WASHINGTON STATE UNIVERSITY
**Energy Program**

*Photo by Lexie Haln, Lightsource bp; courtesy of the U.S. Department of Energy.*

# Dual-Use Solar Opportunities for Washington State

## Executive Summary

To meet Washington state's directive to replace its fossil-fuel generated energy sources with renewable and non-emitting energy sources by 2045, clean energy such as solar will need to be developed. Solar photovoltaic (PV) installations require five to ten acres per one megawatt (MW) of generated electricity, which can create conflict with other land uses. Across the country and the world, land use conflicts are eased when solar PV is co-located with agricultural operations, often called dual-use solar, allowing food production and ecosystem services to continue on the same site where electricity is generated.

Currently, Washington state lags far behind many other states in dual-use solar applications and research. This report, written by Washington State University (WSU) Energy Program as mandated by the Washington State Legislature, provides information such as dual-use solar research, benefits, considerations, policies, and incentives. The intent of this report is to increase the opportunities and practice of dual use in Washington.

**The Washington State University (WSU) Energy Program** delivers program management, on-site assessments, analytical tools, and training to meet evolving energy challenges in the State of Washington, the Pacific Northwest, the United States, and internationally.

Partnering with a wide range of agencies, organizations, institutions, and businesses, our energy experts identify energy challenges and develop solutions.

Our customers include large and small businesses, public and private utilities, manufacturing plants, local and state governments, federal agencies and facilities, schools and universities, national laboratories, tribes, professional and trade associations, and consumers.

Our staff of energy engineers, energy specialists, technical experts, and software developers work out of Olympia, Washington. The WSU Energy Program is a self-supported department within the University.

We are part of the College of Agricultural, Human and Natural Resource Sciences (CAHNRS). Our Director reports to the Associate Dean of the College/ Director of WSU Extension.

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# Introduction

WSU Energy Program was directed and funded by the Washington State legislature to compile the latest information on opportunities for dual use and colocation of PV solar with other land values by June 30, 2023. This report is that deliverable.

The directive was part of a proviso[1] in the 2021 biennium budget to carry out a least-conflict solar siting pilot project with the goal of identifying areas where there would be the least amount of potential conflict in the siting of utility-scale solar photovoltaics (PV). Both the dual-use report and the Least-Conflict Solar Siting Report are available on the WSU Energy Program Least-Conflict Solar Siting website.[2]

Dual-use solar is the practice of solar photovoltaic (PV) technologies sharing the same land with other uses, usually agricultural such as crop production. The terms agrivoltaics and colocation are also commonly used. Other terms include agrisolar, agrophotovoltaics, and agriphotovoltaics.

In addition to crop production, dual-use activities include animal grazing, pollinator habitat, beekeeping, ecosystem services, and aquaculture. Aquavoltaics[3] is sometimes used to describe floating photovoltaics over water bodies, and panels can also float over aquaculture.  Floating solar PV over bodies of water such as reservoirs and irrigation canals can be considered dual use because shading the water reduces water loss by evaporation.[4]

Solar development is increasing throughout many parts of the world, to meet decarbonization goals. As each megawatt (MW) of generating capacity requires five to ten acres of land, land use conflicts are bound to occur. Washington state is seeing a large amount of interest and numerous proposal from solar developers as the state has mandated fossil-free electricity by 2045. Interest is especially high in the sunny Columbia Plateau region of the state. Land-use conflicts are already occurring as some counties try to preserve their agricultural lands. Dual-use may be one solution to the land-use conflict, allowing for the addition of solar power generation while maintaining farmland and providing important ecosystem services. A 2022 study found that nearly 82% of respondents to a survey conducted by Michigan Technological University said they would be more likely to support solar development in their community if it is integrated with agricultural production.[5] Dual use also offers the potential to balance food production and renewable energy goals. Under the right conditions, both crops and solar production can do better when paired together.[6]

Research on, installations of, and policies and incentives for dual use are rapidly increasing across the U.S. This report is a snapshot in time of the field in mid-2023.

1 ESSB 5092, Sec. 607 (19), p. 460 lines 3-13 *https://lawfilesext.leg.wa.gov/biennium/2021-22/Pdf/Bills/Senate%20Passed%20Legislature/5092-S.PL.pdf*

2 *https://www.energy.wsu.edu/RenewableEnergy/LeastConflictSolarSiting.aspx*

3 *https://www.sciencedirect.com/science/article/pii/S1364032117308304*

4 *https://pv-magazine-usa.com/2022/05/03/njr-clean-energy-ventures-breaks-ground-or-rather-water-on-9-mw-floating-solar-project/*

5 *https://digitalcommons.mtu.edu/michigantech-p/16820/#:~:text=This%20survey%20study%20assessed%20if,if%20it%20integrated%20agricultural%20production*

6 *https://www.nrel.gov/solar/market-research-analysis/agrivoltaics.html*

## Benefits and challenges

Dual-use solar provides numerous economic and environmental benefits, including improved economics for farmers and other agricultural producers, ecosystem services such as maintaining soil health, and expanded siting opportunities for solar development. Farmers benefit by keeping their land in production, and developers may see some soft costs (non-hardware) reduced.

Below are many of the benefits derived from various dual-use activities. More specific information is under the individual activities in the next section.

- Colocation of solar and agriculture such as growing crops and grazing animals can increase local support for solar projects, where otherwise such projects may be perceived as a threat.[7]
- Keeping agricultural land in production can help sustain rural economies and benefit local communities.
- Adding farming to existing solar energy sites may be an approach to increase access to land for historically disadvantaged groups.[8]
- Shading from solar panels can decrease evaporation of water from the soil and transpiration from plants, and potentially reduce irrigation requirements.
- Shading can Improve crop yield and crop resistance in extreme weather, such as droughts, by reducing evapotranspiration.
- Livestock benefit from the shade and cover from solar panels.
- Grazing animals can reduce maintenance and operation costs by decreasing the need for mowing as well as reduce damage from mowers; grazing can also decrease the use of pesticides to maintain vegetation.
- Pollinator habitat on solar sites supports species which can in turn support crop production.
- Native vegetation used for pollinator habitat protects natural habitat, safeguards soil health, improves stormwater retention, and controls wind and soil erosion.[9]
- Landowners may see reduced energy bills from self-generation of electricity. They may gain an additional income stream and increased revenue security, as well as find new market opportunities for shade tolerant crops.
- Benefits for solar developers include:
- Potential facilitation of siting, including decreased permitting time, and reduction in environmental mitigation investments.
  - Lower maintenance and operations costs due to limited mowing needs.
  - Increased solar energy production from the cooler air zone created under modules from vegetation.

The main barriers that may prevent solar developers from implementing dual-use installations are higher initial installation costs because of the need for modified system structures and more complex design, for example needing to raise panels to accommodate tall vegetation or grazers. Research is being done, however, on design modules specific to agrivoltaics. Barriers for farmers include uncertainty about the concept of colocation, uncertainty on how to implement it, and lack of information on which crops may be suitable.

7 *https://digitalcommons.mtu.edu/michigantech-p/16820/#:~:text =This%20survey%20study%20assessed%20 if,if%20it%20integrated%20agricultural%20production.*

8 *https://www.energy.gov/eere/solar/articles/potential-agrivoltaics-us-solar-industry-farmers-and-communities*

9 *https://info.nypa.gov/Health/Agrivoltaics23.pdf*

# Types of Dual Use

A summary of the types of dual use and some of the benefits and challenges are described below. The U.S. is lagging behind other countries in dual-use research and most dual-use projects in the U.S. are still small, under ten acres in size. There is, however, much research and many demonstration projects occurring now; useful information and improved best practices will continue to be developed and promoted.

## Crop Production

There are many dual-use installations growing various crops around the globe and the U.S. Most of the 2.8 GW of solar and crop dual-use installations are in China, Japan, South Korea, and Europe. Research on dual-use crop performance and crop yield in the U.S. is still limited, however existing research shows favorable results, including similar yields as with traditional crop production as well as decreased water use. Increased initial installation costs may occur if, for example, solar panels are raised to reduce crop shading. Shading can have a positive effect by producing higher yields with lower watering requirements in dry climates. However, in wet climates, PV panel spacing may affect on-site water management and eventual yields.[10]

Considerations for crop production with solar PV include:

- Panel height, row spacing, water access, equipment needs, and whether the solar system is fixed or tracking.
    - Width of access rows affects shading and maintenance vehicle access, which in turn affects vegetation management activities.
    - Fixed-tilt or sun-tracking (single-axis tracking) panels can increase generation capacity, but can decrease crop yield depending on the crop.
    - Solar capacity may decrease because of increased spacing or mounting height.
- Technical features need to be considered to improve rain distribution or collection of runoff from panels.
- Shadows are less intense when panels are higher off the ground, benefiting some plants, but this can be costly for installation.[11]
- Microclimates can change under panels, affecting water balance and air temperature.
- Two distinct labor skills sets may be needed, for farmers and for engineers trained to maintain the panels.
- Crop selection is important, and depends on factors such as regional climate, PV array configuration, soil type, and growth habit.
- Since dual-use solar with crops is still new, farmers may lack support until the approach is more proven.

Chad Higgins, with Oregon State University Extension, has done research on the benefits of solar panel shading on certain crops, and the benefits that crops offer the solar panels when growing underneath.[12] However, other research, such as Purdue University's agrivoltaic farm that grows corn and soybeans, focuses on limiting the amount of shade on crops. The difference in shading effects is at least partly due to regional climate and crop selection.[13]

10 *https://www.nrel.gov/solar/market-research-analysis/agrivoltaics.html*

11 *https://www.researchgate.net/publication/229408925_Combining_solar_photovoltaic_panels_and_food_crops_for_optimising_land_use_Towards_new_agrivoltaic_schemes*

12 *https://agsci.oregonstate.edu/newsroom/sustainable-farm-agrivoltaic*

13 *https://www.purdue.edu/newsroom/releases/2023/Q2/purdue-agrivoltaic-farming-structures-and-software-harvest-solar-power-at-lower-cost-and-with-minimal-impact-on-crop-yield.html*

## Grazing

Livestock grazing can manage vegetation under solar arrays, reducing maintenance costs and controlling erosion, while supporting both food and energy production. The animals benefit from shade under the solar panels, and owners of the solar sites benefit from having no or little mowing costs. The most used animals for this purpose are sheep, as they are small enough to pass easily between rows of solar modules and not damage equipment as cattle might. A typical challenge, as with any ranching, is keeping predators away from the animals. Solar PV can also be installed in unoccupied spaces around livestock sheds.[14]

The most popular type of agrivoltaics in North America is grazing sheep under conventional solar panels, often called "solar grazing."[15] The American Solar Grazing Association (ASGA)[16] is a trade association created and managed by sheep farmers to promote grazing sheep co-located with solar installations. They support sheep farmers who contract with solar sites for vegetation management. Solar grazing keeps farmland in farm production, and allows farmers to increase and diversify their revenues. Sheep are often kept on the site through the grazing season, where they "mow" the vegetation, reducing traditional mowing costs.

Researchers from the Electric Power Research Institute (EPRI) surveyed farmers on the East Coast during the summer of 2022 to learn about their perceptions of co-locating solar and farm operations. Those with grazing animals viewed dual-use solar more favorably than those who grew crops. The survey also revealed that the interviewed farmers with little to no interest in farming their land looked more favorably on solar development than those who want to continue farming.[17]

## Pollinator habitat

Native bees, honey bees, and butterflies have experienced population declines over the last decade due to habitat loss, climate change, chemical exposure, pathogens, and pests. Providing pollinator habitat as a dual-use with solar PV can be beneficial by protecting pollinators and encouraging increase in their population. In some cases, pollinator dual usage has also been found to intensify agricultural production on nearby lands. Providing pollinator habitat in and around solar sites is the most researched of the dual-use activities.

Traditional site preparation for utility-scale conventional solar installations with ground-mounted panels includes removal of ground vegetation, which can create loss of pollinator habitat, destroy pollinator nesting sites, compact soil, increase invasive species, fragment existing habitat, and create barriers to pollinator movement. Retaining vegetation and limiting site grading throughout construction is best for pollinators and may not be as costly as removing it.[19]

14 *https://www.sciencedirect.com/science/article/pii/S1364032122002635?via%3Dihub*
15 *https://www.sciencedirect.com/science/article/pii/S2772783122000358*
16 *https://solargrazing.org/*
17 *https://info.nypa.gov/Health/Agrivoltaics23.pdf*
18 *https://rightofway.erc.uic.edu/wp-content/uploads/2020/02/000000003002014869.pdf*
19 *https://www.nrel.gov/news/features/2019/beneath-solar-panels-the-seeds-of-opportunity-sprout.html*

Below are some benefits of pollinator habitat dual use and considerations for installing and maintaining such habitat.

- Reseeding with native vegetation can reduce erosion, improve water quality and soil health, and increase habitat for other wildlife.
- Consider the height of plants in relation to the height of the panels and the impact of shading and variable soil moisture on the plants.
- Factoring pollinator habitat into siting and design has been shown to be the most fiscally efficient option rather than integrating onto an existing site.
- Long-term operations and maintenance costs such as mowing may be reduced.
- Remove invasive plant species to keep the habitat healthy.
- Considerations if mowing a site is needed:
  - Mowing when flowers are in bloom could have detrimental effects on pollinators, as well as the use of herbicides and insecticides
  - Mow in late spring to avoid harming ground nesting overwintering pollinators.
  - Use sheep to mow the vegetation around the panels and elsewhere at the site.

State Pollinator-Friendly Solar Initiatives from the Clean Energy States Alliance[20] provides information on some pollinator-friendly initiatives developed by multiple states, as well as some example pollinator-friendly solar projects. Many states have passed pollinator-friendly laws such as pollinator habitat programs, and pollinator management plans to be used by solar operators.[21]

In late 2015, a "scorecard" was created to assess the level to which a solar PV site is "pollinator-friendly." By April 2021, there were 15 state scorecards available. These scorecards are intended for utilities with solar installations and environmental policy makers. PV project developers and legislators may also find them useful, and scorecards have contributed information to some state dual-use pollinator policies. Washington state does not have a pollinator scorecard, though a state neutral scorecard is available.[22]

Those who develop pollinator scorecards may find it useful to refer to EPRI's research, which found that, among other things, some scorecards are inconsistent, lack implementation of plans, lack a clear purpose, contain no field verification, fail to address whether a site is community-scale or utility-scale, and gives no guidance on when not to establish pollinator habitat.[23]

## Beekeeping

Placing beehives on or near solar sites that have been planted in native vegetation or other pollinator habitats can create new revenue for beekeepers, who also gain resiliency from diverse sources of nectar and pollen for honey production.

## Ecosystem Stewardship (Services)

According to EPRI, "solar ecosystem stewardship involves managing land that hosts a PV array in a way that is environmentally responsible by utilizing native vegetation." One of the most well-researched forms of this is pollinator habitat co-located with solar sites. Ecosystem stewardship siting practices,

*20 https://www.cesa.org/*

*21 https://www.cesa.org/wp-content/uploads/State-Pollinator-Friendly-Solar-Initiatives.pdf*

*22 https://fresh-energy.org/wp-content/uploads/2020/01/Pollinator_FriendlySolar_Scorecard.pdf*

*23 https://rightofway.erc.uic.edu/wp-content/uploads/2020/02/000000003002014869.pdf* similar to pollinator habitat programs, include not displacing topsoils for installation, not using gravel as groundcover, not using herbicides or insecticides, and utilizing native vegetation. Appropriate seed mixes may be more expensive than conventional turfgrass, however maintenance costs will be lower.

Benefits to ecosystem stewardship include:

- Lower temperatures and increased moisture for native vegetation from solar panel shade, which promotes biodiversity, carbon storage, water conservation and soil retention.
- Prevention of soil erosion and decreased water runoff when native grasses and forbs are used, because they tend to have deeper root systems.[24]
- Lower operations and maintenance costs over time due to reduced mowing.

## Controlled Environment Agriculture and Solar Panels

Controlled Environment Agriculture (CEA), also called indoor farming, can provide additional production to traditional agriculture, while also addressing challenges of water, space, resources, and food supply chain logistics.[25] Greenhouse agrivoltaics uses rooftop semi-transparent solar PV modules. It is mostly common in China. The most popular crops grown in these greenhouses include melons, tomatoes, eggplants, berries, and leafy vegetables.

## Floating Solar

Installing floating solar photovoltaic panels over reservoirs and irrigation canals can be considered dual use because of the reduced evaporation which would conserve water. This is especially beneficial considering the increase in global temperatures and drought. Floating solar also avoids the land-use struggle that ground-based solar PV projects often bring. The National Renewable Energy Laboratory (NREL) suggests that floating solar panels could also conserve water for hydroelectric generating systems.[26, 27]

## Hydrogen Production

A different type of dual-use system is being researched in the Netherlands, touted as "circular energy and sustainable production" to harvest hydrogen on agricultural land while maintaining agricultural production. At least one company is developing mobile solar PV panels that combine with an electrolyzer to produce hydrogen, which can then be used as a green fuel for agricultural applications.[28]

# Considerations

"Innovative Solar Practices Integrated with Rural Economies and Ecosystems" (InSPIRE)[29] is a program that explores the environmental compatibility and mutual benefits of solar development on agricultural and native landscapes. Managed by NREL and funded by the U.S. Department of Energy (DOE), the project is the most comprehensive coordinated research effort on agrivoltaics in the U.S. InSPIRE analyses field research across the U.S. to provide information and best practices that can be used to

24 *https://www.sciencedirect.com/science/article/pii/ S0022169412009651*

25 *https://www.frontiersin.org/articles/10.3389/fsufs.2022.891256/full*

26 *https://cleantechnica.com/2023/03/16/new-study-gives-big-boost-to-floating-solar/*

27 *https://cleantechnica.com/2020/10/05/doe-says-combining-floating-solar-with-hydroelectric-could-provide-40-of-the-worlds-energy-needs/*

28 *https://www.h2arvester.nl/?lang=en*

29 *https://openei.org/wiki/InSPIRE*

increase dual-use installations. They look at benefits and trade-offs with region-specific data. InSPIRE hosts a dynamic map featuring nearly 350 sites agrivoltaic installations located across the U.S., with most in the Midwest and East.[30] The only ones in the NW are three for habitat in Oregon, however the map is always changing and new installations may not be included yet. InSPIRE has also created a financial calculator that weighs agricultural revenues, solar energy generation, and financial characteristics to help with the first steps of a project.[31]

Five primary themes were derived from the analysis of data from InSPIRE agrivoltaic field research sites. Called "The Five Cs", these themes are climate, configuration, crops and cultivation, compatibility, and collaboration. The Five Cs help determine the best approach to planning, designing, installing, and operating dual-use projects. Project determinants such as soil quality and water access for the climate category, and panel and row spacing for configuration are discussed in "The 5 Cs of Agrivoltaic Success Factors in the United States: Lessons From the InSPIRE Research Study." [32]

Summary definitions of the "5 Cs" are below.

- Climate, soil, and environmental conditions: The ambient conditions and factors of the specific location that are beyond the control of the solar owners, solar operators, agrivoltaic practitioners, and researchers.
- Configurations, solar technologies, and designs: The choice of solar technology, the site layout, and other infrastructure that can affect light availability and solar generation.
- Crop selection and cultivation methods, seed and vegetation designs, and management approaches: The methods, vegetation, and agricultural approaches used for agrivoltaic activities and research.
- Compatibility and Flexibility: The compatibility of the solar technology design and configuration with the competing needs of the solar owners, solar operators, agricultural practitioners, and researchers.
- Collaboration and partnerships: Understandings and agreements made across stakeholders and sectors to support agrivoltaic installations and research, including community engagement, permitting, and legal agreements.

Leading practices for dual-use with agricultural operations include:[33]

- Stakeholder collaboration: the farmer, solar developer, and utility should process concerns and protocols early in the site-selection process.
- Community education: Dialogue between farmers and solar developers can create a site that is mutually beneficial.
- Policy incentives: state-level incentives can make the increased material costs less expensive for developers.
- Site Safety Practices: Farmers and developers must agree on safety practices so that farmers can access their site for farming operations.
- Crop Selection and Array Design: Farmers should continue to research these elements for the specific crops and regions to be used.

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*30 https://openei.org/wiki/InSPIRE/Agrivoltaics_Map*
*31 https://openei.org/wiki/InSPIRE/Financial_Calculator*
*32 https://www.nrel.gov/docs/fy22osti/83566.pdf*
*33 https://info.nypa.gov/Health/Agrivoltaics23.pdf*

# Dual-Use Research Sites and Installations

There are numerous solar sites co-located with pollinator habitat, crop production, animal grazing, and ecosystem services. Listed below are sites with past or ongoing research. Very few dual-use studies are occurring in the Pacific Northwest.

## Pacific Northwest

- Oregon State University (OSU) is researching agrivoltaics by creating a five acre model sustainable farming system at OSU's North Willamette Research and Extension Center in Aurora, Oregon.[34] They will research soil health, plant physiology, and plant yields. Electricity generated will be distributed through Oregon's Community Solar Program.[35]
- The Colville Indian Reservation is creating an agrivoltaics project with crop production and electricity generation by hosting solar panels and growing crops inside large domes.[36]

A couple of commercial sites have been proposed – one each in Washington and Oregon. Hop Hill Solar and Storage Project is a proposed 500 Megawatt solar PV system in Benton County, Washington on approximately 5000 acres. As of January 2023, they plan to support and fund a research project through a local university to study the impact of co-use on plant nutrient transport, as well as provide the site for a sheep grazing operation by the landowner. This project is still in the proposal stage at EFSEC.[37]

A Grant County, Oregon rancher is partnering with a solar developer on a dual-use project to generate 1.5 megawatts of electricity from solar PV collocated with ranch cattle on about eight acres in Oregon Trail Electric Cooperative territory. The project is expected to be completed in fall 2024.[38]

## Sites outside of the PNW

There are numerous other dual-use research sites. Below are a select few

- Purdue University is conducting field trials combining raised solar panels with traditional crops like corn and soy[39]
- Solar Massachusetts Renewable Target (SMART) program established by the Massachusetts Department of Energy Resources promotes incentives for certain types of solar systems which may be built on farms.[40]
- University of Massachusetts Clean Energy Extension and its research partners are conducting a research project on the impacts and implications of dual use on economic systems, and the impact on crop productivity.[41]

*34 https://agsci.oregonstate.edu/newsroom/sustainable-farm-agrivoltaic*
*35 https://oregoncleanpower.coop/solar-harvest/*
*36 https://crosscut.com/environment/2022/06/farms-central-washington-boost-their-yield-solar-energy*
*37 https://www.efsec.wa.gov/energy-facilities/hop-hill-solar*
*38 https://www.bluemountaineagle.com/news/grant-county-rancher-partners-with-solar-energy-firm-for-first-large-scale-agrivoltaic-project-in/article_a6ca0bc6-b4a5-11ed-b192-a7acb60a8ecf.html*
*39 https://www.purdue.edu/newsroom/releases/2023/Q2/purdue-agrivoltaic-farming-structures-and-software-harvest-solar-power-at-lower-cost-and-with-minimal-impact-on-crop-yield.html*
*40 https://ag.umass.edu/clean-energy/research-initiatives/solar-pv-agriculture*
*41 https://ag.umass.edu/clean-energy/research-initiatives/solar-agriculture/researching-agricultural-economic-impacts-of-agrivoltaics-dual-use-solar*

- Cornell University is studying benefits of pollinator-friendly plantings on solar farms. One goal is to see if wildflower plantings increase pollinator populations, another is to see if wildflower plantings on solar farms encourage pollinators to visit crop flowers. Other research is looking at how sheep grazing may influence pollinator habitat and sequestration of soil carbon.[42]
- As part of InSPIRE, researchers from Argonne National Laboratory are counting bees visits at pollinator friendly vegetation grown underneath or near solar panels.[43]
- Sustainably Colocating Agricultural and Photovoltaic Electricity Systems (SCAPES)[44] is a program researching agrivoltaic systems in a variety of land and climate types to help determine the crops best suited to pair with solar, and assess microclimatic and plant responses to the presence of solar panels. SCAPES is led by the University of Illinois at Urbana-Champaign with various partners. Project sites are at:
  - Solar Farm 2.0 in Illinois
  - Agrivoltaics Learning Lab at the University of Arizona
  - Jack's Solar Garden in Colorado, which is currently the largest commercially active research site for dual use in the U.S with 1.2 MW and 5 acres of farmland. Various researchers are growing crops and there is a large pollinator habitat around the solar array.[45]
- In 2022, DOE's Foundational Agrivoltaic Research for Megawatt Scale (FARMS) funding program provided $8 million to six projects.[46] FARMS is aimed at developing best practices, seeking replicable models, providing new economic opportunities, and reducing land-use conflicts.[47] Projects partner with agriculture extensions to help educate farmers about agrivoltaic practices. The Six projects awarded funding are:
  - Iowa State University – addressing technical and socioeconomic factors of AV systems
  - Ohio State University – Integrating agricultural, forage, and livestock production system in utility scale solar farms
  - Rutgers University – increasing technical understanding and developing novel outreach strategies for farms near culturally diverse metropolitan areas
  - Solar and Storage Industries Institute – identifying barriers to implementation
  - University of Alaska Fairbanks – unlocking mid-market solar in northern climates and rural North America
  - University of Arizona – studying crop production and grazing without significant modifications to design

42 *https://sustainablecampus.cornell.edu/buildings-energy/solar-energy*

43 *https://www.energy.gov/eere/solar/articles/buzzing-around-solar-pollinator-habitat-under-solar-arrays*

44 *https://scapes.illinois.edu/*

45 *https://www.jackssolargarden.com/*

46 *https://www.energy.gov/eere/solar/foundational-agrivoltaic-research-megawatt-scale-farms-funding-program*

47 *"DOE Announces $8 Million to Integrate Solar Energy Production with Farming."* U.S. Department of Energy, Dec. 8, 2022. Accessed March 2023. *https://www.energy.gov/articles/doe-announces-8-million-integrate-solar-energy-production-farming*

# Policy, Funding, and Other Approaches to Dual-Use Solar

Policies can influence implementation of dual-use projects at federal, state and local levels. Local land-use policies have been shown to be the most significant catalyst or inhibitor of dual-use solar development.[48]

There are various federal and state laws and policies that support and promote dual-use solar, including tax incentives, grants, land-use laws, and renewable portfolios. Agrisolar Clearinghouse has an interactive map detailing dual-use financial incentives in the US, including potential funding sources, assistance programs, utility incentives, and tax breaks.[49]

## Federal

Federal policies include tax credits and incentives, grants, and research. Two federal bills were recently proposed in May 2023 to help include dual use as the drive for solar PV projects moves forward. If enacted, both provisions would be incorporated into the Farm Bill.[50]

***Existing***

- The Inflation Reduction Act changes tax laws that significantly impact the solar manufacturing industry in the U.S. and incentivize increased installations of solar projects. The Loan Programs Office (LPO) at the Department of Energy now has about $100 billion in new loan authority to invest in solar (and potentially dual-use) projects.[51]
- Federal Solar Tax Credits for Businesses has tax credits for businesses, nonprofits, and local and Tribal governments. The Investment Tax Credit (ITC) is the only corporate tax credit for solar development. There are no restrictions that would disallow solar on specific locations, so it would be acceptable for using with dual-use. [52,53]
- USDA's Rural Energy for America Program (REAP) program has over $2 billion for renewable energy systems and energy efficiency improvement grants for agricultural producers and rural small business owners through 2031. This can include construction of solar energy systems and does not present conflicts with dual-use projects.[54]

*48 Pascaris, Alexis S. "Examining existing policy to inform a comprehensive legal framework for agrivoltaics in the U.S." Energy Policy, December 2021. Accessed March 2023.*

*49 https://www.agrisolarclearinghouse.org/financial-information-map/*

*50 https://pv-magazine-usa.com/2023/06/23/agrivoltaics-seeking-mainstream-recognition-in-farm-bill/?utm_source=dlvr.it&utm_medium=linkedin*

*51 https://www.energy.gov/lpo/articles/program-guidance-title-17-clean-energy-program*

*52 Pascaris, Alexis S. "Examining existing policy to inform a comprehensive legal framework for agrivoltaics in the U.S." Energy Policy, December 2021. Accessed March 2023.*

*53 https://www.energy.gov/eere/solar/articles/federal-solar-tax-credit-resources*

*54 https://www.rd.usda.gov/inflation-reduction-act/rural-energy-america-program-reap*

***Proposed***

- New federal legislation has recently been proposed that would prioritize solar projects through the REAP program that include the creation of pollinator habitats.[55]
- In addition to the new REAP pollinator habitat proposal, a bipartisan bill, the Agrivoltaics Research and Demonstration Act of 2023, has been proposed that would direct the USDA to study current research in agrivoltaics including gaps in knowledge, create a regulatory definition of "agrivoltaic system", and establish a research demonstration network through the USDA Agricultural Research Service (ARS) to investigate how agrivoltaics can increase productivity, enhance agricultural resilience, protect biodiversity, and increase economic opportunities for rural communities.[56]

***State***

Various state policies approach supporting dual-use solar through tax and other financial incentives, state land-use laws, renewable portfolio standards, and pollinator scorecards. State tax incentives include incentivizing dual-use solar practices through land use taxes. Land-use tax changes can disincentivize farmers from integrating solar development into their operation.

***Washington State***

- The 2023-24 biennium Washington state budget provides over $10 million for a "Dual-use Solar Pilot" for "a pilot program that will provide grants and technical assistance to support planning, predevelopment, and installation of commercial, dual-use solar power demonstration projects." This fund will be administered through the Department of Commerce (Commerce).[57]
- Also in the budget, Commerce will administer almost $40 million in grants for community solar projects for low-income communities for FY24 and FY25. Priority will be given to projects with certain siting criteria such as "dual-use solar projects that ensure ongoing agricultural operations, and other sites that do not displace critical habitat or productive farmland." [58]

***Other States***

- Massachusetts offers grants through its Agricultural Energy Grant Program (ENER) to improve energy efficiency and the adoption of renewable energy practices by the state's farms.[59]
- Massachusetts also has guidance from SMART on how solar sites can qualify for a tariff-based incentive, which is paid directly by participating utility companies.[60]

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*55 https://www.merkley.senate.gov/news/press-releases/merkley-booker-introduce-new-legislation-to-create-pollinator-habitats-surrounding-solar-power-projects*

*56 https://www.heinrich.senate.gov/newsroom/press-releases/heinrich-braun-introduce-bipartisan-bill-to-support-agrivoltaics-research-and-demonstration*

*57 ESSB5187 section 132 (9). Page 97. https://lawfilesext.leg.wa.gov/biennium/2023-24/Pdf/Bills/Senate%20Passed%20Legislature/5187-S.PL.pdf?q=20230516172937,*

*58 ESSB 5187 section 132 (5). Pages 94 and 95. https://lawfilesext.leg.wa.gov/biennium/2023-24/Pdf/Bills/Senate%20Passed%20Legislature/5187-S.PL.pdf?q=20230516172937,*

*59 https://www.mass.gov/service-details/agricultural-energy-grant-program-ener#:~:text=Overview,alternative%20energy%20by%20Massachusetts%20farms.*

*60 https://masmartsolar.com/*
*https://ag.umass.edu/clean-energy/fact-sheets/dual-use-agriculture-solar-photovoltaics*

- New Jersey established the Dual-Use Solar Energy Pilot Program for unpreserved farmland, which enables a limited number of farmers to have agrivoltaics systems on their property while the technology is being tested, observed, and refined. This program is run by the New Jersey Agricultural Experiment Station at Rutgers University.[61]
- Colorado recently passed a bill to fund "new or ongoing demonstration or research projects that demonstrate or study the use of agrivoltaics."[62]
- Massachusetts has developed a dual-use shading analysis tool to make initial assessments on the effects of PV system design on light distribution at ground level. New Jersey is adapting this tool to their region.[63]
- At least six states have implemented voluntary standards for pollinator friendly dual-use solar. These regulations have helped local energy providers, such as Community Choice Aggregations (CCA)[65], incorporate pollinator-friendly practices onto their solar farms. A local renewable electricity provider, MCE, in California became the first CCA to adopt pro-pollinator policies.[66]

***Local***

Local governments tend to have the most influence on land-use policies through land-use laws and comprehensive plans. The Implementation of dual-use can allow land to stay in agriculture and help preserve the agricultural roots of rural communities while allowing landowners and counties to take advantage of environmental and economic benefits of clean energy development. Listed below are a few considerations that should be addressed while developing land-use and comprehensive plans for dual-use development.

- Get community input for zoning and siting regulations
- Allow for mixed land use using overlay districts, allowing a special permit for solar in certain zones, or allowing development when certain land use standards are met. This can include placing a certain percentage of land into pollinator habitat.
- Be mindful how certain dual-use goals interact. Native vegetation or pollinator friendly habitat requirements may preclude or limit grazing opportunities, for example.
- Use local ordinances to minimize impacts during construction and decommissioning, such as clearly identifying expectations and obligations. Financial guarantees can be required to ensure funds are available for decommissioning, preventing responsibility by local governments.

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*61 https://ecocomplex.rutgers.edu/agrivoltaics-research.html*

*62 https://www.agrisolarclearinghouse.org/agrisolar-news-roundup-community-solar-projects-colorado-agrivoltaics-bill-signing-agrisolar-research-in-oregon/*

*63 https://massgov.github.io/DOER/doer.html*

*63 https://www.utilitydive.com/news/in-bid-to-help-bees-xcel-to-require-vegetation-disclosure-in-solar-rfps/539521/*

*65 https://www.epa.gov/green-power-markets/community-choice-aggregation*

*66 https://www.solarpowerworldonline.com/2020/02/mce-becomes-first-cca-to-require-pollinator-friendly-solar-projects/*

## Select Resources

- AgriSolar Clearinghouse – nationwide hub with resources such as technical assistance, financing options, research studies, and more. ***https://www.agrisolarclearinghouse.org/***
- InSPIRE has some of the best, current information on agrivoltaics, and includes a primer, the 5 Cs, information on research sites, a data portal, and financial calculator for analyzing potential financial benefits and drawbacks for project planning. ***https://openei.org/wiki/InSPIRE***
- Solar Farm Summit Agrivoltaics Index – numerous resources (many listed in this report) plus current news. ***https://solarfarmsummit.com/agrivoltaics-index***
- DOE Agrivoltaics Market Research Study provides information on types of dual use, benefits and challenges, and reviews design, costs, social acceptance, technical barriers, and legislation. Their extensive list of citations includes information from across the globe. ***https://science.osti.gov/-/media/sbir/pdf/Market-Research/SETO---Agrivoltaics-August-2022-Public.pdf***
- Agrivoltaic Leading Practices – Technical report from EPRI, who performed web-based research and a grower survey. ***https://info.nypa.gov/Health/Agrivoltaics23.pdf***
- A Review of Research on Agrivoltaic Systems ***https://www.sciencedirect.com/science/article/pii/S1364032122002635?via%3Dihub//***
- Solar Market Research & Analysis, by NREL provides information on benefits of agrivoltaics with many links, as well as key projects and resources ***https://www.nrel.gov/solar/market-research-analysis/agrivoltaics.html***
- American solar grazing association. ***https://solargrazing.org/***
- Farmer's Guide to Going Solar. ***https://www.energy.gov/eere/solar/farmers-guide-going-solar***
- Overview of Pollinator-Friendly Solar Energy ***https://rightofway.erc.uic.edu/wp-content/uploads/2020/02/000000003002014869.pdf***
- State Pollinator-Friendly Solar Initiatives ***https://www.cesa.org/wp-content/uploads/State-Pollinator-Friendly-Solar-Initiatives.pdf***
- Colorado State University Extension has a fact sheet, Agrivoltaics in Colorado, with an interesting graphic showing advantages, challenges, and array types for different dual-use activities. ***https://extension.colostate.edu/wp-content/uploads/2023/04/Agrivoltaics-Fact-Sheet-Final-2023-1-1.pdf***
- Massachusetts SMART program has fact sheets about dual use with farms which although geared for Massachusetts, still has much useful information. ***https://ag.umass.edu/clean-energy/research-initiatives/solar-pv-agriculture***
    - Location Considerations for Ground-Mounted Solar PV Arrays,
    - Dual-Use: Agriculture and Solar Photovoltaics
    - Dual-Use: Farm Operations Considerations
    - Dual-Use: Crops and Livestock Considerations
    - Information for dual-use solar with cranberry production ***https://ag.umass.edu/clean-energy/research-initiatives/dual-use-solar-agriculture/dual-use-solar-pv-cranberry-production***

# Conclusion

Washington state lags far behind other states with dual-use installations, research, incentives, and education. However, the momentum of dual-use solar in the U.S. and the world is rapidly increasing, making it an excellent time for Washington to join the movement. Given the land-use conflicts surrounding solar PV proposals in Washington, providing funding, incentives, resources, and education for dual use in a timely manner is advised. Solar grazing and pollinator habitat dual-use installations are better researched and possibly more amenable to farmers and solar developers as there is with dual-use installations with crops. Floating PV is also a great opportunity to increase the state's solar capacity while avoiding land-use conflicts. Opportunity should be taken to work with and educate the agricultural and local communities about the benefits of dual-use solar. The state's universities could provide much needed, regionally local research on crop production and other dual-use agricultural research, as is being done at Oregon State University.

Dual-use solar provides numerous economic and environmental benefits. It would also benefit Washington state's climate policies and goals, especially if enough consideration, resources, and funding were put into the field sooner than later.