New Jersey Small Wind Turbine Failure Analysis

Technical Services Agreement Summary

S. Hughes and L.J. Fingersh

Produced under direction of the State of New Jersey by the National Renewable Energy Laboratory (NREL) under Technical Services Agreement number TSA 11-372 and Task No WTAD.1000.

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

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NOTICE

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Introduction

Two safety-related incidents involving small wind systems occurred in New Jersey in 2011, prompting the New Jersey Office of Clean Energy (OCE) to temporarily suspend the wind component of the Renewable Energy Incentive Program (REIP). One incident occurred on January 8, 2011, at a home in Villas, New Jersey, and involved a fire in a 10-kilowatt (kW) Xzeres unit. The second incident occurred on March 2, 2011, on a site owned by Jim Knoeller in Forked River, New Jersey, and involved the separation of three rotor blades from a 40-kW Enertech E44A turbine. As a consequence of the rotor blade separation at the Knoeller site, a separate Enertech E44A turbine installed on a property owned by Spyro Martin (also in Forked River, New Jersey) was shut down, pending a determination of the cause of the rotor blade separation incident in Forked River. The Martin wind turbine was later put back into service after Enertech conducted an internal review and provided new blades with an alternate blade root attachment structure.

The New Jersey OCE contracted with the National Renewable Energy Laboratory (NREL) to conduct a thorough and comprehensive investigation of the two incidents at the Villas and Knoeller sites. This investigation included, but was not limited to visits to each site for a visual inspection of the equipment and surrounding areas; interviews with each of the customers, installers, and component manufacturers; and inspection of the blades, inverters, and other system components involved in the incidents.

Work was performed under a technical services agreement (TSA) with the State of New Jersey, TSA 11-372.

Xzeres Assessment and Recommendations

On January 8, 2011, a failure in the controls of a wind turbine at the residence of Mr. Dennis Hasson, in Villas, New Jersey, caused fires in the turbine nacelle at the top of the 97-foot tower, and in the turbine control electronics system located in the residence's garage. The wind turbine was a Xzeres Wind Corporation Model 442, with a rotor diameter of 23.6 feet, a rated power of 10 kW at 25 mph (11 meters per second), and a "swept area" of 442 square feet. The turbine was replaced with a new Xzeres unit that had electrical design improvements incorporated. The incident investigators provided a report to the New Jersey OCE that addressed the chronology and reasons for the incident, estimated future risks for this and similar products, and provided a number of recommendations based on their analysis (Fingersh, Forsyth, and Wills 2012).

The following recommendations are from the Xzeres work.

- Improve the present
  Villas 442 site by:
    - Replacing the Xzeres 442 turbine's electrical system
    - Posting the shutdown procedure on site
    - Training first responders
    - Inspecting other existing ARE and Xzeres 442 installations for potential problems
    - Adopting UL6142 requirements for small wind turbines
    - Allowing installation of Xzeres 442 wind turbines in New Jersey.

Enertech Assessment and Recommendations

The Enertech incident occurred on March 2, 2011, at the Knoeller site in Forked River, New Jersey, and involved the separation of three rotor blades from a 40-kW Enertech E44A turbine. As a consequence of the rotor blade separation at the Knoeller site, a separate Enertech E44A turbine installed at the Martin property (also in Forked River, New Jersey) was shut down, pending a determination of the cause of the rotor blade separation incident in Forked River. The Martin wind turbine was later put back into service after Enertech conducted an internal review and provided new blades with an alternate blade root attachment structure.

NREL contracted with Dynamic Designs and Wetzel Engineering to conduct a technical assessment of the failure of the Enertech E44A and its blades at the Knoeller site. Investigators collected information from all parties involved in the turbine's design, installation, and operation and examined the modified blades installed on the turbine at the Martin site. The investigators delivered a report to the New Jersey OCE that provided an assessment of the incident, an estimation of future risks, and a number of recommendations based on their analysis (Hughes 2013).

The primary conclusions of the Enertech blade failure assessment include the following:

- The Knoeller blades failed because of excessive stress concentrations in the blade roots
- Unbolstered blades present a high risk of failure
- Lack of documentation provided for this study prevented the investigators from endorsing the redesigned, bolstered blade configuration. As a result, investigators came to the following conclusions:
    - Discrepancies in data and information indicate a lack of design stability
    - Stress levels observed in the bolster-to-laminate bond in the characteristic model exceed certification body guidelines
    - Bolstered blades appear to represent a reduced, but still serious, risk of failure.
- The discrepancies in the approach used by Enertech in the design and testing of the turbine blades relative to the International Electrotechnical Commission (IEC) standards indicate that the turbine would not meet the IEC 61400-2 or IEC 61400-23 standards.

Compared to the level and amount of information that is normally expected for a rigorous design or certification assessment, this assessment was impaired by the limited amount of information provided by Enertech. Enertech did not provide the technical information needed to properly determine if the turbine conformed to a finalized and stable Enertech design, and whether or not the design met the Enertech-stated performance and reliability expectations (statements of compliance to IEC 61400-2, IEC 61400-23, or any other standards should be made by qualified certification agencies rather than manufacturers or designers).

In addition to the root cause of failure assessment, investigators provided protocol recommendations for accepting turbines into the New Jersey REIP (Hughes 2013). A draft report was circulated for comment and Enertech's responses were included in the Appendix.

The investigators recommended an incentive program that encourages rigorous design, testing, and manufacturing practices that are consistent with internationally accepted wind turbine standards. Although this is not a required or common practice, turbines with IEC 61400-1 type certification are subjected to the most rigorous design evaluation and testing requirements. Systems with this certification are most likely to perform according to specifications and offer high levels of reliability. The following recommendations were provided by the investigative team to the State of New Jersey for accepting small wind systems into its REIP:

- Require turbine certification to IEC standards by an agency accredited by the International Organization for Standardization
- Consider withholding incentives for systems with pending certifications until type conformity is issued from the certification body
- Scrutinize groups that provide turbine certification or evaluation services and/or require that they have proven competency in design evaluation and certification
- Consider allowing qualification for small wind systems by a noncertifying body. Because the small wind certification process is in a nascent phase, requiring IEC type certification may be too restrictive for emerging systems. Therefore, qualification by a noncertifying body may be an option for systems that fall into this category; however, this approach is open to interpretation as to what constitutes a qualified reviewing agency.

References

Fingersh, L.J.; Forsyth, T.; Wills, R. (2012). New Jersey Small Wind Turbine Failure Analysis.

Hughes, S. (2013). New Jersey Small Wind Turbine Failure Assessment. Enertech E44A Blades, Forked River, New Jersey