Combining conventional and concentrated solar technology results in efficiency gains

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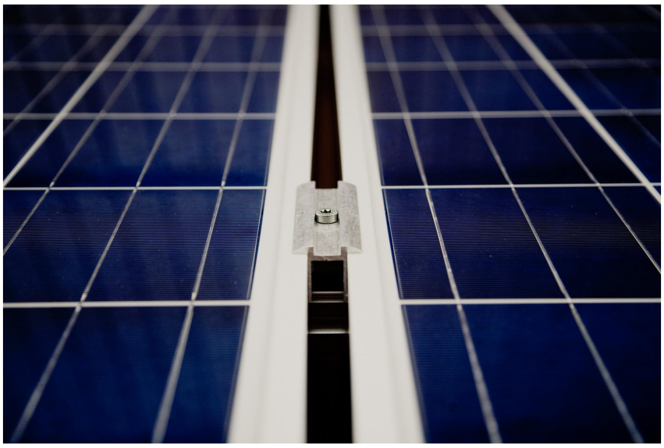

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(Tech Xplore)—An international team of researchers has found a way to increase solar cell efficiency in areas where there is small degree of cloudiness. In their paper published in *Proceedings of the National Academy of Sciences*, the team describes how they combined two solar technologies to produce a product that was more efficient than either alone in certain geographical areas.

Solar engineers have found that using concentrated photovoltaic modules is the most efficient way to produce solar energy in very sunny locales—in such modules, lenses are used to direct sunlight onto photovoltaic cells. Such modules work very well when exposed to near constant sunlight, but suffer dramatically if even thin clouds disperse the sunlight periodically. In other regions where there are more clouds, solar energy is typically produced using flat panel solar cells because they can produce energy from dispersed sunlight. In this new effort, the researchers combined the qualities of both technologies to provide the most efficient means of producing solar energy in places that get a small degree of cloudiness.

The new design has two variations; the first was built by simply cutting flat panel cells into strips and placing them onto the concentrator module back-panels. The second involved taking the opposite approach, putting the multi-junction cells on top of traditional flat panels. Both approaches allowed for producing energy under ideal sunny conditions and also when the skies were partially clouded—when unobstructed sunlight hits either of the two designs, it is directed by the lenses to a photovoltaic cell, but when it is diffused, the light strikes the flat panels. This approach offers the best of both worlds in a single collector. The sunnier it is, the more efficient the design works.

The researchers report that testing (at three sites at latitude between 35.9º to 40.2º north) showed efficiency improvements of between 1.0 and 8.4 percent over traditional flat panels depending on weather conditions. They also note that such hybrids would cost approximately 7.5 percent more to make than traditional panels. They suggest their hybrid module/panels would provide the best option for users in areas that are partly to mostly sunny for most of the year.

More information: Kyu-Tae Lee et al. Concentrator photovoltaic module architectures with capabilities for capture and conversion of full global solar radiation, *Proceedings of the National Academy of Sciences* (2016). DOI: 10.1073/pnas.1617391113

Abstract
Emerging classes of concentrator photovoltaic (CPV) modules reach efficiencies that are far greater than those of even the highest performance flat-plate PV technologies, with architectures that have the potential to provide the lowest cost of energy in locations with high direct normal irradiance (DNI). A disadvantage is their inability to effectively use diffuse sunlight, thereby constraining

widespread geographic deployment and limiting performance even under the most favorable DNI conditions. This study introduces a module design that integrates capabilities in flat-plate PV directly with the most sophisticated CPV technologies, for capture of both direct and diffuse sunlight, thereby achieving efficiency in PV conversion of the global solar radiation. Specific examples of this scheme exploit commodity silicon (Si) cells integrated with two different CPV module designs, where they capture light that is not efficiently directed by the concentrator optics onto large-scale arrays of miniature multijunction (MJ) solar cells that use advanced III–V semiconductor technologies. In this CPV+ scheme ("+" denotes the addition of diffuse collector), the Si and MJ cells operate independently on indirect and direct solar radiation, respectively. On-sun experimental studies of CPV+ modules at latitudes of 35.9886° N (Durham, NC), 40.1125° N (Bondville, IL), and 38.9072° N (Washington, DC) show improvements in absolute module efficiencies of between 1.02% and 8.45% over values obtained using otherwise similar CPV modules, depending on weather conditions. These concepts have the potential to expand the geographic reach and improve the cost-effectiveness of the highest efficiency forms of PV power generation.

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