Small Wind Turbines – The Future of Wind Energy?

Small wind turbines can be a solution for energy problems in the future. However, some problems interfere with the worldwide success of the technology.

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Small Wind Turbines - Overview

Small wind turbines (SWTs) enable homeowners, businesses and institutions to generate their own clean, renewable and cost-effective electricity. Although SWTs have many advantages, the technology struggles within the energy market because of uncertain policies and standards as well as high costs. This white paper provides information on the current state of the small wind energy market and analyzes the existing applications and their potential opportunities and challenges to give an outlook on the future of small wind energy.

The SWT market and its leaders, PG 4

At the end of 2012, a cumulative total of at least 806,000 small wind turbines were installed all over the world. China is by far still the largest market.

Common applications of small wind energy systems, PG 6

In recent years, the market for larger, grid-connected systems has particularly increased in industrialized countries such as the USA, the UK and Denmark.

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Manufacturing costs, quality issues, missing legal frames and support schemes are the main challenges and are crucial for the future development of SWTs.

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The worldwide demand for clean and affordable energy will lead to a growing demand for small wind. Particularly in developing countries, SWTs can easily contribute to bringing electricity to millions of people in rural areas.

Fast Growing Demand for Wind Energy

Due to its scope for deployment and the progress of developments, wind energy is set to comprise an everincreasing proportion of the total energy mix over the next few years.

In parallel to the larger wind farm development, small wind turbines (SWT) offer a sustainable solution to fundamental problems surrounding the supply of energy and the demand for distributed energy generation. This is especially applicable in developing countries, but is also becoming more and more relevant in industrial countries. Rising energy prices, the associated desire for decentralized electricity generation and concerns about global climate change have convinced many people to seek alternative sources of energy.

Commonly used on residential, agricultural, commercial, government and industrial sites, small wind energy systems enable homeowners, businesses and institutions to generate their own clean, renewable and cost-effective electricity. These systems can be either physically or virtually connected to the customer utility meter to deliver onsite power, or connected directly to the local distribution or micro-grid to support local grid operations or offset nearby electric loads.

Although SWTs have many advantages, the technology struggles within the energy market because of uncertain policies and standards as well as high costs.

1. The SWT Market and Its Leaders

At the end of 2014, a cumulative total of at least 945,000 small wind turbines were installed all over the world. This is an increase of 8,4% (7,4% in 2013) compared with the previous year, when 872,000 units were registered.

Most of the growth took place in only three countries: China, the USA and the UK. This proves that the world market for small wind turbines is still in its infancy. In most countries, at least a handful of small wind turbines can be found but actual market size in the vast majority of countries cannot sustain mass production.

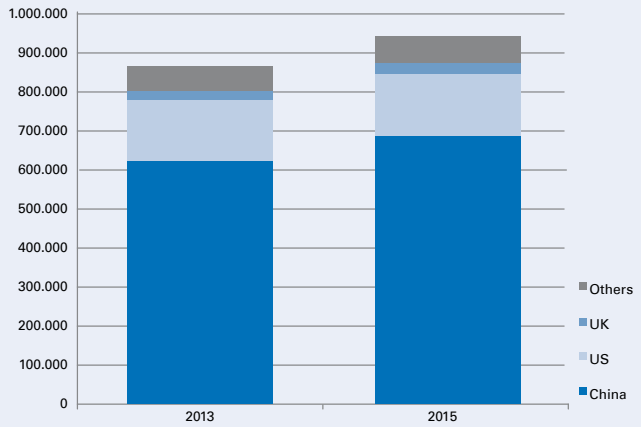
More and better standards and certification are imperative for making small wind a success all over the world. Although there is no current mandatory requirement, the certification of SWTs is recommended to build trust among project investors and insurers. TÜV Rheinland supports small wind turbine manufacturers around the world with certification services, applying the IEC 61400-2 standard to reduce liability risks and ensure safety for people and the environment.
China continues to lead by far the market in terms of installed units. 64,000 units were added in 2014, which represents 9,000 more than in 2013, reaching 689,000 units installed by the end of 2014.

This represents 72% of the world market, both in terms of total as well as newly installed units. Using small wind energy since the early 1980s, it is estimated that, around half of the turbines in China continue to produce electricity.

In the USA, the number of units installed in a year felt to 1,600 units in 2014, following a first decrease of 2,700 units in 2013. With a total cumulative units installed of 159,300, USA is the second largest market, clearly behind China, but well ahead of a number of medium-sized small wind markets. Germany, Canada, Japan and Argentina are all medium-sized markets with total number of small wind turbines between 8,500 and 16,000 units.

Despite the unfortunate changes in the Feed-In scheme introduced in November 2012, the small wind market in the UK saw an increase in the number of installations in 2014. 2,237 SWTs were installed in 2014, which represents a substancial increase when compared to the only 500 units installed in 2013, but still far from the numbers reached in 2012. An interesting fact: for every turbine installed in the UK, one is also exported overseas. 2,614 units were exported to continental Europe, the USA, and Asia.

Installed SWT units 2013 - 2015



What Is a Feed-in Tariff?

A feed-in tariff (FIT) is a policy mechanism designed to accelerate investment in renewable energy technologies. It achieves this by offering long-term contracts to renewable energy producers, typically based on the cost of generation of each technology. The small wind sector has especially benefited from the growing global trend of feed-in tariffs. Unfortunately, only few countries have yet implemented specific FIT schemes for small wind.

The overall recorded small wind capacity installed worldwide has reached more than 830 MW by the end of 2014. This is an increase of 10,9% compared with 2013, when 749MW were registered. The previous years' growth rates, 10,4% in 2013 and 16,1% in 2012, demonstrate a strong recovery of the global market for SWT.
China accounted for 41% of the global capacity, the USA for 30% and UK for 15%. Together, these three leading markets comprise 86% of the world market in 2013.
The USA small wind market grew only by 3,7MW in 2014, a 34% decline in new capacity compared with 2013 and a 80% decrease compared with 2012. The small wind market accounted for $20 million in investment, that is $16 million less than in 2013. (2014 Distributed Wind Market Report, U.S. Department of Energy)

In terms of new installations in 2014, China again led with 64,000 added units. The US and the UK markets developed at similar range, installing 1,600 and 2,237 new units respectively. However, the American and British markets enjoy circa 30% of the size of the Chinese market.
Five countries (Canada, China, Germany, the UK and the USA) are home to over 50 % of the small wind manufacturers. By the end of 2011, there were over 330 small wind manufacturers worldwide offering complete one-piece commercialized generation systems and an estimate of more than 300 additional firms supplying parts, technology, consulting, certification and sales services.
Because turbine manufacturers are predominantly located in China, North America and several European countries, the production of small wind remains concentrated in just a few regions of the world.
Developing countries continue to play a minor role in small wind manufacturing. Despite the tremendous wind resources of Africa, Southeast Asia and Latin America, where many regions are ideally suited for small wind application, domestic small wind industries have not been established.

As consumer interest increased and new companies entered the sector, the small wind industry in general, however, demonstrated remarkable growth in the past decade. More than 120 new small wind manufacturers were established worldwide between 2000 and 2010. China alone has since had an exceptional manufacturing capacity of more than 180,000 units per annum (as of 2011) illustrating how large the small wind sector could possibly become in other world regions and on the global scale.

Definition: Small Wind Turbine

Technically, there are several definitions of small wind turbines: The most important international standardization body, the IEC, defines SWTs in standard IEC 61400-2 as having a rotor swept area of less than 200 m2, equating to a rated power of approximately 50 kW generating at a voltage below 1'000 V AC or 1'500 V DC. In addition to this standard, several countries have set up their own definition of small wind. The discrepancy of the upper capacity limit of small wind ranges between 15 kW to 100 kW for the five largest small wind countries.

2. Common Applications of Small Wind Energy Systems

Small wind turbines can be used for residential, commercial and industrial applications. The versatility is a major advantage of the small wind energy systems.

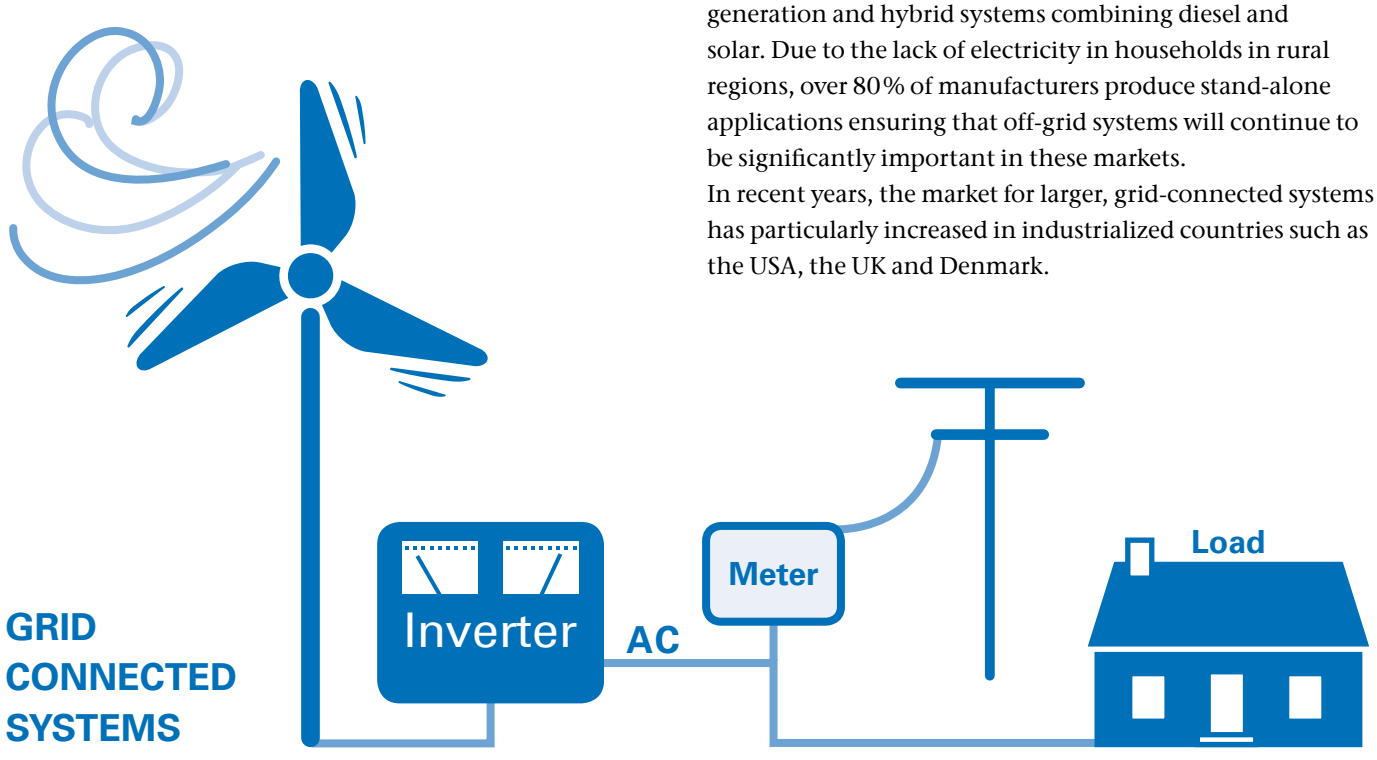
There are two different types of small wind turbines: horizontal axis and vertical axis. As these terms suggest, they differ in the orientation of their rotating axes. Traditionally used in wind farms, horizontal axis wind turbines (HAWT) are most common. However, vertical axis wind turbines (VAWT) possess a number of inherent advantages in the small wind energy sector. Although turbines based on a horizontal axis generate energy more efficiently, vertical axis turbines make less noise and are therefore better suited for use in urban and residential areas. The early HAWT technology has dominated the market for over 30 years. Based on the study of 327 small wind manufacturers at the end of 2011, 74% of the commercialized one-piece small wind manufacturers invested in the horizontal axis orientation while only 18% adopted the vertical design.

The possible applications of SWT are many and varied, making small HAWT and VAWT popular for deployment in isolated systems and small grid connected systems.

Today, common applications of small wind turbines, whether as an isolated or grid-connected system, include:

- Residential
- Commercial and industrial
- Fishery and recreational boats
- Hybrid systems
- Pastures, farms and remote villages
- Portable systems for leisure
- Pumping
- Desalination and purification
- Remote monitoring
- Research and education
- Telecom base stations

Although small wind energy turbines can be used as wind pumps or to generate heat, such systems are most commonly used for power generation.
Despite a market trend leaning towards a grid-connected system with larger capacity, isolated applications continue to play an important role in remote areas of developing countries. Off-grid applications include rural residential electrification, telecommunication stations, off-shore generation and hybrid systems combining diesel and solar. Due to the lack of electricity in households in rural regions, over 80% of manufacturers produce stand-alone applications ensuring that off-grid systems will continue to be significantly important in these markets.
In recent years, the market for larger, grid-connected systems has particularly increased in industrialized countries such as the USA, the UK and Denmark.



3. Challenges Regarding Small Wind Turbines

Small wind turbines depend on the cost of the technology, the enactment of supportive policies and economic incentives, fossil-fuel prices, investor interest, consumer awareness, certification and quality assurance, permitting processes and regulations, and wind evaluation tools. All these facts lead to a major struggle for the small wind energy technology.

One of the main factors and challenges in the dissemination of small wind energy is cost. Although the small wind industry is still under development, it is clear that large economies will help to reduce manufacturing costs in the future. However, appropriate legal frameworks and support schemes are needed in order to achieve cost reductions necessary for small wind markets to see even further growth. Therefore, political incentives continue to play a key role for the wider deployment of small wind.

The success of the small wind market also depends on stable and appropriate support schemes. Today, feed-in tariffs, net metering, tax credits and capital subsidies are the major energy policies geared specifically towards small wind. The small wind sector has especially benefited from the growing global trend of feed-in tariffs (FITs). However, only a few countries have implemented specific FIT schemes considered to be the best tool for grid-connected small wind.

Another major problem for small wind turbines is the lack of specific standards and certification to promote the sales of SWTs and the growth of a healthy and well-established market. TÜV Rheinland currently provides type and component certification according to the IEC 61400-2 standard. Services include design review, type testing, manufacturing surveillance and assistance with CE Marking as well as noise, performance and yield measurements.

However, because it is not mandatory, there is no consistent basis for certification. SWT testing and certification can be performed following IEC standards, EU directives and single country standards as well as according to the International Energy Agency (IEA). All of these standards are continuously adapting to SWT requirements.

Due to the high cost of SWT certification, many SWTs are sold without any proof of quality in design or performance. Customers with a limited knowledge about the involved technology are left confused and distrustful and markets become stagnate.

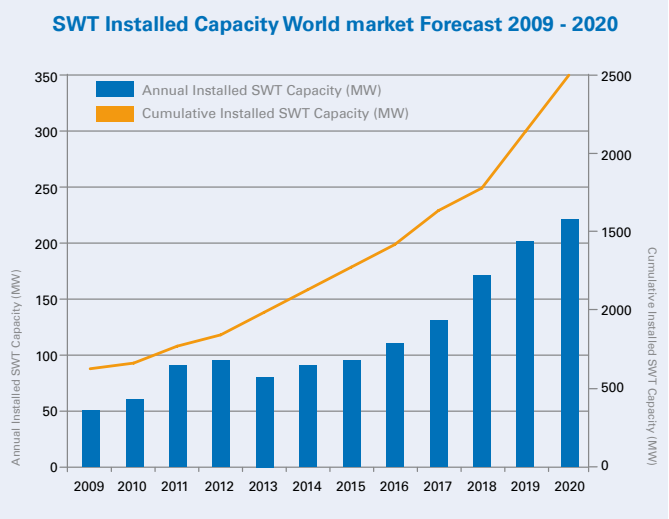
The accurate prediction of on-site wind speed is essential to calculate the electricity output of a small wind generator and determine its economic performance. As wind assessment tools are costly in relation to the cost of a small wind turbine, this evaluation presents a real challenge for the small wind industry. However, it is important to underscore the importance of these on-site assessments.

4. The Future of Small Wind Turbines

The increasing demand for clean and affordable energy all over the world will without doubt lead to an increasing demand for small wind. In particular in the developing countries, small wind can easily and fast contribute to electrify millions of people in rural areas.

As predicted, the global small wind market took a new expansion path starting 2014, which continued in 2015 - at least in terms of installed capacity and the size of the new turbines installed in China and Europe.
A minimum growth rate of 11% is expected for 2016 and at least 115 MW of new installed capacity.

Based on a conservative assumption, the market could subsequently see a steady compound growth rate of 20% from 2015 to 2020. The industry is to reach approximately 240MW of newly installed capacity every year and to achieve a cumulative installed capacity of about 1,75GW by 2020.



Source graphic: small-wind.org

For small wind turbines several trends are developing within different sections:

Blade and rotor design:

- New aerofoil design and improved shapes
- Variable chord and twist distributions, significantly improving the overall performance of SWT
- Further noise emission reduction thanks to changing design parameters
- Magnetic bearings to reduce losses in small wind turbines

Off-grid:

- New storage technologies
- Improved sizing tools
- Improved understanding of hybrid systems and W/D systems
- Wider offer of components (sizes, manufacturers)
- Communication protocols

Generator:

- Solutions for cogging torque reduction, such as asymmetric poles
- Low rotational speed SWT, based on hybrid planetary gear and PMG

Grid connected:

- Interconnecting power electronics
- Better communication protocols
- Standardized interfaces (“plug&play” devices)
- Simpler, more uniform and better-understood technical requirements for network operators

source: www.wind-energy-the-facts.org

Governments and international organizations such as IRENA have begun to understand the potential of small wind energy and are now including small wind in their renewable energy programs. Several industrialized countries have ambitious small wind targets and corresponding policies in place. Political support coupled with specific standards and certifications for small wind turbines will further increase the installed capacity of small wind energy in the upcoming years.

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