Harvesting the Sun Twice: Agrivoltaic Farming

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Opportunities for Berry Growers from Australia's energy transformation

Australia is currently undertaking a radical transformation to run its electricity supply mainly on renewables. Australia has abundant renewable resources, and in particular the solar energy potential is vast with approximately 58 million petajoules (PJ) of solar radiation falling on the country annually. This equals approximately 10,000 times Australia's annual energy consumption, making it a logical and easily harvestable renewable source.

Ground-mounted solar panel arrays offer several benefits related to clean power provision. However, they are land intensive, and there are concerns that arable land could be diverted from food to energy production.

Unlike traditional systems that compete for land, agrivoltaic energy systems integrate solar electricity generation and food production on the same plot, using the land for both purposes simultaneously. For growers, agrivoltaic systems offer the potential for greater returns from harvesting the sun twice, for both berry and energy production.

What exactly is agrivoltaic farming?

In agrivoltaic farming, solar panels are integrated into plant production systems at several metres in height with gaps between the arrays, enabling crops to be grown underneath (Figure 1). These are called 'overhead' or 'stilted' systems and differ from traditional solar farms where arrays are mounted close together and at ground level to maximise energy capture.

New designs termed 'interspace' or 'vertical' agrivoltaic systems are also emerging with vertical solar panels integrated parallel to agricultural areas.

The co-location of renewable energy and crop production on the same area of land may reduce the efficiency of either power generation, agricultural production, or both. However, studies such as the one led by the Fraunhofer Institute for Solar Energy Systems ISE, have demonstrated that the dual use of land is resource efficient and increases the land use efficiency as demonstrated in Figure 1. In addition, there are many situations where agrivoltaic systems benefit crop growth.

Are there more benefits to agrivoltaic farming?

Increased land use efficiency is not the only benefit associated with agrivoltaic energy systems. Most importantly, the panels mounted at height can also create a more favourable microclimate for the crops grown underneath. A simplified representation of microclimate changes beneath the solar panels is summarised in Figure 2.

In detail, research has proven that average daytime air temperature underneath the panels is lower than average daytime air temperature in open fields and this difference is more pronounced during hotter periods. The temperature difference is caused by the shade created by the panels as well as by the transpiring crops. From a crop production perspective, the cooling effect of the panels can offer benefits to the crops grown underneath by reducing thermal stress, particularly during hotter periods and heat stress events.

Conversely, nighttime temperature is generally slightly higher underneath the panels compared to open fields, and this warming is linked to the sheltering effect of the panels preventing radiative cooling and reducing conductive heat loss. The slightly warmer temperatures can protect crops during cold snaps from ice crystal formation which otherwise can significantly affect crop performance, for example, flowering.

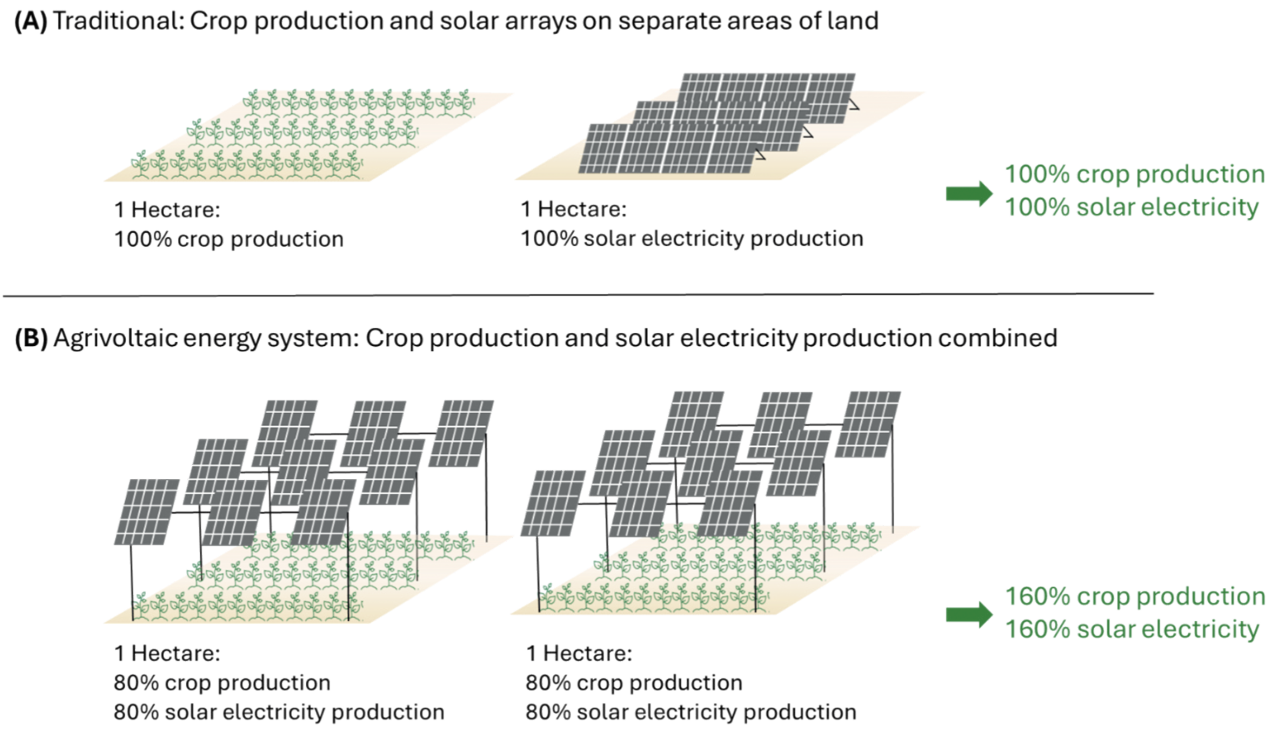

Figure 1. A comparison of the efficiency of (A) traditional farming versus (B) agrivoltaic energy systems. Currently land is mostly allocated to either photosynthesis or photovoltaics - to either grow crops or to generate electricity. As demonstrated by the Fraunhofer Institute for Solar Energy Systems ISE, co-location of both systems is compatible, more resource efficient, reduces competition for land and unlocks new sources of income for farmers. *(Diagram redrawn from Fraunhofer ISE.)*

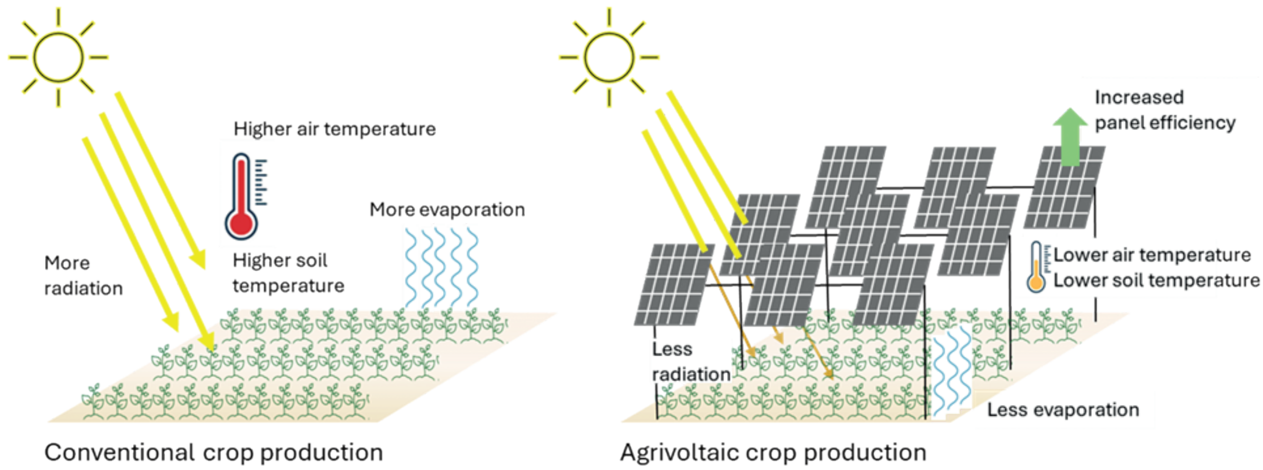

Figure 2. Simplified representation of microclimate beneath solar panels during the day. During the night, temperatures remain higher under agrivoltaic systems with the potential benefit of reducing the incidence of frost.

Water dynamics are also altered by the panels with evaporation losses being lower underneath the panels compared to the open field because of the shade created by the panels. This means that soil moisture persists for longer in agrivoltaic farming thereby benefiting crop production. For example, crop water use efficiency, defined as biomass produced per unit of water used, is often greater underneath the panels. The reduced soil evaporation also affects soil temperature, which is generally lower underneath the panels compared to the open field.

The most obvious change in microclimate underneath the panels relates to changes in amounts of solar radiation. Sunlight absorbed by solar panels decreases the quantity of solar radiation available to the crops underneath.

The decrease in sunlight does not necessarily result in a loss of yield but can affect crop performance in several ways. Depending on the extent of shade created by the panels combined with the shade tolerance of the crop type grown underneath the panels, the climate and seasonal effects, the reduction in light may either have little or no impact, negative impact, or may even have positive impact on crop yield.

For example, it has been shown that many crops, including berries, can benefit from a decrease in solar irradiation with up to 30% more yield compared to open field paddocks. Any negative effects on yield caused by the structure can be mitigated through redesign, e.g., by changing the panel density, tilt, height, etc. It is also noteworthy that integrating solar panels into crop production systems does not only affect the crops growing underneath but also can improve the efficiency of the panels by lowering their operating temperature due to the cooling effect of the crops underneath. Another benefit of agrivoltaic farming is improved working conditions for farm staff, as the solar panels provide shade and cooler temperatures.

The current situation in Australia

Many crop production areas in Australia experience stressful environmental conditions including high light intensities combined with water limitations, heat stress and extreme events such as severe hailstorms resulting in crop yield and quality fluctuations and leaving farms exposed to economic challenges.

Consequently, crop protection measures are significantly increasing across Australia to address climate challenges, use water more efficiently and to achieve stable crop yields and better quality.

Agrivoltaic farming has the potential to create an advantageous crop growing environment particularly in challenging environments while at the same time helping with the transition to renewable energy. Yet, knowledge about the suitability of different crop types for agrivoltaic farming in Australia is still in its early stages. The exceptions are research on pears ('panels over pears') conducted at Agriculture Victoria's Tatura SmartFarm and a research collaboration on grapevines under panels ('vitivoltaics') recently launched across Victoria, South Australia, Tasmania and Western Australia, funded by AgriFutures (Figure 3).

Figure 3. Grapevines under panels (vitivoltaics) at the University of Melbourne's Dookie Campus. Vitivoltaics suggests a significant co-benefit potential for agrivoltaic farming Photo credit: Greenwood Solutions

Are strawberries a promising crop for agrivoltaic farming?

The leaves, flowers and fruit of strawberry are highly vulnerable to physical damage from hail and to sun damage (colour bleaching, sunburn) from direct exposure to radiation but at the same time need adequate sunlight for red colour development and leaf photosynthesis.

The use of solar panels may provide a solution by reducing sun exposure and canopy temperatures during critical developmental stages and physically protecting the crop against hail.

Strawberry is also sensitive to water stress and needs frequent irrigation to maintain productivity. As shown in previous studies, solar panels could reduce transpiration and avoid periods of high evaporative demand that inevitably results in water stress.

Additionally, since 2017 the strawberry crop in southern Australia is suffering plant deaths averaging 20% from an epidemic of charcoal rot caused by the soil-borne fungus *Macrophomina phaseolina*. This pathogen infects and causes disease to strawberry crops under hot (>35°C), water-stressed conditions.

Consequently, agrivoltaics may provide a management solution to growers for this disease by reducing temperature and water stress, thereby minimising their current reliance on soil fumigant chemicals.

In 2024, a field day and workshop were held in Victoria for growers on the potential of agrivoltaic farming for berry production. Growers were questioned on their perceptions of the innovation and were mostly attracted to the prospect of reducing their power costs (Figure 4).

They also saw the potential commercial benefits of reducing sunburn in fruit, improving conditions for workers, hail protection and improving overall sustainability of their operations. At the same time, growers identified the need for more specific information on return-on-investment and the impact on berry production before being able to properly assess the appropriateness of the technology for their farms.

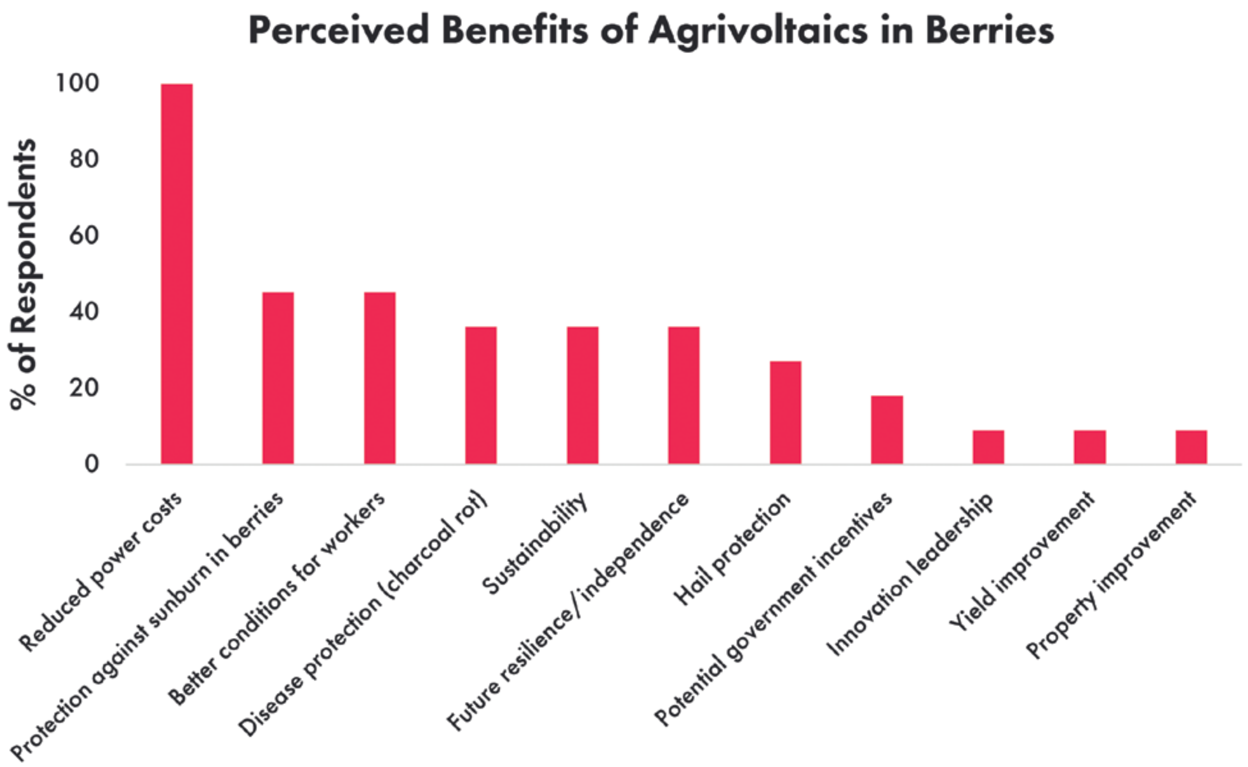

Figure 4. Perceptions of industry on the potential benefits of agrivoltaic farming for berry production at a field day and workshop held in Victoria in 2024

These objectives will be tested over the next year in a pilot study within a commercial strawberry production system in the Yarra Valley where an AgriFutures-funded agrivoltaics structure will be installed in one of the fields over the next couple of months. First results are expected within a year, but much more research will be needed to develop agrivoltaics towards commercialisation for the berry industries.

Agrivoltaics is one way the berry industries can contribute towards Australia's commitment to the 2015 Paris Agreement on climate change and restricting the increase in global average temperatures to well below 2°C of warming.

Acknowledgements

Dr Sabine Tausz-Posch gratefully acknowledges AgriFutures for crucial funding supporting agrivoltaics research at The University of Melbourne and the Drought Hubs across Southern Australia via projects 'Agrivoltaics: A Win-Win for Farmers?' (Grant number: 108500) and 'Plant Production Agrivoltaics Across Southern Australia' (Grant number: 110186).

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The recent webinar on UC Davis Cultivars (8 August 2025) provided an introduction to UC Davis varieties with UC Davis's Strawberry Breeding Program Director, Mitchell Feldmann, and UC Davis Strawberry Breeder Glenn Cole

Recorded on 6 June 2025, we showcased an introduction to CBC varieties with CBC's Head Breeder and R&D director, Kyle VandenLangenberg where Kyle walks growers through CBC's breeding operations in California