Quantum Dot Materials Can Reduce Heat, Boost Electrical Output

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Researchers at the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) have shown that nanotechnology may greatly increase the amount of electricity produced by solar cells.
In a paper published in a May issue of the American Chemical Society's *Nano Letters* journal, an NREL team found that tiny "nanocrystals," also known as "quantum dots," produce as many as three electrons from one high energy photon of sunlight. When today's photovoltaic solar cells absorb a photon of sunlight, the energy gets converted to at most one electron, and the rest is lost as heat.

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The research demonstrates the potential for solar, or photovoltaic, cells that reduce wasteful heat and maximize the amount of the sun's energy that is converted to electricity—a key step toward making solar energy more cost-competitive with conventional power sources.

The NREL research team, led by Arthur Nozik, included Randy Ellingson, Matt Beard, Justin Johnson, Pingrong Yu, and Olga Micic, and worked in collaboration with theorists Alexander Efros and Andrew Shabaev of the Naval Research Laboratory (NRL) in Washington, D.C.

The findings are further confirmation of pioneering work by Nozik, who in 2000 predicted that quantum dots could increase the efficiency of solar cells, through a process now termed "multiple exciton generation," or "MEG". Last year, Richard Schaller and Victor Klimov of Los Alamos National Laboratory in New Mexico were the first to demonstrate the electron multiplication phenomenon predicted by Nozik, using quantum dots made from lead selenide.

"We have shown that solar cells based on quantum dots theoretically could convert more than 65 percent of the sun's energy into electricity, approximately doubling the efficiency of solar cells," Nozik said. The best cells today convert about 33 percent of the sun's energy into electricity.

The NREL and NRL researchers' paper also describes a new theoretical foundation for the multiple exciton generation process that is based on certain unique aspects of quantum theory.

The recent work demonstrates MEG in quantum dots of a second semiconductor material, lead sulfide.

The NREL/NRL work not only shows higher overall efficiency for multiple exciton generation, it also establishes that the process occurs with lower photon energies, meaning it could make use of an even greater portion of the sun's light spectrum.

Beyond potential use for photovoltaic cells, similar quantum dot technology may someday be used in photoelectrochemical cells, which could become a clean and renewable way to produce hydrogen directly from water and sunlight.

Source: National Renewable Energy Laboratory