iea wind

2009 SMALL WIND ANNUAL REPORT

International Energy Agency

*The IEA Wind agreement, also known as the Implementing Agreement for Co-operation in the Research, Development, and Deployment of Wind Energy Systems, functions within a framework created by the International Energy Agency (IEA). Views, findings, and publications of IEA Wind do not necessarily represent the views or policies of the IEA Secretariat or of all its individual member countries.

1. SUMMARY

In 2009, a new activity was launched under the International Energy Agency Wind Implementing Agreement (IEA Wind) for the small wind sector. The main focus of this activity, called Task 27, is to develop recommended practices for consumer labeling of existing commercial small wind turbines. Participants will also exchange information about the status of the small wind industry in the member countries.

This report outlines the status of the small wind sector in 2009 in the countries participating in Task 27. (For more information about IEA Wind and the consumer label developed under Task 27, see www.ieawind.org.)

Seven countries submitted a report to this first international Small Wind Turbine (SWT) Annual Report for 2009: Australia, Japan (only general data), the Republic of Korea, Spain, Sweden, the United Kingdom, and the United States of America. Small wind turbines with a rated capacity of up to 100 kW were included in this report.

Table 1.1. **2009 Small Wind Turbine National Statistics from the IEA Wind Task 27 Member Countries**

Country	Cumulative installed wind capacity	2009 Yearly estimated energy production	Units installed during 2009 less than 1 kW		Units installed during 2009 from 1 kW to 10 kW		Units installed during 2009 greater than 10 kW and up to 65 kW	Units installed during 2009 greater than 65 kW and up to 100 kW
			Off-grid	Grid-tie	Off-grid	Grid-tie	Grid-tie	Grid-tie
	MW	MWh/year	nº	nº	nº	nº	nº	nº
Australia	**0.2**	**325**	**(57*)**				**-**	**-**
Japan	**5.9**	**4,260**	**1,230**	**3**	**696**	**118**	**7**	**0**
Korea	**1.04**	**1,367**	**-**	**-**	**-**	**11**	**-**	**-**
Spain	**7.02**		**92**		**182**	**-**	**3**	**-**
Sweden	**1.7**	**2,100**	**6**	**4**	**6**	**64**	**19**	**-**
United Kingdom	**28.7**	**35,800**	**2,524**	**-**	**602**	**-**	**149**	**5**
United States	**16.95**	**-**	**6,904**	**0**	**452**	**1,817**	**66**	**62**
Totals	61.51	43,852	10,756	7	1,938	2,010	244	67

* Each < 10 kW, grid-tie and off-grid combined, these numbers are not included in the totals

Note:

- Imported units are included.
- Grid-tie applications include all AC output, including wind/diesel and AC microgrids.
- Off-grid applications include all DC output, including battery charging and water pumping.

Australia Remarks

These estimated figures were based on the number of renewable energy certificates (RECs) created for each turbine installation. The Australian government supports renewable energy deployment through the Renewable Energy Target (RET) program The RET guarantees a market for additional renewable energy generation, using a mechanism of tradable RECs.

The Office of the Renewable Energy Regulator (ORER) oversees the RET scheme and makes available information about the RECs through an Internet-based registry system. This includes RECs created by small generating units (SGUs) such as small wind turbines. ORER defines a small wind turbine as having an installed capacity of no more than 10 kW and an annual electricity output less than 25 megawatt-hours (MWh). ORER define a formula to calculate the number of RECs accredited to a small wind turbine:

Equation 1:

$$Annual\,number\,of\;eligible\;RECs = 0.00095 * rated\;power(kW) * resource\,availability(hrs/year)$$

Where the rated power of the system is provided by the turbine manufacturer and the resource availability is determined by the number of hours the system can operate at the system's rated capacity.

Using the above formula, the cumulative 2009 SWT installed capacity and estimated energy production were estimated and are shown in Table 1.1. A number of assumptions were used in this estimation:

- RECs are claimed for a 5-year "deeming period" in advance when the SWT is installed.
- A default value for the resource availability of 2,000 hours is provided for the owner (in the absence of monitored data). These default data have been used and correspond to a capacity factor of around 22% for an SWT installation.
- The average operational time for turbines installed in 2009 was 6 months.

Spain Remarks

The Institute for Diversification and Saving of Energy (IDAE) supplied the figures in the tables above. IDAE is a state-owned business entity that reports to the Spanish Ministry of Industry, Tourism, and Trade**.**

IDAE's mission is to coordinate and manage the measures and funds destined for energy saving and efficiency strategy and renewable energy plans. In conjunction with the autonomous regions, the IDAE works to increase public knowledge and awareness, provide technical advice, and manage and finance example technology innovation projects with the potential for replication.

Most of the small wind turbines subsidies (grid-isolated small wind turbines up to 5 kW maximum) already installed in Spain were supported by capital, and the average subsidy should be around 30% of the eligible investment.

Sweden Remarks

These figures are approximate.

Table 1.2. **Estimated 2009 Average Small Wind Turbine Cost**

Country	Average cost for grid-tie applications (€/kW)	Average cost for off-grid applications (€/kW)
Spain	3,900	2,300
United Kingdom	3,500	1,700

Note:

- Imported units are included.
- Grid-tie applications include all AC output, including wind/diesel and AC microgrids.
- Off-grid applications include all DC output, including battery charging and water pumping (but the costs for battery or pump or PV panels in case hybrid wind/PV are not included).

Table 1.3. **Types of Incentive Programs in 2009**

Program type	National	Regional	Description
Enhanced feed-in tariff	***Korea***	***Australia*** (NSW, ACT {gross}; WA, VIC, {net}), ***United States***	An explicit monetary reward is provided for wind-generated electricity, paid (usually by the electricity utility) at a rate per kilowatt-hour somewhat higher than the retail electricity rates paid by the customer
Capital subsidies	***Korea, Spain, United Kingdom***	***Sweden*** (Västra Götalands län), ***United States***	Direct financial subsidies aimed at tackling the up-front cost barrier, either for specific equipment or total installed wind system cost
Green electricity schemes		***Australia*** (all states and territories), ***United States***	Allows customers to purchase green electricity based on renewable energy from the electricity utility, usually at a premium price
Wind-specific green electricity schemes		***Australia*** (all states and territories), ***United States***	Allows customers to purchase green electricity from wind plants from the electricity utility, usually at a premium price
Renewable portfolio standards (RPS) or renewables production obligation (RPO)	***United Kingdom***	***United States***	A mandated requirement that the electricity utility (often the electricity retailer) source a portion of its electricity supplies from renewable energies
Wind requirement in RPS		***United States***	A mandated requirement that a portion of the RPS be met by wind electricity supplies (often called a set-aside)
Investment funds for wind energy		***Australia***	Share offerings in private wind investment funds plus other schemes that focus on wealth creation and business success using wind energy as a vehicle to achieve these ends
Income tax credits	***Korea***	***United States***	Allows some or all wind installation expenses to be deducted from taxable income streams

Program type	National	Regional	Description
Net metering		***Australia*** (WA, SA, NT, QLD, VIC, Tas), ***United States***	The system owner receives retail value for any excess electricity fed into the grid, as recorded by a bi-directional electricity meter and netted over the billing period
Net billing		***Australia*** (NSW, ACT {gross}), ***United States***	The electricity removed from the grid and the electricity fed into the grid are tracked separately, and the electricity fed into the grid is valued at a given price
Commercial bank activities		***Australia*** (example: Generation Green Loan from Bendigo Bank in Victoria)	Includes activities such as preferential home mortgage terms for houses, including wind systems and preferential green loans for the installation of wind systems
Electricity utility activities		***Australia*** (green electricity schemes available in all States and Territories), ***United States***	Includes green power schemes allowing customers to purchase green electricity, wind farms, various wind generation ownership and financing options with select customers, and wind electricity power purchase models
Sustainable building requirements	***Korea***	***United Kingdom***	Includes requirements on new building developments (residential and commercial) to generate electricity from renewable, including wind microgeneration
Special planning activities			Areas of national interest set aside for considering wind energy development

2. AUSTRALIA

2.1 Implementation

2.1.2 Industry Status

SOMA Power Pty Ltd. is Australia's only fully commercial small wind turbine manufacturer. SOMA has manufactured turbines up to 1 kW in capacity for more than 30 years (see Fig. 2.1.).

Figure 2.1. SOMA 1-kW turbine (Source: http://www.somapower.com.au)

A few other manufacturers with demonstrated technology are in the final stages of product commercialization, including:

1) Aerogenesis Wind Power

A 5-kW unit was developed from R&D at the University of Newcastle in New South Wales (see Fig. 2.2).

Figure 2.2. The 5-kW Aerogenesis turbine (Source: http://www.aerogenesis.com.au)

2) Windpods

Fig. 2.3 shows an example of a Windpods unit. These units are designed for onsite generation in urban environments and are available on a large, commercial scale rather than a household scale.

Figure 2.3. The 1-kW Windpods unit (Source: http://www.windpods.com/index.html)

3) EcoWhisper Turbines

A commercial 20-kW prototype (see Fig. 2.4.) is currently being tested, and the company plans to develop a 10-kW prototype.

Figure 2.4. The 20-kW EcoWhisper machine (Source: http://www.ecowhisper.com.au/main/page_home.html)

4) Altaus Pty Ltd

Altaus has a 1-kW vertical-axis wind turbine (VAWT) in pre-production and is developing a 20-kW unit (see Fig. 2.5).

Figure 2.5. Wind tunnel testing of a 20-kW Altaus prototype (Source: http://www.bendigoadvertiser.com.au/news/local/news/general/backyard-generation-gets-grant/1596537.aspx, main Web site: http://www.altaus.com.au/)

It is estimated that there are approximately 10 to 15 other SWTs in various stages of research and development across Australia.

2.2 Incentive Programs

In 2009, the Australian federal government significantly changed small wind incentives. Prior to June 2009, small wind incentives were only available for off-grid installations (at least 1 kilometer from the main electricity grid) or installations at schools. The mechanism for off-grid installations was provided by the Remote Renewable Power Grants Program (RRPGP), which provided up to 50% of the capital cost of the renewable generating equipment. For a wind installation, this included the wind turbine, tower, controller, dump load, cabling, and circuit protection. By June 2009, the RRPGP program ended in most Australian states with the exception of Western Australia, where the program continued until December 2009. The mechanism for school installations is the National Solar Schools Program, which provides grants of up to $50,000 (up to $100,000 for eligible multi-campus schools) to eligible primary and secondary schools to install solar and other renewable power systems, including small wind turbines. The National Solar Schools Program continues, with $51 million in funding available to schools in the 2010-11 funding round.

On July 9, 2009, the Australian federal government introduced the Solar Credits Program, which provides support to households, businesses, and community groups that plan to install small-scale solar PV, wind, and hydro systems. This support takes the form of a multiplication of the number of RECs able to be created for eligible installations; thus additional RECs or "solar credits" are created for an installation. For the period beginning June 9, 2009 and ending June 30, 2011, the first 1.5 kW of a small wind generation unit is eligible for five times the number of RECs, as calculated from Equation 1 in the summary section above (the RECs attributed to the power output in excess of 1.5 kW are calculated using Equation 1 with no multiplier). Owners of small-scale renewable systems typically would receive a discount on the system or cash payment is return for solar credits.

At a state and territory levels, feed-in-tariffs (FITs) provide incentives for grid-connected renewable energy systems. The state of New South Wales (NSW) and the Australian Capital Territory (ACT) have **gross** FITs, whereas the states of Western Australia, South Australia, Queensland, Victoria, and Tasmania as well as the Northern Territory have **net** FITs. The net FIT in South Australia currently excludes small wind, and the net FIT in Queensland is currently under review for eligibility criteria for small wind. There is no nationalized program of tariffs. Further information on the details of the state and territory tariffs can be found at http://www.energymatters.com.au/government-rebates/feedintariff.php

2.3 R, D, & D Activities

2.3.1 National R, D, & D Efforts

Small wind technology R&D occurs at a number of universities across Australia. Some examples include:

- University of Adelaide, South Australia: urban wind modeling
- University of Newcastle, NSW: blade manufacturing, aerodynamics
- University of Technology Sydney, NSW: generators, control
- University of Sydney, NSW: wind tunnel testing
- University of Wollongong, NSW: noise assessment
- Monash University, Victoria: small wind in developing countries

- RMIT University, Victoria: wind tunnel testing
- Curtin University, Western Australia: small wind inverter testing
- Murdoch University, Western Australia: field testing, urban wind studies.

The University of Newcastle in New South Wales and Murdoch University in Perth, Western Australia are arguably the most active in the area of small wind turbines.

2.4 Testing, Labeling, and Certification Activities

2.4.1 Available Test Centers and Facilities

In August 2008, Murdoch University was awarded a $1.05 million grant from the Federal Department of the Environment, Water, Heritage, and the Arts to establish the National Small Wind Turbine Centre (NSWTC). The new centre augments the existing wind turbine monitoring and assessment resources available at Murdoch University. The NSWTC commenced operation in December 2008 and aims to stimulate the small wind market and industry in Australia by focusing its activities in four areas: testing, standards and labeling, professional development and training, and research. The main activity of the NSWTC will be to provide independent testing services to wind turbine manufacturers, but the standards and labeling is also important to improve product quality for consumers and to simplify and harmonize standards so that manufacturers can enter export markets. Further information on the National Small Wind Turbine Centre is available at http://www.rise.org.au/research/NSWTC/

In December 2009, construction began on a new turbine testing facility in Henderson, Western Australia (see Fig. 2.6). No turbines were tested during 2009, but on February 4, 2010, a SOMA 1000 (1-kW, 5.73 m^2 swept area) system was installed at the NSWTC test site. The turbine is being tested in accordance with standards relating to power performance, acoustic performance, and durability.

Figure 2.6. Construction of the testing facility for the National Small Wind Turbine Centre

2.5 The Next Term

Figures from the ORER registry indicate significant growth in the number of SWT installations, based on the number of RECs registered in 2010. To date there have been 75 installations (of turbines less than 10 kW) in 2010 compared to the 57 installations in 2009. The size of the installations is most interesting: an estimated 43 of the 75 cases are installations of 10-kW turbines, compared with only 1 recorded 10-kW installation in 2009. This indicates that owners are installing turbines up to the limit of the support under the Federal Solar Credit Scheme. State policies are also having an influence, and it is significant that all 43 of these 10-kW installations are in NSW, which is one of only two states in Australia to introduce a gross FIT. The fact that the size of the installations is growing indicates that owners are installing larger, grid-connected systems to get the most combined benefit of the solar credits and FIT.

Looking further ahead, it is likely that there will be changes to the regulations governing REC creation, and it is expected that toward the end of 2010, an endorsement of the small wind installation by the Clean Energy Council will be required in order to create Small Wind RECs.

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3. REPUBLIC OF KOREA

3.1 Overview

The cumulative installed wind power in the Republic of Korea was 304 megawatts (MW) in 2008 and 392 MW in 2009, increasing by 29% over 1 year. The Congress plans to approve an RPS proposal for new and renewable energy. The utility firms prefer wind energy, which is considered to be the most cost-effective among all renewable energy sources.

The government has begun to concentrate R&D efforts on localizing components to secure the supply chain in 2009. To provide a track record in the field for local development, a 20-MW wind farm demonstration project will be completed in 2014.

3.2 National Objectives

The installed capacity of wind turbines increased 29% in 2009. Due to the drastic increase in oil prices early in 2009, the average system marginal price of electricity was 122.63 Korean Won (KRW)/kWh (0.08€/kWh), compared to 105.04 KRW/kWh (0.07€/kWh) in 2009, which means wind energy is comparable in economics with existing liquefied natural gas sources in Korea.

3.2.1 Wind Generation Capacity

New installed capacity was 88 MW in 2009, compared with 111 MW of installed wind generation capacity in 2008 (the decrease is attributed to the financial crisis). Total electrical output was 678 gigawatt-hours (GWh) from the total installed capacity of 392 MW, and that was 0.15% of the national electric demand.

The largest wind farm completed in 2009 was the Youngyang wind farm, which is equipped with 41 Aciona 1.5-MW wind turbines and represents 61.5 MW of power capacity.

3.2.2 Urban Integration Experiences

The government encourages urban integration of wind power. In 2011, any new construction, expansion, or remodeling of public buildings larger than 1,000 square meters will be required to incorporate 10% renewable energy to meet total expected energy demands. The required ratio will be increased every year until 2020 and finally reach a 20% minimum.

3.2.3 National Targets

The national target is for wind power to reach 7.3 GW by 2030 (as stipulated in the Third National Energy Plan 2030), sharing about 12.6% among renewables. Renewable energy is expected to reach 11% of total energy consumption by 2030.

3.3 Implementation

3.3.1 Economic Impact

At the end of 2009, in addition to the existing megawatt-scale wind turbine manufacturers, more than 100 companies had entered the small wind turbine industry. This resulted in the need for wind turbine experts, and in response, the government supports the programs that train these experts. Due to the dramatic increase in the wind energy industry, the statistics on workers associated with the wind industry, including the supply chain, are unknown.

3.3.2 Industry Status

For megawatt-scale wind turbines, Daewoo Shipbuilding & Marine Engineering (DSME) acquired DeWind, and STX was taken over by Harakosan. In addition, DSME is expected to produce a prototype 2-MW wind turbine late in 2010. There are now 10 Korean manufacturers of megawatt-scale wind turbines.

Concerning small wind turbines, more than 100 companies are now engaged under the government incentive programs. A few of the companies entered the market successfully. Small wind industry requirements are for residential and urban integration with or without grid interconnection.

Figure 3.1. SAMDORIE 3-kW by SeolTech

Figure 3.2. SAMDORIE installed in Thailand

3.3.3 Operational Details

A total of 155 small wind turbines are now in operation. Among the 155 installed units, 70 units are below 1 kW, and 85 units are less than 10 kW. Eleven units were installed in 2009, and all of them are subsidized under the One Million Green Homes program.

3.3.4 Wind Energy Costs

So far, most of the wind turbines have been imported from overseas. This has created additional costs for owners due to exchange rates and logistics. Due to the short history of well-developed business models based on private capital, there are not enough statistics available to break down the costs.

3.4 Incentive Programs

The government subsidizes to encourage small wind dissemination, employment, and a favorable investment environment. The national incentive program subsidizes part of the installation costs of new and renewable energy facilities to enhance deployment and to relieve the end user’s cost burden. The government subsidizes 50% of the installation cost for wind turbines smaller than 10 kW for demonstrations or for private use.

3.5 R, D, & D Activities

3.5.1 National R, D, & D Efforts

The government will sponsor urban-integrated small wind turbine projects for 4 years, beginning in 2010, and has planned a 1.6 million € R&D budget for the project. Cost-effective small wind turbines are to be developed in cooperation with universities and industries. Social acceptance is another important issue, so emphasis will be placed on noise reduction and safety enhancement.

3.6 Testing, Labeling, and Certification Activities

3.6.1 Testing Activities

The Korea Energy Management Cooperation (KEMCO) issues certificates for small wind turbines upon completion of tests at official test centers. In 2009, three small wind turbines were tested in accordance with national standard KS C IEC 61400-2, which is equivalent to IEC 61400-2. Design reviews were not performed for all three wind turbines because only power performance tests were conducted. Only one wind turbine was domestic; the others were imported.

3.6.2 Labeling

Korea does not yet have standard procedures and regulations for labeling. However, the government recognizes the importance of a labeling system, so the Korea Institute of Energy Research (KIER) has joined with IEA Wind Task 27 to develop a recommended practice for consumer labeling in 2010.

3.6.3 Certification Program

The certification scheme has been designed to guarantee the quality of manufactured or imported systems and enhance the reliability for users, thereby expanding the deployment of new and renewable energy systems and helping create the foundation for growth. It focuses on promoting the commercialization of technologies that have already been developed and establishing the infrastructure for further deployment through performance evaluation and standardization.

The certification program also offers benefits to small wind turbine manufacturers by giving extra point for those with certifications seeking by self-governing bodies or the government competitive bids. The government subsidizes up to 80% of the certificate test cost to encourage small wind turbine manufacturers.

3.6.4 Available Test Centers and Facilities

KIER and Kangwon National University are the only official test centers in Korea. KIER has its own test fields on Jeju Island with an ISO 17021 certificate. Both centers are capable of conducting design review, power performance, acoustics, duration, and safety and function tests in accordance with international and domestic standards.

3.6.5 Resume

Table 3.1. **2009 National Progress on Testing Activities (Only Public Information)**

Turbine size	Design file submitted	Power performance	Acoustics	Duration	Safety & function	Labeling	Certification
70 W		Complete		Complete	Complete		
2.4 kW		Complete	Complete				
3 kW		In progress		In progress	In progress		

3.7 The Next Term

In 2010, an additional 300 MW of wind power will be installed, and the RPS will be enacted. Furthermore, it is highly likely that the government will support the development of offshore wind farms.

In the small wind sector in 2010, a 50% increase in test requests is expected as a result of the one million green homes program.

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4. SPAIN

4.1 Overview

The cumulative installed small wind power in Spain was 6,51 MW in 2009. According to the data from subsidized installations, only 34 small wind turbines were installed in 2009, all of them off-grid applications. The 34 installed turbines included 14 small wind turbines of 1 kW or less, 17 small wind turbines with a rated power between 1 kW and 10 kW (most of them 5 kW to 6 kW), and three small wind turbines between 10 kW and 65 kW (most of them 12 kW to 15 kW rated power).

The current situation of the commercial small wind sector in Spain should be defined as expectant. The central government is developing the new 2011-2020 renewable energy plan, in which small wind is included as a different technology from large wind, with specific power targets for every year until 2020. The door to small wind grid-connected applications will open based on 1) a new regulation to ease the grid-connection procedures, especially for wind turbines up to 10 kW, and 2) a new support scheme based on FITs, which could encourage development in this sector in the coming years.

In the industrial area, the situation is exciting because several manufacturers (IBAIA Energias renovables, SONKYO Energy, SILIKEN Wind S.L) are working on new horizontal-axis wind turbine (HAWT) designs, mainly in the rated power range from 3 kW to 7 kW but also in larger turbine designs up to 15 kW. Other manufacturers (IDM-EOL, BAI WINDS, GEOLICA) are working on new vertical-axis wind turbine (VAWT) models.

Existing manufacturers, such as BORNAY Aerogeneradores with more than 30 years experience manufacturing small wind turbines or SOLUCIONES ENERGETICAS and WINDECO with experience in small wind turbines for off-grid applications, are improving their designs especially for the new grid-connected applications.

Several manufacturers are developing small wind turbines under license, such as Carlo Gavazzi, Lakota, or Aerogeneradores Canarios ACSA (LMW).

Finally, there are many distributors of foreign wind turbines operating in Spain, like Southwest Windpower (Air Breeze, SkyStream) or Bergey (Xl1, Excell) from the United States; Proven from the UK; Fortis, Turby, or Donqi from Holland; or Ropatec from Italy.

In relation to the R&D activities, the main project is the PSE-MINIEÓLICA (2006-2010), led by CIEMAT and ROBOTIKER.

4.2 National Objectives

During 2009, the Spanish government started a draft of the Action Plan for Renewable Energy Sources 2011-2020. This plan should probably include small wind in a different section from large wind, with specific conditions for grid connection, promotion, targets, and FITs.

Until now capital subsidies for off-grid applications have been applied with very limited results because of the high level of electrification. Few grid-connected small wind turbines have been installed, and most of these are for research or demonstration purposes (universities, research centers, official buildings, etc.). These projects have poor economics because of the high investment cost and inability to receive profit from selling the energy injected into the grid.

There are only four instances of urban integration of small wind turbines in Spain. Three of them were demonstration projects based on foreign wind turbines (Turby, Ropatec, Donqi,), and one used a domestic turbine (IDM-EOL)

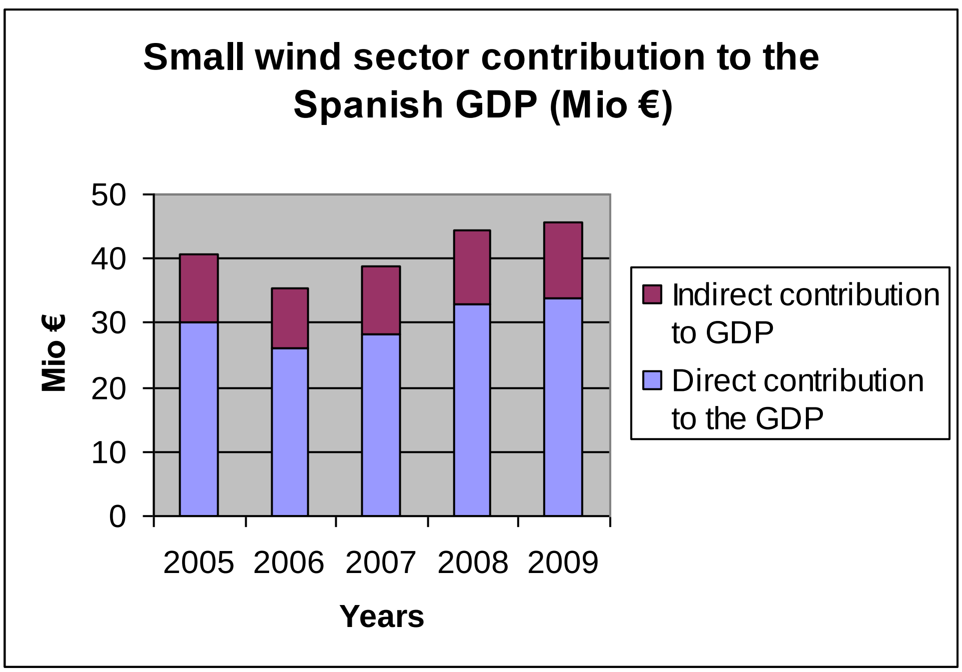
No studies have been conducted about the social acceptance of small wind in Spain, but studies about the social acceptance of wind energy in general have shown a high level of acceptance, even taking into account the great number of wind farms installed on Spanish territory. The small number of small wind installations to date in Spain and the siting (most of them are in remote locations such as farms, isolated houses, or inhabited places like telecom applications) could be the reason for this lack of social awareness about problems like noise emissions or visual impact. These issues will play an important role when new grid-connected applications, some in urban environments, are deployed.

4.3 Implementation

The small wind sector in Spain is still in an early stage of technological development, so its contribution to the GDP is based mainly on exportation of small wind turbines for isolated applications (rural electrification, telecommunications, water pumping, etc.) and R&D activities developed by the different companies for new products for grid connection (open field [HAWT] and even urban applications [HAWT and VAWT]).

4.3.1 Economic Impact

The contribution of the small wind sector to the Spanish GDP in 2009 surpassed 45.8 Mio € (33.8 Mio € in direct contribution) and 12.0 Mio € in indirect contribution [1].



Spain's great wind development experiment has produced a powerful industrial sector of manufacturers, developers, and producers. National products offer high quality for residential applications, including urban, off–grid, or grid-connected applications.

Figure 4.1. Small-wind-sector contribution to the Spanish GDP

However, because of the lack of regulations for grid-connected applications (except for small experimental facilities), most of the small wind applications in Spain are grid isolated.

4.3.2 Industry Status

In Spain, most small wind turbines are sited at rural, isolated dwellings powered by renewable energy, mainly hybrid systems utilizing solar photovoltaic and small wind. Most of these dwellings are used on weekends. There are also telecommunications power supply applications (GSM repeaters, surveillance systems, isolated cameras, emergency systems, etc). Water pumping and sea water desalinations are also very common applications.

Figure 4.2. Bornay wind turbine Inclin 6 kW

Most of the current manufacturers are handcraft based, but now manufacturers are moving to industrialization. Some of them are designing their small wind turbines for mass production to achieve lower costs following the required learning curve for this technology.

***Table 4.1.* Spanish Small Wind Turbine Manufacturers**

Manufacturer	Model	Type	Rated power (kW)
Bornay Aerogeneradores www.bornay.com	Inclin 600 Bee 800 Inclin 1500 Neo Inclin 3000 Neo Inclin 6000 Neo	HAWT (Bat) HAWT (Bat) HAWT (Bat/Grid) HAWT (Bat/Grid) HAWT (Bat/Grid)	0.6 0.8 1,5 3.0 6.0
Solenersa www.solener.co	Velter B Velter D Velter I Velter II Velter XV	HAWT (Bat) HAWT (Bat) HAWT (Bat) HAWT (Bat/Grid) HAWT (Bat/Grid)	0.3 0.5 1 2 15
Windeco www.windeco.es	Vento 5	HAWT (Bat/Grid)	5
Sonkyo Energy www.sonkyoenergy.com	Windspot 1.5 Windspot 3.5 Windspot 7.5	HAWT (Bat/Grid) HAWT (Bat/Grid) HAWT (Bat/Grid)	1.5 3.5 7.5
Siliken Wind www.siliken.com	SW 2.1 SW 2.8 SW 3.4 SW 4.1	HAWT (Bat/Grid) HAWT (Bat/Grid) HAWT (Bat/Grid) HAWT (Bat/Grid)	2.1 2.8 3.4 4.1
Zytech Aerodyne www.revolutioninthewind.com	Lakota Long Bow	HAWT (Bat) HAWT (Bat)	0.9 1.0

4.3.3 Operational Details

Spain's experience with small wind applications can be defined as successful. The size of the turbine at most small wind installations is around 1 kW. The typical capacity factor is 1,200 hours.

Figure 4.3. Windeco Vento 5 5-kW turbine

Figure 4.4. Solener Velter XV 15-kW turbine

Figure 4.5. SONKYO Windspot 3.5-kW turbine

Figure 4.6. Siliken SW 2.2 1-kW turbine

4.3.4 Wind Energy Costs

The cost of the energy produced by small wind turbines is still higher than the domestic electricity tariff (around 16 c€/kWh). Taking into account the average specific cost of 3.900 €/kW for grid-connected small wind turbines (1 kW to 3 kW) and the typical yearly average wind speed of 5m/s for these applications, the COE obtained is still at least two times over the domestic tariff. It is important to note the high sensibility of this COE with the installation cost.

4.4 Incentive Programs

A new proposal of SWT grid-connection rules is expected for the end of 2010. This new regulatory frame will establish grid-connection rules for small wind turbines up to 100 kW connected to the Low Voltage (LV) network. In this way, the technical and economical conditions for grid-connected small wind turbines will be established. Those technical conditions for small wind installations and procedures for small wind turbines up to 10 kW are starting to define interconnection requirements for small wind in Spain. Just to remark the first inclusion of small wind in the Spanish RES energy action plan with a target of 370 MW by 2020.

4.5 R, D, & D Activities

A new national R&D plan was developed in 2008, covering the period from 2008 to 2011. It is based on the national science and technology strategy instead of thematic areas as in previous calls. There are also other R&D programs promoted by the Autonomous Communities for wind energy research activity at the regional level.

The "PSE Projects" are a powerful instrument in which Strategic National Consortiums for Technological Research are led by the industrial sector in collaboration with the public and private research centers.

The most important project, called PSE-MINIEOLICA (http://minieolica.ciemat.es), is developing to promote the Spanish small wind energy sector (new developments of turbines up to 100 kW). This project involves more than six manufacturers of small wind turbines and components, three engineering companies, five public and private research centers, three universities, and three end users.

The 16 sub-projects are organized in three main areas:

- Product development supporting manufacturers to develop new products. New designs will cover market needs in the power range between 1 kW and 5 kW for urban and residential applications (innovative horizontal- and vertical-axis wind turbines) and from 20 kW to 100 kW for reliable, robust, and efficient small wind turbines for residential, industrial, and agricultural applications.

    - **SUBPROJECT 1.1:** *Development of a new 100-kW wind turbine with high availability. TURBEC*
      LEADER: DEL VALLE AGUAYO
    - **SUBPROJECT 1.2**: *Development of a 25-kW variable-speed, stall-regulated wind turbine, without a gearbox and with a predictive speed control. V25 QUATRO*
      LEADER: WINDECO-OBEKI INNOBE
    - **SUBPROJECT 1.3:** *Development of a 50-kW variable-speed, pitch-regulated wind turbine, with an asymmetric synchronous multi-pole generator. VELTER 50*
      LEADER: SOLENERSA
    - **SUBPROJECT 1.4**: *Development of a 5-kW VAWT.*
      LEADER: INDESMEDIA-EOL
    - **SUBPROJECT 1.6:** *Development of a converter for grid connection.*
      LEADER: BORNAY AEROGENERADORES

- Technical development breaking technological barriers and advancing technological development in key areas for small wind turbines.

    - **SUBPROJECT 2.1**: *Aerodynamics and structural design. New materials and manufacturing technologies for rotors and other structural elements: blades, shaft, tower, chassis. Alternative structural design. Development of design tools*.
      LEADER: INTA (National Institute for Aeronautical Technology research)
    - **SUBPROJECT 2.2:** *Development of multipurpose systems for the regulation, control, and supervision of small wind generation.*
      LEADER: TTA-TRAMA TECNO AMBIENTAL

- Infrastructure development activating and supporting the small wind turbine sector. The objectives of this area are promotion, dissemination, sensitization, and information collection for the small wind turbine sector.

    - **SUBPROJECT 3.1**: *Testing and certification of the existing small wind technology, both in isolated and grid-connected modes*.
      LEADER: CIEMAT
    - **SUBPROJECT 3.2:** *Development of the Spanish wind map, adapted for small wind use***.**
      LEADER: UNIVERSITY OF MURCIA
    - **SUBPROJECT 3.3***: Installation and demonstration of small wind measurement systems in an urban environment.*
      LEADER: LOISTESPIRAL
    - **SUBPROJECT 3.4:** *Evaluation and design of a wind energy and hydrogen demonstration project.*
      LEADER: INTA (National Institute for Aeronautical Technology research)
    - **SUBPROJECT 3.5:** *Application of a small VAWT in an urban environment.*
      LEADER: BESEL
    - **SUBPROJECT 3.6:** *Normalization, Legislation, and Characterization of Small Wind Generation*
      LEADER: CIEMAT

4.5.1 National R, D, & D Efforts

Figure 4.7. 5-kW VAWT prototype developed by INDESMEDIA EOL (PSE-MINIEÖLICA)

The Spanish government has devoted a great deal of effort to develop the small wind sector. Most of this effort is focused in the PSE-MINIEÖLICA (promotion of small wind technology in Spain) project.

Highlights of this project are:

- Duration: 4 years (from 2007 to 2010)
- Total budget funded: 6.3 Mio € (4.15 Mio€ granted, 0.3 Mio € loan and 0.061 Mio €r of refundable advance).

In general, the public budget for small wind is decreasing and the private budget is increasing.

4.5.2 Collaborative Research

During 2009, the most ambitious collaborative research was the activity developed under IEA Task 27, "*Development and Deployment of Small Wind Turbine Consumer Label,"* with more than 10 countries involved.

4.6 Testing and Certification Activities

As of 2009, Spain does not have a national SWT certification program. Existing small wind turbines are not certified against IEC standards; only the CE mark is required.

As most of the applications are off grid, no specific grid codes or requirements exist for small wind. Technically speaking, if someone desires to connect a small wind turbine to the grid, it must adhere to the requirements included in the Royal Decree 661/2007, developed for large wind farms (low-voltage ride-through solutions are required, for example).

CIEMAT is leading the testing of small wind turbines in Spain, as well as IEA Task 27, which is focused on quality labeling for small wind turbine customers.

Table 4.2. 2009 National Progress on Testing Activities (Public Information)

Size of turbine	**Design file submitted**	**Power performance**	**Acoustics**	**Duration test**	**Safety & function**	**Labeling**	**Certification**
1.5 kW/24		Complete	In progress	In progress	Complete		
3 kW/48		Complete	In progress	In progress	In progress		
5 kW/300		Complete	Complete	In progress	Complete		
5 kW/Grid		Complete	Complete	In progress	In progress		
3 kW/48		Complete	In progress	In progress	In progress		
10 kW/Grid		Complete	In progress	In progress	In progress		

4.6.1 Test and Certification Program

Some tests (power performance curve, duration test, noise emissions test, function and operation test, blade static test) are ongoing at CIEMAT test facilities funded by the Science and Innovation Ministry thought the PSE-MINIEÖLICA project. To date, eight wind turbines have been tested (Bornay aerogeneradores, Solenersa, and Windeco).

During the past years, other small wind turbines from foreign manufacturers have been tested: Zephyr 1-kW battery, Bergey Xl 48 V, Bergey Excel, Vergnet 10 kW.

4.6.2 Test Centers and Facilities

CIEMAT has specific test facilities for small wind turbines at CEDER (Centro de Desarrollo de las Energías Renovables) in Soria province, 200 km north of Madrid. At CEDER, there are four test facilities, three of them in the same test field: PEPA I (small wind turbines up to 5 kW, four sites), PEPA II (small wind turbines up to 15 kW, four sites), PEPA III (small wind turbines up to 100 kW, two sites) and a new test site in a Class 2 position (IEC 61400-2 SWT Class) in a mountain area 60 km from the main CEDER facility.

Figure 4.8. CIEMAT-CEDER SWT test facility

Besides the outdoor facilities, CEDER has a complete blade test facility (for static and dynamic tests of blades up to 11 m in length) and a test bench for small generators and gear boxes up to 7 kW.

Finally, this facility is ready for a water pumping wind systems test and complete hybrid systems test.

4.7 The Next Term

The future of small wind sector in Spain is promising. The upcoming new regulations specific for small wind will facilitate the integration of this technology as a means of electricity production in domestic, residential, commercial, and industrial areas. The government is analyzing the possibility of establishing support (FIT, net metering) to facilitate this potential new source especially for grid-tie applications and to reach the ambitious targets of the new Spanish action plan for renewable energy sources in 2011-2020.

At the same time, the quality of the small wind turbines offered in the market, as well as the installers, must be guaranteed.

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5. SWEDEN

5.1 Overview

The market for small wind turbines in Sweden is small according to 2009 figures, but the country nevertheless has a number of companies selling small wind turbines and related systems. Some of these companies focus on export (e.g., to areas of the world where there is a large need for off-grid projects). The Swedish grid has been extended to almost all parts of the country (with the help of subsidy), which of course limits the number of off-grid projects here. Activities have been suggested that could increase the Swedish market for grid-connected small wind turbines, such as net billing, but it's not clear if or when that may be implemented.

5.2 National Objectives

Sweden has no national objectives specifically for small wind turbines, but there are some related regional activities (for example, the city of Malmö is investigating small wind turbines for urban integration). The national objective for wind power in general is 30 TWh/yr by 2020, and the activities to reach that goal are focused on large wind turbines.

5.3 Implementation

5.3.1 Economic Impact

No numbers are available on the economic impact of small wind turbines in Sweden.

5.3.2 Industry Status

In Sweden, about 10 companies develop, design, or manufacture small wind turbines, and a few more develop, design, or manufacture only the electrical system for small wind turbines. Manufacturing sometimes happens in Sweden, but in other cases, component manufacturing takes place in other countries with lower labor costs. There are also a number of pure importers of small wind turbines.

Figure 5.1. Svensk Vindkraft Industri AB (SVIAB) is a veteran of the small wind turbine industry. SVIAB's 750-W rated wind turbine has been mass produced, and reference installations are still in successful operation after more than 20 years. (Photo: Sven Ruin)

The maturity of these companies and their products vary, from start-ups with a new wind turbine design to old-timers with decades of experience. Some of the companies are small, with only one or a few employees, and are not making a profit under present conditions.

5.3.3 Operational Details

Much of the electricity production in the small wind sector (up to 100 kW) in Sweden comes from old wind turbines of Danish design. It is also worth noting that the figures presented for Sweden in Table 1.1 are probably not complete, so the actual installed wind capacity, energy production, and number of installed units are probably higher.

5.3.4 Wind Energy Costs

Small wind turbines are often connected on the consumer's side of the electricity meter. A special condition in Sweden is that wind-generated electricity "sold" back to the grid under such circumstances is often not paid for by the utility (and net metering/billing is usually not used). Owners who wish to get paid for selling electricity will often face costs for changing the electricity meter, etc., which can exceed electricity sales from a small wind turbine.

5.4 Incentive Programs

Sweden has an electricity certificate system, with a goal to increase renewable electricity generation. In addition, many utilities have green power programs. However, these systems are normally not effective for promoting the smallest generators, like small wind turbines (or solar PV, which has an investment subsidy). An exception is Swedish NGO SERO's launch of a special green power program called SERO-el®, in which the power plant owner is paid well for the sold electricity and funds are created to promote environmentally sustainable projects, in particular for renewable energy. These funds may support, for example, pre-studies of small wind turbine projects.

There is also national support for technical development of wind energy, but it is aimed at large wind turbine applications.

In some cases, regional incentive programs may also be available, such as a 30% investment subsidy for small wind turbines on farms in Västra Götalands län.

Figure 5.2 Test of a 10-kW VAWT, developed by Vertical Wind in cooperation with Uppsala University for Ericsson. The wind turbine is mounted on an Ericsson Tower Tube, an innovative design that houses base stations and antennas. (Photo: Mikael Bergkvist)

5.5 R, D, & D Activities

The Swedish R, D, & D efforts related to small wind are typically carried out within the companies active in this field; e.g., to develop renewable energy solutions for telecom base stations (mainly for use in other countries, where the power grid is not as far-reaching or reliable as in Sweden). The expected benefits are often related to export. A few Swedish universities also conduct some research related to small wind turbines. The Swedish wind turbine manufacturer Vertical Wind, with products in the 10-kW to 200-kW range, is a spin-off from VAWT research at Uppsala University.

5.6 Testing, Labeling, and Certification Activities

During 2009, preparatory work took place to establish a small wind turbine testing facility on the southern part of Öland, an island in the Baltic Sea with flat terrain suitable for power curve measurements without site calibration. For many years, Chalmers University of Technology has also performed some technical tests of small wind turbines on Hönö, a small island on the west coast of Sweden.

5.7 The Next Term

During 2010, work on revised rules for grid connection and net billing are expected to take place in Sweden. The Swedish Energy Agency will support active participation in IEA Wind Task 27 regarding the development of a consumer label for small wind turbines. Experts from the country will also participate in the revision of the design standard IEC 61400-2.

Small wind turbine testing and certification is expected to begin in Sweden during 2010 through Intertek Semko AB.

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6. UNITED KINGDOM

6.1 Overview

In 2009, UK small wind systems continued to grow their contribution to national energy requirements, with overall annual energy production reaching 35.8 GWh, according to RenewableUK (previously British Wind Energy Association) Small Wind Systems UK Market Report 2010 (1). The report revealed that annual deployment of small wind turbines in 2009 surpassed previous records by almost 20%, growing to 8.64 MW. This steady growth resulted in the total installed UK capacity of 28.7 MW at the end of the year.

2009 witnessed growing interest in grid-connected applications, and small wind turbines, as opposed to micro wind turbines, are expected to continue to provide the lion's share of annual deployed capacity.

UK manufacturing market revenues stood at £17 million, with the sector providing almost 1,800 UK-based jobs. However, 2009 witnessed more small wind turbines being exported than installed in the UK. Compared with 2008 figures, UK manufacturing exports rose by 45% to £7.5 million, which provided an economic boost for the country. In addition, due to weaker pound sterling, this success translates into a 180% increase in export trade over the past 3 years.

Greater deployment of small wind systems across the UK territories has been undermined by delays in introducing the streamlined planning system through General Permitted Development Orders (GPDO). Although set to be implemented in April 2008, GPDO policy is still not implemented, which has caused many consumers to delay installing small wind turbines in the meantime.

However, with the arrival of new financial incentives in April 2010, the UK small wind systems sector is expected to grow at an unprecedented rate, delivering ever greater revenues and a significant increase in employment in this sector. RenewableUK Market Report estimates that the small wind market will grow by 181% in 2010.

6.2 National Objectives

6.2.1 Wind Generation Capacity

Progress in the development of wind energy in 2009 continued along the same growth path achieved in the 5 years that preceded it. More than 1 GW of new wind power capacity came online during 2009, 800 MW onshore and 285 MW offshore.

In addition, in 2009 Europe's largest wind farm came online at Whitlee on Eaglesham Moor in Scotland. The farm consists of 140 wind turbines delivering 322 MW of wind energy. Average onshore wind turbine size in 2009 was a record-breaking 2.1 MW.

More than 14,000 small-scale wind turbines have been installed in the UK to date. In 2009, some 3,280 turbines were deployed, delivering 8.64 MW capacity. The total installed UK small wind capacity reached 28.7 MW at the end of the year.

Throughout 2009, an average 2.5% of UK electricity was generated by wind power.

6.2.2 Urban Integration Experiences

Few comprehensive technical monitoring exercises have been performed to date to determine how the small wind turbine technology performs in the urban setting. Field trials were undertaken as part of the exercises, which provided a better indication of the realistic opportunities for installing domestic small wind turbines in the UK.

The results of these exercises revealed poorer energy performance in urban sites compared to rural settings, which was a direct result of inadequate wind resource availability. One study showed that urban building-mounted sites did not generate more than 200 kWh, corresponding to load factors of 3% or less (see Table 4). In some cases, installations were found to be net consumers of electricity due to the inverter taking its power (up to 10 W) from the main supply when a turbine was not generating (2).

6.2.3 National Targets

The UK has committed to a legally-binding EU renewable energy target to source 15% of UK's energy consumption from renewable energy sources by 2020.

Since renewable heat and fuel production in the UK are at extremely low bases, UK Renewable Energy Strategy 2009 estimates that this will require around 30% of the UK's electricity to be generated from renewable sources by 2020, including 2% from small-scale generation, such as small wind systems.

Although there are no national wind energy deployment targets, the UK's National Renewable Energy Action Plan (NREAP) estimates that onshore wind will provide the most renewable electricity capacity, at 14.89 GW, while offshore wind is estimated to deliver 12.22 GW of capacity by 2020. Furthermore, UK is committed to deliver 10% of electricity from renewable energy sources by 2010, which is also expected to be largely met by wind energy.

The Climate Change Act, which came into force in November 2008, creates a new legal framework for the UK to reduce, through domestic and international action, greenhouse gas emissions to at least 80% below 1990 levels by 2050. The Government is required to set 5-year carbon budgets, which place binding limits on greenhouse gas emissions and define the trajectory toward the 2050 target.

6.2.4 Social Acceptance

A May 2008 Department for Business, Enterprise, and Regulatory Reform (BERR) (now Department for Business Innovation and Skills, or BIS) survey of awareness and attitudes toward renewable energy discovered that public support for renewables in the UK remains high.

The survey revealed that 84% of the general public support the use of renewable energy, with 80% in favor of the use of wind power and 64% stating they would be happy to live within 5 km of a wind power development.

Findings from 42 surveys carried out between 1990 and 2002 showed that, on average, 77% of the public are in favor of wind energy and only 9% are against.

Earlier studies have also shown that public concerns about landscape change and noise diminish once the wind turbines are installed.

With regards to small wind turbines, attitude toward them are not always negatively affected by their visual appearance. Some people living within sight of the systems tend to perceive them as being noisy. The public attitude toward small wind turbines is likely to change in line with increased knowledge of the actual likely noise levels.

6.3 Implementation

Although previously expected increases in annual deployment of small wind turbines have not been realized due to delays in introducing streamlined planning policy, the UK small wind sector continued to grow its contribution to national economy in 2009, as considered below.

6.3.1 Economic Impact

Figure 6.1 Ampair 6-kW turbine

The UK small wind industry is a dominant supplier to a relatively large UK consumer market. In 2009, more than 20 UK small wind turbine manufacturers supplied three-quarters of the UK market demand, generating £17 million (€19.5 million) of revenue in 2009. This represented the small wind market expansion by 25% compared to 2008.

With weakened currency rates for the pound sterling, UK manufacturers enjoyed a 45% growth in export market revenues in 2009. The steady growth in export markets for UK manufacturers came from across the sub-20-kW range of small wind turbines, with particular increases in the sales of micro wind turbines. The gross export revenue in 2009 was £7.5 million (€8.6 million).

The number of people employed in the small wind sector in the UK was 1,755, a decrease of 7% compared to 2008. This is seen as a result of the global economic crisis and the lower-than-anticipated market growth.

Furthermore, in 2009, RenewableUK estimated the UK small wind sector to have generated a level of energy that would have emitted 22,580 tons of carbon dioxide if sourced from the national grid.

6.3.2 Industry Status

UK manufacturers produce turbines in the sub-20-kW range and currently export 60% of their production to more than 100 countries. In 2009, the EU and North America were the dominant markets for UK exports.

Besides small wind turbine manufacturing, the UK small wind industry is active in the following fields:

- Small wind testing services (UK testing companies could provide services to support testing outside the UK)
- Small wind certification services (UK certification bodies can sell their ability to certify product from non-UK origin)
- Anemometry equipment

- Site assessment services (resource estimation, related software design and leasing arrangements, related business processes)
- Turbine installation services
- Power electronic equipment (inverters, control systems)
- Electronic engineering services (system control, hardware design, performance optimization)
- Mechanical engineering services (mast design, foundation design, aerodynamic blade design, acoustic design).

Figure 6.2. Small wind turbines

With growing interest in grid-connected applications, small wind turbines (as opposed to micro wind turbines) continue to provide the majority of annual deployed capacity.

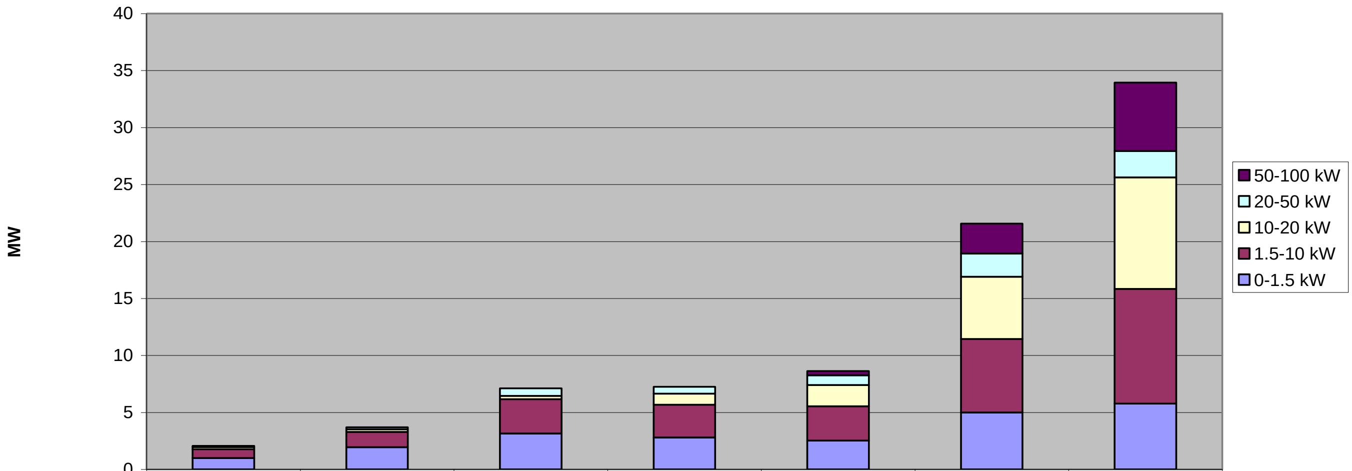
In 2009, significantly more wind turbines were installed for off-grid applications than on-grid (2,040 and 1,240, respectively). However, it is anticipated that the main growth market will be for applications connecting to the grid, while off-grid applications will experience stable levels of increasing annual UK deployment in the future.

Currently, many off-grid applications are installed within the leisure (e.g., marine) and industrial segment of the market.

Annual deployment for building-mounted systems has dropped noticeably following a peak in 2007, representing 10% of the total deployment in 2009. Free-standing turbines, as opposed to building mounted, are expected to continue to make up the lion's share of existing installations for the foreseeable future.

6.3.3 Operational Details

In 2009, the average size of small wind turbines installed in the UK grew from 2 kW to 2,6 kW. Figure 6.3 illustrates that small wind turbines will continue to grow in size. Furthermore, significant growth is anticipated in the emerging small-medium wind turbine category (50 kW to 100 kW) in the coming years.



	2005	2006	2007	2008	2009	2010	2011
50-100 kW	0	0	0	0	0.375	2.625	6
20-50 kW	0.105	0.175	0.665	0.595	0.84	2.03	2.31
10-20 kW	0.195	0.225	0.3	0.975	1.875	5.46	9.795
1.5-10 kW	0.775	1.345	3.005	2.875	3.01	6.455	10.06
0-1.5 kW	0.992	1.943	3.147	2.796	2.524	4.988	5.777

Year

Figure 6.3 Annual deployed UK small wind turbine capacity (MW)

With more than 20 manufacturers and many foreign companies active in the UK market, a wide variety of products varying in size and design is available. VAWTs are a relatively new entrant into the mainstream UK small wind sector, but it is anticipated that they will play an increasingly important role as the overall market grows. HAWTs are forecast to provide a significant proportion of the overall number of annually deployed micro and small wind turbines in the near future.

It is a well-established industry fact that wind turbines located in built-up areas will generate less electricity than their counterparts in open and exposed locations. Typical load factors of small wind turbines in both urban and rural locations are summarized in Table 6.1 (4). The average capacity factor is expected to improve yearly in line with technology development.

Table 6.1 Summary of Key Parameters

System size /type	Load factors						Technology lifetime	Typical hub height
	5.5 m/s	6 m/s	6.5 m/s	7 m/s	7.5 m/s	> 8 m/s		
B-M < 1.5 kW urban	2%	2%	2%	2%	2%	2%	10 years	2m above building
B-M < 1.5 kW rural	8%	8%	8%	8%	8%	8%	10 years	2m above building
Mast mounted micro (urban)	2%	2%	2%	2%	2%	2%	10 years	10 m
Mast mounted micro (rural)	8%	10%	12%	13%	13%	14%	10 years	10 m
1.5 – 15 kW urban	7%	7%	7%	7%	7%	7%	15 years	10 m
1.5 – 15 kW rural	15%	15%	19%	23%	23%	26%	15 years	10 m
15 – 50 kW urban	7%	7%	7%	7%	7%	7%	15 years	15 m
15 – 50 kW rural	15%	15%	19%	23%	23%	26%	15 years	15 m
50 – 100 kW	10%	15%	19%	23%	23%	26%	20 years	25 m

6.3.4 Wind Energy Costs

Table 6.2 shows estimated costs for small-scale wind energy project elements.

Table 6.2 Current Technology Cost

System size / type	Fixed cost (per site)	Marginal cost (£/kW)	Annual maintenance cost
Micro (<1.5 kW)	€4,000	€2,300	€125
1.5-15 kW	€11,450	€2,300	€250
15-100 kW	€3,430 total per kW		€85 per kW

- A capital cost of £5,500 (€6,300) is assumed for a retrofit 1-kW turbine (building integrated).
- Capital costs for tower-mounted micro-wind for a typical installation range from c. £15,000 (€17,160) for a 2.5-kW system to £22,000 (€25,165) for a 6-kW system. The installation cost is a significant portion of the total cost at this scale. The capital cost of these installed turbines is relatively insensitive to capacity and strongly based on electrical and mechanical installation and size-independent hardware.
- For micro/small wind systems, maintenance cost estimations are based on a bi-annual check and service taking half a day. The actual maintenance may vary depending on the turbine quality and location.
- Capital costs for the small- to large-scale turbines are based on an installed cost of £46,000 (€52,615) for a 15-kW turbine, £150,000(€171,570) for a 50-kW turbine, and £250,000 (€285,950) for a 100-kW turbine. Costs include civil works for an average site.

Costs are expected to decline as the installed base grows and supply chains mature and as wind turbine-specific power electronics are developed further (4).

6.4 Incentive Programs

The Renewable Obligation (RO) is the main mechanism for supporting renewable electricity generation in the UK. Introduced in 2002, the RO places an obligation on licensed electricity suppliers in the UK to source an increasing proportion of electricity from renewable sources.

Eligible renewable generators receive Renewables Obligation Certificates (ROCs) for each MWh of electricity generated. These certificates can then be sold to suppliers to fulfill their obligation. Suppliers can either present enough certificates to cover the required percentage of their output or pay a “buyout” price for any shortfall.

In April 2009, the banding approach to the RO was introduced to promote new technologies. Microgeneration technologies (up to 50 kW), due to proportionately higher cost, were granted the highest 2-ROC per MWh banding (9p/kWh).

To further promote small-scale renewable energy technologies, in 2006 the government introduced the Low Carbon Building Program (LCBP) that pays grants toward the cost of installing microgeneration technologies on domestic properties or on public buildings and businesses. The program is divided into two phases:

(1) Under Phase One, the maximum allowance for domestic or private businesses is capped at £2,500 (€2,860).
(2) Phase two of the program covers community projects and public buildings. Phase Two projects are eligible for up to 50% funding of project costs.

For both phases funding is agreed in advance of the project once the property in question has met the relevant energy-saving criteria. The grant is paid in arrears once the successful installation is completed.

The LCBP initially entitled homes installing microgeneration technologies to receive up to £4,000 (€4,580) per kW installed with a maximum grant of £15,000 (€17,170). The program was popular, and the £500,000 (€572,215) monthly fund was fully allocated. In April 2007, the grants were suspended, and in June 2007 a grant capped at a maximum of £2,500 (€2,860) was introduced. As a result of the cap, the level of grant applications and microgeneration installations decreased considerably.

In 2009, the government proposed to introduce a feed-in tariff in the UK to further promote the adoption of renewable technologies, including small-scale wind turbines. With the new scheme customers will receive a payment for each kWh of electricity generated, with an additional payment for electricity exported to the grid. Specific benefits of a feed-in tariff are expected to include greater transparency and an easier process for customers to sell excess electricity generation, as well as a better opportunity to determine the cost effectiveness of an installation before purchase.

6.5 R, D, & D Activities

6.5.1 National R, D, & D Efforts

In 2009, limited public funds were available for small wind R&D activities. Individual companies, on the other hand, were actively investing in R&D throughout the year. However, the results of these investments are not publically available.

6.6 Testing, Labeling, and Certification Activities

During 2009 and 2010, several small wind turbines were tested and certified in accordance with the British Wind Energy Association (BWEA) small wind safety and performance standard for certification in accordance with the MCS 006 standard under the Microgeneration Certification Scheme (MCS). Test organizations include NaREC and TUV-NEL, and certification organizations include TUV-NEL and BRE-C. Testing has taken place at a variety of test sites, from the Scottish islands to Cornwall. The most notable test site is Myres Hill near Glasgow, which is owned and operated by TUV-NEL and which has approximately 20 test stands. The site is used by a number of organizations, including NaREC on a commercial basis. Test results need not be taken only at UK test sites or by UK test organizations, but they must be audited by accredited test and certification bodies. Similarly non-UK certification bodies have been working to achieve accreditation for the purposes of MCS. There are approximately 60 turbines in the process of achieving certification under MCS, and four have achieved full certification to date.

6.7 The Next Term

Currently annual energy production levels in the UK are only scratching the surface of what may be possible in the future. Following the introduction of the FIT in 2010, sharp increases are anticipated for the UK market, with manufacturing industry-wide revenue increases of up to 181%.

However, it will be crucial to make the planning system work efficiently, effectively, and cohesively to ensure successful UK market growth.

Furthermore, 2010 will witness a significant number of turbines being tested in accordance to international standards to fulfill the condition to be eligible for the FIT.

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Author

Indre Vaizgelaite, RenewableUK (previously British Wind Energy Association)

7 UNITED STATES OF AMERICA

7.1 Overview

In 2009, the U.S. small wind industry had growth of 15% per the American Wind Energy Association (AWEA) Small Wind Turbine Global Market Study. (See http://www.awea.org/smallwind/pdf/2010_AWEA_Small_Wind_Turbine_Global_Market_Study.pdf)

This was viewed as significant growth given the U.S. recession in 2009.

Also in 2009, AWEA finalized the "AWEA Small Wind Turbine Performance and Safety Standard," which is based on sections of the IEC 61400 series of wind energy standards.

7.2 National Objectives

There are no specific U.S. national market objectives but the following points are illuminated.

7.2.1 Wind Generation Capacity

In 2009, there is an estimated growth of 20 MW of installed small wind turbine capacity.

7.2.2 Urban Integration Experiences

The U.S. Department of Energy (DOE)/National Renewable Energy Laboratory (NREL) sponsored a Built-Environment Wind Turbine workshop in August 2010 to understand previous work performed for this small wind market niche. Based on the AWEA Small Wind Turbine Global Market Study report, 2009 installations of built-environment wind turbines made up 2% of the total installed small wind capacity.

7.3 Implementation

7.3.1 Economic Impact

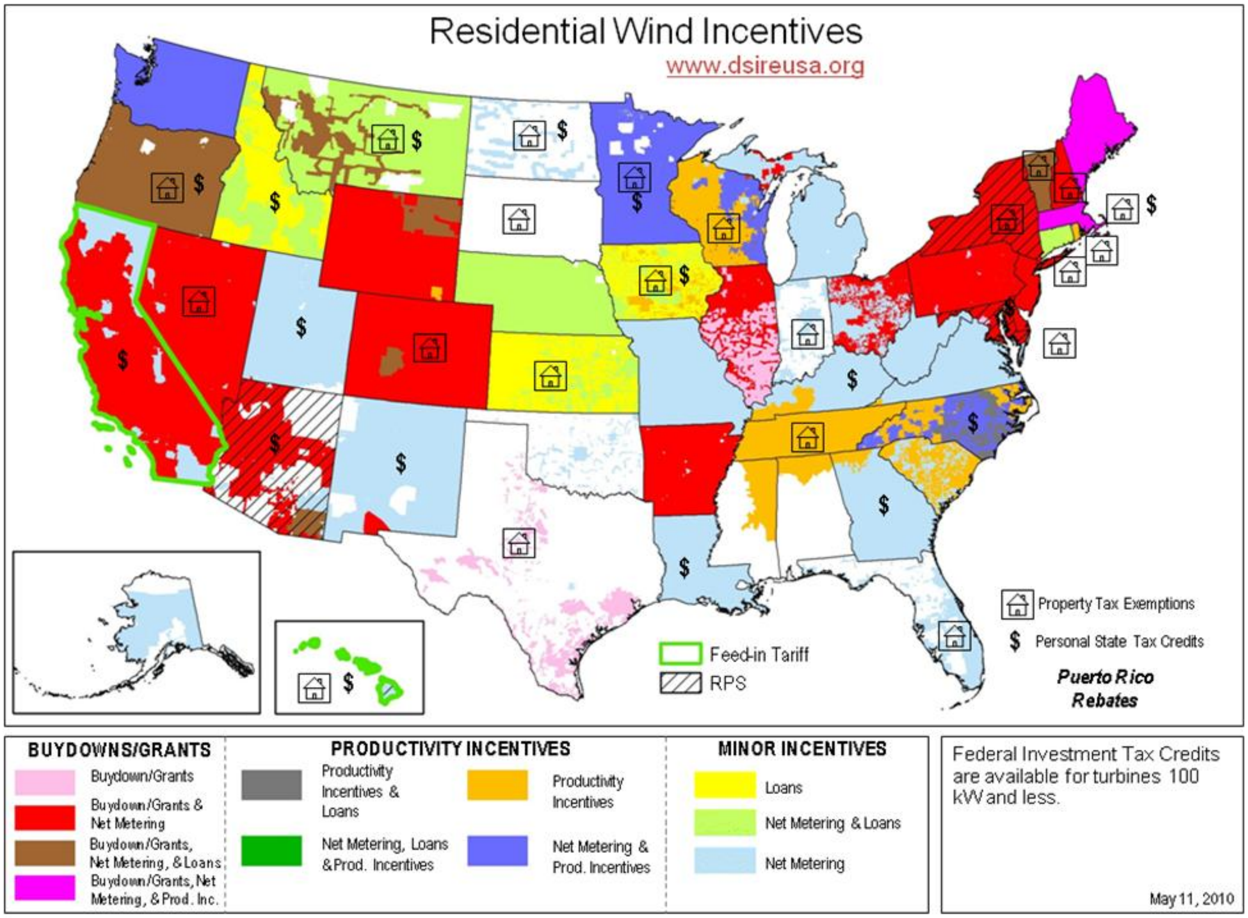
The small wind industry had more than $82 M in sales in 2009.

7.3.2. Industry Status

There were 95 U.S. small wind turbine manufacturers that reported to the AWEA Small Wind Global Market Report.

7.4 Incentive Programs

There are a wide variety of incentives at the federal, state, and utility level, and these incentives change rapidly. A snapshot of the incentives as of May 2009 (from the www.irecusa.org site) is shown here.



7.5 R, D & D Activities

The DOE's main focus for small wind research has been accredited testing of small turbines up to 200 m^2. Accredited testing is being conducted at NREL's National Wind Technology Center (NWTC) in Boulder, Colorado. Results of those tests are available at http://www.nrel.gov/wind/smallwind/independent_testing.html.

Also, four Regional Test Centers (RTCs) were competitively chosen to be NREL's satellite testing facilities. These RTCs are Intertek in Cortland, New York; Kansas State University/Colby Community College in Colby, Kansas; West Texas A&M in Canyon, Texas; and Windward Engineering in Spanish Fork, Utah. While these RTCs are supported by NWTC test engineers, they are currently unaccredited and are beginning to prepare their test sites and install their test turbines.

7.5.1 National R, D, & D Efforts

Focused testing work is currently in place to help stabilize the U.S. small wind turbine market. With a long-term federal Investment Tax Credit at 30% of the installed turbine costs, the number of U.S. small wind manufacturers has increased.

7.5.2 Collaborative Research

The United States is positioning to help IEA Task 27 in the formation of an international label that can be used across the world and in the development of strategies for built-environment wind turbines. Further, we have used raw test data from our turbine tests to set up a proficiency Round Robin exercise to determine whether different international test organizations get the same analysis results. This type of Round Robin work helps to validate different test and analyses methodologies.

7.6 Testing, Labeling, and Certification Activities

7.6.1 Testing Activities

In 2009, NWTC staff members tested the Mariah Windspire (terminated in January 2009), Abundant Renewable Energy 442, Gaia 11 kW, and the Entegrity EW50.

7.6.2 Labeling

The Small Wind Certification Council (SWCC) has developed a consumer label for turbines granted SWCC certification. The label is based on the draft label from IEA Task 27.

7.6.3 Certification Program

The SWCC — a newly developed, independent certification body — certifies that small wind turbines conform to the requirements of the new AWEA Small Wind Turbine Performance and Safety Standard. The SWCC issues certified turbines easy-to-understand labels for Rated Annual Energy Output, Rated Power, and Rated Sound Level. The label will also confirm that the turbine meets the AWEA Standard's durability and safety requirements. SWCC's Web directory will include power curves, annual energy performance curves, and measured sound pressure levels for each model certified. State-level small wind incentive programs are now transitioning to using certification as the pathway to eligibility for program funding.

7.6.4 Available Test Centers and Facilities

See Appendix 1.

7.7 The Next Term

The United States is continuing its focus on small wind testing and certification. The NWTC will complete the IEC accredited testing of the original small turbines under test (ARE 442, Entegrity EW50, Gaia, Ventera) plus add up to three more turbines for accredited testing.

Authors

Trudy Forsyth, National Renewable Energy Laboratory's National Wind Technology Center

Brent Summerville, Small Wind Certification Council

APPENDIX 1

U.S. Organizations Accredited to Test Small Wind Turbines

Global Energy Concepts, Inc. (GEC-DNV)

- a DNV company

Mail: 1809 7th Ave., Suite 900, Seattle, WA 98101

Phone: (206) 387-4200

Contact: Luke Simmons

E-mail: Luke.Simmons@dnv.com

Web: www.globalenergyconcepts.com

Test site location: N/A

Turbines tested to date: More than 132; all turbines having a rated capacity of 100 kW or larger

Accreditation: Accredited by the American Association of Laboratory Accreditation (A2LA) in accordance with ISO/IEC 17025:2005 to conduct tests per IEC 61400-12-1,-12, -13 and the MEASNET Power Performance Measurement Procedure: 2000

Other comments: While our expertise is in testing of utility-scale turbines, we're happy to discuss testing of smaller turbines and can work with all involved parties to come up with a cost-effective solution that meets the requirements of relevant standards.

National Renewable Energy Laboratory (NREL)

National Wind Technology Center (NWTC)

Mail: 1617 Cole Blvd., Golden, CO 80401

Phone: (303) 384-6987

Contact: Arlinda Huskey

E-mail: Arlinda.Huskey@nrel.gov

Web: www.nrel.gov/wind

Test site location: NWTC, Boulder, CO

Turbines tested to date: > 20

Accreditation: Accredited by the American Association of Laboratory Accreditation (A2LA) in accordance with ISO/IEC 17025:2005 to conduct tests per IEC 61400-11, -12, -21, -23, -13, -1, and -2, MEASNET Acoustic Noise Measurement Procedure: 1997, MEASNET Power Performance Measurement: 2000, and MEASNET Power Quality Measurement Procedure: 2000.

NREL Regional Test Centers

High Plains Small Wind Test Center

Mail: Barry Kaaz, Colby Community College, 1255 South Range, Colby, KS 67701

Contact: Barry Kaaz, mobile 785-462-0411, office 785-460-5429

Contact: Ruth Douglas Miller, office 785-532-4596

E-mail: rdmiller@ksu.edu, barry.kaaz@colbycc.edu

Web: www.ece.ksu.edu/psg/wac

Test site location: KSU Agricultural Research property just south of Colby, KS, at 39.38 N, 101.08 W.

Turbines tested to date: None; the High Plains Test Center is just starting under an NREL grant. However, our engineering team has 20 years experience testing and evaluating manufacturing processes and products across many industries.

Accreditation: N/A

Other comments: Mean average wind speed is 6.5 to 7m/s at 30 m, and strong directional winds (prevailing N-S) are common during the entire year, so we anticipate rapid durability testing.

Intertek

- a Nationally Recognized Testing Laboratory (NRTL)

Mail: 3933 US Route 11, Cortland, NY 13045

Phone: (607) 758-6245

Contact: Joseph Spossey

E-mail: Joseph.Spossey@intertek.com

Web: www.intertek.com/energy/wind/small-turbine

Test site location: Intertek is currently testing wind turbines at customer sites to CSA C61400-12-1 and -11 and -21. We are currently finalizing our own test site in New York.

Turbines tested to date: Intertek has done design reviews and field evaluations of more than 1.6 GW of large wind turbines for GE Wind, Gamesa, Vestas, Acciona, REPower, and Aaer. Intertek has tested small wind turbine components – generators on a test stand and inverters – and is testing our first complete small wind turbine.

Accreditation: Accredited by OSHA to test all wind turbine components in the US and SCC in Canada. We are pursuing certification accreditation now that Canada has adopted CSA C61400-2. Intertek is currently in the process of achieving accreditation for wind turbine testing by A2LA.

West Texas A&M University

The Alternative Energy Institute, Wind Test Center

Mail: P.O. Box 60248 W.T, Canyon, Texas 79016

Phone: (806) 651-2295

Contact: David Carr, dcarr@wtamu.edu

E-mail: aeimail@wtamu.edu

Web: www.windtestcenter.org

Test site location: Canyon, TX

Turbines tested to date: AEI has had a cooperative agreement with USDA since 1976. Between AEI and USDA, we have installed more than 70 wind turbines (50 W to 100 kW), most of them prototypes or first-production units. Turbines have been installed at the AEI Wind Test Center (Canyon, TX); USDA location (Bushland, TX), and others at field locations, primarily in Texas. At the Wind Test Center, we are testing eight turbines, and another one is used for electricity for the Renewable Energy Demonstration Building (a Bergey 10-kW, installed in 1994). We also have 2 kW PV, so we are a net energy producer.

Accreditation: N/A

Other comments: We also have a test stand for small blades. In the past, we have tested 10 blades.

Windward Engineering

Mail: 10768 S. Covered Bridge Canyon, Spanish Fork, UT 84660
Phone: (801) 798-8784
E-mail: info@windwardengineering.com
Web: www.windwardengineering.com
Test site location: Spanish Fork, UT
Turbines tested to date: >9. Not all for the purpose of collecting IEC test data.
Accreditation: N/A
Comments: We have limited space and resources as we have six existing or proposed installed turbines. A client willing to do their own installation and testing will get quicker results. The test site wind is excellent for rapidly producing performance and duration test data. It should be noted that we are involved with producing small wind turbines with Endurance Wind Power as well as running the test facility for Windward Engineering.

U.S. Non-Accredited Test Organizations

Appalachian State University

Beech Mountain Small Wind Research & Demonstration Facility
Mail: ASU Energy Center, 20 Kerr Scott Hall, Boone, NC 28608
Phone: (828) 262-7333
Contact: Dr. Dennis Scanlin
E-mail: wind@appstate.edu, scanlindm@appstate.edu
Web: wind.appstate.edu
Test site location: Beech Mountain, NC
Turbines tested to date: 12; 200 W to 20 kW
Accreditation: N/A
Other comments: Energetic Class 5 ridge top research and demonstration site. Open to the public.

Channel Islands Acoustics

Mail: 676 West Highland Drive, Camarillo, CA 93010
Phone: (805) 484-8000
Contact: Bruce Walker
E-mail: bwalker@channelislandsacoustics.com, noiseybw@aol.com
Web: www.channelislandsacoustics.com
Test site location: Nationwide; Western states preferred
Turbines tested to date: Bonus, Nordtank, Micon, Mitsubishi, GE, Tacke, Zond, Jacobs, Windmatic, Polenko, Clipper, Vestas, Aeromann, Carter, ESI, FlowWind, Danwin, Floda, NedWind, Vawtpower, etc. Sizes ranging from 10 KW to 2+ MW.
Accreditation: INCE Board Certified
Other comments: Bruce Walker, Ph.D., INCE Bd. Cert. is the principal consultant and has provided acoustical testing and consulting services to the wind energy industry for over 25 years. We offer targeted diagnostic sound and vibration testing and acoustic noise emissions testing according to IEC 61400-11. We maintain a full complement of acoustical test and analysis equipment, with current NBS-traceable certifications.

DynaTech Engineering, Inc.

Mail: 1830 Sierra Gardens Drive, Suite 30, Roseville, CA 95661
Phone: (916) 783-2400
Contact: Lyn Greenhill, PE
E-mail: lyng@dynatechengr.com
Web: www.dynatechengr.com
Test site location: Northern California
Turbines tested to date: 4
Accreditation: N/A
Other comments: Authorized by California Energy Commission for IEC 61400-2 testing and analysis. DynaTech is a mechanical engineering consulting firm specializing in rotating machinery.

GREAT (Global Renewable Energy Assessment Testing) Laboratory

Mail: World Cal, Inc., 2012 High Street, Elk Horn, IA 51531
Phone: (712) 764-2197
Contact: Mike Howard
E-mail: MHoward@liberty-labs.com
Web: www.world-cal.com
Test site location: 2012 High St., Elk Horn, IA 51531 and 1346 Yellowwood Rd., Kimballton, IA 51543
Turbines tested to date: 3- and 6-kW VAWT with Ginlong PMG
Accreditation: We have applied for accreditation under ISO 17025 with A2LA and expect to have this completed by mid-summer.
Other comments: Obtain GREAT Seal for your turbine from our Global Renewable Energy Assessment Testing Lab. We have more than 40 acres available for turbine testing as well as indoor labs for inverter tests and evaluation. Additional acreage of up to 200 acres will be added later this summer.

Northern Colorado Wind Test Center (NCWTC)

A collaboration between RRD Engineering and CPP Wind Engineering
Mail: 670 Cody St., Lakewood, CO 80215
Phone: (970) 581-8091
Contact1: Rick Damiani, RRD Engineering
E-mail: r.damiani@rrdengineering.com
Web: www.RRDengineering.com
Contact2: Brad Cochran, CPP Wind Engineering
E-mail: bcochran@cppwind.com
Web: www.cppwind.com/services/renewable_energy/renewable_energy.html
Test site location: The test site is located in Weld County, Colorado. The site is open grassland with annual mean wind speed of 5 m/s at a height of 20 m above grade and experiences approximately 185 hours per year of mean wind speeds in excess of 15 m/s. The site utilizes state-of-the-art data collection and communication instrumentation and software to minimize response times and man-hour requirements for data analysis and reporting.
Turbines tested to date: Five turbines at various sites throughout the Rocky Mountain West. Testing has

included power performance, duration, and acoustical noise evaluations following the IEC 61400-11 (noise) and IEC 61400-12 (power performance) test standards. In addition, CPP has conducted turbine development tests for dozens of wind turbines (hundreds of configurations) in its large atmospheric boundary layer wind tunnels and through CFD modeling.

Accreditation: N/A

Other comments: The principal investigators are registered professional engineers in Colorado. They have been actively involved in the development of both the AWEA and IEC test standards. RRD Engineering and CPP have 15 years of experience providing turbine design and evaluation services using a combination of wind tunnel modeling, FEA and CFD modeling and field testing, along with conducting wind resource assessments for small and utility-size wind applications.

Pine Ridge Products LLC

Mail: 1646 East Highwood Road, Belt, MT 59412

Phone: (406) 738-4283

Contact: Logan Bryce

Email: wlbryce@pineridgeproducts.com

Web: www.pineridgeproducts.com

Test site location: Belt, MT

Turbines tested to date: 11

Accreditation: N/A

Other comments: Specializing in 10 kW and below, turbulent Class 5 wind site.

South Dakota Wind Application Center (SDWAC)

South Dakota State University (SDSU)

Mail: South Dakota Wind Application Center, Box 2219, Crothers Engineering Hall 234, Brookings, SD 57007

Phone: (605) 688-4301

Contacts: Michael Twedt, Michael.Twedt@sdstate.edu; Matthew Hein, matthew.hein@sdstate.edu

Test site location: 141 acres (more than ½ square-kilometer). Testing site is within 3 miles of the SDSU campus and is located on SDSU property. All access rights are controlled by SDSU, and the surrounding land is primarily used for agriculture with all residential structures far outside the required setback distances. Interstate 29 is approximately 2 miles from the proposed site, and the Brookings Regional Airport is within 4 miles of the proposed site for efficient transportation. The northern climate of eastern South Dakota provides excellent performance testing conditions with an appropriate wind regime, temperature profile, and precipitation matrix.

Latitude: 44.3530 **Longitude:** -96.7913

Turbines tested to date: N/A

Accreditation: The South Dakota Wind Application center is actively pursuing accreditations recommended by the National Wind Testing Center (NWTC) and American Wind Energy Association (AWEA).

Other comments: We monitor performance of seven small wind turbines, and all technical concerns related to the South Dakota Wind for Schools program are directed through our office. The Engineering College of SDSU has extensive material testing capability. The imaging, mechanical testing, and Non-Destructive Evaluation (NDE) techniques can identify the material structure and the structure's correlation to strength and performance, as well as help evaluate the material pre- and post-manufacturing characteristics and operation fatigue. The Department of Wildlife and Fisheries at SDSU indicates an opportunity to explore interactions between wind machines and wildlife. The Climatology Department at SDSU places an emphasis on renewable resource evaluation and houses the South Dakota Wind Resource Assessment Network (WRAN), which specializes in wind resource assessment and turbine performance prediction in South Dakota. Recruitment opportunities may also present themselves, as interaction with the university and your company will undoubtedly include capable members of the student body.

The Cadmus Group, Inc.

Mail: 57 Water Street, Watertown, MA 02472
Phone: (617) 673-7106
Contact: Shawn Shaw
E-mail: shawn.shaw@cadmusgroup.com
Web: www.cadmusgroup.com/clean_energy
Test site location: Cadmus conducts small wind turbine testing at various sites across the northeastern United States. We will work with interested manufacturers to identify an appropriate test location and conduct testing to IEC 61400 and AWEA standards. Cadmus also conducts design reviews, post-installation inspections, and monitoring of wind projects at existing sites.
Turbines tested to date: Testing and energy-production monitoring is ongoing on more than 40 small wind turbines, with detailed testing in progress on seven turbines. Models tested include the Bergey Excel-S, Aircon 10, ARE 442, Eoltec Scirroco, Endurance S250, and others.
Accreditation: N/A
Other comments: Our team conducts a wide range of wind-energy-related consulting activities such as testing, design reviews, wind resource assessment, site evaluation, and development of software tools for predicting small wind system performance.

USDA-Agricultural Research Service

Conservation & Production Research Laboratory
Mail: P.O. Drawer 10, Bushland, TX 79012-0010
Phone: (806) 356-5724
Contact: Brian Vick
E-mail: Brian.Vick@ars.usda.gov
Web: www.cprl.ars.usda.gov
Test site location: Bushland, TX
Turbines tested to date: Between AEI and USDA, we have installed more than 75 wind turbines (50 W to 100 kW), most of them prototypes or first-production units.
Accreditation: N/A

Wind Energy Center (WEC)

University of Massachusetts at Amherst
Mail: Bldg ELAB 160 Governors Drive, Amherst, MA 01003
Phone: (413) 577-2139
Contact: William Stein
E-mail: wstein@ecs.umass.edu
Web: www.ceere.org/rerl
Test site location: Mt Tom, Leyden, MA (pending)
Turbines tested to date: ESI-80, Electro, Umass Windfurnace-WF-1, Dakota Wind and Sun (4 kW Jacobs clone), Windcharger
Accreditation: N/A

Other comments: The WEC has been involved in all aspects of wind power since the late 1970s, including design, prototyping, wind tunnel and atmospheric testing of small and large wind turbines.

WindTesting.com

Mail: PO Box 1138, Tehachapi, CA 93581
Contact: Brent Scheibel
E-mail: Service@WindTesting.com
Web: www.WindTesting.com
Test site location: Tehachapi, CA
Turbines tested to date: 30
Accreditation: N/A