Achieving Greater Efficiencies and Lower Costs by Replacing First Generation Turbines with Modern Ones

Few countries took the initiative of implementing green energy solutions before the whole world started talking about it. The alternative energy quest led them to install wind turbines onshore in open spaces to power households and industries. Today, those wind farms have aged and need to be reprogrammed and repowered to make efficient use of renewable energy resources.

When the global recession hit most industries badly, the wind power sector also suffered with a fall in annual wind turbine installations and repowering projects. The wind markets have now recovered as a result of the growing Asia-Pacific, South American and African regions, and steady European and North American wind markets.

The global wind repowered market is a growing industry expanding from cumulative installed capacity of an estimated 877 MW in 2005 to an estimated 2,499.4 MW in 2011. But sadly, this is just 22% of the total repowering potential of the global wind farms. According to Global Data, 44,000 MW wind farms would be closer to their repowering deadline by 2020. [i]

In 2011 alone, wind farms worth 170.1 GWh were repowered to expanded capacities of 723.9 GWh. With continuous developments in increasing wind farm capacities and efficiencies, the power generation is expected to reach 14,532.3 GWh by 2020. [ii]

Denmark was the first to support wind repowering because it had setup wind parks back in the 1980s, which have over the years become less efficient. With a large number of small, aging wind turbines (10 to 15 years old and less than 75kW

capacity) littering the country, Denmark decided to embark on a repowering program. Back in 2011, the global wind repowering market was heavily populated by the mature markets of Denmark, Germany, United States, and even India. With Denmark seizing the biggest chunk of the market at 51.6%, it produces 213.1 MW from repowered capacity, followed by Germany with 43.1% of the total global repowered capacity.[iii]

To date, Denmark has successfully repowered two-thirds of the oldest turbines in the country. Denmark has shaped a wind repowering policy through the Energy Policy Agreement of March 2004, encouraging replacement of older turbines. Other mature markets such as Germany, Spain, and United States have also followed suit.[iv]

With repowering, first-generation wind turbines can be replaced with modern multi-megawatt wind turbines offering advantages of higher efficiency and lower costs, and a higher utilization degree with much better grid integration.

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High Efficiency and Lower Costs with Wind Repowering

As wind turbine installations become older, they have to be replaced with new technologies and power ratings. Advances in wind turbine technology, production processes, and materials have increased the efficiencies of new turbines. The newer wind turbines

have a high power rating and improved blade technology as compared to older technologies in first generation wind turbines.

Most of the time, one new wind turbine may replace the electricity production of several old turbines. Technical innovations have resulted in larger wind turbines with longer, lighter blades that drastically improve wind turbine performance and the efficiency of power generation from wind energy.

Apart from the high power ratings of the new wind turbines, there is also the benefit of low cut off wind speed, and reduced costs of building higher towers and wind project capital and maintenance costs. For instance, gearless wind turbines have 80% fewer moving parts and no gear oil. As a result, service costs and insurance costs are reduced.

Yet there are many challenges with relation to the repowering of wind turbines before efficiencies can be achieved. These challenges require technical advances so that maximum energy can be obtained and utilized from a renewable natural resource, wind.

Repowering wind turbines requires an integration of the installed wind farm with the grid infrastructure. Large-scale wind energy integration with the grid sometimes falls short of expectations when the exiting grid infrastructure is poor. As a result, the issue of integration of renewable energies before its full wind energy potential can be realized has to be properly dealt with. Technical challenges related to the following aspects of grid connection to the national electrical network and design of wind turbines and wind farms include:

- Solving electricity transmission problems in the network grid
- Making sure the entire power generation and transmission is stable and secure

- Mulling over the issues related to wind turbine integration and wind farm grid connection to optimize efficiency
- Assessing the impacts of wind turbines on the voltage quality and its fluctuations
- Addressing any thermal limit issues in the electrical network

Repowering Taff Ely Wind Farm

Taff Ely Wind Farm, one of the oldest wind farms located 10 kilometers north east of Bridgend, South Wales, is operated by RWE npower since October 1993. The wind farm consisted of 20 wind turbines, each with a maximum output of 450 kW and a combined maximum output of 9 MW, was manufactured by Nordtank A/S of Denmark.

Organizations such as the Environment Agency, the Royal Society for the Protection of Birds, Countryside Council for Wales, and the Ministry of Defense were contacted to evaluate how to effectively go about the repowering program to overcome low efficiency of the existing wind farm. RWE npower Renewables had proposed wind repowering of the Taff Ely in 2011 by replacing the existing 20 turbines with seven larger, more efficient turbines. It is expected that this repowering will double the energy output from the site.

The old turbines had a capacity of 9 MW while the newer ones will have an installed capacity of 14 MW and 17.5 MW. The decrease in the number of turbines will also increase the distance of the wind farm from the nearest property by 300 meters.[v] Not only will there be a 65% reduction in the number of turbines but also a 105% increase in turbine height is expected from 53.5 meters to 110 meters.

Repowering Wind Farms in Netherlands

There were three repowering projects carried out during the period between 2004 and 2009 in the province of Noord-Brabant in Netherlands.[vi] One of them is the Halsteren wind farm which is located in a nature reserve west of the city of Bergen op Zoom. The first generation of 8 turbines was setup in 1989 which were later replaced between 2004 and 2007. After repowering, the wind farm capacity of previously 4.5 megawatts was increased to 6.8 megawatts. The increased annual output of 14.7 million kWh is enough to provide green power for around 4,200 households.

Another farm in the Netherlands, the Volkerak wind farm situated along the Volkerak docks near Willemstad, had seventeen wind turbines, each with a capacity of 500 kW installed over a period of four years starting 1991. When the exploitation costs were high, they were replaced in 2005 with eleven new turbines each with a capacity of 850 kW. After repowering, the wind farm capacity of previously 8.5 MW was increased to 9.35 MW. The increased annual output of 16.8 million kWh is enough to provide green power for around 4,800 households.

Yet another Netherlands example is that of the Sabinapolder wind farm which came into operation in 1995. Sabinapolder wind farm consisted of seven wind turbines, having a capacity of 750 kW each. After repowering to maximize outputs, seven modern wind turbine units were installed with a capacity of 850 kW each. This increased the installed capacity from 5.25 MW to 5.95 MW. Moreover, the output per annum of around 13 million kWh, now supplies over 3,700 households with green power.[vii]

Modern Turbines Offer Better Grid Integration

Image via Flickr: Payton Chung

Repowering or the replacement of first-generation wind turbines with modern multi-megawatt wind turbines has made better use of available wind energy. More wind power from the same piece of land, using fewer turbines with lower costs, higher efficiency and a better power grid integration are some of the benefits of these modern turbines.

Initially, when wind power was used for commercial purposes, wind energy only made up a few percent of total grid capacity. But today, it covers complete towns in some areas and connections have been made to high-voltage and extra high-voltage grids. Major issues with wind power integration were evident with older turbines such as connection requirements for wind power plants to maintain a stable and reliable supply, extension and modification of the transmission infrastructure.

New turbines offer better integration to electricity network because they use a connection method similar to the conventional energy generation plants and also achieve a greater degree of use. They also help in stabilizing voltage since they have switched capacitors that are applied when generation and VAR demand increases.

A recently developed wind turbine is able to maintain the desired grid voltage and supply reactive power supply to the utilities because it is manufactured using power electronics and a variable speed rotor.

The original Buena Vista wind farm in California was owned by Int'l Wind Companies. It started working in 1981 using 179 Windmaster 211 turbines, relying on accompanying overhead collector power lines and transformers. After a successful $40m repowering, 38 one-MW MHI turbines replaced the older, smaller models. Not only has this resulted in increased efficiency and lower costs but the overhead power lines have been replaced by underground electrical systems. The wind farm supplies electricity to the US electric power company PG&E. [viii]

Upgrading Old Farms an Economical and Sustainable Solution

Not only does wind repowering offer the opportunity to make better use of land and existing resources, it offers the opportunity to create more sustainable, powerful wind farms that meet the growing energy requirements of modern society. Given the incredibly high capital investments in wind farms today and the sound financials that result from wind repowering, this is a trend that will no doubt continue in the decades to come.

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