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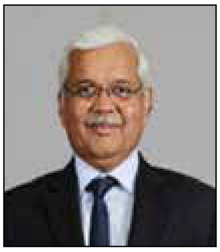
Wind Turbine Generators: The Evolution of Tower Technology



Vinod R Tanti, Chief Operating Officer (COO), Suzlon Group

One of the most important components of a wind turbine is its tower.

Often the importance of the role that the tower plays in the design of a wind turbine goes unnoticed. Most people assume its primary function to be carrying the nacelle and rotor to which the blades are attached. However, the tower is responsible for many more functions, one of which is to raise the turbine above surrounding obstacles and to a height where clean and unobstructed wind becomes available and harvest the maximum wind energy by accommodating the suitable size rotor dia. Furthermore, the tower needs to absorb the large static and dynamic loads brought about by the power of varying wind.

Given its role in the smooth operation of a turbine and in effective energy generation, the tower has undergone a large amount of innovation in design and construction over decades. This has resulted in numerous types of towers, each catering to set of conditions and circumstances. The height of the turbine, the wind conditions and the type of land – flat ground, mountainous terrain, thick covering of tall trees or rocky and uneven ground – are all important aspects of the tower design. Each of these factors plays a role in determining the most effective tower structure that will provide the desired result of stability, height and load bearing capacity.

Up until 15 years ago, lattice towers were the norm for wind turbines. Manufactured with welded steel profiles, they offered the advantages of a sturdy base that could better absorb the buffeting of winds with reduced wear and tear. Furthermore, when compared to the more recent tubular towers, they required less steel, thereby offering a large cost advantage. However, when height became a consideration to overcome the problem of low wind, lattice towers fell short.

Many regions were left untapped because their wind resources were not strong enough at the prevailing wind turbine heights for adequate generation. Capitalising on cleaner and stronger winds required an increase in hub height. The solution was to develop taller turbines. The science behind this is quite simple. A wind turbine's power output is a function of the cube of the wind velocity and density. As a result, a small increase in wind speed, as felt by a taller tower, will have a large impact on energy generation. The height of the tower is thus dependent on the cost of manufacturing such a tall tower versus the increase in value brought on by increased generation.

Another advantage of a taller tower is to tap air that is less turbulent resulting from absence of obstructions such as trees and buildings. Towers under 100 metres in height can face greater wear and tear due to higher wind turbulence as a result of a higher number of obstructions. Taller turbines overcome this drawback as they face less turbulent winds, increasing their life. Hence, the fact that taller towers were the next step in tower technology evolution was a given. The question then became one of how, because lattice towers could not accommodate such heights. In fact, lattice towers were optimum until the height of 60 metres. Consequently, when the time came for towers that were over 60 metres in height, wind turbine manufacturers made the move from lattice to tubular towers.

Tubular towers are built in individual sections of 20 metres to 30 metres each and flanges at either end. With a tower that has a thick base and narrower top, the tower is made logistic-friendly by being bolted together only once on-site. The conical shape allows for greater cost efficiency than a straight tower and greater stability through a wider base. However, the tubular tower too has a height limitation. When applied to turbines of over 100 metres, the design needs to incorporate a thicker base. This adversely impacts the cost. Furthermore, this design becomes unfeasible for transport, resulting in applicability to only those sites that are accessible through unobstructed roads or vessels and availability of required size steel plates and manufacturing infrastructure. Some players in the industry have achieved success on the design, transport and installation of such tubular towers that go up to 120 metres.

Suzlon, however, took a different path. With the innovation of a hybrid tower, it presented itself as a solution in going higher than conventional towers.

The hybrid tower is a combination of a lattice tower and a tubular tower. A tubular tower is attached to a lattice base with a unique transition piece. Placed on top of a lattice base, the transition piece acts as a elevated foundation for the tubular sections of tower, allowing the transition from one type of tower to the other to be stable, safe and effective. Although completely constructed using steel, the hybrid tower offers the advantage of reduced material usage and therefore less weight.

The lattice base uses 33% less concrete in its foundation than a tubular tower of the same height would, resulting in reduced cost of foundation.

In fact, the hybrid tower is evidence of weight optimization in tower design. A reduced mass per kW of energy, through reduced steel usage, translates into increased natural resource saving and greater environment-friendliness. Testament to this is the fact that at a height of 120 metres, a tubular tower would weigh much higher, as compared to a hybrid tower.

Furthermore, its wide stance, achieved through the lattice tower base as opposed to a tubular one, offers enhanced stability, cohesive to achieving greater height. This allows the wind turbine generators to scale new heights where wind speeds and consequent generation are greater. As a result, sites that remained previously unviable become viable, overcoming the limitations of windy site scarcity.

Logistics play a very important role for the advantage of cost, time and other related risks. Hybrid towers overcome numerous potential problems and offer increased accessibility as they are also constructed on site. This makes them more logistic-friendly and consequently, cost effective. It also provides local employment.

Hybrid towers are increasingly becoming the norm as the industry moves towards higher hub heights. Suzlon too has embraced this step and introduced the S97 and S111, the latest innovations from our 2.1 MW platform of products. The S97 120m turbine is, in fact, the highest all-steel tower wind turbine in the world at a height of 120 metres. Keeping with the national movement to increase investment in, and use of, renewable energy, Suzlon's hybrid towers have been designed to lower the Levelized Cost of Energy (LCoE) and offer a safe and secure investment with excellent, long term Return on Investment (ROI). These hybrid towers combine a lattice base with a tubular tower, brought together with a unique transition piece. As a result, we have been able to scale a height of 120 metres and open up those sites that were previously unusable due to low wind resource. The evidence of design success lies in the fact that the prototype of the S97 120m hybrid tower, commissioned in Gujarat in June 2014, has achieved a 35% Plant Load Factor (PLF) which is higher than the industry average of 25% to 30%.

But there is more than meeting the need for height, reduced weight, reduced cost and greater stability that goes into designing a hybrid tower. Tower technology, in practice, is heavily reliant on quality control. A flawless design can be rendered ineffective if not supported by quality control and stringent parameters that are analysed for optimum versus actual.

Wind turbine manufacturers need to ensure that their towers can accommodate heavy static and dynamic loads. Tolerances, which can be allowable as deviations from the set design parameters, need to be kept at a minimum. This can be achieved through quality checks at every stage of manufacture and installation.

Another point of consideration during the manufacture of towers and tower components is production time. The difference in production cycle time can affect customer decision when selecting a renewable energy partner. How successful a plant is, and how optimized its production cycle time is, depends on its setup. Suzlon, for instance, uses a linear production setup that places heavy focus on manpower. It gives us a 16 day production cycle, which is at par with industry standards.

To conclude, it can be stated that the tower is the foundation on which a turbine is installed. The time now is for taller turbines that enable larger rotors/diameters. History proves that necessity is the mother of invention – lattice towers gave way to tubular towers, and now we are moving towards the technology of hybrid towers. Yet, regardless of the type of tower, what remains consistent is the advantage of cost, weight, logistics, and production time. One these aspects, tower technology across the industry remains common; and the aim is to bring about the best in each aspect while also maintaining quality and minimising deviations from design.

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Theme of the Next Issue

The theme of the next issue of Indian Wind Power is "Gearbox Technology".

We invite relevant articles to the theme. We solicit your cooperation.

Editor