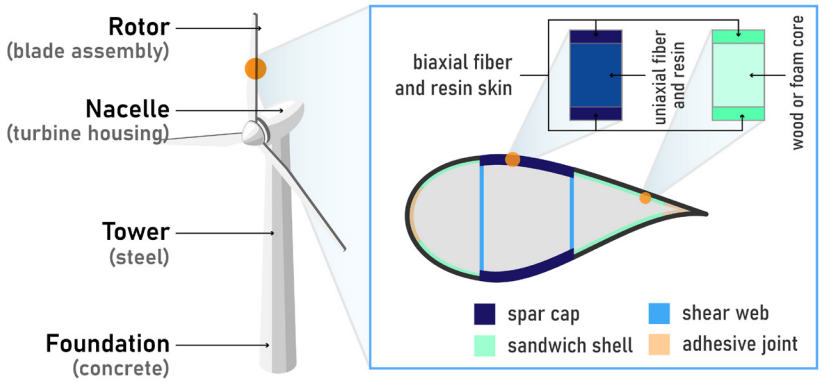
WIND TURBINE
END-OF-LIFE MANAGEMENT

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

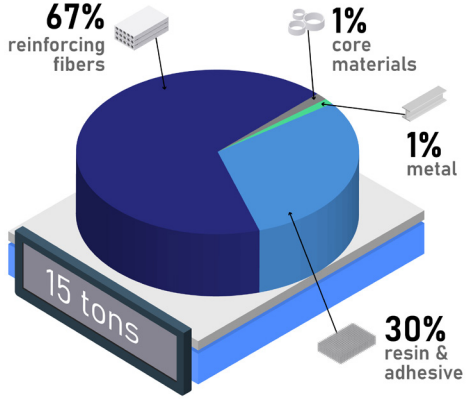
WIND TURBINE DIAGRAM



Drawings not to scale

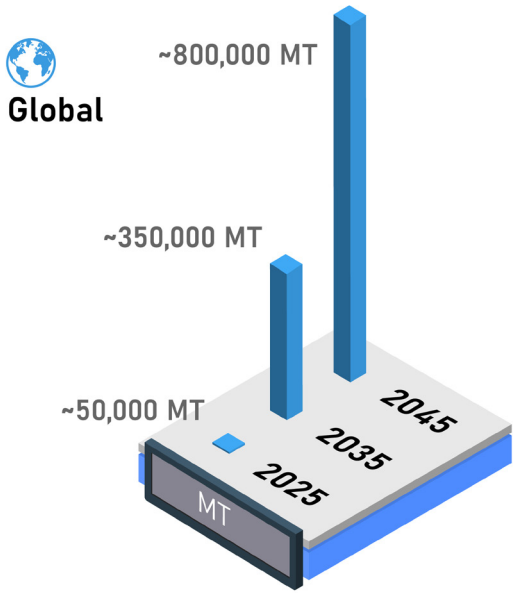
Wind turbines are made of 80-90% recyclable materials like steel and concrete. The blades and nacelles, made from fiberglass composite materials, are the primary materials that are not routinely recycled.

WIND TURBINE BLADE COMPOSITION



The structure of wind turbine blades is mainly composed of glass fiber reinforcing, resin and adhesive. Lightweight fill materials are used to support the blade shape, metals are used the lightning protection system and connection to the rotor hub, and small amounts of carbon fiber reinforcing are used in critical areas.

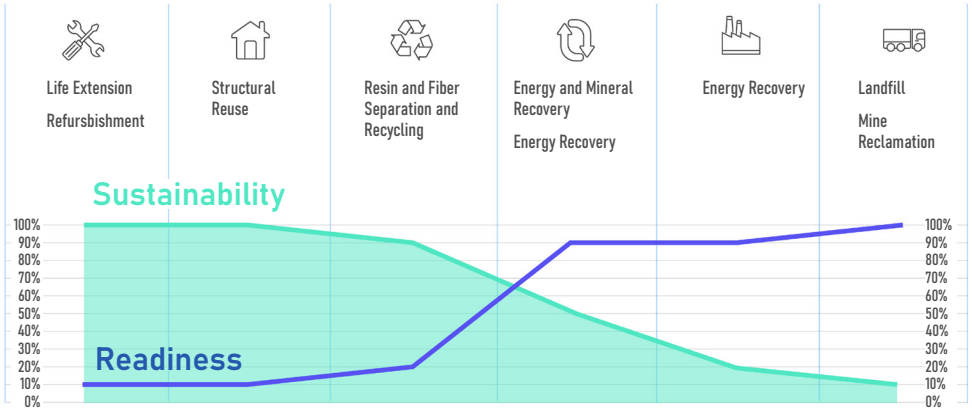
BLADE MATERIAL PROJECTIONS



Data Source: BloombergNEF, 2020

Wind Turbine Blades have a long service life. As a result, projected tonnage of waste blades lags installation dates by about 25 years, and estimated waste turbine blade volumes reaching 800,000 metric tons by 2045. However, a recent trend to repower existing US wind farms has resulted in thousands of tons blades for disposal before they have reached their service life.

END OF LIFE HIERARCHY

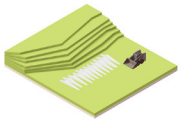


End of life options for wind turbine blades range from commercially available landfilling to emerging second life uses in structures. The ability these of end of life options to recover the full value of reinforcing fibers, resins and fill materials comprising blades varies widely. Commercial technologies, like use in cement kiln feed, and near commercial technologies, like gasification, compromise by recovering value of resin and fill as energy and fibers as lower quality reinforcement or mineral. Emerging technologies, like thermoplastic resins, promise to allow recovery of high quality resin and fibers.

RECYCLING AND REUSE

Commercial Technology

Cement Kiln Fuel



Mine Reclamation

Emerging Technology

100% reuse
transmission tower, building roof

100% recycling of fiber and resin
Alternative blade construction (Thermoplastic)

Partial recycling (fiber and energy)
Thermolyzer

Photographer: Ryan Beach / NREL

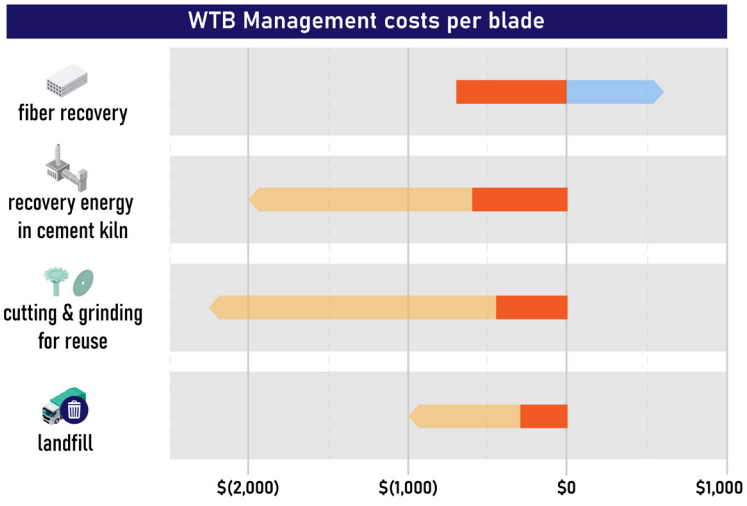
Key Challenges for Emerging Technologies:

100% Reuse: Fitness for Use, Alignment between supply and demand

100% Recycling: Industry Adoption of Thermoplastic Resin; Fiber Quality

Partial Recycling: Fiber Quality

EoL COSTS



Data Source: EPRI, 2020

Reinforcing fibers are the main source of value in wind turbine blades. However, current recycling methods damages or destroys the fibers, and leaving low value products.

Technologies aimed at recovering high quality fibers or improve fiber properties post recycling are being explored by researchers.

R&D NEEDS

- Life Extension Technologies
- Field Processing Technologies for End of Life Blades
- Recyclability of Alternative Resins
- Lifecycle analysis for emerging management technologies
- Development of technologies to improve fiber quality and secondary fiber markets

ADDITIONAL EPRI RESEARCH

This fact sheet summarizes current and prior EPRI research deliverables on EoL management topics for renewable energy and battery energy storage technologies:
EPRI Research Activities on Renewable and Battery End-of-Life Management.
EPRI, Palo Alto, CA: 2020. 3002019572.

REFERENCES

Decommissioning Plans for Wind Farms: Issues, Uncertainties, and Opportunities, 2021 (3002019651)

Wind Turbine Blade Recycling Preliminary Assessment, 2020 (3002017711)

End-of-Life Disposal and Recycling Options for Wind Turbine Blades, 2018 (3002012240)

National Renewable Energy Lab Alternative Resin Blades https://www.nrel.gov/manufacturing/comet-wind-blade-resin.html

Re-Wind Network Structural Reuse of Blades https://www.re-wind.info/

Learn more about EPRI Wind End of Life Research: epri.com/eawind

Learn more about EPRI Wind Energy Research: Program 206: Wind Generation

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