



## PHOTOVOLTAICS

A floating PV array in Walden, Colorado. Photo by Dennis Schroeder, NREL 53287

# Advanced Materials and Next-Gen Tech Research Pave the Way for PV Everywhere

At NREL, we see potential for photovoltaics (PV) everywhere. Our research is unlocking capabilities to enable PV across a full range of applications and locations. You'll find unique breadth and depth in our PV resources and expertise, all concentrated within a single world-class lab complex.

## Ubiquitous PV? R&D Is the Key

The markets for residential and commercial rooftop power and utility-scale generation continue to grow. But PV can ultimately be ubiquitous—that is, *PV everywhere*—as next-generation technologies begin to meet energy needs for varied uses. As such, there is a growing need for research that advances PV applications related to:

- Utility and residential power
- Power in space
- Solar windows
- Remote power
- Military operations
- Transportation
- Building-integrated design.

## Why Partner With NREL?

We have partnered with more than 200 private-sector companies and government agencies to develop new technologies for different applications and custom needs, including:

- Dynamic hydride vapor-phase epitaxy—to drastically lower the cost of high-efficiency III-V PV
- Perovskite R&D—for greater efficiency, durability, and scalability
- Solar windows—quantum dot technologies direct light at specific bandgaps to PV on window frames, and perovskite windows produce power when opaque and provide daylighting when clear
- Group V doping, reliability, and grid integration—for terrestrial cadmium telluride (CdTe) PV
- Lift-off processes—to create lightweight PV
- CdTe solar cells on flexible glass—for automobile and window uses
- Building-integrated PV—for aesthetics, power, and efficiency
- Ultralight, flexible, portable modules—for aircraft and defense applications.

Our external funding level for advanced PV was about \$14 million in fiscal year 2021.



## Here's Where the Rubber Meets the Road

Our capabilities—supported by state-of-the-art equipment, leading-edge techniques, and expert staff—have breadth and depth. And they're all located under one roof at NREL.

- **Synthesis:** We work across a wide range of materials and processes, including silicon, perovskites, CdTe, copper indium gallium diselenide (CIGS), III-V, multijunction solar cells, organic materials, novel epitaxy and liftoff, flexible glass, and polymer substrates.
- **Characterization:** We perform microscopy and imaging on scales ranging from atoms to modules, laser spectroscopy, and advanced measurements to determine electro-optical properties. We also perform state-of-the-art surface and interface analyses.
- **Stability and certification:** We conduct accelerated lifetime testing, solar cell efficiency certification, outdoor field analysis, product lifetime analysis, and packaging development. We also develop and test qualification standards.
- **Analysis, computation, and theory:** We perform state-of-the-art device simulations for every technology, ab-initio calculations, new materials discovery, bottom-up cost analysis, market surveys, irradiance analysis, and systems and grid integration analysis.

## Partner With Us

We have multiple paths for partnering, including licensing NREL intellectual property, testing and characterization, techno-economic analysis, and generating new technology solutions through cooperative R&D agreements.

### Contact Us

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Some photovoltaic technologies, such as thin films, can be flexible and lightweight, so can be used for applications such as aerial transportation or where power needs to be portable. *Photo by NREL 13564*