Fact Sheet:

Recycling and Waste Considerations for Solar and Wind Energy Systems

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Wind and solar project deployment can increase project materials in waste and recycling streams. As more projects deploy, concerns arise about handling materials at a project's end of life. Many states are discussing long-term recycling and waste solutions for solar and wind energy systems. Material recycling and reuse opportunities vary depending on state laws and access to recycling facilities or disposal sites (e.g., some states designate certain components as a type of waste, such as landfill-safe, e-waste, or hazardous waste). Efforts to recycle or repurpose materials or system components are often hindered by limited markets and uncertainty about long-term capacity.

For local communities, waste and recycling are important upfront considerations of energy systems. Communities have a significant opportunity to shape disposal and recycling procedures by requiring a disposal plan as part of the decommissioning process.

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SOLAR SYSTEM RECYCLING AND REUSE OPPORTUNITIES

The number of solar panels in waste stream increases with more solar projects. The International Renewable Energy Agency estimates that by 2050, between 60 and 78 million tons of material will be generated globally from solar panels that will require one of the three options for end of life: recycling, reuse, or disposal.[1] Understanding recycling and reuse opportunities requires examining solar system components. There are two main solar panel types: crystalline-silicon (c-Si) and thin-film (primarily cadmium telluride [CdTe]) panels.

- Both panel types are composed of a large portion of bulk materials, including glass and aluminum (which together are the largest portion of the panel by weight, over 80%) along with copper and plastic.
- There are also minor panel parts, some of which have value (silver and copper) and some of which pose a risk for both reuse and recycling (lead and fluorine encapsulants).
- Thin-film panels have more complicated end-of-life treatments, given the cadmium in the wafers. These panels only make up about 3% of the PV industry market and trends show a steady decline in prevalence. [2]

Reuse, Recycling, or Landfill?

Interest is starting to grow in **reusing and repurposing** solar photovoltaic (PV) panels in secondary markets. A panel at the end of its design life will generally still produce energy at 80% of its rated capacity. However, manufacturer warranties typically expire by conventional end of life, and there are limited or largely unformalized market institutions for reselling the panels. Utilities or electric codes may restrict the opportunity to reinstall and interconnect used panels without warranty or current certification.

Panels can be **recycled**. Industry experts estimate that as of 2018, the recycling costs associated with solar PV panels range from $20 to $24 for one 300-watt DC panel ($0.066 to $0.08 per watt DC), which is equal to less than 5% of a typical system installation cost.[3] Cutting-edge manufacturing and recycling outfits have proven that it's possible to recover over 90% of a panel's semiconductor materials and approximately 90% of glass for reuse. While some manufacturers are offering take back programs to ensure recycling, these are available for a very small portion of the market.

Panels can, in most states, be **landfilled**. While panels only comprise a tiny fraction of the solid waste stream, some estimate the potential disposal volume in worst cases could exceed 10% of the total global e-waste added in 2014, which was a record-setting year for solar waste. This potential increase signals an urgency to provide proactive, creative waste management strategies to solar system deployment.[4]

WIND SYSTEM RECYCLING

Wind energy systems are made of steel (71-79% of the total turbine by weight); fiberglass, resin, or plastic (11-16%); iron or cast iron (5-17%); copper (1%); and aluminum (0-2%).[5] Most salvable materials are in the turbine, while the resin and fiberglass compose the blades. The disposal dilemma is with the turbine blades: no opportunity for recycling currently exists and the blades, which average between 100-150 feet in length, must be landfilled.

In the short history of US utility-scale wind energy systems, systems that reach end of life are often difficult to recycle and are landfilled. Turbine blade materials are landfill-safe, but some communities and solid waste planners have concerns about landfill capacity.

The economics further reduce motivation to recycle turbine blades; by the end of a turbine's life (20 to 30 years after construction) the resin and fiberglass materials have little to no value. Turbine owners are often unable to justify the cost of recycling, resulting in an even higher proportion of blades ending up in landfills.

This creates an incongruence between wind energy as a renewable form of electricity generation and as inevitable landfill waste. As support grows for better recycling and more sustainable options for wind turbines, opportunities to repurpose components are developing (e.g., grinding them into pellets for building materials, which can be used for decking materials, pallets, and piping), but few have graduated to scale.[6]

New Innovations

With growing attention to the issue, more research is focused on opportunities for recycling and reuse of energy system materials in novel ways, including high-value recycling processes that recover environmentally sensitive materials. Researchers are also investigating new construction methods. For example, the National Renewable Energy Laboratory is researching thermoplastic materials or turbines that can be melted down and reused at end of life, while others are investigating innovative new uses for old turbine parts, like using turbine blades for coastal sea walls.[7]

Solar developers are contributing to better practices. The Solar Energy Industries Association is working to develop new protocols for future panel retirement by establishing uniform, cost-effective recycling practices that include identifying vendors and service providers, aggregating end-of-life solar components, and streamlining and improving recycling processes.[8] Finally, for both solar and wind, projections for the global disposal and recycling market could be worth upwards of $360 million by 2024, ushering opportunities for green job and workforce development.[9]

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Endnotes

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