Researchers propose a new method for wind turbine blade recycling

April 23 2024

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While wind energy is becoming one of the fastest-growing energy sources in the world, wind turbine blade waste emerges as a critical issue. Addressing this urgent environmental concern, Lithuanian researchers have developed an innovative solution, claiming that the benefits of pyrolysis can help reduce pollution.

Wind turbine blades play a crucial role in harnessing renewable energy

but as these blades reach the end of their operational lifespan, the issue of disposal becomes a serious concern.

Made from composite materials, such as layers of fiberglass or carbon fiber reinforced with epoxy or polyester resin, these wind turbine blades can be used for 20 to 25 years. While these materials ensure the strength, lightness, and stiffness of turbine blades, they also significantly complicate the recycling of the equipment.

Pyrolysis: A promising strategy for wind turbine blade recycling

However, until a few years ago, wind turbine blades were almost impossible to recycle. Conventional disposal methods, such as landfilling, pose environmental risks and resource depletion. Globally, teams of researchers are looking for innovative solutions to these issues.

In 2022, Dr. Samy Yousef, a researcher at Kaunas University of Technology (KTU) Faculty of Mechanical Engineering and Design, and a team of researchers from the Lithuanian Energy Institute completed a series of experiments to find a way to recycle wind turbine blades.

Their experiments consisted of breaking down old composite materials, such as glass fiber-reinforced epoxy resin composites, in a pyrolysis process using a special catalyst. By doing so, they aimed to separate valuable components for reuse and recycle old composite materials into useful energy.

Previous experiments on samples of wind turbine blades have provided valuable insights into their composition and pyrolysis process. However, limitations in the availability of samples interfered with the identification of the actual recycling outcome. A need for a real wind

turbine blade to continue research was expressed.

In 2023, Dr. Yousef and his team continued their experiments. This time—on real wind turbine blade fragments, provided by a Danish company "European Energy A/S."

"In our new research, experiments were performed on fragments of real wind turbine blades, allowing the yield and composition of final products to be determined," says Dr. Yousef. The findings have been published in the journal *Environmental Research*.

The main component is dangerous to health and the environment

The analysis of several wind turbine blades revealed that unsaturated polyester resins are predominant in the production of wind turbines in the Baltic region due to their cost-effectiveness compared to epoxy resins. Styrene, a main component of polyester resin, poses significant environmental and health risks.

"When disposed of in landfills, it becomes highly toxic for humans and can cause lung cancer. In addition, styrene can pollute and poison groundwater and soil," explains Dr. Yusef.

To address this, the research team made of KTU and Lithuanian Energy Institute scientists successfully extracted styrene from blades in the form of styrene-rich oil using a pyrolysis reactor.

"The main goal of the research was to find a way to extract carbon fibers and resin from old wind turbine blades that are difficult to dispose of because they contain toxic substances and aren't biodegradable," says Dr. Yousef.

He adds that during the experiments the fibers, carbon and fiberglass were also recovered and purified through an oxidation process, offering a sustainable filler material to enhance the mechanical properties of composite materials.

In addition, the environmental impact of blade treatment using the pyrolysis process was calculated. Conducting the life cycle assessment, Dr. Yousef's team has discovered the significant environmental potential of blade waste pyrolysis compared to landfill disposal. In particular, regarding global warming, stratospheric ozone depletion, and fossil and mineral resource scarcity.

"Results revealed remarkable improvements in various environmental indicators, with enhancements that range between 43% to 51%. This is a great achievement," says Yousef.

However, Dr. Yousef emphasizes that the strategy still raises certain environmental challenges due to post-treatment processes such as washing and oxidation.

"These issues need to be carefully managed, and only then should future developments take place," he says.

More information: Samy Yousef et al, Recovery of energy and carbon fibre from wind turbine blades waste (carbon fibre/unsaturated polyester resin) using pyrolysis process and its life-cycle assessment, *Environmental Research* (2023). DOI: 10.1016/j.envres.2023.118016

Provided by Kaunas University of Technology