STEM

Solar-Combined Thermoelectric Power Generation Simulator

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Photovoltaic (PV) devices are gaining popularity in harnessing solar energy as a form of sustainable energy source to generate electricity. However, these devices including tandem PV cells are limited to utilizing only high-energy photons from the solar spectrum. This curtails their efficiency, restricting them from being employed in megawatt-scale power generation. This study develops a software tool that allows engineers to tap into the wasted wavelengths of the spectrum by adding a thermoelectric (TE) module and a bottoming steam turbine cycle, thus spreading the use of the spectrum. The tool allows investigation into how power output and thus overall efficiency can be enhanced by combining these systems. In the TE device, solar heat develops a temperature gradient to generate electricity via the Seebeck effect. A steam-driven Rankine cycle through

a heat exchanger connects to thermal storage at the bottom side of the TE. This storage allows dispatchability for off-sunlight power demand at a modest cost. The simulation tool computes expected power output and efficiency at each individual stage of the combined system. The user is at liberty to manipulate material properties such as the band gap of PV materials, which is a key parameter to optimize the PV efficiency. Test runs indicate that overall efficiency of power generation has increased up to 50% by the combined system for 1,000 suns using optimized band gap and TE module design. This system can be used as a basis for future models in high-efficiency distributed energy production.

Research advisor Kazuaki Yazawa writes, "System performance analysis is a challenge in such combined systems to fully utilize the solar spectrum into electricity. Multi-physics are involved and the interaction is controlled by filtering wavelength. The development of the software tool provides a tremendous benefit for engineers to explore the impact on system by technical development."