Toward a Disaster Resilient California

GROWING A SUSTAINABLE FUTURE:

Agrivoltaics in California's Water-Energy-Food Nexus

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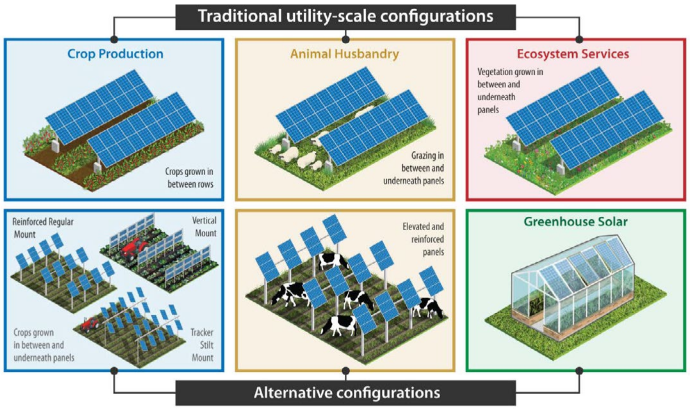

Figure: Types of commercially deployed agrivoltaic systems. From the NREL report, *The 5 Cs of Agrivoltaic Success Factors in the United States: Lessons From the InSPIRE Research Study*.

SUMMARY

- Agrivoltaics is the co-location of solar photovoltaic panels on agricultural land that results in the production of both electricity and an agricultural product or service.
- Early research suggests that agrivoltaics may offer benefits to food production, energy production, working and natural land conservation, and water use efficiency.
- Agrivoltaics has the potential to keep productive agricultural land in production while providing additional revenue for producers.
- Understanding location-specific outcomes of the interaction between a crop type and panel design is necessary to determine best practices and viability of agrivoltaic systems in different regions of California and the U.S.

INTRODUCTION

Agrivoltaics (or agrisolar) is the strategic co-location of solar photovoltaic panels (solar panels) on agricultural land. Broadly, agrivoltaics systems can include grazing land, crop land, and sometimes pollinator habitat. For the purposes of this document, agrivoltaic systems are solar panels above or immediately next to growing agricultural crops.

The proposed benefits from this co-location are being researched but initial reports suggest it could have benefits for crop production, reduced water use, soil health, and increase solar panel efficiency. However, the degree to which these benefits are realized vary with crop type, solar panel type and arrangement, geographic location, and other factors. Therefore, it is important to conduct place-based research to understand the impact of crop type and panel arrays on energy production and agricultural yield for a given location.

Key Questions about AGRIVOLTAICS IN CALIFORNIA

1. What are potential economic, social, energy, and agricultural productivity impacts of agrivoltaic systems on farms and the state's agricultural economy?
2. What is the potential of agrivoltaic systems to reduce the impacts of extreme heat on crops, livestock, and agricultural workers?
3. Are the impacts of agrivoltaic systems different among the different regions of the state with different climate conditions? Do agrivoltaics make sense in California at an individual farm level?
4. Which crop types and panel arrangements work best in the different regions of CA? How will that vary with region?

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SELECT EXPERTS

The following experts can advise on agrivoltaics:

KAREN ROSS (Moderator)
Secretary of the California Department of Food and Agriculture

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EXPERTISE: Agrivoltaics in California and semi-transparent solar panels.

JORDAN MACKNICK PHD
Distinguished Member of Research Staff
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EXPERTISE: National and regional implications of energy pathways, including agrivoltaics.

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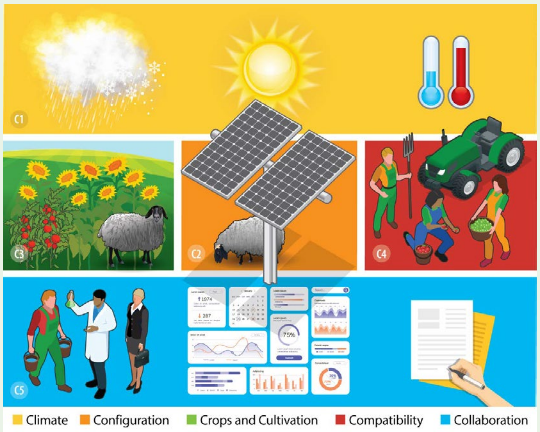

Figure and modified text from the NREL report *The 5 Cs of Agrivoltaic Success Factors in the United States: Lessons From the InSPIRE Research Study*.

The Five Cs of Successful Agrivoltaics Deployment:

Climate: Ambient conditions and factors of the specific location.

Configuration: The choice of solar technology, the site layout, and other infrastructure that can affect light availability and solar generation.

Crop selection and cultivation: The methods, vegetation, and agricultural approaches used for agrivoltaic activities and research.

Compatibility: The compatibility of the solar technology design and configuration.

Collaboration: Understandings and agreements made across stakeholders and sectors.

LAND USE & ENERGY PRODUCTION

As demand for renewable energy goes up, there has been increased interest in converting both natural and working lands to solar development. Rather than developing more natural lands or converting productive agricultural lands to utility-scale solar farms, agrivoltaics may offer a different path whereby farmers could install solar panels on working lands while still prioritizing food production.

Solar energy is a key part of the US's — and California's — strategy to decarbonizing the electricity sector. According to a DOE Solar Futures Study, **solar energy could provide up to 40% of the US's electricity by 2035**. That could require an estimated 5.7 million acres (less than 1% of current farmland in the contiguous US).

The scale that is right for each farm and the amount of energy it could produce are questions that need to be examined nationally and regionally. While some farms may be able to install large agrivoltaic systems, not all farms may be suitable for installing large agrivoltaic systems. Over a county or region, however, small portions of many farms could scale up to have a larger cumulative impact on zero-emission energy production. Once generated, there are several potential applications for solar energy production.

If a farm is close enough to transmission lines, a farmer could sell their solar energy to the grid and the associated utility organizations. Alternatively, if a farm does not have easy access to transmission lines or other infrastructure, there may be ways for farmers to use energy on a farm as more vehicles and equipment become electric. Additional research would help to inform the ways farmers could sell or use the electricity they generate and the economics at multiple scales (e.g., individual farmers, agricultural communities, and regional markets)

WATER USE & CROP YIELD

Current evidence suggests that **agrivoltaics may reduce water use and increase yield for some crop species**. Due to increased shade over soil and plants, less water is lost to evaporation from the soil and plant surfaces. In some studies, shading has increased water use efficiency by 328%. Other studies have demonstrated an increased agricultural yield at the end of a growing season – up to three times increased yield for some crops – compared to plants not located in the shade of solar panels.

An improved understanding of how plants can yield more at the end of a growing season despite increased shading may lead to a better solar panel design and arrangement to maximize crop performance and how such optimizations may vary with different growing regions. If agrivoltaic systems do indeed reduce water use while maintaining or improving agricultural yield, there could be planning benefits for farmers in arid landscapes such as the Central Valley of California. For example, with reduced water use from their agrivoltaic system, a farmer in the Central Valley may be able to keep some land in production that would otherwise need to be taken out of production because of water limitations.

FARM WORKERS

Agrivoltaic systems may provide additional benefits to farm workers. The **additional shade can provide a cooler work and rest space for workers**. If agricultural lands are being kept more reliably in production with the addition of agrivoltaics, jobs may be more dependably preserved.

It may **create new job opportunities** as solar panel installments would require a workforce to install them and maintain them in rural communities. Furthermore, additional revenue for solar energy production may have impacts on local communities and economies that would need to be observed to better understood.

While it is easy to focus on these hypothetical benefits to farm workers and communities, it will also be important to weigh them against the cost of installing and maintaining agrivoltaics systems.