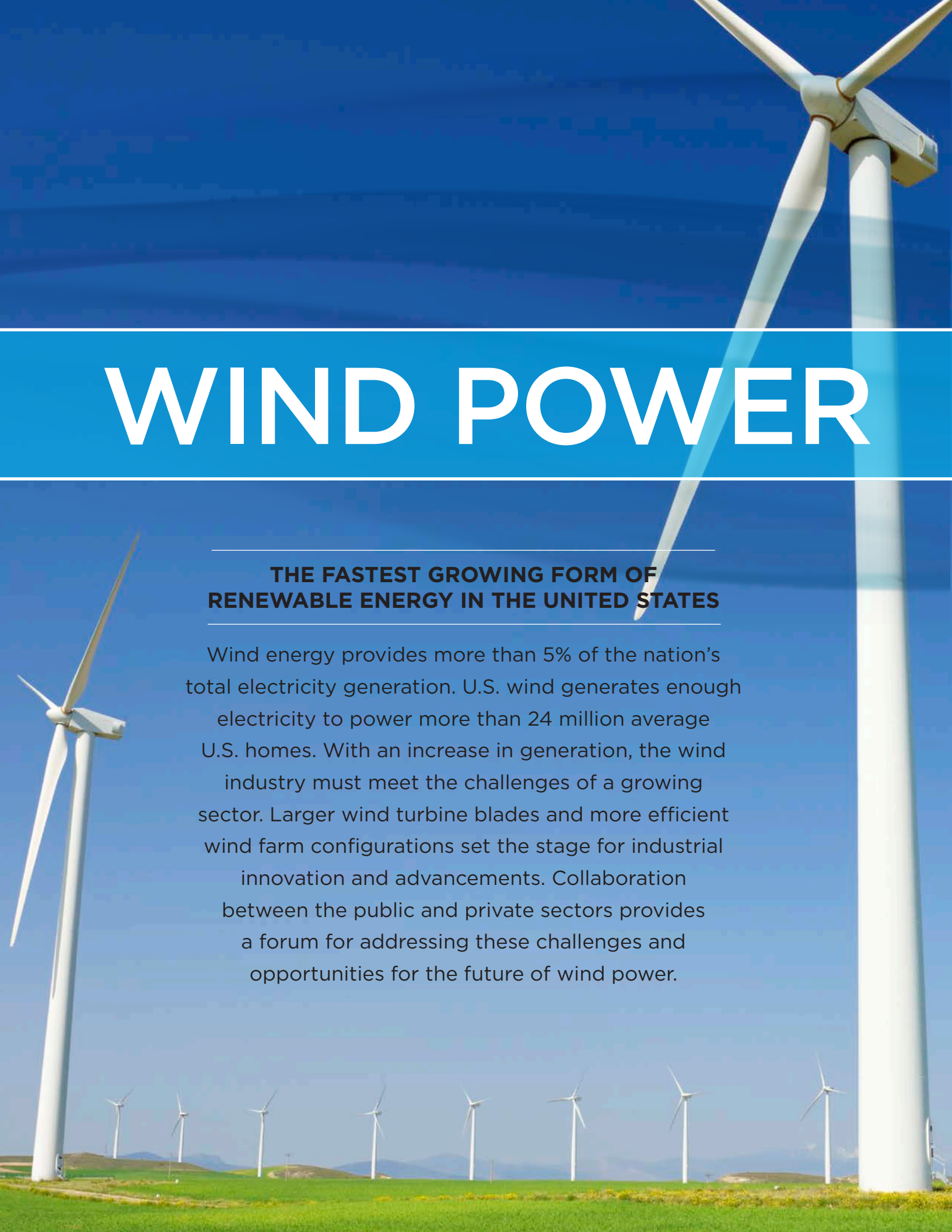
TRANSFORMING WIND TURBINE BLADE MOLD MANUFACTURING WITH 3D PRINTING

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy



WIND POWER

THE FASTEST GROWING FORM OF RENEWABLE ENERGY IN THE UNITED STATES

Wind energy provides more than 5% of the nation's total electricity generation. U.S. wind generates enough electricity to power more than 24 million average U.S. homes. With an increase in generation, the wind industry must meet the challenges of a growing sector. Larger wind turbine blades and more efficient wind farm configurations set the stage for industrial innovation and advancements. Collaboration between the public and private sectors provides a forum for addressing these challenges and opportunities for the future of wind power.

The U.S. Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy (EERE) plays a strategic role in promoting clean and secure energy by increasing our nation's competitiveness through manufacturing clean energy technologies. Investments in the research and development of cross-cutting platform technologies have the ability to revolutionize the delivery of clean energy. Wind component manufacturing provides opportunities to grow domestic jobs and lease and tax revenues in local communities while also strengthening and supporting our nation's economy and electricity sector.

WORKING TOGETHER TO BUILD A FASTER AND LEANER FUTURE FOR WIND TURBINE MANUFACTURING

Innovation in the design and manufacturing of wind power generation components continues to be critical. As a result of this challenge, DOE's Wind Energy Technologies Office (WETO) and Advanced Manufacturing Office (AMO), both within EERE, are partnering with public and private organizations to apply additive manufacturing, commonly known as 3D printing, to the production of wind turbine blade molds. The traditional method of blade design requires the creation of a plug, or a full-size representation of the final blade, which is then used to make the mold. Creating the plug is one of the most time-intensive and labor-intensive processes in wind blade construction, saving time and money.

Specific aerodynamic research on wind turbine rotor wakes, funded by WETO, calls for custom research blades outfitted with special sensors. These research blades would require a unique plug, mold, and tooling design, which would be expensive. WETO leveraged AMO's existing expertise to develop an innovative solution for creating the research blade mold. 3D printing the mold eliminates the need for a plug and provides the opportunity to pioneer innovative design features, such as air heating through built-in ductwork instead of hand-laid heating wires embedded in the mold. The ground-breaking project engages Oak Ridge National Laboratory's Big Area Additive Manufacturing, or BAAM, machine developed in collaboration with Cincinnati Incorporated. BAAM is 500 to 1,000 times faster and capable of printing polymer components more than 10 times larger than traditional industrial additive machines. With research blades measuring 13 meters (42 feet) in length, BAAM provides the necessary scale and foundation for this ground-breaking advancement in wind blade research and manufacturing.

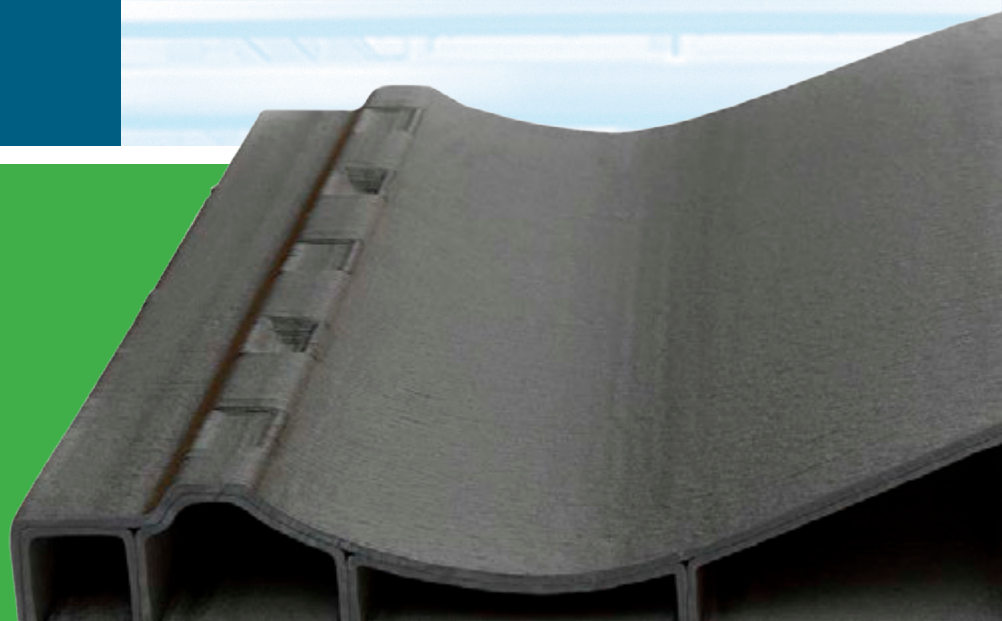
DOE is leading our nation toward a secure energy future and increasing domestic industry competitiveness through research and development of innovative manufacturing technologies such as 3D printing.

WHAT IS 3D PRINTING?

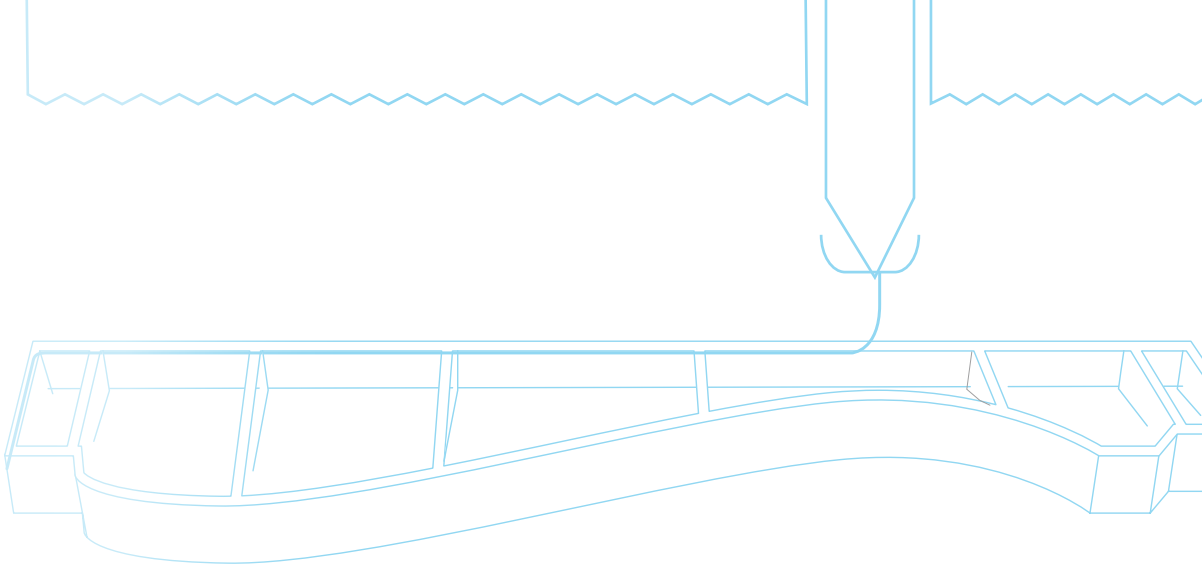
3D printing, or additive manufacturing, is the process of producing a three-dimensional, solid object from a digital file. A 3D printer layers semi-molten material into the computerized shape—a process that offers improved design flexibility, decreased energy consumption, and reduced time to market.

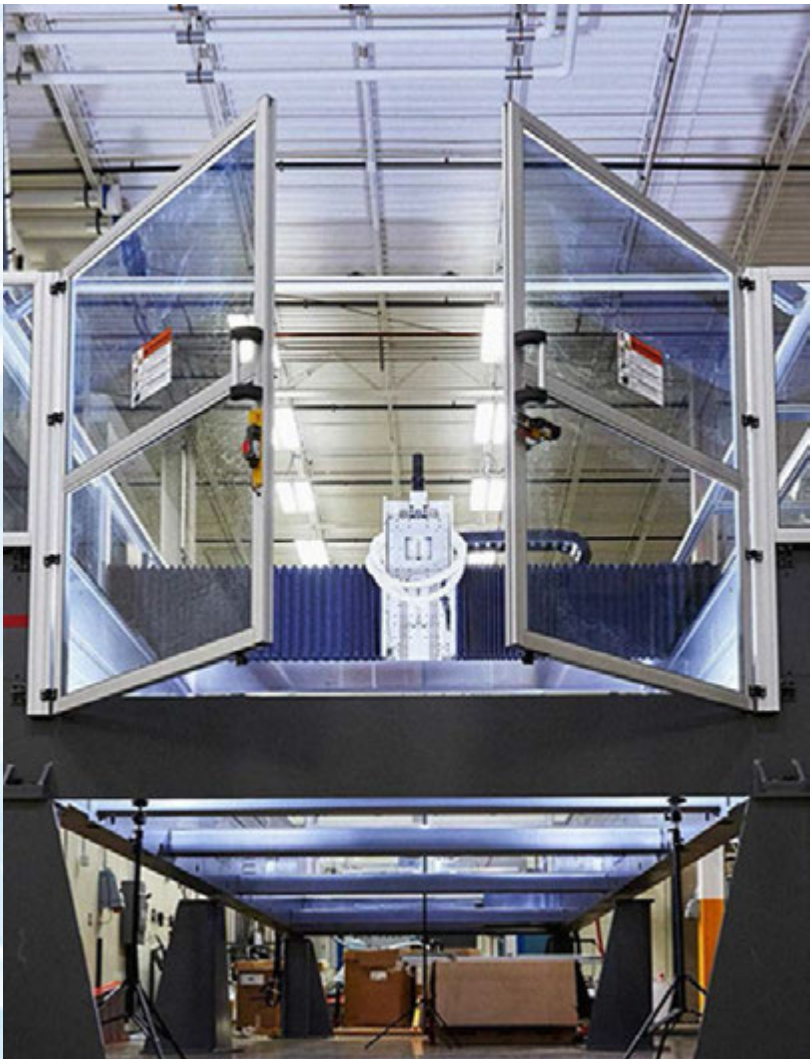
INNOVATIVE NEW PROCESS USES 3D PRINTING TO CREATE MOLDS

1. The mold is designed using computer-aided design (CAD) and a file is generated for BAAM to follow.
2. The BAAM machine extrudes heated composite material based on the CAD file design layer by layer until the component is fully developed. This process occurs for each piece of the mold.
3. A layer of fiberglass is applied on top of the mold, and excess material is machined off to achieve the desired shape and smoothness.
4. Heating duct work is installed and the mold pieces are assembled together.
5. The research blades are produced from the completed mold.



A side view of a section of the mold. The hollow design allows for an innovative use of hot air to heat the mold during the curing of the blade.





A view of the Big Area Additive Manufacturing machine that produced 3D print molds for manufacturing of research wind turbine blades.

DOE works with wind technology suppliers to promote advanced manufacturing capabilities. Goals include increasing reliability while lowering production costs and promoting a domestic industry able to meet manufacturing demands while competing globally.

The U.S. wind market has grown substantially over recent years, creating a robust supply chain. Over 500 facilities across the country specialize in blades, towers, generators, and turbine assembly. Modern wind turbines are increasingly cost effective and reliable and have scaled up in size to multimegawatt power ratings. As wind plants grow in size, rotor wake research has become critical for power generation efficiency.

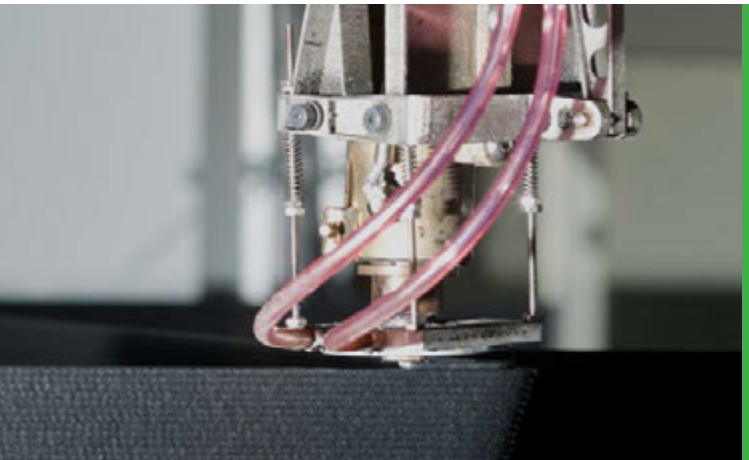
1 CHALLENGE

With a rapidly changing global economy and a need to increase the nation's competitiveness in the manufacturing of clean energy technologies through research into new, more efficient methods, the traditional blade manufacturing sector must strive forward with advanced innovation. For the wind industry, 3D printing could transform turbine blade mold manufacturing, making it faster and leaner than ever before.

2 OPPORTUNITY

Trends toward larger wind turbine blades—which currently average over 45 meters in length—and our drive for global competitiveness inspires us to explore new manufacturing technologies. Additive manufacturing promises to lower costs and enable innovative blade designs that can push the limits of clean energy production.

An up-close view of the BAAM nozzle layering carbon fiber composite material.



PROJECT GOALS AND OBJECTIVES

- Demonstrate the utility of large-scale additive manufacturing as a platform technology for renewable energy systems.
- Explore innovation that leads to reduced costs in wind blade manufacturing.
- Increase U.S. manufacturing competitiveness through innovative applications that advance clean energy technologies.

3 COLLABORATION

This public-private partnership accelerates development and collaboration among EERE's Wind Energy Technologies Office, Advanced Manufacturing Office, Oak Ridge National Laboratory, Sandia National Laboratories, and TPI Composites. This partnership applies individual strengths to create a 3D printed blade mold, which can have far-reaching implications for the entire industry.

4 INNOVATION

The blade mold was 3D printed using the Big Area Additive Manufacturing (BAAM) machine. BAAM is not only more energy efficient than traditional manufacturing methods, but it is also 500 to 1,000 times faster than other industrial additive machines.

5 IMPACT

Success will enable the rapid development of innovative, more efficient blade designs that can be built using a cost-effective 3D printed manufacturing process. This innovation can open new opportunities in the United States for growth in the rapid, low-cost manufacturing of large composite structures in industries beyond wind. Going forward, any industry that requires large composite structures—marine, transportation, and petroleum to name a few—could benefit from this groundbreaking technology.

ADVANCING MANUFACTURING AND CLEAN ENERGY—TOGETHER

The innovative wind blade mold will be used to build ten research wind blades. One blade will undergo structural testing at NREL's National Wind Technology Center, while three rotors (nine blades) will be flown on test turbines at the Scaled Wind Farm Technology (SWiFT) facility at Texas Tech University.

The revolutionary 3D-printed blade mold research will provide information necessary to build a new, fast, and cost-effective way to make large wind energy components. Not only will the project investigate the rejuvenation of U.S. manufacturing through ground-breaking innovation, but also potentially decrease the cost of wind power nationwide—and provide more clean, affordable, reliable, and domestic energy for our nation.

The Wind Energy Technologies Office and Advanced Manufacturing Office collaborate with public and private sector partners. These organizations provide a wealth of technical expertise and experience to this project.

Oak Ridge National Laboratory (ORNL) delivers expertise in additive manufacturing.

Sandia National Laboratories (SNL) develops and supports aerodynamic design of the blades and research blade testing at SWiFT.

TPI Composites manufactures the blades and collaborates with ORNL and SNL on the mold design and construction.

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For more information, please visit:

U.S. Department of Energy's Wind Energy Technologies Office: *energy.gov/eere/wind*

U.S. Department of Energy's Advanced Manufacturing Office: *energy.gov/eere/manufacturing*

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