UL Solutions

End-of-life considerations for renewable energy assets

Understanding disposal and recyclability for renewables and batteries

Renewable energy components such as solar, wind and battery are critical to accelerating a sustainable future. Managing their end-of-life disposal and recyclability is complex and challenging, but also presents key opportunities to create a more circular economy within the renewables sector. Here's what you need to know:

By the numbers:

By 2030, IRENA estimates that more than **78 million metric tons** of solar panels will reach end of life

As of 2023, only about **10%** of solar panels are recycled globally, with the majority still ending up in landfills

The global volume of end-of-life batteries from electric vehicles is expected to reach **21 million tons** annually by 2030

The recycling rate for lithium-ion batteries in the U.S. is only approximately **12%** as of early 2024

More than **11 million tons** of waste is projected to be generated from wind turbine blades by 2030

End-of-life challenges and opportunities:

01 Lack of recycling infrastructure for renewable energy assets

Current State:
Many regions lack the facilities and technology required to efficiently recycle renewable energy components.

Impact:
Many of these assets and materials end up in landfills, contributing to waste and a missed opportunity for reuse or repurposing.

Example:
In the U.S., only a limited number of facilities are equipped to efficiently recycle solar panels, resulting in logistics issues and increased transportation costs, while also limiting overall recycling rates.

Opportunities to address:
Invest in developing specialized recycling facilities and technologies for renewable energy components. This includes establishing regional recycling centers to reduce transportation costs and logistical challenges. Some manufacturers do accept their products back at their end of useful life, but some recyclability issues can also be managed during design and development.

02 High costs of recycling processes

Current State:
Current costs of recycling renewable assets can be greater than new material production due to complex processes needed to safely break down and separate core materials.

Impact:
High costs discourage companies from investing in recycling infrastructure and processes, which slows the adoption of more circular economy practices.

Example:
Complex processes to safely separate metals like lithium, cobalt and nickel make recycling lithium-ion batteries cost-prohibitive in the absence of sufficient economies of scale.

Opportunities to address:
Innovate and scale up recycling technologies to achieve economies of scale, which can help reduce costs. Research and development can focus on more efficient, less expensive methods for breaking down complex materials. Financial incentives for domestic supply chains and subsidies can encourage companies to invest in recycling infrastructure, making it more economically viable compared to disposal.

03 Insufficient regulatory frameworks to mandate recycling

Current State:
Regulatory recycling policies vary widely across regions and often do not mandate comprehensive recycling practices.

Impact:
Regional inconsistencies create uncertainty for manufacturers and other stakeholders and can lead to non-compliance or reduced investment in recycling initiatives.

Example:
While the European Union has made strides with directives like the Waste Electrical and Electronic Equipment (WEEE) Directive, other geographies have not yet adopted similar policies.

Opportunities to address:
Advocate for and develop comprehensive regulatory policies that mandate recycling practices for renewable components. Learning from models like the EU's WEEE Directive, other regions can implement similar frameworks to promote consistent recycling efforts and compliance. Implementing extended producer responsibility (EPR) programs can also drive adoption of end-of-life management practices.

04 Technology limitations for proper recycling

Current State:
Existing recycling technologies are not yet advanced to efficiently process all materials used in renewable energy. Lack of supply chain traceability with respect to material composition is a further impediment.

Impact:
Additional advances in recycling technology will be needed to recover and reuse all materials now being used in renewable energy systems. This technology gap reduces the effectiveness of current recycling efforts.

Example:
The composite nature of fiberglass wind turbine blades makes them challenging to recycle. Current solutions, such as repurposing for construction materials, is innovative, yet costly.

Opportunities to address:
Invest in R&D to advance recycling technologies and encourage innovation through grants or competitions that could lead to breakthroughs in more effective, economical recycling methods.

05 Lack of consumer awareness and incentives

Current State:
Consumers and businesses may not be fully aware of the importance and benefits of recycling components, including lithium-ion batteries.

Impact:
Without sufficient awareness and incentives, there is less motivation to participate in recycling programs or invest in sustainable practices.

Example:
Incentive programs that offer financial benefits for recycling solar panels or batteries are limited, reducing participation rates.

Opportunities to address:
Launch awareness campaigns to educate consumers and businesses about the benefits of recycling renewable assets. Implement incentive programs, such as tax credits or rebates, to encourage participation in recycling initiatives and investment in sustainable practices.

Market opportunities:

Demand for recycled materials and assets is on the rise

35%
Annual anticipated increase in demand for recycled materials in the energy sector.

$40 billion
Expected global market for battery recycling by 2030.

$1 billion
Projected growth in the solar panel recycling market by 2030.

Increased benefits and efficiencies from recycling

15%
Cost reductions offered by certain emerging battery recycling techniques.

30%
Increased efficiencies from innovations in solar panel recycling technology anticipated out to 2026.

50%
Reduction in greenhouse gas emissions associated with manufacturing if renewable energy assets are recycled.

Capitalizing on the opportunity

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We help our customers innovate, launch new products and services, navigate global markets and complex supply chains, and grow sustainably and responsibly into the future. Our science is your advantage.

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