Section 5:
Land Conversion Issues with Grid-Scale Solar Development
Goals of This Publication

Our primary goal with this guide is to explain the emerging solar energy development trends occurring in the Commonwealth and what might be expected in the next few years. The guide is intended to inform municipal and county officials about grid-scale solar development so they can potentially add clear, regionally consistent language addressing the specific issues around solar energy development to their zoning ordinances and other regulations.

A resources list at the end of this publication provides sources of further information. A glossary defines unfamiliar terms. A notes section provides sources for statistics and additional information. Over time as new information becomes available to further inform this discussion, it will be added to this guide, including information about new legislation affecting solar development and the evolution of new solar technologies.

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Land Conversion Issues with Grid-Scale Solar Development

Introduction

As energy transitions are occurring across the nation, the conversion of land, mainly in rural communities, to energy production, is increasing. With estimates of 80,000 acres of land surface being converted to solar energy production in the Commonwealth by 2030, impacts to the current use of land have risen to the forefront of most grid-scale solar discussions. Concerns focus mainly on the impact to prime farmlands but also include siting on forested and other lands.

Lands that are attractive for grid-scale solar development (GSSD) may expand. The federal Investment and Jobs Act of 2021 authorized the construction of new high-voltage power lines, which could open up more properties to this potential development.

Loss of Farmland

In the Northeast and Mid-Atlantic, the amount of remaining farmland is limited, so governments tend to be protective of this resource. During the planning and permitting of new solar facilities, this may require extra regulatory steps and a plan for on-site agrivoltaics—the combination of GSSD with some limited agricultural activities, such as sheep grazing, beekeeping, growing vegetables, or other types of conventional ag production scaled to fit among the installed solar panels (see below).

Siting GSSD on farmland can be appealing for a few reasons:

- With one contract the company can get access to a significant number of acres. Often, with larger planned GSSD projects, a number of contiguous properties must be leased to make the project commercially feasible.
- The land is already cleared.
- Taxes are lower in rural areas.

When comparing agriculture to GSSD, the margin of net profit per acre for agriculture will vary from highly productive ground to marginal ground, but solar is likely more profitable on all types of land on a per acre basis.

Credit: Photo by Werner Slocum, NREL 65581
if farming is a family’s livelihood, they also need to consider issues such as the next generation’s wishes for the farm and the land, the opportunities to and desire to farm in some fashion within the solar array, and community interests.

There are also secondary issues of allowing the transition of prime farmland for any other type of development, from housing to commercial warehouse construction, or in this case, GSSD. For example, agricultural support industries such as grain mills and feed stores could face challenging economics to stay in business and support area farmers if many acres in an area are filled with solar panels. So thoughtful consideration of all types of land transitions, including new energy development, is critical going forward.

Some argue that pausing farming for about 25 years allows the soil to rest and return in better condition at the end of the solar array’s life. Others suggest that once set aside for energy production it’s likely that these lands may be redeveloped at the end of the project’s life with new, more efficient panels or for the next optimized energy source down the road and that the land may not be farmed again in the manner it was prior to GSSD.

**Solar and Forest Land**

When GSS is proposed for forest land, the trees are often of low value and the land is generally not as highly productive as open farmland. Private forest land has been broken into smaller and smaller parcels in the Mid-Atlantic over the last several centuries. These smaller parcels often lose their full ecological function as they decrease in size.

The Chesapeake Bay Foundation recommends that governments incentivize solar installations in appropriate locations through credits, regulatory relief, and/or faster application processing for preferred locations. They recommend providing no state

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**Strategies to Reduce Farmland Loss**

To reduce the loss of farmland, solar developers are using siting protocols to develop land more efficiently, which may include the use of bifacial panels to increase power yields, not leaving odd pieces of farmland undeveloped, and maximizing access to other parts of the site for continued farming.

Various states have adopted preference and penalty programs to steer grid-scale solar (GSS) placement. Massachusetts and New Jersey offer positive incentives for development on preferred sites. Numerous states impose a tax penalty for converting land covered by preferential agricultural tax assessments to GSS. Some states provide incentives to owners of high-quality farmland to limit their ability to develop their land. New Jersey, Massachusetts, and Connecticut have processes that can stop or delay solar development on farmland. It should also be noted that these states have considerably less farmland available within their borders than Pennsylvania does, and the farmland they have is facing intense development pressures from other sectors as well, such as housing and industry. It is estimated that GSS in Pennsylvania might take up 1% of available land in the state if it is built out as projected to 80,000 acres.

As of July 2022, the Pennsylvania General Assembly had not chosen to incentivize or disincentivize GSS projects on any type of land.

Municipalities may minimize future impediments to returning GSS land to farming by considering what their ordinance requires on the land. For example, a stormwater retention pond would require earth-moving, and the farmer is unlikely to get that land back to farming. Minimizing interior access roads is another way to ensure more of the solar site may be returned to some type of agricultural production in the future.
incentives to locate GSS on forest lands of more than 20 acres. Some counties and municipalities are limiting forested acre transitions to less than 5 acres per project through language in local solar ordinances.

**Use of Brownfields/Greyfields, Abandoned Mine Lands, and Other Reclaimed Sites as GSS Sites**

There are numerous advocates for the placement of GSSD on brownfields, closed landfills, abandoned minelands, and other sites that have seen previous industrial use. This is happening to some extent, and can help preserve other open land, but solar developers typically prefer to build the most economically efficient projects. Brownfields and other previously developed sites often have or may have environmental pollution problems left over from the previous use of the site that must be addressed. One big limitation to the reuse of brownfield sites is they are often not close to high-voltage transmission lines and/or the needed electrical substations that provide access to the regional power grid.

Pennsylvania’s brownfield program offers liability protection for future landowners, which should encourage more brownfield development for GSSD.

Historic power production facilities already in place—for example, a coal plant that may be scheduled to come off-line—can be extremely valuable as solar production sites because of the existing connections to the power grid. The zoning for these sites would typically already allow for GSSD. Municipalities may be approached for GSSD at these sites.

Unused power production facilities on the site would likely be demolished. The existing grid connections would be revamped because the amount of power stemming from solar is different from that from coal.

The U.S. Environmental Protection Agency’s (EPA) RE-Powering America’s Land initiative
encourages renewable energy development on brownfields when this development is consistent with the community’s vision for the site. USEPA and the U.S. Department of Energy’s National Renewable Energy Laboratory have also developed guidance on how to best redevelop municipal landfills for GSSD.

A greyfield site is underused land, often in an industrial area. It may also host formerly viable commercial land use such as a shuttered or unused mall and its parking lots. Greyfields have the advantages that they do not include legacy environmental pollution problems and they are often less expensive to develop than rural areas because they are already served by utilities.

It could be ideal to funnel GSSD to brownfields and greyfields locations when they exist near electrical transmission infrastructure. However, legacy pollution or its potential, especially on brownfield sites, can raise the development cost and uncertainty for these sites. Reclaimed mineland may have drainage issues, and rooftop development involves expensive engineering. Municipalities can encourage or discourage use of different types of land for GSSD with their zoning ordinance.

**Agrivoltaics as a Means of Preserving Farm Functionality and Diversifying Income**

It is increasingly common that the ground underneath a solar array is planted in seed mixes of native grasses and legumes, or in other cases, with pollinator-friendly flowering plants. The vegetation still might need to be mowed several times per year because some of these plants get tall enough to block light to the panels. The lease should address how this regular maintenance will be done and the project must be planned to allow for this. Companies typically pay $300–$500 per acre per year (in 2022) for mowing, sometimes to the landowner, if this is agreed in the terms in the solar lease controlling the GSS project. Paying the landowner to mow or graze the site can make the deal more palatable to landowners and the community.

**Grazing**

Similar payments may be made to a shepherd for their sheep to graze a site. (Horses and cows are big enough to potentially damage the solar panels, and goats may eat the panel wiring, so sheep are preferred). Many sites will be mowed because there aren’t enough sheep to graze all the sites.

Research at Cornell University found in 2018 that labor hours needed for site vegetation management were 2.5 times less with sheep grazing than with mechanical and pesticide management. Tampa Electric reported that...
sheep grazing reduced their vegetation maintenance costs by 75% over traditional mowing at its GSS sites, although cost savings estimates closer to 20–40% may be more common.

Agrivoltaics is relatively new, and possibilities and accommodations are still being worked out. Farmers in England have raised poultry under solar panels. The panels must be high enough that the poultry don’t roost on the panels and potentially foul them. Some farmers are proposing manure injection on land between the solar panels. Grazing GSS lands with sheep may also increase carbon storage in the soil over time.

The American Solar Grazing Association is a producer-owned business cooperative with about 450 members that assists its farmer members in techniques and skills when negotiating contracts with solar companies. In some cases, they organize the sharing of transportation equipment to move livestock.

Benefits of Agrivoltaics

The establishment of grazing or native pollinator habitat on solar farms allows both GSSD and agricultural land use to coexist.

- Agrivoltaics can provide various benefits:
- Use native vegetation for soil and water protection, decreasing erosion.
- Increase farm viability, helping farm family financial security for about 25 years, diversifying farmer income and preserving the rest of the land.
- Possibly increase future fertility of soil.

Challenges with Agrivoltaics

- Requirements and recommendations are still being fine-tuned through research and trial and error. Several states, including Massachusetts, have proposed or passed legislation requiring pollinator habitat or agrivoltaics with GSSD.

- The cost of native seed mixes is higher than traditional revegetation seed mixes.
- Seedling establishment takes a few years, and during this time competitive grasses and weeds must be kept at bay.
- Stormwater management permit requirements can be difficult to achieve until the plants are fully established.
- Zoning requirements restricting vegetation height may need to be revamped. Shepherds want the grass to grow to about 18 inches high before bringing in sheep.

Agrivoltaics Best Practices

These are some best practices for agrivoltaics:
- Plant short, low-maintenance, native seed mix underneath and around the panels.
- Use a diverse pollinator seed mix between panel rows.
- Plant site buffers with pollinator-friendly vegetation.
- Plant native shrubs along the property boundary if compatible with other screening vegetation.
- Strive for a diversity of native flowers that bloom throughout the growing season, as well as native grasses.
- If possible, use underutilized areas of the farm, such as sloping pasture or support land.
- Many solar developers try to work with the landowner if they’re interested in working the site through beekeeping or grazing.
The organization is interested in cooperatively marketing lambs and wool produced from solar-grazing flocks. Currently, more than 50% of the lamb and mutton consumed in the U.S. is imported from New Zealand and Australia, so expanding market opportunities for local lamb and wool would benefit both area farmers and the local economies where this additional solar grazing may occur.

The American Solar Grazing Association, in partnership with Ernst Conservation Seeds & Pollinator Service in northwestern Pennsylvania, developed a seed mix called Fuzz & Buzz specially designed for solar grazing and to support a diverse range of pollinators. The plant mix grows to 2–3 feet high, so it doesn’t shade the panels, and has been optimized for palatability to sheep.

**Pollinator Habitat**

Pollinator species when managed correctly will eventually suppress weeds, requiring less herbicide. Their deep root systems help reduce erosion. But for the first few years until the plants are established and out-competing grasses and weeds, the vegetation may need more maintenance.

With typical grass below panels, solar arrays are often mowed every 4–6 weeks in the growing season, when the grass gets close to the panels. This is an inefficient system because it’s a regular expense throughout the ~25-year life of the project. If specially chosen pollinator-friendly plants are planted under panels instead, they grow to only 2–3 feet high, which is below the panels, and mowing can happen just once or twice a year.

Operators of pollinator-planted solar arrays typically work with local conservation groups, seed growers, and consultants to choose and buy seed tailored to and local to the site, and to oversee the vegetation.

Research conducted on pollinator habitat under solar panels in Minnesota found:

- Three times more beneficial plant species than on traditionally managed GSS arrays.
- Four times more pollinating insects.
Additional benefits may also accumulate. Encouraging pollinators and other beneficial insects might help increase local agricultural yields. Higher energy output may result from a solar array planted in pollinator habitat because the plants keep the ground cooler and solar panels operate more efficiently when they are cooler.

At least fifteen states have guidelines for pollinator seed mixes and management practices. Maryland and Minnesota have developed pollinator-friendly solar certification programs.

Before proposing a pollinator project, it’s important to consider what pesticides have been used on the land in the past because some can linger in the soil and kill seeds.

**Crops**

Growing crops under solar panels is not yet common and is done mostly at research sites. One commercial solar crop site operates in Colorado; other sites are in the planning phase. There is considerable research in both the U.S. and Europe to find new options for diverse forms of agriculture to be commercialized under solar panels. Crops in GSS arrays benefit from a mix of sun and shade, and cooler temperatures in summer and during the day and warmer temperatures in winter and at night. These minor differences basically balance out to produce little difference in crop growth rates, but the environment can be more comfortable for farmworkers. The growing season may be extended and water needs may be less.

Some crops that have done well in the GSS setting include lettuces, tomatoes, peppers, chard, kale, broccoli, and brussels sprouts. But this is likely only commercially viable in smaller acreage settings.

The panels might be raised higher (to ~7–10 feet) to give the option of growing vegetable crops underneath them. But if the panels stand higher, they become more obvious, so a higher fence might be needed and the...
viewshed of the project will increase. Higher panels may be subject to higher wind speeds, requiring longer support posts, which may be more expensive. There may also be ordinance language with maximum height limits.

**GSSD on Preserved Farmland**

Pennsylvania’s Clean and Green Program provides preferential tax treatment for enrolled agricultural lands. GSSD may not occur on enrolled lands. Landowners can withdraw from the program if they want to host a solar array, but rollback taxes, and a penalty are due for the period of enrollment in the program. Typically, the developer would pay those taxes and the penalty. Broadly, an amendment to the Clean and Green Program permits solar development as long as 50% or more of the energy produced is used on the property, but that would not apply for GSSD.

In the interest of farmland preservation, the Pennsylvania Department of Agriculture oversees the state’s Agricultural Security Areas (ASA) and Conservation Easement Purchase programs. If land is enrolled in a qualifying ASA, state or local governments can purchase conservation easements from the farmer. These exist in perpetuity and prevent the landowner from allowing GSSD on the land.

There are currently no restrictions or limitations related to GSSD on a property that is simply enrolled in an ASA. However, the property may be removed from the ASA when the township does a 7-year review if it no longer meets the evaluation criteria in the ASA. There is no penalty for changing use or removing property.

For land under conservation easement purchased with federal, state, or local money or any combination thereof in Pennsylvania, GSSD is not currently permitted.

It’s an open question whether GSSD would be allowed on land under conservation easement from a private land trust. Some land trusts have struggled to draft easement language to allow responsible siting of GSSD, because the conversion to GSSD normally does not adhere to the mission of the land trust.

**Conclusion**

Farmland is an attractive option for GSSD, but governments can develop incentives or penalties to steer this development as they prefer. Brownfields, greyfields, abandoned mine lands, and other reclaimed sites can be economical to develop for this use if there is transmission infrastructure close by. Agrivoltaics—grazing or encouraging pollinator habitat or possibly growing vegetables under solar panels—can allow for economic and environmental benefits to developers, farmers, neighbors, and ecosystems. Farmland enrolled in Pennsylvania’s Clean and Green Program cannot be developed for GSSD without the rollback taxes and penalties being paid. Land under a publicly funded conservation easement cannot be developed for GSSD. It remains unclear whether lands under private conservation easement can be developed in this way.

**For More Information**


American Solar Grazing Association. [https://solargrazing.org/](https://solargrazing.org/)


Notes

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Agrivoltaics best practices


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