MUNICIPAL OFFICIALS' GUIDE TO GRID-SCALE SOLAR DEVELOPMENT IN PENNSYLVANIA

Section 4:
Environmental Impacts of Grid-Scale Solar Development

PennState

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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4 ENVIRONMENTAL IMPACTS OF GRID-SCALE SOLAR DEVELOPMENT

Introduction

As people see more grid-scale solar development (GSSD) pop up on the landscape, they may wonder if these installations have adverse effects on human or animal health. This section addresses baseline environmental assessment prior to construction, stormwater management, leaching of metals from panels, stray voltage concerns, radiation and electromagnetic fields, impacts to wildlife, and disposal or recycling of panels at the end of their useful life.

Grid-scale solar (GSS) arrays are a recent addition to the landscape, but photovoltaic technology and its potential environmental effects have been studied since the 1950s. There are many ways solar developers can minimize the impact of GSSD on the environment .

Site Selection

In addition to the site selection criteria discussed in Section 1, solar developers prefer to avoid:

- Floodplains and wetlands.
- Corrosive or rocky soil.
- Karst landscapes.
- Sites likely to experience higher than average risk of tornadoes, snow loads, and wind.
- Shading: A 50 percent drop in efficiency can occur with even 10 percent shading of an array.
- An airport within 2 miles. If this can't be avoided, the Federal Aviation Administration requires developers to conduct a glint and glare study (see Section 3).
- A cell tower on the same property. Some cell tower agreements have language deterring solar development.
- Crossing over a railroad easement.
- Proximity to cemeteries, golf courses, or residential neighborhoods.
- Properties in Pennsylvania's Clean and Green program, a preferential tax assessment program through which property taxes are based on use values rather than fair market values.

Planning recommendations:

- Minimize placement of GSSD on agricultural land classified as "prime."
- Encourage the use of agrivoltaics—the farming of the ground underneath a solar array—especially on prime agricultural land.

Baseline Environmental Assessment

When a reputable solar developer identifies a site of interest for GSSD, they conduct site-specific environmental studies for:

- Toxic and hazardous waste liability.
- Wildlife habitat.
- Threatened and endangered species.
- Wetland and waterway delineations.
- Cultural resources, to look for signs of important artifacts buried at the site.

- Viewshed, to inform design of site screening from nearby roads and neighboring residences.
- Sound assessment.
- Consultation with the U.S. Fish and Wildlife Service and state wildlife agency, to check for nonpublic information about the site.

Planning recommendation:

- Require most or all of the above site-specific studies to be conducted and reports submitted with permit application.

Best Management Practices (BMPs) for Construction and Operations

- Implement avoidance strategies and setbacks from sensitive and valuable habitat.
- Use previously disturbed land at each site as much as possible.
- Schedule construction outside of breeding season, if possible.
- Manage invasive plant species by applying appropriate control measures.
- Promptly and sustainably dispose of waste generated during construction to avoid attracting wildlife.
- Follow Avian Power Line Interaction Committee recommendations on power lines and electrical infrastructure as needed to protect raptors from collision and electrocution.
- Conduct wildlife and natural resources awareness training for staff and contractors on sensitive resources.
- Develop environmental management plans to document and track sustainability commitments and site-specific environmental data.
- Follow all commonly accepted biosecurity measures when working on or between farms hosting animal/livestock operations to reduce the spread of animal diseases or invasive pests.

Planning recommendation:

- Require use of most or all of the above BMPs for construction and operations.

Stormwater Management

The Pennsylvania Department of Environmental Protection (DEP) and county conservation districts are involved

Stormwater management should be improved on this portion of the site. Hay bales help to slow the flow of stormwater. Replanting grass would be most helpful. *Credit: Penn State MCOR*

in reviewing a site design to manage stormwater, depending on site construction and layout. DEP requires a National Pollutant Discharge Elimination System (NPDES) permit for solar projects with earth disturbance greater than 1 acre.

Different governing bodies evaluate GSSD differently when it comes to stormwater management. Some governing bodies consider the panels to be impervious (impenetrable to water) and therefore require stormwater management for 100% of the water that hits the panels. This deters this development by raising costs. Other governing bodies, such as the U.S. Environmental Protection Agency (USEPA), have decided that solar panels are pervious, meaning that precipitation falling on them rolls off and soaks into the ground and does not leave the site. This requires a less complex and less expensive stormwater management plan. Other entities consider them to be 25% or 50% pervious, and everything in between. Municipalities may signal their relative openness to GSSD by how they rate solar panels' imperviousness.

The treatment of the roads within a GSS array affects stormwater management because it figures in the percentage of the site that is impervious to precipitation. The main access road to a site is typically gravel, but the interior roads are typically seeded to grass. The interior roads are for mowing, repair, maintenance, and emergency access.

Existing federal, state, and local rules help guide GSSD to minimize impacts on surface and groundwater, and wetlands. Built stormwater management features such as berms, swales, and retention ponds help to minimize erosion and stormwater runoff.

County conservation districts approve earth-moving plans (erosion and sedimentation (E&S) plans). Projects are expected to use E&S best practices as needed. These include minimizing the extent and duration of earth disturbance, protecting existing drainages and vegetation, avoiding soil compaction, and preventing or minimizing increased stormwater runoff.

Other specifications that may need to be met include impervious surface coverage limits, which relate to E&S control and stormwater control, and landscaping requirements. Stormwater controls must be maintained for the life of the project.

This access road has been planted with grass.
Credit: Penn State MCOR

Planning recommendation:

- Require the submission of a complete stormwater management system design with permit application as applicable.
- Consider the municipality's requirements for stormwater management planning. Also review DEP's solar stormwater guidance found at: https://files.dep.state.pa.us/Water/BPNPSM/StormwaterManagement/ConstructionStormwater/Solar_Panel_Farms_FAQ.pdf

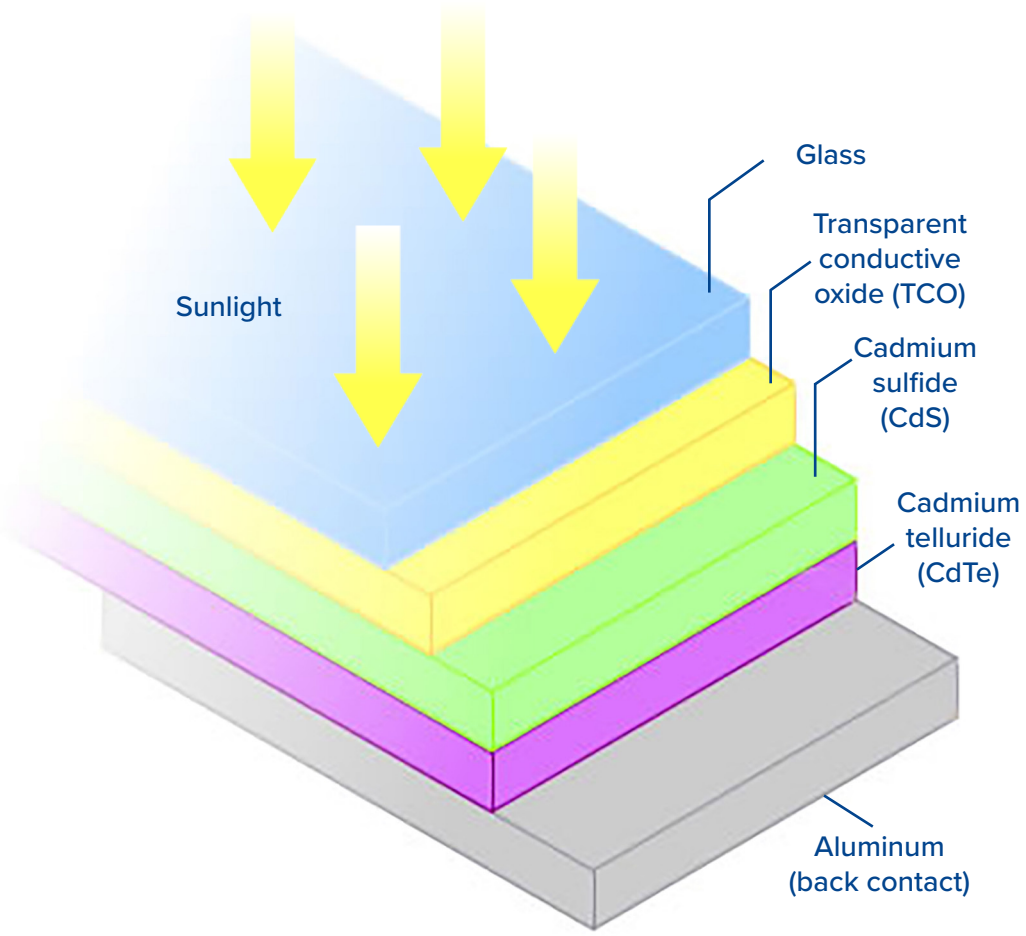
Leaching of Metals from the Panels and Integrity of the Panels

Solar panels typically consist of tempered glass, common plastics, copper, silver, and semiconductor materials that can be recovered and reused, and an aluminum frame. To protect photovoltaic (PV) cells in crystalline silicon–based panels from corrosion throughout their years of useful life, the cells are encased between two layers of plastic to keep out moisture. The top of the panel facing the sun is finished with tempered glass and the underside, facing the ground, with a plastic sheet. The material encapsulating the PV cells is the same material that's used in car windshields to give them extra strength. So if a panel is damaged, it may crack but is unlikely to break into small pieces. A panel's warrantied life depends on it remaining intact.

Solar panels used in GSS are either crystalline silicon or thin film . Crystalline silicon–based technology consists of silicon wafers that are made into cells and assembled into panels. Nontoxic silicon makes up more than 25% of the earth's crust.

Crystalline silicon–based panels in a GSS array contain only very small quantities of a few other chemicals and metals. These are embedded into the tempered glass–encased array and do not have direct exposure to the external environment, and thus, are not subject to leaching. A tiny amount of lead (typically less than 0.5 ounce) is used in a crystalline silicon–based panel.

Thin-film panels consist of thin layers of the semiconductor cadmium telluride (CdTe) embedded on glass, polymer, or metal. As described above, solar panels are enclosed in a hard, tough case, so the metals inside them pose negligible toxicity risk to public health and safety. Most of the metal and other valuable materials in old or broken panels



Schematic of the layers of a CdTe solar panel.

Adapted from US DOE Solar Energy Technologies Office. https://www.energy.gov/eere/solar/cadmium-telluride

can be reused in future panels, so having a viable panel decommissioning plan and recycling program is helpful.

The USEPA uses the toxicity characteristic leaching procedure (TCLP) to determine whether, with breakage, contaminants from solar panels could leak at toxic levels to groundwater from landfills. USEPA has strict limits under the federal Resources Conservation and Recovery Act. Most or all solar panels being installed today pass this test, and manufacturers adhere to various performance and safety standards, including those of UL (Underwriters Laboratory). The panels are labeled nonhazardous waste and can be disposed of in landfills.

If there is continuing concern about leaching of heavy metals from GSS panels, baseline testing of soils where the panels will be installed can be done to determine the presence of any chemicals or metals of concern, and compared against future testing post-construction.

Some local building codes include specifications for wind speeds that all built structures, including ground-mounted solar arrays, must meet. Assessments of GSS facilities after Hurricane Sandy in 2012 and Hurricane Matthew in 2016 found only minor or no damage from wind or flooding.

Planning recommendations:

- Require the solar developer to submit the results of the TCLP test for the panels they propose to install with the permit application.
- Require that the GSSD meet local building code specifications for wind speed.

Radiation and Electromagnetic Fields

In modern life we are all exposed to electromagnetic fields (EMF) with no known health impact. EMF from solar arrays are "non-ionizing." Non-ionizing radiation does not have enough energy to damage DNA. Non-ionizing fields come from computers, appliances, cell phones, and wireless routers.

EMF generated by solar arrays is similar to that generated by household appliances and quickly dissipates with distance, posing no health risk to neighbors. EMF levels at the perimeter fence of a solar array are less strong than those experienced when close to a television, refrigerator, or microwave. EMF from a solar array disappears at night when the system does not produce energy.

People with a pacemaker or other similar medical device sometimes wonder if the EMF from a solar array could affect device operation. Inverters produce the greatest EMF in a solar facility, and they are typically located near the center of the facility to reduce exposure to EMF and noise from their cooling fans. The level of EMF at the edge of a GSS array is well below recommended exposure limits and continues to decrease with distance from the array.

Planning recommendations:

- Recommend placement of inverters, transformers, and electricity storage systems (batteries, etc.) near the center of the facility or away from residential areas.

Stray Voltage Concerns

Some neighbors raising livestock next to a proposed GSSD may express concerns about "stray voltage." The U.S. Department of Agriculture defined "stray voltage" as "a small voltage (less than 10 volts) measured between two points that can be simultaneously contacted by an animal." Some animals, especially cows and pigs, are more sensitive to stray voltage than people are. If they are subjected to continuous stray voltage, their eating and drinking behavior may be affected, thereby reducing production.

Some farmers have stated that underground power lines contribute to the problem, and underground power lines would be present at a GSSD. But studies show that stray voltage likely results from old and mismatched wiring and electrical equipment on the farm, rather than any interaction with a GSSD.

Because GSS facilities are in essence power plants, the equipment in a solar array is capable of producing deadly electric shock. But the substantial perimeter fencing and appropriate signage about the dangers, as required by the National Electric Code, should keep the public out of the facility.

Planning recommendation:

- Require an 8-foot fence around the site perimeter, with signs as required by the National Electric Code warning of potential shock hazards.

Impacts to Wildlife

Threatened and Endangered Species

Reputable solar developers in Pennsylvania consult with the U.S. Fish and Wildlife Service and the Pennsylvania Department of Conservation and Natural Resources to determine whether endangered or threatened species may be present at the site. They identify potential impacts to threatened or endangered species during construction, operations, or maintenance, and work to lessen impacts. Most companies seek to avoid animal mortality and disruption or loss of breeding, wintering, and migration habitats. They aim to lessen impacts by using construction buffers around sensitive habitat when it can't be avoided, especially during breeding and nesting season, and by setting aside funding to offset unavoidable impacts.

Credit: Deb Nystrom, Flickr, Licensed under CC BY 2.0

Birds

Some people think that GSSD kills birds. This stems from confusion with concentrated solar thermal development, which occurs almost exclusively in the Southwest. The 2020 New York Solar Guidebook for Local Governments concluded that there is "minimal impact" to birds from GSSD in New York, given a review by the National Renewable Energy Laboratory. Another U.S. Department of Energy summary of the impact of GSSD on birds stated that the impact "isn't well understood" and is currently being studied.

Planning recommendations:

- Require the submission of a habitat/ threatened and endangered species study with permit application.
- Require mitigation of habitat and wildlife impacts.
- Require use of native plants for site vegetation and screening.
- Specify minimum distance of panels and other site equipment from waterways or wetlands.

Disposal and/or Recycling of Solar Panels at the End of Their Useful Life

As noted above, both crystalline silicon–based and cadmium telluride (CdTe) thin-film panels are safe to dispose of in landfills. But reputable solar panel manufacturers plan for recycling and decommissioning of the panels they produce.

Solar panel recycling is still fairly new because there hasn't yet been a great volume of panels that have reached the end of their useful life. As more panels reach the end of their life, dedicated solar panel recycling facilities will be better able to maximize the efficiency of recycling.

In 2016 the US Solar Energy Industry Association (SEIA) started a national solar panel recycling program in cooperation with leading panel manufacturers. The goal is to make the industry landfill-free. The program aggregates the services offered by recycling vendors and panel manufacturers, making it easier to select a cost-effective and environmentally responsible end-of-life panel management solution.

Europe has a successful mandatory solar industry–funded program for panel recycling. It makes manufacturers responsible for end-of-life panel management.

The balance of a GSS system (non-panel components, including inverters and transformers) contains common and generally benign materials that would be found with other forms of electricity production.

In 2016–'17, a North Carolina assessment found the salvage value of solar array equipment to be greater than estimates of the cost to remove the entire system.

Because solar arrays can replace fossil-fuel-burning electricity generation, they help clean the air, reduce pollution-induced illnesses, and divert metals from the waste stream. Research from the U.S. Department of Energy's National Renewable Energy Laboratory and the Lawrence Berkeley National Laboratory suggests that the benefits provided by the reduction in air pollution from solar energy are worth more than the electricity generated.

Recommendations for panel bonding and decommissioning are discussed in Section 6.

Conclusion

The negative health and safety impacts of GSSD have been shown to be negligible. Assuming deployment of new GSS technologies is commercially viable, there are added benefits of air pollution reduction and health improvements associated with solar facilities.

For More Information

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Notes

p. 3: "A 50 percent drop in efficiency can occur with even 10 percent shading of an array."

Source: Renewable Energy Ordinance Framework, Solar PV Delaware Valley Regional Planning Commission. 2016. https://www.dvrpc.org/energyclimate/ModelOrdinance/solar/pdf/2016_DVRPC_Solar_REOF_Reformatted_Final.pdf

p. 6–9: Information on leaching of metals from the panels and integrity of the panels, radiation and electromagnetic fields, and disposal and/or recycling of solar panels

Source: Health and Safety Impacts of Solar Photovoltaics. 2017. North Carolina Clean Energy Technology Center. North Carolina State University. https://content.ces.ncsu.edu/health-and-safety-impacts-of-solar-photovoltaics

p. 7: "EMF generated by solar arrays is similar to that generated by household appliances and quickly dissipates with distance, posing no health risk to neighbors."

Source: Top Five Large-Scale Solar Myths. National Renewable Energy Laboratory. 2016. https://www.nrel.gov/state-local-tribal/blog/posts/top-five-large-scale-solar-myths.html

p. 7: USDA definition of stray voltage

Source: Effects of Electrical Voltage/Current on Farm Animals: How to Detect and Remedy Problems. 1991. U.S. Department of Agriculture, Agriculture Handbook No. 696. https://naldc.nal.usda.gov/download/CAT92970513/PDF

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p. 8: Review of bird impacts from GSSD

Source: A Review of Avian Monitoring and Mitigation Information at Existing Utility Scale Solar Facilities. Environmental Science Division, Argonne National Laboratory, Apr. 2015. https://doi.org/10.2172/1176921

p. 8: GSSD impact to birds "isn't well understood"

Source: Large-Scale Solar Siting. n.d. Solar Energy Technologies Office. U.S. Department of Energy. https://www.energy.gov/eere/solar/large-scale-solar-siting