Innovative and Recyclable Thermoplastic Wind Turbine Blades

Currently, nearly all utility-scale wind turbine blades are manufactured using traditional thermoset resin systems such as epoxy, polyester, or vinyl ester. Decommissioned thermoset blades cannot easily or economically be recycled at the end of life, with the vast majority of them ending up in landfills. Researchers at the National Renewable Energy Laboratory (NREL) are working to change that.

Tapping into NREL's wealth of fundamental wind energy science research, development, and validation activities, NREL worked to develop a novel approach to manufacturing wind turbine blades using a thermoplastic resin system, which would enable blade recycling at the end of life, with industry partners Arkema, Johns Manville, TPI Composites, Huntsman, Strongwell, Sika Advanced Resins, Chomarat, Composites One, DowAksa, Creative Foam, and Chem-Trend, as well as the Colorado Office of Economic Development and International Trade, and Oak Ridge National Laboratory.

The team works to develop a blade using recyclable thermoplastic materials. *Photo by David Snowberg, NREL 41767*

Through the Institute for Advanced Composites Manufacturing Innovation (IACMI), this partnership supports efforts by the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy's Advanced Manufacturing Office to identify solutions to catalyze research, development, and adoption of energy-related advanced manufacturing technologies.

Advanced Composite Materials Evaluation

Next-generation advanced composite materials have several potential advantages NREL is working to harness, including enhanced sustainability and reduced carbon fiber costs. The research team evaluated several thermoplastic resin systems for use in the manufacturing process of megawatt-scale wind blades. A technoeconomic evaluation indicated that Arkema's Elium reactive thermoplastic resin provides the best path to commercialization as it requires 60% less energy to manufacture and can be infused and cured at room temperature.

Opportunity

Advanced composite materials, such as this new thermoplastic resin system, could lead to longer, lighter weight, lower cost, and recyclable wind turbine blades. Using these advanced materials, the team developed a 9-meter wind blade at NREL's Composites Manufacturing Education and Technology (CoMET) facility with impressive results:

- **Demonstrated potential for recycling at the end of a wind blade's life**
- **Potential to reduce the equipment capital costs associated with blade production by up to 30%**
- **Potential to decrease the critical cycle time during production by up to 20%**
- **Potential to improve durability in service and to enable easier blade repairs**
- **Technoeconomic analysis showing the reduction in the overall cost of the blade.**

NREL researchers used advanced composite materials to create a 9-meter recyclable thermoplastic wind turbine blade.
Photo by Samantha Rooney, NREL

Additionally, the foam core used in the 9-meter blade is made from post-consumer polyethylene terephthalate plastic.

The positive results from the 9-meter blade experiment show promise for further research and potentially full-scale experimentation. The team has validated blades between 9 and 25 meters long, but commercialization of this innovative technology will require demonstration of feasibility up 60 meter blade lengths and larger.

Path to Commercialization

The overall goal of the project is to provide a path to commercialization for thermoplastic resin systems and the compatible specialized fiberglass. As a follow-on to the IACMI project, Arkema internally produced a prototype 25-meter thermoplastic blade that is undergoing structural characterization. Arkema plans to manufacture three additional 25-meter blades for field validation on a wind turbine. NREL and IACMI will join forces with industry partners to continue to help with the commercialization process of thermoplastic resin wind turbine blades.

Contact

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