EXHIBIT M: FARMER'S GUIDE TO GOING SOLAR (BY OTHERS)

Farmer's Guide to Going Solar

Solar Energy Technologies Office

Read "The 5 C's of Agrivoltaics Success" from the National Renewable Energy Laboratory.

Agrivoltaics is defined as agriculture, such as crop production, livestock grazing, and pollinator habitat, located underneath solar panels and/or between rows of solar panels. It offers the opportunity to harvest the sun twice, potentially benefiting farmers, rural communities, and the solar industry.

The U.S. Department of Energy Solar Energy Technologies Office (SETO) is researching the opportunities and trade-offs of agrivoltaics. This guide helps answer some questions that farmers may have about agrivoltaics.

WHAT ARE THE BENEFITS OF CO-LOCATING SOLAR AND CROP PRODUCTION? —

Farmers and solar energy developers can benefit from co-locating solar and crop production in different ways.

Benefits to **farmers and landowners** include:

- Agricultural land and farm ownership preservation for future generations.
- Additional revenue for farmers through land lease payments or other financial agreements.
- Potential water savings due to the shade from PV panels, which can reduce water requirements for crops and livestock, particularly in arid regions.
- Potential extension or modification of growing seasons by changing the temperature, shading, and water absorption of the soil around the panels.
- Increased ability for farmers to grow high-value, shade-tolerant crops.
- Opportunity to market crops to sustainability-minded consumers.
- Nutrient and land recharge of degraded lands, depending on farming practices.

Benefits to **solar developers/owners/operators** include:

- Potential for reduced solar operations and maintenance (O&M) costs, for example, by using grazing livestock to eliminate or reduce mowing.
- Potential increase in PV performance through cooling the underside of the panel with evapotranspiration from the vegetation underneath.
- Economic opportunity for rural communities, for example, through local job creation and tax revenue.

Farmers interested in learning more about the benefits of agrivoltaics can visit the National Center for Appropriate Technologies' **AgriSolar Clearinghouse**, which connects businesses, land managers, and researchers with trusted resources to support the growth of co-located solar and sustainable agriculture. You can also read about our research on agrivoltaics through the National Renewable Energy Laboratory's **InSPIRE project**, which includes an agrivoltaics primer, published research portal, and map of sites in the United States.

WILL SOLAR PANELS IMPACT THE HEALTH OF THE SOIL UNDERNEATH OR AROUND THEM?

Silicon-based PV cells are the most commonly used solar photovoltaic technology. Most solar panels have a glass layer on top that protects the PV cell and an aluminum or steel frame. An **Electric Power Research Institute report** found that "leaching of trace metals from modules is unlikely to present a significant risk due to the sealed nature of the installed cells."

Some solar modules use cadmium telluride (CdTe). Cadmium compounds are toxic, but studies show that such compounds cannot be emitted from CdTe modules during normal operation or even during fires. Industrial incineration temperatures, which are much higher than grassfires, are required to release the compounds from the modules.

In some cases, agrivoltaics can improve soil health. For example, **grazing sheep** beneath solar panels has been shown to increase the soil organic carbon uptake.

CAN SOLAR PANELS CHANGE THE MICROCLIMATE UNDERNEATH THE PANELS AND WORSEN INVASIVE SPECIES OR OTHER PEST PROBLEMS?

Microclimate effects depend on the design of the solar system and the surrounding environment. Air temperatures tend to be cooler under the panels during the day and warmer under the panels at night. **One study** found that soil temperatures under the panels were less than that of soil temperatures in full sun all day and higher at night. There have

been no studies linking solar development with pest problems or invasive species, but studies have shown that crops and native plants can thrive underneath solar installations.

WILL SOLAR PANELS HEAT UP AND DRY OUT VEGETATION OR CROPS UNDER THE PANELS?

Agrivoltaics can enable farmers to grow shade-tolerant crops and to diversify crop selection, while also extending growing seasons and reducing water requirements. Solar panels will actually cool crops and vegetation underneath during the day due to shading and keep them warmer at night. Some studies have shown that these temperature differences cancel each other out, so that daily average crop temperatures are similar under panels compared to full sun crops. High temperatures are often detrimental to crop yields. **One study found** that shading from solar panels produced lettuce crop weight equal to or greater than lettuce grown in full sun. In other cases, depending on the crops and growing conditions, impacts on yields can be more nuanced and depend on system design.

CAN DOMESTICATED ANIMALS LIKE SHEEP, GOATS, OR CATTLE GRAZE AT GROUND-MOUNTED SOLAR FACILITIES?

Sheep are grazed at some solar facilities in the United States and Europe. Unlike goats, sheep do not climb on or harm the panels. According to **data gathered** by NREL's InSPIRE project, as of December 2022, 794 megawatts of power generated by solar panels in the United States incorporate sheep grazing. Raising the height of PV panels is not necessary to accommodate sheep grazing, because vegetation is accessible to sheep beneath the panels at standard heights. Sheep grazing can benefit solar operators by reducing mowing, herbicide, and other vegetation management needs at the site. Local shepherds also benefit as they can be paid to provide sheep and to manage the grazing.

Cattle grazing is being conducted at a few PV facilities, but cattle can pose a risk to the equipment, and additional fencing or higher panels may be required to permit co-location. These measures may raise the cost of the solar installation. **Research** to facilitate cattle grazing under solar arrays is ongoing.

CAN YOU GROW NATIVE VEGETATION OR POLLINATOR HABITAT UNDERNEATH SOLAR PANELS?

Yes, solar installations can support native vegetation and pollinator habitat species. **Low-height plants** can thrive underneath solar panels, avoiding the need for mowing and keeping the panels unshaded. Fifteen states are using **Pollinator-Friendly Scorecards** to promote planting of pollinator habitat underneath ground-mounted solar projects. Pollinator habitat under solar arrays can benefit farms by increasing local agricultural yield and can also host beekeeping operations.

A SETO-funded **project led by the University of Illinois Chicago** is studying the economic, ecological, and performance impacts of pollinator plantings co-located at five solar PV facilities (10 megawatts or larger) in the Midwest and Mid-Atlantic regions. The project is developing guidance and decision-making tools, such as a pollinator planting manual, cost-benefit calculator, and native seed mix selection tool, for solar developers and landowners.

For more information about pollinator-friendly standards and practices for solar sites, visit the **University of Illinois Chicago project website** and the **Center for Pollinators in Energy website**.

WILL USING LAND FOR SOLAR PANELS DRIVE UP THE PRICE OF FOOD?

There is no documented evidence of solar panels increasing food prices. Solar projects planted with pollinator habitat can potentially increase local agricultural yields through increased pollination and other beneficial insect services. Fifteen states are using Pollinator-Friendly Scorecards to promote planting of pollinator habitat underneath ground-mounted solar projects. In addition, solar can provide several benefits to agricultural land managers that may offset capital costs of installing solar:

- Solar operators may lease farmland to host the solar panels, providing new sources of revenue and diversifying sources of farm income.
- Solar can be installed on marginal agriculture lands and provide an additional source of revenue for farms. This revenue stream can offset operating expenses of the farm and provide economic resilience during years with low crop production.

- Co-location of solar installations and crop and/or grazing can be designed to accommodate both electricity and agricultural production.
- Shade under solar panels can enable the production of high-value, shade-tolerant, and hand-harvested crops that may not normally be available in the market (e.g., lettuces in desert areas).

IS IT SAFE TO SPRAY AGROCHEMICALS NEAR SOLAR PANELS?

Herbicide is currently sprayed at some solar facilities to prevent weed growth. Agrochemicals should not present an issue. Care should be taken to not spray panels themselves, but if it occurs, the panels can be washed off with water as they are made of glass and steel or aluminum and have been designed to withstand outdoor conditions.

CAN SOLAR PANELS POWER MY IRRIGATION EQUIPMENT?

Yes, solar can power irrigation equipment. Solar can offset power required for pumping and provide power to remote irrigation systems, requiring no grid connection.

I LEASE MY FARMLAND. CAN I STILL INSTALL SOLAR PV?

Depending on the lease terms, solar may or may not be allowed on the site. If current farming operations are suitable for solar or if unused land exists, solar may be suitable.

I CAN'T DRIVE MY TRACTOR THROUGH OR AROUND SOLAR PANELS. ARE THERE WAYS I CAN STILL INSTALL SOLAR?

Solar facilities can be designed with increased spacing between rows to allow for equipment access. Small tractors or other farm equipment are also potential options. There is no one-size-fits-all solar design and developers should account for land and farming needs in the design process.

I NEED TO BURN MY FIELDS EVERY YEAR. CAN I STILL INSTALL SOLAR PV?

You should not burn crops underneath or around solar installations; this could lead to electrical fires and damaged equipment. If there is a need to conduct annual burns, this should be communicated to the solar developer upfront during the site selection process.

MY FARMLAND FLOODS IN THE SPRING. CAN I STILL INSTALL SOLAR PV?

Solar can be installed in flood plains, but all electrical equipment will have to be installed above the projected level of flooding. Raising equipment could increase the cost of installation and may negatively impact the project economics. Also, the cost of insurance could be higher for PV systems in a flooding area. Areas that will not be flooded may be better suited for PV installations.

WHAT ARE THE IMPACTS OF DUST ON THE PERFORMANCE OF SOLAR PV PANELS?

Power generation loss due to soiling should be incorporated into PV system generation estimates. NREL's **PVWatts** soiling calculator assumes that on average, 2% of power potential will be lost to soiling, but these losses are highly dependent on local weather and

soiling conditions. Having vegetation underneath and around solar panels can reduce the levels of dust and soiling on panels.

CAN MY LAND BE CONVERTED BACK TO AGRICULTURAL LAND AFTER THE LIFE OF THE SOLAR SYSTEM?

Land can be converted back to agricultural uses at the end of the operational life for solar installations. The life of a solar installation, roughly 30 years, can provide a recovery period for the land, increasing the value of that land for agriculture in the future. Depending on the nature of the solar operation, crops may or may not be present in the soil during the lifetime of the facility. Giving soil a rest can **maintain soil quality** and **contribute to the biodiversity** of agricultural land. On the other hand, implementing agrivoltaics and planting crops such as legumes underneath the solar installation can increase nutrient levels in the soil. The impacts of solar development and operations on soil is the subject of a **SETO-funded project** at Argonne National Laboratory.

CAN SOLAR INSTALLATIONS BE MODIFIED TO ACCOMMODATE FARMING?

The height of PV panels can be raised to allow for easier access to crops. Raising the height of PV panels, however, can increase the cost of the solar installation due to the need for additional steel for the foundational posts. The length of steel foundational posts underground may also need to be increased to accommodate the additional wind loading.

Another common way to adapt the design of a solar installation for agrivoltaics is to increase the spacing between panels and between rows, which allows for additional sunlight to reach the crops and increases the accessibility of the site to equipment. Increasing spacing, however, decreases the amount of electricity that can be produced on a given piece of land, so there is a trade-off between solar and agricultural productivity.

HOW CAN I START THE PROCESS OF ADDING SOLAR TO MY FARM?

Farmers interested in learning more about agrivoltaics can visit the **AgriSolar Clearinghouse**, which connects businesses, land managers, and researchers with trusted resources to support the growth of co-located solar and sustainable agriculture.

CAN I GET TAX CREDITS OR FINANCING TO INSTALL SOLAR ENERGY?

The Agrisolar Clearinghouse shares financial incentives, tax breaks, and other relevant financial programs on an **interactive map** on its website.

Learn more about SETO's **agrivoltaics research**, see other **solar energy resources for professionals**, and check out our agrivoltaics blog posts below.

The Potential of Agrivoltaics for the U.S. Solar Industry, Farmers, and Communities

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Buzzing Around Solar: Pollinator Habitat Under Solar Arrays

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