Wind Power:

A Clean Revolution in the Energy Sector

Document History: Version 0.1

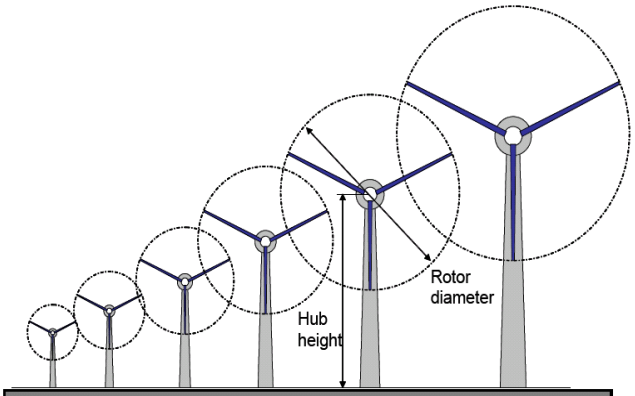
Date	Revision	Revised by	Approved by	Description

Overview

Renewable power is without a doubt the best source of energy that civilization can count on. It is more equally divided among nations, supports local GDP and country development, reduces dependence on "non-friendly" countries, is not volatile to energy prices and, most importantly, doesn't pollute. The economic and environmental advantages make it indispensable. But then, why wind of all renewable resources? Because it is the most cost effective of all with the clear potential to be even cheaper than traditional sources in the near future. This article would address the main reasons and trends leading to the conclusion that wind energy is not only more cost effective and adapted than other alternative sources but also shows the biggest potential for growth and an increasing openness for innovation.

Industry Development

It all started 20-25 years ago, when the first modern wind turbines were built, mainly in northern Europe and California as a result of government incentives. They were relatively small and inefficient and usually had a registered capacity (generator size) of 30KW and blade diameter of about 15 meters. As the industry developed, these turbines became bigger and bigger. Today's average wind turbines have a registered capacity of about 1.5MW – 2MW and blade diameter of about 80 meters. The biggest turbines have a registered capacity of 5MW, blade diameter of about 120 meters, and a nacelle that is attached to a 120-meter tower. The weight of these large machines is about 300 tons. The annual yield of a typical turbine under the same wind conditions (at the same site) grew from 35MWh (30KW turbine, 1980) to 3,500 MWh (a typical 1.5MW turbine today). This 100-fold improvement is based on engineering improvements and the adoption of new technologies. The main engineering improvements derive from an increase in turbine size, so the blades can sweep a bigger area and are installed at greater heights where the wind is stronger; thus a bigger generator that extracts more energy from the same wind can be used. The new technologies that were adapted enable the turbine to reduce energy losses once the wind is captured by the turbine. These technologies mainly relate to the blades, generator and power electronics (grid connection).



	1980	1985	1990	1995	2000	2005
Nominal power	30 kW	80 kW	250 kW	600 kW	1.500 kW	5.000 kW
Rotor diameter	15 m	20 m	30 m	46 m	70 m	115 m
Hub height	30 m	40 m	50 m	78 m	100 m	120 m
Annual energy yield	35 MWh	95 MWh	400 MWh	1.250 MWh	3.500 MWh	17.000 MWh

Value Chain

To create this rapid capacity growth, the new wind industry developed a relatively simple value chain. The first stage of the value chain is comprised of component manufacturers – i.e.,

manufacturers of blades, towers, gearboxes, generators, associated power electronics, and control software. The second stage is the wind turbine manufacturers, who integrate the components to produce wind turbines. In general, most wind turbine manufacturers outsource most components. The final turbines are then delivered to developers who build and manage wind farms. Developers locate a tract that is known to have wind, measure the wind for a year or two, and then purchase turbines that suit the wind behavior at that specific location. The entire process of building a wind farm from scratch usually takes three to five years. From initial operation, the lifespan of a wind farm is 20-25 years, with about 97% availability. To ensure proper performance, in a typical year the maintenance regime of a turbine includes two scheduled and about three non-scheduled treatments. In fact, even with scheduled treatments it is difficult to achieve 97% availability, necessitating extensive turbine refurbishment every six to ten years. For example, on the average gearboxes break every eight years and the power electronics and blades require even more frequent repairs. Upon delivery most turbine manufacturers provide a two year turbine warranty. Some manufacturers provide a three year warranty that with difficulty can be negotiated to extend to five years. During this time period, the manufacturers will contract local workshops to replace malfunctioning components. After the warranty period ends, it is impractical to extend the manufacturer's warranty, so turbine owners employ a combination of methods to keep their machines working.. Big wind farms usually have their own operating and maintenance (O&M) team, and other local O&M workshops provide additional assistance when needed. In general, during a turbine's life about 20% of project cost should be associated with O&M.

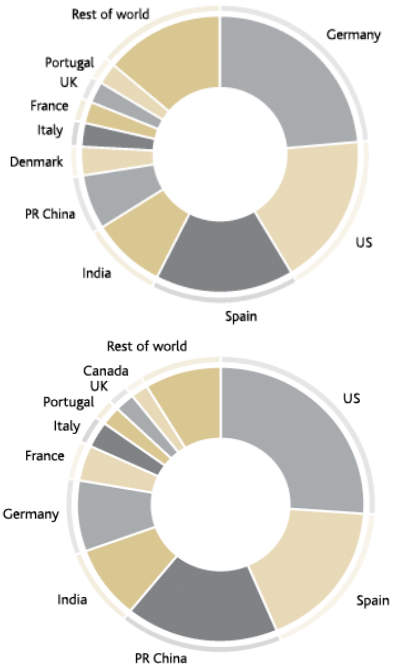
Overview of Insourcing Levels of Leading Manufacturers

Company	Towers	Blades	Generators	Gearboxes	Control systems
Acciona	0%	0%	0%	0%	0%
Ecotècnia	0%	0%	0%	0%	90%
Enercon	50%	100%	100%	n/a	100%
Gamesa	40%	90%	30%	20%	100%
GE	0%	0%	0%	10%	80%
Goldwind	0%	0%	0%	0%	0%
Mitsubishi	20%	80%	100%	100%	100%
Nordex	15%	20%	0%	0%	40%
Repower	0%	0%	0%	0%	20%
Siemens	20%	90%	10%	90%	20%
Sinovel	0%	0%	0%	0%	0%
Suzlon	30%	90%	25%	0%*	60%
Vestas	30%	80%	20%	0%	100%

Source: Make Consulting

Most wind turbines are installed in Europe, mainly in Spain and Germany. However, among the countries that are installing newer high- capacity wind turbines are the US, China and India. In 2008 the US actually reached first place in terms of new capacity and generated $18 billion revenues. In the last five years in Western Europe and North America, in terms of new capacity for electricity production, wind energy is second only to natural gas combined cycle power stations. In China the market is booming and the country's total capacity

doubled for the fourth year in a row. As a result of this rapid world growth, in just 25 years annual sales in the wind energy industry grew from scratch to $51 billion (2008 figures). In 2008 about 27GW of new wind power capacity was added globally, growing cumulative wind capacity to 121GW.



In relative terms, Denmark is the leading country in wind power adoption. About 20% of its electricity power stations are wind turbines. In Germany, the leading country in absolute terms, wind capacity contributes about 6% of total electricity capacity. In the European Union wind energy accounts for about 4% of installed electricity generation capacity. For the European Union to reach its binding goal of 20% green energy by 2020, wind energy for electricity production is slated to reach 12%-13% of installed capacity (By 2020 all green power production, including hydro and thermal, is planned to reach about 35% of installed capacity). To reach these binding figures the wind energy market in the countries of Europe will have to continue for the coming 10 years the same 30% annual growth rate that has been achieved in the last 10 years. The only practical way for European countries to meet these figures is to install wind turbines in the sea (offshore) because the good (windy) locations on shore are insufficient and already occupied by previously installed turbines. Thus in recent years we have seen a huge effort by European countries to install large turbines in the ocean. In the US, wind capacity has just reached 1% of total power production capacity. Although this figure is lower than in Europe, availability of windy locations indicates that US potential is bigger than the European potential in terms of wind energy generation. Despite the rapid industry growth in China and India, wind energy has not yet reached 1% of general capacity. China is currently massively developing the Mongolia area and planning GW wind farms there. Mongolia wind- generated electricity is then planned to be transferred to more populated cities along the coast.

Trends

As wind energy becomes a major source for electricity production, it hits the core of the power production industry. The business trends show that the wind energy industry is maturing fast; however, this process still requires continuous development of new technologies to make wind energy cheaper than traditional sources and to efficiently transfer its produced electricity long distances to consumption areas.

Business Trends

1. Adoption of the traditional energy business model:

In the last 100 years the traditional energy industry has developed an energy transfer business model. Basically, energy is extracted where it is available and then transferred to the places where it is needed. For example, most European countries enjoy Russian natural gas that is extracted thousands of kilometers from the final consumption locations and transferred by pipeline. Oil is extracted from the sands of Arab countries and shipped to industrial countries to move cars and industry. In the beginning, wind turbines were built relatively close to consumption locations. However, the European offshore efforts, the massive Chinese wind development project in Mongolia, and planned huge wind farms in Texas indicate a shift to a model where wind energy is extracted in windy locations and then transferred as electricity to consumption locations. This trend will require massive electricity grid development and more efficient long-distance electricity transfer technologies. Another result of this trend is the development of larger wind farms.

2. Shift from a European-based to a global industry:

Since the industry was invented in Europe, European companies such as Vestas, Siemens, and Enercon captured most market share. Now that markets are booming in the US, India and China, new companies from these countries are gaining significant market share. For example, Vestas from Denmark is losing its piece of the pie, while Suzlon from India and GE from the US are rapidly increasing their share. In China the government requires that 70% of each turbine that is sold in China be manufactured in China. As a result know-how all along the value chain is currently imported into China.

3. New entrants:

Most turbine manufacturers outsource production of turbine components. Consequently, the barriers to entry are relatively low, and many new players have been entering the market. In 2004, 96% of the cumulative capacity was manufactured by about 10 big players and the other 4% by many small players. In 2007, not only did the market share among the big players change dramatically, but the share of small players also grew to 10.5%. Some of these new players even entered the prestigious top 10 list of big players. For example, Sinovel and Goldwind from China, which hardly existed 5 years ago, captured 7.6% of new installations in 2007.

4. Repowering existing turbines:

As many windy locations are already occupied by less efficient turbines (older designs) and the availability of new windy locations is limited, there is a strong incentive to retrofit these existing turbines or replace them with newer ones. In cases of replacement, the old ones are shipped to secondary markets such as South America, Eastern Europe and India. In Germany alone, in the near future a 15GW repowering market is expected to evolve. Current lack of capital halts many new and replacement projects and, as a result, increases the retrofit likelihood.

Technology Trends

1. Improved cost effectiveness of wind turbines:

Improved cost effectiveness is achieved through reducing the initial cost of turbines, increasing their efficiency via fewer losses once wind is captured by the turbine, and improving their reliability via a reduction in both non-working hours and O&M-associated expenses. At the moment there is no clear winning design. For example, some gearless designs (14% of the market) claim to be more reliable; however, their cost and weight are significantly higher than gear-based designs. Each one of these three frontiers is expected to advance through technology innovation and improved engineering. As modern turbines produce more energy from given wind, each percentage point of improvement is more significant.

2. Start-up innovation:

Most of the technology advantages during the first 20 years of the industry were innovated or engineered by the leading players. In recent years the industry reached a significant scale and started to interest the venture capital and private equity communities. As a result more and more start-ups that introduce new technologies are being funded and are entering the market. A natural entry point for start-ups is at the component stage, as most turbine manufacturers outsource component development and there are many new aggressive turbine manufacturers seeking superior technologies. For example, TPI Composites Inc., a Scottsdale, Ariz.-based provider of wind turbine blades to Mitsubishi Power Systems and General Electric, has recently raised $20 million in Series B funding. Backers include GE, Landmark Growth Capital Partners, NGP Energy Technology Partners and Angeleno Group. New turbine designs are also emerging in the market; for example, Clipper WindPower, a US turbine manufacturer that was founded in 2001, already reached $800 million in revenues in 2008. Clipper introduced a new innovative gearbox technology that mainly eased turbine maintenance. Most new turbine designs are improvements of the basic traditional design. The simple reason is that there are still plenty of places to significantly improve these designs. In the last 20 years, there have been many different attempts to develop completely new designs based on wind concentrators, vertical blades, or multiple turbines on one tower; however, there is no commercial use for these designs, since at the end of the day they all proved to be less cost effective than traditional designs. Another mitigating reason is that testing a completely new design is extremely expensive before it can be proven and gain market recognition. Currently there are a handful of wind-related start-ups in Israel, such as IQwind and Coriolis.

3. Grid compliance:

As wind turbines capture a significant portion of the electricity grid, they are required to meet the same grid compliance regulations as traditional power stations. These requirements are already in place in Europe and in the US and are expected to be instituted in the near future in other major markets such as India and China. As a result, governments are expected to give incentives to retrofit grid connection in existing turbines. For example, the Spanish government already provides incentives to old turbines that improve grid compliance through

new technologies. Furthermore, one of the most dominant turbine technologies, called doubly fed turbine technology, may lose market share, since in terms of grid compliance, it is inferior to other technologies.

Summary

As illustrated in this document, the wind energy industry is developing extremely rapidly. Continues engineering improvements and the adoption of new technologies have increased production of a typical turbine by 100-fold in the past 20 years to enable greater energy production by wind turbines. Tremendous market growth is reflected through Sales of $51 billion in 2008 in a market which has exited only 25 years. With a look to the future, installations offshore by European countries and the expansion of wind generation capacity in China and the U.S. are expected to drive the ongoing increase in global wind energy installations.

The industry's simple and open value chain contributes significantly to its growth by facilitating the entrance, mostly at the component stage, of new players who are willing to adopt new technologies to gain market share. These players agree to take the risk of investing in new technologies for the possibility of producing improved turbines and creating an advantage in the industry.

Past experience shows that the ecological and business aspirations of countries and wind industry players can be attained by encouraging the innovation of new technologies. When these are aimed at the reduction of costs and an improvement in efficiency of wind energy production, wind energy has the potential to reach the economics of traditional sources and replace fusil fuel based electricity production.

Gideon Ziegelman

Gideon is the CEO of IQWind. IQWind develops groundbreaking core technology for the wind energy industry as part of the clean revolution.