

Wind Turbine End-of-Life Strategies



Wind energy plays an important role in creating a cleaner, healthier environment. It's a leading climate change solution that decreases smog-creating air pollution and saves billions of gallons of water annually. Studies show a typical wind turbine repays its carbon footprint in less than six months.

When a wind turbine reaches the end of its 20 to 30-year lifespan, most of its material, like steel, has substantial salvage value and is recyclable. Other components, like the blades, require different strategies.

Lifetime extension

Extending the lifetime of existing blades is one of the most economically and environmentally friendly measures wind developers take to reduce the need for replacements. While the blades are quite durable, decades of exposure to the elements can slowly chip away at their efficiency. Blade repair and monitoring technology is rapidly improving, allowing the industry to use fewer and fewer blades to produce the same amount of clean, zero-carbon electricity. General improvements in turbine technology are also leading to greater electricity generation per turbine, adding to these blade efficiency improvements.

Re-use

The U.S. wind power industry, joined by scientists, researchers, national laboratories, and environmental collaborators, is moving ahead with innovative methods to re-purpose turbine blades. At the end of their decades-long lifetime of providing clean, emissions-free energy, the blades are a perfect fit for pedestrian bridges, playground equipment, public benches, signage, powerline structures, and highway sound barriers. Scientists are modeling how blades can even be used to replace roofing for homes.

The U.S. Department of Energy is partnering with businesses to research practical ways to repurpose wind turbine blades. Innovative partnerships like Re-Wind, a collaboration between the Georgia Institute of Technology and Queen's University Belfast, are deploying design and logistical concepts in the field, such as prototyping methods to reuse the decommissioned blades in buildings, infrastructure, landscape, and public art.

Putting blades to new uses has a two-fold environmental benefit. First, the blades remain beneficial to local communities and are given a second life. Additionally, with a repurposed blade, there is no need to build the structure the blade is replacing. This further improves sustainability.

Recycling

Wind turbine blades on average are 85 percent recoverable and efforts are underway to solve the technical challenges of turbine blade recycling. Research from groups like the National Renewable Energy Laboratory, the Institute for Advanced Composites Manufacturing Innovation, the American Composites Manufacturers Association, and the Electric Power Research Institute is leading to advanced recycling technologies, such as recyclable blade resin. Eventually, blade components may also be recycled to manufacture new blades, creating a circular economy of use.

Entrepreneurs are also exploring the business opportunities recycling wind turbine blades can create. Several startups are developing processes to break down the blades and refabricate them into other useful products, including decking, insulation, building panels, railroad ties, pallets, particle boards, and cars.

Sustainability and environmental stewardship are primary



Wind turbine blade manufacturing facility

focuses for the U.S. wind industry, with major wind suppliers working hard to increase the recyclability of their products. Vestas, one of the world's oldest and largest wind turbine manufacturers, has committed to producing only zero-waste wind turbines by 2040, with intermediate targets along the way.

Disposal

Unlike much of the U.S. disposal stream, wind turbines are made from safe, inert materials that do not leach hazardous waste into the surrounding soil or groundwater. Five materials account for 98 percent of the mass of a typical turbine: steel, iron, fiberglass, copper, and aluminum. Steel, which represents about 70 percent of the turbine mass, is 100 percent recyclable and among the world's most recycled materials. The turbine blades are primarily made of fiberglass and similar materials, along with balsa wood.

Like many other industries, the U.S. wind industry pays a fee to dispose some material in landfills. This includes some turbine blades at the end of their decades-long lifecycles. The city of Casper, Wyoming, for example, has earned over \$600,000 for taking decommissioned blades, resulting in additional funding for local communities.

"This is the least problematic waste in terms of environmental concerns that we've ever gotten," says Cindy Langston, Solid Waste Division Manager at the Casper, Wyoming landfill. "We get tires, asbestos, contaminated soil, pretty nasty stuff... Truly, those turbine blades are the most inert, non-problematic waste we're accepting."

It's important to put wind turbine blades into context - blades represent a vanishingly small portion of U.S. landfills and are among the least environmentally harmful materials entering landfills. The Electric Power Research Institute [estimates](#) there will be 2.1 - 4 million tons of cumulative blades put in landfills between 2020 and 2050. In comparison, 139 million tons of U.S. municipal solid waste went to landfills in 2017 alone. On an annual basis, wind turbine blades make up as little as 1/2000th, or 0.05 percent, of the volume going into landfills. Plastic plates and cups alone make up roughly ten times as much.

U.S. Waste Going to Landfills

Waste Source	Annual tons (in thousands)	% of Total Annual Waste	Reference
Food	30,630	22	EPA 2017
Clothing and Footwear	8,900	6.4	EPA 2017
Yard Trimmings	8,650	6.2	EPA 2017
Diapers	3,340	2.4	EPA 2017
Vehicle Tires	1,220	0.88	EPA 2017
Towels, Sheets and Pillowcases	990	0.71	EPA 2017
Trash Bags	920	0.66	EPA 2017
Plastic Plates and Cups	870	0.63	EPA 2017
Wind Turbine Blades	70 - 133	0.05 - 0.09	EPRI 2018 EPRI 2020

Wind and the environment

The range of turbine end-of-life technologies will continue to expand, given the continued focus on solutions from the industry, along with public and private organizations. The U.S. wind industry remains committed to protecting the environment by delivering carbon-free power through responsible development and sustainable solutions.

- U.S. wind power avoids the carbon pollution of over 42 million cars.
- By expanding to 35 percent of the grid by 2050, wind energy can cumulatively avoid more than 12.3 billion metric tons of carbon pollution, equivalent to [one-third](#) of global annual carbon emissions.
- Wind turbines leave [98-99 percent](#) of a property-owner's surrounding land free for other uses, such as farming, ranching, wildlife habitat, and recreation.
- U.S. wind projects save 103 billion gallons of water every year and help address air pollution, reducing sulfur dioxide emissions by 232,000 metric tons and nitrogen oxides by 168,000 metric tons.
- Blades do not contribute to methane emissions. Municipal solid waste landfills are the third-largest source of human-related methane emissions in the U.S.