



NREL analysts are helping to pave the way for repair, reuse, and recycling of solar photovoltaic system materials *Photo courtesy of iStock 1161159566.*

Circular Economy for Photovoltaics

NREL is working to enhance the sustainability of photovoltaic (PV) systems by increasing the energy these systems produce over their lifetimes, reducing the energy and materials consumed in their manufacture and installation, and enabling reuse or recycling. These efforts are designed to help transform the “linear economy”—where materials are simply used and disposed—into a circular one.

Much of NREL’s ongoing PV research aims to improve the sustainability of PV. Sustainability is a complex goal—it can be advanced by developing new PV technologies, but also by improving the lifetime and reliability of mature technologies, or even improving how installed PV systems are managed, especially at the end of their life.

Research Areas

- **Improving PV Lifetimes**—Extending the amount of time that a PV system can operate, and increasing the energy it can produce over that lifetime, reduces the total amount of materials, energy, and labor needed to deploy solar energy resources. NREL is studying how PV modules and their component materials perform—and

Why Partner with NREL?

- NREL’s advanced testing and modeling capabilities provide insight into PV performance, materials demands, end-of-life options, and tradeoffs among circular economy pathways.
- NREL’s ongoing work in the discovery and improvement of emerging PV technologies helps ensure a diverse, secure, and sustainable supply chain for solar energy.
- NREL is committed to ensuring our research gets to market—where it can improve everyday life and strengthen our economy. We have nearly 900 active agreements with almost 600 partners, over half of which are private-sector companies.



fail—over time, with a goal of extending their useful life. The NREL-led *Durable Module Materials Consortium (DuraMAT)* aims to enable sustainable, high-energy-yield, 50-year modules by understanding and addressing the factors that cause wear-out and failure in various types of PV modules.

- **PV Modeling and Analysis**—NREL is applying its long-standing expertise in modeling and analysis to PV sustainability in order to understand materials demands over time, improve end-of-life options, and understand how future generations of PV can be designed for circularity.
- **Developing Diverse PV Technologies and Supply Chains**—NREL's work in emerging PV technologies helps ensure a diverse, secure, and sustainable supply chain for solar energy. In particular, NREL has numerous research efforts focused on perovskite solar cells, including a partnership with the *U.S. Manufacturing of Advanced Perovskites (US-MAP) Consortium* that is focused on accelerating domestic commercialization of perovskite technologies.

Core Competencies and Capabilities

- **Accelerated Testing of Modules, Components, and Materials**—NREL tests PV modules, components, and materials under accelerated conditions to provide early indications of potential failures and to predict field performance and lifetime.
- **Outdoor Testbeds**—NREL maintains several outdoor testbeds to study the long-term performance of fielded PV modules.
- **PV in Circular Economy (PV_ICE) Modeling Tool**—NREL's PV_ICE tool dynamically models both materials demands and end-of-life materials for PV installations over time, and can evaluate tradeoffs among circular economy pathways.
- **Analysis for Improved End-of-Life Options**—NREL's analysis capabilities provide insight into improving end-of-life options for today's PV modules and understanding of how future generations of PV can be designed for circularity.

Contact Us

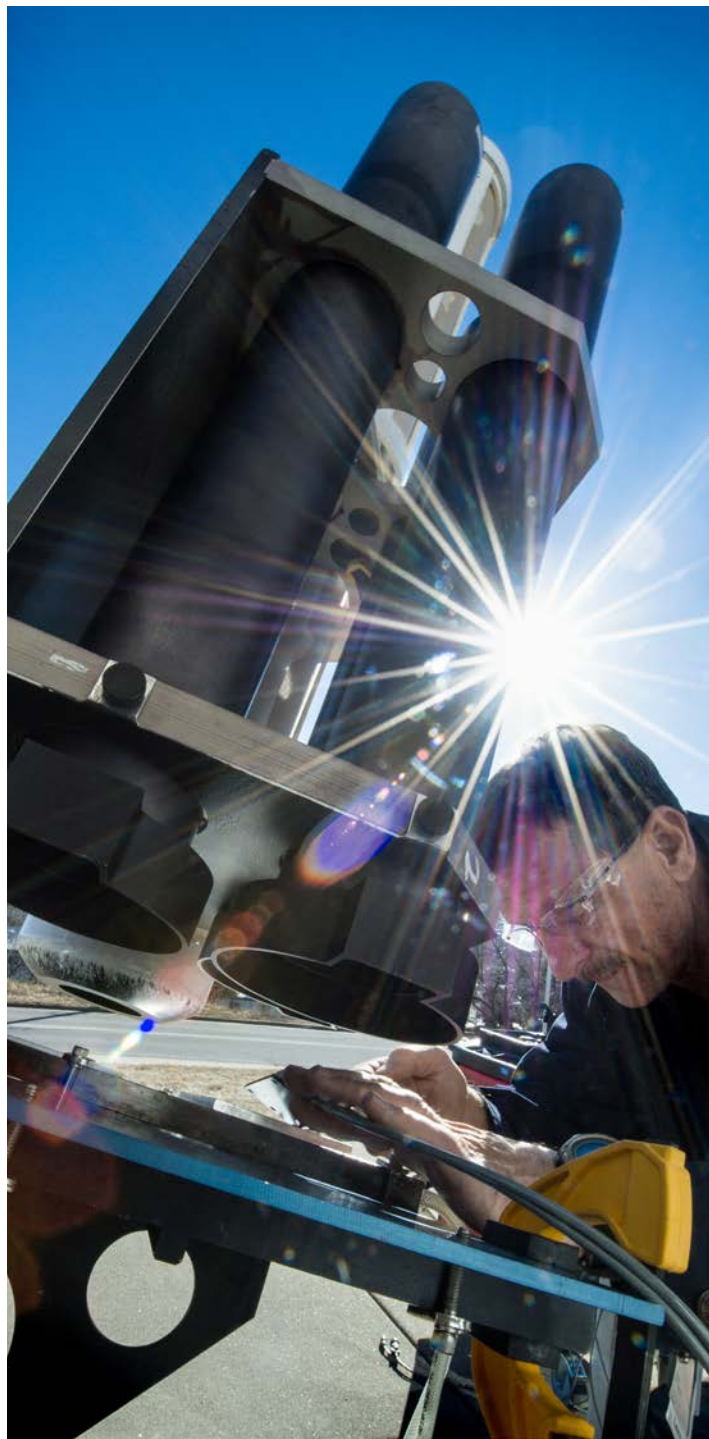
Technical

Teresa Barnes
teresa.barnes@nrel.gov
303-384-6682

Laura Schelhas
laura.schelhas@nrel.gov
303-275-3722

Partnerships

Maria Curry-Nkansah
maria.currynkansah@nrel.gov
303-384-7218



NREL researcher Larry Ottoson uses collimating tubes and calibrated reference cells to set up a test of solar cells at NREL's Outdoor Test Facility. Photo by Dennis Schroeder, NREL 35524