Michigan Agrivoltaics Information Guide

Part 2: Agrivoltaics system design and costs

September 2026

Agrivoltaics—the practice of integrating solar photovoltaics with agricultural activity on the same piece of land—is quickly moving from an experimental application to a production-ready system on a large scale. While the resulting economic, environmental, and community benefits of agrivoltaics systems provide strong incentives to develop these systems, doing so requires careful planning and consideration of each project's unique circumstances. This section of the Agrivoltaics Information Guide provides a brief overview of the design considerations and cost impacts of agrivoltaics systems. This resource will be useful for farmers who own their land and developers with limited experience implementing agrivoltaics.

Key takeaways

1. Agrivoltaics systems are unlike conventional photovoltaic systems in their design, often including raised panels, increased row spacing, and altered orientation. System design will largely depend on the associated agricultural activity.
2. Unique system designs to accommodate agricultural activities result in increased materials costs and reduced energy revenue. Balancing electricity production with agricultural activities and selecting an appropriate business and financial model are fundamental to developing an agrivoltaics system.

Agrivoltaics system design

Agrivoltaics projects have unique design considerations that differ from traditional solar projects seeking to optimize energy production. Each agrivoltaics project will have unique goals, and its form and design will differ to meet those goals.

In agrivoltaics configurations, solar panels are typically be elevated higher off the ground. This allows for more light to reach vegetation underneath the panels and ensures wildlife can move freely. While the appropriate height of any agrivoltaics system will depend on a variety of factors, including geographic location, crop and soil type, and available financial resources, the following can serve as general guidelines.

Compared with traditional, energy-focused photovoltaic (PV) systems, projects incorporating sheep grazing often require the least amount of adaptation. While energy-focused systems may have clearances as low as 1.5 feet between the ground and the lower panel edge,[1] projects suitable for sheep grazing only require clearances of 2–3 feet.[2] Larger livestock, such as cattle, and vegetable crops will require 6–8 feet.[3] To allow harvest equipment to pass underneath, panels may need to reach 15 feet.[4]

In addition to height, the spacing of individual solar panels and the distance between rows of arrays are often increased to allow more light to reach the ground.[5] Panel spacing can vary substantially, from just over 6 inches to more than 20 feet.[6]

Row spacing often depends on the type of agrivoltaics system deployed. South-facing fixed-tilt and single-axis tracking systems incorporating agricultural activities will typically have row spacing twice as wide as energy-focused designs.[7] Row spacing for aerial systems, which often resemble the metal roofing structure of a small warehouse, typically ranges from just over 2 feet to more than 30 feet.[8]

Vertical bifacial arrays, which capture reflected light from the ground, frequently use wider spacing (~30-70 feet).[9] This design allows for a more even distribution of soil moisture during rainfall events, but it lacks the same level of crop protection from adverse weather as overhead systems.

While row distance is one way to understand the photovoltaic footprint of an agrivoltaics system, another is using a ground coverage ratio (GCR). GCR is a simple metric that measures the area occupied by solar panels relative to the total area of a site when looking down from directly above the site.

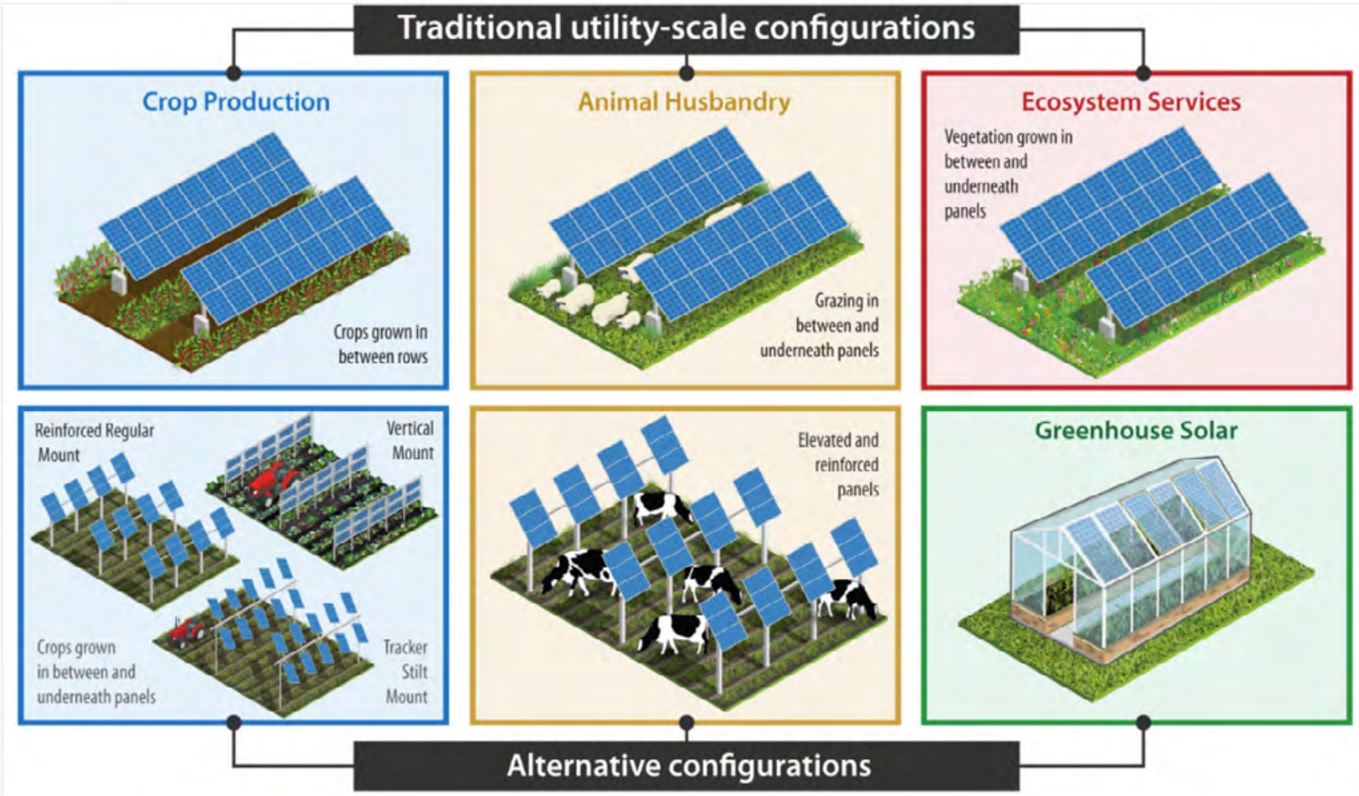
A ratio of 0.0 indicates no coverage (i.e., a completely open field), whereas a ratio of 1.0 indicates full coverage (i.e., the site is fully covered by solar panels). The GCR of energy-focused, fixed-tilt arrays can reach 0.50.[10] However, many agrivoltaics systems will not exceed a GCR of 0.25,[11] with vertical bifacial arrays having GCRs in the low to mid-single digits.[12]

Panel orientation (i.e., the direction it faces) can also be an important factor in system design. While south-facing, fixed-tilt arrays can produce areas that are constantly in shade, changing their orientation by approximately 30 degrees can provide an equal distribution of light at ground level.[13] Photovoltaic arrays in agrivoltaics systems can also be oriented east to west (e.g., single-axis tracking systems and vertical bifacial arrays), allowing for more light to reach crops.

Additional system modifications will likely be necessary to accommodate the specific type of agricultural activity on site. To prevent equipment damage and to protect the animals, sites hosting livestock need to ensure electrical wires are kept high and tight along the underside of panels. Special barriers may need to be installed to prevent animals from clogging intake pipes with hair from rubbing against them. Buried lines should reach a minimum depth of 30 inches to allow adequate root growth and prevent severing by agricultural equipment.[14] Perimeter fencing will need to extend below ground level to prevent predators from accessing sites with animals.

Agrivoltaics systems can also be designed to promote precision agriculture. Emerging dynamic systems that integrate artificial intelligence to alter panel position to maximize light exposure or protect crops from hail, heavy rain, sunscald, or frost are being piloted to evaluate their effectiveness. The responsiveness of these systems to changing conditions helps to realize the synergistic relationship between solar photovoltaics and agriculture. Agrivoltaic systems can take a variety of configurations, as shown in figure 1.

Figure 1. Basic configuration options when designing solar systems



Source: Novel agrivoltaic configurations. Source: Macknick, Jordan et. al; The 5 Cs of Agrivoltaic Success Factors in the United States: Lessons from the InSPIRE Research Study. NREL/TP-6A20-83566.

Note: The graphic demonstrates the range of agrivoltaic system configurations, emphasizing that greater panel heights, row spacing, and panel spacing affect agricultural productivity, ecosystem benefits, and energy generation. The objective of strong system design is to find the optimal balance for the specific scenario.

Design implications for system cost

While numerous technical and design modifications can be made to promote agricultural activities within solar arrays, they often increase capital costs. For instance, the need for higher panel heights increases materials costs for the racking system. The single-axis trackers and specially designed panels used in some agrivoltaics projects also add costs compared to conventional fixed-tilt systems.[15]

While agrivoltaics systems can benefit from reduced site grading and maintenance costs post-construction, they often incur higher labor costs during installation due to the need to adopt special practices to avoid soil compaction.[16]

These additional costs are accompanied by reduced revenue from energy production due to the greater spacing between individual panels and rows of arrays.

While capital costs for agrivoltaics systems will generally be higher than for similar energy-focused systems, costs can vary widely across different configurations. A 2020 report from the National Renewable Energy Laboratory found that fixed-tilt agrivoltaics systems integrating grazing or pollinator services incur capital expenditures (CAPEX) that are only around 5% higher than equivalent energy-focused installations.[17] This differs markedly from raised, 8-foot-clearance systems, where the total installed costs were found to be 50% greater than those of a traditional fixed-tilt system, with the racking component of the raised system three times the cost of the traditional system.[18]

Vertical bifacial arrays can provide significantly lower investment costs than overhead agrivoltaics systems, with CAPEX about 20% higher than traditional fixed-tilt systems.[19] For additional detail, table 1 provides a comparative overview of the costs, revenues, and design considerations across a variety of agrivoltaic system configurations, illustrating the economic trade-offs associated with them.

Capital costs are expected to decline in the future as system designs for agricultural categories become more standardized and supply chains more established. Alternative materials, such as wood, are also being piloted to lower these costs. However, due to the above considerations, agrivoltaics systems are likely to remain more expensive to install than energy-focused systems, highlighting the importance of policy incentives.

Despite higher capital costs, agrivoltaics systems can realize savings on operations and maintenance.[20] In agrivoltaics projects with crops, the presence of these plantings underneath the panels removes the need for mowing. Ecovoltaic sites planted with native grasses or pollinator species and grazed by livestock are increasingly yielding economic returns compared to sites using conventional turfgrass with mowing needs.

While dependent on a range of variables (region, topography, size), according to a 2020 industry survey conducted by *Utility Dive*, sheep grazing in solar arrays costs between $250 and $750 per acre.[21] This price point makes the practice of solar grazing economically attractive for many developers.

In 2018, Tampa Electric (TECO) issued a bid for vegetation management at a number of its solar facilities. Selecting sheep grazing as its preferred strategy for these facilities, it realized a 75% savings over previous mowing costs.[22] While this level of savings is unusually high (30% is typical),[23] it demonstrates the potential benefits of prior planning, as TECO made upfront investments in quality seed mix, fencing infrastructure, and water wells to create sheep-ready solar arrays.

In 2018, Enel Green Power began grazing sheep on its 150-megawatt Aurora Project in Minnesota. While Enel claims the cost savings have been modest, it cited other benefits, including reduced fire risk and equipment damage from mowers.[24]

While vegetation management costs and damage to solar arrays can decrease for agrivoltaics projects involving sheep grazing, it should be noted that damage to racking system pilings and farm equipment is still possible for projects using farm machinery to assist with planting or harvesting crops. Equipment repair costs and cleaning costs can also increase due to panel height, which may require specialized lift equipment to access. However, for locations like Michigan that do not experience a prolonged dry season, panel cleaning is less of an issue, and proper system design can reduce the frequency and impact of farm equipment strikes.

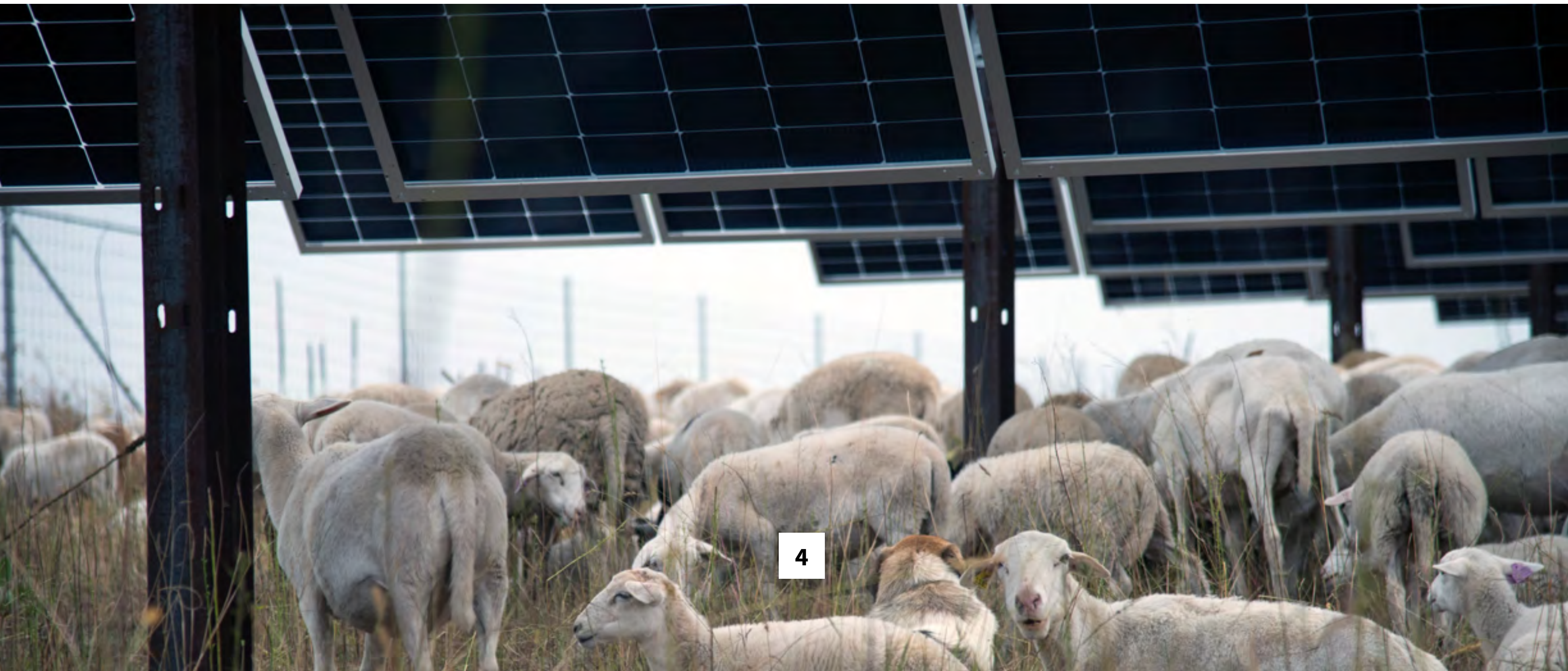


Table 1. Agrivoltaics cost and design considerations

	Fixed-tilt, energy-only PV system	**Fixed-tilt agrivoltaic system**	**Fixed-tilt agrivoltaic system**	**Elevated, increased-panel- spacing agrivoltaic system**	**Elevated, single-axis agrivoltaic system**	**Vertical, bifacial agrivoltaic system**
Agricultural/ ecological use	None	Pollinator habitat	Sheep grazing	Tree fruits, berries, herbs, leafy greens	Row crops (wheat, potatoes), fruits and vegetables (melons, squash)	Row crops (wheat, potatoes, corn)
System cost ($/watt)	1.89	2.04	2.04	2.96	2.34	2.31
Total system cost ($)	4,205,180	2,409,764	2,409,764	3,488,421	3,977,659	3,297,080
Operations and maintenance cost ($/year)	44,444	24,733	23,555	18,844	27,118	22,755
Revenue from electricity generation ($/year)	83,624	45,826	45,826	45,826	76,065	53,043
Change in farm revenue (if farmed previously)	-100%	-100% Does not account for increased yields to neighboring fields from pollinators	-100% Minimal, if previously pasture Could provide an income opportunity for sheep owners	Minimal, with potential to increase for some crops (blueberries)	~ -10%	~ -10%
Harvest method	None	If honey is harvested, often done offsite	Meat processing occurs offsite	Hand-harvested, tractors	Hand-harvested, tractors	Tractors, combines

Source: The quantitative values in this table were generated using the InSPIRE Agrivoltaics Calculator developed by the National Renewable Energy Laboratory (NREL).

Note: The results were derived using a hypothetical 10-acre farm in Kalamazoo, Michigan. Both the pollinator habitat and sheep grazing examples used increased interrow spacing. All configurations, except the vertical-bifacial one, used monofacial panels. All cases assumed no policy incentives were in place.

Endnotes

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[2] WSP USA and Agrivoltaic Solutions LLC, Considerations for "Grazing-Ready" Solar Facilities: Planning for Integration of Sheep, prepared for the New York State Energy Research and Development Authority (NYSERDA) and the New York State Agricultural Technical Working Group (NYSERDA, May 2024), 12.

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[5] National Renewable Energy Laboratory, Agrivoltaic Designs and Configurations (National Renewable Energy Laboratory, November 2024).

[6] Sarr et al., "Agrivoltaic, a Synergistic Co-Location," 7.

[7] Kate Doubleday, Introduction to the 3-Part Agrivoltaics Knowledge Series: Agrivoltaics 101 (National Renewable Energy Laboratory, July 2024). NREL cites row distances as 12 feet for energy-focused designs (utility-scale projects) and 24 feet for agrivoltaics projects.

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[11] Christian Dupraz, "Assessment of the Ground Coverage Ratio of Agrivoltaic Systems as a Proxy for Potential Crop Productivity," *Agroforestry Systems* 98 (2024): 2679–96. The GCR of 0.25 was based on achieving a crop relative yield (RY) of 80%.

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[16] Kelsey Horowitz, Vignesh Ramasamy, Jordan Macknick, and Robert Margolis, Capital Costs for Dual-Use Photovoltaic Installations: 2020 Benchmark for Ground-Mounted PV Systems with Pollinator-Friendly Vegetation, Grazing, and Crops (National Renewable Energy Laboratory, December 2020), 11.

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[19] Horowitz et al., Capital Costs for Dual-Use Photovoltaic Installations, 7.

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[23] Freehill-Maye, "Sheep, Ag and Sun."

[24] Freehill-Maye, "Sheep, Ag and Sun."