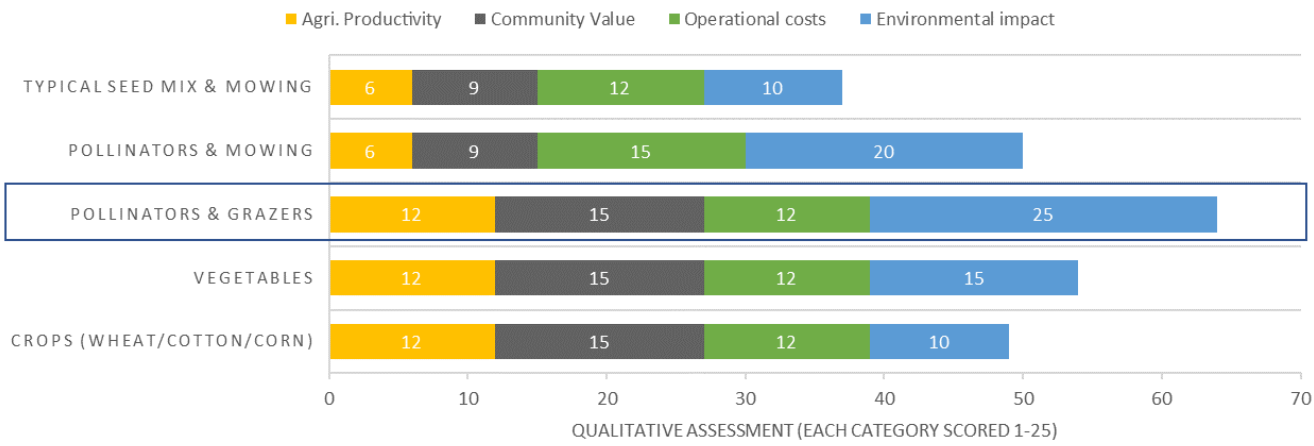
Suggested Strategy Report

Preferred option considering all inputs: **Pollinators and Grazers**

The following report details our recommendations for what is to be considered to implement dual-use agriculture and photovoltaics (APV) on the site.



The reason this has been opted to be most suitable is because it has the following key advantages:

- Compatibility with the solar panels – no compromise or complication of technical design
- Sheep are farmed in the area, which indicates there is a market and relevant skillset

Report breakdown:

1. Grazers Considerations
2. Pollinator Considerations
3. PV Panel Considerations
4. Developer Considerations
5. Designers Considerations
6. Shepherd Considerations
7. Operators & Managers Considerations
8. Envision Considerations
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Grazers Considerations

- For this site, Arup recommends the use of Sheep as optimal grazers because this will support the local economy, optimize land productivity, efficiency, and total societal value, and because sheep make sense for the local climate, site conditions, ecoregion, and market
- The map of sheep herds in the US indicates that there are shepherds, thus relevant expertise, nearby the site. It is important to hire someone with local husbandry experience. You can find them by joining the American Solar Grazing Association which connects solar developers to sheep farmers

Pollinator Considerations

- For this site, Arup recommends spreading around organic pollinator-attracting species to vegetate the site and provide habitat, food, and refuge for bees, butterflies, moths, bats, hummingbirds, and beneficial insects. This is a crucial sustainability strategy to support the resilience of our planet and people, as pollinator species are the backbone of our food supply. Pollinator species are necessary players in the fight against biodiversity loss, invasive species, decreasing crop yields, and diminishing vegetation worldwide [11]. The USDA states that bees also contribute an annual $18 to $27 billion to agriculture in the US by improving quantity, health, and quality of crop yields [10]
- Pollinator-attracting species grow like weeds but are kept tamed by the grazing sheep
- Identify native pollinator-attracting species and chose native over exotic whenever possible. According to the USDA, native plants help reduce pesticide use and the need for maintenance; they help protect biodiversity and at-risk species; they thrive in harmony with other native vegetation and wildlife, supporting native fauna with essential food and habitat [13]
- Analyze soil and water conditions onsite to plan a preparation strategy to get the land ready for pollinator-attracting species to thrive; these species vary from needing dry to moist soil
- Source seeds locally and choose locally viable species. Consult the native pollinator-friendly plant lists that Xerces Society produces, broken down state-by-state: https://xerces.org/pollinator-conservation/pollinator-friendly-plant-lists [16]

- Vary seed mixes around the site, including the perimeters, between the panels, and beneath the panels, to ensure blossoms year-round, greater biodiversity, and therefore increased resilience
- Create fencing around site with pollinator-attracting species
- Determine migration patterns of the pollinator species to ensure the necessary habitat and food are in bloom to support the species migrating through the area as seasons change. Pollinator species may find home in the region during either winter or summer months, or simply migrate through the area [14]
- Install a bird bath, hummingbird feeder, and salt lick in multiple zones around the site [15]
- Define local culture around pollinator species and save the bees movement, so it may be used to the project's advantage and local farmers support the project because they are aware of the benefits of the introduction of these pollinator species in the local area
- Plant a temporary cover-crop to reduce the need for mowing and decrease unwanted weeds that compete with young pollinator species
- Check for pollinator protection information in your county or state to ensure best management practices are followed [12] https://www.epa.gov/pollinator-protection/find-best-management-practices-protect-pollinators
- When the solar farm is decommissioned eventually, the site will provide ideal conditions for future agriculture to thrive. Soil will be naturally built up over the years, preparing the site for agricultural use, instead of leaving the land degraded or unimproved as traditional solar farms often do. We have a unique opportunity to leave the land better than we found it, and contribute to positive environmental, economic, and social change along the way

PV Panel Considerations

- For this site, Arup recommends bifacial panels that are mounted at a standard height, as the sheep and pollinator species do not require vertical height. The panels risk less damage from mowers and rocks since sheep will be grazing the site to tame weeds instead of needing mowers
- Panels have Ecoppia robot cleaning devices attached to automatically clean the panels overnight, while using no water. They self-clean themselves and get power from their very own solar panel. This reduces water demand for the PV and allows a higher percentage of the water allotment to be used for irrigating crops, and helps ensure water use limit is not exceeded
- Panels have gutters attached to their lowest edge to catch water runoff from rain events. The water is collected and directed to a retention tank for later irrigation use
- An in-depth analysis by a solar radiance engineer must be performed to understand optimal spacing and transparency of the panels given specific site conditions

Why this is the best option:

- There are preexisting sheep grazers nearby, thus it is a proven agricultural practice in the area and local expertise exists about the market as well as O&M of a sheep herd
- Over half of lamb meat consumption in the US is currently imported, while trends are favoring local sustainably raised meat. Plus, we import live sheep. Thus, there is great room in the market for domestic flocks to sell meat and livestock [7]

- PV + sheep + pollinators = a great combination because sheep will not cause damage to the panels or wires, the sheep keep the weeds at bay to avoid any shade on the PV panels, and the pollinator species are a good source of feed for sheep
- Opportunity to enhance community relations and knowledge sharing between sectors; higher community acceptance when there are cute sheep running around and farmers are benefiting from pollinator-attracting species
- Vegetating the site with pollinator species helps reduce maintenance costs by cutting out the need for mowers and harmful chemical use
- This triple-use solution allows for a great increase in land productivity to optimize profit, and create positive social and environmental impact

Advantages:

- Land use efficiency increases up to 80%, which is crucial to consider in a world with rapidly diminishing land availability yet dramatic population growth, and thus increased demand on the food system. This sustainable ranching strategy can help directly feed the local economy in an environmentally and socially sustainable manner, while pollinator-attracting species indirectly help increase crop yields on farms nearby
- Sheep farmers are provided optimal land for grazing their herd. Sheep thrive with the conditions of a solar farm, as the panels provide much welcomed shade during hot months *[cite]*
- When pollinator-attracting species are protected and supported, they provide habitat for bees which can help increase yields, and therefore economic gain, of surrounding farms
- Soil health increases because the soil becomes more biodiverse, able to retain more water, prevent erosion, sequester more carbon, and maintain a higher organic carbon content
- Local economy is supported by higher land use efficiency &the introduction of new green jobs
- PV panels operate at a higher efficiency than they would at a traditional single-use plant because they perform best under cooler temps. The panels are able to generate more energy due to the effect of evapotranspiration from the pollinator plants on cooling the air beneath the panels
- Farmers are better able to keep their land regardless of agricultural market fluctuations. Income is more reliable, consistent, and diversified, thus increasing profit and resilience, helping support the local economy as a whole
- Tax revenue from agriculture yield and energy production, plus the creation of green jobs, help grow the local economy

Challenges:

- Continuous coordination between the developer, energy company, and operators
- Identifying yield targets for the grazers and sheep
- Management of sheep, including paddock design
- Environmental impact of PV structures due to raw material usage
- System compatibility & adaptability to both current practices and future markets

Developer:

- Understand local land-use, PV farm, and livestock grazing regulations. This information varies by jurisdiction, is always changing, and is often not readily available online. It is helpful to hire a third party to do this research, as there is no consistency when it comes to solar regulations
- Attempt a pilot study onsite during initial stages of project development before implementing strategies on the site at large, the optimal time is 3yrs of experimentation
- Develop a plan to protect agricultural function of the land in the long-run and assure stakeholders that APV is not a threat to traditional agricultural land, but instead an asset
- Complete a copy of the state's pollinator-friendly solar scorecard, if available. If not, contact the Center for Pollinators in Energy, davis@fresh-energy.org, for further info [8]
- Determine tax rates, incentives, and investigate if there's a possibility of a feed-in tariff
- Prepare for a lengthy permit process
- Arrange community engagement to gain the trust and acceptance of local stakeholders
- Complete environmental, social, and economic assessments of the site
- Consider how to make the supply chain and onsite employment more equitable, and aim to improve the wellbeing of all involved in the process from cradle-to-cradle; including increasing educational opportunities, gender equality, affordable access to the renewable energy, supporting local economies,
- There is no need to disturb the topsoil when planting pollinator-attracting species or introducing grazers to the site, thus saving site preparation expenses [4]
- Decide if the project will attempt to achieve a certification, such as Envision
- Partner with a local organization that is focused on increasing local biodiversity
- Join an APV professional association, if possible
- Ensure the site is net-positive carbon in order to limit environmental impact and increase quality
- Plan to create an annual sustainability report on yearly goals, commitments, and achievements

Designers:

- Understand natural features of the site, including land/topography, climate, history, type of surrounding farms, crops grown in the region, optimal shading rates for those crops, loss of biodiversity & habitat due to traditional PV plants in the area
- Identify local partners to consult on the project, including farmers, botanist, biologist, ecologist, BLM offices, agricultural extension offices
- Analyze what resources are locally abundant onsite and which resources are scarce/limited
- Establish power generation goals with the developer and sheep herd goals with the shepherd
- Understand local culture and popular opinion about PV, sheep, and pollinator species, so you may use this information to your advantage to gain public support
- Systems thinking programming of site, focusing on circularity, synthesis, relationships, emergence, collaboration, interconnectedness, wholeness, feedback loops, and total design
- Avoid the use of gravel, and instead specify a pollinator-friendly groundcover where needed
- Design for system compatibility & adaptability to both current practices and future markets
- Identify risks and liabilities to specify safety protocols

Shepherd:

- Based on site conditions, decide what characteristics of the sheep will allow the heard to thrive. For example, sheep with shorter hips and more rounded muscles tend to have shorter strides which makes them ideal for a flat site, not a hilly one
- Define the local market for sheep products, including wool, meat, milk, cheese, breeding, and skins, to identify gaps in the market and products that are most popular
- Based on the local culture and market, decide which characteristics of the sheep will make the products most marketable and unique, in order to decide the type of sheep to bring on site [5]
- Understand the quantity and cost of food inputs necessary, including grass, hay, and grain to support each sheep
- Set up a National Sheep Improvement Program (NSIP) account to track sheep data, receive trainings, get access to open discussion forums, and connect with a network of other sheep breeders [6]
- Determine optimal grazing management systems
    - Rotational grazing is shown to be most beneficial at the beginning of the season because they are brought to a fresh paddock (patch) of grass each morning, which helps the sheep gain muscle weight during the most advantageous time [1].
    - Continuous grazing could be considered for the rest of the season because, overall, sheep are shown to spend more time grazing with this management technique [1]. This is due to a few factors, including the shelter that PV panels provide to the sheep to protect them from the elements, heat, wind, and rain [2]. It could also be attributed to the depletion of fresh grass in continuous management grazing, and the sheep graze more to compensate for the quality, nutrients, and freshness of their forage crop [3]. But sheep tend to selectively eat what they want, leaving a few undesirable weeds growing out of control since they have such a big area to graze and subsequently the luxury to avoid certain plants, thus rotational grazing can often be considered the best option.

Operators & Managers:

- Understand sensitive site conditions
- Communicate with the shepherd to manage the movement and activities of sheep onsite
- Clean panel gutters when necessary and ensure overall that the water collection, retention, and redistribution system is functioning properly to irrigate crops
- Cut out the need for herbicides with a pollinator-friendly ground cover, and avoid any chemical use. If absolutely necessary, use a chemical at night when bees aren't active [15]
- Determine how to digitalize and automate O&M as much as possible, using monitoring technology with risk alerts and a feedback loop built-in
- Ensure a balance of ideal pollinator conditions and ideal grazing conditions. When the pollinator-attracting species are at 10% growth, they have the most protein content, and often they are cut at that point for feed. But in doing so, the flower nectar that attracts the pollinators is lost. To avoid a negative impact on pollinator potential, grazing must be managed so that some paddocks have time to develop into 100% bloom; find a balance that works for the site [9]

Envision Certification Considerations:

Envision Category	Envision targeted questions
Quality of Life	**Does the project improve safety, wellbeing and mobility for stakeholder and the local community?**
	Does the project take the following into account:
	Improving community quality of life? (including minimizing noise and light pollution)
	Improving construction impacts and safety?
	Improving access and mobility?
	Enhancing public space/amenities or local character?
Leadership	**Does the project incorporate multidisciplinary collaboration, sustainability planning and enhancing the local economy?**
	Does the project take the following into account:
	Commitments to clear sustainability goals?
	Provide stakeholder engagement?
	Incorporating long-term monitoring and maintenance?
	Developing local skills and capabilities or otherwise stimulate economic prosperity?
Resource Allocation	**Does the project reduce the use of materials, energy and water?**
	Does the project take the following into account:
	Reducing construction and operational waste?
	Supporting sustainable procurement?
	Utilizing renewable energy? (Or reducing operational/construction energy consumption)
	Reducing construction and operational water consumption?
Natural World	**Does the project improve siting, conservation and ecology?**
	Does the project take the following into account:
	Providing wetland and surface water buffers?
	Managing stormwater?
	Reducing pesticide and fertilizer use?
	Enhancing functional habitats and protecting soil health?

	Does the project reduce emissions and incorporate resilience?
Climate and Resilience	Does the project take the following into account:
	Reducing net embodied carbon?
	Reducing GHG emissions?
	Assessing and mitigating climate change vulnerability?
	Evaluating risk and resilience?

UN Sustainable Development Goals this dual-use strategy helps to address: 1, 2, 7, 8, 9, 11, 12, 13, 15, 17

Sources

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