End-of-Life Management for Solar Photovoltaics

Solar Energy Technologies Office

What Is End-of-Life Management for Photovoltaics?

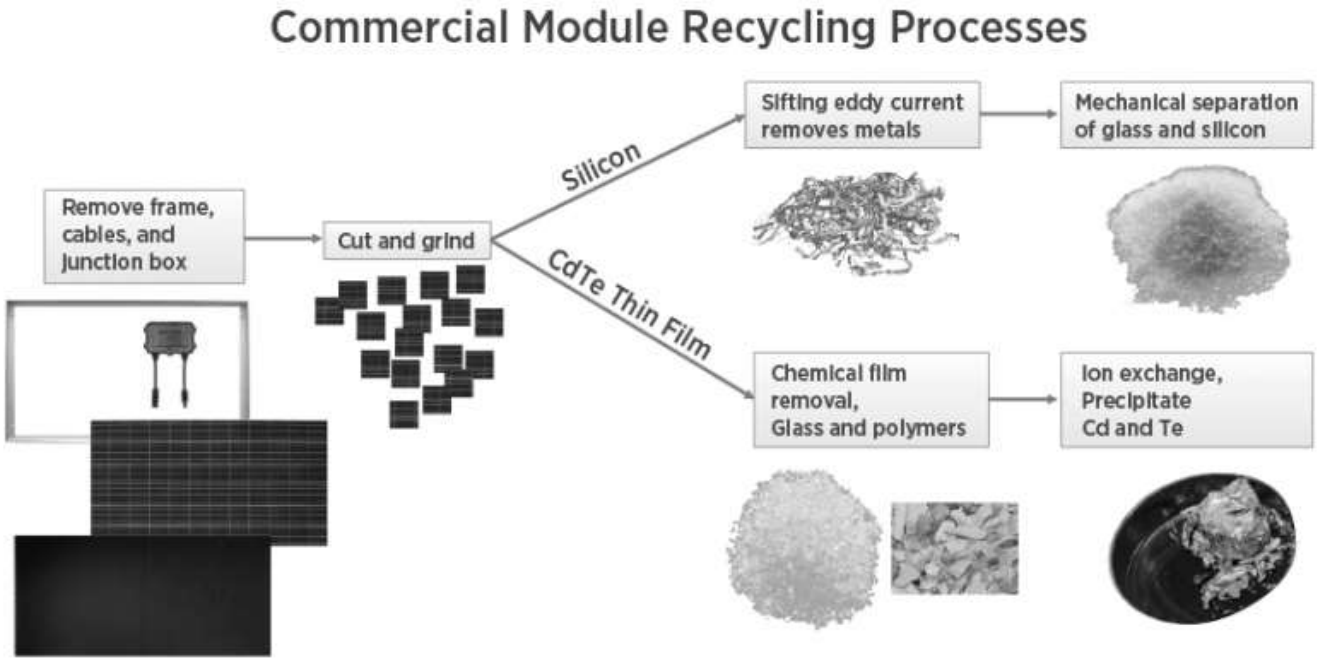
IMPROVING PRACTICES

Read about SETO's PV End-of-Life Action Plan

End-of-life management for photovoltaics (PV) refers to the processes that occur when solar panels and all other components are retired from operation. There are millions of solar installations connected to the grid in the United States, which means there are hundreds of millions of PV panels in use. Most PV systems are young—approximately 70% of solar energy systems have been **deployed in the past five years**. The estimated operational lifespan of a PV module is about 30-35 years,

although some may produce power much longer. So, while there are not many systems entering the waste stream right now, more systems will come to the end of their useful life in the next few decades.

In addition, new materials, designs, and practices can help to reduce PV manufacturing's environmental impact by minimizing waste, energy use, negative effects on human health, and pollution. **Learn more about PV materials and how they work**.



Why Is PV End-of-Life Management Important?

According to the **International Renewable Energy Agency**, cumulative end-of-life PV waste in the United States in 2030 is projected to be between 0.17 and 1 million tons. To put that in perspective, there are 200 million tons of **solid waste**, excluding recycled and composted materials, generated in the United States each year. While weather damage and installation errors cause most end-of-life issues now, some consumers and plant operators may choose to upgrade their panels before the warranty period expires or to take advantage of technological improvements.

Recycling processes for cadmium telluride and silicon PV modules exist, but in the U.S., the total cost of recycling is greater than the cost to landfill. Focusing on PV end-of-life management will help the U.S. Department of Energy Solar Energy

Technologies Office (SETO) reduce the environmental impacts of solar energy and ultimately make solar energy more affordable. **Learn more about SETO's goals**.

SETO Research in PV End-of-Life Management

SETO funds research to develop new materials and designs that can make PV products longer-lasting, less energy-intensive to produce, easier to recycle, and even less polluting at the end of life. New practices can improve understanding of environmental impacts to prevent unintended pollution or human health effects. SETO's **Photovoltaics End-Of-Life Action Plan** outlines a five-year strategy to establish safe, responsible, and economic end-of-life practices.

SETO has funded projects at the National Renewable Energy Laboratory (NREL) on life-cycle analysis of PV modules and cost models for module recycling. SETO also funds NREL to coordinate PV sustainability efforts for the International Energy Agency Photovoltaic Power Systems (IEA-PVPS) program. These efforts focus on recycling research and analysis, assessing the life cycle of PV modules, improving environmental safety and health in PV manufacturing, and publishing reports on end-of-life management for PV panels. SETO has also supported NREL to survey state and local policies related to end-of-life modules.

NREL published the **first assessment of worldwide efforts to recycle PV modules** and identified the best ways to manage disposal. The researchers investigated lessons learned from IEA-PVPS to help inform manufacturers and other stakeholders about recycling requirements for PV hardware and efforts to design reusable modules and other equipment. The **report** finds that more research and development is needed in silicon purification processes, methods to avoid waste in manufacturing, lowering recycling costs, and other areas.

Additional awards:

- In 2016, SETO awarded $700,000 to **EnergyBin**, a company that created an online marketplace for solar-industry overstock and hard-to-find components. This marketplace allows decommissioned materials to be reused, in the form of discounted, warrantied solar project components from vetted, reputable

sources. This gives new life to old materials while reducing project construction and maintenance costs.

- In 2017, SETO awarded $900,000 to **SRI International**, an independent nonprofit research organization, to develop a more efficient process to recycle the silicon waste generated by the wafer-cutting process into PV-grade silicon.
- In 2018, SETO awarded $150,000 to **NREL** to analyze PV end-of-life management and the effectiveness of efforts to design modules and other equipment for easier reuse.
- Together with the Energy Department's **Advanced Manufacturing Office**, SETO is funding a project at NREL focused on developing a certification for sustainable modules and designing recyclable modules.

Search the **Solar Energy Research Database** to learn more about individual SETO-funded projects.

Additional Resources

- NREL: **Solar Photovoltaic Module Recycling: A Survey of U.S. Policies and Initiatives** – Researchers at NREL surveyed existing and proposed policies related to PV recycling in the United States to provide insight on policy and industry standards that can help enable PV module recycling.
- NREL: **A Circular Economy for Solar Photovoltaic System Materials: Drivers, Barriers, Enablers, and U.S. Policy Considerations** – There are several potential barriers that could hinder various options for repairing, reusing, and recycling PV. This report analyzes the logistical, economic, and regulatory factors that could both impede and encourage end-of-life options for PV systems in the United States.
- NREL: **Best Practices at the End of the Photovoltaic System Performance Period** – Refurbish, repower, or decommission? There are many important environmental and business considerations when it comes to responsible and cost-effective options for end-of-life PV system hardware. This report considers the costs and other factors for each end-of-life option for a PV system.
- Lawrence Berkeley National Laboratory: **Benchmarking Utility-Scale PV Operational Expenses and Project Lifetimes: Results from a Survey of U.S. Solar Industry Professionals**

- IEA-PVPS: **End-of-Life Management of Photovoltaic Panels: Trends in PV Module Recycling Technologies**
- Springer Nature: **Design for Recycling Principles Applicable to Selected Clean Energy Technologies**
- IEA-PVPS: **End-of-Life Solar PV Panels 2016**

Learn more about **PV research**, other **solar energy research in SETO**, and **current and former funding programs**.

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Forrestal Building
1000 Independence Avenue, SW
Washington, DC 20585

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