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Boost Financials By Improving Collector System Performance

Adequate collector system design, installation and commissioning can strengthen a weak link in today's wind farm reliability chain.

BY BEN LANZ AND BRUCE BROUSSARD

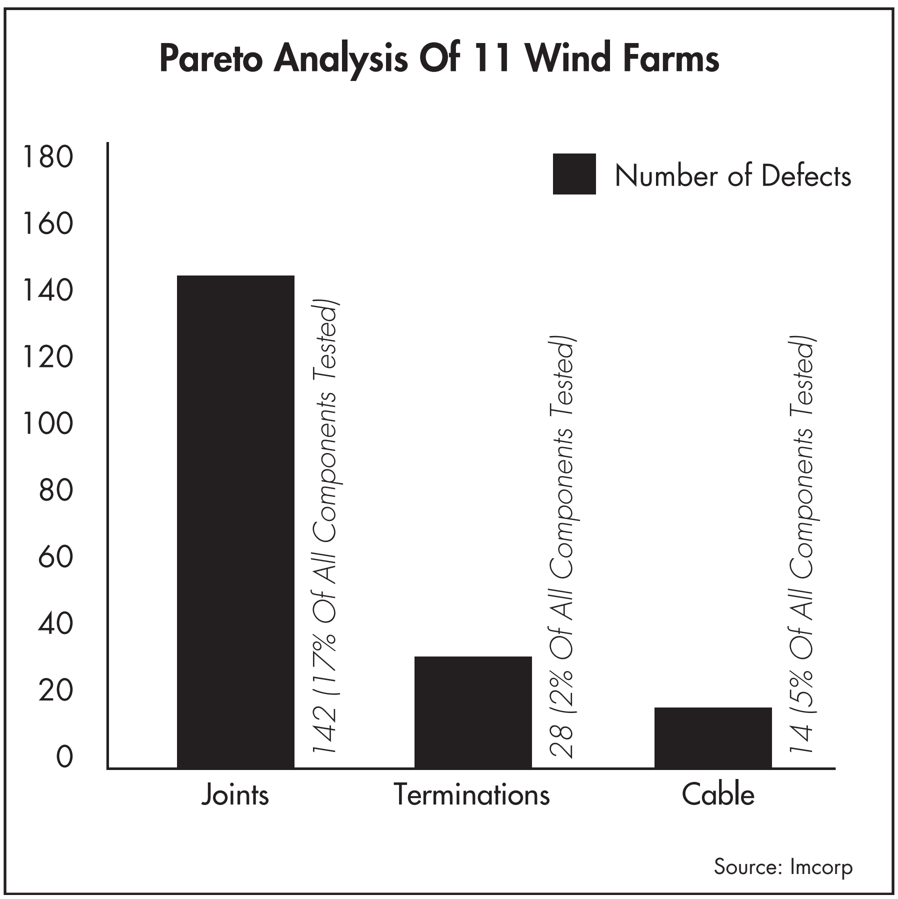
It is 10 degrees below zero, and the wind is howling across the mountaintop, causing the tower blades to spin with great velocity. The MWh meter is churning out the pure clean renewable energy when the electrons stop flowing suddenly and the abundant harvest of the precious energy is lost.

It is peak production time for this wind farm, a time that leaves no room for error if the owners are to maximize the return on their investment. Yet, not everything that could have been done to assure the productivity was done, therefore hurting the financial performance of the site.

To take this dramatization one step further, the snow is three feet deep and the ground is frozen. While the site operator is certain that his collector system has failed, it is going to be days or even weeks before the fault can be repaired. These failures could result in tens of thousands of dollars in lost revenue, damaged equipment from fault currents and degradation of existing equipment.

Under these extreme environmental conditions, the emergency crews would have to wait for reasonable weather conditions to avoid frostbite, then attempt to get equipment in place to fault locate, followed by a couple of days to thaw the ground. Finally, they will attempt to move the excavation equipment in place to make the repairs. On hillsides and in the wilderness, this is a challenging and costly task to which most site managers can relate.

Could this scenario have been avoided? Absolutely. But at what price? Wind farm developers face decisions of this nature throughout the planning, engineering, construction and operating phases of their site's lifecycle.



Although many will spend their time and investment on turbine-centric activity to assure the availability of their energy producing assets, there is a much overlooked area that can return significant financial rewards if addressed early on in the design, construction and commissioning phases of the site development.

Adequate collector system design, installation and commissioning can provide a tremendous payback and help strengthen one of the weakest links of today's wind farm reliability chain.

Financial analysis

Deciding to design, install and commission a site's collector system for reliability requires a thorough analysis of all of the risk assumed when a traditional status quo approach is taken. A closer look provides a clearer picture of how devastating a collector system outage can be to the financial performance of a wind farm.

The costs associated with a collector system failure include lost revenue, emergency fault location expenses, emergency repair, excavation, equipment, and future lost cable life due to harmful fault location techniques. On the basis of one such dramatic failure, the added costs associated with a reliable commissioning diagnostic test clearly can be justified.

A partial discharge diagnostic evaluation conducted offline at 60Hz is presently the most reliable and cost-effective commission test available. Due to the widespread cable collector system failures documented, performing 60Hz offline partial discharge diagnostics to commission a cable collector system is a prudent risk management decision.

The following example of a wind farm with 50 2 MW turbines that experiences a homerun collector system cable fault illustrates this point.

With 18 2 MW turbines producing 16,200 kWh (45% utilization) at $.05/kWh, production is worth approximately $810 per hour. If it takes 24 hours to locate, excavate, repair and re-start the system, the lost production equals about $20,000. Include an additional $12,000 for emergency response and repair cost, and the total out-of-pocket expenses for a single failure escalate to approximately $32,000.

At $20,000 in lost revenue per day, imagine the losses that would add up if repairs were not possible until spring due to extremely harsh environmental conditions. Every week of downtime would amount to more than $140,000 in lost revenue.

Design tips and best practices

Many parameters play a role in the design of a reliable collector system. Parameters that are known to contribute to collector system reliability are

- neutral shield size
- cable length
- cross-bonding
- conductor crimp tools
- number of joints installed
- thermal properties of the soil
- joint design, and
- quality of cable purchased.

The following are best practices related to each issue considering economic, operability and reliability tradeoffs.

Neutral shield size should be 1/6th of the conductor cross section or greater. This assures that the thermal effects due to system harmonics are considered, faults will not burn a large section of the neutral shield and non-destructive fault location techniques and partial discharge (PD) diagnostics will be effective.

Cable section lengths should be limited to 1.5 miles (8,000 feet) between sectionalizing cabinets. This allows faults to be sectionalized and non-destructive fault location and PD diagnostics to be effective. These cabinets provide great accessibility for cross bonding, fault location, and PD diagnostics, and they help minimize the number of buried joints.

Cross-bonding should only be used where the interconnections are accessible above ground. Cross-bonding points are inherently unreliable because they are labor- and skill-intensive. When the cross-bonding points are accessible, they are simple to install and allow non-destructive fault location and PD diagnostic techniques to be used. Junction boxes with separable connectors serve this purpose well.

Conductor crimp tools and methods should be specified and verified. Although a simple process, the correct installation of the conductor crimp will prevent joint reliability issues.

The number of joint installations should be minimized. Joints are the most unreliable part of the cable collector system.

Thermal properties of the soil surrounding the cable should be tested and accounted for in the design. Ampacity calculations are only valid if the thermal profile of the cable is known.

Buried and non-separable T and Y joints should never be used. They are inherently unreliable and unnecessary as junction boxes when separable connectors are available. T and Y designs cannot be properly commissioned with PD diagnostics and make finding a fault exponentially more difficult and harmful to existing cable assets.

Cable manufacturers should be specified and their quality control programs verified. Their factory acceptance tests should be scrutinized, verified or witnessed. This will assure that quality name brand products with good reliability are used and costly warranty battles are prevented.

Joint design should be simple, and an application-specific training should be required. Although heat shrink joints are robust when installed correctly, cold shrink designs tend to be more user-friendly and thus are more likely to be installed correctly. Training by the manufacturer on the specific joint design is recommended to assure that crews understand the installation process.

Commissioning process

The key to an efficient and effective collector system commissioning process is proper planning and preparation. The implementation process of a cable reliability assurance program is the vehicle that will deliver robust reliability assurance at the lowest possible cost to your collector system.

The process consists of five steps. Each step is broken into tasks, and the tasks are broken down further into action items. Following this process will ensure the wind farm collector system will last the predicted life with the highest reliability at the lowest possible cost.

Operational challenges

Intelligent tools are available that can ensure that failures on cable collector systems are being avoided. Many wind farms constructed over the past decade continue to experience reliability challenges as a result of ineffective DC and VLF high potential (Hipot) commissioning methods.

Today, some operators of large wind farms are beginning to capitalize on their ability to manage a reliable collector system using offline PD diagnostics.

"It is difficult on a wind farm to maintain high turbine availability when the collection system is unreliable," says a recent wind farm customer about his experience with offline power frequency PD diagnostics. "Wind farm cable failures will never happen at a convenient time. Offline power frequency PD diagnostics is the proactive approach to collector system reliability. Proper planning and preparation is key to minimizing down time and a successful cable reliability program."

The purpose of the commissioning processes is supposed to be to eliminate these issues before the site goes into operation, even though IEEE400-2001 standard section 42 indicates that "even massive insulation defects in extruded dielectric insulation cannot be detected with DC." Many still believe that these Hipot methods will give them the capability to insure collector system reliability.

Tom Wier, a consulting engineer at Stantec in Portland, Ore., who designs wind farm electrical systems, clarifies. "The offline power frequency partial discharge diagnostic method duplicates the cable manufacturers' test procedures as close as technically possible for a field test. It is the best way to insure not only that cable and accessories meet the established IEEE cable system standards, but also that the installation of the system will meet the criteria also."

It is true that the withstand/breakdown practices have been around in the power utility industry for many decades, but the expectation that commissioning collector cable with these destructive methods (as indicated by IEEE standards) provides reliability is not realistic.

Technological advancements have made it possible to perform laboratory-quality partial discharge methods in the field to systematically compare IEEE PD thresholds and ICEA cable manufacturer's standards. The results pinpoint the defect location, identify the component (joint, termination or cable insulation) and indicate the urgency of the repair, while being compared to acceptable thresholds defined by IEEE.

Consider performing a survey of the system before the collector system warranty has expired. Furthermore, when purchasing a wind farm, be sure that out-of-sight underground assets are at an adequate quality level to assure the investment is protected.

Knowing that any lost production is costly, your cable diagnostics partner should work with you to minimize downtime by offering service options that increase the productivity of the diagnostic processes. Proper planning and preparation strategies are developed before the process begins to systematically work along with the customer to achieve the highest efficiency.

These procedures will provide the ability to manage any downtime and direct the reliability maintenance process. When considering a $30,000 to $50,000 cost (per a large wind farm operator) per failure, adequate cable diagnostic is an inexpensive insurance policy that can save lost revenue, damaged equipment, high costs of emergency crews and premature aging by destructive fault-locating thumping techniques.

Operation case study

One operational wind farm in Colorado with 1.5 MW GE turbines went online three years ago and has averaged three failures per year after the site had been commissioned with a DC Hipot before going into service. The failure cost was from $20,000 to $50,000, with a majority of the failures in the cable insulation. The site operator could only react by waiting for the failure and arranging for the emergency repairs. The problems were traced back to a cable manufacturer. As a result, the operator took action to perform an offline 60Hz PD diagnostics test.

The diagnostic crew was able to pinpoint each defect and recommended the necessary actions to correct each issue. As verification, the removed sections of cable were dissected at a laboratory. The wind farm owner proactively planned and strategically went through the collector system, identifying six defects in the cable insulation, four splices needing immediate repair and five 600A T-bodies experiencing PD at serious levels that would have led to failure.

This proactive approach prevented as many as 15 failures. PD diagnostic is able to pinpoint the location of defects in cable insulation, splices and terminations, while being compared to IEEE and ICEA standards. Remember, this is not an application of a stress voltage trying to fail or breakdown the cable as a Hipot is designed, but rather an intelligent tool to detect, locate and eliminate the defects before failure. WP

Ben Lanz is senior application engineer with IMCORP, a Storrs, Conn.-based provider of cable diagnostic equipment and testing services. Bruce Broussard is the company's vice president of operations, North America. They can be reached at (860) 427-7620.