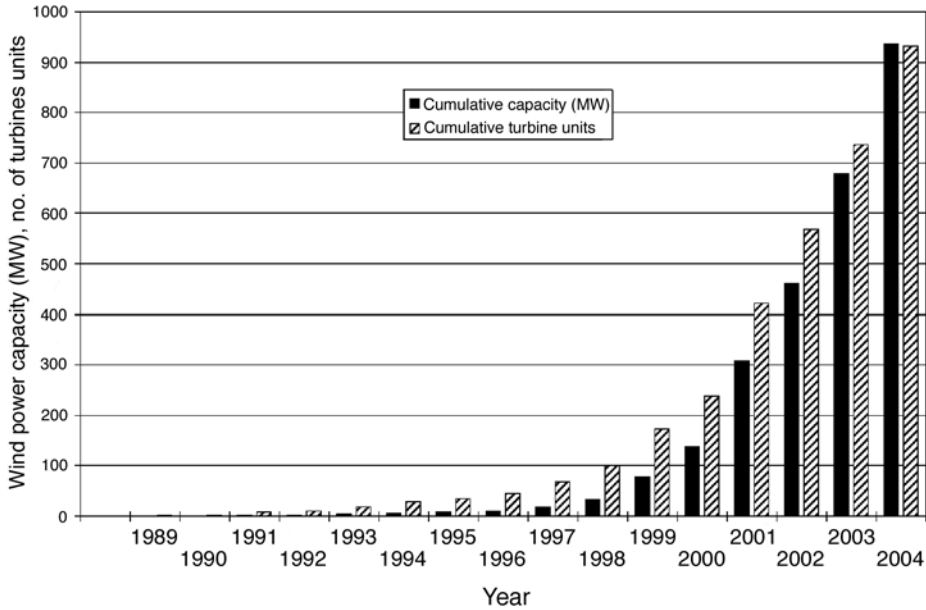


Figure 1 History of wind turbine development in Japan (Data source: NEDO).

been conducting several subsidy programs to promote wind energy market development since 1995. The programs cover wind measurements (Field Test Program), initial investment (New Energy Business Support Program) and a few other subsidies. Actually, these programs have stimulated the markets and realized the rapid development of wind power generation in Japan. The subsidy rate ranges from 1/3 to 1/2, and reaches 100% for field testing. The contribution of the subsidy is evaluated through cost of energy (COE). For example, the COE was 12.5 Yen/kWh without subsidy but 10.2 Yen/kWh with subsidy in 1999.

### Unit Cost Reduction

Since most wind turbines are imported from Europe and the United States, unit cost itself is considered to be the same as in Europe or the United States. However, some other factors such as transportation cost and the additional cost to stabilize the power for grid connection require additional plant cost.

## 5.0 DEPLOYMENT AND CONSTRAINTS

### Wind Turbines Deployed

Commercial wind farms during fiscal year 2004 are listed in NEDO's statistics, and large projects are shown in Table 1. The largest one is 42 MW plant built in Kamaishi, Tohoku area developed by Tomen (Figure 3). Figure 4 shows regional distribution of wind power plants and capacity. The Tohoku area has the highest density, followed by Hokkaido and Kyushu areas.

### Operational Experience

In Japan, the outstanding technical issues related to wind power are power quality, typhoon attacks, lightning strikes, and high turbulence at hilly sites. In September 2003, a huge typhoon attacked Miyako Island. All seven wind turbines on the island were severely damaged: three were struck down, three lost blades, and one had its nacelle cover broken. The destroyed turbines were all imported from Denmark or Germany. The maximum wind speed was 74.1 m/s, which means the typhoon was the seventh largest

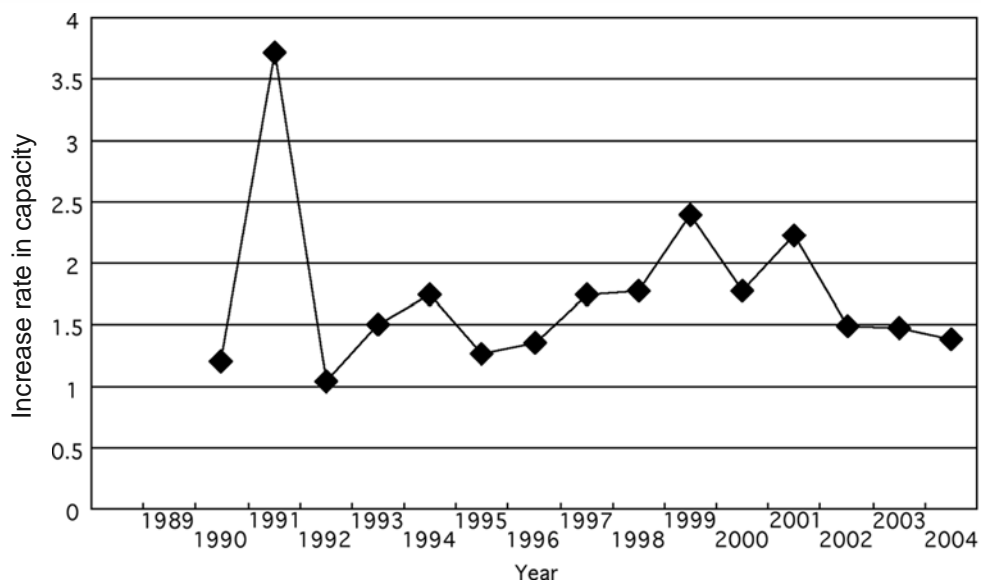


Figure 2 History of increase rate in wind power capacity.



Figure 3 In 2004, Urus Energy developed the largest wind farm in Japan at Kamaishi, Iwate. Power output is 42,900 kW from 43 units of 1-MW Mitsubishi Heavy Industries Ltd. wind turbines.

Plant No.	Area	Prefecture	City/Town	Capacity (MW)	Turbine rating (MW)	Number of units
1	Tohoku	Iwate	Kamaishi	42.0	1.00	42
2	Tohoku	Akita	Nishime	30.0	2.00	15
3	Chubu	Aishi	Tahara	22.0	2.00	11
4	Kyushu	Kumamoto	Aso	17.5	1.75	10
5	Kyushu	Nagasaki	Sikamachi	15.0	1.00	15
6	Kanto	Chiba	Choshi	13.5	1.50	9
7	Tohoku	Aomori	Totsumura	13.0	1.30	10
8	Kyushu	Saga	Hizen	12.0	1.50	8
9	Kyushu	Oita	Kuju	11.0	1.00	11
10	Kyushu	Kagoshima	Yoshida	10.4	1.30	8
11	Hokuriku	Ishikawa	Nakajima		1.50	6
12	Kyushu	Saga	Genkai		1.50	6
13	Hokkaido	Hokkaido	Nemuro	7.5	1.50	5

**Table 1 Large wind power plants developed in fiscal year 2004. All were for commercial purpose.**

in history. In principle, the typhoon accident is considered a natural calamity because the wind speed experienced at hub height would have been greater than 90 m/s. However, typhoons are not uncommon on Miyako Island – the first, third, fifth, and seventh highest wind speeds have been recorded there during past half century. The Government set up a committee to explore typhoons incidents on the island.

Lightning is also a difficult issue in Japan. Many turbines have been hit by lightning and winter lightning poses a specific threat due to its intense power and electric current that are much higher than the world average.

Power quality and grid capacity issues are very important on a small island like Japan, which is discussed below.

### Main Constraints on Market Development

Grid capacity, or power quality, has become one of the most important issues in Japan. The regional

utility has limited available capacity for wind generation to 250 MW in the Hokkaido area and 150 MW in the Tohoku area. The limits would vary as experience is gained; however, these limits are the greatest barrier to achieving the national target by 2010. RPS was expected to accelerate wind power development, however, since the introduction of new energy is an obligation for electric power companies, contracts have been awarded to cheaper biomass generation.

## 6.0 ECONOMICS

### Cost of Energy

According to model estimation for a 25-MW wind farm discussed at a national committee, the COE is 10.2 Yen/kWh with subsidy. Today, the COE is from 9.00 to 11.00 yen/kWh for medium-scale wind turbines (unit capacities between 500 kW and 1,000 kW) and is 7.00 to 9.00 yen/kWh for large-scale wind farms comprised of wind turbines with capacities of more than 1,000 kW.

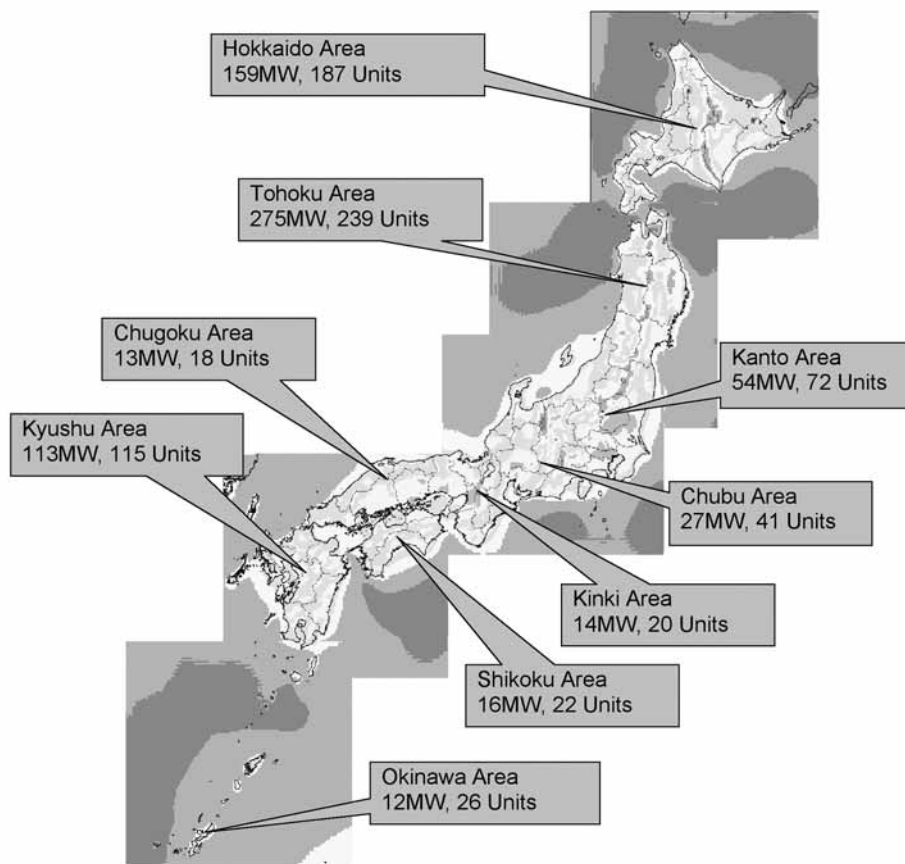


Figure 4 Regional distribution of wind power plants.

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

The current wind turbine cost is approximately 100,000 Yen/kW. The installation cost is decreasing as large-scale wind power plants increase. The cost differs depending on wind conditions, grid condition, and plant size. According to NEDO's experience in 1999, initial cost was ranging from 250,000 Yen/kW to 300,000 for medium wind farms, while about 200,000 Yen/kW for large wind farms (20 MW). Today, it is ranging from 130,000 Yen/kW to 200,000. The average electricity purchase price is about 18.00 yen/kWh.

## 7.0 INDUSTRY

### Manufacturing

Mitsubishi Heavy Industries, Ltd. (MHI) is the only national manufacture that supplies medium-to-large wind turbines. Last year, MHI started development of a 2.4 MW wind turbine. The main features are shown in Table 2. After component testing, a system will be built and tested in Yokohama.

Last year, a new subsidy scheme for small wind turbines was created that stimulated the industry. The industry includes MHI and several other manufacturers that provide small wind turbines.

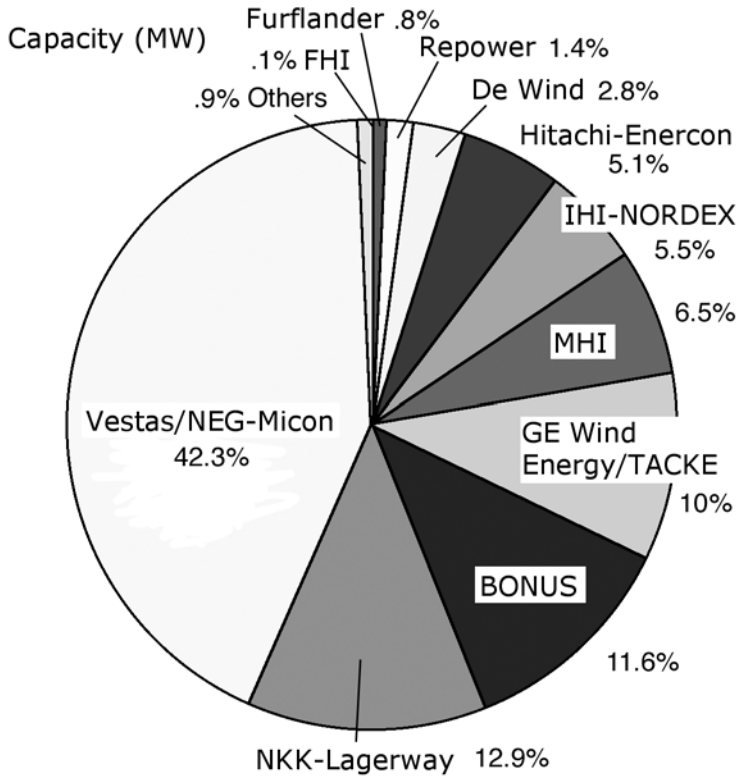


Figure 5 Japanese market share of manufacturers.

Rotor diameter	92 m
Hub height	70 m
Cut-in/Rated/Cut-out wind speed	3.0/12.5/25.0 m/s
Rated power	2,400 kW
Operation	Variable speed 9.0–16.9 rpm
Design	IEA Class IIA
Extreme wind design	IEA Class I (70 m/s)
Pitch control	Individual
Special safety system (against typhoon)	SmartYaw

Table 2 Main specifications of Mitsubishi MWT92 wind turbine.



## Industry Development and Structure

Market share among manufacturers is shown in Figure 5. Vestas/Micon turbines have 42% of the market for wind generation in Japan. MHI's contribution is 6.5%. In 2002, the wind industry organized the Japan Wind Power Association to develop the wind industry.

## 8.0 GOVERNMENT-SPONSORED R, D&D

### Priorities

The main governmental support tools for wind energy are subsidies. The total budget for the main three programs, Field Test Program, New Energy Local Introduction Supporting Program, and New Energy Business Supporting Program, was 40,990 million Yen in Fiscal Year 2003. The Government ended support for wind energy R&D programs (Sun-shine Program) in fiscal year 2002 (March 2003). However, some demonstration programs are being conducted. They are focused on grid performance or power quality. Two of these are developed by NEDO: "Techniques for Grid Stabilization" and "Battery-Supported Wind Farms."

In 2003 and again in 2004, a significant number of wind turbines were damaged by typhoon attacks from south to north in Japan. Considering these accidents, the government set up the following committees.

- Committee of Wind Turbine Availability Improvement
- Committee of Numerical Wind Power Prediction
- Committee of Design Methods against Extreme Winds
- Committee of Lightning Protection
- Technical Committee of Grid Connection.

Improving the integration of IEC standards and Japanese Industrial Standards (JIS) is an important task, because Japanese external conditions differ from those in IEC Standards in several respects. Typhoon and lightning are the main topics. Japan Electrical Manufacturers' Association (JEMA) supports this task under METI's initiative in order to develop J (=Japanese)-class wind models with which any manufacturer can design a turbine at any place in Japan. To derive models, wind measurements with high sampling speed are undertaken.

Japan has huge wind energy potential on offshore. Therefore, offshore technology is necessary in Japan. However, no big projects or research programs have been initiated. This is because the water, even in the near-shore area, is not shallow.

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## CHAPTER 14

# MEXICO

### 1.0 INTRODUCTION

Estimates have indicated that Mexico's most important wind resource would be sufficient for the installation of at least 5,000 MW of wind power. This figure is based on rough regional estimates, because detailed evaluations of wind resources have yet to be carried out. Other sources indicate many areas in the country with moderate wind resource that could eventually be efficiently tapped using improved wind turbine technologies. Based on the experiences of other countries, it is reasonable to expect that extensive exploration and improved wind speed measurements throughout the country will result in higher estimates of Mexico's wind energy potential.

Mexico's largest wind energy resource is found in a sizeable region (about 6,600 km<sup>2</sup>) known as "La Ventosa" located in the Isthmus of Tehuantepec in the State of Oaxaca (Figure 1). Average annual wind speeds in this region range from 7 to 10 m/s, measured at 30 m a.g. Given the favorable characteristics of this region, particularly its topography, it is estimated that up to 2,000 MW of wind power could be commercially tapped in La Ventosa. In fact, a 1.6-MW pilot plant located in one of the best sites in the region (La Venta), has operated for more than eight years at an average capacity factor of around 40%. This compares favorably to wind power plants located in the best inland sites in the world.

Even with a good wind resource, the implementation of wind power in Mexico is still incipient and inconsequential due a considerable number of barriers. To remove these major barriers, actors from public and private sectors are working together. In one action, the Global Environment Facility (GEF) (through the United Nations Development Programme (UNDP)) and the government of Mexico are co-financing a project entitled "Action Plan for Removing Barriers to the Full-Scale Implementation of Wind Power in Mexico." The first phase of this project started in early 2004. Also during 2004, several companies continued negotiations for wind power projects. By the end of 2004, a group of companies announced the creation of a Mexican Association of Wind Power ("Asociación Mexicana de Energía Eólica" –AMDEE). In addition, the Federal Electricity Commission launched a call for proposals to construct a 100-MW wind power plant in "La Ventosa"; the results of the bidding process will be known by the second half of February 2005.

### 2.0 NATIONAL POLICY

At present, it is clear that both the energy and the environmental policies in Mexico consider that wind energy could be a realistic way for diversifying energy supply within a sustainable development framework. The National Development Plan, as well as the Energy Sector Program, take into account the promotion of wind energy. In addition, energy supply in Mexico is aimed at securing projected economic development. Therefore, both the energy and the environmental ministries are coordinating actions to establish a shared vision concerning common goals and challenges, global climate change being among the main concerns.

National consumption of electricity is expected to increase at an average annual rate of 5.6% for the period 2004 to 2013. This growth will result in a projected requirement of 306 TWh of electricity generation for 2013, representing an increase of 81 TWh

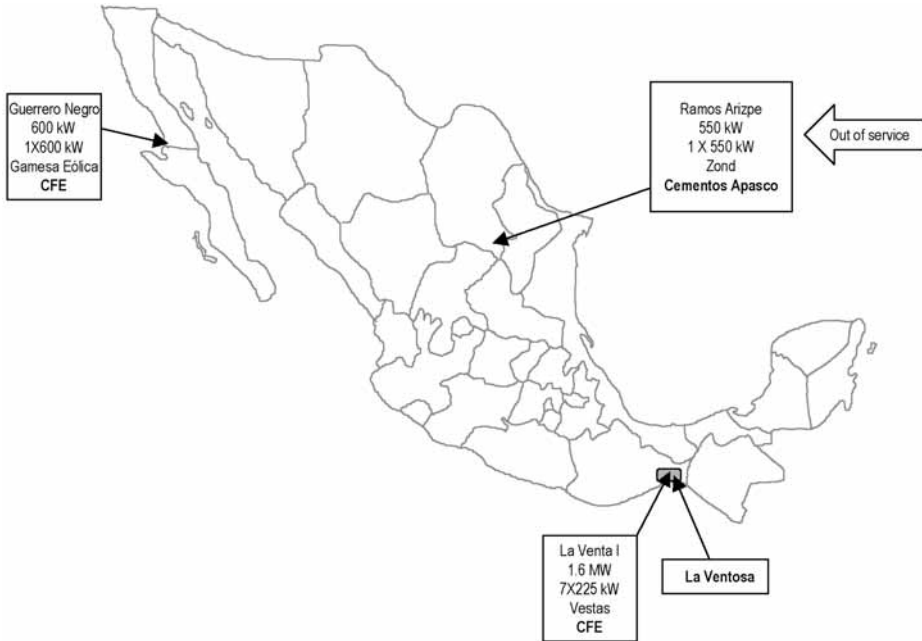


Figure 1 Location of wind turbines installed in Mexico (December 2004).

and equivalent to 25 GW of additional new generating capacity. Of this, 7.3 GW is already under construction or planned, the majority using combined-cycle gas-turbine technology, in addition to several new hydro and geothermal plants. The remaining 17.7 GW will come from new projects. An opportunity niche therefore exists for supplying a reasonable portion of the non-committed 17.7 GW of new capacity using Mexico's wind energy resource. Unfortunately, there are a number of barriers that must be removed in order to make wind power development in Mexico a reality.

### Strategy

By the end of 2003, the GEF approved the project Action Plan for Removing Barriers to the Full-Scale Implementation of Wind power in Mexico. This wind power action plan began in January 2004. Phase 1 of the project (2004 to 2006) is launching a comprehensive and systematic effort to reduce identified barriers to wind power development, beginning with a coordinated initiative aimed at improving the institutional and regulatory frameworks affecting on-grid

wind-power development. An educational campaign, geared toward raising awareness of the benefits of wind energy among government officials, will be carried out simultaneously.

Technical information and human resource barriers will be addressed through the creation of a Regional Wind Technology Centre. At this center, local technicians and engineers will obtain hands-on experience in the operation of wind turbines. Wind energy equipment will be assessed for operation under local conditions, and international standards and best practices will be adapted and applied for Mexico.

A preliminary assessment and mapping of wind energy resources at the most promising areas in the country will also be carried out as part of Phase 1, in order to obtain the wind resource data essential for the development of commercial projects. A set of comprehensive feasibility studies will be completed in Phase 1, in conjunction with any required preparatory activities; all of this is geared toward the formulation of business-demonstration wind power plants.

Matching the wind power action plan, special attention will be placed on the implementation of the Clean Development Mechanism as an important element for improving economic feasibility of wind power projects. Phase 2 of the wind power action plan (2007 to 2009) will launch a competitive bidding process for three prototype projects that could be supported with GEF resources to serve as temporary production incentives. Next, the technical and economical performance of commercial wind power plants will be monitored and documented; suitable financial mechanisms will be established; and a national campaign, based on lessons learned, best practices, and specialised human resources, will be aimed at consolidating a sound wind power market.

The action plan will pave the way to a complementary project known as the Large Scale Renewable Energy Development Project currently under the consideration of the GEF, through the World Bank, from an initiative of the Ministry of Energy. The Large Scale Renewable Energy Development Project could start in 2005 (insertion in one of GEF's Work Plans has already been approved, but final endorsement is pending). The project is aimed at opening a profitable IPP renewable energy market by creating a "green fund" that would be used to complement a regulated buy-back price for renewable energy.

Simultaneously, the government of Mexico, through the Federal Electricity Commission (CFE), has launched a bidding process to construct a 100-MW wind farm (La Venta II). The project will be carried out under the modality of Financed Public Work (FPW). This means that a private contractor is responsible for the total financing and construction of the wind farm. The CFE will pay to the contractor the total amount of the contract once the wind farm is commissioned. After that, CFE will own and operate the wind farm. It is expected that La Venta II will become an important advancement within CFE with regard to increasing knowledge on how to merge wind power technology into the national electrical system, gaining confidence on operation and maintenance issues, and assessing direct and indirect benefits.

## Progress Toward National Targets

The Program of Investment for the Electric Sector (2004 to 2013) prepared by the Federal Electricity Commission is considering the installation of 404 MW of wind capacity. Four wind power stations of 101 MW each will be constructed within the period 2006 to 2013. La Venta II will be the first project to be commissioned by mid 2006.

Despite these activities, there is no specific national target that takes into account other kinds of wind power projects (neither for self-supply nor for small producers). However, several private projects for more than 400 MW are waiting for better regulatory conditions.

## 3.0 COMMERCIAL IMPLEMENTATION

The total installed capacity of wind turbines in Mexico is 2.2 MW and no additional capacity was installed in 2004. Considering the size of the national electrical system, the contribution from wind energy to the national electricity demand is negligible. Trends are unpredictable, however. Although a number of wind project developers are trying to move forward, several barriers are holding back the initiatives. Although project developers affirm that they will soon start construction, starting dates continue to be delayed.

## 4.0 SUPPORT INITIATIVES AND MARKET STIMULATION INSTRUMENTS

In September 2001, the Federal government through the Regulatory Energy Commission issued the first incentive for renewable energy. Embedded in the current legal and regulatory framework, this new incentive is a model agreement for the interconnection of renewable energy power plants to the national electrical grid. It allows self-supply generators to interchange electricity between different billing periods (e.g., base to peak). In this fashion, self-suppliers do not necessarily have to sell surplus electricity to the Federal Electricity Commission, because generation delivered to the grid during certain periods can be credited to compensate for the electricity extracted

from the grid during a different period. The interchange is allowed based on the ratio of the marginal costs between different billing periods; therefore, it is required to generate more than 1 kWh during a base period to match 1 kWh required in a peak period.

This administrative incentive improves the economic feasibility of some self-supply wind power projects, especially those for municipal public lighting, where a considerable quantity of electricity could be generated during the daylight period when no electricity is required. Before this incentive, electricity transmission charges for a renewable energy self-supply project were computed based on its rated capacity; today, these charges are reduced to the power plant capacity factor level. The new model agreement is expected to facilitate some self-supply wind power projects that have been waiting for better regulatory conditions. Unfortunately, three years have passed since the incentive was issued, and there are still no projects under this modality.

In December 2004, a new incentive was issued. As a result, 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 are allowed to deduct 100% of the investment in one year (one-year depreciation). Before this change, investors in equipment for electricity generation were allowed to deduct only 5% in one year (20-year depreciation). The equipment must operate for the next five years following the tax deduction declaration; otherwise complementary declarations are obligatory.

## 5.0 DEPLOYMENT AND CONSTRAINTS

No additional wind turbines were installed during 2004. Eight wind turbines are operating in Mexico (Table 1).

During 2004, electricity production from “La Venta” wind power station was 5.5 GWh. The facility operated at an annual capacity factor of 40% (Reported by Eng. Carlos García Aguilar, General Manager of La Venta Wind Power Station). Data from previous years revealed that the 600-kW wind turbine installed at Guerrero Negro, operated at a capacity factor of 25%. Annual average wind speed at this site is around 8 m/s at 50 m a.g. However, performance data for the year 2003 and 2004 was not released.

### Main Constraints on Market Development

The main constraints on wind-power market development in Mexico are as follows:

- Electricity for the industrial sector is subsidised.
- 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.
- A national program for wind power deployment does not exist. Particularly, IPP projects are required by law to be included in the Electric Sector Prospective Document, which, up to now, has not included any IPP wind power project.

Location	Manufacturer	Wind turbines (kW)	Capacity (MW)	Commissioning date	Owner
La Venta, Oax.	Vestas	7 x 225	1.57	1994	CFE
Guerrero Negro, B.C.S.	Gamesa Eolica	1 x 600	0.60	1998	CFE
<b>TOTAL</b>		8	2.20		

(1) Cementos Apasco (Cement factory).

(2) By mid 2002 this machine went into flames.

**Table 1 Wind turbine installations in Mexico by the end of 2004.**

- There is a critical need to increase awareness among some decision makers of the potential benefits of wind power.
- Comprehensive studies to formulate and evaluate other potential incentives are required.

## 6.0 ECONOMICS

Electricity prices to consumers vary depending on the region, time of day, and voltage. For electricity billing purposes, the country is divided into eight regions. Each region has its own timetable for electric tariffs throughout the day. Table 2 shows the average price for electricity in different sectors.

A niche of economic opportunity for wind energy already exists in the commercial and public service scenarios. The challenge is to develop and implement an adequate strategy for creating a convenient wind power market. At present, a special buy-back price for wind energy has not been set in Mexico.

## 7.0 INDUSTRY

A 5-kW wind turbine of Mexican design is currently manufactured in Mexico, primarily for export markets. A Mexican company has manufactured a number of 750-kW electric generators for an international wind turbine company. Mexican industry has the potential to contribute to wind power development. A number of wind turbine components - including towers, generators, gears, conductors, and transformers - could all be manufactured in Mexico using existing infrastructure. More than 200 Mexican companies have been identified as having the capacity for manufacturing parts required for wind turbines and for wind power plants. The country also has excellent technical expertise in civil, mechanical, and electrical engineering, which could be tapped for plant design and construction.

## 8.0 GOVERNMENT SPONSORED R, D&D

In 1994, "La Venta" 1.6-MW wind power plant was the first demonstration project sponsored by the Mexican Government. Next, a 600-kW wind turbine

Sector	Average price (Mexican Pesos/kWh)
Industrial	0.75
Agricultural	0.30
Residential	0.95
Commercial	1.70
Public services	1.40

**Table 2 Electricity prices in Mexico for 2004.**

was installed at Guerrero Negro in 1998. The Federal Electricity Commission operates both of these projects. During 2004, the Mexican government did not sponsor the construction of any additional wind power stations neither for demonstration nor for local capacity building.

Under the auspices of the Ministry of Energy, the Electrical Research Institute (IIE) is the Executive Agency of the project Action Plan for Removing Barriers to the Full-Scale Implementation of Wind Power in Mexico. Therefore, with financial support from GEF/UNDP and co-financing of the government of Mexico, the IIE is addressing a number of technical issues, including the implementation a Regional Wind Technology Centre, which aims to offer the following provisions:

1. Support to interested wind turbine manufacturers for the characterization of their products under the local conditions at La Ventosa
2. A means to train local technicians for operation and maintenance of a diversified range of wind turbines
3. An easily accessible national technology display that facilitates the encounter between wind turbine manufacturers and Mexican industries, thus promoting the identification of possible shared business ventures
4. A modern and flexible installation to obtain hard operational data on the interaction of specific types of wind turbines with the electrical system
5. A means to understand international standards and certifications (issued abroad) in order to identify additional requirements to fit local conditions

6. A means to increase the level of national research and technology development, including joint projects or specific collaboration activities with prestigious overseas R&D institutions.

Wind data currently available in Mexico is scarce (except for few sites). Wind energy resources in several promising areas have not been evaluated. Therefore, the wind power action plan includes the exploration and assessment of the wind energy resource at both known and new regions. Within the public sector, IIE and CFE are installing and operating several anemometers.

Furthermore, by contract with CFE, the IIE is carrying out a feasibility study for a wind power station. By contract with the Regulatory Energy Commission, the IIE is carrying out a study that deals with capacity credit for wind power.

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## CHAPTER 15

THE  
NETHERLANDS

## 1.0 INTRODUCTION

The share of renewable energy in the Netherlands energy supply increased in 2004 to 1.8% of the total primary energy consumption of 3,283 PJ. The target is 5% in 2005 and 10% in 2020. The domestic production of renewable electricity in 2004 increased to 4.9 TWh or 4.5% of the total electricity consumption of 113 TWh. The target is 6% of electricity from renewable sources in 2005. This now seems achievable.

In 2004, the net increase in installed capacity in the Netherlands was 196 MW, bringing the total installed capacity to 1,072 MW. The production of wind electricity in 2004 increased to 1.9 TWh or 1.7% of the total electricity consumption.

In October 2004, the Ministry of Economic Affairs organised a policy workshop about the “Development of Offshore Wind Energy in Europe” within the framework of the Dutch presidency of the EU. During the workshop, high-level government officials of EU

member states and representatives of interest groups prepared the Egmond Policy Declaration. This policy declaration describes a number of measures and actions required by the European Commission, Member States, TSOs, and market parties. The Egmond Policy Declaration was presented to the EU Council of Ministers for Transport, Telecommunication and Energy on 29 November 2004.

On 29 December 2004, the Minister of Transport, Public Works and Water Management published the policy rules to issue building permits in the Netherlands for the construction of offshore wind farms under the Public Works and Water Management Act.

From the Monitoring and Evaluation Program of the Near Shore Wind farm most results are available of the baseline measurements for the environment on birds, fish, sea-mammals and sea bottom organisms.

## 2.0 NATIONAL POLICY

## National Goals

The government policy for renewable energy gives priority to wind and biomass energy. They are supposed to give the greatest contributions to the 2020 target. The realisation of 6,000 MW of installed wind capacity off shore is seen as possible and necessary. The targets are summarised in Table 1.

Targets	2005		2010				2020			
	%	TWh	%	PJ	TWh	MW	%	PJ	TWh	MW
Energy from RE			<i>5</i>	<i>150</i>			<i>10</i>	<i>300</i>		
Electricity from RE	<i>6</i>	<i>6.5</i>	<i>9</i>		<i>10.6</i>					
Possible from wind				<i>20</i>	<i>3.5</i>	<i>1,500</i>		<i>130</i>	<i>22.4</i>	<i>7,500</i>

**Table 1 Targets for contributions from renewable energy sources. Targets are in italic. Percentages are renewable energy of national energy or electricity; avoided fossil fuel in PJ.**

The government creates the conditions to reach these targets through various instruments that facilitate demand and supply for renewables. These include: fiscal incentives and financial instruments; spatial planning; a competitive green market; administrative agreements; research and demonstration programs; CO<sub>2</sub> reduction subsidies and joint implementation mechanisms.

### EU Policy Workshop on Offshore Wind

On Thursday, 30 September and Friday, 1 October, the Ministry of Economic Affairs organised a policy workshop about the "Development of Offshore Wind Energy in Europe" in Egmond aan Zee, the Netherlands (within the framework of the Dutch presidency of the EU). Minister Brinkhorst opened the workshop. Gertjan Lankhorst, Director General Energy of the Ministry of Economic Affairs, chaired the workshop. During the workshop, high-level government officials of EU member states and representatives of interest groups (TSOs, NGOs) prepared a policy declaration in various panel discussions. The Policy Declaration on the Development of Offshore Wind Energy in Europe describes a number of measures and actions required by the EC, Member States, TSOs, and market parties. These cover topics like joint research on environment, technological developments, and large-scale grid integration. Central in the recommendations on market development is the necessity of further cost price reductions. It was recognised that the market for offshore wind energy could also benefit from a stable investment climate and more efficient licence procedures. Further (joint) research on site-specific environmental impacts was also considered important. ([www.offshorewind.nl](http://www.offshorewind.nl))

Recommendations on large-scale electricity grid integration concerned necessary changes in energy legislation, streamlining administrative procedures, and finding solutions for the intermittency problem.

The Egmond Policy declaration was presented to the EU Council of Ministers for Transport, Telecommunication and Energy on 29 November 2004. The Ministry of Economic Affairs and SenterNovem made a background document for the

participants in the workshop<sup>1</sup>. This contains a brief overview of the status and outlook of offshore wind energy.

### 3.0 SUPPORT INITIATIVES AND MARKET STIMULATION INSTRUMENTS

The latest overview of support initiatives and market stimulation instruments including fiscal incentives was given in the Netherlands chapter of the 2003 IEA Wind Annual Report. From January 2003 to January 2005, the financial framework for renewable energy stimulation changed from demand stimulation to production stimulation.

The tax scheme titled Energy Investment Deduction (EIA) aims to save energy by stimulating investment in energy efficient assets and renewable energy technologies. It allows investment in wind power plants to be deducted from taxable profit up to a percentage of investment costs. In 2004 and before, this percentage was 52%, and from 2005 this percentage is 44%. With a taxation level of 31.5% for Dutch entrepreneurs, the EIA amounted to an 18% discount in 2004 and a 13% discount from 2005 of the investment costs if the entrepreneur can use the full deduction. The maximum deduction is 107 million euro per year per fiscal entity. The EIA can be seen as a reduction in investment costs. To prevent abuse of the scheme, from 2005 the deductible investment per kilowatt is capped. The cap is differentiated for onshore wind turbines to 1,100 euro/kW, for offshore wind turbines to 2,250 euro/kW, and for small wind turbines (<25 kW) to 5,000 euro/kW.

The Green Funds Scheme is a government tax incentive instrument. Investing in the Green Funds Scheme means that individual investors lend their own money to banks, at a lower interest rate, which is then compensated by a tax incentive (environmental tax credit). The 'green banks' can then offer cheaper (1-2% lower) loans to wind projects.

In 2003, the government introduced the scheme called Environmental Quality Electricity Production (Milieukwaliteit Elektriciteits Productie abbreviated MEP). Under the MEP, domestic producers of renew-

able electricity who feed into the national grid will get paid a fixed subsidy per kilowatt hour. The government guarantees the subsidy for a maximum of ten years. The MEP differentiates the level of producer support for RE technologies. The highest support level is granted for offshore wind, PV, small (< 50 MW) stand-alone biomass installations, hydro, wave, and tide energy. For onshore wind, the production support is for a maximum of 18,000 full load hours in ten years. The subsidy is financed by a levy on all connections to the electricity grid in the Netherlands. This levy is fully compensated by means of a reduction of the ecotax (REB 36i) on fossil energy consumption. The MEP producer support exists along with a partial ecotax exemption (REB 36i) for renewable electricity consumption. The MEP support levels in 2004 (1 July) and 2005 (1 January) are adapted in line with the phasing out of the renewable ecotax REB (36i) exemption.

Table 2 gives an overview of the support levels from 2003 to 1 July 2006. The support levels from 1 July 2006 (*italic*) have been recommended to the Ministry of Economic Affairs<sup>2</sup>.

Thus the total kilowatt-hour price that producers of electricity from renewable sources can expect consists of:

- from the electricity company, the avoided generation costs of conventional electricity (market prices)

- from the electricity company, the production incentive REB 36i
- from the government, a subsidy under the MEP scheme.

It is predicted that the avoided generation costs of conventional electricity after 1 July 2006 will rise from 0.027 to 0.037 euro/kWh. The prediction is based on forward OTC-prices and historic Amsterdam Power Exchange prices.

## 4.0 DEPLOYMENT

### Installed Capacity

In 2004, 163 turbines were installed with a total capacity of 196 MW, and 89 turbines with a total capacity of 29 MW were removed. This brings the installed capacity at the end of 2004 to 1,072 MW. The net increase in installed capacity for 2004 of 196 MW is 26% less than in the record year 2003 (Figure 1).

Of the new turbines, for the second successive year, the average installed capacity decreased from 1,301 kW in 2002, to 1,266 kW in 2003, and 1,203 kW in 2004. The average hub-height decreased slightly from 66 m in 2002, to 61 m in 2003 and 59 m in 2004. This change is mainly due to the large amount of wind turbines installed in projects with one or two wind turbines in the range of 750 to 1,000 kW. The swept area per unit of installed power seems to be stabilising at around 2.3 m<sup>2</sup>/kW in 2002, 2003, and 2004 (Figure 2).

MEP-category	2003	2004 until 1 July	2004 after 1 July	2005	2006 until 1 July	2006 after 1 July	2007
REB-exemption (36i)	2.9	2.9	1.5	0	0	<i>0</i>	<i>0</i>
Wind onshore	4.9	4.9	6.3	7.7	7.7	<i>6.5</i>	<i>6.5</i>
Wind offshore	6.8	6.8	8.2	9.7	9.7	<i>9.7</i>	<i>9.7</i>
Levy per connection (euro)	34		36	47		<i>49</i>	<i>51</i>
Size of MEP fund RE	141 million		164 million	181 million		<i>199 million</i>	<i>n.a.</i>

<sup>a</sup> For a period of maximum 10 years up to a maximum of 18,000 full load hours to 1 July 2006.

**Table 2 MEP tariffs in euro cents 2003 to 1 July 2006 and proposed tariffs from 1 July 2006 through 2007.**

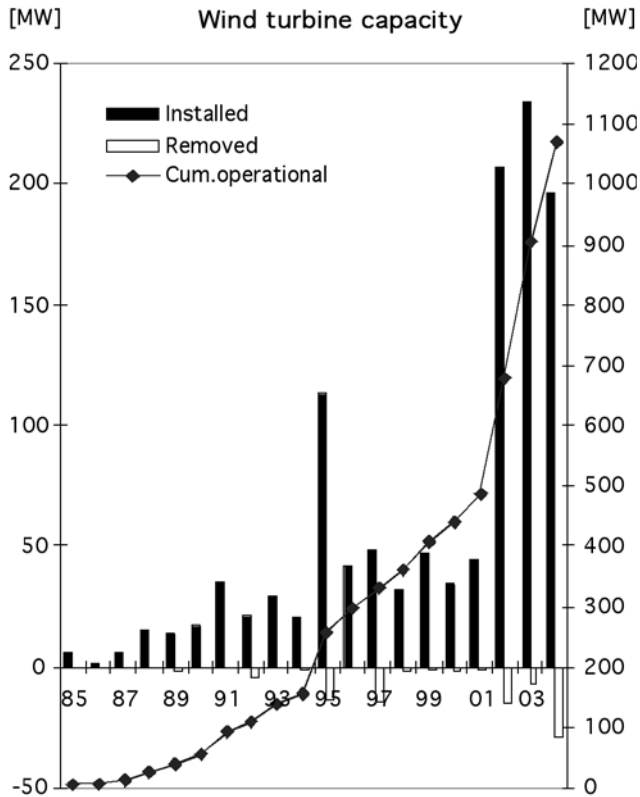


Figure 1 Installed, removed, and total wind capacity.

In 2003, 96 turbines with a total capacity of 7.3 MW and an average capacity of 160 kW were decommissioned. In 2004, 89 turbines with an average capacity of 326 kW were decommissioned. The doubling in the capacity of decommissioned turbines is due to the decommissioning of the following machines: 37 Lagerwey 18-m, 80-kW; plus 36 NedWind 500-kW; 2 Windmaster 750-kW; and 6 Windmaster 500-kW turbines. Of the decommissioned turbines in 2004, 49 with an average capacity of 278 kW and a total capacity of 13.6 MW were replaced with 41 turbines with an average capacity of 1,220 kW and a total capacity of 50 MW. The net repowering effect was 36 MW.

### Wind Turbines Deployed

Of the wind turbines installed in 2003, 45% are from NEG-Micon and 34% from Vestas. If you take into account the merger from NEG-Micon and Vestas,

the Vestas share was 79% (Table 3). Nordex has a relatively large share mainly due to two projects: 5 machines at the ECN test field in Wieringerwerf and 11 machines at Rotterdam, Hartelkanaal. The Enercon share of 26% of new installations in 2003 fell to 4% in 2004. New turbine types were the prototype General Electric (GE) Wind 88-m diameter, 2.5-MW turbine with a hub height of 85 m that is installed at the ECN test field and four NEG-Micon 54.5-m diameter, 1.0-MW turbines.

Six wind farms, with an installed capacity greater than 10 MW were completed in 2004. The largest was 22.5 MW, with 11 Nordex 2.5-MW, 80-m diameter turbines at Rotterdam, Hartelkanaal. The second largest used six NEG-Micon 72-m diameter, 2.1-MW turbines at the Rotterdam-Maasvlakte. The third largest used five Nordex 2.5-MW, 80-m diameter turbines at the ECN test field in Wieringerwerf (Figure 3). Sizeable projects were also installed at Zeewolde and Lelystad in

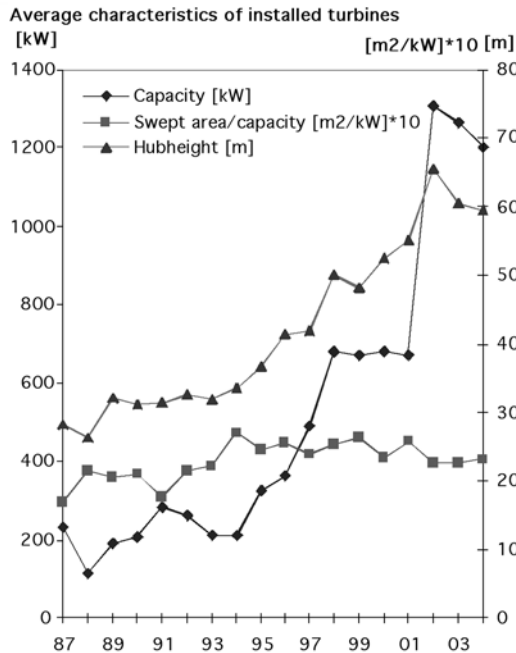


Figure 2 Average characteristics of installed turbines.

Manufacturer	Number of Turbines	Capacity in MW	Percent of total	Rotor area in m <sup>2</sup>
NEG-Micon	76	87.8	45	202,371
Vestas	69	66.5	34	165,251
Nordex	14	35.0	18	70,372
Enercon	2	4.0	2	7,697
GE Wind	1	2.5	1	6,082
Bonus	1	0.3	0	755
Total	163	196.1	100	452,527

Table 3 Distribution by manufacturer of new wind turbines installed.

the province Flevoland. This province now houses 484 MW, which is 43% of the total installed wind capacity in the Netherlands (1,072 MW). Additional details are noted in Table 4, and more project information can be found at <http://home.wxs.nl/~windsh/nwturab03.html>.

The large energy companies in the Netherlands realised 40 MW (20% of total) with three wind farms Eneco at Rotterdam Hartelkanaal; EPZ at Rotterdam-

Maasvlakte; and Essent at Borssele and Halsteren. Other companies, farmers, and project developers established all other projects.

### Contribution to National Energy Demand

Total national electricity consumption in 2003 was 109,777 GWh. Wind provided 1,330 GWh of

	Manufacturer	Turbine models	Height [m]	Diameter [m]	Capacity [MW]	Swept area [m <sup>2</sup> ]
Wind farms > 5MW						
Rotterdam, Hartelkanaal	Nordex	NO 80-2500	80	80	22.5	45,239
Rotterdam-Maasvlakte	NEG-Micon	NM 72-2100	70	72	12.6	24,429
Wieringerwerf	Nordex	NO 80-2500	80	80	12.5	25,133
Zeewolde, Ooievaarsweg	NEG-Micon	NM 55-950	55	55	10.5	25,661
Hoofdplaat	Vestas	VS 80-2000	78	80	10.0	25,133
Lelystad, Hoge Knartocht	NEG-Micon	NM 55-1000	70	55	10.0	23,328
Borssele	NEG-Micon	NM 92-2750	78	92	8.3	19,943
Zeewolde, Bloesemlaan	Vestas	VS 52-850	35	52	7.7	19,113
Zeewolde, Bloesemlaan	NEG-Micon	NM 55-1000	70	55	7.0	16,330
Halsteren	Vestas	VS 52-850	60	52	6.0	14,866
Berkhout	Vestas	VS 52-850	49	52	6.0	14,866
Various < 5MW	Danish/Dutch/ German	-	-	-	83.2	198,486
Total					196.1	452,527

**Table 4 Features of wind plants installed in 2004.**

electricity, which is about 1.2% of it<sup>3</sup>. In 2004, we estimate the national consumption to be 112,641 GWh, and the Central Bureau of Statistics (CBS) estimates that wind provided 1,853 GWh, which is about 1.7% of that. This is an increase with 40% against 2004 (Table 5). The amount of electricity produced from wind has doubled in two years. This was mainly due to the increased installed capacity and to a good wind

year in 2004. In a normal wind year, the installed capacity of 1,072 MW can generate about 2,100 GWh of electricity.

### Progress Toward National Targets

In 2004, the share of renewable energy in the Netherlands energy supply increased from 1.5% in 2003 to 1.8% of the total primary energy consump-



**Figure 3** Nordex 2.5-MW turbines at ECN test site Wieringerwerf. Photo courtesy of Jos Beurskens.

tion of 3,283 PJ. The target is 5% in 2005 and 10% in 2020. The domestic production of renewable electricity increased from 3.3% in 2003 to 4.5% in 2004 of the total electricity consumption<sup>4</sup>. This 4.5% consists of 3,083 GWh from biomass and 1,853 GWh from wind. In total, 4,936 GWh of 112,641 GWh national electricity consumption<sup>4</sup>. The target is 6% electricity from renewable sources in 2005. This now seems achievable.

## 5.0 DEPLOYMENT AND CHALLENGES (CONSTRAINTS)

### Spatial Planning for Wind on Land

The main challenge for wind on land still is securing enough sites for wind turbines. Under the Administrative Agreement National Development Wind Energy (Dutch acronym BLOW), each province has a target to designate locations for wind turbines (specified in megawatts) before 2005. The agreement is aimed at realising 1,500 MW of wind capacity on land in 2010. Under the BLOW agreement, each

province is working in the framework of its spatial policy, to designate locations for wind turbines. Co-operating municipalities, on a regional level in various provinces, showed progress in administrative procedures this year to designate locations, most notably in Flevoland, Brabant and North-Holland and South-Holland. For example, Flevoland revised its planning policy and increased its target to 1,000 MW, Gelderland to 100 MW, and Brabant to 230 MW.

In order to stimulate the deployment of wind energy, SenterNovem implements a number of support facilities: an expert pool, coaching municipalities in the planning procedures and communication processes, wind excursions, regional meetings, a CD-Rom with facts and figures, a helpdesk, and a workshop "Participation in Wind Energy projects." Of the 2,700 MW of known wind farm initiatives, about 2,000 MW fall within the provincial spatial plans, 300 MW fall within the municipals spatial plans, about 1,300 MW fall within the municipals spatial planning policy, and about 700 MW require a change in municipals spatial plans.

	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	0.46	79,582
1991	88	0.73	80,803
1992	147	1.21	83,173
1993	174	1.43	84,318
1994	238	1.97	87,067
1995	317	2.62	89,058
1996	437	3.61	92,259
1997	475	3.92	95,735
1998	640	5.28	99,292
1999	645	5.33	101,508
2000	829	6.85	104,718
2001	825	6.82	107,139
2002	910	7.51	108,306
2003	1,330	10.98	109,777
2004	1,853	13.57	112,641
CBS	* 2004 numbers estimated		

**Table 5 Wind-generated electricity, avoided fossil fuel, and national electricity consumption.**

The actual progress in installed capacity towards the BLOW targets per province is given in Table 6.

A new challenge (or constraint) is the interpretation of hindrance of wind farm for aviation radar by Air Traffic Control Netherlands. The Ministry of Transport, Public Works and Water Management intends legislation (under the Air Traffic Act) about the height of objects and their influence on radar posts and radio traffic around regional airports. The present interpretation of the rules would block a number of planned wind projects with a capacity of a few hundred mega-

watts, especially in Brabant and South-Holland. On the order of SenterNovem, a research institute, TNO (Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek) conducted a detailed study about the effects of wind turbines on aviation radar<sup>5</sup>.

The national railway manager ProRail allows one demonstration project with wind turbines directly over a freight railway line. ProRail wants to gather one year of experience with this construction before it adapts the rules on wind turbines near railway lines. This will not be before 2006. If the project is successful, there is a potential for locations of several hundreds of megawatts over freight railway lines.

### Scheme to Issue Offshore Building Permits

The Netherlands Exclusive Economic Zone (NEEZ) covers an area of 60,000 square kilometres. The Dutch State has exclusive economic rights in this area and with it the exclusive right to issue permits for the construction of wind farms. The Netherlands part of the North Sea provides therefore for enough space to accommodate 6,000 MW of wind power (the government's target for the year 2020). The scheme to issue these permits in principle opens the entire NEEZ for the realisation of wind farms. The Minister of Transport, Public Works and Water Management published it on 29 December 2004. The scheme is applied under the Public Works and Water Management Act (Wbr) and laid down in policy rules. The Wbr policy rules describe the requirements that a request for a building permit has to satisfy. The ministry will only grant building permits for individual wind farms that do not cover more than a 50-km<sup>2</sup> area.

The information to be provided by the applicant for a building permit request are at minimum: co-ordinates of the borders of the wind farm; type and design of the wind farm; information about the 'utility and necessity' of the wind farm in the NEEZ; information about the impact of rightful use of the sea by others; information about the impact on the environment; an erection and construction plan; a maintenance plan; a safety plan; a marking plan based on the



Province	Total capacity 2004 [MW]	BLOW Goal 2010 [MW]
Flevoland	454	220
Noord-Holland	185	205
Zuid-Holland	152	205
Fryslân	104	200
Groningen	80	165
Zeeland	64	205
Brabant	31	115
Overijssel	6	30
Drenthe	1	15
Limburg	1	30
Gelderland	0.5	60
Utrecht	0.2	50
Total	1,078	1,500

**Table 6 Progress towards BLOW targets of installed capacity per province.**

IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities) recommendation on the marking of offshore wind farms; an emergency plan; the intended time of use; a decommissioning plan and a certificate of the design assessment of the wind turbines. The actual procedure for the applicant includes a mandatory Environmental Impact Assessment (EIS) and the request for a building permit under the Wbr. It is roughly as follows.

The applicant supplies an inception memorandum (notification of intent or starting note) for the EIS to the Directorate Water Management North Sea (DNZ). If more parties apply for the same or overlapping area, DNZ informs them and tries to organise discussions to fine-tune the initiatives.

After receipt by DNZ of the final inception memorandum, DNZ sends it to the Committee for Environmental Impact Assessment and other statutory advisory bodies. DNZ publishes inception memorandum, e.g. in the Government Gazette.

The Committee for Environmental Impact Assessment and the statutory advisory bodies have the opportunity to give advice within nine weeks. Anyone concerned may also comment on the memorandum.

Within thirteen weeks DNZ gives guidelines for the EIS to the applicant, taking into account the advice for guidelines by the Committee for Environmental Impact Assessment.

The applicant then starts producing its EIS. There is no time limit and in this phase it can supply to DNZ a draft version for review. During the same time the applicant can have reviewed one draft version of the building permit request by DNZ.

The applicant then completes its EIS and sends it together with the building permit request to DNZ. Up to this time in the procedure other applicants may provide their EIS and building permit request for the same area.

DNZ is obliged to appraise the EIS on the basis of the guidelines and legal requirements within six weeks. If DNZ deems the EIS acceptable and the building permit request is complete, DNZ notifies other applicants that supplied an inception memorandum or a later supplied EIS/building permit request for the same area. DNZ from then on will not process the other applications for the same area.

Within 10 weeks, DNZ sends the EIS and the building permit request to the Committee for Environmental Impact Assessment (CEIS) and the statutory advisory bodies. DNZ then deposits the EIS and the building permit request for public perusal and notifies the public e.g. in the Government Gazette. During at least four weeks, anyone concerned can make written remarks on the EIS. At a public hearing, anyone concerned can make oral remarks on the EIS. The Committee for Environmental Impact Assessment reviews the EIS both for completeness and scientific quality, taking into account the comments from the advisers and public participation and gives advice on the EIS within five weeks after the public hearing.

Upon receipt of the CEIS's advice, DNZ produces the decision for the draft building permit as soon as possible.

sible. Within two weeks after informing the applicant and other administrative bodies concerned, DNZ is obliged to post the draft building permit and EIS for public perusal and notifies the public. They are available for four weeks until the time has passed within which appeals against the decision can be made. The statutory advisory bodies send their advice to DNZ within four weeks of publication. And anyone concerned can make written observations against the draft. DNZ decides about the building permit request within six months of its reception. All information about the Dutch scheme to issue offshore building permits is available from the website [www.noordzeeloket.nl](http://www.noordzeeloket.nl).

### Geographic Information System (GIS maps)

Parties planning the construction of offshore wind farms will have to base their decisions on government spatial policies under which specific areas are ruled out for wind farms, because of other activities in the Netherlands Exclusive Economic Zone. This concerns activities in, for example, military areas, shipping routes, disposal sites, search areas coarse sand resources, and cable routes.

The Directorate General Department of Waterways and Public Works, of the Ministry of Transport, Public Works and Water Management, charts all activities with the help of a Geographic Information System (GIS). In these GIS files, the exact co-ordinates are laid down of the military areas, shipping areas, pipelines, etc. SenterNovem has published maps, made on the basis of these GIS files on the website [www.offshorewind.nl](http://www.offshorewind.nl). The website allows downloading of the maps as PDF files. In the PDF files, it is possible to zoom in on details with a size of several hundreds of meters. The maps are intended to provide first guidance on the use of NEEZ to the interested layman and the (international) professional.

### Offshore Grid Integration

The Ministry of Economic Affairs finalised the Connect 6,000 report in May 2004<sup>6</sup>. After analyses, the report develops a vision on the integration of 6,000 MW offshore wind power in the Netherlands electricity

grid and outlines the responsibilities and measures required by government institutions, grid operators, and market parties.

The most probable locations for wind farms are located 25 to 50 km off the North- and South-Holland coast. The 380-kV stations Maasvlakte and Beverwijk are regarded as the necessary points of connection. KEMA Transmission and Distributing Consulting has estimated that with preparations and realisation, an investment of around 300 million euro is involved and a timescale of 9 to 14.5 years. There is a strong preference for bundling of cables at both points of connection. In the first coming years, 3,000 MW to 3,500 MW can be connected without reinforcement of the land grid, assuming the present levels of supply and demand for power. This consists of 1,000 to 1,500 MW connected to the 150-kV grid and about 2,000 MW connected to Beverwijk and Maasvlakte. The present land grid must be reinforced to be able to connect 5,000 MW or more. The Electricity Act of 1998 does not apply for connections, grids, grid operators, and tariffs outside the twelve-mile zone. The report specifies the areas where further clarity is required.

The project team that wrote the Connect 6,000 report evaluated the feasibility of the target of 6,000 MW against aspects of efficient use of available space, spatial planning, and ecology and arrived at three policy options.

1. The markets turn: "everyone its own cable"
2. The government as director: "TenneT grid at sea"
3. First market then government: "Transition"

Policy option 1 appears less favorable because the many required sea-land cable crossings will in the long run prevent the full development of 6,000 MW of offshore wind power. Policy option 3 is favored in the report. It departs from the presumption that the first wind farms will connect individually. After that, action is needed from the government to secure the possibilities of connection for the future and to enable the wish of policy makers for bundling of cables. This means facilitating of individual connections in the short term and creating the possibilities and maybe

an obligation of bundled construction in the middle-long term. The project team furthermore voiced the opinion that, in order to be able to realise the declared ambition of 6,000 MW, connections can best take place under the direction of the national grid operator TenneT.

The Ministry of Economic Affairs will establish a new project team in 2005 to further implement the findings of this Report Connect 6,000.

## 6.0 ECONOMICS

### Trends in Investment and Financing

Due to the commercially sensitive nature of project costs, there are no reliable statistical data for unit cost reduction for the last several years. In 2003, we reported data from the Dutch Wind Energy Association published in 2002. These gave a breakdown of investment costs and O&M costs for projects. The project costs were 1,119 euro/kW with 944 euro/kW for turbines. O&M costs were 38 euro/kW or 3.43% of the investment.

The Ministry of Economic Affairs contracted ECN and KEMA in 2004 to assess the financial viability of the different renewable electricity production technolo-

gies. The Ministry used this assessment to decide on the level of the MEP subsidies required to bridge the difference between cost and market prices for each renewable electricity source and technology for the years 2006 and 2007. The report<sup>2</sup> provides a detailed description of the assumptions, calculations and stakeholder inputs underlying the financial gaps for the establishment of the MEP subsidies for new projects.

Table 7, Table 8, and Table 9 on unit cost developments are taken from this report.

Based on an average price of 1,125 euro/kW, the investment in 196 MW of new wind turbines totalled 221 million euro in 2004. Wind farms are generally financed on a 20/80 equity bases. Banks like ING, Rabo, Fortis, Triodos, etc. have Green Funds with an abundance of capital for cheaper loans to wind projects. Almost all wind farms are financed through Green Funds.

### Costs of Energy and Buyback Rates

Generally buyback rates are negotiated between the wind energy producer and the buying energy company for 10-year contracts. The information is commercially sensitive and contracts are confidential.

Year		Assumptions for MEP tariffs			Advice for MEP tariffs	
		2003	2004	2005	2006	2007
Investment costs	[euro/kWh <sub>e</sub> ]	1,150	1,125	1,100	1,100	1,100
Full load hours	[hours/year]	1,800	1,800	1,800	2,000	2,000
Fixed O&M-costs	[euro/kWh <sub>e</sub> ]	NA	39	39	39	39
Variable O&M-cost s	[euro/kWh <sub>e</sub> ]	0.018	NA	NA	NA	NA
Economic lifetime	[year]	15	15	15	15	15
Imbalance costs	[euro/kWh <sub>e</sub> ]	0.006	0.006	0.006	0.006	0.006
Net kWh-price*	[euro/kWh <sub>e</sub> ]	0.021	0.021	0.021	0.026	0.026
Maximum full load hours	[hour]	18,000	18,000	18,000	20,000	20,000

\* Avoided generation costs minus imbalance costs of 0.006 euro/kWh

**Table 7 Technical and economical assumptions of wind on land.**

	Costs year 1 to 5 [euro/kW/year]	Costs year 6 to 15 [euro/kW/year]
Maintenance- and warranty contracts	8 to 11	NA
Maintenance contract	NA	11 to 15
Insurance machine failure (0.6 to 1.0% of turbine-investment)	5.4 to 9	5.4 to 9
Insurance machine failure own risk	1.0	1.0
Insurance machine failure effect (0.5 to 0.6% of expected yield)	1.0	1.0
Reservation for repair after year 5	NA	2.2
Total	15.4 to 22 (incl. warranty)	20.6 to 28.2 (no warranty)

**Table 8 Structure maintenance, warranty, and insurance costs wind development on land.**

		Points of departure 2003	International bandwidth	Data NSW and Q7	Recommended for MEP tariffs 2006/2007
Investment costs	[euro/kWh <sub>e</sub> ]	2,000	1,675 to 2,250	2,000 to 2,250	2,000 to 2,250
Full load hours	[hours/year]	3350	-	3,350 to 3,500	3,350 to 3,500
Fixed O&M-costs	[euro/kWh <sub>e</sub> ]	NA	67 to 101	60 to 90	80
Variable O&M-costs	[euro/kWh <sub>e</sub> ]	0.023	NA	NA	NA
Economic life-time	[years]	15	NA	NA	15
Imbalance costs	[euro/kWh <sub>e</sub> ]	0.006	-	-	0.006
Net kWh price *	[euro/kWh <sub>e</sub> ]	0.021	-	-	0.026

\* Avoided generation costs minus imbalance costs of 0.006 euro/kWh

**Table 9 Technical-economical assumptions for wind development offshore.**

Reliable sources indicate a buyback rate for onshore wind energy of around 0.085 euro/kWh for 2003 and 0.092 euro/kWh for 2004.

The average electricity purchase price according to CBS Statline was: 0.182 to 0.167 euro/kWh for domestic use up to 3,000 kWh in 2004; 0.105 euro/kWh for small business users of up to 50,000 kWh in 2002; and 0.107 to 0.065 euro/kWh for industrial users of more than 50,000 kWh in 2001.

## 7.0 INDUSTRY

### Industry for Onshore Wind Farms

The following Dutch wind turbine manufacturers were operating in 2004. Zephyros B.V is a company owned by the Triodos bank and BVT, a German wind farm developer. Zephyros bought the rights for the 70-m diameter, 2-MW, direct-drive turbine from the former Lagerwey. At the end of 2004, Zephyros started a new assembly factory for the production of several dozen of this turbine type.

Energia Wind Technology (EWT) is a company run by former employees of Lagerwey. EWT is assembling, marketing, and selling direct drive wind turbines using the 750-kW technology of the former Lagerwey. Other wind turbine manufacturers with offices in the Netherlands include GE Wind Energy GmbH, Vestas Nederland Windtechnologie, and Enercon Benelux. A manufacturer of wind turbine towers is Rheden Steel that supplied towers for several offshore wind farms.

Energy companies Nuon, Eneco, Delta and Essent fully own or have shares in onshore wind farms. Project developers for onshore wind farms are, amongst others, Groenraedt, WinWind, Siemens. Ecofys, KEMA, and Weom do consultancy for project development. Supporting manufactures NGuP, CTC, AERotor, and Mecal were also active.

The Dutch association of wind turbine owners, PAWEX, represents the owners of several hundreds of megawatts in contract negotiations with energy companies. PAWEX also represents owners' interests in consultations about rulings of the Dutch energy authority Dte.

Windunie is a kind of co-operative that represents the owners of approximately 300 MW of wind power. These include most small-scale community and individual (mostly farmers) owners, as well as some companies (the biggest company owner has 45 MW of wind generation). Windunie started in 2001 and has a board of six farmers. Windunie negotiates prices for the basic buyback rates with three dominant energy companies in the Netherlands. Windunie's ultimate goal is to become an energy company. At present, it is evolving into a supplier of green electricity. It has formed a commercial alliance with a small energy marketing company in Maastricht that takes care of the business side of this venture. A consumer can come to Windunie for its electricity supply, and choose down to the individual turbine from where their supply will be matched. The location code and address of a customer's turbine is on their bill.

### Industry for Offshore Wind Farms

There are several offshore wind farm project developers. One is Evelop, which will further develop the 120-MW wind farm Q7 and is involved in the development of a wind farm in the United Kingdom. E-Connection developed the project for the wind farm Q7. The combination of Shell Wind Energy and Nuon has developed and will build the Near Shore Wind Farm (NSW).

Other companies install and build offshore wind farms. Mammoet Van Oord worked on Arklow Bank, Scroby Sands, Horns Rev, Nysted, Middelgrunden, Samsoe, Utgrunden, Ytte Stengrund, and Bockstigen. Oceanteam installed cables for Arklow Bank. Ballast Nedam is the turn-key contractor for the near shore wind farm. Volker Wessel Stevin Marine contracting did cable trenching for North Hoyle and Scroby Sands.

Several companies develop technology for offshore wind. GustoMSC designs and supplied jacking systems of the Mayflower Resolution, a turbine installation vessel. Suction Pile Technology is designing a combined suction pile and gravity foundation for water depth up to 50 meters. Wind turbine, tower, and foundation are installed in one unit from a barge.

## Wind Turbine Testing and Experiments

GE Wind has built a prototype for testing its 2.5-MW, 88-m diameter turbine with a hub height of 85 m on ECN's test site in the Wieringermeer (Figure 4). ECN has installed five Nordex 2.5-MW, 80-m diameter turbines on the production part of its test-site. The investment was around 11 million euros. These turbines will, amongst others, be used in the project "Validation measurements of turbulence, wakes and of extreme fatigue loads at the ECN wind turbine test farm Wieringermeer" and the "Field experiment and development of acoustic-optic registration of bird collisions on wind turbines." More information about ECN's test site can be found at <http://www.ecn.nl/wind/products/mmt/index.en.html>.



**Figure 4** Erection of the GE Wind 2.5-MW turbine at the ECN test site. Photo courtesy of General Electric Wind.

## 8.0 GOVERNMENT SPONSORED R,D&D

### Renewable Energy Program

The government agencies for the Ministry of Economic Affairs Novem and Senter have merged into one agency SenterNovem as of 1 May 2004. The new agency SenterNovem employs about 1,000 people and implements support activities in the area of sustainability and innovation.

The program Renewable Energy in the Netherlands (DEN) ended in 2004. The results of the projects awarded in the period 2001 to 2004 will become available in the years up to 2008.

#### CONTRACTS AWARDED UNDER SENTERNOVEM RENEWABLE ENERGY PROGRAM

From the 2003 budget of 4 million euro for renewables, 2.2 million euro was awarded to these wind research projects with total costs of 3.6 million euro.

- ECN: Heat and flux turbine control, to enhance output of large wind farms; Heat and flux turbine fundamental theory, to enhance output of large wind farms; Controlling wind tunnel experiments, to enhance output of an array of large wind farms; Fibre Optic Blade Monitoring phase III. Measuring strains in a blade with fibre optics instead of strain gauges; Zephyros BV. Field experiment with innovative direct drive wind turbine control;
- WinWind BV: Technical development of the RailWind turbine concept, a design for a turbine built over railways.
- AE Rotor Techniek B.V.: Development of an innovative 2-MW rotor blade for wind turbines.

From the 2004 budget of 6.7 million euros for renewables, 1.5 million euro was awarded to these wind research projects with total costs of 3.0 million euro.

- ECN: Wind Turbine design and optimisation tool FOCUS-6, integration of new R&D results.
- Delft Technical University. De Ampelmann: Model testing of a motion compensated platform for access to offshore wind turbines.
- Delft Technical University. Mangrove: Bottom

founded support structures for offshore wind turbines in waters between 30 and 50 m depth.

- WinWind BV: Technical development of the RailWind wind turbine - Phase 2 Detailed Design.
- Advanced Tower Systems: Field test of a prototype hybrid concrete-steel tower for wind turbines up to 120 meters high.

Summaries in Dutch of the project proposals can be found at <http://www.senternovem.nl/duurzameenergie/projecten/>.

#### RESULTS FROM COMPLETED R&D PROJECTS

ECN completed the implementation of a computer code to analyze offshore wind turbines in the frequency domain. The program allows quick computation of loads for offshore wind turbines in the design stage. The linearised models, which are intermediate results when using TURBU Offshore, are very well suited for aeroelastic stability analysis and control design. ECN also completed a design tool for integrated design of wind turbine control mechanisms. The design tool is able to design and test, control algorithms for wind turbines and it generates the computer codes to be implemented in the controllers. ECN gathered data to establish the wake effects of large offshore wind farms and gathered the data with a model wind farm of 30 turbines of 25-cm diameter in a boundary layer wind tunnel. The scale models are truly rotating variable-speed, pitch-controlled turbines comparable to full-size wind turbines of 100-m diameter. A large number of measuring results are available for many different farm configurations. The measurements will be used to validate wind farm and boundary layer models.

Fabricom Oil & Gas successfully completed the field experiment of an Offshore Access System designed by P&R systems. The company further demonstrated the system in Qatar at an oilrig.

Full summaries in Dutch and final reports are available from <http://www.senternovem.nl/duurzameenergie/projecten/>

## Offshore Demonstrations

### NEAR SHORE WIND FARM

The Near Shore Wind farm (NSW) is a 100-MW demonstration farm supported by the government. The NoordzeeWind consortium consisting of Shell Wind Energy and NUON Renewables, is going to build the NSW near Egmond aan Zee. The wind farm will be built 8 to 15 km from the coast in 15 to 20-m deep water. The turbines will be 36 Vestas 3-MW, 90-m diameter machines, built on a monopile. Erection of the wind farm is expected in 2006.

The Minister of Transport, Public Works and Water Management published the final building permit in March 2004. Environmental interest groups filed two objections against the building permit. At the end of 2004, one objection was withdrawn after negotiations with NoordzeeWind about compensating measures. The Council of State rejected the other objection shortly after that. This means that the building permit is irrevocable.

### MONITORING AND EVALUATION PROGRAMME

The Monitoring and Evaluation Programme Near Shore Wind farm (NSW-MEP) defined the required and recommended measurements to be carried out in the area of technology and economy and the area of nature and environment. On the order of the government, SenterNovem manages the NSW-MEP Project Organization. The project organization guards the learning objectives and assures that they can be reached. It reports results to the Ministry of Economic Affairs. For the collection of data on nature and environment, SenterNovem collaborates with the State Institute for Coast and Sea (RIKZ), which is part of the Directorate North Sea of the Department of Traffic and Waterstate.

NSW-MEP environmental baseline measurements on behalf of the government for birds, fish, sea-mammals, and sea-bottom organisms began 1 April 2003 and continues through 2004. The available results

for these studies are described in the following paragraphs<sup>7</sup>.

*Preliminary study into bird research methods for the NSW-MEP* - The Vertegaal Coastal Ecology Consultant finished a preliminary study into bird research methods for the NSW-MEP in January 2004. The report treats the existing and future methods of measuring and calculating bird collision risks. Furthermore, the report treats in detail the ways to carry out research on disturbance as well as methods for investigating barrier effects.

*Available data/reports baseline study birds* - The consortium Alterra/Bureau Waardenburg/ NIOZ conducted the baseline studies for birds in the period of March 2003 to October 2004. The consortium delivered the accompanying report at the end of October 2004. The report describes the research methods and results.

*Available data/reports baseline study fish* - The consortium Alterra/RIVO conducted the baseline studies for fish in the period of March 2003 to August 2004. It delivered the accompanying report about pelagic fish at the beginning of July 2004 and the report concerning demersal fish the end of October 2004. Both reports describe research methods and results.

*Available data/reports baseline study Benthic Fauna* - During 2003 and 2004 the fieldwork of the baseline studies for the Benthic research NSW-MEP took place. The Institute of Estuarine and Coastal Studies (IECS), Hull England carried out the study. IECS examined, categorised and described the collected samples. IECS completed the baseline study benthos and the accompanying final report. The study treats the research methods and the results.

*Available data/reports baseline study sea mammals* - The consortium Alterra/NERI/ NIOZ/Ecologic conducted the baseline studies for sea mammals in the period of March 2003 to September 2004. The consortium delivered the accompanying report at the end of October 2004. The report describes research methods and results.

The results of the baseline studies, together with the results of the expected effect study, will be used to determine the effects of the structure and presence of the wind farm. The NSW operator NoordzeeWind is responsible for collecting and supplying all the other data of the NSW-MEP. First measurements are expected in 2006.

#### INTERNATIONAL ACTIVITIES: COD

The Concerted action on Offshore Deployment (COD) an EU project with participating countries Netherlands, United Kingdom, Germany, Denmark, Sweden, Ireland, Belgium and Poland, compares and shares information on non-technical aspects of offshore wind farms. It has identified more than 180 studies in the area of environment. A database with description of all these studies is available on the website <http://www.offshorewindenergy.org/>.

#### New R, D&D Developments

The Energy Research Strategy (EOS) is a policy of the Netherlands government. The Ministry of Economic Affairs' EOS program pursues a sustainable energy supply in the Netherlands while maintaining the security of supply. The policy began in September 2004 and will terminate approximately in 2008. SenterNovem is the Agency responsible for its implementation.

In 2001, the Ministry of Economic Affairs started a review of the fragmented energy research carried out by research institutes (about 150 million euro per year) that covered too many subjects. The so-called Energy Research Strategy (EOS) project, after an inventory and consultation with interest groups and stakeholders, was further detailed in 2002 and 2003. EOS defined the following five thrust areas: energy-efficiency in industrial and agricultural sectors; biomass; new gas/cleaner fossil fuels; built environment; offshore wind generation and electricity grids.

The Ministry implements the strategy through various subsidy schemes and the organisation of platforms of stakeholders. The subsidy schemes are: New Energy Research (NEO); EOS Long Term (EOS-LT); EOS Demonstration (EOS-Demo); EOS



Unique Opportunities (EOS-UKR). Projects are awarded subsidy in rounds of tenders. These cover the entire spectrum of Research, Development, and Demonstration.

*New Energy Research (NEO)* stimulates non-conventional research. It covers the entire energy research area: generation, conversion, storage, efficiency, renewables, etc. Projects are non-conventional and new; lead to sustainability and new research areas; have a high technological risk; and are innovative. NEO is targeted to inventors, scientists, students, entrepreneurs, and researchers.

*EOS Long Term (EOS-LT)* is targeted to Netherlands universities, research institutes and (SME-) enterprises that carry out energy research. EOS-LT supports researchers with promising plans that in the long term lead to a sustainable energy supply. EOS-LT aims at research that strengthens the Netherlands knowledge position and frees the way for the introduction of innovative energy technologies. The subsidy scheme stimulates research in the defined thrust areas and areas for international co-operation mentioned above. Subsidies are awarded for: fundamental research, which enhances general scientific and technical knowledge and has no industrial or commercial goal; industrial research, which acquires new or improves existing knowledge to be used to develop new products, processes, or services.

*EOS Demonstration (EOS-Demo)* stimulates demonstration projects that lead to energy conservation and/or an increase in the use of renewable energy. Demonstration projects test new technologies, methods, and applications in a realistic environment. The subsidy scheme supports projects in the defined thrust areas and areas for international co-operation mentioned above. The subsidy is 40% of the additional costs compared to a reference situation.

*EOS Unique Opportunities (EOS-UKR)* supports transition experiments that contribute to the change towards a sustainable energy economy in the Netherlands. To be supported, the project has to be on a recognised path of transition. These paths are: efficient and green gas; efficiency of chains of production and materials; green biomaterials; alternative

motor fuels and renewable electricity. The transition experiments aim to verify how a new (part of) an energy system behaves in a concrete practical situation and how the environment reacts to it. A coalition with a Netherlands market party as leader carries out the experiment. Transition experiments are evaluated with the following criteria: the contribution of the reduction of CO<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub>; costs per ton of avoided CO<sub>2</sub> in a scaled-up situation in 2020; the contribution of the reduction of other emissions like heavy metals, dioxins, PAKs, NO<sub>x</sub>, SO<sub>2</sub>, fine particles and waste; source and sustainability of used raw materials and aspects of CO<sub>2</sub> sequestration. The subsidy is 40% of the additional costs compared to a reference situation.

Table 10 gives the funding levels for these subsidy schemes.

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Author: Jaap L. 't Hooft, SenterNovem, the Netherlands.

Subsidy scheme	Budget Allocated 2004 [euro]	Budget Indication 2005 [euro]
New Energy Research (NEO)		1.8 million
EOS Long Term (EOS-LT)	10 million	20 million
EOS Demonstration (EOS-Demo)	16 million	10 million
EOS Unique Opportunities (EOS-UKR)	12.5 million	20 million

**Table 10 Funding levels for the Energy Research Strategy (EOS) project subsidy schemes.**

## CHAPTER 16

## NEW ZEALAND

## 1.0 INTRODUCTION

## Energy Resources

New Zealand has a wealth of renewable energy resources. The availability of hydro, geothermal, wind, bio-energy, and solar resources is more than sufficient to supply New Zealand's four million residents with an entirely renewable-based electricity supply. Renewable sources currently provide 29% of total consumer energy and about 70% of the electricity supply.

National electricity production is approximately 40,000 GWh per year from 8,600 MW of installed capacity. In a normal hydrological year, hydro provides about 62% of electricity generation, with the balance comprising gas (22%), geothermal (6%), coal (7%), and other (3%). In a 1-in-20 dry year, loss of hydro generation can be greater than 15% (about 4,000 GWh out of 24,000 GWh mean year capacity). In recent 'dry years,' such as 2001, this shortfall has been made up by increased thermal generation (gas and coal) and by demand reductions.

## Wind Energy

New Zealand's location in the 'roaring forties' latitudes provides the country with an exceptional wind energy resource. Several regions in the lower North Island offer annual mean wind speeds of 9 to 10 m/s,

or even higher. Technical availability of wind energy is estimated at 100 TWh/yr, over 2.5 times the present electricity demand. Commercial availability, considering sites that could deliver wind power for less than 0.10 New Zealand Dollars (NZD) per kilowatt-hour (kWh), is estimated at 8 TWh/yr, requiring some 2,500 MW of wind energy plant.

Over the last decade, there has been an increasing commercial interest in harnessing wind energy. The first demonstration wind generator was installed in Wellington in 1993. Three commercial wind farms have since been installed, all in the lower North Island. These comprise of the 8.65-MW Hau Nui wind farm near Martinborough, the 68-MW Tararua wind farm near Palmerston North, and the 90-MW Te Apati wind farm also near Palmerston North.

## Sector Reform

The New Zealand electricity industry has undergone major structural reform in the past six years. These changes have seen the New Zealand electricity sector move from a centrally planned monopoly environment, to a fully competitive generation market with typically vertically integrated generation and retail companies. Transmission and distribution are still monopoly industries.

In 1996, a number of generating stations were separated from the monopoly generator, Electricity Corporation New Zealand (ECNZ), to form a competing entity (namely, Contact Energy). Following this initial move towards a competitive generation market, in 1999, the state-owned generator (ECNZ) was further devolved into three competing state-owned enterprises (Meridian Energy, Genesis Power, and Mighty River Power).

The Electricity Reform Act 1998 forced separation of electricity distribution companies into 'network' and 'energy retail' businesses with separate ownership

of each. Thus, distribution companies were no longer permitted to own generation or trade electricity. This change saw the formation of New Zealand's fifth main generator, TrustPower.

The restrictions imposed on the distribution companies regarding ownership of generation plant were relaxed (though not wholly removed) in the Electricity Industry Reform Amendment Act 2001. This change allowed network companies to own embedded renewable generation.

These reforms slowed the uptake of renewable energy until July 2000, when the Energy Efficiency and Conservation Act came into force. The main purpose of the Act is to promote energy efficiency, energy conservation, and the use of renewable sources of energy. It mandates three areas of activity, as listed below.

- Responsibilities of the Minister of Energy
- Development and implementation of a National Energy Efficiency and Conservation Strategy
- Responsibilities of the Energy Efficiency and Conservation Authority (EECA).

Further reform was imposed on the industry in 2003 after the industry failed to agree on voluntary arrangements for self-regulation. This reform resulted in the creation of a regulator with wide industry oversight, namely the Electricity Commission. The Electricity Commission is a *Crown entity* set up under the *Electricity Act* to oversee New Zealand's electricity industry and markets. It began operating in September 2003, with the industry rules (Electricity Governance Regulations and Rules) coming into effect in March 2004. The Commission regulates the operation of the electricity industry and markets (wholesale and retail) in accordance with the Electricity Act and government energy policy. The Commission's principal objective, as set out in the Electricity Act, is to ensure that electricity is produced and delivered to all classes of consumers in an efficient, fair, eligible, and environmentally sustainable manner. The Commission is also required to promote and facilitate the efficient use of electricity.

## Demand Growth

A major determinant of the future security of the electricity supply is demand growth rates. Over the past 10 years, demand growth has averaged 1.8% per annum. Higher economic growth rates, rising population, and the prospect of more energy intensive projects, such as wood processing, will put upward pressure on demand. This demand will be partially offset by increasing power prices as the Maui gas reserves are depleted and climate change policies are instituted including negotiated greenhouse agreements (NGAs), a carbon charge, and Projects to Reduce Emissions. However, electricity demand growth is expected to continue above 1% despite these measures.

## New Generation Capacity

Gas is currently a critical fuel for electricity generation. At present, it fuels 22% of New Zealand electricity generation in a normal hydrology year, rising significantly in a dry year (for example in 2001, it rose to about 30%). Gas-fired generation, using Combined Cycle Gas Turbine (CCGT) technology in particular, is likely to be the preferred fuel for new generating capacity, along with investment in wind energy. However, this is dependant on availability of suitable volumes of gas at viable prices. Because of the uncertainty over future gas prices, there is significant work being undertaken investigating and developing both geothermal and wind as economic generation alternatives to CCGTs.

## Market Model

The current electricity industry market model relies essentially on market participants responding to price signals to balance supply and demand in the longer term. As supply tightens (and the probability of dry-year shortages increases), average spot prices (and therefore hedge contract prices) will rise, signaling the need (and providing financial incentives) for construction of new generation. Commercial pressures

in the competitive generation market are expected to ensure that capital is invested wisely and costs are minimized.

## Climate Change

In October 2002, the government announced its policy package for reducing greenhouse gas emissions in response to climate change and the Kyoto Protocol. On 10 December 2002, the Prime Minister, Rt. Hon. Helen Clark, signed the instrument of ratification for the Kyoto Protocol to the United Nations Framework Convention on Climate Change.

Now that Kyoto has been ratified, the price of carbon that will apply from 2008 will impact on the costs of new and existing fossil fuel-fired generation.

## 2.0 NATIONAL POLICY

### Strategy

The core government policy for energy is to ensure its delivery in an efficient, fair, reliable, and environmentally sustainable manner to all consumers. EECA is funded by the government for the purpose of promoting the uptake of energy efficiency, energy conservation, and renewable energy.

The Energy Efficiency and Conservation Act 2000 required the Minister to draft and implement a National Energy Efficiency and Conservation Strategy (NEECS). The purpose of this strategy is to give effect to the government's policy on a continuing improvement in energy efficiency and a progressive transition to renewable sources of energy. The strategy is intended to create a sustainable energy future that will provide all New Zealanders with economic, social, and environmental benefits, and also to assist New Zealand to meet its international climate change commitments.

In September 2001 the government released the NEECS -Towards a Sustainable Energy Future. The NEECS contains two high-level targets for 2012 over a year 2000 baseline:

- Economy-wide energy-efficiency improvement of at least 20%

- 30 PJ of additional consumer energy from renewable energy sources.

In 2000, renewable energy supplied 133.5 PJ, or 29%, of consumer energy. This means that by 2012 a minimum of 163.5 PJ of consumer energy should be supplied by renewable sources. No quantifiable targets have been set specifically for the electricity sector, nor for the wind energy sector to contribute to the 30 PJ target. However, wind energy is expected to be a major contributor.

## 3.0 DEPLOYMENT

### Installed Capacity

Installed wind farm capacity has increased significantly in 2004. Two existing wind farms have been expanded, and one new project has been developed. New Zealand's installed wind plant now comprises of four projects:

1. The Brooklyn demonstration wind turbine in Wellington city. This turbine is a single Vestas V27 of 225-kW capacity. The machine, owned by Meridian Energy, has operated well since 1993 setting performance records for its type at the outset. (It is believed to still hold the five-year generation record for its type and size.) Annual output continues to be in the range of 0.85 GWh to 1.05 GWh.
2. Hau Nui wind farm. The first stage of this wind farm was built in 1997 and is owned by Genesis Power. This first stage comprised seven Enercon E-40s of 500-kW rating (Hau Nui translates from the indigenous Maori language as 'strong wind'). A retrofit program was completed in early 2000 to Version Four of the Enercon E-40. Hau Nui is claimed to be the world's first wind farm built without any form of subsidy or market support. Hau Nui wind farm was expanded in 2004 with the addition of 8 more Enercon E40 turbines. This second stage of development has expanded the site capacity from the original 3.5 MW to 8.65 MW.

3. Tararua wind farm. The first stage of this wind farm was commissioned in 1999, and it is now owned by TrustPower Ltd. This first stage consists of 48 Vestas V47 wind turbines of 660-kW capacity. They generate about 130 GWh annually. TrustPower expanded this site in 2004 by adding a second stage of an additional 55 Vestas V47 turbines. This has more than doubled the site installed capacity, which is now a total of 68 MW.

4. Te Apiti wind farm. Meridian Energy commissioned their first wind farm in late 2004. The project has 90 MW of installed capacity, consisting of 55 Vestas 1.65-MW turbines (model NM70).

### Rates and Trends in Deployment

Pre-feasibility studies and site monitoring continues to take place for a number of potential developments. Consents are also being sought for a significant number of projects, indicating that wind will play an increasingly important role in the sector.

- Meridian has gained consents for another 70-MW wind farm near Mossburn in the South Island. Meridian also announced at a recent conference that they have identified sites for 700 MW of installed capacity at less than 0.06 NZD/kWh.
- New Zealand Wind Farms Ltd are seeking planning consents for a 50-MW wind farm, which will be the first commercial development of the New Zealand-designed 500-kW wind turbine from sister company Windflow Technologies.
- Genesis Power are seeking planning consents for a 20-MW wind farm in the north of the North Island.
- Trustpower are seeking planning consents for an additional 120 MW of installed capacity at their Tararua wind farm site. This will be the third stage of that project.

### Contribution to National Energy Demand

Wind-generated electricity contributed about 154 GWh to New Zealand's demand in 2004. However, this understates the current installed capacity due to the commissioning of three projects part way through the year.

## 4.0 MARKET DEVELOPMENT AND STIMULATION

### Main Support Initiatives and Market Stimulation Incentives

The mechanisms listed below have been developed within the Climate Change Programme to help implement the NEECS targets.

- Negotiated Greenhouse Agreements (NGAs)
- Emissions charge from 2007 (capped at 25 NZD/tonne carbon dioxide equivalent)
- Projects to Reduce Emissions.

The Project to Reduce Emissions program supports projects in New Zealand that will reduce greenhouse gas emissions over the first commitment period of the Kyoto Protocol, 2008 to 2012, including renewable energy. The second tender round was held in 2004 and awarded six million emission units to 24 projects, including wind farms. Emission units are internationally tradable and add to the financial value of a project that will reduce greenhouse gas emissions. They are available for projects that are additional to business-as-usual, which means they help bring forward projects that would not otherwise be economic. Meanwhile, EECA is running complementary renewable energy programs to achieve the additional 30 PJ of renewable energy NEECS goals. These programs are designed to support renewable energy development by engaging with stakeholders and working to minimize the barriers, including those listed here, that inhibit the realization of the full potential of renewable energy. Barriers include:

- Lack of renewables knowledge and information among key parties and decision-makers
- Lack of economies of scale for some technologies.
- Institutional regulatory/planning approaches that might discriminate against some renewable energy opportunities.

### Unit Cost Reduction

The unit cost of wind energy at the most cost-effective sites in New Zealand lies between 0.05 and 0.08 NZD/kWh, representing some of the cheapest unsubsidized wind power in the world. New Zealand does not yet have a competitive wind turbine manu-

facturing industry, and thus wind projects are still exposed to the vagaries of international exchange rates. The sole prospective New Zealand wind turbine supplier, Windflow Technology Ltd, is currently seeking consents for its first commercial wind farm (following its demonstration turbine at Gebbies Pass near Christchurch).

## 5.0 DEPLOYMENT AND CONSTRAINTS

### Wind Turbines Deployed

A total of 175 utility-scale wind turbines are deployed in New Zealand, comprising four separate projects. A summary of these is provided in Section 3.0.

### Operational Experience

Approximately 320 turbine-years of operation has been gained to date in New Zealand. This experience involves four turbine types. New Zealand-trained wind energy consultants, engineers, and fitters are currently deployed in several countries.

### Main Constraints on Market Development

Following are several market barriers to the development of wind power in New Zealand.

- Low electricity prices and price volatility
- The dependence of turbine cost on international exchange rates
- Compliance costs for planning approval for those applications requiring public notification under the Resource Management Act 1991 (RMA)
- Attentions of the utilities focused on the introduction of industry regulation
- Uncertainty over proposals for new CCGT and coal plants, with the potential to defer need for other new generation, including renewables
- Low R&D funding of wind power.

## 6.0 ECONOMICS

### Trends in Investment

The wind farm projects to date have been balance-sheet funded by the generator owners. To date, no

international wind farm developers have projects in New Zealand, although overseas companies are among the wind site prospectors.

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

There is no premium or fixed price offered for wind power in New Zealand, and projects are subject to standard market conditions. The average wholesale price for electricity over the last few years is approximately 0.05 NZD/kWh. However, significant variation in price is seen according to seasonal parameters such as lake levels and hydro inflows.

## 7.0 INDUSTRY

### Manufacturing

New Zealand has suitable manufacturing infrastructure to support any wind turbine assembly needs. Towers for some of the existing wind farms were made locally. The northern cities of Auckland and Whangarei have successful boat-building industries that would be able to further support rotor blade manufacture. A low New Zealand dollar and a competitive local industry could offer economic manufacturing opportunities to wind turbine suppliers. In addition, the high wind speed sites available in New Zealand could offer cost-competitive and accelerated R&D programs.

### Industry Development and Structure

The New Zealand wind energy industry evolved over the last decade to support the construction of the first wind farms. Two companies, Garrad Hassan Pacific and PB Power Ltd., emerged to offer consultancy services to the fledgling industry. It is notable that these companies are now active both in New Zealand and several other countries.

Currently, all participants in the electricity industry from the generators, and System Operator through to the Electricity Commission are becoming more aware of the role of wind power. It is also becoming apparent that rules changes may be required in the electricity market to allow the large-scale integration

of wind power in an efficient manner. This is not seen as a barrier to wind power, rather an evolution of the market.

Meanwhile, other existing service companies are engaged to provide financial, legal, engineering, planning, and acoustic expertise. Tower construction, civil engineering, and electrical suppliers were involved in the projects to date.

In 2001, Windflow Technology Ltd. secured shareholder funding for its launch as a wind turbine manufacturer. The company has developed a two-bladed teetered-rotor wind turbine employing a torque-limiting gearbox. Windflow is currently seeking planning consents to develop a 50-MW wind farm. Local content is being maximized, including rotor blade manufacture in Auckland by Wind Blades Ltd.

## 8.0 GOVERNMENT-SPONSORED R, D&D

### Priorities

The Foundation for Research, Science and Technology (FRST) is the key government agency for the sponsorship of R, D&D. Funding is streamed through several portfolios. Although there is notional support within the energy portfolio for renewable energy technologies, it is notable that wind power has received only a small amount of funding in recent years.

### New R, D&D Developments

Windflow Technology Ltd is developing a wind turbine design for commercialization. The Windflow blades are the first utility-scale rotor blades made in the southern hemisphere. A prototype 500-kW Windflow turbine has been undergoing operational testing since mid 2003.

Several academic institutes continue to support post-graduate research in wind energy. These include the Energy Studies Unit at Massey University, the Mechanical Engineering Department at Auckland University, Otago and Canterbury Universities, and several polytechnics.

New Zealand organisations such as Industrial Research Ltd. (IRL) are actively engaged in wind energy research through programs with the Australian Cooperative Research Centre for Renewable Energy (ACRE). The electrotec unit at IRL runs a 300,000 NZD annual program to develop and demonstrate economically viable combinations of renewable small-scale (up to ~10-MW unit size) energy systems and to help develop an infrastructure to build and sell advanced-technology distributed energy products and services in New Zealand and overseas.

### Offshore Siting

Potential offshore wind farm sites are believed to be available around the New Zealand coastline; however, these are not being pursued at the present time. This is largely because the on-land sites represent better financial returns given the higher average wind speeds and/or lower development costs.

### References and Further Information

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 New Zealand Treasury, <http://www.treasury.govt.nz/crownentity/default.asp>  
 Public Access to Legislation: <http://www.legislation.govt.nz/>

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## CHAPTER 17

## NORWAY

## 1.0 INTRODUCTION

In 2004, the installed wind power capacity in Norway increased from 100 MW to 160 MW. High production per installed unit of capacity is achieved due the favorable wind conditions at Norwegian sites, i.e. the installed 160 MW will produce about 0.5 TWh/year.

In Norway, the interest in wind power as a commercial source of electricity is high. By the end of 2004, there were project plans for over 5,000 MW. However financing and public acceptance remain substantial hurdles to overcome for the installation of wind turbines. The price rise for electricity in the Nordic electricity market in fall 2002 and winter 2003 dramatically increased the general interest in energy and also somewhat the interest in wind energy. However, since the long-term future electricity prices still are quite low, (about 250 NOK/MWh, 30 Euro/MWh) this situation in itself is not a strong enough incentive to spur new investments in wind energy.

## 2.0 NATIONAL POLICY

## Strategy

Key features of Norwegian energy policy strive to improved energy efficiency, create more flexibility in the energy supply, decrease dependence on direct electricity for heating, and increase the share of renewable energy sources (other than large hy-

dropower) in the energy supply mix. The national objectives for renewables in Norway are the following:

- Limit energy use considerably more than if developments were allowed to continue unchecked
- Decrease dependency on electricity for heating and increase use of water-based central heating systems with renewable energy sources, heat pumps, and waste heat of 4 TWh by the year 2010
- Increase wind power generation to 3 TWh/yr by 2010
- In total, achieve 12 TWh/year in savings or new renewable energy by 2010.

## Progress Toward the Wind Target

The target for wind power of 3 TWh of generation by 2010 represents approximately 1,000 MW of installed capacity, at the average availability at the most favorable sites. By the end of 2004, Enova, a governmental enterprise, had signed contracts with energy utilities for 1.7 TWh of wind power production. Approximately 300 GWh of this capacity was installed and 330 GWh was under construction. In 2004, Enova signed contracts with four new projects, which represent an estimated energy production of 570 GWh.

The interest in wind power is high and several projects have been notified. More than 900 MW has received concession, and of these, 117 MW are expected to be completed and connected to the grid within 2005. This indicates that the 3 TWh target can be reached by 2010, although it depends on effective economic incentives being put in place. In addition, projects totaling annual production of 15 to 20 TWh have been notified, including a 1,400 MW (4.5 TWh/year) of offshore wind power projects, suggesting substantial development also after 2010.

### 3.0 MARKET DEVELOPMENTS AND STIMULATION

The Norwegian government has put forward a proposal to implement a green certificate model to support electricity from renewables. It is expected that Stortinget (the Parliament) will ratify the proposal in 2005. The new market for green certificates will primarily stimulate new production from hydro and wind power plants. Other renewables (e.g. power from biomass) will hardly be able to compete. There is still a considerable amount of hydro power in Norway, which is cheaper to develop than wind power. However, due to many temporary hydro power deployment constraints, it is expected that the certificate market will contribute 3 to 4 TWh of new wind power in 2010 and 6 to 9 TWh in 2015, depending on the volume of the certificate market settled by the government.

Since 2002, Enova has administered investment grants for wind power. In the white paper number 9 (2002-2003) Stortinget asked Enova to suggest an interim arrangement to move from the existing investment grant system to the green certificate market.

In October 2004, Enova announced the interim arrangement, an investment aid with a payback rule if the investor chooses to enter the certificate market. This arrangement was for wind power only. Enova offered up to a maximum of 25% investment grants for new wind farms. Seven projects applied for grants and four projects were awarded grants. These projects are listed in Table 1.

### 4.0 DEPLOYMENT

The total installed capacity for Norway is 160 MW, corresponding to 0.5 TWh/yr. The high production per installed unit capacity is achieved due the favorable wind conditions at Norwegian sites. In 2004, 28 wind turbines were installed corresponding to 60 MW of new capacity. The average size of the new turbines erected during the year was 2.3 MW.

The Utsira project is a wind/hydrogen demonstration project to show how renewable energy can provide a safe and efficient supply to isolated areas. During periods with sufficient wind, the surplus electricity is used to produce hydrogen. The stored hydrogen is then later used in a fuel cell to produce electricity in periods with a shortage of wind. The developer, Norsk Hydro AS, has received the Platts Global Energy Award for this project.

### 5.0 DEPLOYMENT AND CONSTRAINTS

Market forces, grid capacity, and environmental concerns are issues in Norway. Wind power gets no special feed-in tariff and has to compete on the Nordic electricity market. The operating support received earlier has now been removed. Their ability to compete will be substantially improved when the green certificate market is implemented. In some places, the grid capacity is an important constraint. This is particularly the case in the northern counties where the wind conditions are most favorable. Since 1995, applications for concessions comprising 150 MW have been denied due to environmental reasons.

Energy utility	Location	Estimated energy production (GWh/year)	Installed capacity (MW)
Statkraft	Kjøllefjord	155	40
Statkraft	Skallhalsen	230	65
Nord- Trøndelag E-verk	Hundhammerfjellet	140	41
Trønderenergi AS	Valsneset	45	15
		570	161

Table 1 Wind power projects awarded grants in 2004.

Wind turbine project	No. of units	Total power [MW]	Yearly production [GWh]
Hitra	24	55.0	155.0
Sandhaugen	1	1.5	4.5
Utsira	2	1.2	5.0
Hundhammerfjellet	1	3.0	10.8

**Table 2 Realized projects 2004.**

## 6.0 ECONOMICS

### Trends in investment

The unit cost of the Norwegian wind turbines erected in 2004 is approximately 8,200 NOK/kW (1,000 euro/kW), including infrastructure and grid connection.

Estimates of production costs from sites with average wind conditions suggest a production cost of about 320 NOK/MWh (40 euro/MWh), including capital costs (discount rate 8%, 20-year period), operation, and maintenance. Thus, compared with the spot market electricity price (long-term expected price is about 250 NOK/MWh), wind energy cannot yet compete on current commercial terms. Neither is wind energy competitive with the price of many new hydropower projects which still is an option for new green power.

## 7.0 INDUSTRY

ScanWind Group AS is a Norwegian-based manufacturer of large wind turbines (3 MW and larger) for use in Class 1 wind areas. The company has developed a 3-MW directly driven wind turbine design (ScanWind 3000 DL) and a geared version of the same size (ScanWind 3000 GL). Both designs have been tested as prototypes at Hundhammerfjellet wind park in Mid-Norway for its customer, Nord-Trøndelag Elektrisitetsverk. The ScanWind 3000 DL has a 3.4-

MW permanent magnet generator directly connected to the shaft. Another model, the ScanWind 3000 GL, has a new type of gear with variable speed ratio between the turbine and the standard asynchronous generator. The ScanWind 3000 DL has been tested for two years (2003 through 2004) with very good results. The ScanWind 3000 GL has been tested since December 2004 with the same positive experience.

ScanWind started the delivery of ScanWind 3000 DL to the Norwegian market in summer 2004, while the geared version will be introduced domestically late in 2005.

## 8.0 GOVERNMENT-SPONSORED R, D&D

### Test Station for Wind Turbines

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 in Trondheim, NTNU, took a joint initiative to develop a test station for wind turbines at the western coast of Mid-Norway. The test site is under construction and will be in operation by summer 2005.

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Figure 1 Opening day of the 55-MW Hitra Vindpark, 14 October 2004.

## CHAPTER 18

## PORTUGAL

## 1.0 INTRODUCTION

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

## 2.0 NATIONAL POLICY

## Strategy

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

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

The main action taken during 2004 regarding the electric sector was the constitution of the Iberian Market of Electric Energy (MIBEL) decided by Portugal and Spain on 20 January 2004 and officially ratified by both the Portuguese Assembly and Presidency in the Dec.-no. 19-B/2004 (*in I SÉRIE-A N.o 93*).

Some practical measures that were officially approved included: the simplification of administrative processes and environmental license granting (e.g. DC 51/2004 de 31 de Janeiro, DR, n° 26- II série); the approval of the report and conclusions of PNAC –National Plan of Climatic Changes (Resolution of the Council of Ministries (RCM) n.o 119/2004 *in I SÉRIE-B N.o 179*); and the implementation of RCM n.o 171/2004 that promotes the development of a program to diminish the Portuguese dependency on oil and the high energy usage of Portuguese industry.

## Progress Toward National Targets

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

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

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

(7,000 MW approximately) that were received in the last call opened in January 2002.

### 3.0 COMMERCIAL IMPLEMENTATION

#### Installed Capacity

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

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

#### Rates and Trends in Deployment

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

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

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

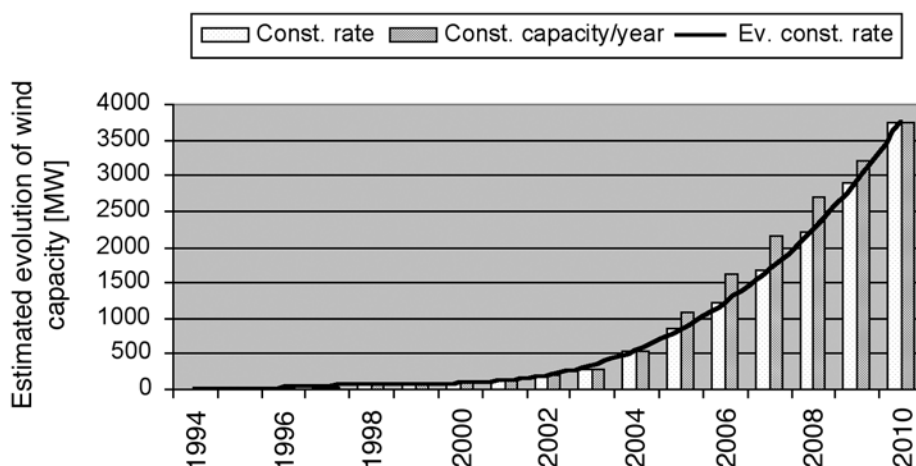
**Table 2 Number of installed wind turbines and capacity by wind park in 2004.**

Project Name	Local	Owner / Developer	P(WT) [kW]	Manufact.	Model	2004 Inst. cap. [MW]	2004 Inst. WT [n°]
Lomba Seixa II	Montalegre	GRUPO ENERSIS	1500	GEWE	1.5SL	12.0	8
Borninhos	Macedo Cavaleiros	GRUPO ENERSIS	2000	Enercon	E66	2.0	1
Fonte Quelha	Cinfães	GRUPO EDP (ENERNOVA)	1500	GEWE	1.5s	12.0	8
Alto Talefe	Cinfães	GRUPO EDP (ENERNOVA)	1500	GEWE	1.5s	12.0	8
Padrela	Vila Pouca de Aguiar	GRUPO EDP (ENERNOVA)	1500	GEWE	1.5s	7.5	5
Ribamar	Mafra	PE RIBAMAR	2000	Repower	MM82	6.0	3
EEA II	Vila Pouca Aguiar	FINERGE/EHATB	2000	Enercon	E-66	12.0	6
Archeira II	Mafra	NOROESTE	2000	Enercon	E66 20-70	2.0	1
Moinho Velho	Arruda	BIOWATT	2001	Enercon	E66 20-71	2.0	1
Cabreira	Vieira do Minho	GRUPO SIIF (EOLENERG)	2000	Enercon	E66	20.0	10
Dirão Rua	Sabugal	FINERGE	600/2000	Enercon	E-66+E-40	2.6	2
Cadraço	Tondela	FINERGE	1200	Enercon	E-58	1.2	1
Amêndoa	Mação	ENERVENTO	1650	Neg Micon	NM82	14.9	9
S. Todo Mundo	Cadaval	GRUPO ENERSIS	2000	Vestas	V80	10.0	5
Vilar Chão	Vieira Minho	ENERMINHO	2000	Enercon	E-66	2.0	1
Açor	Arganil	GRUPO EDP (ENERNOVA)	2000	Enercon	E66/2.0-E70	20.0	10
Sra Vitória	Nazaré	GRUPO ENERSIS	1500	GEWE	1.5SL	12.0	8
Mosteiro	Sabugal	TECNEIRA	1300	Izar Bonus	B62	9.1	7
Moinho Manique	Mafra	FINERGE	600/2000	Enercon	E-66+E-40	2.6	2
Escusa	Mafra	GRUPO ENERSIS	1000	Winwind	WW1	2.0	2
Carreço-Outeiro	Viana do Castelo	GRUPO GENERG	2300	Nordex	N90	20.7	9
Amaral	Alenquer	TECNEIRA	2000	Gamesa	G80	8.0	4
Vila Nova	Miranda do Corvo	ENERNOVA	2000	Vestas	V80	20.0	10
Malhadizes	Penela	GRUPO ENERSIS	2000	Enercon	E-66	12.0	6
Teixeiró	Teixeiró	ENERGIA VERDE	2000	Repower	3*MM70+4*MM82	15.0	7
Castanheira	Mogadouro	ELINERGIA	2000	Repower	MM82	4.0	2
Alagoa de Cima	Alto Minho	EÓLICA DE ALAGOA	1500	GEWE	1.5s	13.5	9
Chaminé	Sines	GRUPO GENERG	2300	Nordex	N90	6.9	3
TOTAL						264.0	148

	Total installed capacity (Dec. 2004) [MW]	Total installed WT (Dec. 2004) [n°]
Continent	547	448
Azores	5	22
Madeira	10	43
TOTAL	562	513

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

### Wind capacity trend (2004-2010)



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

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

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

### Contribution to National Energy Demand

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



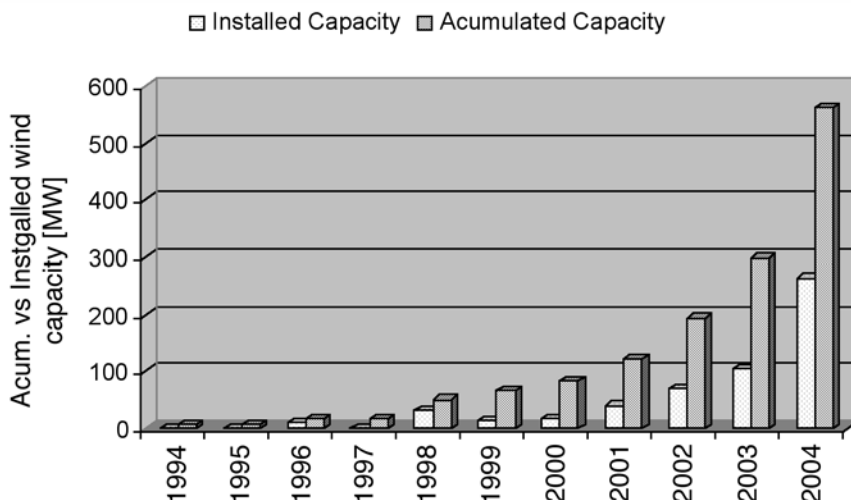


Figure 2 Installed and accumulated wind power capacity (1994-2004).

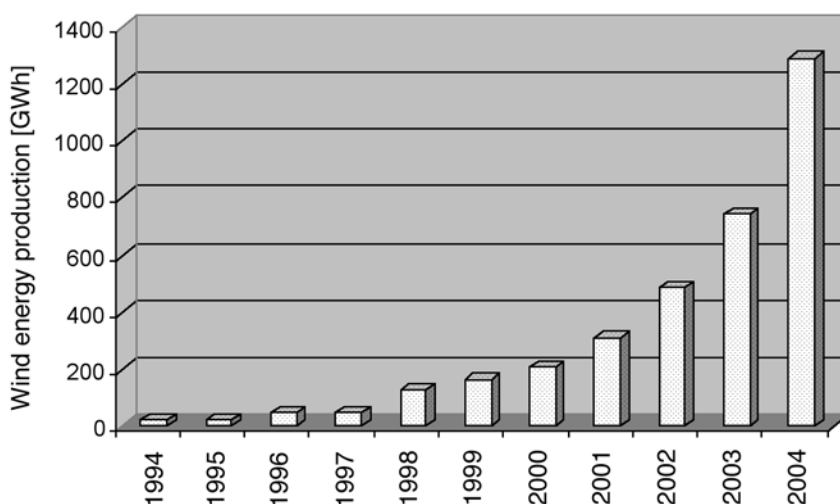


Figure 3 Estimated wind energy production (1994-2004).

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

#### 4.0 MARKET DEVELOPMENT AND STIMULATION

##### Main Support Initiatives

As mentioned, no significant government initiatives concerning wind energy were introduced in 2004,

since the main steps to achieve the national objective of promoting the installation of 3,750 MW of wind capacity by 2010 were taken between 2001 and 2003. The financial incentives under the POE/PRIME programme (2000-2006) continued to be applied in 2004, together with tax reductions for RES. The most significant governmental contribution continues to be the POE/PRIME partial support of the costs of the transmission and distribution network reinforcement requested for the grid integration of further wind capacity in remote areas of the country.

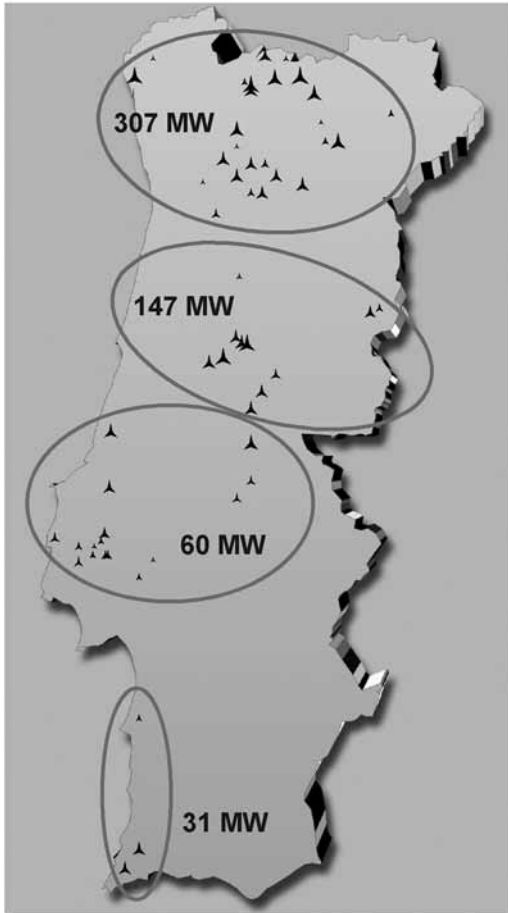


Figure 4 Location of wind parks in Portugal.

### Unit Cost Reduction

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

## 5.0 DEPLOYMENT AND CONSTRAINTS

### Wind Turbines Deployed

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

### Operational Experience

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

### Main Constraints on Market Development

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

## 6.0 ECONOMICS

### Trends in Investment

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

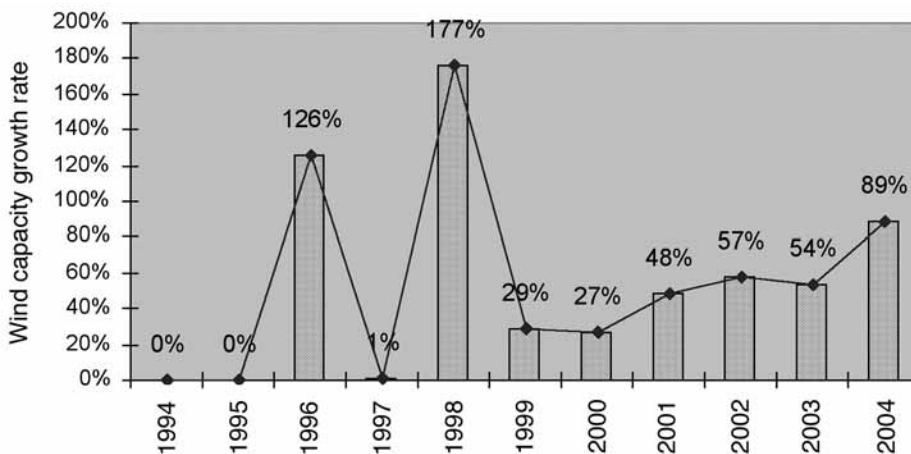


Figure 5 Wind capacity growth rate in the 1994-2004 period.

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

## In Unit Costs of Energy and Buy-Back Prices

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

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

## 7.0 INDUSTRY

There are no industrial production units of wind turbines in Portugal. However, there are three

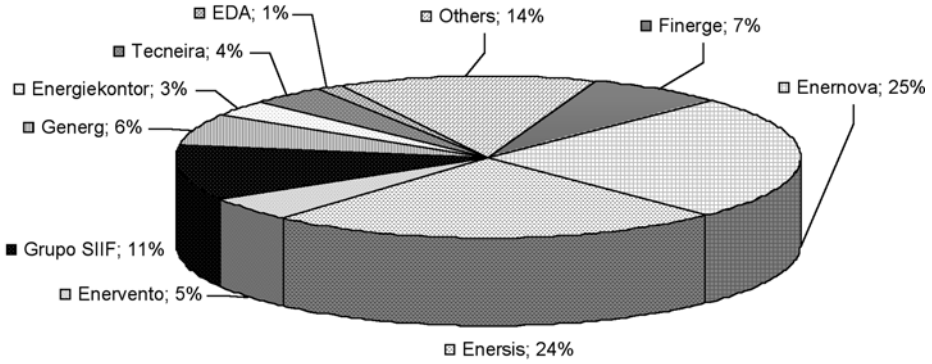
Portuguese manufacturers of tower technology and electrical equipment, namely power transformers and wind park cabling.

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

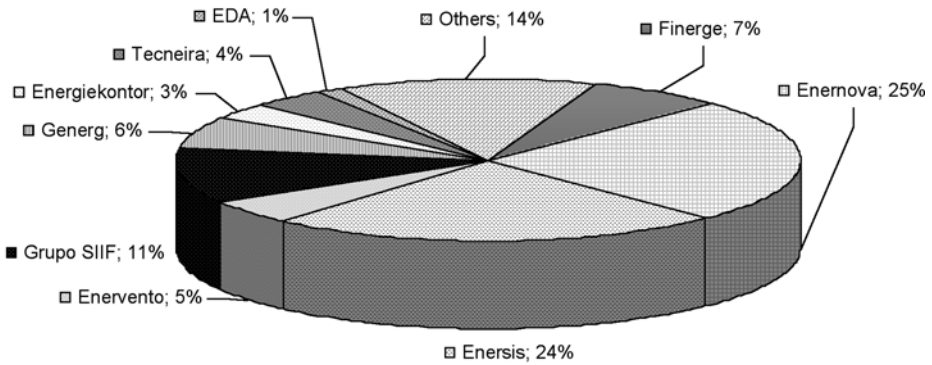
## 8.0 GOVERNMENT-SPONSORED R, D&D

### Priorities

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



a) by wind turbine manufacturer.



b) by wind park developer.

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

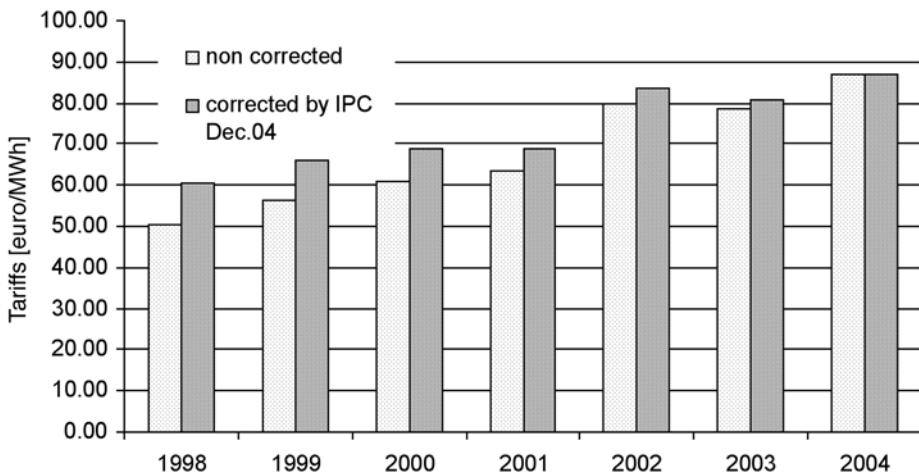


Figure 7 Evolution in wind energy tariffs applied in Portugal in recent years.

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

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

anemometric stations covering most of the continental territory.

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

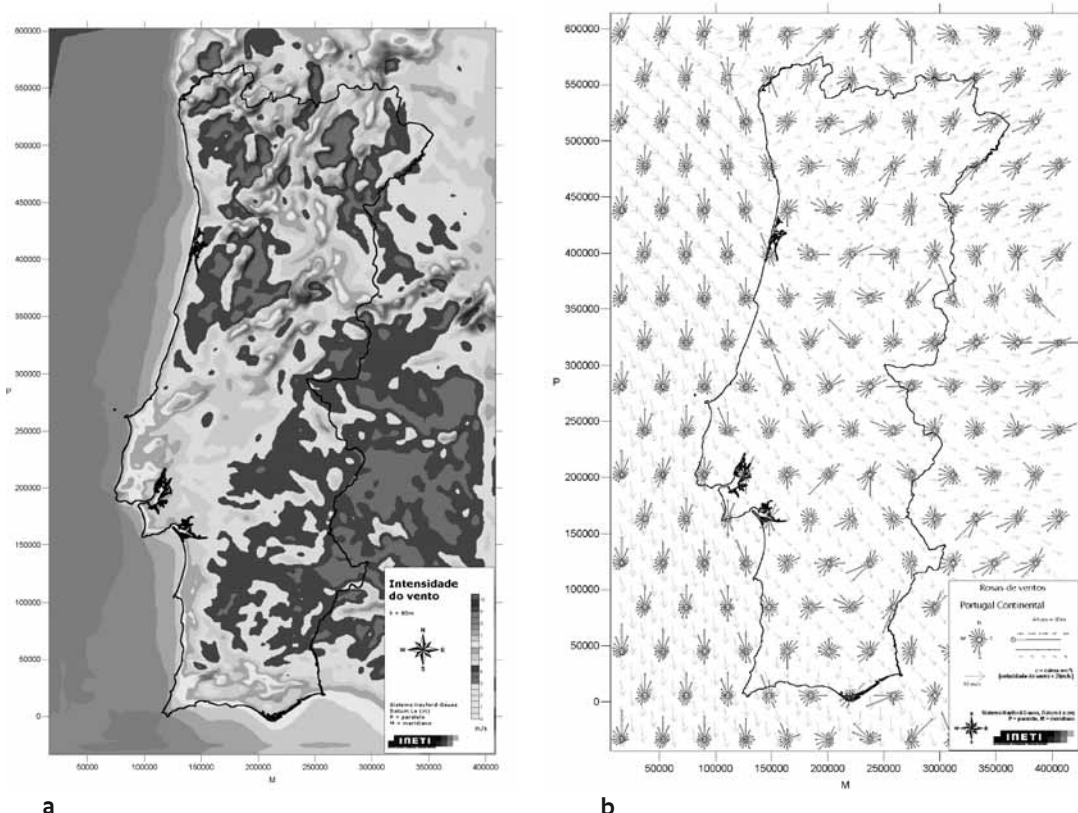


Figure 8 Wind atlas (a) mean wind speed at 80 m a.g and (b) wind roses in continental Portugal.

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

Among other projects funded by the Portuguese government through FCT, is project DIPTUNE coordinated by INESC Porto (N° POCTI /41614/ESE/2001). This project analyzes how wind generation and dispersed generation (DG) can contribute to improving grid operation efficiency and assuring system operation robustness. This is achieved through the delivery of ancillary services from wind generators and other DG units. During 2004, several studies have been developed to identify how, through on-line continuous control of reactive power from DG units and wind parks, it is possible to reduce losses and improve voltage profiles in high-voltage (HV) distribution grids. The identification of control techniques for controlling doubly fed induction generator (DFIG) for the provision of primary frequency control was successfully developed. Also fuzzy control techniques were developed to control crow bar operation in DFIG during grid short-circuits. Definition of distribution management system and energy management system tools able to deal with these DG capabilities was developed. As an outcome of this project, several papers were published in CIGRE Symposia and IEEE transactions.

### New R, D&D Developments

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

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

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

### Offshore Siting

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

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## CHAPTER 19

# SPAIN

### 1.0 INTRODUCTION

Wind energy in Spain continues the successful growth started in the middle nineties, taking a leading worldwide position along with Germany and the United States. At the end of 2004, wind power in operation in Spain was over 8,200 MW. During 2004, the Spanish market was the first market worldwide with 2,061 MW installed in the year. The main reason for this growth is the stable legal framework for electricity producers using renewable energy sources.

The regulations contained in the Special Regime of the Electrical Sector Act imply that electricity producers using wind have guaranteed access to the grid and the price of a kilowatt-hour generated has a bonus over the sale price of electricity.

The electricity generated by wind power plants represents nearly 6% of the total electricity demand in Spain, and plans show the possibility of reaching the national target of 13,000 MW of grid-connected generation by the end of 2011. The new government has announced that the Spanish Energy Plan is going to be updated during 2005, and the expectation is that the target for wind energy will be upgraded one more time. The new figure of 20,000 MW for 2012 has appeared in the newspapers.

The wind industry in Spain is a solid sector involving more than 400 enterprises. It shows great potential, strong investment in R&D activities, and job cre-

ation. New manufacturers, investors, producers, and researchers have been incorporated into the wind energy business in 2004, and a process of mergers and association between companies has occurred.

### 2.0 NATIONAL POLICY

The contribution to the electric system of each type of generation is shown in Table 1 for 2004. During 2004, the overall demand for electricity was a 3.7% higher than in 2003 with a total value of 247,409 GWh. The difference between production and demand is due to transmission losses and the balance of electricity transfer to France, Portugal, and Morocco.

During 2004, the contribution of thermal coal plants to total production was 30.2%, followed by nuclear plants (23.9%), and hydro power plants (11.3%). The electricity produced inside the Special Regime (that includes cogeneration, small hydro, and renewable energy) was 43,732 GWh (16.53% of the total production), 10.54% higher than in 2003. The production of wind energy plants reached a value of 14,178 GWh, 18.1% higher than in 2003.

#### Strategy

The strategy of the Spanish government is to meet 12% of total primary energy consumption from Renewable Energy Sources by 2010. This strategy is summarized in the Program for Promotion of Renewable Energies (PPER). The wind energy target for 2010 was to reach 8,974 MW installed, with an average production of 21.5 TWh/year (equivalent to 1,852 ktep). The target has been modified ("Electricity and Natural Gas Plant: Transmission Grid Development: 2002-2011") and the new figure is 13,000 MW for the year 2011, contributing with 28.6 TWh to the electricity demand. The new target represents an increase of 45% over the previous goal set in 1999 and was approved by the Council of Ministers on September 2002.

Energy Balance and Power Capacity 2004			
Source	Electricity production (GWh)	Variation 2003/2004 (%)	Power installed by 31 Dec (MW)
Hydro	29,977	-22.70	16,658
Nuclear	63,153	2.10	7,876
Coal	79,971	5.50	12,075
Fuel/Gas	18,157	3.50	9,953
Combined cycle	29,555	97.20	8,259
<b>Total norm regime</b>	<b>220,814</b>	<b>5.70</b>	<b>54,821</b>
<b>Special regime</b>	<b>43,732</b>	<b>10.60</b>	<b>15,745</b>
<b>Wind energy</b>	<b>14,178</b>	<b>18.10</b>	<b>8,133</b>
<b>Electricity demand</b>	<b>247,409</b>	<b>3.70</b>	<b>-</b>

Table 1 Energy balance and power capacity for 2004. Source: Red Electricia de España.

The structure of the energy sector for 2011 is described in Table 2 and shows a strong effort to modify the primary energy consumption toward a more clean and efficient system, increasing the contribution of the natural gas, saving of energy, and renewable energy sources.

The new government has announced that the Spanish Energy Plan is going to be updated during this year. Because there is a strong delay in the progress of installations of other renewable energy resources, mainly biomass power plants, the expectation is that the target for wind energy is going to be upgraded to 20,000 MW for 2012.

### Progress Toward National Targets

It is clear that the situation for the wind energy is optimistic for the fulfillment of the Spanish targets. According to the present data, the target will be reached sooner than planned. The majority of the autonomous communities have regional wind energy programs that give a total of more than 10,000 MW to be installed in the next few years (exceeding the present national target).

### 3.0 MARKET DEVELOPMENT AND STIMULATION

The promotion of renewable energy has been a stable national policy for several years. All political parties have kept a similar policy regarding support to renewables. The main tools within this policy at a national level include the following.

- A payment and support mechanism enshrined by the Parliament through an Act (Electric Act 54 /1997): Renewable producers are entitled to connect their facilities and transfer the power to the system through the distribution or transmission grid
- Renewable energy producers are entitled to receive a remuneration
- The Renewable Energy Plan including Mid-Term objectives for each technology (Renewable Energy Plan 2000-2011)

In addition to traditional support mechanisms, a new support framework for renewable energy sources (Royal Decree 436 March 2004) has been enacted. It lays down new payment options. The owners of new renewable facilities have to choose between two options: To sell the electricity to the distribution com-





Figure 1 Wind farm in a mountainous region.

Electricity Generation (%)		
	Year 2002	Scenario 2011
Natural Gas	9.7	34.2
Oil	9.9	4.8
Coal	35.9	12.0
Nuclear	27.6	20.1
Renewables	20.1	28.9
Energy Consumption		
Natural Gas	12.2	22.6
Oil	51.7	47.6
Coal	17.3	8.2
Nuclear	13.0	9.0
Renewables	5.6	12.0

Table 2 Targets for the year 2011.

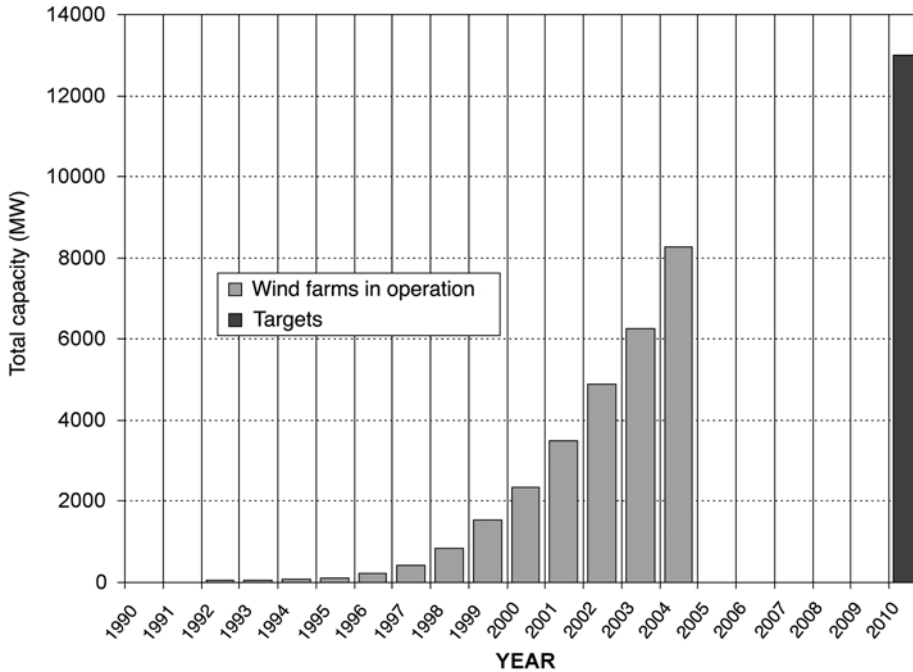


Figure 2 Wind installations in Spain and targets for 2011.

pany at a regulated tariff per kilowatt-hour or to sell the electricity freely in the market through the market wholesale pool or through bilateral or term contracts. For the first option, the regulated tariff per kilowatt-hour consists of a percentage between 80 and 90% of the Average Electricity Tariff (AET) plus a reactive power supplement and a supplement for continuity of the supply against voltage dips during the first four years of operation.

For the second option, operators who sell the electricity freely in the market receive remuneration as follows:

- The hourly price per kilowatt hour set in the electricity pool market
- Premium per kilowatt hour set out as a percentage of the AET
- An incentive for participating in the market
- A reactive power service supplement
- A capacity payment
- A supplement for continuity of the supply against voltage dips during the first four years of operation.

In both cases power production forecast obligation and deviation penalties are set out.

The Average Electricity Tariff (AET) is the total cost of the electricity system divided by the forecast demand of electricity from consumers. The AET is set and published every year by the government. The AET for the year 2004 amounts to 0.072072 euro/kWh

The new regulations included in the Royal Decree 436/2004 from March 2004, take account of important aspects of demand from the sector: stability and transparency in the mechanisms that determine the revenues and long term guarantee for the scheme payments.

#### 4.0 DEPLOYMENT

##### Installed Capacity

In 2004, more than 2,000 MW of wind power were installed, and the total power on 31 December 2004

was 8,263 MW, according to data supplied by the Renewable Energy Sources Producers Association (APPA - <http://www.appa.es>). Data supplied by the Manufactures and Promoters Association "Plataforma Empresarial Eólica" (<http://www.plataformaempresarialeolica.com>), show about 8,529 MW, including wind farms in the testing phase. A total of 430 wind farms are in operation in the national territory, with 10,597 wind turbines. The size of the average wind farm is near 20 MW.

The models used in the wind farms are wind turbines from 750 to 1,500 kW rated power. The average power per unit installed during 2004 reached 1,006 kW, showing the size increasing compared to the value of 840 kW during the previous year. The average unit size of all wind turbines installed in Spain is 805 kW.

**Rates and Trends in Deployment**

Annual power installed continues growing as seen in Figure 3. The regional distribution of the installations is shown in Figure 4.

At present, almost all the Spanish autonomous communities are incorporating wind energy into their energy structure. Aragon, Castilla-León, Castilla La Mancha, and Galicia are the autonomous communities with more activity during 2004. Investors in Spain are mostly big companies with a strong capability of promotion and development. Several regional governments are interested in the promotion of small investors and municipalities, and they are preparing new regulations for this. Galicia, Navarra, and other regions have a special procedure to promote small wind farms of less than 5 MW.

**Contribution to National Energy Demand**

The production of wind power plants for 2004 was 14,178 GWh. (Reference: National Energy Commission). The total demand for electricity in Spain during 2004 was 247,409 GWh (3.7% higher than the previous year). The evolution of the wind energy production is shown in Table 3.

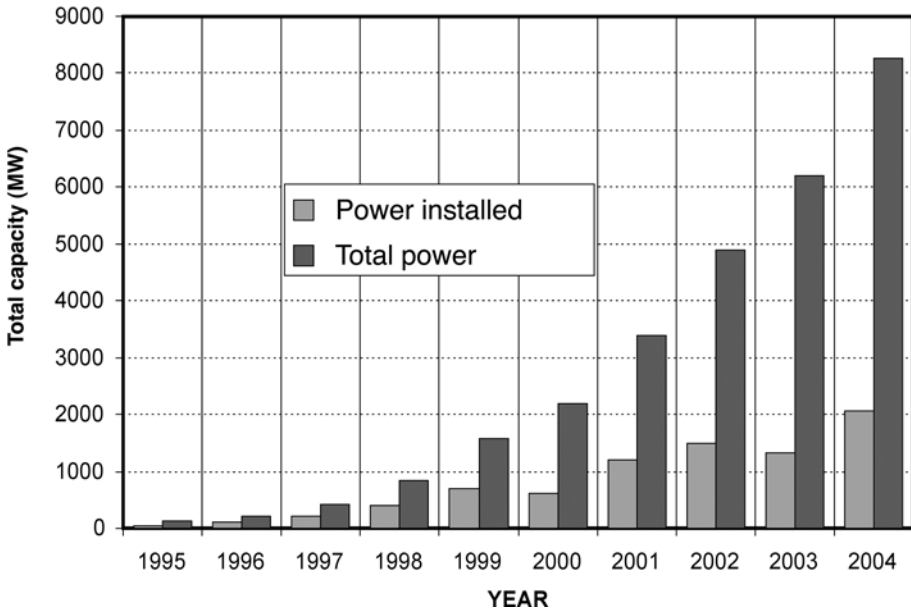


Figure 3 Annual power installed.

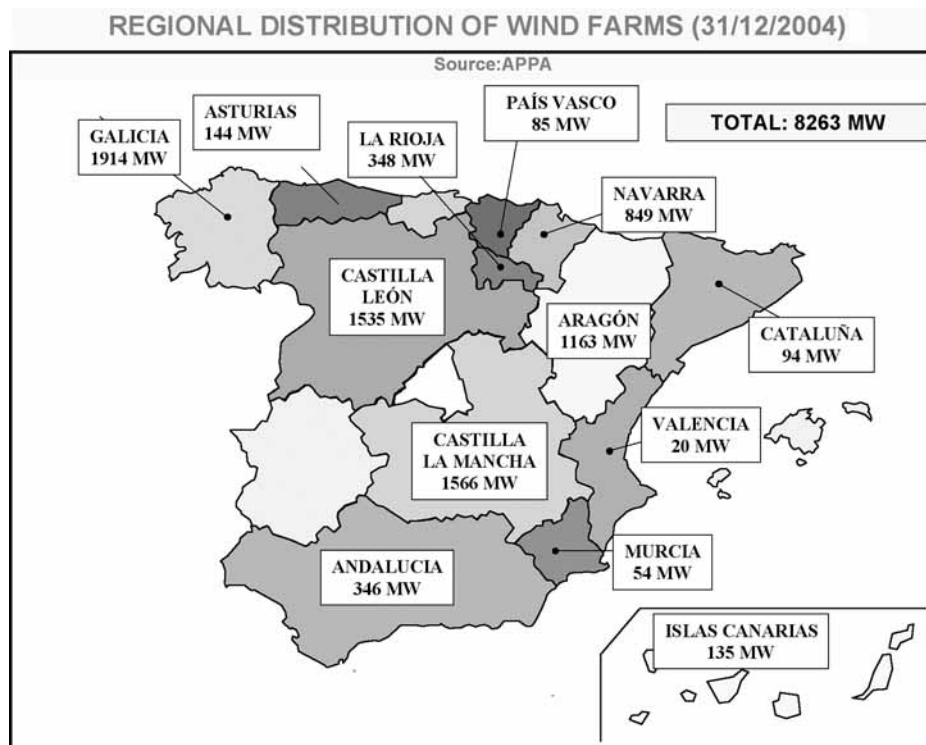


Figure 4 Regional distribution of wind installations.

Year	Production (GWh)
1999	2,696
2000	4,700
2001	6,932
2002	9,603
2003	11,370
2004	14,178

Table 3 Growth in wind energy production since 1999.

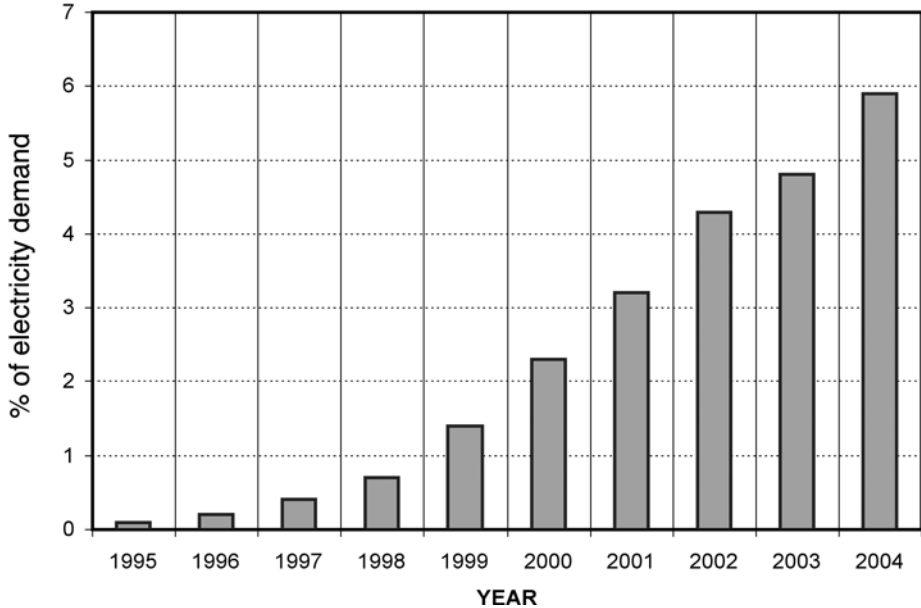


Figure 5 Electricity generation by wind energy.

Wind electricity covered 5.7% of the total electricity demand in the country in 2004. In Figure 5, we see how the percent contribution by wind electricity to total demand has grown. The day of maximum production was 19 December, with a total of 86,775 MWh supplied to the grid. Wind energy is already fully integrated into the Spanish electrical system. Information about the instantaneous production of Spanish wind farms ( and historical data of previous periods) is available on the Internet at [www.ree.es](http://www.ree.es).

## 5.0 DEPLOYMENT AND CONSTRAINTS

The rapid increase of installed power has been welcomed by Spanish society, which appreciates not only the contribution to conserving the environment but also the industrial development and associated job creation. Job creation is the most important aspect of wind energy for the Spanish population. The benefits obtained at a local level (landowners and municipalities) are favoring the development of new installations.

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

Recently, some opposition has emerged (in the areas with strong development) against the installation of new wind farms. In these cases, local ecology groups complain about the landscape impact and the possible impact on bird life. That opposition causes delays in the permission of windfarms.

The main constraint in market development is the existing limitation on the capacity of the grid for energy transmission. Generally, the wind farms are located in areas with low-density population, and the grids are weak and require reinforcement and improvement.



Figure 6 Wind farm under construction in Castilla-Leon.

Concerted actions between utilities and developers are ongoing in order to solve the problem.

## 6.0 ECONOMICS

The Royal Law 2818/1998-23 December 1998, about the Electrical Special Regime for renewable energy plants connected to the grid, fixed the conditions of the plants to be included in this special regime. This law was a new step in the strategy for promoting the use of renewable energies, with the specific target that “the contribution of the renewable energies to the Spanish energy demand, will be at least 12% for the year 2010.” All the installations using renewable energy as a primary source, with a capacity equal to or lower than 50 MW, could be included in that regime. The regime gives two choices to the producers, one is a fixed price for the kilowatt hours generated, and a second option is a variable price calculated from the average price of the market-pool, plus a bonus per kilowatt hour produced. The fixed price and the bonus will be up-dated every year by the Spanish Ministry of Energy and Industry according to the annual variation of the market price.

The up-dated values for the years 2002-2004 (before approval of the new scheme in March 2004) are presented in Table 4. The evolution of the fixed price of electricity generated by wind is shown in Figure 7.

## 7.0 INDUSTRY

Activity in the wind energy field has stimulated the development of the Spanish wind industry, including not only the manufacture of complete wind turbines but also the manufacture of components for the wind industry: blades, generators, gear boxes, towers, wind sensors, etc. In addition, the service sector (installation, maintenance, engineering) continues the growth experienced during previous years.

Job creation associated with wind energy is, according to the promoters associations, around 7,000 direct jobs in 2003 (and near 20,000 indirect jobs). The estimate for 2011 is around 51,000 jobs related with the wind energy activity when the capacity of 13,000 MW will be reached.

Renewable Source	Buy-Back electricity prices for RES in the period 2002-2004 (euro/kWh)					
	year 2002		year 2003		year 2004	
	Bonus added to the base price	Fixed price	Bonus added to the base price	Fixed price	Bonus added to the base price	Fixed price
Small Hydro	0.030051	0.063827	0.029450	0.064849	0.029450	0.064849
Wind Plants	0.028969	0.062806	0.026625	0.062145	<b>0.026625</b>	<b>0.062145</b>
Primary Biomass	0.027887	0.061724	0.033236	0.068515	0.033250	0.068575
Secondary Biomass	0.025781	0.059620	0.025122	0.060522	0.025136	0.060582
Primary Biomass: Agricultural Crops						
Secondary Biomass: Agricultural and Forest Residues						

**Table 4 Buy-back electricity prices.**

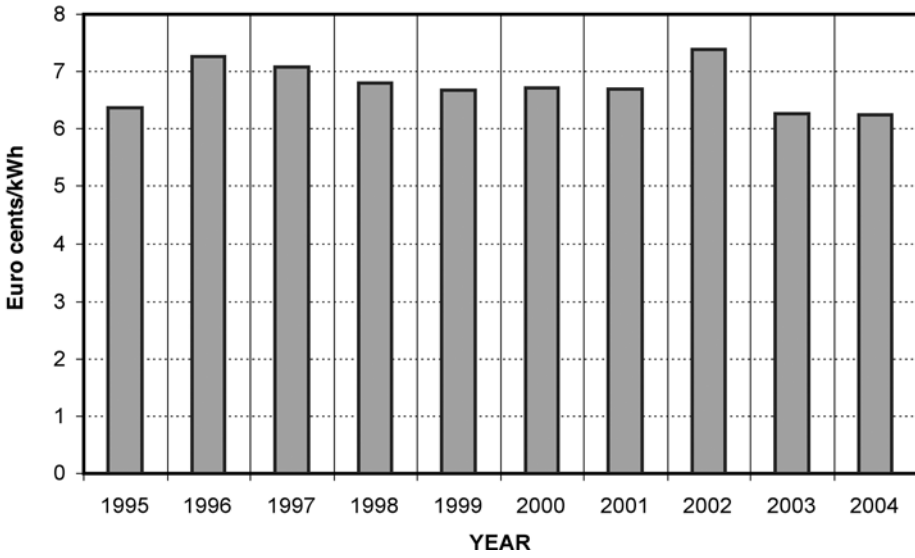


Figure 7 Evolution of the electricity price for wind energy.



Figure 8 Wind farm with small wind turbines (5kW grid connected).



## Manufacturing

The companies that are leading the Spanish domestic industry are Gamesa Eólica, Ecotécnia, GE Wind Energy, and Neg Micon (Vestas). New manufacturers are emerging, like MTorres and EHN. MTorres is a company with activity in the aeronautical field with a prototype 1.5-MW, upwind, direct-drive, multipole generator, pitch-regulated windturbine. EHN is a big wind developer that has designed and put in operation its own model of a MW-class wind machine: a pitch-controlled, variable-speed turbine. The objective of the design is to be able to cover at least the 30% of its own installations. Another new company called Ingetur has started manufacturing the EHN models and is also designing new ones. Other manufacturers are beginning activities in Spain, such as DeWind, Nordex, or Enercon with ambitious plans in the south east of the country.

Gamesa Eólica is the leading company in the Spanish market and is one of the leading companies in the world market. In 2003, the company reached the fourth position with a share of the world market of 11.5%. Gamesa has already supplied wind turbines to more than eight countries and has an extensive

marketing network. This network includes its own companies in Germany and United States and sales offices in Italy, Greece, Portugal France, the United Kingdom, and Brazil. The are 17 subsidiary factories of Gamesa Eólica with 2,161 employees. The company manufactures wind turbines between 660 kW and 2 MW and also manufactures the majority of the components (blades, nacelles, gearboxes, towers, etc.). Gamese has developed new models (G52 RCC-800kW and G80 RCC-1.8MW) using a new electronic power control system (Rotor Current Control) to optimize the efficiency of the wind turbine for specific site conditions.

During 2003, Gamesa acquired the company MADE, one of the pioneering wind companies in Spain. MADE has developed ten different models of wind turbines since 1982, from the first design of a 24-kW, to the last, a 2-MW turbine. With this acquisition, the Gamesa group increased its capabilities for design and production and covered a wide range of technology options.

Ecotécnia started activities in wind technology development in 1981, having more than 20 years of experience in that field. The company has three facto-

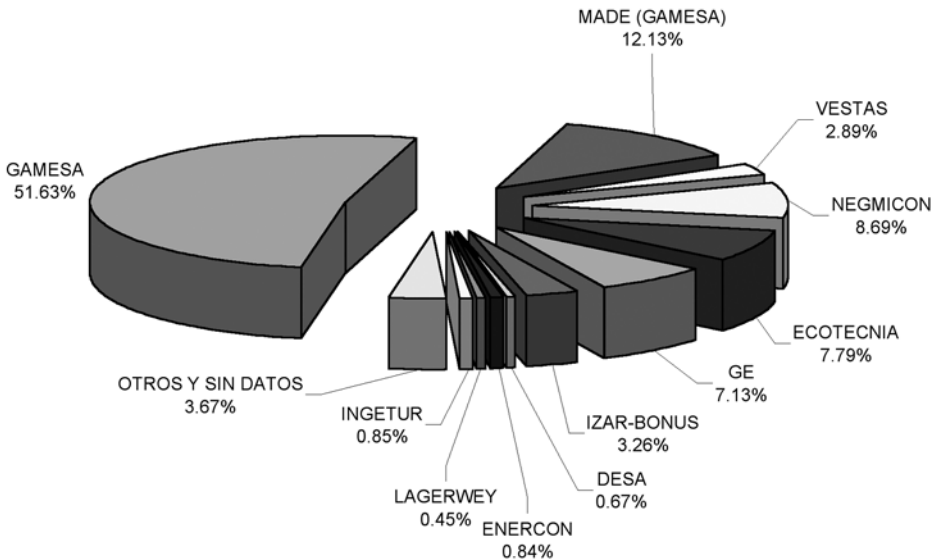


Figure 9 Share of power installed by manufacturers. (Source: Plataforma Empresarial Eólica).

ries, with 350 workers. Recently, the company opened a new office in France. Since April 1999, Ecotécnia has been a member of the group Mondragón Corporación Cooperativa (MCC). This organization includes a workforce of 68,625 people distributed in 170 companies structured into various groups: Financial, Industrial, and Distribution, along with the Research and Training areas. Ecotécnia produces wind turbine models of 48, 62, 74, and 80-m diameter. The turbines have rated power between of 750 and 1,670 kW. A prototype turbine of 3-MW rated power and 100-m rotor diameter is under development.

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

Vestas (Neg-Micon) has three factories in Spain with 160 workers. It is manufacturing models from 750 kW of rated power up to 2.7 MW, covering a wide range of site and wind conditions. The Spanish factories can produce more than 400 wind turbines per year.

The market for small windturbines in isolated applications showed active development during 2004 in Spain. In the sector of small wind turbines, Bornay is the company leader with active development in Spain and in the international market (Japan, Tanzania, Chile, Germany, etc). Bornay is manufacturing models from 60 W to 6 kW and is developing new models of 7.5 kW, 15 kW, 30 kW, and 50 kW. The company Solener is also manufacturing small wind turbines from 300 W to 15 kW and developing new prototypes from 25 and 40 kW rated power. Other companies like Atersa and Ecotécnia are supplying small wind turbines using foreign technologies from Vergnet and Bergey.

### Industry Development and Structure

Around 400 companies are involved in the wind sector in Spain covering different areas of activity: wind turbine manufacturers, tower supply, blade manufacturing, gear-box industry, control system equipment, electric and electronic equipment, erection and maintenance of wind turbines, engineering services, civil works, wind assessment, audits, etc. The current state of technology implies several options: Wind turbine manufacturers using Spanish technology, Spanish manufacturers with technology transfer agreements, and foreign technology with factories in Spain.



Figure 10 A 12-kW wind turbine at the CEDER test plant.

Domestic manufacturing capability is estimated at more than 2,500 MW per year. Two Spanish companies, Gamesa Eólica and Ecotécnia, were among the world's ten largest manufacturers in 2004. Spanish industry is also planning international projects and increasing the marketing activities in other countries.

The wind industry is spread throughout the Spanish territory (almost all the autonomous communities are involved in the development of the wind energy industry), and new factories for components have been opened during 2004.

## 8.0 GOVERNMENT SPONSORED R, D&D

### Priorities

The "National Energy Program for Scientific Research, Development and Technological Innovation (2004-2007)" centralized the Spanish R&D projects in the energy sector. The target areas defined in the plan for wind energy projects are the following:

- Development of infrastructure and tools for design of new wind turbines
- Technology Cost Reduction: improvement of efficiency, availability, reliability and maintenance, and security in the operation; techniques and hardware development for preventive maintenance
- Integration in the electric system: wind power penetration in weak grids; energy storage
- Wind turbines designed for special sites
- Wind farm design and resource assessment
- New technologies and systems focused on the environmental integration of wind energy systems.

During 2004, 36 wind energy projects were submitted to the program, covering all the target areas. The 20 projects approved accumulated a budget of 30.67 million euro. The majority of the projects (19) were supported through soft condition loans, totaling 10.3 million euro, that represent an equivalent budget of 3.6 million euro. The projects were presented mainly by industrial companies in cooperation with

engineering companies and research centers and universities.

### New R, D&D Developments

The research centers and universities involved in R&D projects have increased their activities in 2004. The wind power industry in Spain has a strong innovative character and its contribution to R&D growth is considered strategic. According to the Manufactures and Promoters Association "Plataforma Eólica Empresarial" the R&D investment by Spanish manufacturers amounts to 11% of the companies' gross value added, well above the average 1% of Spanish companies as whole, and higher than other industries such as the electronic equipment industry (5.4%).

The main public R&D organizations in the field of wind energy in Spain are CENER, located in Navarra, and CIEMAT, a center for research in the technology and environmental aspects of energy production. Within CIEMAT, the Department of Renewable Energy is stressing activities in the field of autonomous wind systems. It has a broad field of activity from development of components (small wind turbines, flywheel storage, control management units, etc.), to the testing of whole wind turbines and components at the CEDER test plant center in the Soria province (Figure 10).

Other research centers active in wind research projects include the Instituto Tecnológico Canario (ITC) and Instituto Tecnológico de Energías Renovables (ITER) in Canary Islands, the Centro de Automatización, Robótica y Tecnologías de la Información y de la Fabricación (CARTIF) in Castilla-León, the Centro de Investigación de Recursos y Consumos Energéticos (CIRCE) in Aragón.

### Offshore Activities

A study carried out by Greenpeace Spain, "The need for an offshore wind generation plan in Spain.-VIENTO EN POPA-June 2003," estimated an offshore wind generation potential of 25,000 MW off the Iberian Peninsula (less than 30 km from the coast, in water 30 m deep). The study also stressed the necessity of new



Figure 11 Traditional Spanish wind turbine in Catoira (Galicia).

regulations covering the public interest of the project, long-term price guarantees, and a plan for the organization of offshore activities.

Several projects are in different stages of development concerning offshore wind farms. Nine projects have applied for administrative permission along the Spanish coast. One of the first offshore initiatives was

the project named Mar de Trafalgar. The project is a 1,000-MW wind farm in the south of the country, using wind turbines from 2.5 to 5 MW.

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## CHAPTER 20

# SWEDEN

### 1.0 INTRODUCTION

The total installed wind power capacity in Sweden by 31 December 2004 was 452 MW, an increase of 48 MW since 31 December 2003. Of this capacity, 22.5 MW was offshore. The production from wind power in 2004 was 0.9 TWh (preliminary estimate), which corresponds to approximately 0.5% of the electricity production mix in Sweden. Contributing to this production, the 3-MW prototype wind turbine Näsudden II on the island Gotland set a new world record for electricity generation by a single wind turbine. By 3 October 2004, it had generated 49.49 GWh of electricity.

In late 2004, it was determined which large-scale projects would receive support from the government-sponsored demonstration program that has a budget of 350 million Swedish Krone (SEK). The Swedish Energy Agency released a Swedish IEA web portal where Sweden's representation in IEA Implementing Agreements and annexes will be presented with links to the respective IEA websites.

### 2.0 NATIONAL POLICY

Since 1 January 1996, Sweden has had a deregulated electricity market. The country's energy policy is to create conditions for efficient use and cost-efficient supply of energy – with minimum adverse effects on human health, the environment, and the climate. A

decision to phase out nuclear power, the commitment to reduce greenhouse gas emissions in line with the Kyoto Protocol, and the limitation of further expansion of hydropower resources make it very important to develop and market alternative energy sources and energy efficiency measures. Wind energy is one of the key elements in the transformation of the energy system.

### Strategy

In 2002, the Parliament established a planning target (as opposed to actual production) for wind power of 10 TWh by 2015, if economic conditions for wind power investments are sufficient. The purpose of the target is to emphasize wind power installations among regional and local authorities and thereby remove planning and permission obstacles so that wind power production can reach 10 TWh.

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 of 10 TWh from 2002 to 2010. The tool to meet the target is a market-based system with electricity certificates (RECS). The Swedish certificate system was evaluated during 2004.

The government supports the development and installation of wind turbines in the following efforts that are mainly managed by the Swedish Energy Agency.

- “Technical developments in coordination with market introduction for large scale plants offshore and in arctic areas” with a budget of 350 million SEK and runs from 2003 to 2007
- R&D projects with a budget of 23 million SEK during 2004
- Assessment of areas of national interest for wind power
- Follow up on the planning target by distributing the target on a regional level.

## Progress Toward National Targets

Project plans corresponding to about 3.5 TWh of wind power are underway with a proposed start of production before 2010. The realization of these plans is dependent on many factors but particularly on obtaining the necessary permits and transparent quota levels for 10 to 15 years in the electricity certificate system.

Since October 2004, 49 areas in 13 counties are now of national interest for wind power. In a permission context, a national interest for wind power will be judged against other national interests such as environment protection, fisheries, and navigation. Designating suitable areas for wind power expansion is one way of increasing the prospect of attaining Parliament's target. The assessment provides a signal that these areas are highly suitable for expansion of wind power. The process was based on documents from the county administrative boards. It is difficult to estimate how large a contribution of wind power electricity the designated areas can provide. This rests on, among other things, licensing enquiries, the competitiveness of wind power, and the price of electricity.

## 3.0 MARKET DEVELOPMENT AND STIMULATION

### Main Support Initiatives and Market Stimulation Incentives

In 2003, the Swedish Energy Agency launched a project to support technical developments in coordination with market introduction, for large-scale wind 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. The budget is 350 million SEK and the project will run for five years.

Of the total budget for market stimulation, 283 million SEK has been allocated to two large projects with far-reaching plans on deployment: Lillgrund and Utgrunden II. Vattenfall AB owns the rights to the project Lillgrund, which received 213 million SEK. The Lillgrund project is located in Öresund, between Sweden and Denmark and consists of 48 turbines.

The estimated production from this plant will increase the current production of wind power in Sweden by 40%. The second project Utgrunden II, owned by Sydkraft Vind AB, is located in Kalmarsund on the east coast. The plant will consist of 20 turbines of 4.5 MW and four demonstration turbines. Both owners expect the respective plants to start producing electricity by 2007. In addition, 35 million SEK has been allocated to environmental and social acceptance studies. The studies will be associated with the above mentioned sites and be performed before and after deployment.

The previous support system with investment grants was replaced by a new market-based system with tradable electricity certificates on 1 May 2003, as a consequence of the EU directive 2001/77. The certificate system will move the cost for supporting renewables from the public treasury to the electricity consumers. Approved power plants receive one certificate for every generated MWh from sources such as wind, solar, small hydro (up to 1,500 kW), biomass, and new hydro. Hence, owners of approved plants have two products on the market: electricity and electricity certificates. They can be sold independent of each other.

The system includes a compulsory quota on the electricity consumers, which means that they by law have to buy certificates that correspond to the quota of electricity consumption during that year. The quota will be increased by the Parliament every year and the quota for 2004 was 8.1%. For 2010, the quota is planned to be about 17%. The sanction to be paid to the state for consumers and electricity suppliers that do not fulfill their quota demand, was decided by Parliament to be 150% of the average certificate price during that year, but a maximum 0.240 SEK/kWh was set for 2004. The cap was in force during the first two years, 2003 and 2004.

The Swedish Energy Agency overhauled the electricity certificate system during 2004. It was noted that no major new investments were made as a result of the electricity certificate system in the first quota year (May 2003 to May 2004). The players' investment behavior had been characterized by uncertainty about the system's survival after 2010. The Swedish Energy Agency proposed that the electricity certificate system

should be made permanent and that long-term quota levels should be set if the necessary investments in renewable electricity are to take place. A permanent electricity certificate system with transparent quotas for a period of 10 to 15 years will most likely reduce much of today's uncertainty about the system. A conclusion from the review was that Sweden needs about 4 TWh of wind power by 2010 in order to fulfill Sweden's target in the EU directive 2001/77.

Another assignment from the government to the Swedish Energy Agency during late 2004 was to analyze the possible effects of a common certificate market with Norway. An expansion of the Swedish system to include Norway may become reality in 2007.

Wind power plant owners receive a production support called an environmental bonus. The electricity certificate system will gradually replace this bonus, and after 2009, this bonus is expected to be zero. During this time, the bonus for wind turbines offshore will be slightly higher than for those onshore.

## 4.0 DEPLOYMENT

### Installed Capacity

The expansion of the annual power generation from wind turbines (in GWh) and the installed capacity (in MW) on 31 December each year in Sweden is shown in Figures 1 and 2. (Note: Numbers for 2004 are preliminary estimates.)

### Rates and Trends in Deployment

The total installed wind power capacity in Sweden is 452 MW, an increase of 48 MW from 31 December 2003 (+ 12 %). The number of wind turbines has increased during 2003 by 42 to 723 turbines (+ 6%). Wind power generation during 2004 was 850 GWh, an increase of 25% since 2003 (850 GWh). The wind year for 2004 was normal in Sweden, 101% of a normal wind year.

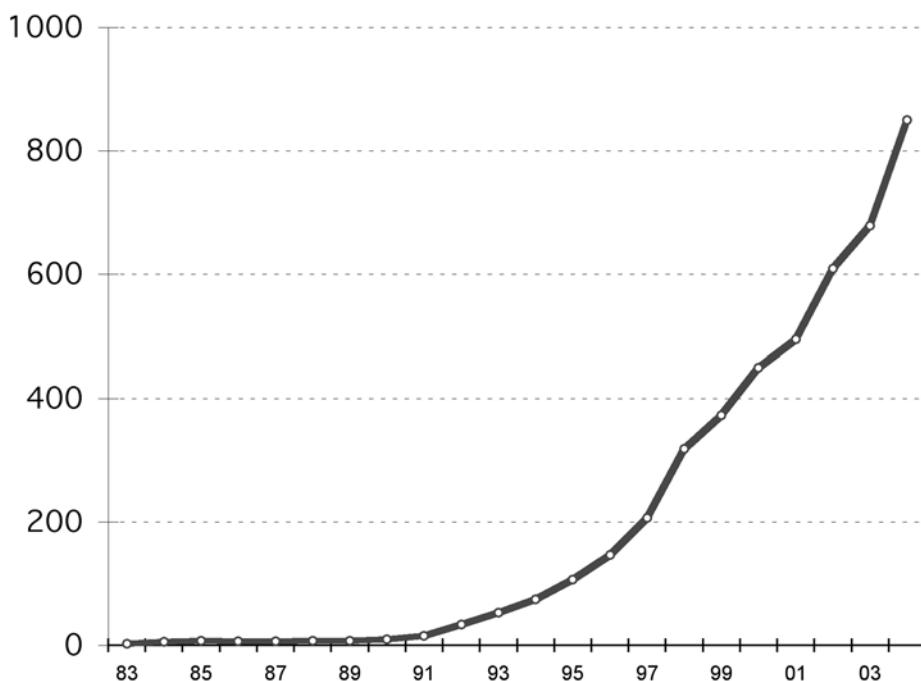


Figure 1 Wind Power Generation (GWh).

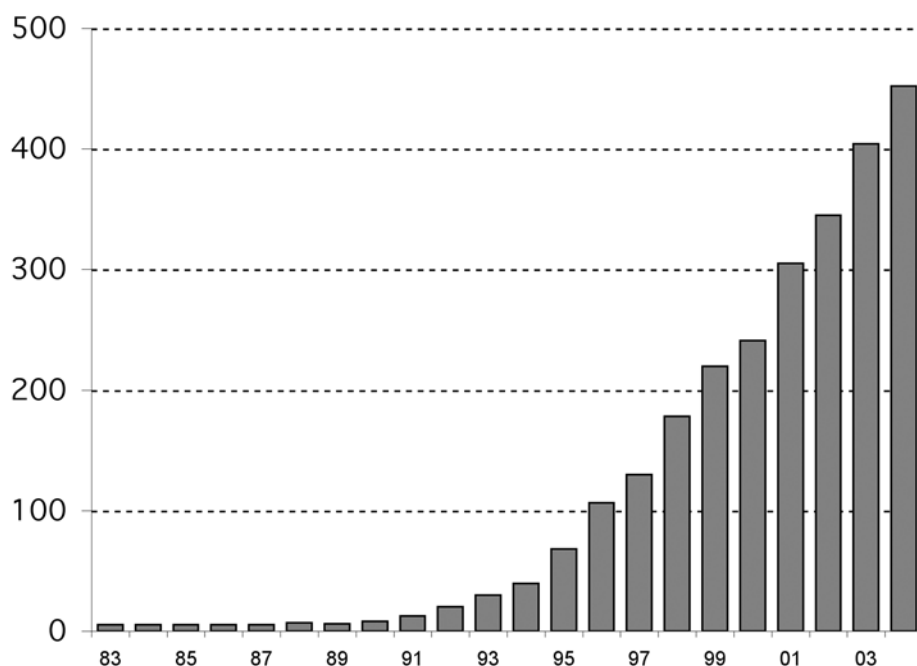


Figure 2 Wind Power Capacity (MW).

	2003 (MW)	2003 (TWh)	2004 (MW)	2004 (TWh)
Hydropower	16,097	52.8	16,097	60.0
Nuclear power	9,424	65.5	9,424	68.0
Thermal power production (CHP, cold condensing, GT)	6,374	13.4	6,374	12.6
Wind power	404	0.6	442	0.9
Net import		12.8		5.7
Total	32,299	145.1	32,337	147.2

Table 1 Total installed electricity capacity and generation in Sweden, 31 December 2003 and 2004 (preliminary estimate).



## Contribution to National Energy Demand

Wind power contributes to the national energy demand with 0.5 % of the total electricity production.

## 5.0 DEPLOYMENT AND CONSTRAINTS

### Wind Turbines Deployed

The average capacity of turbines installed in 2004 was about 1MW. With a reduced cost of production in combination with the proposed changes to the electricity certificate system, reasonable conditions for further development are expected. According to the Swedish wind turbine monthly and annual statistics, the average availability during 2003 was 99.1%. In 2002, the same figure was 98.1%. During 2004, the average availability in Sweden was 99.1%.

### Main Constraints on Market Development

The process to go from planning a new power plant to achieving its electrical production takes much time, especially for projects with an installed capacity greater than 10 MW. Such projects require permission from the government.

Environmental aspects offshore put an end to far-reaching plans to build a 300-MW plant consisting of 50 to 60 turbines on the west coast. Several authorities argued to reject the project because of the protection values of the area, conflicts with national interests in the area, and lack of knowledge of the consequences of the plant.

National interests exist for various areas of importance for the nation such as environment protection, fisheries, navigation, etc. Since October 2004, there is also now a national interest for wind power. In a permission context, different national interests will be compared and judged on equal terms. To use lack of knowledge as an argument may be less common in the future when the previous mentioned environmental studies offshore are completed at the sites that have received demonstration support from the state.

## 6.0 ECONOMICS

### Trends in Investment

There are project plans corresponding to about 3.5 TWh of wind power with a presumed start of production before 2010. Investments in large-scale wind power plants are dependent on the long-term economics. The electricity certificate system is and will be a significant income source, so its conditions are of high importance to potential investors. The electricity certificates for renewable electricity generation replaced the investment subsidy in 2003. An overhaul of the system performed by the Swedish Energy Agency was reported to the government in November 2004. The overhaul contained a chapter on wind power only, which aimed at evaluating the effects the new system had on wind power. One conclusion was that up to that time, the electricity certificate system had not generated any large new investment in wind power. The recommendations from the Swedish Energy Agency were to make the system permanent and set the quota far enough in the future to create investment conditions more reasonable than today. If these recommendations are implemented by the Parliament, a reduced economic risk and a higher growth in wind power deployment is expected. A long-term commitment to the system makes it trust-worthy and increases the possibilities for a liquid forward market for certificate contracts.

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

The economic conditions for current owners of wind power plants are good, thanks to former and current support schemes such as investment grants, produc-

Market tender price	0.26 SEK/kWh
Environmental bonus	0.12 SEK/kWh
Electricity certificates	0.23 SEK/kWh
Local grid value	0.01 SEK/kWh
Total average of industry	0.62 SEK/kWh

**Table 2** Approximate prices received for electricity by wind power plant owners in 2003.

tion support (so called environmental bonus), and certificates.

The average spot market price in Sweden on North Pool during 2004 was 0.256 SEK/kWh (www.nordpool.no, under Spot market and then Monthly prices). The base price for electricity generation in Sweden is usually set by the forward price on electricity. Since the deregulation in 1996, monthly average spot prices for the Swedish market have varied between a low of 0.066 SEK/kWh in 2000 and a high of 0.668 SEK/kWh in 2002. Average annual price in 2003 was 0.333 SEK/kWh and in 2002 it was 0.252 SEK/kWh.

On top of the market price, the wind turbine owner receives by law an "environmental bonus," which, during 2004, was 0.12 SEK/kWh for on-shore wind power and 0.17 SEK/kWh for off-shore plants. Since May 2003, wind power producers can sell one certificate for every MWh produced. The average price on certificates in 2003 was 0.23 SEK/kWh. The wind turbine owner also gets an income from the net owner, related to the value of the decreased electricity net losses, which on average results in about 0.010 to 0.015 SEK/kWh. An average wind power plant owner received the prices listed in Table 2 during 2003 (approximate prices).

## 7.0 INDUSTRY

Several manufacturers have service and sales activities in Sweden, such as Vestas, Enercon GE Wind, and Scan Wind. Sweden has several subcontractors selling bearings, electrical components, castings, and towers. The subcontractors are a multi-national group of companies as well as smaller entities that find the wind power market applicable to their know-how.

The utilities in Sweden are engaged in studies, demonstration, and evaluation projects. Utilities have co-coordinated research and development activities in a jointly owned company, Elforsk AB. Additionally, the largest Swedish utility, Vattenfall AB, has a wind energy development program of its own.

A prototype turbine, the 3,000-kW Näsudden II on the island Gotland, set a new world record for electricity generation by a single wind turbine. By 2 February 2004 it had generated 46,056 GWh since 1 June 1993. The generator has been connected to the net for 44,909 hours. The former generation record was 36,634 GWh set by the 3,000-kW wind turbine at Maglarp in southern Sweden between 1982 and 1993.

## 8.0 GOVERNMENT-SPONSORED R, D&D

An extensive energy policy program implying restructuring and development of the energy system started in 1998. The responsible authority for transforming the Swedish energy supply system into an ecologically sustainable system is the Swedish Energy Agency, which was formed on 1 January 1998. The main driver of this work was a substantial long-term concentration on research, development, and demonstration of new energy technology. Over one billion euro has been allocated to the program. An R&D program received 60% of the budget and ran from 1998 to 2004. This long-term effort was aimed at promoting renewable energy sources and new conversion and end use energy technologies.

The program was evaluated and found to meet most of its goals, such as focus, quality, and relevance. However, increased prioritizing and concentration of resources for R&D are proposed in the government bill. Another area for improvement is implementation of R&D. New products are needed to meet the challenges of transforming the energy system to a sustainable one.

The main goal for Swedish wind energy R&D is to stimulate the deployment of wind power by decreasing the production cost and with that make wind power more competitive on the electricity market. Although the Swedish wind energy R&D program came to an end in 2004, information about results from the program and other news are still available on the webpage <http://www.vindenergi.org>, run by the Swedish Defence Research Agency (FOI) and financed by the Swedish Energy Agency.

## Priorities

As a consequence of the evaluation of the long-term R, D&D program, the government assigned the Swedish Energy Agency to prioritize and focus its overall R, D&D activities. The first step of the work with prioritizing was a report in late October, "Priorities and Focus of Investments in Research, Development and Demonstration in the Energy Field." Six areas in terms of R, D&D in the energy field were highlighted. These are energy system studies, energy use in housing and commercial premises, energy intensive industry, the transport industry, the electric power system, and biofuel-based energy systems. As far as wind power is concerned, issues relating to network integration, the need for balancing power, and the development of offshore wind power are the priority areas. Issues regarding operation and environment were also mentioned.

The government announced the level of the appropriation for energy research over the next seven-year period in September 2004. The budget was cut by

some 40% compared to the previous period 1998 to 2004 and hence the work of setting priorities became even more important. The new budget will be almost 50 million euro per year for the period 2005 to 2011.

## New R, D&D Developments

### Generator

According to a report from the research project partly financed by the Swedish Energy Agency, a generator prototype has been developed on a patent application with a configuration of permanent magnets and wire-wound stator, with the bearing of the machine placed in the air gap. The layout is an outer pole machine and the application is for wind power. The technical solution was verified by a pilot generator of 144 kW (max 177 kW). The tests show that the concept meets the estimated performance and has the potential to be scaled up to 4 MW, and even further to 10 MW. Calculations and construction have been performed at VG Power AB. Manufacturing and testing have been performed at Luleå Generator Service. The founder of



**Figure 3. Offshore plant Utgrunden in Kalmarsund, Photo by Stefan Jakélius.**

the bearing concept, Staffan Engström, has continuously participated in the project. Lars Henriksson, Vattenfall has participated as a reference.”

A long-term project to map out the wind resources in Sweden has partly been reported to the Swedish Energy Agency. The project is managed by Hans Bergström at the Department of Earth Sciences Meteorology. The present result is a national map on a 5 km scale. The entire project, on a 1 km scale is expected to be finished in 2006.

### Offshore Siting

The following wind projects have been built offshore in Sweden:

- 1990 Nordersund, one 220-kW turbine,
- 1998 Bockstigen-Valar, five 500-kW turbines
- 2000 Utgrunden, seven 1,400-kW turbines
- 2001 Yttre Stengrund, five 2,000-kW turbines.

Planning for several Swedish wind farm projects offshore was further developed during 2004. The projects are planned to be located along the entire coastline, but with a concentration in the very southern part of Sweden. The outcome of the plans is dependent on the economic prerequisites as well as permission from the government (for plants greater than 10 MW).

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## CHAPTER 21

## SWITZERLAND

## 1.0 INTRODUCTION

Swiss policy toward energy has been described by Mr. Michael Kaufmann, program manager of SwissEnergy and vice director of the Swiss Federal Office of Energy (SFOE), in the introduction to the Swiss Wind Energy Concept, published 26 August 2004.

“The Swiss energy policy puts its confidence in being able to increase energy efficiency through reduction of energy consumption and through increased use of renewable energy. Both paths are necessary for the voyage into a sustainable energy future. There is no technology that can ensure alone our future energy supply. Each renewable form of energy is necessary; each region in Switzerland must contribute with its resources to the national supply. In this sense, wind energy has an important weight in Switzerland. Up to ten wind parks are necessary to fulfill the goal of SwissEnergy and to take another small step into the energy future of Switzerland.”

Wind energy is an important part of the national program “SwissEnergy.” As part of the effort to increase the role of wind energy, Switzerland participates in the IEA – Implementing Agreement on Wind Energy Research and Development, Annex XIX Wind Energy in Cold Climates.

## 2.0 NATIONAL POLICY

The objectives set for the new SwissEnergy 10-year program are derived from the Federal Constitution and the Energy and CO<sub>2</sub> Laws, and reflect Switzerland’s commitments under the international convention on climate warming. All activities and projects within the Wind program focus on installing wind power generators at evaluated sites during the short and medium term. The operational experience thus gained will contribute significantly to fulfilling the goals set by SwissEnergy in the field of renewable energy.

Targets of the Federal Department of the Environment, Transport, Energy and Communications (DETEC) are for 50 to 100 GWh by 2010. In 2003 and 2004, with its offices, the Swiss Agency for the Environment, Forests and Landscape (SAEFL), SFOE, and the Federal Office for Spatial Development (OSD), a concept has been elaborated and conducted on behalf of the SFOE (Kozept Windenergie Schweiz, BFE, 2003).

As a result of this concept, there are now assessments of wind potential, which were calculated on the basis of real wind conditions on the sites and on the feasible number of plants to be installed.

## TIME HORIZON 2010: 100 GWH

The Federal Department of Environment, Transport, Energy and Communications (DETEC/UVEK) has defined the goal for wind energy within the framework of SwissEnergy up to 2010: Implementation of 64 plants on 10 sites, some already in planning and relatively unproblematic from the point of view of landscape protectors.

## TIME HORIZON 2025: 600 GWH

All prioritized sites in cantonal areas are laid out in the concept of Wind Energy Switzerland, i.e. also the ones accepted by the cantonal authorization entity as possible sites. Possible energy production on wind

park sites equals 320 GWh, plus around 10% of the individual plants, which fulfill the criteria of the concept and will bring in another 280 GWh.

TIME HORIZON 2050: 4,000 GWH

All possible sites from the concept Wind Energy Switzerland plus all individual plants which fulfill the criteria of the concept; only sites with annual mean wind speed greater than or equal to 4.5 m/s: some 2,850 GWh/yr from individual plants, 1,150 GWh/yr from wind parks.

### 3.0 MARKET DEVELOPMENT AND STIMULATION

Research on wind energy is focused on wind power generation in hilly and mountainous terrain to provide more know-how to enhance Swiss companies' opportunities in the globally booming wind energy market. In 2004, the budget for wind energy related R&D projects was 340,000 euro. An amount of 300,000 euro is spent on promoting activities.

Indirect promotion of wind energy is coordinated by the Swiss Wind Energy Association, Suisse Eole (<http://www.suisse-eole.ch/default-d.htm>), in collaboration with the cantonal institutes of energy, energy suppliers, and energy planners. The management and administration of the wind energy research program is being carried out by the same person, which

guarantees an optimal coordination. Based on recommendations out of an evaluation, Suisse Eole will seek to position itself more as competence center for wind energy.

### 4.0 DEPLOYMENT

The year under review (2004) was a good year for the wind energy industry in Switzerland. The company Juvent SA installed two more wind energy plants with a capacity of 1.75 MW each on Mont Soleil, close to the existing wind park at Mont Crosin and the big PV testing plant. With this, the installed capacity of wind energy in Switzerland has increased 65% up to 8.87 MW.

The 23 installed wind energy plants in Switzerland have produced an estimated 6,290 MWh of electricity in 2004 (Figure 1). Since the two new plants were only installed in October, the increased capacity has not shown its full effect on energy production. Electricity produced by wind energy meets 0.01% of the total use of electricity in Switzerland. Today, almost 12% of the targets for 2010 have been achieved.

### 5.0 DEPLOYMENT AND CONSTRAINTS

The Federal government's wind energy program offers support to planners and operators of wind

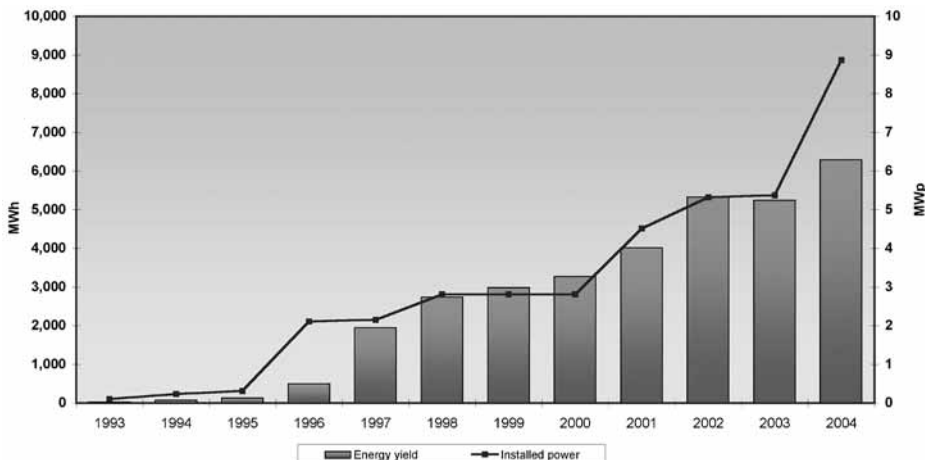


Figure 1 Development of Swiss wind energy production.



**Figure 2** Installation of a 1.75-MW wind turbine on Mt. Crosin by Juvent SA.

energy projects in various ways (wind energy manual, location maps, regional planning aid, promotion subsidies, wind energy association, etc.). Suisse Eole is the organization for supporting wind energy in Switzerland. It supports the wind energy branch in fulfilling the goals of the Federal Office of Energy. Suisse Eole is a recognized partner of the program SwissEnergy.

Since 2000, wind energy plants installed in Switzerland have the following generating capacities: 6 kW (9 plants), 800 kW (1 plant), 850 kW (2 plants), and 1.75 MW (2 plants). The installation of the biggest turbines was a challenge - not the least of which was difficult exploitation in hilly and mountainous terrain.

Due to several technical and administrative problems (inverter problem, fissures on the blades, and bankruptcy of the turbine producer and of the generator supplier), the pilot plant on the "Gütsch" near Andermatt (Lagerwey 800 kW) has been replaced with an Enercon E-40, Class 1. Since November 2004, this machine has been working very well without problems in this severe climatic environment.

Because of fundamental opposition from the Swiss Foundation for Landscape Protection, a national concept has been worked out, which allows the realization of the goals set by DETEC. Using the agreed upon criteria, possible sites for small wind parks have been defined, described, and plotted on maps. This concept will also reduce the uncertainties in the planning procedure by the cantons. Due to the growing market for green electricity, there is a good chance, that demand for wind power will rise in the near future.

## 6.0 ECONOMICS

### Trends in Investment

Wind energy plants are not subsidized anymore in Switzerland. Unfortunately, the finances for pilot and demonstration plants have been cut completely. 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.

The specific costs of larger wind power plants amount to about 2,000 Swiss francs (CHF) per kW (1,380 euro). Thus, the prime costs at windy locations are lower than 0.20 CHF /kWh. (0.135 euro). Wind energy offers good opportunities for local energy production in remote areas and its importance will increase in a liberalized electricity market. The production costs of the newest (2001) installed 850 kW wind energy plants, amount to about 0.12 CHF/kWh (0.085 euro).

The Swiss energy law obliges energy suppliers, to rebuy the energy produced by independent producers at the price of 0.15 CHF/kWh (0.105 euro). Since



Figure 3 Enercon E-40, operating on Mt. Gütsch, 2,340 m above sea level.

1 January 2005, these costs have to be paid by the high-voltage grid operators.

## 7.0 INDUSTRY

Considering the limited access and the rough climatic conditions, both offshore installations and power plants in mountainous areas must achieve high reliability. This opens market opportunities for the expensive, but highly qualified, electrical and measuring industry in Switzerland. Firms like Gebrüder Meier AG (Generators), ids AG, and Vivatec (Inverter) have already faced this challenge. Aventa AG produces small power plants up to 6 kW, and 11 units are already installed in so-called low wind areas.

## 8.0 GOVERNMENT-SPONSORED R, D&D

The concept of energy research of the Swiss government 2004-2007 presented by the Federal commission of energy research activities in Switzerland (CORE) during the energy research con-

ference in November 2003 indicates the following issues for the wind program.

“The utilisation of wind power in Switzerland is still confronted with problems of acceptance as well as with highly technological requirements due to the sites in the mountains. The planned goals of 50 GWh up to 100 GWh by the year 2010 should be concretised spatially with a national concept and the necessary planning tools should be developed. The specific problems for wind plants in mountains and an important local supplier industry of wind plant components justify the resumption of research activities. These activities will also create the possibility to exchange experiences on an international level.”

## Priorities

The following strategies and focal points for 2004 to 2007 have been describe in the Energy Research Programme “Wind energy 2004-2007” as follows:



**QUALITATIVE GOALS:**

- Coordination of national research activities in the area of wind energy
- The specific know-how gained through specific research focal points of wind energy use in hilly and mountainous terrain will give the Swiss enterprises a chance of success within the internationally booming wind energy industry
- Developing a center of competence “Wind Power Generation in Mountainous Areas”

energy in mountainous regions”

- Concept for decentralized energy production in areas with limited access

Wind power generation holds an enormous potential of great economic importance beyond the small Swiss market. Its development is linked to the crucial fields of competence of the Swiss electrical and mechanical industry. A substantial home market is an invaluable asset for Swiss companies on the international market.

**QUANTITATIVE GOAL:**

- Coordinated with the goals of SwissEnergy, Switzerland should produce 50 to 100 GWh of electricity from wind production by 2010

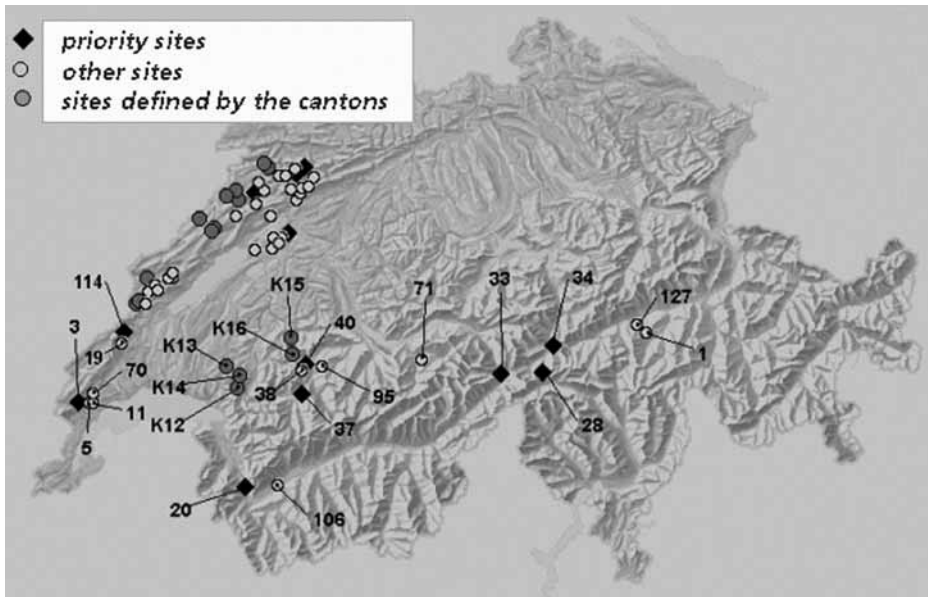
Author: Robert Horbaty, Swiss Wind Energy Program, Switzerland.

**FOCAL POINT: RESEARCH:**

- Increasing acceptance of wind energy use
- Development of innovative components
- Development of innovative concepts

**FOCAL POINT: IMPLEMENTATION:**

- Power electronics
- Construction of a competence center “Use of wind



**Figure 4: Presentation of the identified sites of the concept Wind Energy Switzerland.**



## CHAPTER 22

UNITED  
KINGDOM

## 1.0 INTRODUCTION

More than 250 MW of new capacity was commissioned in 2004 in the United Kingdom, a 38% increase over the total installed up to 2003 and a record for the UK wind industry. This included the UK's second offshore wind farm at Scroby Sands, just off the east coast of England. Predictions for 2005 show that a potential of 500 MW of new capacity is scheduled to be installed, and over 700 MW had gained approval during 2004.

The contribution of wind energy in the United Kingdom to the national demand is quite low, only 0.32%, but this is set to rise dramatically over the next few years with predictions of about 7 to 8% by 2010.

The Renewable Obligation (RO) remains the key support mechanism for renewable energy in the UK. In 2003, the second year of operation of the RO, eligible renewables accounted for 2.4% of generation, short of the 2003 target of 4.3%. The government is currently carrying out a review of the operation of the RO but is unlikely to make significant changes. Consistent operation of the RO would provide increased confidence to developers and financiers to accelerate construction programs and realize a return on their investment.

## 2.0 NATIONAL POLICY

The UK government is committed to putting the environment at the heart of its decision-making, and, as a result, renewable energy is high on the political agenda. On 24 February 2003, the government released its Energy White Paper: Our Energy Future – Creating a Low Carbon Economy. The Energy White Paper set out a bold, new strategy for energy policy until 2050. It established a clear long-term framework against which business and domestic customers could plan and make decisions with confidence.

In April 2004, a joint Department of Trade and Industry/Department for Environment, Food and Rural Affairs (DTI/DEFRA) report was published, "First Annual Report on Implementation of the Energy White Paper." The report states that the government remains committed to the four objectives:

- To put the UK on a path to cut carbon dioxide emissions by some 60% by about 2050, with real progress by 2020
- To maintain the reliability of energy supplies
- To promote competitive markets in the United Kingdom and beyond, helping to raise the rate of sustainable economic growth and to improve our productivity
- To ensure that every home is adequately and affordably heated.

## Strategy

The White Paper lists more than 130 commitments that must be delivered. Some of these are specific new undertakings; others reinforce existing policies and programs, while others provide a wider policy framework. These have been broken down into 11 overall work streams: Climate Change; Reducing UK Emissions; Energy Efficiency; CHP; Renewables; Social including Fuel Poverty; International Energy Relations; Innovation, Education, Skills, and Research; Transport; Security of Supply; and Delivery Partnerships. Achieving the White Paper commitments

requires close integration across departments and wider efforts. To facilitate this, the White Paper announced the creation of a sustainable energy policy network (SEPN). This is a network of policy units from across government departments, devolved administrations, regulators, and key delivery organisations that are jointly responsible for delivering the White Paper.

During July 2004, the Energy Bill became law following progress through Parliament. The Offshore Production of Energy part of the Energy Act 2004 puts in place a comprehensive legal framework for offshore renewable energy projects (wind and wave and tidal) and extends the boundary for such projects beyond the UK's territorial waters to the 200 mile point. The Act establishes a Renewable Energy Zone (REZ), adjacent to the UK's territorial waters, within which renewable energy installations can be established. The Act enables the Crown Estate to award licenses for wind farm sites in the REZ on much the same basis as it currently leases sites within territorial waters.

The Act gives the government the additional powers it requires to regulate renewable energy projects in the REZ, principally by extending the requirement for consent under Section 36 of the Electricity Act 1989. The Act also facilitates a streamlining of the consents process for projects within the REZ and in inshore waters by providing for navigation matters within Section 36. The legislation also introduces two new features:

- A safety zone scheme
- A statutory scheme for the decommissioning of offshore renewable energy installations and related electricity lines.

The Act also provides a framework for the implementation of the British Electricity Trading and Transmission Arrangements (BETTA). Currently the market in Scotland operates under different arrangements from England and Wales. BETTA will create a single wholesale electricity market in Great Britain, by extending the arrangements for England and Wales, to Scotland.

## Progress Toward National Targets

In the second year of the operation of the RO, eligible renewables accounted for 2.4% of electricity generation, significantly lower than the 2003 target level of 4.3%. Achieving the 10% target will require a step change in the level of renewable generation and depends on five key factors: the planning system, timely reinforcement of the grid network, wholesale electricity prices, stability of government renewable energy policy, and required additional support for some technologies.

In February 2004, a Renewables Innovation Review was undertaken to:

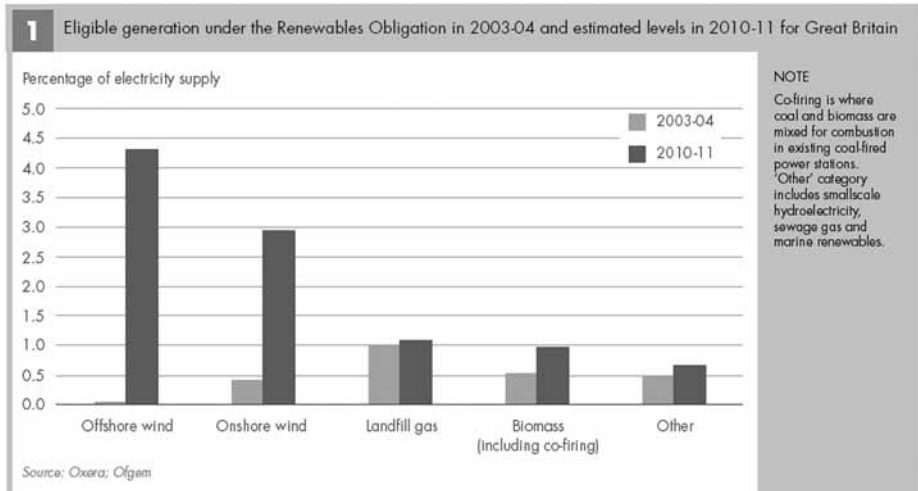
- Identify the key renewable technologies for the delivery of targets and aspirations, for the delivery of the UK's wider carbon reduction aspirations, and for the creation of economic benefits for the UK
- Identify the barriers to the development and deployment of key renewable technologies
- Understand better the innovation process in key renewable energy sectors
- Identify the most cost-effective government measures to facilitate the delivery of targets.

The DTI and the Carbon Trust, both members of the SEPN, jointly conducted the Review.

The Review will feed into the DTI and the government's future funding decisions. It will also contribute to the 2005/06 Renewable Obligation Review.

The key conclusion of the review with respect to wind energy was that the 2010 target can still be met if barriers to deployment can be eliminated. Renewable energy supply is forecast to reach approximately 10% by 2010 given the current RO framework and institutional barriers. Figure 1 presents the expected breakdown of generation levels for 2010, by renewable technology. The difference between estimates is mainly due to recent increases in wholesale electricity prices.

Wind, both on- and offshore, is the only economically viable and scaleable technology under the current RO regime. There is sufficient practical resource in the UK to fulfill the 2010 target and the 2020 aspiration, so wind energy development dominates the near-term



**Figure 1 Eligible generation under the Renewables Obligation (RO) in 2003 to 2004 and estimated levels in 2010 to 2011.**

forecast of renewables growth. The announcement of the increase in the level of the RO and beyond has greatly improved the investment case for wind energy. Now, it is principally institutional barriers that are likely to be on the critical path to delivering the 2010 targets. The regulatory changes to incentivise the grid upgrades, together with technology and planning risks require close monitoring and contingency planning. Key barriers relevant to wind energy that need to be addressed are planning, aviation issues, public opposition, and grid/network connection distribution issues. Offshore wind is likely to be required to achieve the government's targets. Round Two offshore wind projects will require substantial debt financing, and therefore an appropriate financial framework will be important in encouraging investment.

### 3.0 MARKET DEVELOPMENT AND STIMULATION

The key support mechanism to enable the UK to meet its 10% target remains the RO. The new RO and associated Renewables (Scotland) Obligation came into force in April 2002 as part of the Utilities Act (2000). It requires power suppliers to derive from renewables a specified proportion of the electricity they supply to

their customers. The cost to consumers will be limited by a price cap, and the obligation is guaranteed in law until 2027.

Eligible renewable generators receive Renewables Obligation Certificates (ROCs) for each MWh of electricity generated. These certificates can then be sold to suppliers, in order to fulfill their obligation. Suppliers can either present enough certificates to cover the required percentage of their output, or they can pay a 'buyout' price of £30/MWh for any shortfall. All proceeds from buyout payments are recycled to suppliers in proportion to the number of ROCs they present. ROCs can be freely traded and the price varies according to the ratio of ROCs to buy outs (which increase the overall value of the ROCs). ROCs have increased the profitability of renewable energy generation because the certificates can currently sell for more than the power. This is especially true for wind energy generation, which was already producing electricity at competitive prices. ROC trading is administered by the Non-Fossil Purchase Agency Ltd (NFPA). Further details of ROC prices are given in Section 6.0.

The RO percentage target is set to increase each year from its current level of 4.9% in 2004/05 to reach

10.4% by 2010/11. In December 2003, the government announced its intention for the RO percentages to continue to rise beyond 2010/11 to reach 15.4% by 2015/16. A consultation on this proposal and some other changes closed on 1 December 2004, with the aim that the changes will come into effect on 1 April 2005. The changes include measures to secure the buyout fund; increase flexibility for small generators; provide a single recycling mechanism; and recognize Northern Ireland Renewables Obligation Certificates (NIROCs).

In November 2004, the Energy Minister, Mike O'Brien, published the government's plans for the review of the RO. Following the publication of the draft terms of reference in August 2004, the DTI received over 90 comments from key stakeholders. There was strong support for the proposal of a limited review to improve the effectiveness of the RO, whilst avoiding changes to the key operating principles. After two years in existence, this is a good chance to assess the impact of the RO and consider how it can be refined to provide the best environment for producing renewable electricity. Confidence in the RO framework over the long-term is important to the UK. Wherever consideration is given for possible changes to the RO during the review, maintaining that confidence will be a key consideration.

Among the key areas that the review proposes to examine are:

- The effectiveness of the RO since it began in April 2002
- All aspects of the working arrangements of the RO
- The levels of the RO beyond 2015/16
- The potential impact of the EU Emissions Trading Scheme on carbon and on prices and the future cost competitiveness of renewable technologies
- The energy from mixed wastes.

Running alongside the new RO is a drive for increased energy efficiency and the Climate Change Levy. Introduced on 1 April 2001, this is a new tax on energy use by both business and public sectors. The principal aim of the levy is to encourage non-domestic electricity users to become more energy efficient and

so reduce carbon emissions. The levy package as a whole is expected to save at least 5 million tonnes of carbon a year by 2010.

## 4.0 DEPLOYMENT

### Installed Capacity

Figures from the British Wind Energy Association (BWEA) show that during 2004 twelve new projects came on stream representing over 250 MW of new capacity. This raises the total wind generation capacity in the UK to over 900 MW, an increase of 38% and a record for the industry. Table 1 details the projects commissioned in 2004. Of particular note was the commissioning of Scroby Sands, the UK's second offshore wind farm with a capacity of 60 MW. This brings the total of offshore wind power to 124 MW, with much more to follow. Figure 2 shows the distribution of wind projects built in 2004 and wind projects built in the total UK by country. Figure 3 shows the build rate over the last seven years for the whole of the UK.

### Rates and Trends in Deployment

BWEA figures also show that there were 18 wind projects under construction at the close of 2004 totalling over 500 MW of new capacity, all scheduled to be commissioned in 2005. In 2004, 33 new projects were approved through the planning system, totaling some 700 MW and representing an approval rate of 83% for projects determined during 2004. There were 94 onshore projects in planning, representing some 4,767 MW of capacity. Figure 4 shows wind farm planning application success and failure rates from 1995 to 2004. Figure 5 shows projects under construction and approved, by country.

### Contribution to National Energy Demand

The latest available figures are for 2003 and show that the total electricity demand was 399,820 GWh, an increase of just 1.3% over 2002. The contribution from wind was 1,286 GWh during 2003, just 0.32% of the total demand. The average load factor for onshore wind was 24.1% during 2003.

Site	Capacity (MW)	Turbines	Location	Country	Status
Ardrossan	24.00	12	Ardrossan, North Ayrshire	Scotland	Live February
Cruach Mhor	29.75	35	Glendaruel, Kyles of Bute, Argyll and Bute	Scotland	Live May
Llangwryfon (repowering)	9.30	11	Ceredigion	Wales	Live April
3Hs – Holmside Hall	5.00	2	Stanley, County Durham	England	Live May
Crystal Rig	50.00	20	Borders	Scotland	Live June
Ford Dagenham	3.60	2	London	England	Live July
3Hs – Hare Hill	5.00	2	Haswell Plough, County Durham	England	Live August
Mablethorpe (extension)	4.80	8	Mablethorpe, Lincolnshire	England	Live November
Causeymire	48.00	21	Mybster, 30km from John o' Groats, Highlands	Scotland	Live November
Scroby Sands	60.00	30	3km NE Great Yarmouth, Norfolk	England	Live November
Spurness	11.00	4	Gump of Spurness, Sanday, Orkney	Scotland	Live December
Ness Point	2.75	1	Lowestoft, Norfolk	England	Live December
Confirmed new capacity	253.20	148			

Table 1 New projects that began generating electricity in 2004.

## 5.0 DEPLOYMENT AND CONSTRAINTS

As mentioned in Section 3.0 above, the key conclusions of the innovation review was that the 2010 target can still be met if barriers to wind energy deployment can be eliminated. The key barriers to wind energy are planning, aviation issues, public opposition, and grid/network connection distribution issues.

### Main Constraints on Market Development

#### PLANNING

In February 2004, the DTI launched 'It's Only Natural,' a renewable information campaign to raise awareness of the renewable energy sector to key decision makers. The campaign seeks to inform planners, investors, and the wider community of the potential and benefits of renewable energy. The initiative will highlight the investment potential of the renewable sector to the financial community and equip plan-

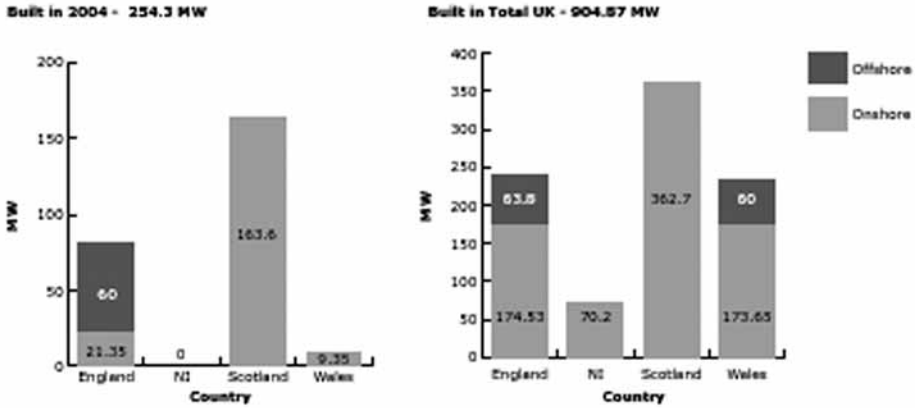


Figure 2 Distribution of projects built in 2004 and built in total United Kingdom, by country.

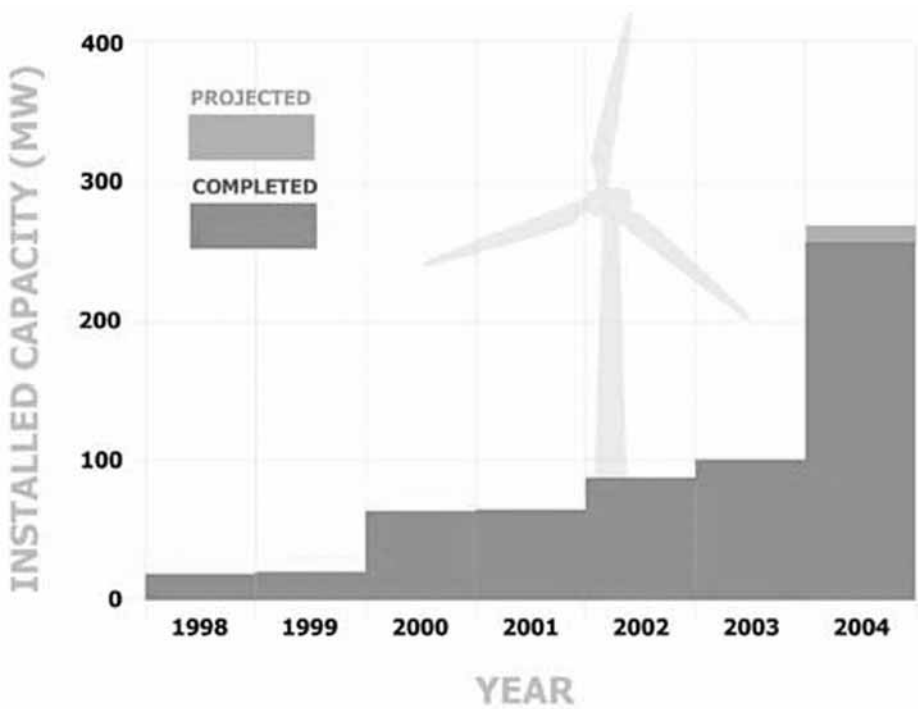


Figure 3 Capacity increases since 1998 for the whole of the United Kingdom.



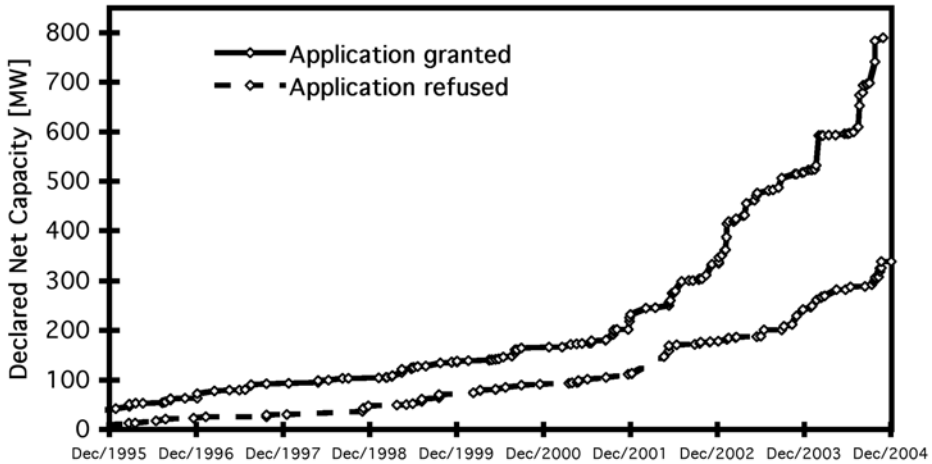


Figure 4 Wind farm planning application success and failure by declared net capacity.

ners with the information they need to make informed judgments about applications.

In July, BWEA released its study into planning delays showing that the average time for achieving final planning consent for a wind farm application is 14 to 30 months (depending on the country), as opposed to the 16 weeks it should take for determination of major projects requiring an Environmental Impact Assessment (EIA). Consenting delays are strongly apparent in Scotland, primarily due to Section 36 cases, which make up nearly 3.5 GW of the 3.9 GW currently awaiting determination there. With more than 1 GW in planning or awaiting Section 36 determination elsewhere in the UK, good planning advice and decision maker awareness is paramount.

Also in July, the Office of the Deputy Prime Minister (ODPM) published Planning Policy Statement 22 – Renewable Energy. PPS22 mirrors the guidance of NPPG6 in Scotland. PPS22's essential ingredient is its call for all issues to be balanced with local environmental, social, and economic considerations and the national need for renewable energy. It encourages criteria-based policies in development plans to allow for national and local factors to be considered in decision making. Provided the national statement filters down to development plans, England should receive more consistent decision making for wind farm

developments. Time will tell, but it is already evident that there is increased developer confidence as with 321 MW put forward, 2004 has been a record year for submissions in England. In December, the ODPM published its PPS22 Companion Guide – Planning for Renewable Energy. This practical guide advises planners how to implement PPS22 in their local communities, explains what makes a 'good' renewable energy application, and advises how to assess the impact of plans on the landscape.

In Wales too, there is optimism as the Welsh Assembly published its long awaited consultation draft of TAN8 (Technical Advice Note) in July after four years of developer anticipation. Imposing a strategic approach to meet its aims, the Assembly has made a first by inserting a dedicated onshore wind target of 800 MW by 2010.

Not only is the policy guidance improving, but so too is the awareness building. In partnership with the DTI, BWEA launched a series of Regional Planning Conferences for planners and Councillors, providing expert information, wind farm site visits, and even turbine tours.

#### AVIATION

A number of initiatives are progressing with the aim of finding solutions to the radar problem that are accept-

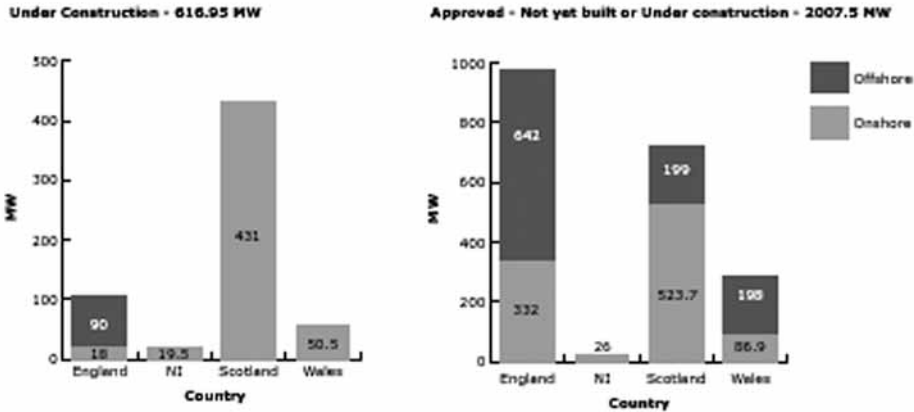


Figure 5 Distribution of projects under construction and approved, by country.

able to aviation regulators. BWEA has been working closely with the DTI to progress an initiative known as the AMS Advanced Digital Tracker (ADT). The ADT has the potential to resolve radar issues around many civil airports and military air traffic radars, freeing up a significant number of wind farm projects. The ADT has the support of the Ministry of Defence (MOD) and the National Air Traffic Control (NATS) and a 'Demonstrator Proposal' is being progressed to contract by January 2005 with the aim of proving the technology.

Meanwhile, the Aviation Working Group and Radar Sub Group are advancing other initiatives, one of which is an improved pre-planning consultation process. The MOD has been taking the lead and intends to launch their Consultation Information System by the end of the year, making it easier for developers to submit inquiries and quicker for the regulators to assess and respond. The aim is to reduce delays in response times to five weeks, providing a more efficient process for all.

**PUBLIC OPINION**

The wind energy debate has intensified during 2004. The media portrayal of this debate continues to emphasize the myths, giving rise to the misconception that wind energy in the UK is neither progressing nor popular. This is far from the case, as not only was 2004 a record year for the wind industry, but four

more opinion polls were published, all demonstrating once again the consistently high level of support for wind energy. Previous studies have shown that this support increases once a project has been built and is highest of all among the residents near wind farms.

In 2004, a number of campaigns were run in the UK with the aim of providing the public with the facts about wind energy. The BWEA's Embrace the Revolution aimed to get people talking about wind energy in a different way and provided a vehicle for the so far largely silent majority to show their support. The campaign was launched on 20 September, and results of new research carried out by NOP show that 74% of the population agree that wind farms are necessary to help meet current and future energy needs in the UK, despite a vocal campaign against their expansion. Embrace the Revolution has proved to be an innovative and successful campaign. It had a media circulation of 38 million, united the wind industry and its supporters, and will be built on in 2005 to further enhance the positive messages of the UK wind industry.

Another campaign, Catch the Wind, was a children's design competition, inviting children across the UK to draw, paint or take a photograph to show people what wind energy meant to them. Jointly funded by the DTI, the aim was to raise awareness of the benefits of wind energy as a sustainable energy resource among the public and the media. The competition attracted over

784 entries, 70% in the 7-10 year old age group. By comparison, a similar competition for a well-known consumer brand achieved only 200 entries. The competition communicated the positive story of wind energy to an audience of up to 7 million parents and children through a variety of media - print, broadcast, and exhibition venues.

#### GRID ISSUES

Onshore grid issues have been dominated this year by the twin regulatory reforms of BETTA and investment proposals for the UK transmission to accommodate new renewable generation seeking to connect to the system (Transmission Investment for Renewable Generation – TIRG).

BETTA will bring a number of important benefits for Scottish consumers and generators. The introduction of BETTA will enable Scottish generators to have access to the wider GB market and this will benefit in particular the Scottish renewable generators. This is because the local Scottish market is too small to take all the potential output from renewable generation coming on stream, and the pre-BETTA arrangements for accessing the English and Welsh markets were complicated and expensive for Scottish renewables. Without BETTA, the upgrades to the transmission system needed in Scotland to facilitate the growth in renewable generation would have been charged only to Scottish users. Under BETTA the cost will be spread across all transmission users in GB.

In December, the UK industry regulator, the Office of Gas and Electricity Markets (Ofgem) announced it was approving investment of £560 million by the three licensees to strengthen the transmission system in Scotland and Northern England to accommodate the growth in renewable generation.

The Energy Act 2004 contains provisions to enable the Secretary of State to establish offshore transmission licensees and allow offshore transmission networks to be developed and regulated. The DTI and Ofgem are currently preparing a consultation document on the options for regulation of the offshore grid. To inform this document, the DTI funded a project by Econnect to assess the practicalities, options, and costs of connecting the Round Two proj-

ects. This project was commissioned during 2004 and the final report was published in December.

## 6.0 ECONOMICS

### Trends in Investment

Finance for wind farms is obtained largely from corporate investors and banks, though there is a small amount of private investment. Since the announcement of the RO, utilities and conventional power generators have become increasingly involved in wind farm development. Because of the high value the obligation places on renewables, corporate investment will yield high returns through an expansion of the core business whilst reducing their exposure to penalty payments. Wind has found particular favor because of its economics, maturity, and ability to deliver relatively quickly. As has already been stated, the investment case for wind has been boosted by the announcement of the increase in the level of the RO and of the review of the RO with input already given by the stakeholders on the draft terms of reference.

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

The present-day costs of installing wind energy in the UK are between £650-850/kW onshore rising to £1000-1200/kW offshore. The additional costs of offshore installation include around £100/kW for the electrical connection to shore and £150/kW for inter-turbine cabling. However, the very large installations now planned will be significantly cheaper and studies suggest that generating costs could fall by 30% or more. This will be achieved partly through economies of scale, partly through moving further offshore to higher wind speeds, and partly through 'learning curve' reductions.

Offshore, the DTI has suggested that present-day generating costs are around £0.051/kWh. Although some early wind farms have reported higher capital costs than this, experience in Denmark suggests that the lower costs are also achievable and so a range of plus or minus 10% around the central value has been used. The prices for fossil-fuelled generation of £0.03/kWh have been drawn from recent government

White Papers, except in the case of gas. In this instance, the recent price movements have been taken into account and, as a result, generation costs from new plants are likely to be close to £0.03/kWh. Once the European Emissions Trading Scheme is implemented, prices of gas and coal-fired generation will increase. There is some uncertainty as to the level at which carbon permits will trade, although most analysts suggest it will be in the range £5-10/tonne of carbon. It is clear that onshore wind prices are significantly below those for nuclear and coal and within the range of prices for gas-fired generation. Offshore wind is currently cheaper than nuclear, but more costly than coal or gas.

Currently, the NFPA conducts green power auctions biannually. These auctions are for electrical output that will be produced by NFFO (Non Fossil Fuel Order) 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 ROCs. In the NFPA power auction number 9 completed in August 2004, the price for wind was £0.0731/kWh. This compares to the February auction price of £0.0626/kWh and the prices in 2003 of £0.0641 and £0.067/kWh for February and August respectively. The prices of ROCs traded in 2004 varied from £46.12/MWh in October to a high of £52.07/MWh in July.

## 7.0 INDUSTRY

### Manufacturing

Wind energy is the fastest growing energy sector in the UK creating jobs with every megawatt installed. To date, about 4,000 jobs are sustained by companies working in the wind sector, and this is projected to increase as the industry grows. The DTI has estimated that Round Two of offshore wind developments alone could bring a further 20,000 jobs for Britain. Recent examples of industry growth in the UK include the Vestas (previously NEG Micon) manufacturing facility on the Isle of Wight. The facility employs over 500

people, 420 of whom live on the island, making this company one of the island's largest employers.

The German turbine manufacturer DeWind was acquired by the UK company FKI in 2002 and employed around 400 people manufacturing complete wind turbines at its plant in Loughborough. Unfortunately, in November 2004, FKI announced its intention to exit the DeWind turbine business due to market forces. The UK's second turbine manufacturer NOI Scotland also ceased trading in 2004 again due to market forces.

In addition to manufacturing, various other sectors are involved in wind energy development, ranging from environmental consultancy, electrical and civil engineering to financial and legal services. The UK now has well-established expertise in consultancy for site exploration, performance and financial evaluation, planning applications, and environmental impact statements. Growing interest in the offshore market has attracted new business for consultants in environmental assessment, meteorology and oceanography. In addition, the increase in offshore activity has resulted in a number of offshore oil and gas contractors redirecting their experience to the development of foundations and installation techniques for offshore wind turbines.

### Industry Development and Structure

In January 2004, the results were published of a joint Renewables UK, Scottish Enterprise, Highlands and Islands, and the Scottish Executive study into the current status of the renewables industry in the UK and an assessment of its future potential. The UK was split into two study areas: Scotland and the Rest of the UK. Key objectives of the study were to:

- Identify the participants in the renewable industry in the UK and map them along the supply chains of the technologies under review
- Determine the size of the current market and the potential size and structure of future markets within the context of the Energy White Paper aspirational goals
- Assess the gaps in existing supply chains
- Determine opportunities for the UK and identify the main constraints.

The study showed that current jobs sustained by UK demand in wind energy are in the order of 3,990, with about 1,490 in Scotland and 2,500 in the rest of the UK.

The analysis pointed out that there is a huge wind resource in the UK and the expected wind capacity gap represents manufacturing investment opportunities, especially for wind turbines and components difficult to transport. The development of offshore wind in the UK should create world-class capabilities, and the UK has the opportunity to maximize its share by encouraging other countries to promote offshore wind development on the basis of successful projects demonstrated in the UK.

The main threat to this scenario is that the growing wind market may be served by non-UK wind turbine suppliers. Such companies may only locate sales offices in the UK, utilizing their manufacturing facilities overseas, particularly if demand in other markets is volatile. In addition, there is increasing competition from manufacturing facilities established in countries with lower labor costs.

The recommendations from the study are that DTI's Renewables UK and the Scottish Economic Development agencies should continue to work with wind turbine manufacturers to establish manufacturing facilities in the UK. In addition, they should continue to work with both overseas manufacturers and manufacturers who assemble wind turbines in the UK, to maximize UK content of turbines.

## 8.0 GOVERNMENT-SPONSORED R&D

Around £1.5 million was spent on the wind program area of the old DTI's R&D Programme on Renewable Energy in 2004. In 2004, the DTI incorporated the New and Renewable Energy Programme into its wider corporate Technology Programme, for which it has secured additional funding over the next three years. The Technology Programme aims to maximize value for money by focusing Departmental support on those areas where the case for it is strongest. For the period 2005 to 2008, the Department has recently agreed an indicative allocation of at least £20 million

per annum of Technology Programme funding to support research and development into renewables and low carbon technologies, subject to high quality proposals coming forward and the ability of the sectors to demonstrate success from the support received. Historically, the DTI provided the large majority of government funding for research into renewable energy. In recent years, however, a wider range of public bodies have offered support to the renewables industry. This has increased the opportunities for companies to obtain funding, provided they develop an understanding of the range of support schemes operating at a regional, national, and European level.

One example is Collaborative Offshore Wind Research into the Environment (COWRIE) set up by the Crown Estates and administered by a steering group of representatives from the offshore industry and government. This research fund, made up of the interest from Round One refundable deposits, has been used to pay for generic environmental work, with application across the whole offshore program. Using the much larger non-refundable option fees that Round Two developers have paid, Crown Estate is founding the COWRIE 2 fund to continue and expand this work.

The group has met regularly since November 2001 and, based upon an assessment of work completed to date in both the UK and other European countries, COWRIE has identified four priority areas for generic research:

- Potential effects of electromagnetic fields (EMF) on fish
- Baseline methodologies for aerial and boat based surveys
- The displacement of birds (especially Common Scoter) from benthic feeding areas
- Potential effects of underwater noise and vibration on marine mammals.

All research contracts have been awarded and work is underway.

The COWRIE research studies are quite separate from the requirements on developers to undertake site investigations to inform the environmental impact assessments or site monitoring requirements, but it

is envisaged that the outcome of the research will be guidance and best practice, which should be of great benefit to developers.

## R&D Priorities

Call number 2 of the Technology Programme announced in April 2004 had offshore wind as a technology area and requested proposals that matched the following priority:

'Funding is available for innovative technologies and approaches that offer the prospect for significant reductions in capital and operating costs of offshore wind farms. We are also prioritising technologies that will reduce the radar cross section of wind turbines, through new materials and designs. Ideally, such proposals should include turbine and component manufacturers.'

Proposals that address the above technology areas were sought for collaborative R&D projects that involve science-to-business and business-to-business interactions. Projects could range from small, highly-focused basic research aimed at establishing technical feasibility, through to applied research and experimental development projects configured to produce technology demonstrators. In particular, projects were encouraged that could demonstrate benefits to a number of business sectors, and ideally should include at least one partner with defined end-user needs. Typically, a project would have a 1 to 3-year duration and require DTI support of up to £1 million, although larger projects would be considered. Projects would generally aim to implement significant business change in a 5 to 7-year time frame, rather than offer immediate payback. In addition, the Engineering and Physical Sciences Research Council (EPSRC) were interested in co-funding applied research projects in the offshore technology area where there was a significant high quality academic component.

Call number 3 of the Technology Programme was announced in November 2004, and the priorities for offshore wind remained the same as the previous call.

## New R, D&D Developments

During 2004, research projects have been carried out on various topics such as looking at the design and manufacture of radar-absorbent wind turbine blades, opportunities for reinforced thermoplastic composites in offshore wind structures, multi-megawatt blade development, and the application of suction caisson foundations to offshore wind turbines. A new project that commenced in 2004 was a novel pile handling and insertion method based on non-percussive techniques for offshore wind turbine foundations.

## Offshore Siting

With progress being made on Round One projects and developers awarded sites for Round Two at the end of 2003, 2004 has been a very busy year for the offshore sector. Construction was completed in 2004 on the UK's second large-scale offshore wind project, Scroby Sands, and 2005 promises completion of two other sites, Kentish Flats and Barrow. With further construction planned for 2006, sometime that year, the UK should become the world's number one offshore wind generator.

Beyond the political scene, there are many stakeholders in the offshore sector that must be kept informed about developments and included in the decisions. BWEA's Offshore Programme has endeavored to reach out to these various interests, through stakeholder fora such as the Fishing Liaison for Offshore Wind (FLOW) group and individual meetings with key players. As Round Two projects are readied to be submitted for consent during 2005, these stakeholder engagements must intensify.

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# CHAPTER 23 UNITED STATES

## 1.0 INTRODUCTION

Total net generation of electric power in the United States was 3,953 TWh in 2004. Of that generation, 49.8% was coal-fired, 19.9% was nuclear, 18.0% was natural gas-fired, 6.5% was hydroelectric, and 3.0% was by petroleum-fired. The remaining 2.8% was generated by renewable resources such as wind, solar, biomass, and geothermal, and wind generated the majority at 0.5% (Figure 1).

The United States added 359 MW to its wind energy capacity in 2004, bringing the total national capacity to 6,740 MW. Wind industry experts predict that, with the renewal of the federal production tax credit in October 2004, the U.S. installations for 2005 will exceed 2,000 MW (Figure 2). The federal production tax credit, or PTC, provides a tax credit of 0.018 U.S. dollars (USD) per kilowatt-hour (adjusted for inflation) to the producer of electricity from wind energy.

This report describes the current status of the U.S. wind energy industry and any changes that occurred to installed capacity, advancements in research and development, new market incentives, economics, and national policies during 2004.

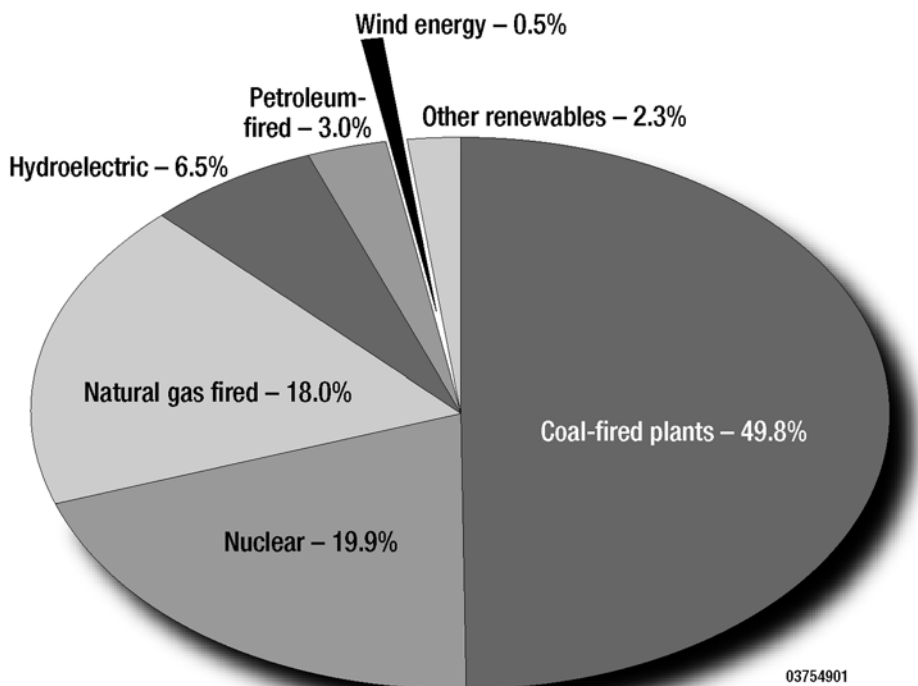


Figure 1 U.S. electricity generation by source as of November 2004.

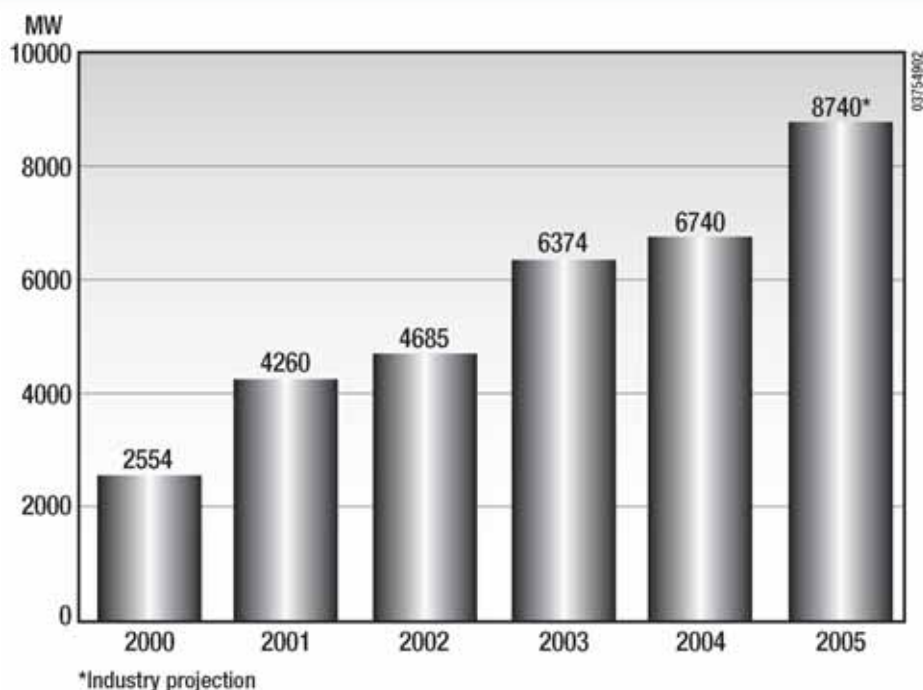


Figure 2 U.S. wind energy capacities 2000 – 2005.

## 2.0 NATIONAL POLICY

One objective of the U.S. National Energy Policy is to “Increase the viability and deployment of renewable energy technologies, by improving performance and reducing costs, and by facilitating market adoption of renewable technologies.” The U.S. Department of Energy (DOE) leads the nation’s effort to develop renewable energy technologies, and wind energy is at the forefront of this effort. The DOE Wind Program supports the national energy policy to increase the viability and deployment of renewable energy by working to improve wind energy technologies through public/private partnerships and by coordinating with stakeholders on activities that address barriers to use of wind energy. The Program’s goals are as follows:

- By 2012, reduce the cost of electricity from large wind systems in Class 4 winds (average wind speeds of 5.8 m/s at 10-m height) to 0.03 USD/kWh for onshore systems and 0.05 USD/kWh for offshore systems
- By 2007, reduce the cost of electricity from distributed wind systems to between 0.10 and

0.15 USD/kWh in 2007 in Class 3 wind resources (average wind speeds of 5.3 m/s at 10-m height), the same level that is currently achievable in Class 5 winds (average wind speeds of 6.2 m/s at 10-m height)

- By 2012, complete program activities addressing electric power market rules, interconnection impacts, operating strategies, and system planning needed for wind energy to compete without disadvantage to serve the Nation’s energy needs
- By 2010, facilitate the installation of at least 100 MW of wind energy in 30 states.

To achieve these goals, the Program is focusing its efforts in two areas; technology viability and deployment.

To increase technology viability, the Program is working with industry to lower the cost of energy produced by utility-scale wind systems that can be deployed in less energetic, Class 4 wind regimes (average wind speeds of 5.8 m/s at 10-m height) and to develop cost-effective, small distributed wind



systems. The Program's strategy is to reduce the cost of wind energy incrementally by analyzing each component of the wind system to characterize and capitalize on technology improvement opportunities. Examples of technology improvement opportunities include: advanced control systems to improve performance and reduce loads; advanced drivetrains that incorporate rare-earth permanent magnets; advanced power electronics to allow variable-speed operation, and taller, self-erecting towers constructed on site using advanced materials.

To increase the deployment of wind energy in the emerging marketplace, the Program is working to resolve many non-technical barriers and to facilitate the installation of wind systems by providing supporting research in power systems integration, technology acceptance, systems engineering, communication, and analytical support.

By including near-term and long-term research in both viability and deployment areas, the Program provides a balance between the need to work with industry to solve pressing short-term technological issues and the need to maintain U.S. industry momentum as a technological innovator.

### 3.0 MARKET DEVELOPMENT AND STIMULATION

Industry experts predict that 2005 will be a record-breaking year for new wind power installations in the United States as a result of the extension of the Federal Production Tax Credit (PTC) in October 2004. The PTC, enacted in 1992 and extended through December 31, 2005, provides a 0.018 USD/kWh credit (adjusted periodically for inflation) for electricity produced from a wind farm during the first 10 years of its operation.

As part of an effort to increase development of renewable energy on Federal lands, the Bureau of Land Management released its draft Programmatic Environmental Impact Statement designed to ease the permitting of wind projects. The statement aims to speed up the environmental reviews needed to develop a wind project on Federal land.

In addition to the Federal incentives, there are several incentive programs on the state level. State programs that support utility-scale wind energy development include renewable energy purchase mandates, renewable energy funds, green power markets, tax incentives and utility resource planning. Of all the state incentives, renewable energy purchase mandates will likely have the largest impact on wind development.

**Renewable Energy Purchase Mandates** – Renewable energy purchase mandates include traditional set-asides directed at individual utilities in a regulated setting and renewables portfolio standards (RPS) that require all retail suppliers to serve a minimum portion of their load with eligible renewable energy. Set-asides and RPS policies are attractive in some states, because they create a strong demand for wind-generated electricity, offer incentives for wind power cost minimization through a competitive process, and can be used in regulated and restructured market settings. In 2004, five states added RPS policies, bringing the total number of states with RPS or mandates to 18. Approximately 2,000 MW of wind power has been supported by these policies to date, and far greater additions are expected in the coming years.

**Renewable Energy Funds** – Most often funded through system-benefits charges (a small surcharge on electricity rates), state renewable energy funds provide significant support for utility-scale wind development. Present in 15 states, these funds are expected to generate approximately 4 billion USD for the development of renewables from 1998 through 2012. Production incentives (USD/kWh supplemental financial payments) are the most common form of incentive employed by renewable energy funds in support of utility-scale wind power, although up-front grants, forgivable loans, and subordinated debt have also been used. By the end of 2004, 1,871 MW in capacity had been obligated with funds under these programs; of those projects, 568 MW have been installed by the close of 2004.

**Green Power Markets** – Voluntary purchases of renewable energy by end-use customers can provide a supplemental revenue stream to support the development of utility-scale wind energy facilities. In

2003, approximately 1.3 billion kWh of green power was sold to retail customers and, by the end of 2004, about 15% of the utilities offered green power to customers in 34 states. Green power programs in the United States had supported the installation of more than 1,500 MW of new wind projects.

**Tax Incentives** – In addition to Federal tax incentives, some states offer supplemental state tax advantages to wind projects. These efforts provide an additional, typically modest, stimulus for wind development.

**Utility Resource Planning** – With the Federal PTC in place, wind is often found to be one of the least-cost resources in some states. As a result, utilities are increasingly turning to wind as a cost-effective resource in their planning efforts. Twelve major utilities in the western United States, for example, are planning over 3,000 MW of wind additions by 2014 on the basis of cost effectiveness.

Many states also have policies and incentives for small wind electric systems. These incentives include net metering, investment incentives, tax incentives, and low-interest loan funds. Investment incentives and net metering are considered the most important programs.

**Investment Incentives** – Often administered by renewable energy funds, more than 10 states offer direct rebates or grants to small wind electric systems, sometimes covering over half of the installed cost of the systems. Not surprisingly, much of the activity by small wind installers is in those states with aggressive incentives of this type, including California and New York.

**Net Metering** – Net metering is an easily administered mechanism for encouraging direct customer investment in renewable energy. Under this policy, electric customers installing their own grid-connected wind turbines would be 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 with net metering, excess generation beyond what the customer uses to offset consumption during the billing period is sold to the utility at

avoided cost or granted back to the utility without payment to the customer. As of September 2004, 41 of the 52 states offered some form of net metering policy.

## 4.0 DEPLOYMENT

In 2004, U.S. wind energy capacity increased by 359 MW bringing the total U.S. net capacity to 6,740 MW. In all, 389 MW were installed, 30 MW were decommissioned for a total net generation of 359 MW. The rate of growth for 2004 was considerably lower than for previous years due to a delay in the extension of the Federal PTC. Although wind energy growth slowed in 2004, with the extension of the PTC in October 2004, industry experts are predicting that 2005 will be a record-breaking year for new wind energy installations.

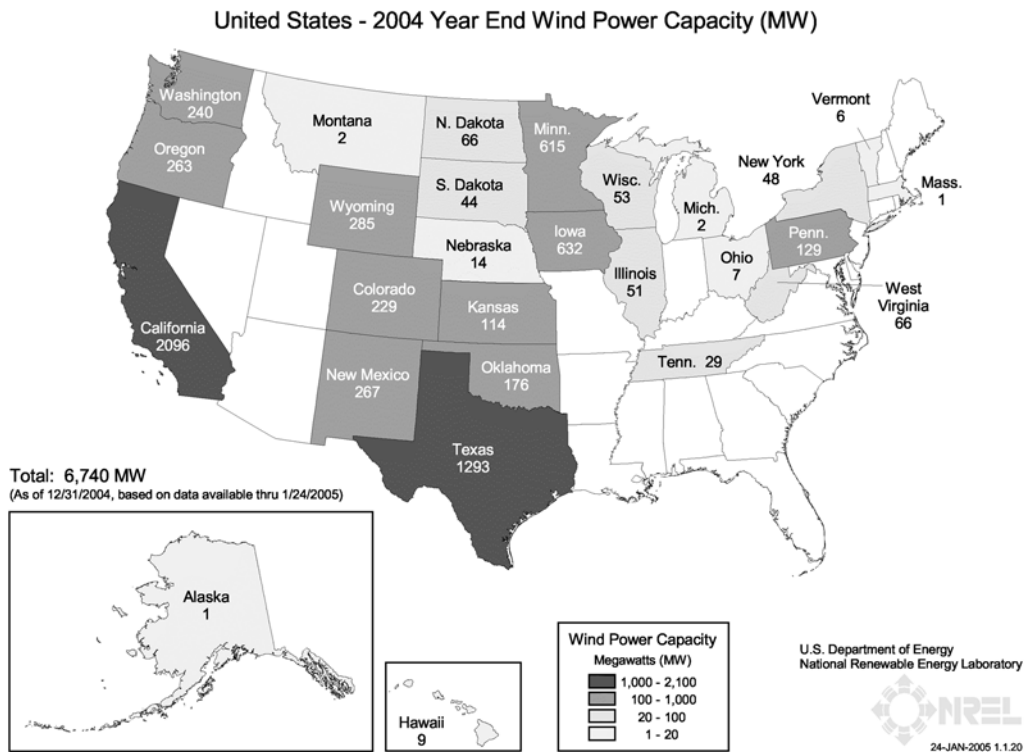
Twenty-five new wind projects and 326 turbines were commissioned in 2004. The new capacity was constructed in 9 states: 161 MW in Iowa, 92 MW in California, 60 MW in New Mexico, 39 MW in Minnesota, 27 MW in Tennessee, 6 MW in Colorado, 4 MW in Ohio, and 1 MW in Illinois. The average size of the turbines was 1.2 MW.

The state of California still held the record for total capacity with 2,096 MW and the state of Texas was second with 1,293 MW. Iowa took third place with 632 MW and Minnesota was fourth with 615 MW (Figure 3). Nine states had over 200 MW and 12 had over 100 MW.

The annual wind energy production for 2004, assuming a capacity factor of 35%, was 19.6 TWh – an increase of 1.2 TWh over 2003. Electricity produced by wind provided about 0.5% of the national electricity supply. Industry members believe that with advancing technologies and policy development, as much as 6% of this nation's electricity requirements could be met by wind energy by 2020.

## 5.0 DEPLOYMENT AND CONSTRAINTS

The deployment of wind energy has increased substantially in the United States during the last



**Figure 3 United States 2004 year-end wind power capacity.**

decade. Nevertheless, transmission constraints, operational policies, and a lack of understanding of the impacts of wind energy on utility grids are three of the toughest barriers facing future deployment. DOE is working to remove these barriers and furthering the deployment of wind energy by working with utilities and utility groups like the American Public Power Association, the National Rural Electric Cooperative Association, power marketing authorities, the National Wind Coordinating Committee's (NWCC) Transmission Working Group, and the Utility Wind Interest Group to identify grid integration issues and analyze transmission constraints.

Lack of sufficient transmission to meet market demand for wind energy is one of the most significant barriers facing wind energy development today. In some cases, high-quality wind resources are located far from load centers. Existing transmission

is controlled by owners of competing generation resources, usually utilities or government agencies. Because the existing transmission was built for current generation and load levels, very little excess transmission capacity is available to serve the development of wind resources.

Since the Energy Policy Act of 1992 was enacted, open access to transmission has been an issue before the Federal Energy Regulatory Commission (FERC). The open access tariffs that transmission providers have filed at FERC limit services available to wind, maintain high costs for transmission services, and include penalties that adversely affect wind economics and require unrealistic controls. These limits on service, high rate levels, and penalties can make the cost of transmission services prohibitive. FERC is working on a standard set of rules for interconnections between generators and the transmission system. Although interconnection

agreements can consume substantial time and effort, FERC is seeking to streamline the process. In December 2004, FERC hosted a conference in Denver, Colorado, titled the State of the Wind Energy in Wholesale Electric Markets. The focus of the conference was short- and long-term measures that can be taken to ensure that wind energy technology receives nondiscriminatory treatment in electric power markets.

As the wind industry continues to grow, siting issues, including interactions with wildlife, permitting processes, aesthetics, noise, and communications interference, can also present a barrier to deployment and must be addressed. In an effort to support continued wind energy industry growth in concert with wildlife preservation, DOE is working with the U.S. Fish and Wildlife Service, American Wind Energy Association (AWEA), and Bat Conservation International to address problems associated with bats and wind turbines. A two-day workshop held in Juno, Florida, in May, drew more than 20 participants including several of the world's leading bat scientists. The workshop's objectives included discussions on state-of-the-art methods and technologies for understanding bat behaviors to prevent future interaction between wind turbines and bats. In October 2004, AWEA held a Wind Power Project Siting Workshop in Portland, Oregon, to address emerging issues and ways to build local support for wind power projects, and in November, the NWCC held a workshop to assess wind turbine/bird/bat interactions and the impacts of wind energy development on wildlife habitats and land.

To assist developers in evaluating future projects, the NWCC produced a guidebook to siting issues, *Permitting of Wind Energy Facilities: A Handbook*. The guidebook is available online at <http://www.nationalwind.org/publications/siting.htm>

## 6.0 ECONOMICS

### Trends in Investment

Investment trends in 2004 changed very little from 2003. While strategic investors, like Florida Power and Light, American Electric Power, Pacific Power

Marketing, and Shell remained the principal source of capital for the industry in 2004, passive institutional investors continued to show interest in wind energy investments and there is an increasing interest in community-owned wind projects.

Passive institutional investors are not interested in being active participants in the industry. They are motivated by tax benefits and overall return and are experienced in other energy tax credit regimes. They are investing in projects developed by other companies. Examples include traditional leveraged lease investors and purchasers of tax credits, regional banks, industrial finance subsidiaries, utility finance subsidiaries, and insurance companies.

Community-owned projects provide greater economic benefits to local communities because all or a significant portion of the projects are owned by community members.

In one successful community project in Minnesota, a group of farmers formed two limited liability companies as a vehicle to pursue farmer-owned commercial wind turbines. Sixty-six investors purchased all available shares. Eighty-five percent of the shares were owned by local farmers, and the remaining 15% were made available to local townspeople. The investors had enough capital to purchase four 950-kW turbines, and the farmers signed a 15-year contract with an energy holding company.

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

Since 1980, the cost of electricity from wind systems without subsidies at excellent wind sites has been reduced from 0.80 USD/kWh (in year 2000 dollars) to between 0.04 and 0.06 USD/kWh (Figure 4). In the best wind areas, some project bids are running as low as 0.02 USD/kWh, including available tax credits. Although costs have decreased significantly, researchers believe that additional improvements could further reduce costs. The goal of the Wind Program is to decrease the current cost of electricity from large wind systems in lower wind speed areas

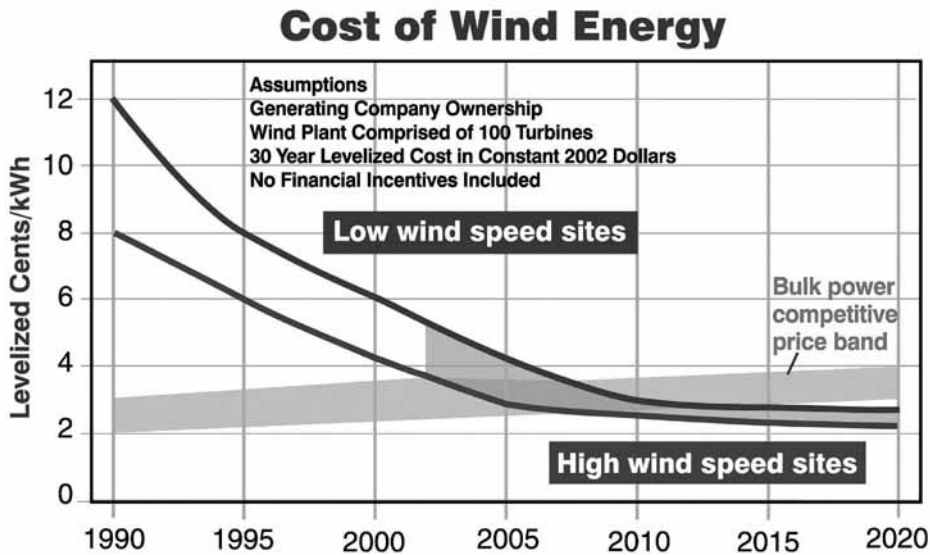


Figure 4 Cost of wind energy in the United States, 1990 to 2020.

(average wind speeds of 5.8 m/s at 10-m height) to 0.03 USD/kWh for onshore and to 0.05 USD/kWh for offshore applications by 2012. The current cost of electricity produced by small, distributed wind systems is between 0.10 and 0.15 USD/kWh in good wind resources. The program goal is to maintain that cost while increasing efficiencies so that small turbines can produce electricity cost-effectively in lower wind speed areas.

## 7.0 INDUSTRY

Several U.S. companies are currently manufacturing wind turbines, and numerous businesses are building components, developing projects, and providing engineering services and related equipment. Two companies are building wind turbines larger than 100 kW and several are building smaller turbines. Information about U.S. firms is available on the AWEA web site at [www.awea.org](http://www.awea.org).

For the last couple of years, the U.S. wind turbine market has been dominated by GE Energy's 1.5-MW machine. Of the 389 MW installed in 2004, GE Energy provided 171 MW, Mitsubishi provided 120 MW, and Vestas provided 97 MW. One installation of an Atlantic Orient turbine and remanufactured turbines account

for the remaining 1 MW of installed capacity in 2004. Most wind energy project developers only completed one project in 2004, so their rankings depend on the size of their project. Clipper Wind was responsible for the largest project built in 2004, the 159-MW Intrepid Wind Energy project. Cielo Wind Power and enXco each developed a 60-MW project, in New Mexico and California respectively. Invenergy entered the wind energy development market with the installation of the 27-MW Buffalo Mountain project for Tennessee Valley Authority. FPL Energy installed a 20-MW repower project in California.

While the component manufacturers and supporting industries are too numerous to list, there were several significant developments in 2004. Second Wind, Inc. introduced satellite connectivity for its Nomad 2 wind resource data logger. Nomad 2 loggers can provide customers with convenient, cost-effective access to wind data from remote locations without connection to cellular or landline phone systems. The wind measurement system can be installed literally anywhere in the world and still be able to transmit the data from the site back to the office on a daily basis.

Global Energy Systems, a new company headquartered in Stevens Point, Wisconsin,

announced plans to build and operate North America's first fully automated facility for manufacturing utility-scale wind turbine components, including towers. The company plans to produce more than 200 towers per year that range from 64 to 91 meters in height.

Spanish-based wind energy company Gamesa Corporation announced its plans to open an advanced technology manufacturing facility for wind turbine blades in Pennsylvania. The company also negotiated 400 MW of new power purchase agreements with Pennsylvania utilities for projects that it is developing in the state. As many as 1,000 jobs are expected to be created that will be directly related to Gamesa's activities over the next 5 years.

Chicago Bridge & Iron's steel-fabrication plant in Provo, Utah, announced that it would be adding 60 workers and investing more than one million USD in expanding its capacity to fill a contract for 150 80-m towers for 1.5-MW wind turbines.

Zoltek Companies, Inc. announced an agreement to supply Vestas Wind Systems of Denmark with carbon fiber and carbon fiber materials worth between 80 to 100 million USD over a period of three years for the manufacture of rotor blades for wind turbine generators. To meet the demand for carbon fibers for wind energy and other commercial applications, Zoltek is planning to expand its facilities in Abilene, Texas, and in Hungary.

### 8.0 GOVERNMENT-SPONSORED R,D&D

The bulk of U.S. wind energy research and development is conducted by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. The total funding dedicated to wind energy research in fiscal year 2004 was 39.8 million USD. The Wind Program focuses its research in two areas: technology viability and deployment.

Under technology viability, researchers work with industry to increase efficiencies and reduce the cost of energy for both utility-scale and small, distributed wind systems for low wind speed regions. Industry partnerships are formed through the award of cost-

shared technology development subcontracts. These subcontracts concentrate on three technical areas: (1) concept design studies, (2) component development and testing, and (3) full turbine prototype development and testing. The funding provided by the program enables industry to develop high-risk, advanced wind technology that they would not be able to fund on their own and explore the effects of increased turbine size on performance and cost.

Under technology deployment, researchers are assisting industry partners with a number of projects to increase utilities' understanding of grid-integration issues and to help them gain confidence in the reliability of new wind turbine products. Information from the projects is distributed through a national outreach effort to investor-owned utilities, electric cooperatives, public power organizations, and energy regulators to encourage the inclusion of wind power in generation portfolios and ensure the continued growth of the wind energy industry.

### Technology Viability

#### TURBINE PROTOTYPE RD&D

In 2004, DOE researchers continued to work with two companies to increase the viability of utility-scale technologies through turbine prototype development and testing; GE Wind Energy and Clipper Windpower.

Clipper Windpower completed the fabrication of most of the components for its 2.5-MW Liberty prototype turbine. The prototype incorporates a distributed drivetrain, advanced blades with truncated root section airfoils, and advanced controls. The National Renewable Energy Laboratory (NREL) completed dynamometer testing on the new drivetrain and the company will begin construction on a site for its new turbine in Wyoming in 2005. Clipper plans to begin field tests on the prototype in 2005, including a full suite of certification tests. A Clipper 45-m blade for this turbine will also undergo fatigue testing at the National Wind Technology Center (NWTC).

GE Wind Energy completed a design conceptualization for a 3- to 5-MW prototype turbine that includes advanced controls and diagnostic systems, an



innovative drivetrain, blades that incorporate advanced materials and load alleviation, and a taller tower.

DOE also worked with several companies to develop more efficient distributed wind prototypes. Bergey Windpower has developed a 50-kW turbine, Northern Power Systems is developing a 100-kW turbine, and Southwest Windpower completed the design and fabrication of a 1.8-kW prototype.

Northern Power Systems began work on redesigning its 100-kW cold weather turbine for agricultural applications. The company's goal is to reduce the cost of energy from its new design from 0.12 USD/kWh to 0.08 USD/kWh at low wind speed sites by increasing energy capture, reducing initial capital costs, increasing reliability, and lowering maintenance costs. The design will incorporate a larger 20-m rotor, a direct-drive, variable-speed drivetrain, and its controller and power converter will be located in its nacelle.



**Figure 5** The Southwest Windpower Storm prototype turbine was installed at NREL in December 2004 for field-testing.

Southwest Windpower completed the fabrication of its 1.8-kW Storm prototype turbine in 2004 (Figure 5). The goals for this project included reducing the cost of energy to 0.10 USD/kWh at sites with 5.4 m/s average annual wind speeds, and reducing the installation cost to 3,500 USD. Initial findings indicate that the project will meet or exceed its goals. The new system was installed at NREL in December 2004 and will be tested to IEC standards for acoustics, power, duration, and safety in 2005.

Abundant Renewable Energy and Wetzel Engineering are both working on preliminary design concepts for small wind turbine systems. Abundant's goal is to develop a design for a 10-kW turbine that will produce 100 kWh per day on average for 0.11 USD/kWh at a site with moderate wind resources. The company completed its conceptual design in June 2004 and expects to have its preliminary design ready for review by April 2005. The goal of the Wetzel Engineering project is to design a 6-kW turbine that can produce electricity for 0.08 USD/kWh at a Class 3 wind site (average wind speeds of 5.8 m/s at 10-m height). The company is working to have its preliminary design ready for review by March 2005.

#### ADVANCED COMPONENT DEVELOPMENTS

To increase technical viability, DOE also worked with several companies in 2004 to develop more efficient, advanced components for both utility-scale and distributed wind systems. These include new lighter weight, high-efficiency drivetrains, power converters, and rotors.

Three of the companies working under the Wind Program are developing new lower cost utility-scale drivetrains that have either completed or will undergo testing at NREL's dynamometer test facility. NREL's 2.5-MW dynamometer conducts specialized tests such as gear tooth contact pattern tests, system endurance/fatigue tests, component efficiency tests, generator/power system characterization, advanced lubrication and wear studies, load mitigation testing, wind turbine control simulations, and transient operation. Dynamometer testing services are provided



**Figure 6** Robert Thresher, director of the National Wind Technology Center at NREL, and the Clipper Windpower 2.5-MW drivetrain at the facility's dynamometer test stand.

at the request of industry partners and are an integral part of the Program's low wind speed development activities.

NREL completed the testing on a 1.5-MW, eight-generator, variable-speed drivetrain for Clipper Windpower. Clipper's goal is to produce a drivetrain that is 30% lighter weight and potentially more efficient than conventional drivetrains. (Figure 6)

One of the systems to be tested at NREL in 2005 was constructed by Northern Power Systems. The company completed the design, fabrication, and factory testing of a new 1.5-MW direct-drive permanent-magnet generator with a novel power converter to allow variable-speed operation in 2004. The goal of this drivetrain project is a 2% reduction in the cost of energy. Another system to be tested at NREL, constructed by Global Energy Concepts (GEC), is a 1.5-MW, single-stage drive, permanent-magnet drivetrain. The goal of this project is to reduce the cost of production by 12.8%. GEC completed the

design, fabrication, and testing of its drivetrain in 2004.

Wind Program researchers are also conducting research that will lead to improved energy capture by wind turbine blades and to lower the cost of blade manufacturing. In 2004, DOE worked with GE Wind to produce a glass-carbon hybrid demonstration blade that will be tested at NREL's upgraded blade test facility in 2005. The 34-m blade is constructed of advanced, lighter weight glass/carbon hybrid materials. Researchers at the DOE Sandia National Laboratories have been working in cooperation with U.S. universities for several years to develop the hybrid lighter-weight materials, aeroelastic designs, and innovative manufacturing processes needed to produce the longer stiffer blades for the larger wind turbines.

While Sandia is developing the materials needed to manufacture the longer blades, NREL is developing ways to test them. In 2004, NREL tested the longest



blade in the facility's history for TPI Composites. The 45-m blade (Figure 7) was 13 feet longer than the facility was designed to handle. To meet the needs of the longer blades, NREL plans to build a 50-m blade test stand in 2005.

The Wind Program is also working with several companies to develop more efficient components for small wind systems. GEC is working on a concept study to develop a blade flap coupling software tool to control loads. Another company, TIAX, LLC, is working on a concept for an axial-flow, permanent-magnet alternator, and Alaska Applied Sciences is designing a 14-m blade to replace worn blades on some of the older turbines on wind farms in California. Another firm, Windward Engineering, is designing a unique over-speed control system. Although most small wind systems manufactured today have passive controls that allow the turbines to shut themselves down in adverse conditions, the systems do not provide consumers with manual stopping capabilities. Windward's active control system will allow the owner/operator to shut the system down under all conditions. The company also plans to build a wind turbine on which to test the new control system in 2005.

## Technology Deployment

In an effort to increase deployment, DOE researchers are working with project operators, utilities, and rural electric cooperatives to collect high-speed power data from a number of operating wind power plants with a total capacity of almost 950 MW. The power measurements are needed to characterize the actual performance of wind farms, evaluate the interconnection and grid operational impacts of existing and proposed wind farms, and develop and validate wind generator and wind farm electrical models used for interconnection studies. In May, a Wind Integration and Interconnection Workshop provided detailed information on analysis methods used in operating impact studies, capacity credit valuations, interconnection issues, and worldwide grid code efforts to more than 160 participants.

DOE is also collaborating with five states to measure wind resources at levels above normal measurements (50 meters above ground level) under its Tall Towers Research Project. Researchers will collect taller tower data to validate meso-scale weather modeling and examine interaction of the "nocturnal jet" and high-hub wind turbines.



Figure 7 NREL receives a 45-m blade sent by TPI Composites for testing.

DOE's Wind Powering America (WPA) activity continues to promote the use of wind energy technologies, increase rural economic development, protect the environment, and enhance the nation's energy security. WPA provides technical support and educational outreach materials about utility-scale development and small wind electric systems to utilities, rural cooperatives, federal property managers, rural landowners, Native Americans, and the general public throughout the country.

### New RD&D Efforts

While the wind industry has experienced constant annual growth during the past decade, to achieve program and industry goals and enable the technology to achieve its full potential, researchers at NREL are exploring innovative applications. These innovations include exploring development offshore

in deep water, the use of wind power to clean and move water, and development of new technologies that will enable wind energy to work in synergy with other energy technologies such as hydropower and hydrogen.

### OFFSHORE DEVELOPMENT

Higher quality wind resources (reduced turbulence and increased wind speed), proximity to loads (many demand centers are near the coast), increased transmission options, potential for reducing land use and aesthetic concerns, and ease of transportation and installation are a few of the advantages drawing attention to offshore wind energy development. In the U.S. onshore markets, where electric transmission capacity is limited, the development of offshore wind would reduce the burden of supplying electricity to coastal cities from the inland transmission system.

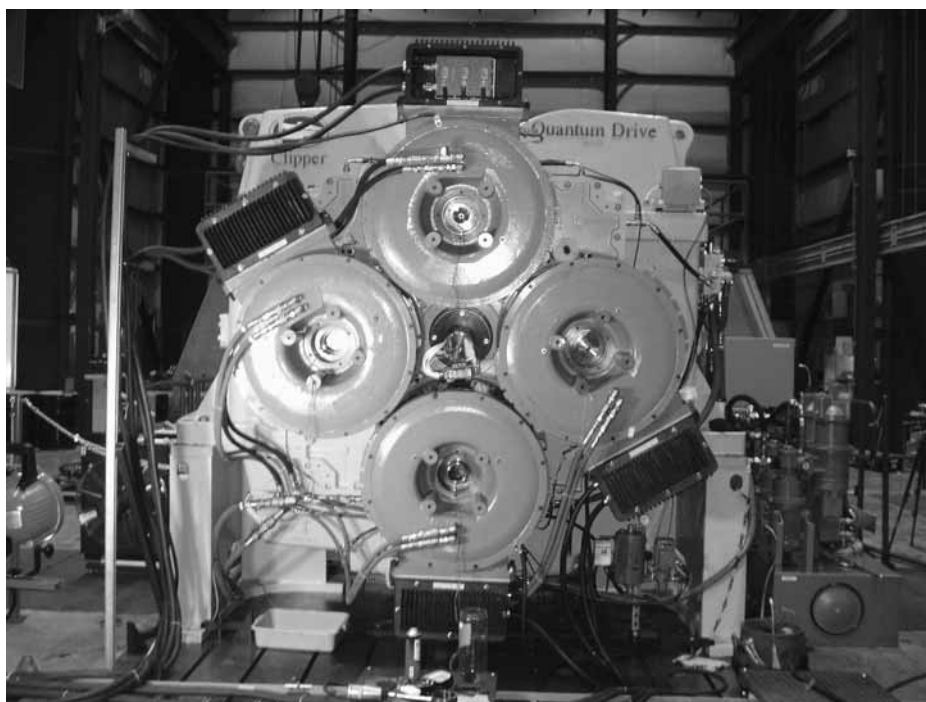


Figure 8 Clipper Windpower's new 2.5-MW turbine incorporates an innovative distributed drivetrain.

Although the United States currently has no offshore wind installations, interest is increasing and there are several proposed applications for offshore projects along the East Coast. One project proposal for a wind farm off the coast of Massachusetts released its environmental impact statement in November 2004 and is currently receiving public comments.

To develop offshore wind resources, especially in deep water areas, U.S. researchers are turning their attention to developing technologies such as the use of floating platforms cabled to the ocean floor as well as technologies that will overcome the challenges facing offshore development (Figure 9). These challenges include: higher investment and development costs, severe environmental conditions, more complicated offshore construction, and higher maintenance costs.

As part of an effort to address the challenges, in March 2004, the IEA Executive Committee approved a proposal for an offshore wind energy annex. The purpose of Annex XXIII – Offshore Wind Energy Technology Development is to provide its participants with an overview of the technical and environmental challenges encountered in offshore applications and to help them understand the need for additional research. The Annex was divided into two subtasks; Subtask 1: Offshore Wind – Experience with Critical Deployment Issues, and Subtask 2: Offshore Wind – Technical Research. Subtask 1, to be led by Risø

National Laboratory in Denmark, will address critical deployment issues for developments closer to shore. Subtask 2, to be led by NREL in the United States, will address the research needs for deepwater development.

The Offshore Wind Energy Technology Development annex held its first meeting in October 2004 in Washington, D.C. Meeting participants included the United States, the United Kingdom, Japan, and Norway and the collaborative research topic discussed was Coupled Turbine/Substructure Dynamic Modeling.

#### WIND AND HYDROPOWER

The United States is also conducting research into the potential benefits of combining wind and hydropower to provide a stable supply of electricity to the grid. As part of that effort, the U.S. participated in the formation of the IEA RD&D Wind Annex XXIV - Integration of Wind and Hydropower Systems. The two purposes of this annex are to conduct cooperative research concerning the generation, transmission, and economics of integrating wind and hydropower systems and to provide a forum for information exchange. The first meeting of this annex will take place in Nevada in February 2005.

Authors: Brian Smith and Kathleen O'Dell, NREL, United States.

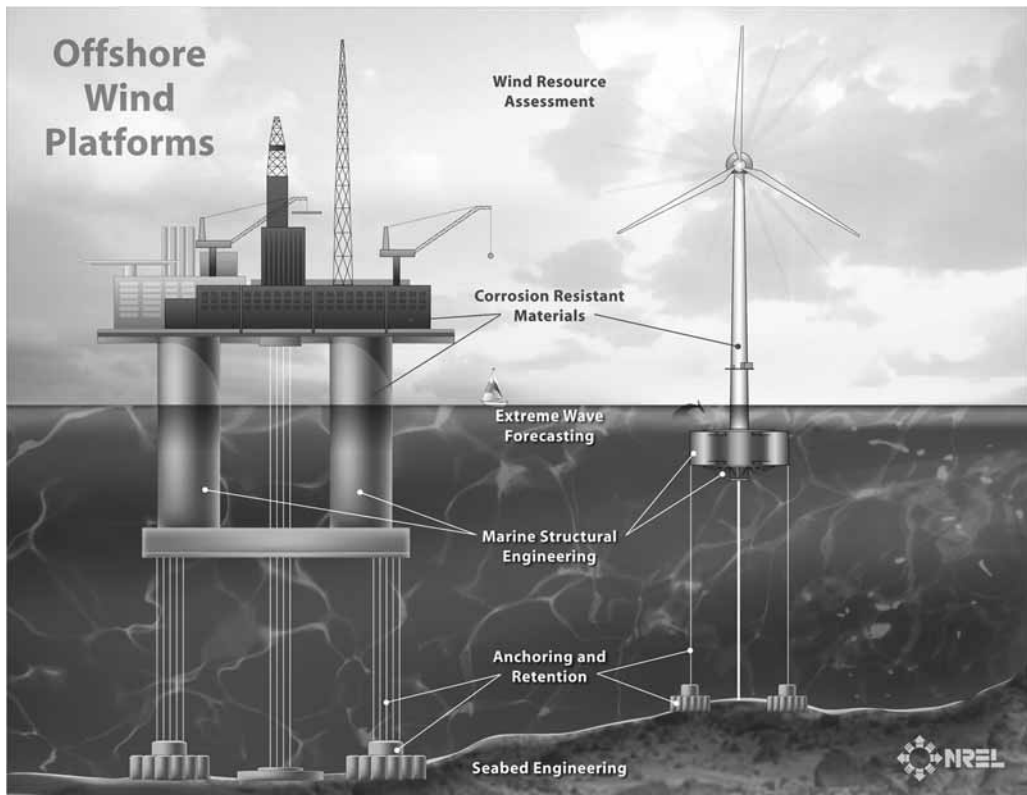


Figure 9 Researchers at NREL are turning their attention to developing technologies such as the use of floating platforms.

# APPENDIX A



Figure 1 Attendees of the 54th Executive Committee in Oulu, Finland.



# APPENDIX B

## IEA Wind Executive Committee 2004.

For current contact information, visit  
www.ieawind.org

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# APPENDIX C

Currency conversion rates used in the IEA Wind Annual Report 2004.

Country	Currency	1 Euro	1 USD
Australia	AUD	1.735	1.281
Canada	CAD	1.629	1.203
Denmark	DKK	7.439	5.494
Finland	Euro	1.000	0.739
Germany	Euro	1.000	0.739
Greece	Euro	1.000	0.739
Ireland	Euro	1.000	0.739
Italy	Euro	1.000	0.739
Japan	JPY	139.029	102.680
Mexico	MXP	15.103	11.154
Netherlands	Euro	1.000	0.739
New Zealand	NZD	1.880	1.388
Norway	NOK	8.232	6.079
Portugal	Euro	1.000	0.739
Spain	Euro	1.000	0.739
Sweden	SEK	9.742	7.195
Switzerland	CHF	1.544	1.141
United Kingdom	GBP	0.707	0.522
United States	USD	1.354	1.000
Source: Federal Reserve Bank of New York ( <a href="http://www.x-rates.com">www.x-rates.com</a> ) December 31st 2004			



# APPENDIX D

## Glossary of terms and abbreviations.

AU	Australia
AUD	Australian dollar
BE	Belgium
CEN/CENELEC	European Committee for Standardization/European Committee for Electrotechnical Standardization (the original language is French); similar to ISO/IEC
CHP	combined heating and power or cogeneration of heat and power
CIGRE	International Council on Large Electric Systems
CN	Canada
COD	Concerted action on Offshore Deployment, an EU project with participating countries Netherlands, United Kingdom, Germany, Denmark, Sweden, Ireland, Belgium, and Poland that compares and shares information on nontechnical aspects of offshore wind farms
COE	cost of energy
DE	Germany
DK	Denmark
DKK	Danish Kroner
DFIG	doubly fed induction generator
DG	distributed generation
DK	Denmark
DNV	certifying organization (Danish)
DSM	Demand-side management
EC	European Commission
EEZ	Exclusive Economic Zone
EIA	Environmental impact assessment
ES	Spain
EU	European Union
ExCo	Executive Committee of IEA Wind

## APPENDIX D

FR	France
FY	fiscal year
GEF	Global Environment Facility
GHG	greenhouse gas
GR	Greece
GW	gigawatts
GWh	gigawatt hour
HAWT	horizontal axis wind turbine
hydro	hydroelectric power
IEA	International Energy Agency
IEC	International Electro-Technical Commission
IEEE	Institute of Electrical and Electronics Engineers
IPP	independent power producer
IRL	Ireland
ISO	international standards organization
IT	information technology; Italy
kW	kilowatt
kWh	kilowatt hour
£	United Kingdom pound
m	meter
m a.g.	meters above ground
Mtoe	million tonnes of oil equivalent
MW	megawatt
MWh	megawatt hour
m/s	meters per second
NA	not applicable
NEDO	New Energy and Industrial Technology Development Organization
NGO	non-governmental organizations
NL	the Netherlands
NO	Norway
O&M	operations and maintenance

PO	Portugal
pdf	portable document format
PJ	peta joule
PSO	Public Service Obligation
PV	photovoltaics or solar cells
R&D	research and development
R, D&D	research, development, and deployment
RE	renewable energy
RES	renewable energy systems
repowering	taking down old turbines at a site and installing newer ones with more generating capacity
RO	Romania
RPS	renewables portfolio standard
S.A.	Sociedad Anonyma
SW	Sweden
SZ	Switzerland
tCO <sub>2</sub> -e per capita	tonnes of carbon dioxide emissions per person
TNO	transmission network operator
TSO	transmission system operators
TW	terawatt
TWh	terawatt hour
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
U.S.	United States
USD	U.S. dollar
VAWT	vertical axis wind turbine
wind index	describes the energy in the wind for the year, compared with a normal year
WT	wind turbine
yr	year

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