Photovoltaic device innovation poised for global impact on the future energy system

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PV device innovation is critical for the ongoing progress of solar, which must expand dramatically over the coming decades to achieve a sustainable energy system. Credit: Werner Slocum, NREL

Recent decades of research and development have produced highly sophisticated solar cells—or photovoltaic (PV) devices—that generated more than 1,000 terawatt-hours of electrical energy globally in 2022. This deployment has been accelerated by improvements in the design and performance of PV devices, as well as significant cost declines,

achieved through innovative research in module, cell, and manufacturing of PV.

PV deployment must grow dramatically in the next few decades—to the multi-terawatt (TW) scale—to achieve a sustainable energy system. Given the urgency of this growth, continued solar cell innovation is crucial.

This need for solar cell innovation is the main idea of a new article in *Device*, "Photovoltaic Device Innovation for a Solar Future." Written by an international team of researchers led by the National Renewable Energy Laboratory (NREL), the article highlights the importance of PV device innovation for the energy transition.

"Through device innovation, we can have a major impact on the global energy system of the future," said Nancy Haegel, director of the National Center for Photovoltaics at NREL and lead author on the paper. "Even what might appear to be small changes, like a percent or two in efficiency, actually have huge impacts at terawatt scale."

The past and future of solar

The paper looks at both the past and future of solar cells. The authors review recent advances and future opportunities in solar cell innovation for four fully commercialized technologies: III-V multijunction solar cells for space and silicon (Si), cadmium telluride (CdTe), and copper indium gallium diselenide (CIGS) for terrestrial power generation.

"There has been an incredible amount of innovation in these types of PV devices, and that innovation has been critical to the progress of solar over the last decade," Haegel said. "Looking ahead, our hope is that this will inspire researchers in the PV community to contribute to device innovation."

Recent advances in these solar cells have largely focused on efficiency, cost reduction, and improved reliability. But at the multi-TW production scale, new challenges, such as materials availability, supply chain, and embedded energy and carbon dioxide (CO_2), begin to affect the PV industry.

"Some of the most exciting areas for innovation—in addition to increasing efficiency, which is always important—include reducing use of scarce materials, developing circular technologies, and obtaining lower-cost dual-junction devices," Haegel said.

Another key direction for future research is the "coupling" of solar cells.

"On the device side, coupling two or more materials to create low-cost tandem devices is becoming increasingly important," Haegel explained. "And on the systems side, the future of PV is going to depend, in large part, on how it is coupled with other energy sectors in the clean energy economy, including transportation, storage, industrial processes, and electrification of building heating and cooling."

A new forum for device-related research

"It's my goal to use *Device* to highlight the many interdisciplinary contributions that it takes to truly take a device from an innovative idea to a technology that makes real-world impact," said Marshall Brennan, editor in chief of Device.

"What Nancy and her colleagues have contributed is a perfect encapsulation of what we're looking to accomplish: understanding technologies that help make real progress on challenges and impact the lives of global citizens while providing context for how to solve the various problems that a new technology will face as it scales. Moreover, NREL's mission to solve energy challenges using creative solutions

aligns with what Device stands for, so I am overjoyed with the opportunity to establish that connection early in the journal's lifetime."

Haegel added, "Given that PV is going to be a key part of the clean energy solution, we are excited to have a PV device article in the very first edition of Device, and we hope that it inspires new people to join the field and new advances in solar cells."

More information: Pierre Verlinden et al, Photovoltaic device innovation for a solar future, *Device* (2023). DOI: 10.1016/j.device.2023.100013

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