A new winter solution: the case for an icephobic coating

As climates shift and weather events become more extreme, it is imperative that wind farm owners and operators prepare for the worst that the cold season has to offer. Ice-based downtime significantly reduces the efficiency, and therefore the profitability, of wind energy installations worldwide. This issue is compounded by the increased energy needs of the communities these installations service in winter.

The industry solutions to combat the effects of cold seasons have been largely stagnant, focusing primarily on removal: hosing down blades with de-icing agents or hot water shot from platforms or helicopters. The sector has also seen the introduction of heated and vibrating blades to prevent the formation of ice. While the latter solutions have proven effective under certain circumstances, they also require costly retrofitting or new installations and require the very same power the turbine is producing to function. Just this year, there was even a report of diesel generators being used to keep turbines from freezing.

These methods are costly. They take time, labor, and a great deal of maintenance. Thus, it is increasingly apparent that ice removal is an imperfect solution to an all too common problem facing owners and operators. There is hope, however, in the future of ice mitigation through the use of icephobic coatings. Phazebreak has developed a patented product, NEINICE, designed to combat ice formation, decrease the length of winter storm downtime, and speed up the recovery process following an ice-related shutdown event.

The switch to a coating-based solution provides certain advantages over removal procedures. The NEINICE coating is significantly less expensive than removal methods, does not add to the maintenance requirements of a blade, except in the case of reapplication, and can work in tandem with heated blades, LPs, and LEPs currently used in the industry. It can be applied with the simple use of rollers, sprayers, or most excitingly, through the use of robotics. Furthermore, coatings add negligible weight to the blades and do not interfere with aerodynamics or alignment. Throughout the life cycle of NEINICE, up to five years depending on the frequency and severity of storms, the time and money required for upkeep are minimal.

Since its inaugural application in 2018, Phazebreak has been perfecting its patented NEINICE icephobic coating and has deployed the product on over 8,000 blades globally. During that time, the company has continued to collect data demonstrating the efficacy of these new solutions.

Just months before the 2021 Valentine's week winter storm that devastated Texas and Oklahoma, Phazebreak had applied NEINICE to 50 turbines on an Oklahoma wind farm and left 50 uncoated as a control measure. What followed was a six-day ice event that ravaged the power grid and caused auto shutdowns across the installation. The operator of the wind farm looked at the data from that storm and reported that the coated turbines had recovered from icing a full day earlier than their uncoated counterparts, and had a 109% improvement in power production.

Though the coated turbines were not able to avoid auto shutdowns entirely, the 24-hour head start into the recovery phase represents thousands of dollars of revenue and desperately needed power being generated.

A separate wind farm in Minnesota experienced its own week-long event just after Christmas of 2022. Again, the wind farm had a mix of turbines coated with NEINICE and uncoated controls. In this instance, both sets of turbines were performing at the same efficiency until December 27th, when both sets were battered by ice and shut down. However, the uncoated turbines' power output continued to flatline until December 31st. Meanwhile, the coated turbines were able to recover and begin producing power at intervals once again, sometimes reaching pre-event levels. Even when the uncoated turbines came back online, they struggled to produce as much power as the coated turbines. Finally, a full eight days after the event began, both sets of turbines returned to pre-event production levels.

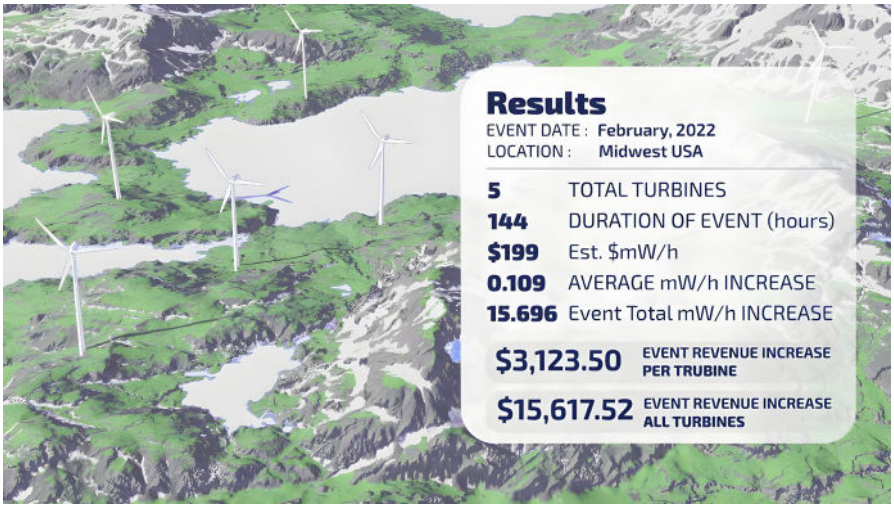
So how do these events translate into actual revenue increases? This was a question that Phazebreak asked in 2022 when the company developed a real-world case study with the help of a customer. From this investigation came what the company has dubbed a 'revenue calculator', which determined the average increase in mW/h seen on five of the customer's coated turbines compared to their uncoated turbines, and extrapolated the increase in revenue that they saw in a single six-day icing event.

In this case, the customer priced the energy they produced at $199 per mW/hr and saw an increase of 0.109 mW/h in their coated turbines during the storm. This meant that they had seen an overall revenue increase of $3,123 on each turbine and an overall increase of $15,617.

This revenue was generated through a reduction of auto-shutdowns and a speedier recovery period for the turbines with icephobic coatings. This increase goes a long way towards covering the costs of application in a single ice event. Since the coating is able to perform for multiple years, this means that an application could quickly pay for itself and continue to generate extra revenue.

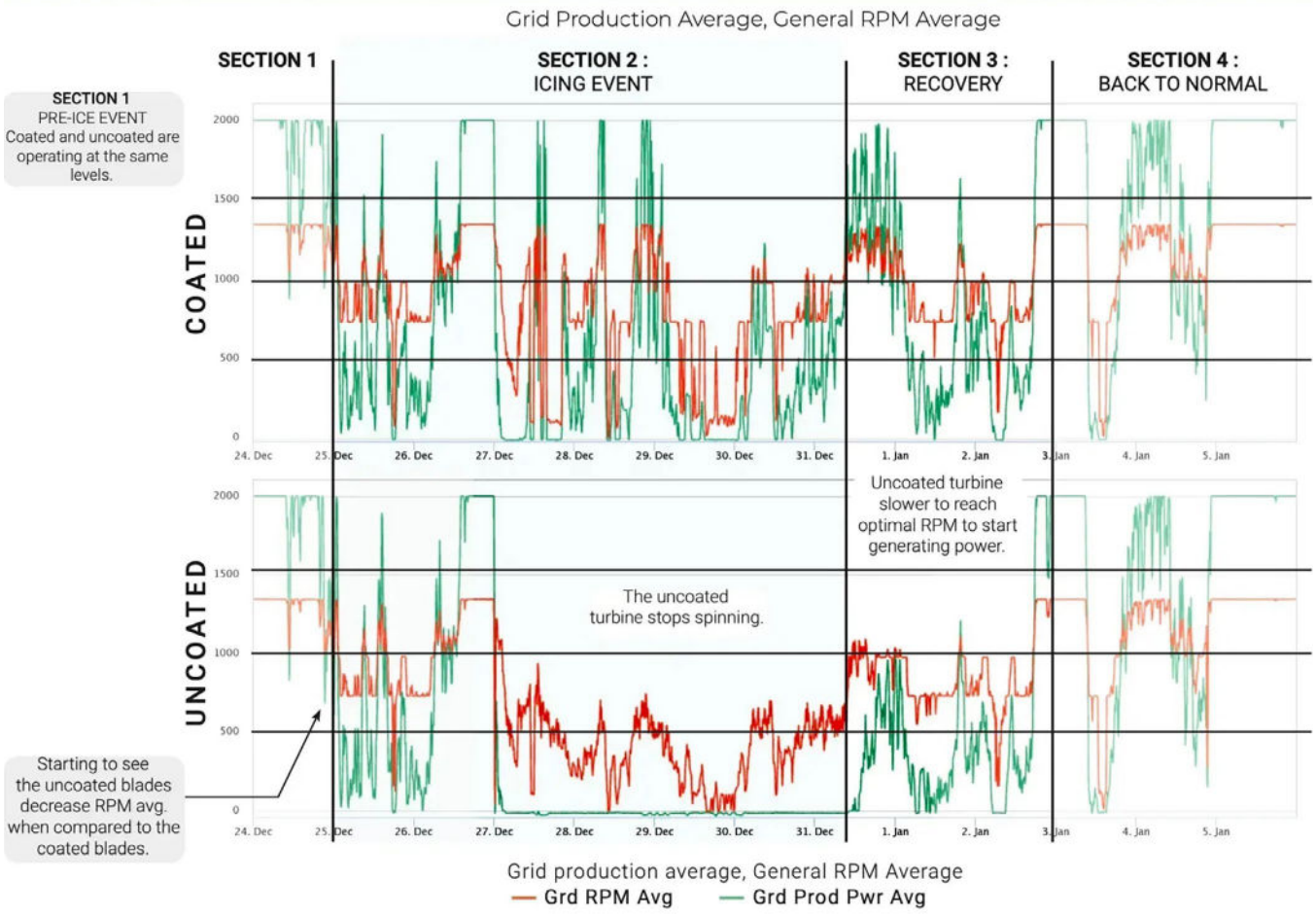
When it comes to application methods, the standard procedure for new installations and repowers is an on-ground application that can be accomplished with a small crew using paint rollers and step ladders. These applications are the easiest and cheapest to accomplish when looking at an icephobic coating solution. However, they are not an option for newly established installations that do not plan to repower in the near future.

For uptower applications, until now the process has always involved platform or rope access. While these methods can work, they can be costly and inconvenient. High winds can limit the time that can be spent working, and crews have to fight against the pot life of any coating they may be working with, a much easier task when not suspended hundreds of feet in the air. However, recent developments in robotics have changed the face of coating applications.



Through Phazebreak's close partnership with Aerones, customers are able to deploy NEINICE efficiently, safely, and with shorter downtimes. Aerones' robots are capable not only of performing standard maintenance to turbine blades but of coating up to two turbines in a single day. The coating is loaded directly into the robots, so the issue of pot life becomes non-existent, as does any user error in the finish of the coating. As the robot passes over the leading edge of the blade it is able to ensure clean, even coverage. Best of all, Aerone's robots are

Icephobic coatings represent a promising new addition to the tools that wind farm operators have to combat wind turbine icing.



able to work at higher wind speeds than human crews, so inclement weather presents less of a threat.

While there are already numerous benefits to using icephobic coatings such as NEINICE, more testing, and new formulations are always being sought. One such formulation in the works is NEINICE Flex, a version of the coating with added flexibility for use on powerlines, cables, and other materials that need increased give to properly function.

Studies into the possible application of these coatings in the solar industry are currently underway, as the coating not only provides a self-cleaning hydrophobic surface but also increases the impact resistance of the panels. This could provide solar panels with protection against flying debris and devastating hail storms.

Icephobic coatings represent a promising new addition to the tools that wind farm operators have to combat wind turbine icing. Whether deployed on their own or working in tandem with current methods of removal, as these mitigation-focused materials evolve, they could eventually lead to great strides toward the year-round reliability of wind energy.

www.phazebreak.com