RECENT TECHNOLOGICAL DEVELOPMENTS IN WIND TURBINES

Software Upgrades, Aerodynamic Modifications and Controller Optimization

Deepika Shenoy
Project Development Engineer
DNV GL – Energy

Wind and solar tariffs in India have fallen significantly in the last few years, where solar tariffs reached a new low of INR 2 per unit recently due to the reverse auction model. This new price will have tremendous pressure on the wind industry to further bring down its levelized cost of energy (LCOE). Some of the major trends developing in this direction are the rise of bigger turbines, software and hardware upgrades and controller optimization for site-specific conditions.

The Rise of Bigger Turbines

Besides lowering LCOE, the wind industry has also the challenge to harness wind power from sites with relatively lower wind velocity, as sites with higher wind velocity are already developed. The current industry approach to tackle both challenges is to come up with a design with longer rotor diameter and higher hub height. While longer rotor diameters enable to capture more wind, the higher hub height allows to access higher wind velocity.

In India, as per the recent Revised List of Models and Manufacturers (RLMM) list, turbine models with more than 130m rotor diameter, the hub height of up to 140m and capacity of more than 3 MW are available for onshore wind. For offshore wind, these parameters are even much bigger – We have even recently undertook the conceptual design of a wind turbine model of 20 MW.

The turbine design process consists mainly of determining hub height, rotor diameter and corresponding changes in the major components. It is an iterative process to select suitable materials and optimise the design parameters for the lowest LCOE. The design process is run against multiple options to bring down the cost while ensuring maximum power output at every wind speed bin level while addressing specific meteorological conditions. The design process is different now than compared to 10 years ago in terms of iterations and granularity of the optimisation level. In DNV GL, a tool that we use to help our customers in the turbine design process is 'Turbine.Architect.' The tool supports turbine design and component technology development by quantification of the technical impact of design and component technology on both the turbine generator as well as the entire wind farm, from the foundation to the electrical infrastructure.

The tool builds a detailed virtual model of the turbine, with realistic load envelopes and strength margins, down to the level of tower plate thickness and sizing bolted ring flanges. With such detailed modelling, issues such as transportation geometry constraints and frequency of vibration interactions can be addressed accordingly. It considers the complete picture, by bringing together cost modelling of not just the machines but the balance of plant, operations and maintenance and economic aspects such as a discounted cash flow model where estimated costs and yield are escalated to LCOE and Net Present Value (NPV). All these factors allow for decisions to be made in the most comprehensive way.

Limitations to Bigger Turbines

It is expected that hub heights and rotor diameters would continue to increase, and wind turbine designs would continue to be optimized for the low wind site conditions. However, the bigger question is how far is this trend able to continue?

With higher hub heights and longer rotor diameters, wind turbines are able to harness higher wind speeds to generate more power; but the cost of wind projects also increase in the aspects of manufacturing, transportation and installation cost, including foundation costs. Once we have passed a certain point, the advantage of more wind and higher velocity may not be enough to compensate for the additional costs incurred. In fact, some of such wind turbine models are not techno-commercially suitable at sites where shear factors are relatively low.

Other than technical challenges, logistical issues from the transportation of wind turbines on Indian roads, and therefore installation, are also limiting the rise in wind turbine sizes. While there are innovations going on for navigating sharp road turns to accommodate the transportation of longer blades, this is still a challenge.

So, all in all, one can say that logistical challenges, as well as higher costs vis-à-vis gain in power output would put a limit to the increase in wind turbine sizes.

Software Upgrades

In recent years, we are seeing software updates by wind farm manufacturers to maximize power output to harness all possible wind bins from existing/installed wind turbines in given environmental conditions. Many manufacturers are now offering power booster and power performance optimization services, with options to operate turbines at wind velocities where cut-in speed is being lowered. Similarly, High Wind Ride Through (HWRT) is being implemented through a software upgrade where the operation of the wind turbine is extended beyond standard cut-out wind speed.

Aerodynamic Modifications

In addition to software upgrades, there have also been attempts to upgrade wind turbine hardware to improve efficiencies. Such performance upgrades mainly come from modifications where add-on of aerodynamic devices such as vortex generators, flaps, leading-edge repair, etc. improve wind turbine generation performance. Such add-ons increase lift, thereby increasing torque through delays in flow separation of wind, or increasing aerodynamic parameters for higher efficiencies at specific wind conditions.

Controller Optimization

Apart from the upgrades mentioned above, which can be applied to wind turbines that have been installed, we are also starting to see a rise in performance upgrades where modifications of controller settings allow turbines to operate at more than rated capacity under the specific condition that loads remain within limits that manufacturers have set. For example, through a modified controller setting, a 2.0 MW turbine can operate at 2.2MW, thereby increasing the power output by 10%. Other enhancements through control systems are for instance pitch optimization, improved soiling operations and uprating to improve performance.

At the wind farm level, some upgrades include wake optimization and better demand side management. These optimization techniques, applied alongside other modifications to individual wind turbines increase the overall production capacity of the wind farm.

Need for Reliability and Safety

While pressures to reduce LCOE of wind projects are leading to the optimization of wind turbine designs, it is also important that the structural integrity and safety of wind projects are not compromised. Earlier turbine models had enough design margin and therefore, many of them continue to operate even beyond their designed lifetime. However, given the current optimization practices, design margins have been significantly reduced and hence it is important that the whole value chain from manufacturing and installation to operation and maintenance are undertaken with highest standard and accuracy band. The wind industry has proven its reliability and safety through maintaining a very high standard for more than two decades, and it is in the very interest of the industry to maintain the same in future.

Snippets

Solar and Wind Power Costs in India will be Comparable to Coal in 2025: Moody's

Power generation from solar and wind projects will likely be cost-competitive relative to coal-based power in India in 2025-2030 period, according to Moody's Investors Service, the global provider of credit rating, research and risk analysis. "We expect the LCOE for new solar and onshore wind – both with battery storage – will be similar to the LCOE for new coal power in 2025, if the LCOE for the former declines at a CAGR of 8% – 16% from H1 2020 to 2025, and in 2030, if the LCOE range declines at a CAGR of 4% — 9% from H1 2020 to 2030," The firm said in a report. The numbers are broadly similar for India and China. It added that the LCOE for those renewable sources with the same storage battery capacity as generating assets declined at a CAGR of 23%-40% from H1 2018 to H1 2020 in China and India.

(Source: ET Energy World, November 19, 2020)

India Experienced First Decrease in Carbon Emissions in Four Decades

Lower energy consumption during the lockdown period related to COVID-19 and a decreased share of coal in the electricity mix has led to the first decrease in carbon dioxide (CO2) emissions in four decades in India. Though temporary, the country experienced a 15 per cent decrease in emissions in March and a 30 per cent decrease in April this year.

(Source: ET Energy World, November 17, 2020)

Blockchain Gets a Push in US Energy Standards Board

The North American Energy Standards Boards (NAESB) puts blockchain and cybersecurity at the front of digital technology standardisation drive. Other technologies and areas reviewed in the digital report include cloud computing, deployable shareware, 5G, energy usage data, data governance requirements, renewable energy certificate tracking, Internet of Things and data analytics.

(Source: Smart Energy, 8 December 2020)