Solar Siting in the South

Maximizing Benefits and Minimizing Impacts to Drive Smart, Sustainable Solar Development

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INTRODUCTION

Solar energy is playing an increasingly important role in how states meet their energy needs. Across our region,[1] local communities, utilities, and solar developers are realizing the benefits of solar energy, including customer bill savings, energy independence, environmental benefits, and economic development. Solar facilities above 1 megawatt in size make up a growing portion of this changing energy landscape and will continue to be an essential part of the South's transition to clean energy. There are currently many review processes in place to evaluate and minimize potential adverse environmental impacts associated with new solar development.

The purpose of this guide is to provide an overview of the environmental review processes that most utility-scale solar facilities in the South currently go through and to provide examples of best practices that developers are embracing to maximize benefits and minimize environmental impacts.

Setting the Stage: The Benefits of Solar Energy

Solar energy is an emission-free, abundant, and clean energy source, especially when compared to alternative sources of electricity. In the South, most of our electricity still comes from coal- and gas-fired power plants.[2] These fossil fuels pollute our air, water, and environment, and are the leading contributor to climate-altering pollution in the United States.

In contrast, solar energy is carbon- and pollution-free in operation. Even when considering lifecycle greenhouse gas emissions—those that occur from manufacturing, operation, maintenance, and decommissioning—solar energy produces less than 10% the emissions of gas generation and less than 5% the emissions of coal generation.[3]

Solar energy also uses significantly less water than coal, gas, and nuclear generation. Solar facilities require very little water for operation, giving them an important role in reducing the water use of the electricity sector.[4] In fact, solar energy co-located with agriculture or native vegetation can help soil retrain moisture and improve water use efficiency, reducing the need for lawn maintenance in areas with overburdened water resources.[5]

Solar Panels and Your Health

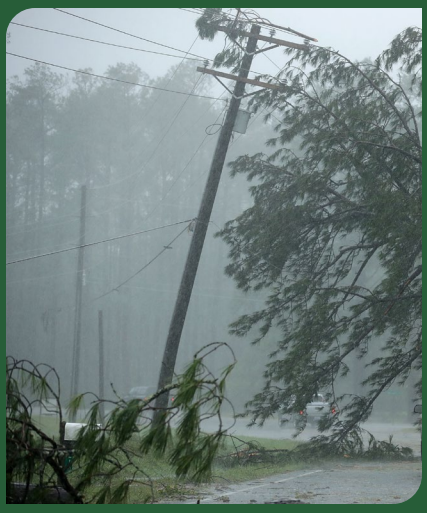
Replacing fossil fuel generation with clean energy like solar is also expected to bring significant community health benefits. Unlike fossil fuel energy sources, solar panels do not produce harmful emissions, fine particulate matter, and other pollution associated with serious health conditions like asthma, cardiovascular disease, and lung cancer.[6] Solar facilities also generate far less noise than other types of energy and do not generate noise at night, allowing solar energy to be safely deployed in residential areas without significant disruption.[7] While solar facilities generate electromagnetic fields (EMF), there are no confirmed negative health impacts associated with exposure to the level of EMF produced by solar panels.[8] In fact, solar panels produce lower levels of EMF exposure than most household appliances, such as microwaves and televisions.[9]

The advantages of solar energy go beyond reduced pollution and water usage. Solar energy diversifies our energy supply, provides a hedge against volatile fuel prices, helps support grid reliability, produces peak energy output when utilities need it the most, increases opportunities for rural electrification, and contributes to much-needed economic development.[10]

Solar Energy Helps Keep the Lights On

Transitioning to clean energy is critical for communities that face an increasing risk of extreme weather conditions, including drought, extreme heat, and hurricanes. Solar facilities that are designed to be resilient and durable make the grid and the communities they serve more resilient.[11] Solar energy has proven to be a reliable form of electricity generation during extreme whether events, even when other forms of generation fail.[12] Solar facilities often continue to power communities during severe weather and, if shut down, can be restarted faster than other forms of energy.[13]

For example, during Hurricane Florence's powerful winds and heavy rainfall in 2018, solar facilities in North Carolina held up with only minimal damage while other parts of the electricity system failed.[14] Solar energy also helped keep the lights on for thousands of Texans during a heatwave in the summer of 2023, filling a gap in energy output caused in part by outages at a nuclear plant and two coal facilities.[15]



Power lines blown down by Hurricane Florence. Photo by Chip Somodevilla/ Getty Images.

The cost of installing solar energy has decreased by more than 40% over the past 10 years,[16] leading to the creation of new jobs and significant growth of the solar industry in the South (Figure 1). Today, utility-scale solar energy is the cheapest form of new electricity generation, costing less than coal, gas, and nuclear generation.[17] The U.S. solar industry has experienced an average annual growth rate of 24% over the past decade, with solar energy accounting for 50% of new electricity-generating capacity added to the U.S. grid in 2022.[18]

The solar industry employs more workers per unit of generation than fossil fuels in general and over twice as many total workers as the U.S. coal industry.[20] Approximately 10.5% of solar workers are represented by a union, collective bargaining agreement, and/or project labor agreement based on national data for 2022.[21] With the passage of the Inflation Reduction Act, the Solar Energy Industries Association forecasts that the number of solar jobs could more than double over the next decade.[22]

In addition to creating new jobs, solar development provides economic investment and revenue generation for local communities. From 2007 to 2020, for example, clean energy development in North Carolina contributed $22.5 billion to the state economy and generated

Figure 1. The growth of solar energy in the South has created new job opportunities across multiple sectors and resulted in the installation of over 22 gigawatts of clean energy, enough to power over 2.6 million homes.

Megawatts installed ↑ Growth projection over the next 5 years

Alabama
813 MW
Enough to power **91,056** homes
716 jobs
↑ 1,418 MW

Georgia
5,200 MW
Enough to power **626,147** homes
5,382 jobs
↑ 3,523 MW

North Carolina
8,459 MW
Enough to power **1,051,876** homes
7,072 jobs
↑ 1,745 MW

South Carolina
2,435 MW
Enough to power **300,822** homes
3,393 jobs
↑ 2,024 MW

Tennessee
906 MW
Enough to power **94,788** homes
4,347 jobs
↑ 1,381 MW

Virginia
4,393 MW
Enough to power **519,386** homes
4,753 jobs
↑ 6,722 MW

$1.4 billion in tax revenue for state and local governments.[23]

Solar energy provides many benefits over fossil fuel-based electricity generation. Still, solar facilities do have some land-use impacts. Utility-scale solar facilities typically require 5–10 acres for every megawatt of generation[24] and are expected to become more efficient as the power density and efficiency of solar facilities continue to improve.[25] The land requirements for solar development can have impacts common to other land uses, such as effects on water resources, habitat, and sensitive species. Because of these potential impacts, existing federal and state laws and local ordinances in many places provide for environmental review of solar facility projects. Some solar developers are going beyond these requirements, finding new and innovative ways to maximize the benefits of their projects and minimize land-use impacts.

ENVIRONMENTAL REVIEW REQUIREMENTS FOR SOLAR DEVELOPMENT IN THE SOUTH

Most solar facilities require some combination of approvals from local, state, and federal authorities prior to construction. The requirements for a particular project generally depend on project size, geography, technology, and jurisdiction.[26]

The following environmental review and permitting requirements commonly apply to utility-scale solar facilities in the South. State and local requirements may differ, but generally address the same environmental impact considerations outlined below.

Federal Environmental Review and Permitting

Solar developers must comply with applicable federal environmental laws, such as the National Environmental Policy Act, the Endangered Species Act, and the Clean Water Act. See Appendix A for additional information on federal siting and permitting requirements.

The **National Environmental Policy Act (NEPA)**[27] requires a pre-construction review of the effects of and alternatives to all federally controlled solar facility projects and non-federal projects that require federal authorization or permitting, such as access to federal transmission lines.[28] During the NEPA review process, the lead federal agency involved must evaluate the reasonably foreseeable environmental impacts associated with the proposed solar facility project and consider a reasonable range of alternatives to the project. The level of review given to projects varies with the likelihood of significant environmental impact.[29] The most common solar development requirement under NEPA is an Environmental Assessment (EA). An EA is a public document that provides sufficient evidence and analysis to assist the agency in determining whether to prepare a more extensive Environmental Impact Statement (EIS) for a proposed action, and to comply with NEPA when no EIS is required. As a best practice, developers should minimize project impacts to the greatest extent possible and include mitigation measures in the initial project design, which may help streamline the environmental review process.[30]

Projects that may affect threatened or endangered species or their habitat require compliance with the **Endangered Species Act (ESA)**.[31] The ESA requires that a federal agency authorizing, funding, or carrying out any action that may affect protected species consult with the U.S. Fish and Wildlife Service.[32] Project developers should work with the reviewing agencies to engage the U.S. Fish and Wildlife Service in a discussion about impacts to species protected by the ESA.

For utility-scale solar facility projects requiring federal approval, a Section 7 consultation will occur as part of the federal permit review process. Although such consultation is required only for activities that involve federal action or approval, project developers are advised to consult with the U.S. Fish and Wildlife Service when there is even a possibility for protected species impacts due to potential liability under Section 9 of the ESA, a strict liability provision that does not require intent or knowledge of a violation. Developers who believe their activities may impact federally listed species may obtain a Section 10 Incidental Take Permit to minimize liability under the ESA.[33] Developers seeking such a permit must prepare a Habitat Conservation Plan to ensure that the effects of the authorized incidental take are adequately minimized and mitigated.[34]

Finally, similar federal wildlife protections exist for listed and non-listed bird species under the Bald and Golden Eagle Protection Act and Migratory Bird Treaty Act.[35] Early consultation with the U.S. Fish and Wildlife Service to identify potential impacts to protected species can help minimize potential liability under this act.

Clean Water Act (CWA) provisions must also be met if a solar facility project will cause a discharge of pollutants into federally protected surface waters or require the dredge or fill of federally protected wetlands.[40] Section 301 of the CWA prohibits the discharge of pollutants, including water or sediment, into federally protected

Protecting Pollinators: Solar Farms and Sensitive Bat Species

Bats play an essential role in pest control, pollination, and seed dispersal. Research estimates that the value of services bats provide to the U.S. agricultural industry may be as high as $53 billion per year.[36] Unfortunately, many bat species in our region face significant threats from disease and habitat destruction. The South is home to four federally protected bat species (the gray bat, the Indiana bat, the northern long-eared bat, and the Virginia big-eared bat) and one candidate for federal protections (the tricolored bat).[37] Several additional bat species in our region are protected under state wildlife laws.[38]

Solar development that involves tree cutting or abandoned mine lands can disturb sensitive bat roosting and foraging habitat. Where bat species are present, and land-disturbing activities cannot be avoided, steps should be taken in consultation with the U.S. Fish and Wildlife Service to minimize and mitigate impacts to vulnerable bat species. This may include preparing a bat habitat assessment, obtaining an incidental take permit, or planting night-blooming vegetation.[39]

Other protected species in the South include the federally threatened gopher tortoise, the federally endangered eastern indigo snake, the federally endangered rusty patched bumble bee, bald and golden eagles, and protected migratory birds. Partnering with federal and state wildlife agencies can help solar developers select sites that avoid, minimize, and mitigate impacts to sensitive wildlife and habitats. Careful planning and use of best management practices during solar facility development can relieve the burden on affected species and ensure that they continue to thrive in our region.

A northern long-eared bat.

surface waters without a permit. A National Pollutant Discharge Elimination System (NPDES) permit issued by the U.S. Environmental Protection Agency or delegated state agency may be required for solar facility operations if they discharge a pollutant to surface waters and to address stormwater discharges from construction activities.[41] Construction General Permits (CGPs) are the most commonly issued NPDES permit for solar facility projects.[42] CGPs require developers to prepare and implement a Stormwater Pollution Prevention Plan (SWPPP).[43]

Projects that may require the dredge or fill of federally protected wetlands require a Section 404 permit issued by the U.S. Army Corps of Engineers.[44] When applying for a Section 404 permit, a project developer must show that they have taken steps to avoid wetland impacts and provided compensation for any unavoidable impacts. Projects that require NPDES and Section 404 permits must obtain a Section 401 state water quality certification from the governing state verifying the project's compliance with water quality standards and other conditions of state law.[45]

State Environmental Review and Permitting Requirements

Utility-scale solar facility projects are often subject to state environmental statutes that may require additional compliance measures. Many states have their own versions of NEPA that can apply to both federal and state projects.[46] States may also have their own versions of the ESA that reflect more specific regional wildlife concerns. It is a good idea for developers to consult with state wildlife agencies and natural heritage programs to identify potential impacts to state protected species as well as any additional siting restrictions or permits that may be required. Developers may also need to comply with state wetland laws and obtain state or local permits requiring the use of best management practices to limit soil erosion and sedimentation during any land disturbance phase of the project. See Appendix B for more information on state siting and approval requirements.

Local Land Use, Planning, and Zoning Regulations

Solar facility projects are also subject to local review and approval, and must comply with applicable local land-use, planning, and zoning regulations. Local government approaches to solar siting and permit decisions vary by jurisdiction, and can have a significant impact on the growth of solar energy.[47] Many local government approaches inadvertently or intentionally discourage solar

development by imposing burdensome restrictions that limit a landowner's right to make clean energy investments on their property.[48] According to the National Renewable Energy Laboratory, such restrictive ordinances have the potential to decrease the availability of land for solar development by 38% nationwide.[49] However, when done thoughtfully, local regulations can remove barriers, create incentives, and enact standards for responsible solar development that minimize impacts and balance community needs. Local decisionmakers should consider establishing best practice permitting guidelines. See Appendix C for additional resources.

MINIMIZING THE IMPACTS OF SOLAR DEVELOPMENT

Specific Land-Use Issues Addressed in Environmental Review of Solar Farms

Federal, state, and local environmental review processes for solar facilities in the South address a range of potential impacts, which are summarized below. Within each of these areas, this guide recommends approaches that developers can use to further minimize impacts.

1. Low-Impact Land Use

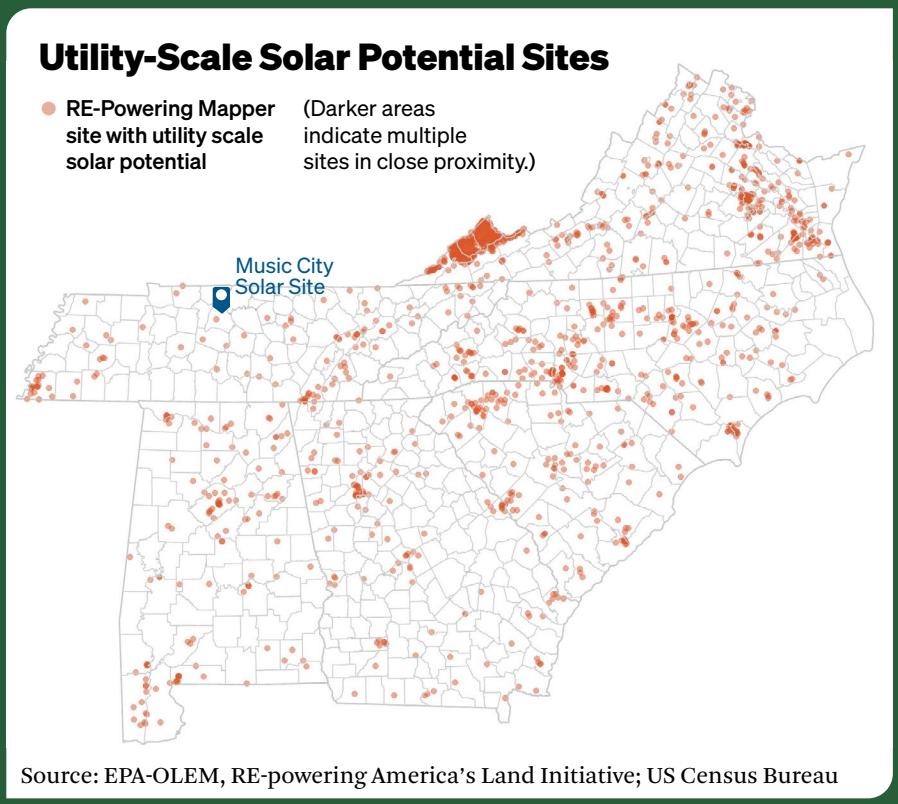
Avoiding and minimizing adverse environmental impacts begins with site selection. Because land disturbance impacts are site-specific, site selection is one of the most important decisions a developer will make. Early mapping for proposed solar facilities can identify biological and cultural resources, agricultural lands, and regional land-use patterns to identify areas where solar development will have the fewest land-use impacts. Using land efficiently can involve siting projects on previously disturbed or altered landscapes or prioritizing areas that will make use of existing transmission infrastructure.

Seeking sites where multiple compatible land uses can be maintained simultaneously is another way to make efficient use of land. Locating solar energy at a site that is already in use (such as agricultural land, rooftops, parking garages, or other energy generation sites like wind facilities) provides dual-use opportunities that maximize efficiency and benefit the surrounding environment, the developer, and the co-locating entity. Solar energy is easily deployable in the built

Siting Solar Energy on Previously Developed and Disturbed Lands

New environmental impacts can be avoided, and a number of benefits realized, through the use of previously developed or degraded lands. This guide uses the term "previously developed or degraded lands" to include any former industrial or commercial sites that could be repurposed for solar development, such as landfills, abandoned mines, and formerly contaminated lands (e.g., revitalized brownfields).[52]

At Music City Solar in Nashville, Tennessee, what was once a landfill is now the city's first community solar installation.[53] The project allows participating customers to invest in the solar facility and receive credits on their bills for the power generated. Music City Solar is part of EPA's RE-Powering America's Land Initiative, which encourages renewable energy projects on current and formerly contaminated lands, landfills, and abandoned mine sites when such development is aligned with the community's vision for the site.[54] The map above shows RE-Powering sites in the South with over 5 megawatts of solar energy potential, as surveyed by EPA.[55]



Source: EPA-OLEM, RE-powering America's Land Initiative; US Census Bureau

environment—it can be sited on existing structures such as rooftops and parking garages, thereby avoiding land impacts altogether.[50] Up to one-fifth of the country's total power needs could be sited on rooftops.[51]

Beyond the built environment, agricultural lands often provide ideal opportunities for the dual use of lands as solar energy can be strategically placed to provide energy while allowing continued productive agricultural use of the site, such as for grazing purposes. Further, solar facilities can provide economic benefits by allowing for the use of degraded agricultural land that would otherwise sit fallow while nutrients and fertility are restored.[56] For example, solar leases can help farmers stabilize their income in the face of declining crop prices, even allowing them to make triple the average rent for pastureland.[57]

2. Minimizing Wildlife and Habitat Disturbance

There are many existing resources to help solar developers identify and avoid potential conflict with sensitive wildlife and important habitat. These resources include mapping tools and databases provided by state and federal wildlife agencies, state natural heritage programs, and non-profit conservation organizations, such as The Nature Conservancy's Resilient Land Mapping Tool and the Southeast Conservation Blueprint Explorer. In many cases, there is existing information on protected species and habitats that can be found in a potential project area.[58] Contacting appropriate agencies early in the planning process can also help developers identify ecologically sensitive areas. See **Appendix C** for additional resources.

As with all forms of development, avoidance must always be the first step. If sensitive areas or species are discovered during a site evaluation, developers should attempt to relocate or redistribute the project. Where impacts appear unavoidable, developers should consult federal and state wildlife agencies to discuss ways to minimize disturbances to wildlife and their habitat. This can include design measures such as downward-facing lights, anti-perch equipment to protect flying species, wildlife corridors to maintain habitat connectivity, and wildlife-friendly solar fencing.

After employing avoidance and minimization strategies to reduce wildlife impacts, developers may be able to further offset impacts. Species relocation, post-siting remediation, and offsite habitat protections may be possible in certain instances; however, these measures are expensive and frequently ineffective because they do not guarantee the long-term protection of the threatened species or habitat.[59] This is another reason developers should seek to identify and avoid biologically sensitive areas before beginning project development.

Developers can further minimize impacts by using existing roads, previously disturbed areas, and existing facilities whenever possible. Developers should avoid excessive vegetation removal and gravel placement—which may cause dust pollution harmful both to the environment and to solar energy output—and should consider leaving protective buffers. Buffer areas, either natural or human-made, can protect important resources such as essential habitat and surface waters. Unnecessary nighttime lighting and construction activities should also be minimized to avoid attracting

Solar-Friendly Approaches to Local Water Protection

Solar facilities differ considerably from most types of development in that the area under, between, and around arrays can be designed and maintained for drainage.[62] This creates a unique opportunity for local governments to establish solar-specific development standards that encourage responsible solar development, address the water quality impacts of the project, and create positive water quality outcomes.

Protective Buffers—Buffer requirements can protect vital wetlands, surface waters, and connected groundwaters by limiting development and other land disturbing activities within a certain proximity of a water resource. Appropriate buffer values should be protective, not excessive. When establishing buffer requirements to protect water resources, communities should consider whether buffers will be natural or artificial. Unlike fences, vegetative buffers benefit both groundwater and surface water quality.

Groundcover Standards—Requiring developers to plant grasses and/or wildflowers under solar panels, between arrays, and in buffer areas can substantially mitigate the stormwater risks associated with solar arrays and result in less runoff than other forms of development and agriculture.

Disconnection—The distance between solar arrays is typically guided by shading considerations rather than stormwater infiltration. Adopting best management practices that encourage developers to leave additional disconnection space between arrays can help ensure that there is adequate groundcover for stormwater to infiltrate and further mitigate stormwater risks.[63] However, strict disconnection requirements can increase the land use requirements of solar facilities.[64] Communities should consider exempting solar development from lot coverage requirements for projects where groundcover and density standards are met, the soil is not compacted, and there is sufficient disconnection space between arrays.

Visual Buffers—Communities often require solar facilities located in residential areas to be visually hidden from the public using opaque fencing or vegetation. By requiring developers to use vegetation, communities—and adjacent landowners—benefit from natural stormwater management. However, excessive buffer distances, especially those with height requirements, can reduce solar facility efficiency and increase project costs beyond what is feasible.

For more resources on establishing best practice permitting guidelines, see **Appendix C**.

migratory birds and other wildlife, especially in periods of the day or year during which wildlife are most vulnerable.

3. Protecting Water Resources

Solar facilities use much less water than other forms of electricity generation.[60] Operational water use is typically limited to cleaning solar panels,[61] and developers should consider options for sustainable, reusable sources for these limited water needs. To further minimize water resource impacts, developers should strive to avoid impacts to wetlands, surface waters, and groundwater by limiting stream crossings for access roads where possible, minimizing or limiting land grading and other soil disturbing activities, avoiding altering existing drainage systems, and rigorously implementing best practices for preventing erosion and sedimentation during construction.

Developers should take special care to avoid impacts to wetlands protected by state or federal law as well as to the contiguous areas necessary to protect those wetlands. Wetlands serve vital ecological functions, including protecting drinking water by filtering out chemicals, pollutants, and sediments; providing natural flood control by absorbing runoff from heavy rains; storing atmospheric carbon; and providing important wildlife habitat. Developers should consider relocating projects that require federal or state wetland permits and enforcing a protective buffer around unavoidable wetland areas to ensure the protection of these important ecological resources.

In addition to protective buffers, developers should consider other ways to protect the vital functions of wetlands such as: 1) minimizing soil disturbance associated with land grading and vegetation removal near wetland areas; 2) limiting erosion, overland flow, and runoff that could impact wetlands; 3) preventing disposal or storage of logs or logging debris in streamside management zones—defined as areas adjacent to streams, lakes, and other water bodies—to protect water quality; and

4) maintaining the natural contour of the site and ensuring that activities do not immediately or gradually convert the wetland to a non-wetland.

4. Land Reclamation and Restoration

Unlike a coal mine, which must eventually be reclaimed or otherwise remain unusable, solar facility sites do not always require reclamation. Solar panels have an estimated lifespan of at least 25 years, and can readily be replaced with new panels, possibly eliminating the need for site reclamation. In cases where above-ground facilities need to be removed, decommissioning plans can help ensure that it is done appropriately. Several states and local governments in the South, including the states of Tennessee, Virginia, and North Carolina, have enacted laws to regulate solar facility decommissioning.[65] Decommissioning regulations generally include the removal of above-ground facilities, solar panel disposal or recycling, and land restoration. Many decommissioning regulations also require developers to provide financial assurance, such as a decommissioning bond, to ensure that there will be funds available to properly decommission the project at the end of its useful life. However, this financial assurance is typically unnecessary because the projected salvage value of solar equipment exceeds decommissioning costs, and because decommissioning requirements will be set by the landowner.

5. Sustainable Landscaping

Sustainable landscaping strategies allow developers to not only preserve the land used for solar facilities, but also enhance it by co-siting solar energy with native vegetation or suitable agriculture practices. Low-height plants, including native vegetation and shade-tolerant crops, can thrive underneath solar panels, reducing the need for mowing to keep panels unshaded.

For sustainable landscaping, developers should select and plant native species where practicable. Benefits of planting native shrubs and groundcovers, such as grasses and wildflowers, include improved erosion control, pesticide avoidance, stormwater infiltration,

Recycling Solar Panels

The two most common types of solar panels—crystalline silicon and thin-film—use materials that are 99% nonhazardous and 95% recyclable using current technologies.[66] While some solar panels can contain small amounts of toxic metals like lead (crystalline silicon) or cadmium (thin-film),[67] most modern-day solar panels pass the Environmental Protection Agency's Toxic Characteristic Leaching Procedure (TCLP) test, meaning the panels are nonhazardous and do not pose a risk of leaching toxic substances into a landfill.[68]

However, solar panels do not have to end up in a landfill. Most solar panels can be recycled or even reused. The solar panel recycling industry is dependent on decommissioning, and while most solar facilities in the South are decades away from decommissioning,[69] it will be feasible to recover and reuse materials like aluminum, glass, and copper at the end of a facility's useful life.[70] The National PV Recycling Program, founded by the Solar Energy Industries Association (SEIA) in 2016, is designed to keep solar panels out of landfills.[71] By working with solar manufacturers and developers, SEIA's program is creating a network of cost-effective recycling and refurbishment providers that can responsibly manage solar panel waste and end-of-life solar panel disposal.

For example, National PV Recycling Partner SOLARCYCLE extracts 95% of the valuable materials in solar panels, like silver, silicon, copper, aluminum, and glass. These materials are returned to the domestic solar supply chain, reducing the need for new mining and helping to create a circular solar economy.[72] While PV recycling is currently more expensive than disposing of solar panels in a landfill, the U.S. Department of Energy's Photovoltaics End-of-Life Action Plan aims to halve the cost of recycling by 2030 and reduce the environmental impact of solar energy modules at end-of-life.[73]

Solar panel recycling facility. Photo by Lotus Energy.

and wildlife habitat.[74] Planting native grasses and wildflowers in low maintenance areas of solar facilities also reduces long-term maintenance costs and emissions.[75] These naturalized meadows, once established, are more drought tolerant, require little to no fertilization, and only need to be mowed once or twice a year.[76]

In addition, native fruiting and flowering plants provide a food source and habitat for wild native bees. Native bees make a considerable contribution to agricultural crops through pollination. Promoting habitat for native bees and other pollinators at solar facilities, when feasible, can have a positive ecological impact on disturbed sites, as well as a positive economic impact on neighboring insect-pollinated crops.[77]

In the agricultural context, allowing the land underlying a project to regenerate by leaving it uncultivated for many years and planting more sustainable species increases the productivity of that land.[78] Developers should also consider using sheep for grazing the project site. Sheep can greatly reduce emissions from gas-powered maintenance equipment, improving air quality and reducing noise pollution.

Additional Siting Considerations

1. Transmission

Transmission is widely recognized as a significant obstacle in solar siting. Without upgrades, the capacity of the U.S. power grid is limited. This means that new transmission infrastructure, such as wires and towers, may be needed to connect a new solar facility to the grid. Constructing new transmission infrastructure can also have environmental and social impacts. Siting solar facilities within existing electrical utility rights-of-way or close to planned grid updates can help reduce the impacts associated with new transmission infrastructure.[80]

2. Financial Incentives

Funding and tax incentives are available to help solar developers and communities save money by going solar. These opportunities usually take the form of federal or state grants or tax credits that seek to incentivize clean energy development,[81] rural and agricultural energy production,[82] low-impact land use,[83] and more. Developers are encouraged to explore these incentives to the extent that they are available, as they can help make solar facilities more profitable for developers and increase local tax revenue for communities.[84]

Family Farmers, Sheep, and Solar Make a Perfect Match

In North Carolina, Sun Raised Farms is setting the bar for sustainable management of solar facilities. Started in 2012 by Chad Ray of Ray Family Farms in Bunn, North Carolina, Sun Raised Farms connects local farmers across the state with solar facility developers. Sun Raised Farms works with solar facility owners to provide an "agricultural" solution to maintaining vegetation on a solar facility. Instead of paying landscaping companies to mow, weed, and spray sites, solar facility owners pay Sun Raised Farms to identify, train, and manage a local farmer to maintain the vegetation using livestock. Sheep in particular are a good match for solar facilities as they keep grass low without damaging the projects. While the farmers have land to graze their sheep, the solar company in exchange gets all-natural lawn care—no pesky weeds shading the panels, no glass-shattering rocks kicked up by lawn mowers. This practice, known as agrivoltaics, is twice as land use efficient as siting solar facilities and pastureland separately.[79]

3. Environmental Justice Considerations

Planning for a clean energy future must be done equitably and with earnest community engagement.[85] This means not only providing opportunities for public comment, but also taking the time to meaningfully address local questions and concerns. Equitable and free access to information in environmental matters is key for full participation in project siting and development.[86] The more a developer understands local values and policies, the more likely it will be to ascertain if the developer will be able to develop a project that is acceptable to the community. Incorporating local public input into development plans can help to ensure that the public understands the proposed project and help to determine maximum benefits before and as proposals are rolled out.

CONCLUSION

Utility-scale solar facilities provide clean, affordable, and sustainable energy to homes and businesses throughout the region. Solar energy avoids air pollution, reduces water use, and results in less land degradation than other forms of energy production. With over 22 gigawatts of solar energy already installed and significantly more planned or in development, the South is already reaping the benefits of solar energy.

Solar facilities, like any development, can have environmental impacts. Existing federal, state, and local environmental review processes provide protection from many adverse impacts. And some solar developers are paving the way for new approaches to sustainable solar siting and project management that seek to minimize impacts beyond what is legally required. Following best practices, along with careful planning, research, and collaboration among developers, community members, and environmental agencies can help ensure that solar energy continues to be one of the cleanest forms of energy available.

APPENDIX A. Common Federal Review, Permitting, and Approval Requirements for Utility-Scale Solar Development

This appendix outlines common federal review, permitting, and approval requirements that developers may encounter as they complete a utility-scale solar facility project.

National Environmental Policy Act (NEPA) Review

42 U.S.C. § 4321
40 CFR parts 1500–1508

Lead Federal Agency

Triggered if project is federally owned, controlled, or requires federal approval or permitting.

Floodplain Assessment

E.O. 11988 (1977)
E.O. 11900 (1977)

Lead Federal Agency

Required if project is subject to NEPA and may impact floodplains or wetlands (environmental review requirement).

Endangered Species Act: Section 7 Consultation

16 U.S.C. § 1536
50 CFR part 402

U.S. Fish & Wildlife Service

Recommended for all proposed projects and required for projects involving a federal approval or permit that may affect federally listed species or their critical habitat.

Endangered Species Act: Incidental Take Permit

16 U.S.C. § 1539
50 CFR parts 13, 17

U.S Fish & Wildlife Service

Required if project may result in the take of or harm to federally listed species.

Migratory Bird Treaty Act: Consultation

16 U.S.C. §§ 703–712
50 CFR part 21

U.S. Fish & Wildlife Service

Triggered if project may result in the take of or harm to protected migratory birds or their nests.

Bald and Golden Eagle Protection Act: Incidental Take Permit

16 U.S.C. § 668a
50 CFR part 22

U.S. Fish & Wildlife Service

Required if project may result in the take of or harm to bald or golden eagles or their nests.

Clean Water Act: Section 404 Permit

33 U.S.C. § 1344
33 CFR part 323
40 CFR part 230

U.S. Army Corps of Engineers

Triggered if project may impact federally protected waters, including wetlands.

Clean Water Act: National Pollution Discharge Elimination System Permit

33 U.S.C. § 1342
40 CFR parts 122–123

U.S. Environmental Protection Agency or delegated state authority

Triggered if project may cause stormwater discharge from site assessment, construction, or operation. Permitting authority is often delegated to a state authority (see Appendix B).

National Historic Preservation Act: Section 106 Review

54 U.S.C. § 306108
36 CFR parts 60, 800

Advisory Council on Historic Preservation, Tribal Historic Preservation Office & State Historic Preservation Office

Triggered if project requires federal approval or permit, affects Tribal land, or is on land in/eligible for listing in the National Register of Historic Places.

Comprehensive Environmental Response, Compensation, and Liability Act: ASTM Environmental Site Assessment

42 U.S.C. §§ 9601–9607S
40 CFR part 312

U.S. Environmental Protection Agency

Applies to projects located on brownfields and when hazardous substances have been released to land, surface water, or groundwater.

Interconnection Approval

16 U.S.C. §§ 824i–824k
18 CFR 2.20
18 CFR part 36

Federal Energy Regulatory Commission or delegated interconnection authority

Required for projects that sell power to the wholesale electricity market, sell electricity across state lines, and for qualifying facilities.

Right-of-way Authorization

43 U.S.C. § 1761
43 CFR part 2800

Bureau of Land Management

Required if project is located on federal land or requires authorization for transmission lines that cross over federal land.

APPENDIX B. Common State Review, Permitting, and Approval Requirements for Utility-Scale Solar Development

This appendix outlines common state review, permitting, and approval requirements that developers may encounter as they complete a utility-scale solar facility project.

State-level Environmental Policy Act Review

Lead State Agency

Many states have their own environmental impact review or environmental planning laws that are similar to the federal NEPA process. The state review may be required when the federal process is not, or in addition to federal review. The state environmental review threshold is established by state statute.

Siting Approval and/or Certificate of Public Use and Convenience

Public Service/Utility Commission or Energy Facility Siting Commission/Board/Council

Some states delegate solar facility and transmission line siting approval to a public service or utility commission or to an energy facility siting authority. These agencies may review all energy projects, only specific types of projects as defined by state regulations, or projects that request a consolidated state process. Approval is often required for projects above an established capacity threshold and for transmission lines above established voltage or length or that cross county boundaries.

Stormwater Discharge Permit

State Environmental Agency

Administration of the federal National Pollution Discharge Elimination System (NPDES) program is often delegated to state agencies. See Appendix A. Many states have developed general permits and permits-by-rule as part of their programs. Permits are triggered by the potential for stormwater discharge from site assessment, construction, and operation.

Clean Water Act: Section 401 State Certification

State Environmental Agency

State Water Quality Certification is necessary to demonstrate that a project will comply with state water quality standards and other conditions under state law. Section 401 Certification is required for projects that need a federal permit or authorization, such as a Section 404 or NPDES permit. Some states may also require Water Quality Certification as part of a state water quality permit.

Wildlife and Habitat Consultation/Permit

State Environmental Agency

Some states issue permits for impacts to state protected wildlife or habitat. More often, these agencies do not have incidental take permits, but consultation is necessary to identify state protected species and habitat within a project area and to determine the need for mitigation measures.

Oversize/Overweight Vehicle Permits

State Department of Transportation

Most states set size and weight limits for vehicles traveling on state roads. Permits are required for vehicles that exceed the established limits. Special permits for construction equipment are often available.

Utility Permit

State Department of Transportation

Required for the placement of utility lines within state rights-of-way.

Entrance/Access Permit

State Department of Transportation

Required for the construction of new roads that require access to state roads.

APPENDIX C. Helpful Resources for Solar Development and Mitigation

This appendix contains resources that will assist in implementing best management practices when siting and developing a utility-scale solar facility project.

Environmental Review & Permitting

- Citizen's Guide to NEPA. Council on Environmental Quality, 2021. https://ceq.doe.gov/docs/get-involved/citizens-guide-to-nepa-2021.pdf.
- Environmental Justice Considerations in the NEPA Process. U.S. Environmental Protection Agency, 2023. https://www.epa.gov/environmentaljustice/environmental-justice-and-national-environmental-policy-act.
- Alabama State Review Framework. U.S. Environmental Protection Agency, 2014. https://adem.alabama.gov/compInfo/FinalADEMSRFReportMarch312014.pdf.
- Georgia Environmental Policy Act (GEPA) Fact Sheet. 2015. https://ceq.doe.gov/docs/laws%2Dregulations/state_information/GA_NEPA_Comparison_23Nov2015.pdf.
- North Carolina State Environmental Policy Act (SEPA) Fact Sheet. 2015. https://ceq.doe.gov/docs/laws%2Dregulations/state_information/NC_NEPA_Comparison_23Nov2015.pdf.
- South Carolina Solar Habitat Act. https://www.scstatehouse.gov/code/t50c004.php.
- Tennessee Environmental Review. https://www.tn.gov/environment/program-areas/na-natural-areas/na-environmental-review.html.
- Virginia Environmental Impact Report Procedure (VA EIR) Fact Sheet. 2015. https://ceq.doe.gov/docs/laws%2Dregulations/state_information/VA_NEPA_Comparison_9Nov2015.pdf.

Siting Guides, Tools, and Best Practices

General

- American Farmland Trust and Smart Solar. https://farmlandinfo.org/solar-siting/.
- The Center for Pollinators in Energy. https://fresh-energy.org/beeslovesolar.
- American Solar Grazing Association. https://solargrazing.org/.
- Handbook on Siting Renewable Energy Projects While Addressing Environmental Issues. U.S. Environmental Protection Agency, 2015. https://www.epa.gov/sites/default/files/2015-04/documents/handbook_siting_repowering_projects.pdf.
- RE-Powering America's Land Initiative, Solar Photovoltaic Decision Tree. U.S. Environmental Protection Agency and National Renewable Energy Laboratory, 2015. https://www.epa.gov/sites/default/files/2015-04/documents/solar_decision_tree.pdf.
- Liability Reference Guide for Siting Renewable Energy on Contaminated Properties. U.S. Environmental Protection Agency, 2014. https://www.epa.gov/sites/default/files/2014-07/documents/liability-renew-energy-contamprop-2014.pdf.
- Best Practices for Siting Solar Photovoltaics on Municipal Solid Waste Landfills. U.S. Environmental Protection Agency, 2022. https://www.epa.gov/system/files/documents/2022-05/best-practices-siting-solar-photovoltaics-municipal-solid-waste-landfills_051722-pub.pdf.
- Best Practices at the End of the Photovoltaic System Performance Period. National Renewable Energy Laboratory, 2021. https://www.nrel.gov/docs/fy21osti/78678.pdf.
- The Value of Existing Infrastructure for Renewable Energy Development. U.S. Environmental Protection Agency, 2020. https://www.epa.gov/sites/default/files/2020-04/documents/re-powering_exisiting_infrastructure_508_041420.pdf.
- Resilient Land Mapping Tool. The Nature Conservancy. http://maps.tnc.org/resilientland/.
- Southeast Conservation Blueprint and Data. Southeast Conservation Adaptation Strategy (SECAS). http://secassoutheast.org/blueprint.
- IPaC (Information for Planning and Consultation) Tool. U.S. Fish and Wildlife Service. https://ipac.ecosphere.fws.gov/.

- NatureServe Explorer. https://www.natureserve.org/access-data.
- National Renewable Energy Laboratory Solar Data and Tools. https://www.nrel.gov/solar/data-tools.html.

Alabama

- Alabama Natural Heritage Data. https://www.auburn.edu/cosam/natural_history_museum/alnhp/.
- Voluntary Best Management Practices for Solar Development Compatible with Conservation of Gopher Tortoises. Gopher Tortoise Council. http://gophertortoisecouncil.org/pdf/gtc_solar_development.pdf.
- Southeast Conservation Blueprint Summary for Alabama. Southeast Conservation Adaptation Strategy, 2023. https://secassoutheast.org/pdf/AL_report.pdf.

Georgia

- Georgia Rare Species & Natural Community Data. GA Department of Natural Resources. https://georgiawildlife.com/conservation/species-of-concern.
- Georgia Low-Impact Solar Siting Tool. The Nature Conservancy. http://bit.ly/GALowImpactSolar.
- Southeast Conservation Blueprint Summary for Georgia. Southeast Conservation Adaptation Strategy, 2023. https://secassoutheast.org/pdf/GA_report.pdf.

North Carolina

- Principles of Low-Impact Solar Siting and Design. The Nature Conservancy, 2023. https://www.nature.org/content/dam/tnc/nature/en/documents/2023SolarGuidanceTNCNC.pdf.
- North Carolina Stormwater Design Manual: Solar Farms. NC Department of Environmental Quality, 2018. https://www.deq.nc.gov/energy-mineral-and-land-resources/stormwater/bmp-manual/2018-e-6-solar-farm-manual/download.
- North Carolina Green Growth Toolbox. NC Wildlife Conservation Commission. https://www.ncwildlife.org/conserving/programs/Green-Growth-Toolbox.
- North Carolina Technical Guidance for Native Plantings on Solar Sites. NC Pollinator Conservation Alliance, 2022. https://ncpollinatoralliance.org/wp-content/uploads/2022/06/NC-Solar-Technical-Guidance-FINAL-May-2022.pdf.
- Southeast Conservation Blueprint Summary for North Carolina. Southeast Conservation Adaptation Strategy, 2023. https://secassoutheast.org/pdf/NC_report.pdf.

South Carolina

- South Carolina Solar Habitat Guide and Siting Tool. SC Department of Natural Resources, 2018. https://www.dnr.sc.gov/solar/.
- South Carolina Natural Heritage Data. SC Department of Natural Resources. https://schtportal.dnr.sc.gov/portal/apps/sites/#/natural-heritage-program.
- Southeast Conservation Blueprint Summary for South Carolina. Southeast Conservation Adaptation Strategy, 2023. https://secassoutheast.org/pdf/SC_report.pdf.

Tennessee

- Tennessee Natural Heritage Data. TN Department of Environmental Conservation. https://www.tn.gov/content/tn/environment/program-areas/na-natural-areas/na-natural-heritage-inventory-program.html.
- Tennessee Environmental Review Tool (ERT). Tennessee Department of Environment and Conservation. https://ert.tdec.tn.gov/.
- Southeast Conservation Blueprint Summary for Tennessee. Southeast Conservation Adaptation Strategy, 2023. https://secassoutheast.org/pdf/TN_report.pdf.

Virginia

- Virginia Solar Energy Facility Guidance. VA Department of Wildlife Resources, 2022. https://dwr.virginia.gov/wp-content/uploads/media/Solar-Energy-Facility-Guidance.pdf.
- Virginia Pollinator Smart Solar Industry: Comprehensive Manual. VA Department of Conservation and Recreation, 2019. https://www.dcr.virginia.gov/natural%2Dheritage/document/solar%2Dsite%2Dcomprehensive%2Dmanual.pdf.

- Solar Siting in Virginia. The Nature Conservancy. http://conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/virginia/Pages/solar-siting-va.aspx.
- Virginia Solar Site Native Plant Finder. VA Department of Conservation and Recreation. https://www.dcr.virginia.gov/natural-heritage/solar-site-native-plants-finder.
- Southeast Conservation Blueprint Summary for Virginia. Southeast Conservation Adaptation Strategy, 2023. https://secassoutheast.org/pdf/VA_report.pdf.

Resources for Local Governments

General

- Solar Power in Your Community. U.S. Department of Energy, 2023. https://energy.gov/sites/default/files/2023%2D03/Solar_Power_in_Your_Community_Guidebook_March2023.pdf.
- Solar@Scale: A Local Government Guidebook for Improving Large-Scale Solar Development Outcomes. American Planning Association, 2022. https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/Solar-at-Scale-Guidebook-V2.pdf.
- Planning for Utility-Scale Solar Energy Facilities. American Planning Association, 2019. https://www.planning.org/publications/document/9184153/.
- Integrating Solar Land Uses: A Regulatory Template for CSRA Communities. Central Savannah River Area Regional Commission, 2015. https://drive.google.com/file/d/1r9GXthKUZxvOjSdYo9yqUWJPJli_p2aa/view.
- City and County Solar Photovoltaics Training Program. National Renewable Energy Laboratory. https://www.nrel.gov/solar/market-research-analysis/solar-decision-support.html.

Model Ordinances and Resources

- U.S. Solar Siting Regulation and Zoning Ordinances Database. National Renewable Energy Laboratory, 2022. https://dx.doi.org/10.25984/1873867.
- South Carolina Solar Ordinances by County. SC Department of Health and Environmental Control. https://scdhec.gov/environment/land-management/solar-panel-stakeholder-group/solar-panel-ordinances.
- North Carolina Template Ordinance for Solar Energy Development in North Carolina. NC Clean Energy Technology Center, 2016. https://nccleantech.ncsu.edu/wp-content/uploads/2018/06/NC-Template-Solar-Ordinance.pdf.
- Georgia Model Solar Ordinance and Guide. Georgia Institute of Technology, Emory University, and the University of Georgia, 2018. https://epicenter.energy.gatech.edu/georgias-model-solar-ordinance/.
- Tennessee Model Solar Ordinance. TenneSEIA (in conjunction with MTAS and CTAS), 2022. https://tenneseiasolar.com/wp-content/uploads/2022/11/Model-Tennessee-Solar-Zoning-Ordinance-Final-4833-3498-8020-9.pdf.
- Utility-Scale Solar Ordinance Recommendations. Alliance for the Shenandoah Valley, 2019. https://shenandoahalliance.org/wp-content/uploads/2019/04/Alliance-Solar-Recommendations-FINAL-3_28_19.pdf.

National Solar Census State Factsheets

- Alabama: Solar and Clean Energy Jobs. Interstate Renewable Energy Council, 2023. https://irecusa.org/alabama-solar-and-clean-energy-jobs/.
- Georgia: Solar and Clean Energy Jobs. Interstate Renewable Energy Council, 2023. https://irecusa.org/georgia-solar-and-clean-energy-jobs/.
- North Carolina: Solar and Clean Energy Jobs. Interstate Renewable Energy Council, 2023. https://irecusa.org/north-carolina-solar-and-clean-energy-jobs/.
- South Carolina: Solar and Clean Energy Jobs. Interstate Renewable Energy Council, 2023. https://irecusa.org/south-carolina-solar-and-clean-energy-jobs/.
- Tennessee: Solar and Clean Energy Jobs. Interstate Renewable Energy Council, 2023. https://irecusa.org/tennessee-solar-and-clean-energy-jobs/.
- Virginia: Solar and Clean Energy Jobs. Interstate Renewable Energy Council, 2023. https://irecusa.org/virginia-solar-and-clean-energy-jobs/.

Solar Energy Incentives and Funding Resources

- Building a Clean Energy Economy: A Guidebook to the Inflation Reduction Act's Investments in Clean Energy and Climate Action. 2023. https://www.whitehouse.gov/wp%20content/uploads/2022/12/Inflation-Reduction-Act-Guidebook.pdf.
- Federal Solar Tax Credits for Businesses. U.S. Department of Energy: Solar Energy Technologies Office, 2023. https://www.energy.gov/eere/solar/federal-solar-tax-credits-businesses.
- Solar Incentives. Solar United Neighbors. https://www.solarunitedneighbors.org/learn-the-issues/solar-incentives/.
- Database of State Incentives for Renewables & Efficiency (DSIRE). NC Clean Energy Technology Center. https://www.dsireusa.org/.

ENDNOTES

[1] This guide defines the "South" as Alabama, Georgia, North Carolina, South Carolina, Tennessee, and Virginia.

[2] Gas and coal made up roughly 54% of generation in 2022. *See* Energy Information Administration. "Monthly Data by State, Producer Sector and Energy Source; Months through December 2022" (EIA-923, Preliminary 2022 Data). U.S. Department of Energy, June 27, 2023. https://www.eia.gov/electricity/monthly/update/.

[3] Based on an operational lifetime of 30 years for solar, coal, and gas power plants. National Renewable Energy Laboratory. *Life Cycle Greenhouse Gas Emissions from Electricity Generation: Update Life Cycle Assessment of Energy Systems.* U.S. Department of Energy, 2021. https://www.nrel.gov/docs/fy21osti/80580.pdf. *See also* Hsu, David D., Patrick O'Donoughue, Vasilis Fthenakis, Garvin A. Heath, Hyung Chul Kim, Pamala Sawyer, Jun-Ki Choi, and Damon E. Turney. "Life Cycle Greenhouse Gas Emissions of Crystalline Silicon Photovoltaic Electricity Generation." *Journal of Industrial Ecology* 16, no. S1 (2012): S122–35. doi:10.1111/j.1530-9290.2011.00439.x; Kim, Hyung Chul, Vasilis Fthenakis, Jun-Ki Choi, and Damon E. Turney. "Life Cycle Greenhouse Gas Emissions of Thin-Film Photovoltaic Electricity Generation." *Journal of Industrial Ecology* 16, no. S1 (2012): S110–21. doi:10.1111/j.1530-9290.2011.00423.x; Whitaker, Michael, Garvin A. Heath, Patrick O'Donoughue, and Martin Vorum. "Life Cycle Greenhouse Gas Emissions of Coal-Fired Electricity Generation." *Journal of Industrial Ecology* 16, no. S1 (2012): S53–72. doi:10.1111/j.1530-9290.2012.00465.x.

[4] National Renewable Energy Laboratory, *supra* note 3.

[5] Hassanpour Adeh, Elnaz, John S. Selker, and Chad W. Higgins. "Remarkable Agrivoltaic Influence on Soil Moisture, Micrometeorology and Water Use Efficiency." *PLoS ONE* 13, no. 11 (2018): e0203256. doi:10.1371/journal.pone.0203256. According to a 2016 study, approximately 37% of the coal mined in the United States and 50% of gas extraction occurred in areas of high or extremely high water stress. Kondash, Andrew J, Dalia Patino-Echeverri, and Avner Vengosh. "Quantification of the Water-Use Reduction Associated with the Transition from Coal to Natural Gas in the US Electricity Sector." *Environmental Research Letters* 14, no. 12 (2019): 1240208, doi:10.1088/1748-9326/ab4d71.

[6] Erickson, Larry E. "Reducing Greenhouse Gas Emissions and Improving Air Quality: Two Global Challenges." *Environmental Progress & Sustainable Energy* 36, no. 4 (2017): 982–88. doi:10.1002/ep.12665; Wiser, Ryan, Dev Millstein, Trieu Mai, Jordan Macknick, Alberta Carpenter, Stuart Cohen, Wesley Cole, Bethany Frew, and Garvin Heath. "The Environmental and Public Health Benefits of Achieving High Penetrations of Solar Energy in the United States." *Energy* 113, no. 15 (2016): 472–86. doi:10.1016/j.energy.2016.07.068.

[7] *See* Massachusetts Clean Energy Center, *Study of Acoustic and EMF Levels from Solar Photovoltaic Projects*. Dec. 2012. https://files.masscec.com/research/StudyAcousticEMFLevelsSolarPhotovoltaicProjects.pdf; Saussus, Peter. "Major Noise Sources and Mitigation Cost Estimates for Gas-Fired Power Facilities." *Power Magazine*, Oct. 1, 2012. https://www.powermag.com/major-noise-sources-and-mitigation-cost-estimates-for-gas-fired-power-facilities/; *HGC Engineering*. "Power Generation and Transmission: Noise & Vibration Assessments, Mitigation and Approvals." Accessed Aug. 9, 2023. https://acoustical%2Dconsultants.com/market/industrial/power-generation-transmission/.

[8] *See, e.g.*, Cleveland, Tommy. *Health and Safety Impacts of Solar Photovoltaics*. NC Clean Energy Technology Center, May 2017. https://nccleantech.ncsu.edu/wp-content/uploads/2019/10/Health-and-Safety-Impacts-of-Solar-Photovoltaics-PV.pdf; National Institute of Environmental Health Sciences. *Report on Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields*. 1999; National Research Council Committee on the Possible Effects of Electromagnetic Fields on Biologic Systems. *Possible Health Effects of Exposure to Residential Electric and Magnetic Fields*. National Academies Press, 1997; World Health Organization. *Electromagnetic Fields and Public Health: Exposure to Extremely Low Frequency Fields*. June 2007.

[9] *See* Cleveland, *supra* note 8; Electric Power Research Institute, *EMF and Your Health: 2019 Update*. 2019. https://www.epri.com/research/products/000000003002016508; Tell, Richard A., H.C. Hooper, G.G. Sias, G. Mezei, P. Hung, and R. Kavet. "Electromagnetic Fields Associated with Commercial Solar Photovoltaic Electric Power Generating Facilities." *Journal of Occupational and Environmental Hygiene* 12, no. 11 (2015): 795–803. doi:10.1080/15459624.2015.1047021; Massachusetts Department of Energy Resources, Massachusetts Department of Environmental Protection, and Massachusetts Clean Energy Center. *Questions & Answers: Ground Mounted Solar Photovoltaic Systems*. June 2015. https://mass.gov/eea/docs/doer/renewables/solar/solar-pv-guide.pdf.

[10] *See, e.g.*, Solomon, Michelle, "It's Time to Rethink Grid Reliability." *Utility Dive*, July 20, 2023. https://www.utilitydive.com/news/grid-reliability-energy-transition-energy-innovation/688423/; Storrow, Benjamin. "Solar Power Bails Out Texas Grid During Major Heat Wave." *E&E News*, June 26, 2023. https://www.scientificamerican.com/article/solar-power-bails-out-texas-grid-during-major-heat-wave/.

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[13] Smith, Grant. "Hurricane Florence Knocked Out N.C. Coal and Nuclear Plants, but Solar and Wind Were Back Online the Next Day." *Environmental Working Group*, Oct. 2, 2018. https://www.ewg.org/news%2Dinsights/news/2018/10/hurricane-florence-knocked-out-nc-coal-and-nuclear-plants-solar-and-wind; Hanley, Steve. "Solar Power Plants Stand Up Well to Hurricane Florence." *CleanTechnica*, Sept. 23, 2018. https://cleantechnica.com/2018/09/23/solar-power-plants-stand-up-well-to-hurricane-florence/; Fakhry, Rachel. "The Myth of the 24/7/365 Power Plant." *Natural Resources Defense Council*, Feb. 13, 2019. https://www.nrdc.org/bio/rachel-fakhry/myth-247365-power-plant.

[14] *E.g.*, *Reuters*, "Duke Energy's Brunswick Nuclear Plant Stranded by Flooding from Florence." Sept. 17, 2018. https://www.reuters.com/article/storm-florence-duke-energy-nuclearpower/duke-energys-brunswick-nuclear-plant-stranded-by-flooding-from-florence-idINL2N1W30ZQ.

[15] Storrow, *supra* note 10.

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[17] International Energy Agency. *Renewables 2022*. IEA, 2022. https://www.iea.org/reports/renewables-2022.

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[20] Interstate Renewable Energy Council, *supra* note 19.

[21] *Id.*

[22] Solar Energy Industries Association. "Impact of the Inflation Reduction Act." Accessed Aug. 8, 2023. https://www.seia.org/research-resources/impact-inflation-reduction-act; *see also* Interstate Renewable Energy Council, *supra* note 19.

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[27] 42 U.S.C. §§ 4321–4370h.

[28] Fraas, Arthur, Valkyrie Buffa, and Lindsay Rich. *Establishing Utility-Scale Solar Projects: Federal Involvement*. Resources for the Future, 2021. https://media.rff.org/documents/WP_21%2D11_Solar_Federal_Process.pdf.

[29] National Preservation Institute. "The NEPA Review Process." Accessed June 5, 2023. https://www.npi.org/nepa-review-process.

[30] Tetra Tech EC, Inc, and Nixon Peabody LLC. *Wind Energy Siting Handbook*. American Wind Energy Association, 2008.

[31] 16 U.S.C. §§ 1531–1544.

[32] 16 U.S.C. § 1536. The U.S. Fish and Wildlife Service is the federal consultation agency for land-based species. Marine species consultations are handled by the National Marine Fisheries Service.

[33] 16 U.S.C. § 1539(a)(1)(B).

[34] 16 U.S.C. § 1539(a)(2)(A).

[35] The Bald and Golden Eagle Protection Act, 16 U.S.C. §§ 668–668d, prohibits the take bald and golden eagles, regardless of ESA status, without prior authorization by the U.S. Fish and Wildlife Service. The Migratory Bird Treaty Act of 1918, 16 U.S.C. §§ 703–12, prohibits the take of protected migratory bird species, regardless of ESA status, without prior authorization by the U.S. Fish and Wildlife Service. *See* Appendix A.

[36] Boyles, Justin G., Paul M. Cryan, Gary F. McCracken, and Thomas H. Kunz. "Economic Importance of Bats in Agriculture." *Science* 332, no. 6025 (2011): 41–42. doi:10.1126/science.1201366.

[37] A fifth species, the tricolored bat, is proposed for listing as endangered. *See* Endangered Species Status for Tricolored Bat, 87 Fed. Reg. 56,381 (Sept. 14, 2022).

[38] For example, Alabama's regulation of nongame species protects five bat species that are not federally listed as endangered or threatened (including the tricolored bat, which is proposed for listing as federally endangered). Ala. Admin. Code. r. 220-2-.92(1)(e) (2023). Other states in our region similarly protect non-federally listed bat species. Ga. Comp. R. & Regs. 390-4-10-09(1) (2023); Tenn. Comp. R. & Regs. ch. 1660-01-32-.02(1)(f), .03(1)(f) (2021); North Carolina Wildlife Resources Commission. "Protected Wildlife Species of North Carolina." 2021. https://www.ncwildlife.org/Portals/0/Conserving/documents/Protected%2DWildlife%2DSpecies%2Dof%2DNC.pdf; South Carolina Department of Natural Resources, *South Carolina Bat Conservation Plan*, ch. 1. 2020. https://www.dnr.sc.gov/wildlife/bats/SCBatConservationPlanChapter1.pdf; Virginia Department of Wildlife Resources. "Special Status Faunal Species in Virginia." 2023. https://dwr.virginia.gov/wp%2Dcontent/uploads/media/virginia-threatened-endangered-species.pdf.

[39] *See*, *e.g.*, Virginia Department of Wildlife Resources. *Solar Energy Facility Guidance*. 2022. https://dwr.virginia.gov/wp-content/uploads/media/Solar-Energy-Facility-Guidance.pdf; Virginia Department of Conservation and Recreation. *Pollinator Smart Solar Industry: Comprehensive Manual*. 2019. https://www.dcr.virginia.gov/natural-heritage/document/solar-site-comprehensive-manual.pdf; North Carolina Pollinator Conservation Alliance. *North Carolina Technical Guidance for Native Plantings on Solar Sites*. 2022. https://ncpollinatoralliance.org/wp-content/uploads/2022/06/NC-Solar-Technical-Guidance-FINAL-May-2022.pdf.

[40] 33 U.S.C. §§ 1251–1388. Discharges of pollutants into waters of the U.S. requires permitting under Section 402 of the CWA, while filling wetlands or other waters of the U.S. requires permitting under Section 404.

[41] 40 C.F.R § 122.1(b)(1). In most states, the U.S. Environmental Protection Agency delegates its permitting authority for the NPDES program (authorized under Section 402) to the state environmental agency.

[42] Fraas, *supra* note 28.

[43] *Id.*; *see also* Great Plains Institute. *Best Practices: Photovoltaic Stormwater Management Research and Testing (PV SMaRT)*. Jan. 2023. https://betterenergy.org/wp-content/uploads/2023/01/PV-SMaRT-Best-Practice.pdf; U.S. Environmental Protection

Agency. *Developing Your Stormwater Pollution Prevention Plan*. 2007. https://www3.epa.gov/npdes/pubs/sw_swppp_guide.pdf.

[44] 33 U.S.C. § 1344.

[45] 33 U.S.C. § 1341(a)(1).

[46] The states with NEPA-like requirements in the South are Georgia, North Carolina, and Virginia. Council on Environmental Quality. "States and Local Jurisdictions with NEPA-like Environmental Planning Requirements." Accessed June 6, 2023. https://ceq.doe.gov/laws-regulations/states.html.

[47] Geocaris, Madeline. "NREL Releases Comprehensive Databases of Local Ordinances for Siting Wind, Solar Energy Projects." Press Release. National Renewable Energy Laboratory, Aug. 9, 2022. https://www.nrel.gov/news/program/2022/nrel-releases-comprehensive-databases-of-local-ordinances-for-siting-wind-solar-energy-projects.html.

[48] *See* Eisenson, Matthew. *Opposition to Renewable Energy Facilities in the United States*. Sabin Center for Climate Change Law, May 2023. https://scholarship.law.columbia.edu/sabin_climate_change/200/.

[49] Lopez, Anthony, Wesley Cole, Brian Sergi, Aaron Levine, Jesse Carey, Cailee Mangan, Trieu Mai, Travis Williams, Pavlo Pinchuk, and Jianyu Gu. "Impact of Siting Ordinances on Land Availability for Wind and Solar Development." Nature Energy (2023). doi:10.1038/s41560-023-01319-3.

[50] Lopez, Anthony, Billy Roberts, Donna Heimiller, Nate Blair, and Gian Porro. *U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis*. National Renewable Energy Laboratory, 2012. http://www.nrel.gov/docs/fy12osti/51946.pdf.

[51] *Id*.

[52] Several states in our region have brownfield redevelopment programs that encourage developers to clean up and revitalize properties that are or may be contaminated by a hazardous substance. *E.g.*, N.C. Department of Environmental Quality. "Brownfields Redevelopment Section." Accessed Aug. 9, 2023. https://www.deq.nc.gov/about/divisions/waste-management/brownfields-redevelopment-section; Virginia Economic Development Partnership. "Virginia Brownfields Restoration and Economic Redevelopment Assistance Fund (VBAF)." Accessed June 6, 2023. https://www.vedp.org/brownfields.

[53] *Music City Solar*, https://gosolarmusiccity.com/.

[54] U.S. Environmental Protection Agency. *RE-Powering America's Land Initiative: Project Matrix*. Oct. 2022. https://www.epa.gov/system/files/documents/2022-11/re_on_cl_tracking_matrix_oct_22.pdf.

[55] U.S. Environmental Protection Agency. "EPA RE-Powering Mapper 3.0." Accessed July 10, 2023. https://geopub.epa.gov/repoweringApp/?page=Page-1.

[56] Sabin, Suzanne. "Solar & Farming: A Perfect Marriage." *Carolinas Clean Energy Business Association*, Oct. 5, 2021. https://carolinasceba.com/solar-farming-a-perfect-marriage/.

[57] Ryan, Joe. "Harvesting Sunshine More Lucrative than Crops at Some U.S. Farms." *Bloomberg*, Mar. 29, 2016. http://www.bloomberg.com/news/articles/2016-03-29/harvesting-sunshine-more-lucrative-than-crops-at-some-u-s-farms.

[58] The U.S. Fish and Wildlife Service's IPaC (Information for Planning and Consultation) Tool allows developers to see if a proposed project may impact federally listed species, critical habitat, migratory birds, or other natural resources. State Natural Heritage Programs also maintain an inventory of the federal and state protected species that occur within the state. See Appendix C for more information.

[59] *See* Hernandez, Rebecca R., Shane B. Easter, Michelle L. Murphy-Mariscal, Fernando T. Maestre, M. Tavassoli, E.B. Allen, Cameron W. Barrows, et al. "Environmental Impacts of Utility-Scale Solar Energy." *Renewable and Sustainable Energy Reviews* 29, no. 2014 (2014): 766–79. doi:10.1016/j.rser.2013.08.041.

[60] Kondash, *supra* note 5.

[61] Macknick, Jordan, Robin Newmark, Garvin Health, and KC Hallett. *A Review of Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies*. National Renewable Energy Laboratory, 2011. https://www.nrel.gov/docs/fy11osti/50900.pdf; *see also* Macknick, Jordan, and Stuart Cohen. *Water Impacts of High Solar PV Electricity*

Penetration. National Renewable Energy Laboratory, 2015. https://www.nrel.gov/docs/fy15osti/63011.pdf.

[62] Great Plains Institute. *Photovoltaic Stormwater Management Research and Testing (PV-SMaRT): Potential Stormwater Barriers and Opportunities*. Sept. 2021. https://www.betterenergy.org/wp%2Dcontent/uploads/2021/10/PV-SMaRT-Potential-Stormwater-Barriers-and-Opportunities.pdf.

[63] Great Plains Institute, *supra* note 43.

[64] *See id*.

[65] Tenn. Code § 66-9-207; N.C. Sess. Laws 2023-58 (to be codified at N.C. Gen. Stat. ch. 130A, art. 9. pt. 2J); Va. Code Ann. § 15.2-2241.2); *see also* North Carolina Environmental Management Commission. "Final Report on the Activities Conducted to Establish a Regulatory Program for the Management and Decommissioning of Renewable Energy Equipment (HB329 Final Report)." 2021. https://www.deq.nc.gov/documents/files/h329-final-report/open.

[66] Solar Energy Technologies Office. *Solar Energy Technologies Office Photovoltaics End-of-Life Action Plan*. U.S. Department of Energy, March 2022. https://www.energy.gov/sites/default/files/2022-03/Solar-Energy-Technologies-Office-PV-End-of-Life-Action-Plan_0.pdf.

[67] *Id*.; U.S. Environmental Protection Agency. "End-of-Life Solar Panels: Regulations and Management." Last modified Aug. 28, 2022. https://www.epa.gov/hw/end-life-solar-panels-regulations-and-management.

[68] Cleveland, *supra* note 8.

[69] Approximately 70% of the solar facilities in existence were installed since 2017. Solar Energy Technologies Office. "End-of-Life Management for Solar Photovoltaics." Energy.gov. Accessed Aug. 3, 2023. https://www.energy.gov/eere/solar/end-life-management-solar-photovoltaics.

[70] *See* International Renewable Energy Agency and International Energy Agency Photovoltaic Power Systems. *End of Life Management: Solar Photovoltaic Panels*. IRENA and IEA PVPS, 2016. https://www.irena.org/%2D/media/Files/IRENA/Agency/Publication/2016/IRENA_IEAPVPS_End-of-Life_Solar_PV_Panels_2016.pdf.

[71] *See* Solar Energy Industries Association. "SEIA National PV Recycling Program." Accessed July 6, 2023. https://www.seia.org/initiatives/seia-national-pv-recycling-program.

[72] SOLARCYCLE. "SOLARCYCLE Selected as SEIA National Recycling Partner." Press Release. Jan. 24, 2023. https://www.solarcycle.us/press-releases/solarcycle-selected-as-seia-national-recycling-partner.

[73] Solar Energy Technologies Office, *supra* note 66.

[74] Walston, Leroy J., Yudi Li, Heidi M. Hartmann, Jordan Macknick, Aaron Hanson, Chris Nootenboom, Eric Lonsdorf, and Jessica Hellmann. "Modeling the Ecosystem Services of Native Vegetation Management Practices at Solar Energy Facilities in the Midwestern United States." *Ecosystem Services* 47 (2021). doi:10.1016/j.ecoser.2020.101227.

[75] *Id*.

[76] *See* Choi, Chong Seok, Jordan Macknick, Yudi Li, Dellena Bloom, James McCall, and Sujith Ravi. "Environmental Co-Benefits of Maintaining Native Vegetation with Solar Photovoltaic Infrastructure." *Earth's Future* 11, no. 6 (2023). doi:10.1029/2023ef003542.

[77] For guidance on solar- and pollinator-friendly vegetation, see Fresh Energy, "The Center for Pollinators in Energy." Accessed June 12, 2023. https://fresh-energy.org/beeslovesolar.

[78] To learn more about agrivoltaics, the practice of co-locating solar and agriculture, see Solar Energy Technologies Office, "Farmer's Guide to Going Solar." U.S. Department of Energy, 2017. https://www.energy.gov/eere/solar/farmers-guide-going-solar; *see also* Macknick, Jordan, Heidi Hartmann, Greg Barron-Gafford, Brenda Beatty, Robin Burton, Chong Choi, Matthew Davis, et al. *The 5 Cs of Agrivoltaic Success Factors in the United States: Lessons from the InSPIRE Research Study*. National Renewable Energy Laboratory, 2022. https://www.nrel.gov/docs/fy22osti/83566.pdf.

[79]Handler, Robert. "Greener Sheep: Life Cycle Analysis of Integrated Sheep Agrivoltaic Systems." *Cleaner Energy Systems* 3 (2022). doi: 10.1016/j.cles.2022.100036.

[80] The Nature Conservancy. *Power of Place National Executive Summary*. 2023. https://www.nature.org/content/dam/tnc/nature/

en/documents/FINAL_TNC_Power_of_Place_National_Executive_Summary_5_2_2023.pdf.

[81] For example, the Inflation Reduction Act (IRA) of 2022 provides an Investment Tax Credit (ITC) of up to 30% for clean energy development like solar facility projects. 26 U.S.C. §§ 48, 48E. An additional 10% investment tax credit is available for projects located in "energy communities," as defined in 26 U.S.C. § 45(b)(11)(B). 26 U.S.C. §§ 48(a)(14), 48E(a)(3)(A). Solar facilities with a maximum net output less than 5 MW that are placed in service within low-income communities may receive an additional investment tax credit of up to 20%. 26 U.S.C. §§ 48(e), 48E(h).

[82] *See*, *e.g.*, USDA Rural Development. "Rural Energy for America Program Renewable Energy Systems and Energy Efficiency Loans and Grants." Mar. 2023. https://www.rd.usda.gov/sites/default/files/fact%2Dsheet/508_RD_FS_RBS_REAP_RE.pdf; USDA Rural Development. "Powering Affordable Clean Energy Program (PACE)." May 2023. https://www.rd.usda.gov/sites/default/files/RD-FS-RUS-PACE_FINAL508.pdf.

[83] Some state and federal incentives for brownfields development apply to solar facility projects. For example, under the IRA, an "energy community" includes brownfield sites as defined under the Comprehensive Environmental Response, Compensation, and Liability Act. IRC § 45(b)(11)(B). *See also* Virginia Economic Development Partnership. "Virginia Brownfields Restoration and Economic Redevelopment Assistance Fund (VBAF)." Accessed June 6, 2023. https://www.vedp.org/brownfields.

[84] Gilliland, Ed, Avery Palmer, and Daniel Falk. *Large Scale Solar Development: A Playbook for Southwest Virginia*. SolSmart, The Solar Foundation, and The Solar Workgroup of Southwest Virginia, 2020. https://energytransition.coopercenter.org/sites/cleanenergyva/files/2020-12/Solar%20Playbook%20SW%20VA.pdf.

[85] *See* Solar Energy Industries Association. *Solar Industry Policy Principles on Environmental Justice & Equity*. 2021. https://www.seia.org/sites/default/files/2021-04/SEIA-Solar-Environmental-Justice-Platform-April2021.pdf.

[86] UPROSE, Rogue Climate, Taproot Earth, and Climate Justice Alliance. *Principles for a Just Transition in Offshore Wind Energy*. 2023. https://taproot.earth/wp%2Dcontent/uploads/2023/03/JustTransition%2DOffshoreWindEnergy_v2.pdf.