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The Effects of Leading Edge Erosion on Wind Turbine Blades

Key Findings

- The increase in wind penetration brings new and different operational challenges.
- Leading Edge Erosion in turbine blades can have an impact on annual energy production.
- Having a routine maintenance schedule to inspect blades will help identify these issues earlier.

What has changed?

As the nation's fuel mix evolves to include more renewables, it is important to understand the challenges that arise from incorporating these resources into the bulk power system. In 2018, the United States added 6.6 GW[1] of wind generation with another 11 GW[2] scheduled to come online in 2019. In some areas of the country with a large wind resource, during certain periods of time, wind generation can make up over 50 percent of the resource mix. (See Figure 1.)

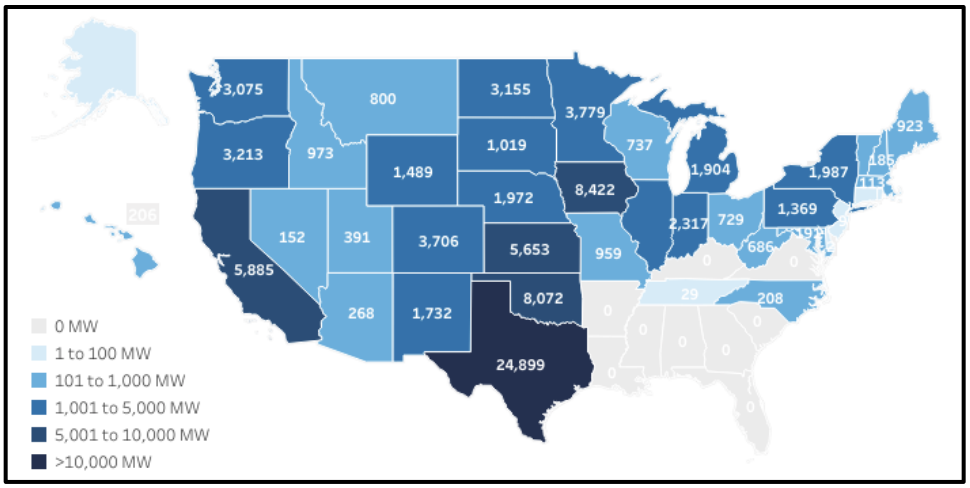

Figure 1: Wind Capacity by State

Source: AWEA

With wind technology becoming more mature and widespread, resource planners and plant operators need to understand how to maintain these turbines to ensure they are running in optimal conditions. As wind resources penetrate more of the electric power sector, identifying the operations and maintenance issues that arise will be important for future wind owners and operators. One such issue to understand is leading edge erosion. According to the Department of Energy's Sandia National Laboratories, "[l]eading edge erosion is an emerging issue in wind turbine blade reliability, causing performance decreases and additional maintenance costs."[3]

[1] Energy Information Administration's (EIA) Today in Energy, "More than 60% of electric generating capacity installed in 2018 was fueled by natural gas", March 2019, available at: https://www.eia.gov/todayinenergy/detail.php?id=38632.

[2] EIA's Today in Energy, "EIA forecasts renewable will be fastest growing source of electricity generation", January 2019, available at: https://www.eia.gov/todayinenergy/detail.php?id=38053.

[3] Maniaci, David. "Leading Edge Erosion". (Sandia Study) Available at: https://energy.sandia.gov/energy/renewable-energy/wind-power/blade-reliability/leading-edge-erosion/.

What is the impact on cooperatives?

Nationwide, electric cooperatives own about 470 MW of wind capacity, with another 7,100 MW under long-term contract. Most cooperatives do not own and operate wind turbines, largely because they cannot directly take advantage of the tax incentives for wind production. With the wind production tax credits phasing out for new projects commenced after 2019, there could be potential opportunities for cooperatives to invest in wind plants directly and understanding the maintenance issues of these renewable resources will help cooperatives plan. So, it is important that, as cooperatives look to their future investments, they understand the complex maintenance issues that may arise.

What do cooperatives need to know or do about it?

Wind turbines are more directly exposed to the natural elements such as rain, snow, and sleet than other generation types and with that exposure comes different challenges. Researchers who have been studying leading edge erosion in wind turbines point to moisture as the potential root cause due to the compounding nature of both rain drop and wind turbine speed: "The erosion process on wind turbine blades typically starts with the formation of small pits near the leading edge, which increase in density with time and combine to form gouges. If left to the forces of nature, the gouges then grow in size and density, and combine to cause delamination near the leading edge."[4] (See Figure 2.)

Figure 2: Wind Turbine Blade Erosion
Source: Armour Edge

As tower heights and blade tip speeds increase on newer wind turbines, design standards have not kept up with the rapid pace of change to account for this issue. Some wind owners and operators are seeing this degradation in blades as early as two years into commercial operation, but it is more common in blades that have been in operation for 6 to 8 years. Many industry stakeholders note that if erosion is left uncorrected, a wind turbine could see a drop in annual energy production, with some researchers pointing to a 5 percent loss per year if erosion is not repaired.[5] They also noted that continuous monitoring of the blades in regular maintenance intervals – whether by drone, camera, or technician – is important to detecting and addressing this maintenance issue. Leading edge erosion can advance to larger issues, such as holes in the leading edge or increase in moisture in blade tips, that could result in catastrophic blade failure in the event of a lightning strike.

There are many leading edge protection (LEP) materials on the market that wind technicians can use to protect against leading edge erosion or to repair damaged blades. Tape, epoxy putty, or other materials can be applied to the edge of the blade, but properly applying these LEP materials requires the optimal curing

[4] Sareen, Agrim, Sapre, Chimay A., Selig, Michael S. "Effects of leading edge erosion on wind turbine blade performance". Wind Energy. 2014; 17:1531-1542, available at: https://m-selig.ae.illinois.edu/pubs/SareenSapreSelig-2014-WindEnergy-Erosion.pdf.
[5] Sandia Study

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environment, including wind speed and ambient temperature. Industry stakeholders note that it can take up to one day to repair blades with erosion issues if the damage is minimal. Some turbine blade manufacturers offer to add LEP to their blades before they leave the factory to prevent leading edge erosion.

Additional Resources:

For more information on wind generation operation and maintenance:
https://www.cooperative.com/programs-services/bts/Pages/TechSurveillance/Wind-Generation-electric-cooperatives.aspx

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