LRO SNAPSHOT
A brief from the Legislative Research Office September 2022

# Agrivoltaic Technology: Multi-Tasking Land-Use

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## What is Agrivoltaics?

Agrivoltaics does not mean potato batteries. The term is a portmanteau and simply means combining agricultural production and solar electricity generation on the same footprint. Solar energy has become cost competitive after years of research and development which, since 2014, has reduced panel cost by nearly 70%.[1] However, one thing about solar power has not changed; it still requires a lot of land.

## How much land?

On average, utility-scale solar installations require 7 or 8 acres per megawatt.[2] By comparison, the average 1000-megawatt nuclear facility only requires 1.3 square miles of land or, around 800 acres.[3] The single reactor at OPPD's Fort Calhoun Station was rated at 1,500 megawatts. To match its output, a solar installation could require 10 to 12 thousand acres of land.

The National Renewable Energy Laboratory estimated 0.5% of land in the contiguous states would be needed to generate 45% of U.S. electricity needs with photovoltaic technology by the year 2050. That seemingly small number is equivalent to 15,000 square miles or, 9.5 million acres. It is also nearly 4% of U.S. cropland.[4]

*Raspberry farm in Babberich/Netherlands with Agri-PV: Net crop yield was increased by about 6 percent compared to conventional raspberry cultivation under foil tunnels*
*Image Credit: [BayWa r.r.](BayWa r.r.) via [PV Europe](PV Europe)*

*APV-system in Italy*
*Image Credit: Ahlers (2014) via ResearchGate*

## Opportunity

Large solar projects are typically designed for the sole purpose of producing energy. Energy-centric planning gives no consideration to the displacement of agriculture or other land development activities. Unused space beneath panels is wasted, adding nothing but additional maintenance costs in the control of unwanted vegetation. However, some project developers and farmers began turning these costs into opportunities by creating mutually beneficial arrangements to manage vegetation by grazing sheep or other small animals under solar installations and around the buffers. This experience led to the obvious question: why couldn't it work with other agricultural systems?

## A Sum Greater than the Whole

Research and practical experience have shown that with appropriate design, combined systems can be more profitable than either solar or agriculture alone. The main reason for this is that these dual-use systems create spatial overlap between the two uses and although neither use achieves 100% economic efficiency, in combination, each use can achieve greater productivity per acre than they can alone.

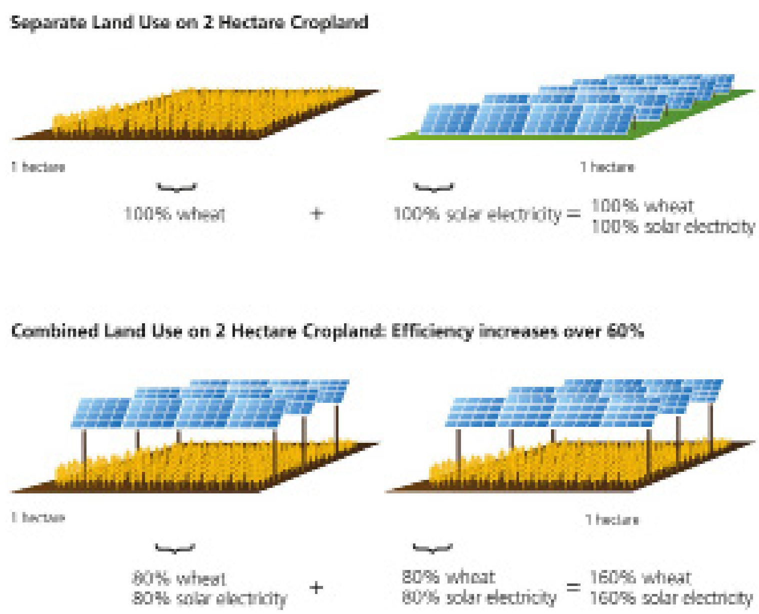



*Image Credit:* metsolar

## Too Much of a Good Thing?

One reason for this additive miracle is a property known as the light saturation point of plants. It is the point at which more sunlight only increases leaf temperature and causes plants to use more water without increasing photosynthesis.[5]

A carefully designed agrivoltaic system can create advantageously shifting patterns of sun and shade in the field, optimizing power production when plants might benefit from increased shading during the heat of the day and optimizing plant growth on the shoulders of the day when power production has dropped.

Similarly, the systems can be manipulated throughout the growing season to account for the angle of the sun, the growth stage of the crop or even the timing of agricultural operations.

The benefits of agrivoltaic systems also flow in the opposite direction as the cooling effects of plant evapotranspiration help reduce panel temperatures and maintain their operating efficiency.

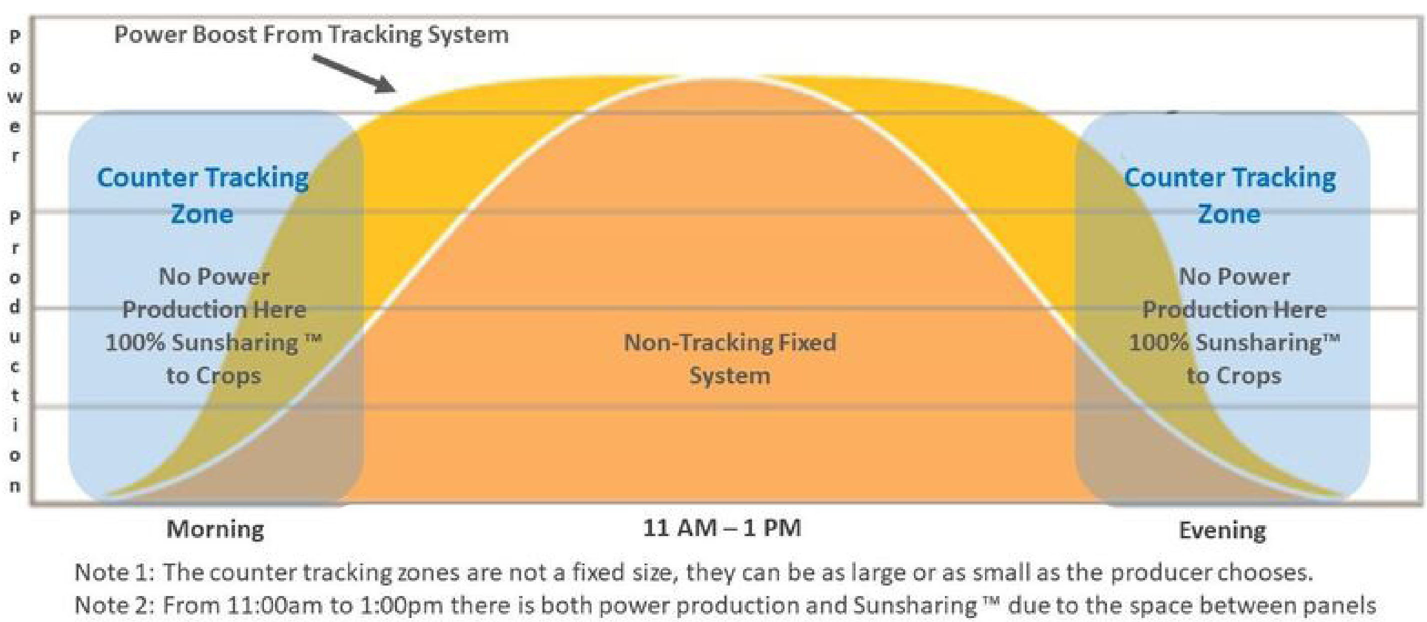
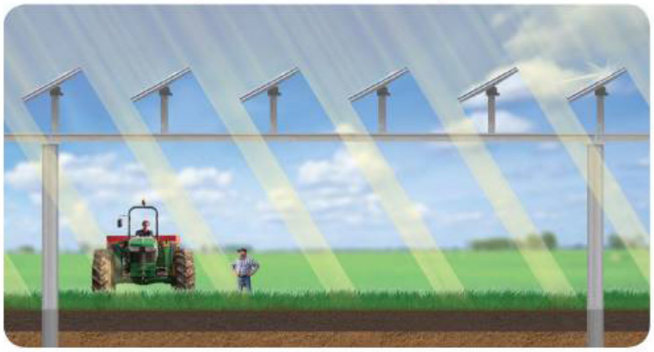


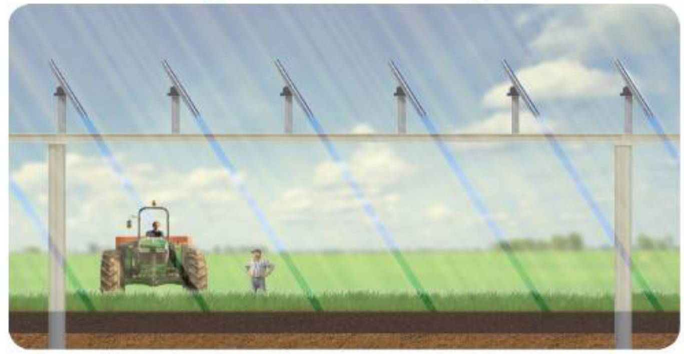

Image Credit: SolAgra

NORMAL TRACKING



Solar panels are perpendicular to the sunlight and provide partial shading

COUNTER TRACKING



The opposite of Normal Tracking where panels are parallel to the sunlight allowing maximum sunlight on crops

*Image Credit:* SolAgra

## Strategies

Three common approaches to agrivoltaic design include increased spacing between rows of solar panels, increased height of mounting hardware and the introduction of tracking actuators. By adjusting row widths, patterns of sun and shade are manipulated to favor the target crop. Increased panel height can create more farming opportunities, allowing the introduction of taller crops, animals and farm equipment. Trading fixed panel mounts for tracking actuators facilitates the daily and seasonal optimization between energy and agricultural production.

Other ideas being explored include bifacial panels, the undersides of which can harvest reflected light. Still another interesting approach involves the development of semi-transparent panels that would intercept and convert to electricity only those wave-lengths of light plants cannot utilize.

## Tradeoffs

Utility-scale agrivoltaic systems can potentially increase land revenue, provide income and employment diversification to rural economies and may help insulate them from fluctuating farm incomes by providing more predictable revenue streams.

However, agrivoltaic systems are not without their drawbacks. They add to the complexity of planning and design for both uses. They introduce fixed infrastructure to agricultural fields which may reduce farming flexibility.

Solar power companies and their insurers are still averse to the risks of introducing machinery in close proximity to photovoltaic infrastructure.

Siting utility-scale solar projects can often meet with community resistance. Objections are frequently raised regarding project aesthetics, the loss of farmland and the potential disruption to the broader agricultural supply economy tied to farming.

Nevertheless, because solar leases may provide roughly two to four times more revenue than for example, corn farming, the financial incentives may be sufficient to drive continued innovation and adoption.[6,7]

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