The forgotten case of small wind turbines

Wind energy systems are expected to play a crucial role in meeting India's ambitious goal of 450 GW of renewable energy installed capacity by 2030, which includes 140 GW of wind energy. In addition to large wind turbines, small wind turbines with less than 50 kW capacity can contribute to this goal. Further, small wind turbines generate decentralised power and reduce energy bills for consumers and power purchase costs for distribution companies, as well as help manage peak demand periods.

These smaller turbines can be installed on telecom towers, coastal areas, and rooftops of houses or industries and in rural hamlets with unreliable electricity supply. If installed in conjunction with a solar photovoltaic (PV) system (a hybrid system), the combined levelised cost of electricity (the average net present cost of electricity generation) may be less than that of a solar PV system with battery backup. Small wind turbines installed in areas with good wind resources can generate more energy than other decentralised renewable energy sources, thereby lowering the cost of energy. As per the Ministry of New and Renewable Energy's Annual Report 2018-19, the penetration of small wind turbines in India is significantly low, with a cumulative installed capacity of 3.35 MW for small wind and hybrid systems. The reasons range from the lack of a conducive policy environment to challenges in wind resource assessment and testing.

Why Small Wind Turbines are Not Taking Off

Wind resource assessment is site-specific and is greatly influenced by the presence of buildings, trees, and other obstacles. For the optimal performance of small wind turbines, an extensive wind resource assessment is needed in the immediate vicinity of the installation site. Small wind practitioners cannot afford wind resource assessment campaigns and, thus, rely on open-source wind resource data, such as that available on the Global Wind Atlas, and expert opinion. The Global Wind Atlas relies on vertical and horizontal extrapolation of measured wind data and does not consider the effect of buildings and other architecture. The meteorological masts that measure wind speeds are usually located far away from the installation site, leading to a risk of wind speeds being over-predicted and the wind turbine not functioning as expected.

Additionally, India inherently is characterised by a low wind speed profile, thereby reducing the number of potential installation sites for small wind turbines. The wind closer to the ground and at rooftops is more turbulent, with speeds lesser than 2 m/s. Although small wind turbines require low wind speeds (as low as 1.5 m/s) to start spinning, the speed needed to produce the rated power (around 5 m/s), may not be available. Thus, more research is needed to design small wind turbines with good aerodynamic performance at low wind speeds. The small wind turbines should also be strong enough to withstand wind turbulence.

The certification process for small wind turbines with the National Institute of Wind Energy is time-consuming and involves the installation of wind turbines on-site for a year. To circumvent this process, suppliers choose to self-certify their turbines.

Compared with the decrease in the cost of solar PV systems, the decrease in the cost of small wind turbines over the years has not been significant. A 1-kW solar rooftop system without a battery costs INR 40,000–70,000, whereas a 1-kW small wind turbine without a battery costs INR 80,000–1,00,000. The higher cost of small wind turbines is primarily because of the lack of economies of scale. The small wind turbines with permanent magnet generators typically require expensive rare earth materials, such as neodymium.

In 2010, the Ministry of New and Renewable Energy launched a small wind and hybrid system programme by providing a capital subsidy of INR 1–1.5 lakh/kW. The scheme ended in 2017, without any policy-level support from the government since then.

The Way Forward

The cost of small wind turbines can be reduced by substituting high-cost materials with low-cost materials, such as aluminium, nickel, and cobalt, and by incentivising production economies of scale. Domestic wind turbine component manufacturing can be included in the Production Linked Incentive scheme, similar to the inclusion of domestic solar PV manufacturing.

Besides, the use of urban wind modelling software that simulates the mean wind speed profiles in the city could solve the uncertainty associated with wind resource assessment. Such software would apply computational fluid dynamics principles, take meteorological-mast-measured wind speeds and digital surface models as inputs, and simulates the mean wind speed profiles for a city.

More research and open-source software are needed to model small wind turbine performance and aerodynamics with high accuracy. Novel small wind turbines, such as airborne wind turbines tied to a tether and flying at 100–150 metres above the ground, can resolve the issue of low wind speed profile at lower altitudes. These systems have been deployed in the Netherlands and the United States.

Meanwhile, the certification process can be speeded up by testing small wind turbines in a wind tunnel that simulates different atmospheric conditions.

To summarise, the small wind sector requires open-source software to improve modelling accuracy, further research on turbine testing and component manufacturing, and a stronger policy push from the government.

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