Initial Feasibility Assessment of Agrivoltaics in Jackson County, IL

April 2024

James McCall, Brittany Staie, William Scott Carron, and Johanna Jamison

Produced for the U.S. Department of Energy by the National Renewable Energy Laboratory (NREL).

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List of Acronyms

CAPEX	capital expenditures
DOE	U.S. Department of Energy
IRR	internal rate of return
MW	megawatt
NPV	net present value
NREL	National Renewable Energy Laboratory
PPA	power purchase agreement
PV	photovoltaic
REC	renewable energy credit
SAM	System Advisory Model
SIU	Southern Illinois University

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Executive Summary

Consistent with concerns raised in other rural communities, the agricultural community in Jackson County, Illinois is hesitant to install ground-based photovoltaic (PV) systems on prime agricultural land. Directly integrating solar energy generation and agricultural activities, an emerging technology known as agrivoltaics, can present uncertainty in a world where agricultural practices are traditionally passed down from generation to generation. Agrivoltaics may present new solutions that collocate both energy production and farming practices on the same land that can enable new or alternate revenue streams and support energy resiliency.

To assess the initial feasibility for agrivoltaics in Jackson County, Illinois, a community coalition in Jackson County requested technical assistance through the U.S. Department of Energy's Communities LEAP (Local Energy Action Program) pilot to perform an initial techno-economic assessment, resource assessment, and feasibility assessment based on the unique agricultural context present in the area. As part of Communities LEAP, the National Renewable Energy Laboratory (NREL) interviewed five Jackson County experts on five crops (vineyards, strawberries, pumpkins, apple and pear orchards, and hemp) to examine the potential for agrivoltaics integration and identify key barriers that could hamper development. NREL performed techno-economic analysis for different agrivoltaic system designs to determine the economic constraints and opportunities of agrivoltaics development. This report provides an initial feasibility assessment of agrivoltaics in Jackson County.

Overall, this report assessed that there are agrivoltaic system designs that might work for crops in Jackson County with more research. All PV system designs assessed in this report yielded negative net present values (NPV), meaning the projects are currently uneconomic assuming the prevailing PV development costs and electricity sale prices. The report presented the average net cash returns per acre for the five crops identified by the Jackson County community to help define the type of crops that may offset the higher PV development costs of agrivoltaics systems. Further research is needed, and pilot projects can assist in demonstrating agrivoltaic feasibility to community stakeholders and the residents of Jackson County.

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Introduction

Consistent with concerns raised in other rural communities, the agricultural community in Jackson County, Illinois is hesitant to install ground-based photovoltaic (PV) systems on prime agricultural land (Heath et al. 2022). Farmland is often flat, geotechnically stable, and has ample sunlight that makes these lands favorable to solar development (Adeh et al. 2019). However, this concept of converting farmland to solar has seen backlash in rural communities due to concerns about land being taken out of production, farming way of life changes, food security, and potential degradation of farmland (Hunter et al. 2022). Agrivoltaics presents potential solutions to these challenges within Jackson County.

As part of their participation in the U.S. Department of Energy's Communities LEAP (Local Energy Action Program) pilot, a community coalition in Jackson County sought technical assistance from the National Renewable Energy Laboratory (NREL) to provide the technical data needed to inform decisions and evaluate the economic potential of agrivoltaics as part of the county's Clean Energy Transition Roadmap. This report summarizes initial feasibility analysis for agrivoltaics in Jackson County.

Agrivoltaics is the practice of co-locating photovoltaic energy generation with agricultural production (Macknick et al. 2022). To support the agrivoltaics pathway, the Jackson County coalition requested technical assistance to perform an initial technoeconomic assessment, resource assessment, and feasibility assessment based on the unique agricultural landscape present in Jackson County.

NREL's technical assistance included an investigation of the diverse stakeholder requirements specific to the southern Illinois region representing both traditional crops and livestock as well as specialty orchards and vineyards. Technical assistance can inform the Jackson County community coalition on what agrivoltaic solutions may look like across the county, help define the financial and economic benefits and barriers, and provide technical data to support decision-making and further develop an agrivoltaic pathway within their Clean Energy Transition Roadmap.

Current Agrivoltaic Trends

As of 2023, most agrivoltaic implementation in the United States has been on land used for sheep grazing and/or integration of pollinator habitat in and around solar panels. Both agrivoltaic activities are compatible with traditional, utility-scale solar design (approximately 18-foot (ft) spacing between support poles and minimum panel edge height of 18–36 inches). To date, there has been minimal integration of crop production with solar panels. Current agrivoltaic sites are mainly pilot project research sites located throughout the county and often small in nature. Examples of larger agrivoltaic sites that integrate crop production include the 4.2 megawatt (MW) University of Maine blueberry site and 1.1 MW Jack's Solar Garden with horticultural operations (NREL 2023a). Several other small crop agrivoltaic projects are in operation and development in Massachusetts, mainly incentivized by a $0.06/kilowatt-hour (kWh) adder from the MA SMART program (Baker et al. 2018).

Other solar designs prominent in Europe and Japan involve raising the panels higher in the air (12–20 ft) and reducing the size and density of solar panels. These systems have not seen much deployment in the United States, potentially due to the high cost to raise panels, easy access to land for U.S. solar sites, lack of policies that mandate continuation of agricultural production with solar sites, and low electricity prices in the United States. However, the agrivoltaics market is evolving in the United States and there is some potential for these designs to be implemented at smaller-scale or community solar projects.

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Common Agrivoltaic Configurations

Below are figures that detail different designs of agrivoltaics implementation. Tradeoffs between upfront capital cost expenditures at the beginning of the project can sometimes lead to lower operational costs over the life of the project, depending on the configuration and management approach.

Standard Utility-Scale Bifacial Design with Crop Production

The system in Figure 1 is a demonstration project with bifacial panels, a one-axis tracker, 18 ft in between support posts, and a minimum ground clearance of 18 inches. At this research site, there are three beds of horticulture crops in between the solar panels growing carrots, tomatoes, peppers, kale, chard, and basil. Some small-scale machinery was used to till the land and prepare beds, but the crops are mainly hand harvested. Extra precaution around burying and marking underground wiring is used to prevent machinery impacting live electrical equipment. There has been some shading of the panels at low tilt angles from workers, but this has not had a substantial impact on overall generation. Due to the low height, worker access has seen challenges, in particular in the crop rows adjacent to the panels.

Figure 1. Bifacial Agrivoltaics Research at NREL (BARN) demonstration site

Photo Credit: Joe DelNero (NREL 2023b)

Standard Utility-Scale Solar with Grazing

Sheep grazing, as shown in Figure 2, can be integrated into solar projects without many changes to the PV design and can reduce costs compared to mowing operations (McCall et al. 2023). Upfront planning including drilling an on-site water well to avoid water hauling, planning for grazing infrastructure, temporary fencing, and sheep handling systems can reduce the cost of sheep grazing. Some pilot projects are looking at cattle grazing at solar sites, but cattle panels need to be lifted, reinforced, or protected with electric fencing to prevent damage to the solar site, which can lead to higher costs. Pollinator habitat or other high-value forage seed mixes are often integrated into grazing groundcover designs, with higher values of forage potentially reducing grazing costs to the developer.

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Figure 2. Sheep grazing at traditional utility-scale solar project in Massachusetts.

Photo Credit: Alexis Pascaris, NREL

Elevated Multi-Use Solar Site

One of the larger commercial agrivoltaic sites in the country to integrate horticulture crops is Jack's Solar Garden in Longmont, Colorado (Jack's Solar Garden 2023). The PV design at Jack's Solar Garden, as shown in Figure 3, contains traditional row spacing with panels raised to 6-ft and 8-ft hub heights for worker access and sunlight gain underneath the panels. Electricity generated is sold directly to subscribers through Colorado's Community Solar program and is sold at a premium over electricity prices including renewable energy credit (REC) payments from the local utility. These increased electricity price sales and RECs offset the cost of raising the panels.

Figure 3. Jack's Solar Garden.

Photo Credit: Werner Slocum (NREL 2023b)

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Elevated Design with Inter-Panel Spacing

Established in 2011, Figure 4 displays one of the longer-running agrivoltaic research projects at the University of Massachusetts in Amherst, Massachusetts. The fixed tilt system has panels raised 10 ft off the ground, with different panel density to allow light through to crops. The height originally was to integrate cattle grazing, but the site was shifted to horticulture production. With the solar resource in Massachusetts, spaces in the panels were integrated to allow enough light to get through to the farming beds. Researchers have found a change in production and ripening times from the shade.

Figure 4. University of Massachusetts Amherst demonstration site.

Photo Credit: Dennis Schroeder (NREL 2023b)

Elevated Orchard Design

Reflective of common design in Europe, the system shown in Figure 5 is from a site in Bierbeek, Flanders, Belgium that integrates a pear orchard underneath PV modules. The panels are raised approximately12 ft in the air in a fixed "tent" design. The panels are typically arranged in a north-south (N-S) orientation to align with common orchard layouts but can be orientated to better match the slope of the orchard. This system is designed to provide hail protection for orchard crops and the panels are semi-transparent to allow light through to the trees. There is a reduction in the overall solar generation of the site compared to conventional solar arrays to allow for continued farming practices. Currently, there are no systems like this deployed in the United States mainly due to increased costs, lack of U.S. certification of the semi-transparent panels, and decreased energy density of the panels.

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Figure 5.Pear agrivoltaic demonstration site in Belgium.

Photo Credits: Ken Anderson, SIU

Vertical Bifacial Design

A newer proposed design for agrivoltaics, as shown in Figure 6, is a vertical bifacial or “solar fence” system. Bifacial panels allow for light to be collected on both sides of the PV panels and this system allows for light collection at lower sun angles in the morning and evening. While overall energy production is generally less than traditional PV designs (some high latitude systems can have close to similar production), vertical bifacial systems can have a lower space footprint and provide electricity production outside of peak solar hours (10 a.m.–2 p.m.). Large equipment can access the areas in between the panels and there is little shading concern with hay and other grasses. There are several pilot projects in development in the United States, but implementation has been limited.

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Figure 6. Vertical bifacial concept in Japan.

Photo Credits: Thomas Hickey, NREL

“Solar-Sharing” – Elevated Panel with Ag-Centric Design

Japan currently has the largest number of agrivoltaics projects (called “solar sharing”) with over 2,000 projects in operation (Graham 2022). Projects are often agriculture-centric with panels raised 10–12 ft in the air at reduced density for light to get to crops, as shown in Figure 7. Lack of land access for energy and agriculture, energy security for rural areas, and federal policies that prioritize these systems on agricultural land have driven implementation in Japan.

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Figure 7.“Solar Sharing” concept in Japan.

Photo Credits: Thomas Hickey, NREL

Jackson County Scenario Analysis

For this technical assistance activity, NREL staff modeled different agrivoltaic designs for the city of Carbondale, performed initial economic analysis, and interviewed five agricultural experts in Jackson County to obtain relevant crop information for the region. Based on input from these experts, this section discusses some of the challenges, opportunities, and research gaps to implement cropping agrivoltaic pilot projects in the area.

Annual Energy Generation

NREL modeled the yearly electricity generation for each kW installed along with the capacity factor (i.e., ratio of actual energy production over theoretical continuous maximum energy production over a year) of each agrivoltaic design scenario. Each scenario includes weather data for a typical meteorological year downloaded for Carbondale, Illinois from the National Solar Radiation Database (NREL 2017). NREL created a System Advisor Model (SAM) file for each design scenario as presented in Table 1 below. The highest generation scenario was a one-axis tracking system. The N-S tent and vertical bifacial systems generated the least electricity.

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Table 1. Annual Energy Generation by Scenario

Scenario	Design parameters	Annual generation (kWh/kW)	Capacity factor	Ground coverage ratio[1]
Fixed, south facing	31 deg tilt (maximized production), bifacial, 25 ft spacing	1,496	17.1%	0.3
One-axis tracking (see Figure 2)	Bifacial, 22 ft spacing	1,698	19.4%	0.33
N-S tent, fixed (see Figure 5)	15 deg tilt, N-S tent, monofacial	1,215	13.8%	0.33
Vertical bifacial (see Figure 6)	90 deg tilt, 30 ft spacing	1,187	13.6%	0.25

The first two scenarios are common in the United States and should have few technical challenges to implement. As mentioned before, vertical bifacial systems have minimal deployment but there are upcoming projects to test this technology. For the N-S tent design, most of these designs have a semi-transparent solar module or disconnected solar cells as shown in Figure 4. There are some concerns from developers that these modules are not UL-certified currently and there may be some issues with obtaining insurance for the project or interconnecting to the grid. Projects to deploy these systems will need to further explore if the design is feasible with local, state, and federal permits and code requirements.

Scenario Cost Modeling

All installed costs for the different scenarios were obtained from an updated version of Capital Costs for Dual-Use Photovoltaic Installations (Horowitz et al. 2020). This updated version includes inflation prices for both steel and solar modules that substantially increased costs compared to previous cost models. For this report, each system cost assumes a 500-kW system. Larger PV systems will see a lower per-unit cost due to economies of scale and explains the trend of growing project capacities seen in the U.S. market as a whole (Bolinger et al. 2023).

[1] Ground coverage ratio is a measure of the surface area of the panels to the overall land area. It is defined as the length of the PV panel divided by the distance between PV panel supports.

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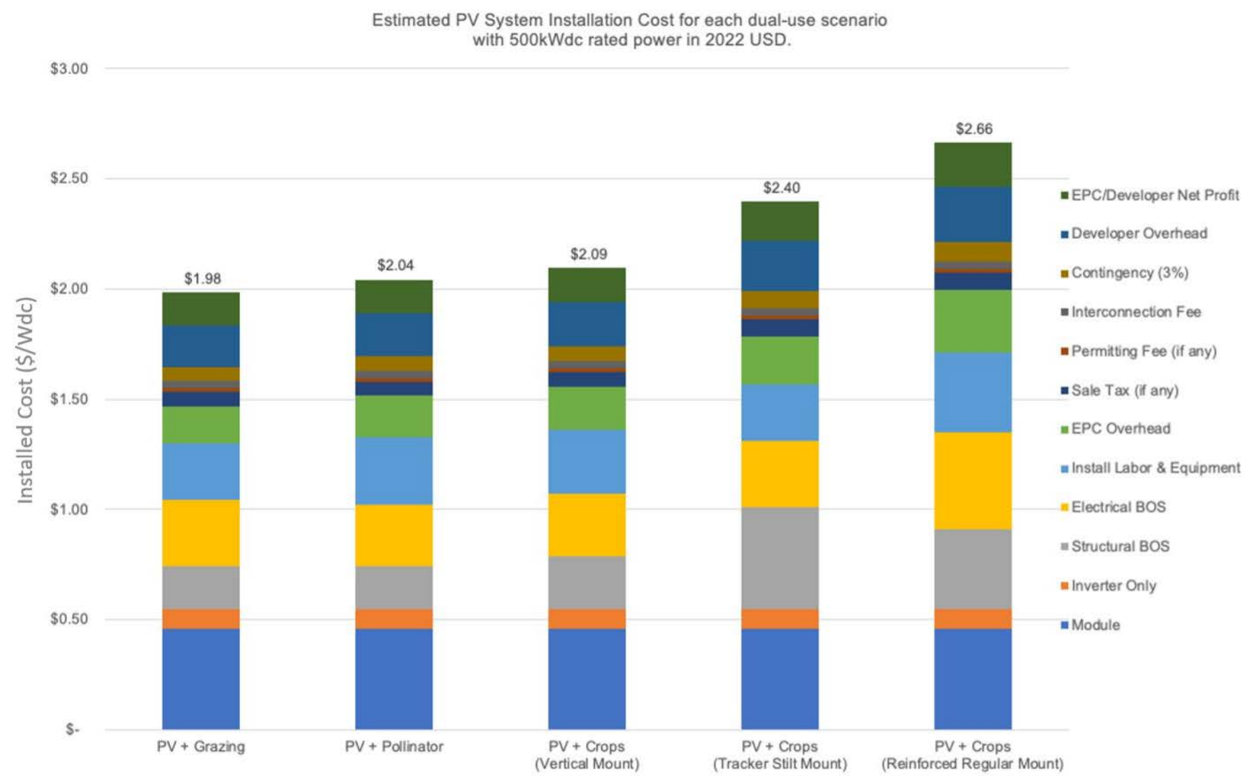

Figure 8. Estimated solar design costs, updated for inflation from Horowitz et al. 2020.

While Figure 8 presents an initial estimate of development costs for different scenarios, there are likely to be large variations in development costs based on many factors (system size, crop type, energy market, inflation, developer experience, etc.). These costs are presented as a guide for initial economic analyses.

Table 2. PV Design Specifications by Scenario

Scenario	Torque Tube Height	Power Density (acre/MW)[2]
Fixed, south facing	8.2 ft	9.8
One-axis tracking – utility scale	4.6 ft	5.9
One-axis tracking - raised	8.2 ft	5.9
N-S tent, fixed	15 ft	13.8
Vertical bifacial	6.4 ft	7

Note that there are many variations on designs presented above in Table 2, in particular in international markets. Some companies are designing one-axis tracking systems that are 14–15 ft in height with smaller and/or semi-transparent panels that allow for increased sunlight to crops that support farming activities. Because these systems have not been seen in the United States and there are no UL-certified semi-transparent panels on the U.S. market, they are not reflected in the above design scenarios.

[2] From Horowitz et al. 2020

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High-Level Economic Analysis

For each scenario above, NREL conducted limited high-level economic analysis to determine the current economic viability to deploy one acre of each technology. SAM was utilized for the analysis and a single owner power purchase agreement (PPA) model was used. For the sale price of electricity, the PPA price of $60/megawatt-hour (MWh)[3] was used and the project was assumed to be developed in cash.[4] The investment tax credit (ITC) was included at 30% of total upfront capital cost and the analysis assumes inverter replacement in year 10 and a 25-year project life. Other inputs were kept at SAM defaults, with an inflation rate of 2.5%, discount rate of 6.4%, and a PPA escalation price of 1%/year. All values in Table 3 and Table 4 below are rough first-order estimates and should only inform scoping/ideation. Most values in the analysis can be highly variable and dependent on development structures, contracts, PPA prices, and costs.

Table 3. One-Acre Initial Economic Analysis Results by Scenario

Scenario	System Size (kW)	Install Cost ($/W)	CAPEX	Annual kWh/kW installed	Annual Generation (MWh/yr)
Fixed, south facing	102.0	2.66	$271,429	1,494	152.5
One-axis tracking – utility scale	169.5	1.97	$333,898	1,695	287.3
One-axis tracking - raised	169.5	2.40	$406,780	1,695	287.3
N-S tent, fixed	72.5	2.41[5]	$175,269	1,211	87
Vertical bifacial	142.9	2.09	$298,571	1,171	167

Note that the above results are based on published numbers and may not reflect the actual cost of PV development. The highest generation scenarios are the one-axis tracking sites that allow for both more capacity to be installed and higher production (kWh/kW installed). Note that vertical bifacial systems have less production than traditional fixed tilt systems but can allow for more installed capacity based on these scenarios.

[3] Based off the rough average of the current fixed price for MISO and Ameren customers and represents a conservative value. This value can be highly variable and can change based on who is buying the electricity.

[4] Purchasing the system in cash is highly unlikely but because of the high variation of interest rates and loan terms a cash purchased system was utilized to compare scenarios. Economic numbers can be update further in the development process.

[5] Based on conversation with European solar developers. It is unclear if this cost would be relevant for the United States.

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Table 4. One-Acre Break Even Results by Scenario

Scenario	IRR at end of project	NPV	Crop profit needed to break even ($/acre/yr)	PPA Price needed to break even w/o crop profit
Fixed, south facing	-.33%	-$110,292	$12,100	$0.157/kWh
One-axis tracking – utility scale	2.85%	-$99,747	$10,950	$0.106/kWh
One-axis tracking - raised	1.44%	-$142,232	$14,620	$0.126/kWh
N-S tent, fixed	-1.53%	-$76,994	$8,450	$0.177/kWh
Vertical bifacial	-0.98%	-$127,620	$14,100	$0.162/kWh

All scenarios result in a negative net present value (NPV) at the end of the project. This means at current electricity sale and PV development prices; projects will be uneconomic over the analysis period. This is generally due to high PV development costs, with most scenarios roughly 2x utility-scale solar development costs (Ramasamy et al. 2022). Results in Table 4 above assume no agrivoltaics-specific incentives or potential operations and maintenance (O&M) cost reductions.

It is still an open question of how to monetize specific pieces of agrivoltaic projects, but revenue diversification would change economics. This is reflected in the second to last column of table 4, where the revenue per acre is calculated to break even at the end of the project. While the calculated numbers are likely high for most commodity crops, some high-value, hand-harvested crops may approach these values (see Table 5 in the next section). The last column in Table 4 above calculates the PPA price needed for the NPV to be zero at the end of the project with no crop profit. Adding some crop profit does decrease this price, as an agricultural profit of $1,500/yr lowers the break-even PPA price for a one-axis raised system from $0.126/kWh to $0.120/kWh. Revenue from PV production often has a larger impact on the PPA price. This highlights the trend in the United States that agrivoltaic sites are generally designed for PV-centric production.

Initial results presented in these scenarios may currently be uneconomic, but there are potential other revenue streams and incentives that may lead to development of agrivoltaic systems. Some other potential revenue diversification measures include participation in community solar programs that often sell electricity at higher prices than the Midcontinent Independent System Operator (MISO) avoided electricity cost, participation in the Illinois Shines program that offers a small incentive for agrivoltaic projects (Illinois Shines and Illinois Power Agency 2023), sale of renewable energy credits (approximately $23/MWh in current markets), participation in higher investment tax credit values (disadvantaged and energy community plus domestic content adders could raise the credit to 50% of solar equipment costs) and designing contracts with farmers to reduce O&M costs of maintaining vegetation and land underneath the solar array. Future analyses could examine the impact of each of these revenue diversification measures, but these sensitivities were outside the scope of this initial analysis.

Crops of Relevance to Jackson County

Based on input from the project team and Southern Illinois University (SIU) staff, five crops of significance to the region were chosen for agrivoltaic suitability analysis in Jackson County: (1)

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grapes, (2) hemp, (3) orchards – apple and peach, (4) pumpkins, and (5) strawberries. Note that corn and soy cropping systems were excluded from this initial selection based on height concerns, tight economics based on commodity pricing, and use of large combine equipment that is incompatible with PV infrastructure without substantial PV design changes (12–15 ft in height).

For each crop, there are several factors that influence PV design feasibility. Factors include:

- Maximum height of the crop to prevent both crop growth being impacted by PV equipment and the crop shading the solar panels, which would reduce generation and potentially lead to reduced panel life. Note that rotational crop heights, if applicable, also need to be integrated into this consideration.
- Amount and quality of light that gets to crop beds. Light incidence with crop beds, with some crops needing full sun at parts of the year and shade at the others, will determine what crops can grow underneath panels. Real-world studies are needed to determine if shade-tolerant cultivars are needed.
- Row and PV support spacing impact the size of crop beds and access for equipment needed to operate in the solar array. Spacing needs to accommodate all farming activities including land preparation, planting, farming additive application, and harvesting.

Table 5 summarizes key metrics consolidated from extensive interviews with the following crop experts:

- Grapes - Scott Albert, vintner at Kite Hill wineries.
- Hemp - Jose DaCunha, expert in cannabis production at SIU.
- Orchard - Wayne Sirles, President of Rendleman Orchards.
- Pumpkins - Alan Waters, SIU, professor of vegetable science and breeding.
- Strawberries - Bill McNitt, McNitt Growers, strawberry farmer.

Table 5. Summarized Findings from Expert Interviews by Crop

Crop	Crop Height – Jackson County	Row Spacing	Farming Considerations	Important Research Questions
Grapes	Trained 6–7 ft high, vertical shoot positioning	8–10 ft spacing	Generally, N-S vine orientation. Hand harvested. Varietals can be shading intolerant. Main factors for choosing the varietal: (1) cold hardiness, (2) disease resistance, (3) potential wine quality, and (4) ease of management. Cover cropping with fescue and clover in between grape rows.	What varietals can be adapted to shade environment? How does microclimate impact grape ripening times? Will higher humidity lead to pest/disease concerns for grapes? Can panels be used to shield fruit from precipitation and lessen mold growth?
Hemp	10–12 ft for fiber	20–45 in. spacing between plants and rows	Drill seeding and large combine used	Shade tolerance and impact on phenology needs to be studied; increased humidity may be an issue

Crop	Crop Height – Jackson County	Row Spacing	Farming Considerations	Important Research Questions
Orchards	Apples – 14 ft Peaches – 10–12 ft	Apple – 10 ft in between trees, 18 ft between rows Peaches – 12 ft in between trees, 18–20 ft between trees. No equipment concerns	Generally, at the top of hills for drainage and wind. Ability to train trees for higher density -> irrigation upgrades needed. Fruit often needs protection from sun scalding.	Pesticide application and soiling concern? Trellis system needs costly upgrades for higher density -> Can PV infrastructure utilize this? Ability to utilize panels for hail and weather protection?
Pumpkins	2.5–3 ft	Planted in rows (25–30 sq ft), 6–8 ft centers, 3–5 ft per row.	10–20 ft drive rows, often planted with clover. 10 ft tractor with 18 ft equipment spacing – trailer often 10–20 ft long and needs room to turn. Spraying is common during season (7–10 times). Rotation with wheat, corn, and soy possible.	How to address pesticide and fungicide application and soiling concerns? How to manage weeds and other vegetation underneath panels to prevent pests? Is there a potential for shade tolerance and humidity concerns?
Strawberries	Up to 2 ft	Raised beds 4–8 in. tall. Bed width: 28–32 in. with two rows of strawberries with one drip line. 5–6 ft center	Grass planted in-between rows to prevent mud/weeds. Often just push mower or small riding tractor. Strawberries planted between 1st - 10th of September and then picked in end of April, early May. Rotation with corn and sun hemp (6–7 ft height).	How can PV system be designed to prevent shading at certain times of year and reduce yield impacts (no shade tolerant varietals)? Is there a potential for PV panels to prevent/reduce impact of frost events?

Potential Feasibility of Crops Based on Agrivoltaic Designs

Based purely on the crop specifications and some minimal design changes to both PV systems, the following agrivoltaic designs may be technically feasible to implement for the crops below:

- Grapes – Based on the crop height, it is unlikely that one-axis utility systems would be feasible and there are potential shading concerns for fixed raised systems (crop based) and vertical bifacial (PV based). Both one-axis raised and raised N-S tent systems may be feasible for grapes.
- Hemp and orchards – The only scenario modeled that would accommodate crop heights of 12–15 ft is the raised N-S tent system. This design is currently used with orchards in European markets and may be feasible if system costs can be reduced.

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- Pumpkins and strawberries – Based on the crop height and row spacing, all the scenarios would accommodate pumpkin growth with some potential changes to solar density to allow for equipment access. However, the solar design may not support wheat, corn, and soy rotational farming practices with pumpkins that may present a barrier. Shading and increased humidity concerns are likely the largest barriers for these crops. The need for pesticide application may impact both electrical and PV infrastructure and will need to be studied.

As shown in the results above, the higher cost of development to accommodate crops will need to be balanced with crop returns. Data on returns for different crops are often difficult to obtain and will vary widely by year, varietal, region, farming practice, etc., but the authors attempted to find some information regarding the returns for the above crops. No information was readily available for Illinois-specific conditions, but Table 6 below provides some order of magnitude for crop returns in different regions. Note that the break-even crop returns from Table 4 in the previous section range from $8,000 to $14,300/acre-yr and wine grapes come fairly close to achieving that return per-acre value. As returns, costs, and yields are highly dependent on farming practices and conditions, this value will change by year and requires further study for a specific application in the region.

Table 6. Average Net Returns Above Total Costs for Studied Crops

Crop	Value/acre	Source
Grapes–wine (2021)	$7,238	(The Regents of the University of California - Davis Campus 2024)
Hemp (1997)	$5,086	(Jelliffe, Lopez, and Ghimire 2020)
Apples (2023)	$3,728	(The Regents of the University of California - Davis Campus 2024)
Pumpkins (2020)	$1,928	(Ag Marketing Resource Center 2024)
Strawberries (2022)	$361	(The Regents of the University of California - Davis Campus 2024)

Conclusion

Overall, there are agrivoltaic system designs that might work in Jackson County with more research. This report examined potential issues, both technical and economic, for crops that are grown in Jackson County. Agrivoltaic vineyards were assessed as a high-value crop that might be able to offset the higher solar development costs. Agrivoltaic orchards were assessed as an application that might benefit from the additional protection the PV infrastructure may afford during extreme weather events such as hail. And agrivoltaic pumpkin production was assessed as a crop that might work better with conventional solar deployment and infrastructure. Continued research and pilot projects will further assist with showing local stakeholders if agrivoltaics systems are feasible. Many options may need to be explored to find workable agrivoltaic solutions.

Some key questions that arose during stakeholder interviews can assist with identification of research questions. Potential research questions and trial areas for agrivoltaics could include:

- Does shade from the panels impact the growing season and support crop production outside the normal production window?
- How will PV infrastructure impact crop rotation and is there a potential for novel crops to be introduced in Jackson County?
- Will there be any impacts of pesticide and herbicide application on PV equipment, either through wire degradation or soiling on the panels?

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    - Are there alternate pesticide/insecticide delivery methods or management practices that need to be developed for agrivoltaic projects?
- What business models and profit-sharing mechanisms will be needed to increase the economic viability of agrivoltaic implementation?
- What changes to farming practices and/or what workforce development considerations are needed to implement agrivoltaics?

Pathways for the community to answer these research questions could include:

- Remain engaged. Continue to meet with stakeholders to assess agrivoltaics needs within the community. Continue to speak with the agricultural community.
- Identify a pilot project site. Continue collaboration between the city, county, university, agricultural community, and the residents of Jackson County to identify potential sites.
- Continue to explore and apply for agrivoltaic funding. Establish resources and points of contact for funding opportunity identification, grant writing, and proposal submissions.

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