Made in the shade: Growing crops at solar farms yields efficiency

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In the threatening trouble of climate change, growing commercial crops on solar farms is a potentially efficient use of agricultural land that can both increase commercial food production and improve solar panel performance and longevity, according to new Cornell research.

The group published new research Feb. 15 in *Applied Energy*.

"We now have, for the first time, a physics-based tool to estimate the costs and benefits of co-locating solar panels and commercial agriculture from the perspective of increased power conversion efficiency and solar-panel longevity," said lead author Henry Williams, a doctoral student in Cornell Engineering.

"There is potential for agrivoltaic systems—where agriculture and solar panels coexist—to provide increased passive cooling through taller panel heights, more reflective ground cover and higher evapotranspiration rates compared to traditional solar farms," said senior author Max Zhang, professor in the Sibley School of Mechanical and Aerospace Engineering, "We can generate renewable electricity and conserve farmland through agrivoltaic systems."

In New York, for example, about 40% of utility-scale solar farm capacity has been developed on agricultural lands, while about 84% of land deemed suitable for utility-scale solar development is agricultural, according to a previous research study from Zhang's group.

By using a computational fluid dynamics-based microclimate model and solar panel temperature data, the group evaluated solar panel height, the light reflectivity of the ground and rates of evapotranspiration (the process where water vapor rises from the plants and soil). They found that agrivoltaic systems can potentially help resolve future global food-energy problems.

The engineers showed that solar panels mounted over vegetation reveal surface temperature drops compared to those arrays built over bare ground. Solar panels were mounted 4 meters above a soybean crop and the solar modules showed temperature reductions by up to 10 degrees Celsius, compared with solar panels mounted a half-meter above bare soil.

The cooling effect due to enhanced evapotranspiration and surface albedo from vegetation and soil is more significant than that induced by greater panel height; and the passive cooling adds to solar panel efficiency, compared with exposed soil or gravel, according to the paper. Better yet, however, the temperature drops leads to an improved solar panel lifespan—and improved, long-term economic potential.

"As you decrease the solar panel operating temperature, you can increase efficiency and improve the longevity of your solar modules," said Williams, "We're showing dual benefits. On one hand, you have food production for farmers, and on the other hand, we've shown improved longevity and improved conversion efficiency for solar developers."

Understanding this mutually beneficial concept comes at a critical time for agricultural production, as global food demands are expected to increase by 50% by 2050, to feed an anticipated 10 billion people, according to the World Resources Institute. At the same time, it is imperative to accelerate the deployment of renewable energy to mitigate the impact of climate change.

In hot climates like the western United States, agrivoltaic farms would be ideal.

"Up to this point, most of the benefits from agrivoltaic systems have revolved around hot and arid climate zones," said Zhang, also the Kathy Dwyer Marble and Curt Marble Faculty Director for the Cornell Atkinson Center for a Sustainable Future, "This paper is taking a step toward evaluating the viability of agrivoltaics in climates representative of the Northeastern U.S. in relaxing the land-use competition the world faces."

More information: Henry J. Williams et al, The potential for agrivoltaics to enhance solar farm cooling, *Applied Energy* (2022). DOI: 10.1016/j.apenergy.2022.120478

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