



# SOLAR@SCALE

A Local Government Guidebook  
for Improving Large-Scale  
Solar Development Outcomes



## About Solar@Scale



Solar@Scale is a partnership between the International City/County Management Association (ICMA) and the American Planning Association (APA) that aims to help cities, towns, counties, and special districts understand and realize the potential benefits of large-scale solar development. For additional information about Solar@Scale visit [icma.org/programs-and-projects/solarscale](https://icma.org/programs-and-projects/solarscale).



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## Introduction

The purpose of this guidebook is to help local government practitioners—including planners, economic development professionals, local government managers, and elected and appointed officials—make decisions that improve large-scale solar development outcomes. Given the variation between state and regional contexts and priorities in the United States, the guidebook avoids a “one-size-fits-all” approach. Rather, users will need to

apply the guidebook’s key points to the social, political, environmental, and economic situations in their community or the communities they serve.

A note on terminology: In the context of this guidebook, “local government officials” (or “local officials”) means local government staff members as well as elected and appointed officials. Similarly, “planning officials” means planning department staff, appointed officials



Figure A. Overview of guidebook

serving on local planning and zoning boards, and elected officials responsible for adopting plans and regulations. And the terms “cities, towns, and counties” and “local jurisdictions” both serve as stand-ins for all general-purpose local governments.

This guidebook contains eight related, but semi-independent, modules (see [Figure A](#)). Modules 1 and 2 provide a broad overview of foundational concepts related to large-scale solar development. Modules 3, 4, and 5 examine how local government practitioners can use plans, zoning regulations, and land-use decision-making processes to maximize the local benefits and minimize the tradeoffs associated with community- and utility-scale solar projects. Finally, Modules 6, 7, and 8 briefly explore other actions practitioners can take to support large-scale solar development. Each module concludes with key takeaways and a list of references and links to supplemental resources.

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**MODULE**

**1**

**DEFINING LARGE-SCALE SOLAR DEVELOPMENT**

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Every community across the U.S. has access to an affordable and abundant source of energy in the form of radiant light and heat from the sun. While small rooftop solar energy systems are common in many cities, towns, and counties across the country, comparatively few local jurisdictions have had any direct experience with large-scale solar energy facilities.

As demand for solar power increases, many local government officials want to help the communities they serve capture the benefits of new large-scale solar projects. Furthermore, because these projects represent a new land use in many jurisdictions, many local officials are curious about the tradeoffs associated with large-scale solar development.

This module aims to demystify the concept of large-scale solar development by unpacking the foundational characteristics of large-scale solar energy facilities and their development, highlighting how project context affects perceptions of project scale, and summarizing the most significant potential benefits and tradeoffs of large-scale solar projects for local jurisdictions.

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## Understanding the Basics of Solar Development

For the purposes of this guidebook, solar development refers to the installation of a solar energy system on real property to convert sunlight to heat or electricity. The three foundational characteristics of each system are the technology it uses, its relationship to the power grid, and its relationship to a site.

### Solar Technologies

Solar technologies convert sunlight into a practical form of energy, most commonly electricity or heat. Passive technologies use site design and nonmechanical building materials to capture or direct light and heat. In contrast, active solar technologies use electrical or mechanical equipment to convert solar irradiance to electricity or heat, or to transport newly converted energy. The three most common forms of active solar technologies are solar thermal systems, concentrating solar power systems (CSP), and photovoltaic (PV) systems.

Solar thermal systems use energy from the sun to heat a fluid, such as water or antifreeze, and provide hot water or space heating and cooling needs for residential, commercial, or industrial facilities (Figure 1-1). While this technology is highly scalable, solar thermal systems cannot effectively transfer heat over long distances.

CSP systems use mirrors to focus light to heat a contained substance, such as molten salts or water, which then generates electricity using steam-powered turbines (Figure 1-2). Unlike solar thermal and PV systems, CSP systems typically require at least 100 acres to produce power at an economically viable scale. Furthermore, few U.S. regions outside the Southwest receive enough direct

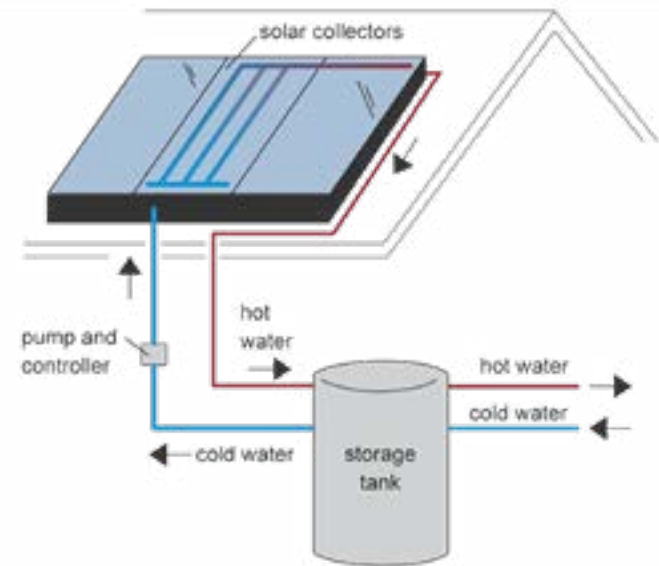


Figure 1-1. Components of a solar thermal system (Source: U.S. Energy Information Administration)

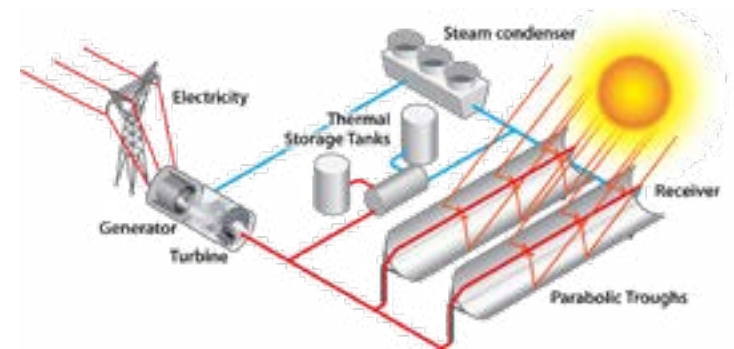


Figure 1-2. Components of a concentrating solar power (CSP) system (Source: U.S. Department of Energy)



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solar radiation to efficiently produce electricity from CSP technology.

PV systems convert the sun’s energy directly into electricity (Figure 1-3). PV technology is useful at virtually any scale. Applications range from pocket-sized solar-powered devices to massive solar power plants that span thousands of acres. The fundamental building blocks of PV systems are cells, panels or modules, and arrays. PV arrays are composed of multiple panels or modules, each of which contains dozens of cells.

Almost all new large-scale solar development projects use PV systems. And a small but rapidly growing percentage of these projects combine PV and energy storage systems to store excess energy for later use and to enhance grid stability (Hays and Hoff 2020; see Module 8).



Figure 1-3. Components of a photovoltaic (PV) system (Source: National Renewable Energy Laboratory)

### Relationship to the Grid

Some PV systems connect to the local electrical grid, while others provide power exclusively to on-site or nearby uses. Grid-connected systems may be “behind” or “in front of” the meter:

- Behind-the-meter systems connect on the customer side of the electric meter and provide electricity to on-site or nearby uses and feed excess power to the grid.
- In-front-of-the-meter systems connect to the local electricity distribution or transmission network on the utility (or supply) side of the electric meter.

Transmission networks use high-voltage power lines to carry electricity long distances. In contrast, distribution networks use lower-voltage power lines to deliver electricity over shorter distances to utility customers. PV systems with a maximum generating capacity of five megawatts (MW) or less typically connect to the distribution network. Systems larger than this often connect to the transmission network (IFC Inc. 2019).

Most large-scale solar development projects connect in front of the meter. However, some large systems provide power directly to large loads, such as universities or factories. These systems may be behind the meter or not connected to the grid at all.

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### Relationship to the Site

Property owners or solar developers can mount PV and solar thermal systems on new or existing rooftops (or shading structures); incorporate PV or thermal cells into building materials such as roof tiles, wall cladding, and even glass; or attach PV arrays, solar thermal panels, or CSP collectors to dedicated mounting structures connected to the ground.

Rooftop and building-integrated solar systems are additions to a structure that serves another purpose or, in the case of purpose-built solar shade structures, are new dual-purpose structures. These systems are typically less noticeable and functionally subordinate to one or more other uses on the same site. In contrast, a ground-mounted system occupies land not covered or shaded by other structures. It may also be subordinate to a principal use, or other uses, on the same parcel of land.

Most large-scale solar development projects use ground-mounted systems and are the principal use of the development site. However, large-footprint commercial and industrial buildings—such as shopping centers, factories, warehouses, and even parking lot shade canopies—can be good hosts for large rooftop systems.

### Putting Scale in Context

There is no universally accepted threshold for what counts as “large-scale” solar development. Solar industry experts typically draw distinctions based on the rated capacity of a system. For example, the U.S. Energy Information Administration considers systems with rated capacities of at least one MW—which, according to the Solar Energy Industry Association, can power roughly 190 homes—to be large, while the National Renewable Energy Laboratory typically uses five MW as the cutoff for large systems.

For local jurisdictions, the amount of space required to host a project is typically more relevant than the system’s rated capacity. Because rated capacity depends on system efficiency and site conditions, it doesn’t translate neatly to spatial requirements.

Furthermore, what is exceptionally large in one context may be unremarkable in another. Perceptions of what constitutes a “large-scale” solar facility can vary based on the land use and development pattern of the

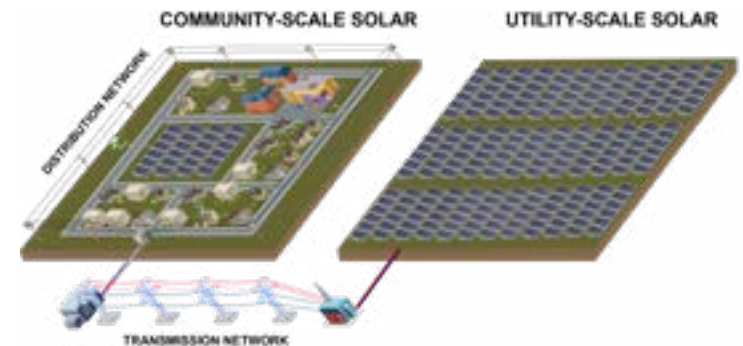


Figure 1-4. Community-scale and utility-scale solar facilities (Source: Adapted from a design by macrovector / Freepik)

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**Table 1-1. Community-Scale vs. Utility-Scale Solar**

Characteristics	Community-Scale Solar	Utility-Scale Solar
Technology	PV	PV or CSP
Relationship to the Grid	Connects to the distribution network either behind or in front of the meter	Connects to the transmission network in front of the meter
Relationship to the Site	Typically ground mounted and the principal land use, but can be sited on large rooftops	Ground mounted and typically the principal land use
Relationship to Existing Land Use and Development Pattern	Fits into the established lot or block pattern of the surrounding area	May require lot mergers, street removal, or new roads for site access
Site Area	1–20 acres	>20 acres
Rated Capacity	250 kW–5 MW	>5 MW

surrounding area. Given the wide potential size range of these projects, this guidebook subdivides large-scale solar development into two classes: community-scale solar and utility-scale solar (Figure 1-4; Table 1-1).

**Community-Scale Solar**

For the purposes of this guidebook, a community-scale solar facility is one that fits into the established lot or block pattern of the local jurisdiction and connects to the electricity distribution network. This means a developer could site the facility in multiple areas of the jurisdiction without having to combine lots or remove streets. Most community-scale solar energy systems require one to 20 acres and have rated capacities between 250 kW and five MW.

Community-scale solar is a broader concept than community, or shared, solar. Shared solar projects allow

multiple local participants to purchase ownership shares or a percentage of the power produced by a solar facility. Utilities, third-party suppliers of wholesale power to utilities, special-purpose businesses, or nonprofits can all develop (or “own”) shared solar energy systems. In contrast, the concept of community-scale solar is not tied to a specific ownership or business model.

**Utility-Scale Solar**

For the purposes of this guidebook, a utility-scale solar facility connects to the electricity transmission network. Most utility-scale solar energy systems require more than 20 acres and have rated capacities of more than five MW. “Solar farm” is a common, but outdated, term for utility-scale solar facilities.

Local government officials should base the threshold for distinguishing between community-scale and utility-scale facilities on local conditions. Some states have special siting

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requirements for projects over a certain size (see [Module 2, Table 2-9](#)). This threshold may be useful in determining an appropriate local definition of utility-scale solar.

Utility-scale solar projects typically follow the transmission network. Greater economies of scale mean they cost less to construct (per MW) than community-scale projects. But developers typically pay higher costs to connect to the transmission network (Gorman, Mills, and Wisner 2019).

**Table 1-2. Solar Development Benefit Types**

Benefits	Local	Nonlocal
Individual	Accrue to specific households, property owners, workers, or organizations within the boundaries of the local jurisdiction	Accrue to specific households, property owners, workers, or organizations outside of the boundaries of the local jurisdiction
Collective	Accrue to large segments of the community within the boundaries of the local jurisdiction	Accrue to large segments of society outside of the boundaries of the local jurisdiction

### Understanding the Benefits of Solar Development

Solar development often produces a mix of “local” versus “nonlocal” and “individual” versus “collective” benefits ([Table 1-2](#)). From a local government perspective, benefits associated with clean energy production, revenue generation, and job creation are often the most important.

#### *Clean Energy*

Large-scale solar facilities produce electricity without generating air pollution or greenhouse gas emissions—which damage environmental and public health—making these projects sources of “clean energy.” Commentators often frame this as a collective, nonlocal benefit because pollution and emissions do not respect local jurisdictional boundaries. In cases where a solar project site’s previous or likely alternative land use would generate air pollution (e.g., heavy industry or a factory farm), the clean energy benefit is both local and regional.



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Additionally, the potential collective, local benefits of large-scale solar development are greatest if the local jurisdiction has made a commitment to clean energy (see [Module 2](#)) or to a “green” economic development agenda. Large-scale solar projects can help jurisdictions meet clean energy goals if local commitments require that projects provide power to local users or utility customers. Similarly, projects can advance goals to develop the local green economy if local governments or utilities require developers to hire local workers or otherwise contribute to the local economy.

Large-scale solar development can also provide individual, local clean energy benefits. Some solar projects give utility customers and local uses the opportunity to either directly receive locally produced or behind-the-meter energy or claim renewable energy credits.

### Revenue

Large-scale solar development projects often generate collective, local benefits in the form of a net increase in tax revenue for local jurisdictions. This is because solar projects typically produce more in tax revenue than they consume in local services. However, actual revenue potential depends on the size of the project, existing or potential alternative land uses, and the treatment of large-scale solar energy systems under state and local tax laws (Brookshire et al. 2020; Blumenstein and Schlusser 2019; Haggerty, Haggerty, and Rasker 2014; Loomis 2020; Magnum, Zorn and Arel 2020). Many states exempt or abate a portion of the property taxes for solar equipment or sites, or they authorize local governments to do so (see [Module 7, Table 7-3](#)).

In some cases, large-scale solar projects may provide additional collective, local revenue benefits. For example, local jurisdictions that own sites that would be suitable for large-scale solar development may be able to generate revenue by leasing these sites to solar developers (see [Module 6](#)).

Large-scale solar development can also provide individual, local revenue benefits. Farmers or other property owners who host projects can collect land rents to supplement their income (USDOE SETO 2021). Projects that provide power to large uses or multiple utility customers (through virtual net metering) may generate net metering credits that reduce utility bills.

### Jobs

Large-scale solar development creates individual and collective benefits in the form of temporary construction jobs. The individual benefits can accrue to local or nonlocal workers, depending on the skillset and capacity of the local workforce and the hiring practices of the developer. The collective benefits accrue locally as temporary workers spend money on food, housing, and entertainment.

The number of workers and time required for construction typically increase with project size. Generally, large-scale projects will have between a few dozen and a few hundred workers on site during the period of active construction, which can range from a few months to a few years (Lumby 2015; SEIA 2021a; YSG Solar 2020).

If a local jurisdiction hosts multiple solar projects, this can create a modest number of permanent jobs. Some solar projects employ site managers, whose positions can

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last throughout the project's life. In some states where there is enough local activity for large-scale solar development, there can be permanent jobs for inspectors and maintenance workers. Often, remotely monitored facilities have agreements with local electricians and maintenance crews that can be deployed as needed.

## Understanding the Tradeoffs of Solar Development

While the local benefits of large-scale solar development can be substantial, capturing these benefits often involves local tradeoffs. However, as with other development projects, the magnitude and extent of these tradeoffs depends on project location and design. The potential tradeoffs most likely to trigger local opposition include changes to local agricultural or other productive lands; effects on wildlands, habitat, or historic or cultural resources; or changes to existing views.

### *Changes to Agricultural or Other Productive Land*

In many rural jurisdictions, the most suitable sites for large-scale solar development are often productive lands currently or recently in use as farms or pasture. These sites are less expensive to develop than other options because they are typically open areas with flat, tilled land or are otherwise nearly ready for solar installations.

If large-scale solar development replaces existing productive land uses, it can challenge local identity (such as agricultural heritage). But in some cases, solar development could complement or supplement existing productive land uses instead of replacing them.

Local officials can minimize or mitigate changes to existing productive lands through policies and actions that

- encourage large-scale solar development on currently underutilized productive land;
- encourage the colocation of PV systems and agricultural activities;

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- encourage large-scale solar development as a redevelopment strategy for previously developed sites, including capped landfills or other brownfields and vacant or underutilized parking lots or other grayfields; and
- discourage or prohibit large-scale solar development on locally significant agricultural soils.

### *Effects on Wildlands and Habitat*

Large-scale solar development has the potential to disturb wildlands or habitat. To prepare land for solar installation, developers may need to grade the site and remove ground cover. They may also want to remove trees to reduce shading and increase or protect access to the solar resource. Finally, solar facilities are typically enclosed by fences, which can limit or prevent wildlife migration.

Local officials can minimize or mitigate effects on wildlands and habitat through policies and actions that

- encourage or require fencing that wildlife can maneuver through;
- encourage or require native ground cover or pollinator-friendly landscaping;
- encourage or require the maintenance of vegetated buffers between projects and streams or wetlands;
- discourage or prohibit removing existing trees; and
- discourage or prohibit projects on sites with high levels of biodiversity and ecological connectivity.

### *Effects on Historic or Cultural Sites*

When large-scale solar projects disturb or occupy historic or otherwise culturally significant sites, they can damage or destroy historic and cultural resources. Visible solar energy systems may detract from valued landscapes, such as historic battlefields or lands traditionally stewarded by Native Americans (American Battlefield Trust 2020a; Patton et al. 2013). Construction and maintenance activities for solar projects can bring unwanted or uninformed visitors to revered or fragile sites. And after construction, new safety and security concerns may preclude traditional use of these lands.

Local officials can minimize or mitigate effects on historic or cultural sites through policies and actions that

- encourage or require screening to minimize the visual appearance of large-scale solar facilities from significant vantage points;
- encourage or require construction practices that minimize land disturbance and noise on or near historically or culturally significant sites;
- encourage or require developers to hire field monitors to ensure mitigation practices are sustained throughout construction and maintenance; and
- discourage or prohibit projects on sites of historic or cultural significance.

Because historic and cultural resources may hold different levels of meaning, local officials should consult with state and local historic preservation offices, tribal authorities, community-based organizations, developers, and other relevant stakeholders, as necessary, to determine appropriate approaches.

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Figure 1-5. PV arrays in a natural landscape (Photo by Dennis Schroeder / NREL)

### Changes to Existing Views

Ground-mounted PV systems consist of dark glass arrays and metal mounting hardware (see Figure 1-5). Since these systems are relatively low to the ground, the change to existing views will primarily, and most significantly, affect those on adjacent properties. In some instances, solar installations might also impact views of nearby scenic corridors or preserved natural features.

Nearby property owners with concerns about changing views often ask whether proximity to a proposed large-scale solar project will lower their property values (Donaldson 2018). There are few studies that explore the effects of large-scale solar facilities on property values. Findings are mixed but suggest that any positive or negative effect on property values is very limited in magnitude and geographic extent (Guar and Lang 2020;

Al-Hamoodah et al. 2018).

Local officials can minimize or mitigate changes to existing views through policies and actions that

- encourage large-scale solar development on previously developed sites; and
- encourage or require landscaped buffers or screens that shield the view of systems from nearby residences or designated scenic highways.

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## KEY TAKEAWAYS

- Almost all new large-scale solar development projects use PV systems.
- PV systems with a maximum generating capacity of five megawatts (MW) or less typically connect to the electricity distribution network, while larger systems often connect to the transmission network.
- Most large-scale solar development projects use ground-mounted systems and are the principal use of the development site.
- Perceptions of what constitutes a large-scale solar facility can vary based on the land-use and development patterns of the surrounding area.
- Large-scale solar facilities produce electricity without generating air pollution or greenhouse gas emissions.
- Large-scale solar development projects often generate a net increase in tax revenue for local jurisdictions.
- Large-scale solar development projects create temporary construction jobs.
- Project location and design affect the magnitude and extent of local tradeoffs associated with large-scale solar development.



## References and Resources

Al-Hamoodah, Leila, Kevita Koppa, Eugenie Schieve, D. Cale Reeves, Ben Hoen, Joachim Seel, and Varin Rai. 2018. [“An Exploration of Property-Value Impacts Near Utility-Scale Solar Installations.”](#) Austin, Tex.: University of Texas at Austin.

American Battlefield Trust. 2020a. [“Solar Energy Development and Historic Battlefields.”](#)

———. 2020. [“Utility-Scale Solar Facility Development: Assessing Impact on Historic Battlefields and Related Resources.”](#)

American Planning Association. 2021. [“Research KnowledgeBase: Solar Energy.”](#)

Barnes, Justin, Chad Laurent, Jayson Uppal, Chelsea Barnes, and Amy Heinemann. 2013. [Property Taxes and Solar PV Systems: Policies, Practices, and Issues.](#) Raleigh, N.C.: NC Clean Energy Technology Center.

Blumenstein, Lev, and Amelia Schlusser. 2019. [“Renewable Energy & Direct Public Revenue in Oregon.”](#) Portland, Ore.: Lewis & Clark Law School Green Energy Institute.

Brehm, Kevin, Blank, Thomas Koch, and Leah Mosier. 2018. [Progress and Potential for Community-Scale Solar.](#) Boulder, Colo.: Rocky Mountain Institute.

Brookshire, Daniel, Jerry Carey, Daniel Parker, Quinn Beckham, Alex Bentley, and Kaitlin Cook. 2020. [“Increased North Carolina County Tax Revenue from Solar Development - 2020 Update.”](#) Raleigh, N.C.: NC Sustainable Energy Association.

Byrne, Genevieve. 2018. [Farmland Solar Policy Design Toolkit.](#) South Royalton, Vt.: Vermont Law School, Farm and Energy Initiative.

Coffey, Darren. 2019. [“Planning for Utility-Scale Solar.”](#) PAS Memo, September/October.

Donaldson, Joseph J. 2018. [“Mitigating Visual Impacts of Utility-Scale Energy Projects.”](#) In *Visual Resource Stewardship Conference Proceedings: Landscape and Seascape Management in a Time of Change.* Newtown Square, Pa.: U.S. Department of Agriculture, Forest Service, Northern Research Station.

Electric Power Research Institute. 2020. [“Land Use Considerations for Large-Scale Solar: Community-Based Stormwater Strategies and Vegetation Management for Sustainable Solar PV Development.”](#) SolSmart Issue Brief, December.

Gorman, Will, Andrew Mills, and Ryan Wiser. 2019. [Improving Estimates of Transmission Capital Costs for Utility-Scale Wind and Solar Projects to Inform Renewable Energy Policy.](#) Berkeley, Calif.: Lawrence Berkeley National Laboratory.

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Gross, Samantha. 2020. [“Renewables, Land Use, and Local Opposition in the United States.”](#) Washington, D.C.: Brookings Institution.

Guar, Vasundhara, and Corey Lang. 2020. [“Property Value Impacts of Commercial-Scale Solar Energy in Massachusetts and Rhode Island.”](#) Kingston, R.I.: University of Rhode Island.

Haggerty, Julia H., Mark Haggerty, and Ray Rasker. 2014. [“Uneven Local Benefits of Renewable Energy in the U.S. West: Property Tax Policy Effects.”](#) *Western Economics Forum* 13(1): 8–22.

Hays, Maxwell, and Sara Hoff. 2020. [“Large Battery Systems Are Often Paired With Renewable Energy Power Plants.”](#) U.S. Energy Information Administration, *Today in Energy*, May 18.

Hernandez, R.R., S.B. Easter, M.L. Murphy-Mariscal, F.T. Maestre, M. Tavassoli, E.B. Allen, C.W. Barrows, J. Belnap, R. Ochoa-Hueso, S. Ravi, and M.F. Allen. 2014. [“Environmental Impacts of Utility-Scale Solar Energy.”](#) *Renewable and Sustainable Energy Reviews* 29: 766–79.

ICF Inc. 2019. [“Interconnection: Plugging RE-Powering Sites into the Electric Grid.”](#) Washington, D.C.: U.S. Environmental Protection Agency.

Interstate Renewable Energy Council (IREC). 2021. [“National Solar Jobs Census 2020.”](#)

Kosciuch K, D. Riser-Espinoza, M. Gerringer, and W. Erickson. 2020. [“A Summary of Bird Mortality at Photovoltaic Utility Scale Solar Facilities in the Southwestern U.S.”](#) *PLoS one* 15(4): p.e0232034.

Loomis, David G. 2020. [“Economic Impact of Wind and Solar Energy in Illinois and the Potential Impacts of Path to 100 Legislation.”](#) Bloomington, Ill.: Strategic Economic Research, Inc.

Lumby, Ben. 2015. [“Utility-Scale Solar Photovoltaic Power Plants: A Project Developer’s Guide.”](#) Washington, D.C.: International Finance Corporation.

Macknick, Jordan, Courtney Lee, Gail Mosey, and Jenny Melius. 2013. [“Solar Development on Contaminated and Disturbed Lands.”](#) Golden, Colo.: National Renewable Energy Laboratory.

Magnum, A. Fletcher, David Zorn, and Martina Arel. 2020. [“The Economic Contribution of Utility Scale Solar Development to Virginia.”](#) Glen Allen, Va.: Magnum Economics.

Massachusetts Department of Energy Resources. 2015. [“Questions & Answers: Ground-Mounted Solar Photovoltaic Systems.”](#)

Morley, David, ed. 2014. [“Planning for Solar Energy.”](#) Planning Advisory Service Report 575. Chicago: American Planning Association.

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Mulholland, Denise, ed. 2018. *Quantifying the Multiple Benefits of Energy Efficiency and Renewable Energy: A Guide for State and Local Governments*. Washington, D.C.: U.S. Environmental Protection Agency.

National Renewable Energy Laboratory. 2020. “[Concentrating Solar Power Projects](#).”

NC Clean Energy Technology Center. 2021. “[DSIRE Programs](#).”

Patton, T., L. Almer, H. Hartmann, and K.P. Smith. 2013. *An Overview of Potential Environmental, Cultural, and Socioeconomic Impacts and Mitigation Measures for Utility-Scale Solar Energy Development*. Lemont, Ill.: Argonne National Laboratory.

Solar Energy Industries Association (SEIA). 2021a. “[Development Timeline for Utility-Scale Solar Power Plant](#).”

———. 2021. “[What’s in a Megawatt? Calculating the Number of Homes Powered by Solar Energy](#).”

Sullivan, Robert and Jennifer Abplanalp. 2013. *Utility-Scale Solar Energy Facility Visual Impact Characterization and Mitigation*. Lemont, Ill.: Argonne National Laboratory.

U.S. Department of Energy, Solar Energy Technologies Office (USDOE SETO). 2021. “[Farmer’s Guide to Going Solar](#).”

YSG Solar. 2020. “[How Long Does It Take to Construct a Solar Farm?](#)”





## MODULE

# 2

### UNDERSTANDING THE MARKET FOR LARGE-SCALE SOLAR DEVELOPMENT

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The U.S. market for large-scale solar development is sensitive to economic and policy drivers at the international, national, state, and local levels. Consequently, the demand for large-scale solar development is not equally distributed across all local jurisdictions.

Local government officials can act in ways that either constrain or expand opportunities for large-scale solar development. Officials who understand the key forces driving demand for large-scale solar development are better positioned to use their authority to influence the extent and nature of large-scale solar development in the communities they serve.

To help increase this understanding, this module summarizes the most significant trends driving national demand for large-scale solar development, the influence of distinct actors on demand in a particular jurisdiction, and how different levels of government exercise authority over proposed projects.

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### Identifying Solar Development Trends

Between 2014 and 2020, the estimated total installed capacity of all grid-connected PV and CSP systems in the U.S. increased from 17.6 to 75.6 gigawatts (GW) (Table 2-8). During this period, the total number of grid-connected solar facilities with rated capacities of at least one megawatt (MW) grew from 1,249 to 4,538 (Figure 2-1).

This linear growth is likely to continue for the foreseeable future. In its latest forecast, the U.S. Energy Information Administration projects that by 2030 the total installed capacity of these larger PV systems will be 390.4 GW (USEIA 2021a).

Two related trends underpin the recent rapid expansion of the market for large-scale solar development: declining costs for solar energy systems and

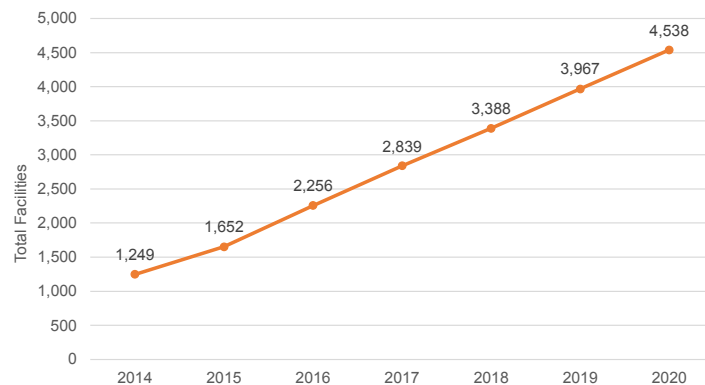


Figure 2-1. Total number of grid-connected solar facilities with rated capacities  $\geq 1$  MW in the U.S., 2014–2020 (USEIA 2020b; 2021c)

an increased focus on climate action. There is also an important consequence of this rapidly expanding market: growing demand for solar energy means growing demand for space to accommodate large-scale solar development.

### Declining Costs

From 2010 to 2019, the median lifetime costs of PV systems with rated capacities of at least five MW decreased by 84 percent (Figure 2-2). Today, these systems produce electricity at prices competitive with all other forms of energy generation (SEIA 2021a; USEIA 2021a). Technological improvements, economies of scale, and incentives have all contributed to declining costs.

Technological improvements have led to more efficient hardware components. For example, the number of solar

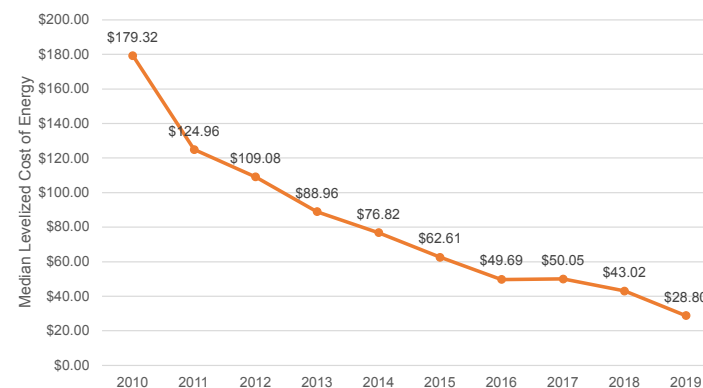


Figure 2-2. Median levelized cost of energy (LCOE) per MWh with 30% federal investment tax credit (ITC) for grid-connected PV systems with rated capacities  $\geq 5$  MW, 2010–2019 (Berkeley Lab 2020)

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panels needed to generate a certain amount of power has fallen (Feldman et al. 2021). This largely accounts for the decrease in solar installation costs.

The expansion and efficiency of plants that manufacture components have also led to reductions in hardware costs. The average annual manufacturing plant output increased from 13 MW to 1,000 MW between 2001 and 2012. Over the same period, changes in plant size contributed to 36 percent of the overall decline in module costs (Kavlak, McNerney, and Trancik 2018). Shared infrastructure, higher yields, and a lower defect rate during production due to increased quality control have led to economies of scale that reduce manufacturing plant-related costs and total costs for module production (Kavlak et al. 2018; Roser 2020).

Government subsidies and mandates have made the increased deployment of PV systems possible, which, in turn, has led to greater efficiency in the production of solar hardware (Roser 2020). These market-stimulating policies have enabled solar PV prices to fall over time. Today, the most noteworthy federal incentive driving competitively priced solar development is the Solar Investment Tax Credit (ITC) (see [Federal Policy](#)).

The soft costs of large-scale PV projects have also decreased, albeit less drastically, during this same period. Soft costs include permitting, inspection, and interconnection; sales tax; engineering, procurement, and construction; and developer overhead and profit. Costs to cover these activities have remained at about the same proportion of total costs, between 32 to 44 percent, for utility-scale PV (Feldman et al. 2021). Soft costs are highly dependent on project-specific characteristics, such as the location, size of the project, and developer.

Declining costs will lead to a substantial increase in large-scale solar development over the next couple of decades. Local government officials and developers will need to work together to strategically disperse this demand, meaning it could affect every community in some way (see [Growing Demand for Space](#)).

### *Clean Energy and Climate Action Goals*

Since 2005, a growing number of states and local governments have made commitments to transition from fossil-fuel to clean-energy consumption.

The most significant commitments include renewable portfolio standards (RPS) or clean energy standards (CES)—requiring utilities to increase energy production from renewable or nonpolluting sources—and climate action plans ([Figures 2-3](#) and [2-5](#)). As of December 2020, seven states have adopted a binding commitment to obtain 100 percent of their electricity from clean sources by a certain year ([Figure 2-4](#)). Meanwhile, more than 200 cities have pledged to achieve 100 percent clean electricity or the similar goal of “net zero” emissions (NRDC 2020).

Climate change mitigation (like greenhouse gas reductions), energy independence, and grid resilience are the primary reasons driving these commitments to clean energy (Mulholland 2018; Byrne 2020). Clean electricity will play a major role in reducing greenhouse gas emissions from transportation, buildings, and manufacturing. State and local governments might also commit to clean energy to advance secondary goals, such as energy security, economic development and resilience, public health, and environmental justice.

Trends in the private realm, such as an increase in corporate sustainability goals and awareness of carbon



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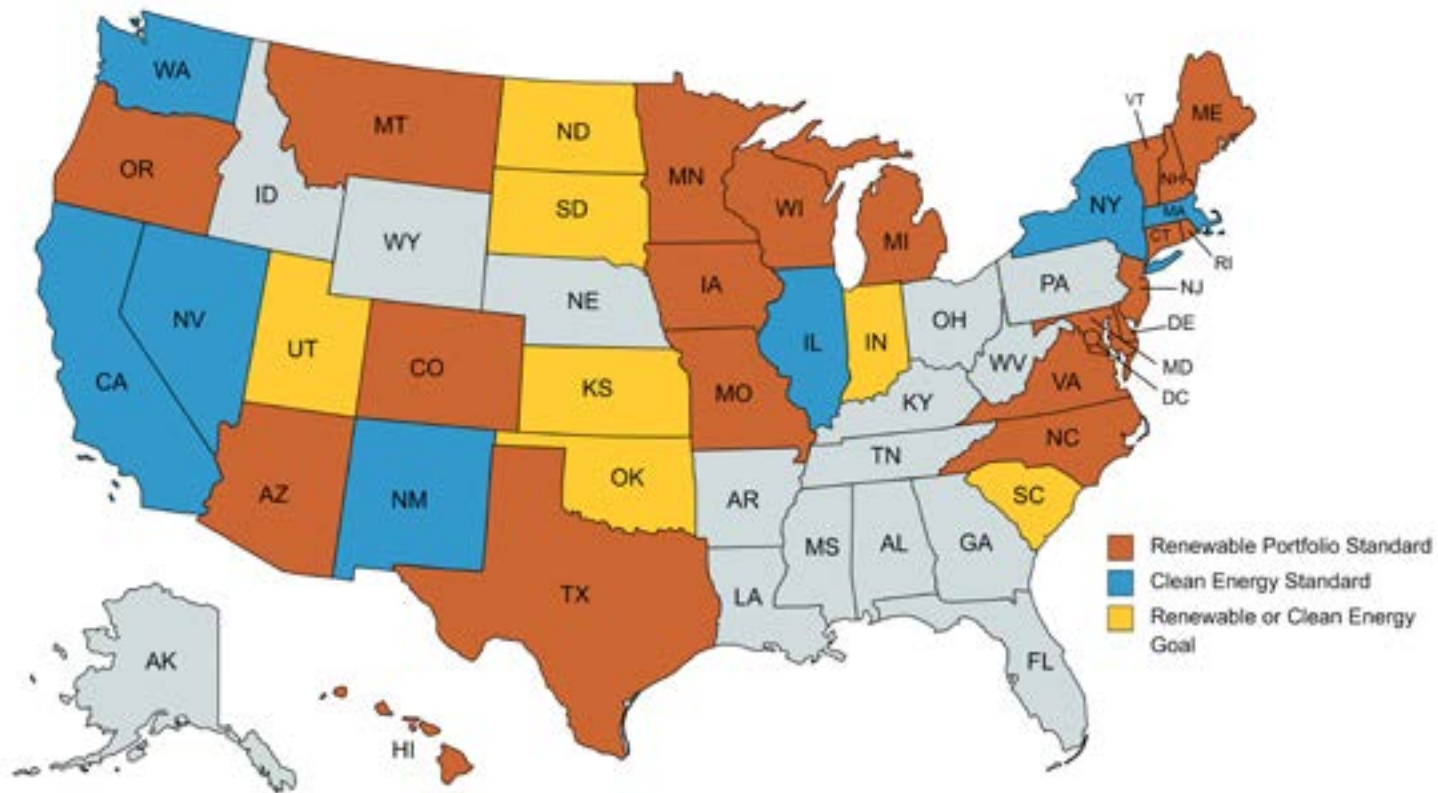


Figure 2-3. States with a renewable portfolio standard, clean energy standard, or renewable or clean energy goal (CCES 2021; NRDC 2020)

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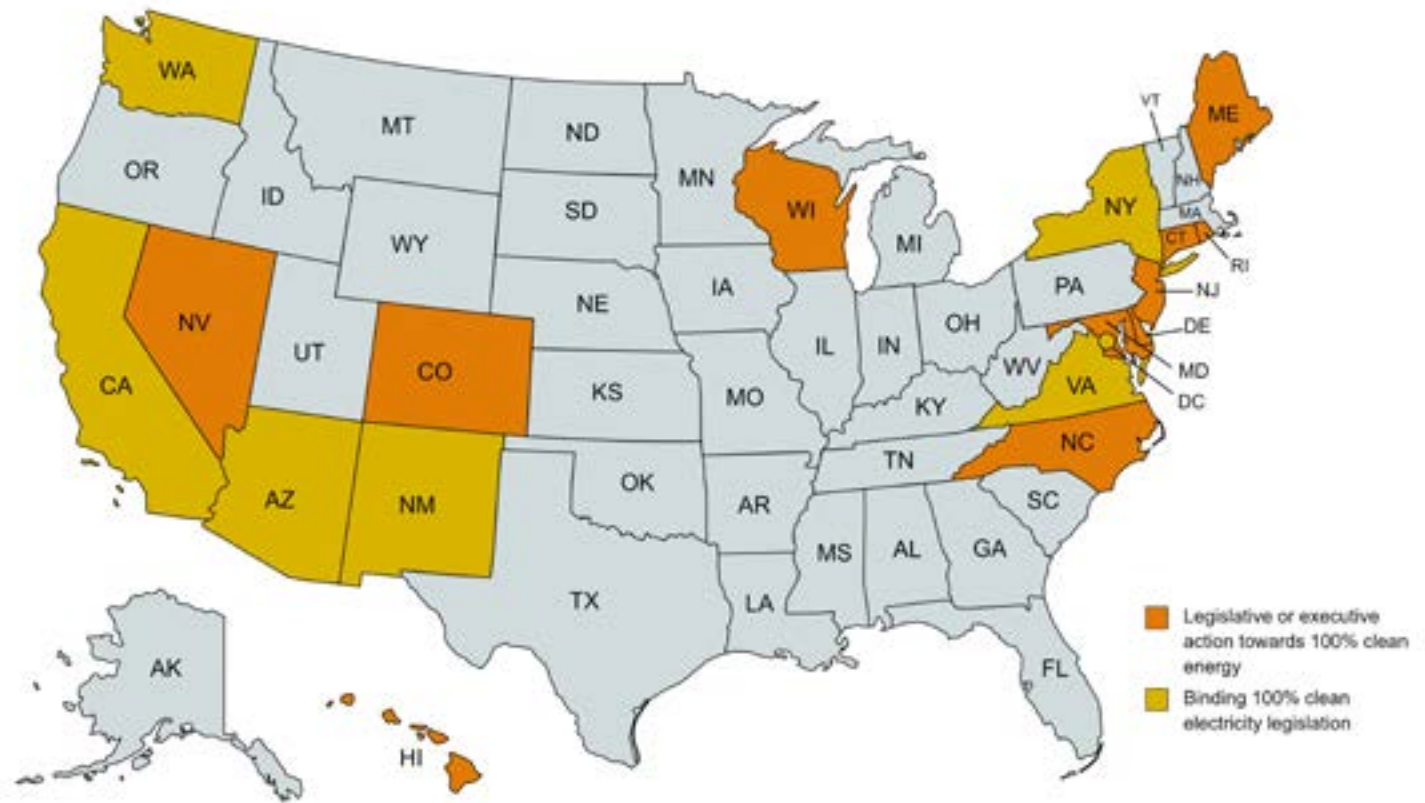


Figure-2-4. States that have established a legislative requirement or non-binding goal to achieve 100 percent clean electricity (Rickets et al. 2020; NRDC 2020)

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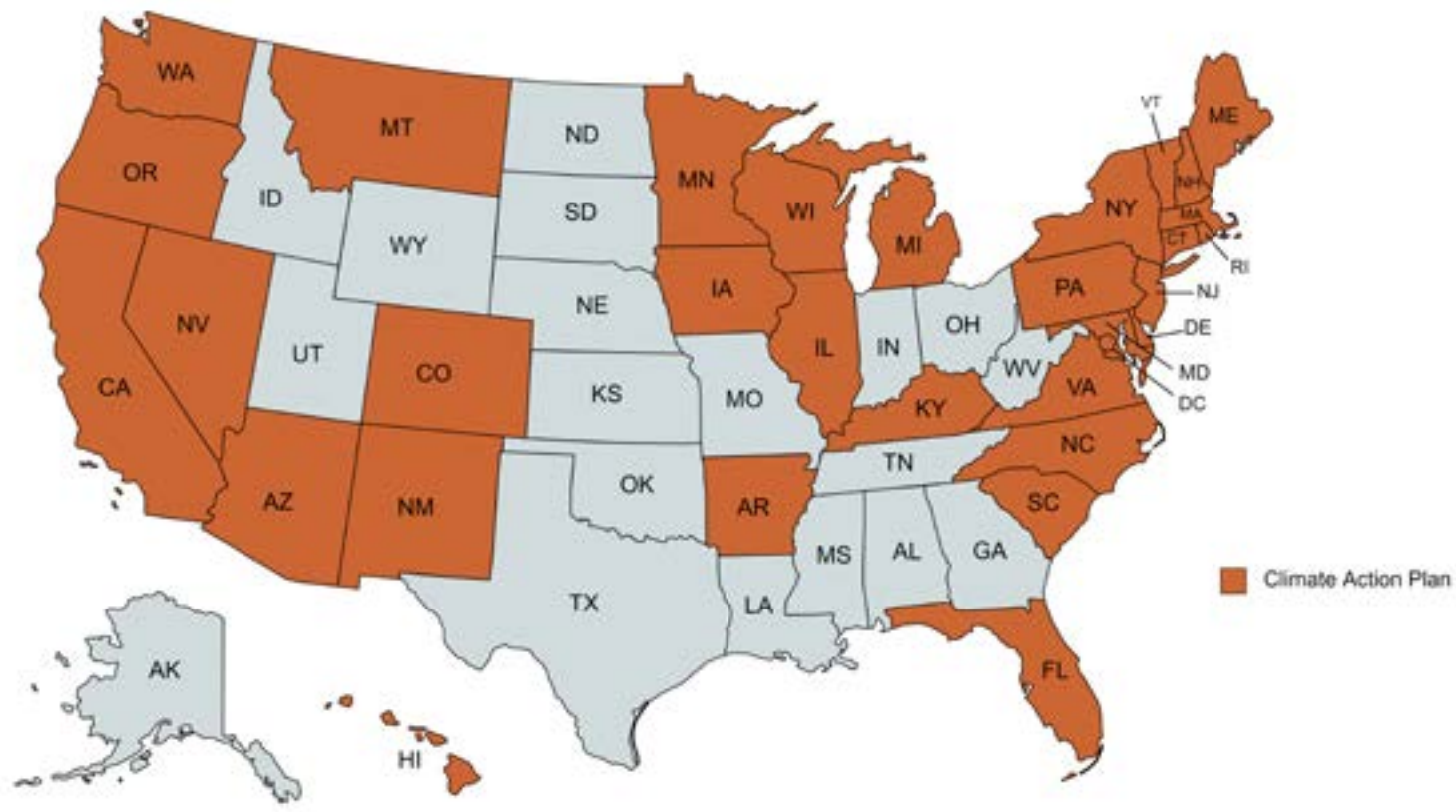


Figure 2-5. States with a climate action plan (CCES 2021)

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footprints, have also played a small role in increasing demand for clean energy (Trumbull 2019; NRDC 2020; see [Major Corporation Interests](#)).

### *Growing Demand for Space*

Large-scale PV and CSP projects are both land-intensive uses. The National Renewable Energy Laboratory (NREL) estimates that projects with rated capacities of at least one MW, on average, require 8.9 acres of land per MW (Ong et al. 2013).

Comparatively, coal and natural gas plants in the U.S. require about one acre per MW (Stevens 2017). This means that solar requires around 10 times the number of acres per MW than nonrenewable sources, even when factoring in land disturbed to produce and transport fossil fuels (Gross 2020).

To meet the upcoming demand for large-scale solar, the U.S. will likely need to devote an additional 1.55 million acres to solar development between 2020 and 2030 (NREL 2020a). But this is a very small percentage of the total land area in the United States and is much less than the space needed for other forms of new development in the near future.

Furthermore, previously developed sites can help meet some of this demand (Macknick et al. 2013). And if grid interconnection is feasible, large-scale solar development is compatible with and can co-locate on space occupied by other land-intensive uses, such as agriculture, transit corridors, and landfills (Gross 2020).

While the Southwest has the best solar resource potential, it would not be cost effective or reliable to concentrate solar development there or in any one region. Instead, large-scale solar projects are ideally located on

the same grid as end users to maximize transmission and distribution efficiency. Solar developers will need to disperse solar installations (and consequently, the demand for space) where demand for solar exists across the country.



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### Identifying Influences on Local Demand

While national trends are clearly signaling an increased aggregate demand for large-scale solar development, the level of potential demand is not equal in all jurisdictions. In part, this is due to constraints on the amount of suitable land for large-scale solar development and the number of property owners willing to host solar facilities in each community. But this is also due to the policies, actions, and interests of a diverse set of local and nonlocal actors.

There are several distinct groups of actors that influence the level of demand for large-scale solar development in particular jurisdictions or areas of the country. These groups include federal and state policymakers, local government officials, utilities, regional transmission organizations, and major corporations and advocacy organizations.

### Federal Policy

Federal policymakers affect local demand for large-scale solar development through tax incentives and purchasing requirements for utilities (Table 2-1).

The ITC provides a dollar-for-dollar reduction in the income taxes owed by large-scale system owners (Blumenstein and Schlusser 2019; SEIA 2021b). Additionally, the Modified Accelerated Cost Recovery System (MACRS) depreciation method allows system owners to deduct the costs of solar equipment over a five-year recovery period (SEIA 2021c).

Under the Public Utility Regulatory Policies Act (PURPA), utilities must interconnect with and purchase power from certified “qualifying” solar projects at the same price they would have to pay to generate or contract for the power in the absence of the qualifying project (FERC 2021; SEIA 2018). In competitive wholesale markets, qualifying projects range in size from one to 20 MW, but in other markets qualifying projects can be up to 80 MW.

**Table 2-1. Federal Policies That Can Affect Local Demand for Large-Scale Solar Development**

Policy	Potential Effect on Local Demand
Adoption of Solar Investment Tax Credit (ITC) and the Modified Accelerated Cost Recovery System (MACRS)	Can make projects feasible in a wider range of locations
Adoption of Public Utilities Regulatory Policies Act (PURPA)	Can increase demand in utility markets where solar power generation is cheaper than other forms of electricity

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### State Policy

State policymakers affect local demand for large-scale solar development through RPS, tax incentives, utility deregulation, virtual net metering or shared solar policies, and location-based incentive programs (Table 2-2).

As mentioned above, over half of all states have an RPS that requires utilities to purchase a certain percentage of their power from renewable sources (NCCETC 2021). Some states also have solar carve-outs that specifically create demand for solar projects.

At least 20 states have adopted some form of property tax incentive for large-scale solar development (see Module 7, Table 7-3, and NCCETC 2021). Some of these incentive programs are tied to specific types of systems, while others apply to all systems, regardless of size or relationship to the grid.

Since the 1990s, more than two dozen states have “deregulated” their electricity markets (Cleary and Palmer 2020). In these states, qualifying utility customers can choose to purchase power directly from suppliers that invest in solar projects instead of from their local utility.

At least 20 states have authorized shared solar projects (Cleveland 2017; NCCETC 2021). Some of these states have authorized virtual net metering, which allows multiple utility customers to offset their electricity use with a single shared system. Others have authorized community solar programs.

**Table 2-2. State Policies That Can Affect Local Demand for Large-Scale Solar Development**

Policy	Potential Effect on Local Demand
Adoption of renewable portfolio standard (RPS)	Can increase demand statewide
Adoption of property tax incentives	Can increase demand statewide
Deregulation of utilities	Can increase demand statewide
Adoption of virtual net metering or shared solar policy	Can increase demand for community-scale projects statewide
Adoption of incentive programs with locational considerations	Can increase demand in locations that meet program criteria

Finally, some states have adopted solar development incentive programs that include locational considerations. For example, Massachusetts’ Solar Massachusetts Renewable Target Program and New York’s NY-Sun Megawatt Block Program both offer incentives for large-scale solar development projects on landfills and brownfields (Massachusetts 2021; NYSERDA 2020).

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### Local Policy and Action

Local government officials can affect local demand for large-scale solar development through the policies they adopt and the strategies they use to implement those policies (Table 2-3). Ideally, these policies and actions are rooted in a community plan that establishes a shared vision

and high-level goals for solar development (see Module 3). Potential implementation strategies include zoning updates (see Module 4), process improvements (see Module 5), development partnerships (see Module 6), and technical or financial assistance programs (see Module 7).

**Table 2-3. Local Policies and Actions That Can Affect Local Demand for Large-Scale Solar Development**

Policy or Action	Potential Effect on Local Demand
Community plans that provide a clear policy direction for large-scale solar development	Can increase demand by signaling to developers that the local jurisdiction is interested in locally sited projects
Zoning updates that explicitly permit large-scale solar development in one or more areas of the jurisdiction	Can increase demand by removing unintentional barriers to solar development and establishing incentives for projects that align with community goals
Process improvements that optimize discretionary land-use reviews for large-scale solar projects	Can increase demand by shortening the development review timeline
Development partnerships that bring large-scale solar energy systems to local-government-owned sites	Can increase demand by providing pre-approved locations for projects and, potentially, customers for the power produced
Technical or financial assistance programs for solar developers	Can increase demand for projects that meet program criteria in locations that meet program criteria

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### Utility Plans and Programs

Utilities affect local demand for large-scale solar development through their system-planning and power-purchasing decisions (Table 2-4). These decisions are tied to the local utility’s business model and governance structure.

The three major types of utilities are investor-owned utilities (IOUs), municipal utilities (munis), and rural electric cooperatives (coops). IOUs are electric utility companies that issue shareholder-owned stock. IOUs can range in size from small local companies serving a few thousand customers to multinational corporations that serve millions of customers. Munis are utilities operated by local jurisdictions. Coops are member-owned nonprofit utili-

ties. They provide service to rural or semi-rural areas that IOUs and munis do not adequately serve.

While IOUs must comply with all applicable public utility commission (PUC) regulations in their state, their primary responsibility is generating a profit for their shareholders. Large IOUs have more ratepayers than munis and coops, so they can make bigger investments in solar projects and the necessary infrastructure upgrades to accommodate those projects. Compared to IOUs, technology upgrades are relatively more expensive for munis and coops, which have fewer numbers of ratepayers to pay the costs of these changes.

**Table 2-4. Utility Policies and Actions That Can Affect Local Demand for Large-Scale Solar Development**

Policy or Action	Potential Effect on Local Demand
System plans that prioritize improvements to accommodate a higher penetration of distributed solar energy	Can increase demand for community-scale projects in the utility’s service area
System plans that identify a need to replace existing power generators or to expand net power generation	Can increase demand in areas where solar power is cost competitive with other sources of energy
Community solar programs	Can increase demand for community-scale projects in the utility’s service area

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### Regional Transmission Organization Plans and Policies

Nine membership-based regional transmission organizations (RTOs) administer the buying and selling of electricity through wholesale electricity markets that provide about two-thirds of all power in the U.S. and half in Canada (IRC 2021; Figure 2-6). Members include utilities, independent power producers, transmission companies, power marketers, and energy traders.

RTOs operate, but do not own, the transmission system

in accordance with the North American Electric Reliability Corporation (NERC), a not-for-profit international regulatory authority. NERC is subject to oversight by the Federal Energy Regulatory Commission (FERC), a federal agency that regulates the interstate transmission of electricity, natural gas, and oil.

RTOs also enforce regional reliability criteria on behalf of their member transmission owners, ensure nondiscriminatory access to the transmission system, and manage and plan for the reliability of the transmission system (Table 2-5).

**Table 2-5. Regional Transmission Organization Policies and Actions That Can Affect Local Demand for Large-Scale Solar Development**

Policy or Action	Potential Effect on Local Demand
System plans that identify transmission network expansion needs	Can increase demand in areas targeted for new transmission infrastructure
System plans that prioritize improvements that would increase grid stability and reliability	Can increase demand in the RTO region
Market policies that make it easier for solar facilities to sell power	Can increase demand in the RTO region

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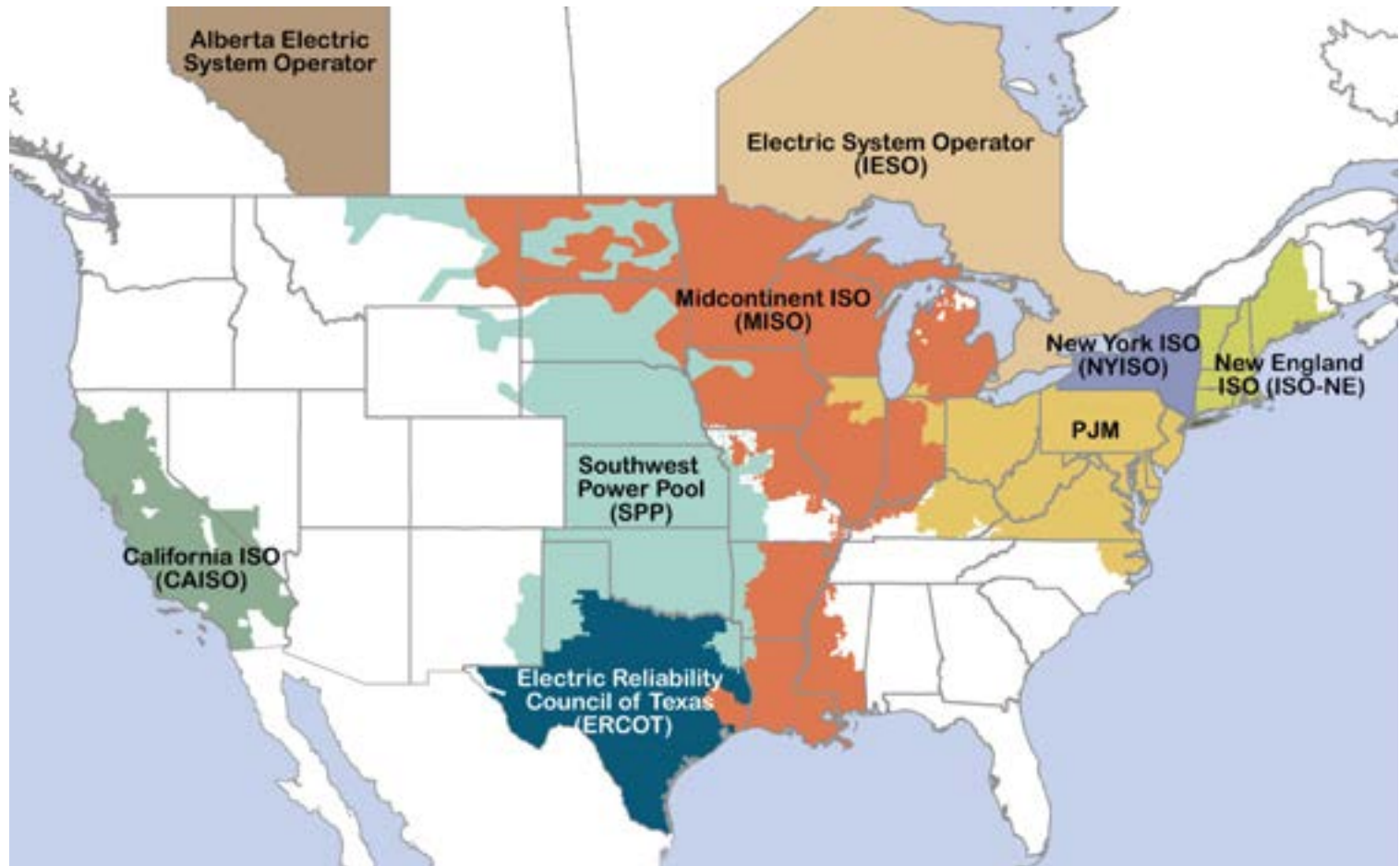
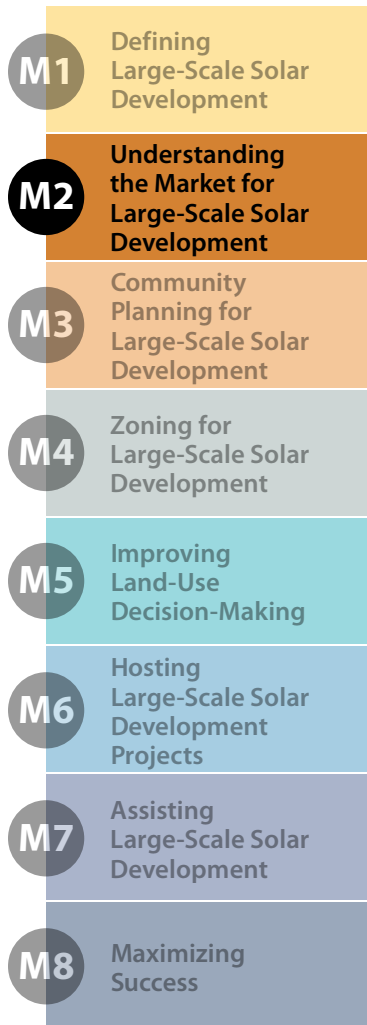


Figure 2-6. The nine regional transmission organizations that operate across North America (Source: BlckAssn / Wikimedia (CC BY-SA 4.0))



### *Major Corporation Interests*

Major corporations can affect local demand for large-scale solar development through their power-purchasing decisions. Many of the largest and most prominent corporations in the U.S., including Amazon, Apple, Facebook, General Motors, Google, and Walmart, have committed to offsetting 100 percent of their electricity use with renewable power (Climate Group 2021). Many other companies have made less ambitious commitments to transition to renewable energy use or otherwise support large-scale solar development.

In some cases, this has driven demand for solar development near energy-intensive facilities, such as data centers or corporate offices. For example, Google has entered into large power-purchase agreements for new data centers in Tennessee and Alabama that helped finance the development of new large-scale solar facilities in these states (Hall 2019). In other cases, major corporations are simply boosting demand for large-scale solar development in the most cost-efficient locations.

### *Advocacy Organization Interests*

Advocacy organizations can affect local demand for large-scale solar development through their influence over each of the groups listed above. Across the country, there are numerous local, regional, and national advocacy groups interested in energy policy, environmental protection, land or resource conservation, or community and economic development. Some of these groups are broadly supportive of solar development. Others may see it as a threat to their core interests. And even advocacy organizations that otherwise support solar development may oppose projects in specific locations if they perceive those projects would conflict with other priorities.



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### Identifying Authorities Having Jurisdiction

Local, state, and federal agencies share responsibilities for reviewing and approving the siting of new large-scale solar facilities. Federal agencies have final siting authority for projects located on federal lands and may review other projects to verify compliance with environmental protection laws. State agencies have final siting authority for projects located on state lands or, in some states, for projects over a certain size. And local jurisdictions retain siting authority for all other projects.

### Federal Agencies

Siting a large-scale solar project on federal land requires permission from the agency that manages or administers that land (Table 2-6 and 2-7). The level of review given to different projects varies with the likelihood of significant environmental impact, but all federally associated projects require some level of assessment. Agencies typically grant permission in the form of a lease or, more commonly, a right-of-way (ROW), which authorizes the holder to use or occupy federal land. For utility-scale solar projects, the BLM has a Solar Energy Program that supports development on BLM-administered lands in the Southwest region.

**Table 2-6. Relevant Federal Laws for Proposed Large-Scale Solar Projects**

Federal Legislation	Applicability
National Environmental Policy Act	All projects on federal land, accessing federally owned transmission lines, receiving federal grants, or requiring federal permits
Endangered Species Act	Projects that may affect threatened or endangered species or their habitat
Clean Water Act, Section 403	Projects that disturb over one acre
Clean Water Act, Section 404	Projects that require filling wetlands



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**Table 2-7. Relevant Federal Authorities for Proposed Large-Scale Solar Projects**

Federal Authorities	Role
Bureau of Land Management (BLM)	Authorizes development on federal land managed by the BLM
U.S. Forest Service (USFS)	Authorizes development on federal land managed by the USFS
U.S. Bureau of Indian Affairs (BIA)	Approves projects on tribal land
U.S. Fish and Wildlife Service (USFWS)	Administers the Endangered Species Act by reviewing projects, conducting environmental assessments, and issuing permits
U.S. Environmental Protection Agency (EPA)	Administers Section 403 of the Clean Water Act by developing and interpreting policy and guidance, and by issuing construction general permits in Massachusetts, New Hampshire, New Mexico, and the District of Columbia  Administers Section 404 of the Clean Water Act by developing and interpreting policy, guidance, and environmental criteria for permit applications
U.S. Army Corp of Engineers (USACE)	Administers the day-to-day aspects of the Section 404 program of the Clean Water Act, including permitting
Federal Aviation Administration (FAA)	Reviews and approves projects at airports that have accepted federal funding to buy land or improve the airport
Department of Defense (DoD)	Administers permitting and leasing on lands used for defense-related purposes

### State Agencies

Most states require public utilities or independent power producers to obtain certificates of public convenience and necessity from public utility commissions for new power plants (or expansions to existing facilities). In some instances, this process preempts local siting authority for certain types of large-scale solar projects. Furthermore, some states preempt local siting authority by requiring developers of solar projects that meet a specific size threshold to obtain a siting permit from a special-purpose siting board.

In total, 18 states preempt local siting authority for at least some types of large-scale solar development ([Table](#)

[2-9](#)). This preemption typically applies to projects over a certain rated capacity or that cover a certain amount of land area. However, three states preempt local authority for all projects that would fit most local definitions of utility-scale solar: Vermont, Connecticut, and Maryland.

In Kentucky, North Dakota, Virginia, and Wisconsin, state siting permits do not preempt local siting authority. In these states, developers or project owners must satisfy both state and local requirements. In more than half of all states, though, local jurisdictions retain the sole authority over project siting.

Additionally, several states have a state-level analogue to the National Environmental Policy Act, requiring

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environmental review of proposed actions, especially if project applicants are receiving any state funding (or, in some cases, state permits or licenses). Some states also have the authority to enact their own regulatory programs for wetlands under the Clean Water Act if they are more stringent than federal programs. Large-scale solar projects may require one or more natural resource management permits addressing wetlands protection, erosion, land disturbance, and stormwater management. For example, outside of areas with municipal storm sewer systems, state agencies generally issue stormwater permits for solar projects that trigger Clean Water Act requirements under the National Pollution Discharge Elimination System (NPDES) program (EPRI 2020).

### Local Governments

In most states, counties, municipalities, and other general-purpose local governments have the authority to approve or deny the siting of large-scale solar development projects on private land (and land owned by the local jurisdiction), as well as regulate the design of the facility. Most commonly, these local jurisdictions control siting through zoning or other land-use and development regulations (see [Module 4](#)).

The specific authority is rooted in state zoning enabling laws and may be limited by other state laws governing solar development, specifically, or energy project siting, generally ([Table 2-9](#)). Furthermore, both general-purpose and special-purpose local governments—such as school, park, and solid-waste management districts—typically have an additional limited authority to approve solar development on land they own through contractual arrangements, such as property leases or procurement agreements (see [Module 6](#)).

**Table 2-8. Estimated Net Summer Capacity (in MW) from Grid-Connected Solar Energy Systems in the U.S., 2014–2020 (USEIA 2020a; 2021b)**

Year	Residential PV systems < 1 MW	Commercial PV systems < 1 MW	Industrial PV systems < 1 MW	PV systems ≥ 1 MW	CSP systems ≥ 1 MW	Total
2014	3,346.3	3,279.7	700.6	8,656.6	1,666.7	17,649.9
2015	5,191.5	3,706.7	880.3	11,905.4	1,757.9	23,441.8
2016	7,527.0	4,022.8	1,215.3	20,192.9	1,757.9	34,715.9
2017	9,626.8	5,155.8	1,365.1	25,209.0	1,757.9	43,114.7
2018	11,720.4	6,271.4	1,555.4	30,120.5	1,757.9	51,425.5
2019	14,249.0	7,167.9	1,796.6	35,710.2	1,758.1	60,681.9
2020	17,237.6	8,430.4	2,055.7	46,090.1	1,758.1	75,571.8

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**Table 2-9. Siting Authority for Large-Scale Solar Projects by State**

State	Authority Having Jurisdiction	State Siting Guidance	State Siting Review Criteria
Alabama	Local government	None	None
Alaska	Local government	None	None
Arizona	Local government (all PV projects and CSP projects < 100 MW); Arizona Corporation Commission (CSP Projects ≥ 100 MW)	None	<a href="#">\$40-360.06</a>
Arkansas	Local government	None	None
California	Local government (all PV projects and CSP projects < 50 MW); California State Energy Resources and Conservation Commission (CSP Projects ≥ 50 MW)	<a href="#">Energy Facility Licensing Process Developers Guide of Practices &amp; Procedures</a>	None
Colorado	Local government	None	None
Connecticut	Local government (< 1 MW); Connecticut Siting Council (≥ 1 MW)	<a href="#">Filing Guides</a>	None
Delaware	Local government	None	None
Florida	Local government (< 75 MW); Florida Siting Board (≥ 75 MW)	<a href="#">Electrical Power Plant Sites and Associated Facilities Application Instruction Guide</a>	<a href="#">\$403.509(3)</a>
Georgia	Local government	None	None
Hawaii	Local government	None	None
Idaho	Local government	None	None
Illinois	Local government	None	None
Indiana	Local government	None	None
Iowa	Local government (< 25 MW); Iowa Utilities Board (≥ 25 MW)	None	<a href="#">Administrative Code §199.24.10</a>
Kansas	Local government	None	None
Kentucky	Local government + Kentucky State Board on Electric Generation and Transmission Siting (≥ 10 MW)	None	<a href="#">\$278.710</a>
Louisiana	Local government	None	None

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**Table 2-9. Siting Authority for Large-Scale Solar Projects by State**

State	Authority Having Jurisdiction	State Siting Guidance	State Siting Review Criteria
Maine	Local government (< 20 acres); Maine Department of Environmental Protection (≥ 20 acres)	<a href="#">Technical Guidance for Utility-Scale Solar Installation and Development on Agricultural, Forested, and Natural Lands</a>	38 MRS §484
Maryland	Local government (< 2 MW); Maryland Public Service Commission (≥ 2 MW)	<a href="#">Solar Facility Siting Guidance</a>	Public Utilities Code §7-207(e)
Massachusetts	Local government (< 100 MW); Massachusetts Energy Facilities Siting Board (≥ 100 MW)	None	§164-69O
Michigan	Local government	None	None
Minnesota	Local government (<50 MW); Minnesota Public Utilities Commission (≥ 50 MW)	<a href="#">Commercial Solar Siting Guidance</a>	§216B.243
Mississippi	Local government	None	None
Missouri	Local government	None	None
Montana	Local government	None	None
Nebraska	Local government	None	None
Nevada	Local government	None	None
New Hampshire	Local government; New Hampshire Site Evaluation Committee (≥ 30 MW)	None	§162-H:16
New Jersey	Local government	None	None
New Mexico	Local government (< 300 MW); New Mexico Public Regulations Commission (≥ 300 MW)	None	§62-9-3
New York	Local government (< 25 MW); New York Office of Renewable Energy Siting (≥ 25 MW)	<a href="#">Siting for Large-Scale Renewables</a>	19 NYCCR §900
North Carolina	Local government	None	None
North Dakota	Local government + North Dakota Public Service Commission (≥ 50 MW)	None	§42-22-09

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**Table 2-9. Siting Authority for Large-Scale Solar Projects by State**

State	Authority Having Jurisdiction	State Siting Guidance	State Siting Review Criteria
Ohio	Local government (< 50 MW); Ohio Power Siting Board (≥ 50 MW)	None	§4906.10
Oklahoma	Local government	None	None
Oregon	Local government (< 160 acres if located on high-value farmland; < 1,280 acres if located on cultivated land or land composed of National Cooperative Soil Survey soils in capability classes I-IV; < 1,920 acres on any other land); Oregon Energy Facilities Siting Council (≥ 160 acres if located on high-value farmland; ≥ 1,280 acres if located on cultivated land or land composed of National Cooperative Soil Survey soils in capability classes I-IV; ≥ 1,920 acres on any other land)	Energy Facility Siting	Administrative Rules §345-022
Pennsylvania	Local government	None	None
Rhode Island	Local government (< 40 MW); Rhode Island Energy Facility Siting Board (≥ 40 MW)	None	§42-98-11
South Carolina	Local government	None	None
South Dakota	Local government (< 100 MW); South Dakota Public Utilities Commission (≥ 100 MW)	None	§49-41B-22
Tennessee	Local government	None	None
Texas	Local government	None	None
Utah	Local government	None	None
Vermont	Local government (< 15 KW); Vermont Public Utility Commission (≥ 15 KW)	None	30 VSA §248(b)
Virginia	Local government + Virginia Department of Environmental Quality (> 5 MW ≤ 150 MW); Virginia State Corporation Commission (> 150 MW)	Permit by Rule Guidance	§56-265.2

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**Table 2-9. Siting Authority for Large-Scale Solar Projects by State**

State	Authority Having Jurisdiction	State Siting Guidance	State Siting Review Criteria
Washington	Local government or Washington Energy Facility Site Evaluation Council (developer's choice)	None	None
West Virginia	Local government	None	None
Wisconsin	Local government + Wisconsin Public Service Commission ( $\geq 100$ MW)	None	§196.491(3)(d)
Wyoming	Local government ( $\leq 30$ MW or 100 acres); Wyoming Industrial Siting Council ( $> 30$ MW or $\geq 100$ acres)		§35-12-113(a)



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## KEY TAKEAWAYS

- Between 2014 and 2020, the total number of grid-connected solar facilities with rated capacities of at least one megawatt (MW) grew from 1,249 to 4,538.
- Technological improvements, economies of scale, and state and federal policies have helped make power from large-scale solar facilities cheaper than other sources of energy in many parts of the country.
- The demand for new large-scale solar facilities, and space to host these facilities, is likely to continue for the foreseeable future.
- The level of demand for large-scale solar development in any particular jurisdiction depends on a mix of practical constraints and the actions of various governmental and nongovernmental groups.
- Local, state, and federal agencies share responsibilities for reviewing and approving the siting of new large-scale solar facilities.
- While many large-scale solar projects are subject to both state and local review processes, local jurisdictions often retain final siting authority for most large-scale solar facilities on private or local governmental land.

## References and Resources

- Alliance for a Sustainable Future. 2020. *Mayors Leading the Way on Climate: How Cities Large and Small Are Taking Action*. Washington, D.C.: U.S. Conference of Mayors.
- America's Pledge. 2019. "Accelerating America's Pledge: Going All-In to Build a Prosperous, Low-Carbon Economy for the United States."
- Barnum, Gary R., Sara E. Bergan, Tamara L. Boeck, Eugene A. Frassetto, Seth D. Hilton, Gregory F. Jenner, Jason A. Johns, et al. 2017. *Law of Solar: A Guide to Business and Legal Issues*, 5th ed. Portland, Ore.: Stoel Rives LLP.
- Blumenstein, Lev, and Amelia Schlusser. 2019. "Renewable Energy & Direct Public Revenue in Oregon." Portland, Ore.: Lewis & Clark Law School Green Energy Institute.
- Bowen, Lauren. 2017. "The Environmental Review of Solar Farms in the Southeast U.S." Charlottesville, Va.: Southern Environmental Law Center.
- Byrne, Genevieve. 2020. *Farmland Solar Policy Design Toolkit*. Washington, D.C.: U.S. Department of Agriculture.
- Center for Climate and Energy Solutions (CCES). 2021. "State Climate Policy Maps."
- Cleary, Kathryn, and Karen Palmer. 2020. "US Electricity Markets 101." Washington, D.C.: Resources for the Future.
- Cleveland, Megan. 2017. "State Policies for Shared Renewable Energy." Washington, D.C.: National Conference of State Legislatures.
- Climate Group. 2021. "RE100 Members."
- Dobbs, Dan. 2019. "How the Tech Giants Are Fueling a Solar Revolution." *Renewable Energy World*, August 6.
- Electric Power Research Institute (EPRI). 2020. "Land Use Considerations for Large-Scale Solar: Community-Based Stormwater Strategies and Vegetation Management for Sustainable Solar PV Development." *SolSmart Issue Brief*, December.
- Farmer, Miles, and Amanda Levin. 2019. "Comparing America's Grid Operators on Clean Energy Progress: PJM Is Headed for a Climate Disaster." *Utility Dive*, July 2.
- Federal Aviation Administration. 2021. "Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports."

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Federal Energy Regulatory Commission (FERC). 2021. [“PURPA Qualifying Facilities.”](#)

Feldman, David, Vignesh Ramasamy, Ran Fu, Ashwin Ramdas, Jal Desai, and Robert Margolis. 2021. [U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark: Q1 2020](#). Golden, Colo.: National Renewable Energy Laboratory.

Gilliland, Ed, and Avery Palmer. 2020. [Large-Scale Solar Development: A Playbook for Southwest Virginia](#). Washington, D.C.: The Solar Foundation/Solar Workgroup of Southwest Virginia.

Goggin, Michael, Rob Gramlich, Steven Shparber, and Alison Silverstein. 2018. [Customer Focused and Clean: Power Markets for the Future](#). Washington, D.C.: Wind Solar Alliance.

Goss, Stephen, Fred Hoover, Glen Andersen, Megan Cleveland, and Jocelyn Durkay. 2017. [Here Comes the Sun: A State Policy Handbook for Distributed Solar Energy](#). Denver, Colo.: National Conference of State Legislatures.

Great Plains Institute. 2020. [“Indiana Renewable Energy Guide.”](#) Custer, Wis.: Midwest Renewable Energy Association.

———. 2020. [“Siting Utility-Scale Solar and Wind in Iowa: A Guide for Local Governments.”](#) Custer, Wis.: Midwest Renewable Energy Association.

———. 2020. [“Siting Utility-Scale Solar and Wind in Michigan: A Guide for Local Governments.”](#) Custer, Wis.: Midwest Renewable Energy Association.

———. 2020. [“Siting Utility-Scale Solar and Wind in Minnesota: A Guide for Local Governments.”](#) Custer, Wis.: Midwest Renewable Energy Association.

———. 2020. [“Siting Utility-Scale Solar and Wind in Wisconsin: A Guide for Local Governments.”](#) Custer, Wis.: Midwest Renewable Energy Association.

Gross, Samantha. 2020. [“Renewables, Land Use, and Local Opposition in the United States.”](#) Washington, D.C.: Brookings Institution.

Hall, Stephen. 2019. [“Largest Ever Solar Farms for Google Data Center to be Built in Alabama and Tennessee.”](#) *9to5Google*, January 17.

ISO/RTO Council (IRC). 2021. [“About the IRC.”](#)

Kavlak, Goksin, James McNerney, and Jessika E. Trancik. 2018. [“Evaluating the Causes of Cost Reduction in Photovoltaic Modules.”](#) *Energy Policy* 123: 700–10.

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Laurent, Chad, Jayson Uppal, David Morley, and Justin Barnes. 2014. "Chapter 2: Overview of the U.S. Solar Market." In *Planning for Solar Energy*. Planning Advisory Service Report 575. Chicago: American Planning Association.

Lawrence Berkeley National Laboratory (Berkeley Lab). 2020. "[Utility-Scale Solar](#)."

Lyons, Cristin, Greg Litra, and Quentin Watkins. 2020. *Informing the Transmission Discussion: A Look at Renewables Integration and Resilience Issues for Power Transmission in Selected Regions of the United States*. Scott Madden Management Consultants.

Macknick, Jordan, Courtney Lee, Gail Mosey, and Jenny Melius. 2013. *Solar Development on Contaminated and Disturbed Lands*. Golden, Colo.: National Renewable Energy Laboratory.

Massachusetts, Commonwealth of. 2021. "[Solar Massachusetts Renewable Target \(SMART\) Program](#)."

Mulholland, Denise, ed. 2018. *Quantifying the Multiple Benefits of Energy Efficiency and Renewable Energy: A Guide for State and Local Governments*. Washington, D.C.: U.S. Environmental Protection Agency.

Navigant Consulting, Inc. 2014. *Eastern Interconnection States' Planning Council Transmission Planning White Paper*. Washington, D.C.: National Association of Regulatory Utility Commissions.

National Renewable Energy Laboratory (NREL). 2012. *Utility-Scale Concentrating Solar Power and Photovoltaics Projects: A Technology and Market Overview*.

———. 2020a. "[Cambium](#)."

———. 2020. "[Solar Technology Cost Analysis](#)."

Natural Resources Defense Council (NRDC). 2020. "[Race to 100% Clean](#)."

NC Clean Energy Technology Center (NCCETC). 2021. "[DSIRE Programs](#)."

New York State Energy Research & Development Authority (NYSERDA). 2020. "[NY-SUN \(Solar Initiative\) Dashboards and Incentives](#)."

Ong, Sean, Clinton Campbell, Paul Denholm, Robert Margolis, and Garvin Heath. 2013. *Land-Use Requirements for Solar Power Plants in the United States*. Golden, Colo.: National Renewable Energy Laboratory.

Ricketts, Sam, Rita Clifton, Lola Oduyeru, and Bill Holland. 2020. "[States Are Laying a Road Map for Climate Leadership](#)." Washington, D.C.: Center for American Progress.

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Roser, Max. 2020. [“Why Did Renewables Become So Cheap So Fast? And What Can We Do to Use This Global Opportunity for Green Growth?”](#) Oxford, U.K.: Global Change Data Lab, Our World in Data.

Solar Energy Industries Association (SEIA). 2018. [“PURPA 101.”](#)

———. 2021a. [“Solar Industry Research Data.”](#)

———. 2021b. [“Solar Investment Tax Credit.”](#)

———. 2021. [“Utility-Scale Solar.”](#)

———. 2021c. [“5 Year Cost Recovery Period for Solar Energy Property.”](#)

Stevens, Landon. 2017. [“The Footprint of Energy: Land Use of U.S. Energy Production.”](#) Logan, Utah: Strata Policy.

The Nature Conservancy. 2017. [Accelerating Large-Scale Wind and Solar Energy in New York.](#) Arlington, Va.: The Nature Conservancy.

Trumbull, Kelly. 2019. [“Progress Toward 100% Clean Energy in Cities & States Across the U.S.”](#) Los Angeles: UCLA Luskin Center for Innovation.

U.S. Department of Energy. 2021. [“RAPID Toolkit: Solar Regulations and Permitting.”](#)

U.S. Energy Information Administration (USEIA). 2020a. [“Electric Power Annual 2019.”](#)

———. 2020b. [“Form EIA-860 Detailed Data With Previous Form Data.”](#)

———. 2021a. [“Annual Energy Outlook 2021.”](#)

———. 2021b. [“Electric Power Monthly: December 2020.”](#)

———. 2021. [“Preliminary Monthly Electric Generator Inventory.”](#)

U.S. Environmental Protection Agency. 2020. [“Permit Program under CWA Section 404.”](#)

U.S. Environmental Protection Agency. 2021. [“National Pollutant Discharge Elimination System \(NPDES\).”](#)

U.S. Fish and Wildlife Service. 2020. [“Energy Development: Permits, Policies, and Authorities.”](#)

Yazykova, Sofia, Jim McElfish, and Lovinia Reynolds. 2019. [Corporate Statements About the Use of Energy: What Does the “100% Renewable” Goal Really Mean?](#) Washington, D.C.: Environmental Law Institute.





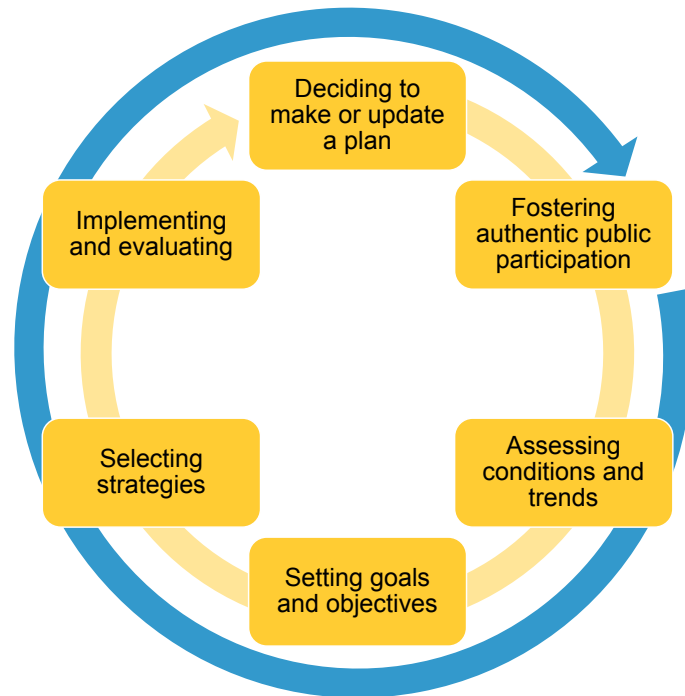
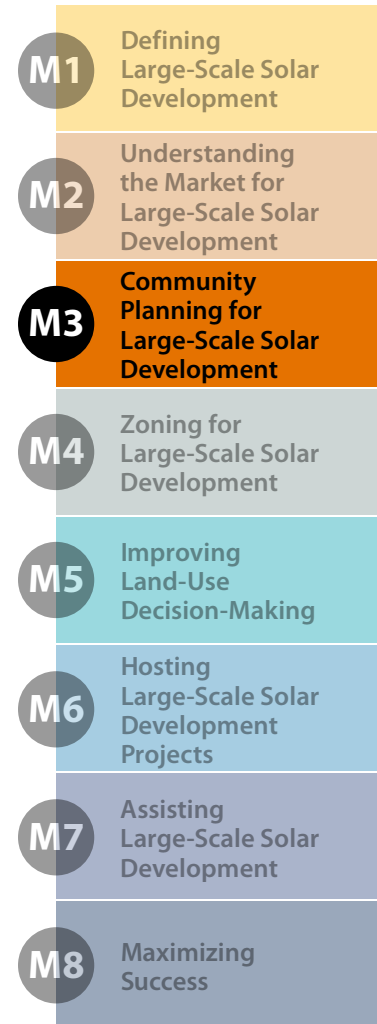
## **MODULE**

# **3**

### **COMMUNITY PLANNING FOR LARGE-SCALE SOLAR DEVELOPMENT**



Cities, towns, and counties use community planning processes to chart their courses for more sustainable and livable futures (Figure 3-1). By establishing shared visions and goals for large-scale solar development, local jurisdictions will be better positioned to maximize the benefits and minimize the tradeoffs of community- and utility-scale solar projects.



Planning processes can help community members identify and begin to break down unintentional barriers to large-scale solar development. They can also provide space for challenging conversations about how different types of large-scale solar projects may affect different segments of the community. Through these processes, local jurisdictions can start laying the groundwork for an equitable distribution of impacts and benefits.

This module outlines five steps local jurisdictions can take to define and integrate a vision and policy support for large-scale solar development into local plans. The first step is deciding to make or update a plan. The next steps are fostering authentic public participation, assessing conditions and trends, and setting goals and objectives. The final step is selecting strategies to advance those goals and objectives. Subsequent modules explore plan implementation and evaluation.

Figure 3-1. The community planning process, rooted in authentic public participation

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### Deciding to Make or Update a Plan

Community planning for large-scale solar development begins with a commitment to make a new plan or to update an existing plan. From a practical perspective, local plans provide a framework to guide public and private decisions about community growth, preservation, and change. From a legal perspective, plan language and maps establish policy support for land-use and development regulations, land-use decisions, and public investments of time or money.

Local jurisdictions can establish policy support for large-scale solar development in the context of a broader comprehensive, functional, or subarea plan-making or plan-updating process. Alternatively, some jurisdictions

may choose to start a new plan-making process to focus specifically on large-scale solar development. In either case, local elected officials can initiate a planning effort by adopting a local resolution or executive order.

### Resolutions and Orders

The local legislative body can establish formal political support for a new or updated plan through a resolution or policy statement (Table 3-1). Alternatively, a chief elected official can issue an executive order or proclamation that serves a similar function. This resolution or order should first clearly and concisely express the reasons why solar energy is relevant or appropriate for the community. Then, it can outline the specific policies, plans, programs,

**Table 3-1. Examples of Resolutions and Policy Statements That Support Large-Scale Solar Development**

Jurisdiction	Policy	Key Features
Butte County, CA	<a href="#">Utility-Scale Solar Guide Vision Statement and Guiding Principles</a> (2017)	<ul style="list-style-type: none"> <li>Presents a vision for the role of large-scale solar development in the county</li> <li>Lists 14 guiding principles for implementation</li> </ul>
Multnomah County, OR	<a href="#">Resolution 2017-046</a> (2017)	<ul style="list-style-type: none"> <li>Sets a goal of meeting 100% of communitywide energy needs through renewable sources by 2050</li> <li>Sets a target of supplying 2% of all energy needs with community-based renewable energy projects by 2035</li> <li>Prioritizes projects that will provide local benefits to communities of color, women, tribes and native communities, and low-income utility customers</li> </ul>
St. Lawrence County, NY	<a href="#">Resolution 132-2020</a> (2020)	<ul style="list-style-type: none"> <li>Encourages solar development on marginal farmland and the co-location of sheep grazing and apiaries</li> <li>Encourages community-serving solar projects</li> <li>Requires payment in lieu of taxes for projects that sell electricity to the grid</li> </ul>

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and land-use regulations that the jurisdiction might implement to encourage large-scale solar development.

For example, the Pace Land Use Law Center’s **Model Solar Energy Resolution** expresses a commitment to craft a strategy for solar development at all scales (Bacher, Nolon, and Zezula 2015). It establishes a task force to study the issue and directs this task force to engage the community, staff, and other stakeholders to develop plans, programs, and regulations to advance the use of solar energy.

*The Comprehensive Plan*

The local comprehensive plan, sometimes referred to as the general plan or the master plan, is the foundational policy document for local governments. The comprehensive plan provides legal support for local land-use and development regulations and decisions. In fact, many states require zoning regulations and

land-use decisions to be in conformance with an adopted comprehensive plan. Ideally, the local comprehensive plan also serves as the primary guide for programmatic and capital investments.

At a minimum, the local comprehensive plan should provide clear policy direction about which areas of the jurisdiction are appropriate for large-scale solar development (**Table 3-2**). Ideally, the plan should support this policy direction by

- explaining that energy from the sun is a free, abundant local resource;
- acknowledging the benefits associated with large-scale solar development;
- describing large-scale solar development opportunities and conflicts; and

**Table 3-2. Examples of Comprehensive Plans That Address Large-Scale Solar Development**

Jurisdiction	Plan	Key Features
Pinal County, AZ	<b>Comprehensive Plan</b> (2019)	Planning guidelines specify that solar projects are compatible with the county’s farming heritage (p.85) Land-use map designates “Green Energy Production” areas for large-scale PV projects (B1)
San Bernardino County, CA	<b>Countywide Plan</b> (2020)	Renewable Energy & Conservation Element (RECE) includes guiding principles for large-scale solar projects RECE designates permissible sites for large-scale solar projects
Stearns County, MN	<b>Shape Stearns: 2040 Comprehensive Plan</b> (2020)	Agriculture element includes a Clean Energy Focus Area Element encourages solar development throughout the county Recommends siting solar projects in ways that reduce land-use conflicts and continuing to require habitat-friendly ground cover on project sites

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- setting targets for the amount of locally produced solar power.

**Functional Plans**

Functional plans are standalone plans for systems or special topics that have spatial planning implications, but are not limited to a single subarea of community. Common examples include energy plans and sustainability or climate action plans.

Local jurisdictions can use a new or updated functional plan to detail a vision and a clear policy direction for large-scale solar development (Table 3-3). However, standalone functional plans do not have the same statutory authority as the comprehensive plan. Consequently, local elected officials should either adopt the functional plan by reference as a component of the comprehensive plan or adopt a comprehensive plan update that incorporates the functional plan’s fact base and policy recommendations.

Table 3-3. Examples of Functional Plans That Address Large-Scale Solar Development		
Jurisdiction	Plan	Key Features
Boise, ID	<a href="#">Boise’s Energy Future: A Community-wide Energy Plan</a> (2019)	<ul style="list-style-type: none"> <li>Recommends increasing community-scale shared solar installations as a short-term strategy</li> <li>Recommends supporting utility-scale solar projects as a long-term strategy</li> </ul>
Raleigh, NC	<a href="#">Community Climate Action Plan</a> (2021)	Recommends evaluating the potential for solar projects on vacant, underutilized, or open spaces, such as a closed landfill site and water district sites
Santa Barbara County, CA	<a href="#">Strategic Energy Plan</a> (2019)	<ul style="list-style-type: none"> <li>Analyzes total solar power potential</li> <li>Discusses opportunities and obstacles for utility-scale solar projects</li> <li>Recommends sites for utility-scale solar development</li> </ul>

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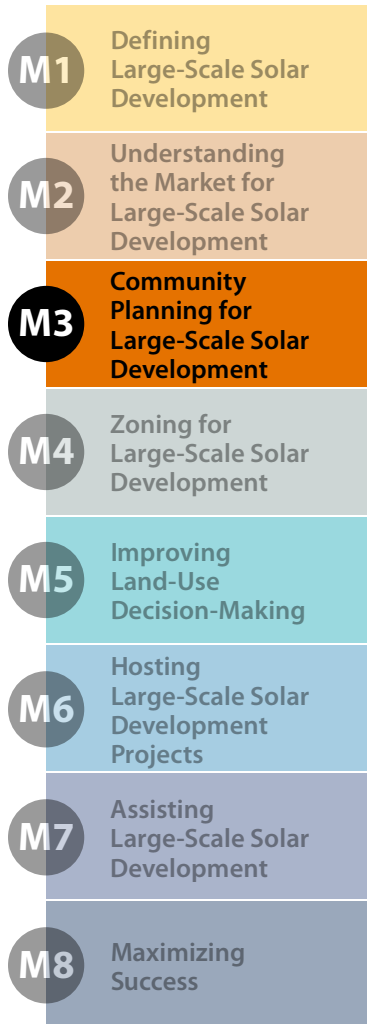
### Subarea Plans

Subarea plans focus on issues of particular importance to a limited contiguous area within a jurisdiction, such as a neighborhood, corridor, or district. Local jurisdictions can use a new or updated subarea plan to signal support for large-scale solar development on a specific site or on multiple sites in the plan area (Table 3-4).

As with functional plans, local elected officials should either adopt the subarea plan by reference into their comprehensive plan or update relevant sections to reflect the community’s new vision for the neighborhood, corridor, or district.

**Table 3-4. Examples of Subarea Plans That Address Large-Scale Solar Development**

Jurisdiction	Plan	Key Features
Dayton, OH	<a href="#">Carillon-Edgemont Neighborhood Plan</a> (2018)	Recommends reusing the site of a former factory for a large-scale solar installation
Pinellas County, FL	<a href="#">Pinellas Gateway/Mid-County Area Plan</a> (2020)	Establishes a vision for a 240-acre solar project on a former landfill site Encourages large rooftop solar installations on industrial buildings
Portland, OR	<a href="#">Sullivan’s Gulch Neighborhood Plan</a> (2019)	Climate Action section includes support for a community solar initiative that would allow local sponsorship and investment in large-scale projects Encourages large rooftop solar installations on commercial buildings



### Fostering Authentic Public Participation

The next step after a local jurisdiction has made a formal commitment to plan for large-scale solar development is fostering authentic public participation. As

[Figure 3-1](#) suggests, it should also be, ideally, a continuous process unto itself. An authentic public participation process actively involves all segments of the community in analyzing issues, generating visions, developing plans, and monitoring outcomes (Godschalk and Rouse 2015). It stands in contrast to processes designed to satisfy the minimum legal requirements for soliciting public input—which typically leads to engagement efforts that exclude or marginalize some population groups.

To foster authentic public participation, local officials must engage key stakeholder groups and design the planning process in a way that upholds principles of inclusivity.

### Stakeholder Engagement

Each local jurisdiction has a distinct set of key stakeholders for large-scale solar development based on its physical, social, and economic context and characteristics. Potential stakeholders include individuals and organizations with specialized knowledge about the technical or practical requirements of solar development, groups that may benefit directly from solar development, and groups that may have concerns about how solar development might affect their quality of life ([Table 3-5](#)).

### Process Design

Inclusivity in planning means that all community members feel welcome to participate and are confident that their participation can positively affect outcomes. The Kirwan Institute has outlined six key principles for equitable and inclusive civic engagement (Holley 2016):

- Embrace the gifts of diversity.
- Realize the role of race, power, and injustice.
- Practice radical hospitality.
- Build trust and commitment.
- Honor dissent and embrace protest.
- Adapt to community change.

Most importantly, process leaders should provide multiple ways for community stakeholders to participate throughout the planning effort. Furthermore, they should select appropriate tools and methods based on the purpose of each planning activity ([Table 3-6](#)).

Finally, process leaders should make efforts to reduce barriers to participation for traditionally marginalized or underrepresented segments of the community. These



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**Table 3-5. Potential Stakeholder Groups to Engage in Planning for Large-Scale Solar Development**

Stakeholder Group	Potential Interests in Large-Scale Solar Development
Local elected officials	Responsible for approving plans, regulations, and public investments that affect the location, timing, and amount of solar development
Local government staff and appointed officials	Responsible for administering plans, regulations, and public investments that affect the location, timing, and amount of solar development
Residents	May be interested in how solar development could affect electricity costs, home values or rents, the local economy, community appearance, or various other issues
Business owners	May be interested in how solar development could affect electricity costs, the local economy, community appearance, or various other issues
Farmers and other large landowners	May be interested in hosting a large-scale solar project or how solar development could affect electricity costs, property values, the local economy, community appearance, or various other issues
Community-based service and development organizations	May be interested in how solar development could affect the quality of life in specific neighborhoods or service areas
Social equity and environmental justice organizations	May be interested in ensuring that solar development benefits low- and moderate-income households, renters, or marginalized ethnic or racial groups
Economic development organizations	May be interested in how solar development could affect the local economy
Environmental protection and land conservation organizations	May be interested in how solar development could affect greenhouse gas emissions, land cover and habitat, air and water quality, or ecosystem services
Electric utilities	Responsible for managing the interconnection of large-scale solar projects; may be interested in owning or purchasing power from large-scale solar facilities
Regional transmission authorities	Responsible for coordinating, controlling, and monitoring the transmission network across a defined regional grid
Solar industry	May be interested in participating in large-scale solar development
Representatives of neighboring jurisdictions	May have prior experiences with large-scale solar development or be interested in how solar development in a neighboring jurisdiction could affect electricity costs, the local economy, or various other issues in their jurisdictions

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**Table 3-6. Potential Purposes of Different Public Participation Tools and Methods**

Tool or Method	Potential Purpose
In-person or online workshops	Focused discussions about solar development issues, potential policy goals and objectives, and implementation strategies
In-person or online focus groups or listening sessions	Identifying solar development issues that merit further discussion
Online or printed surveys	Identifying or prioritizing solar development issues that merit further discussion
Interviews	Learning more about how specific solar development issues may affect different segments of the community
Neighborhood meetings	Focused discussions about the solar development issues of greatest interest to residents of specific neighborhoods
Booths at community events	Building awareness about the planning effort and participation opportunities
Committees or task forces	Providing process oversight or developing policy recommendations
Project websites	Sharing information about the planning effort and participation opportunities or soliciting feedback on solar development issues or draft plan components through web forms, interactive maps, or other online engagement tools
Social media	Sharing information about the planning effort and participation opportunities or soliciting feedback on solar development issues or draft plan components

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barriers may stem from family or work responsibilities, language or literacy, transportation or accessibility, a lack of trust, or various other factors (García, Garfinkel-Castro, and Pfeiffer 2019).

There are several potential strategies leaders may be able to use to broaden participation:

- Partner with community-based organizations to help recruit participants and plan activities.
- Provide refreshments or childcare.
- Select locations accessible by transit or help with alternative transportation arrangements.
- Communicate to participants in their own language or offer translation services, including closed captioning or sign-language interpretation.

### Assessing Current Conditions and Trends

Collecting and analyzing baseline and trend data relevant to local large-scale solar development helps ensure that local elected officials and planning process participants have the best available information to guide planning efforts. Ideally, data collection and analysis should continue throughout the plan-making process as new issues surface. However, data about local electricity consumption and production, the existing policy framework for solar development, and local solar development potential can help structure early conversations about large-scale solar development issues.

#### *Electricity Consumption and Production*

Documenting the pattern of electricity consumption and production in a jurisdiction can help planning process participants understand what role, if any, solar energy systems currently play in meeting local energy needs.

Participants should have access to information about how much power the community needs now, the sources of that power, and how much power the community will need in the future. This includes information about the number, size, location, and customer base of any existing and planned large-scale solar facilities in the community. This knowledge better equips participants to make informed decisions about the role large-scale solar development may play in meeting or offsetting local power demands.

Planners and local government managers will likely need to obtain much of this information from the local utility.

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### Existing Policy Framework

Documenting the existing policy framework for large-scale solar development in a jurisdiction can help planning process participants understand the community's current solar development conditions and the approach local planning officials would use to handle land-use applications for solar development.

This existing policy framework consists of any previously adopted federal, state, local, and utility plans or policies that affect where and how developers can site community- or utility-scale solar projects in a jurisdiction (see [Module 2](#)). At a minimum, participants should have access to information about state siting processes for large-scale solar projects and any solar-specific policy language in local plans and regulations.

Planners and local government managers can supplement their knowledge of the existing framework by reaching out to their counterparts in state energy offices, local utilities, and regional planning agencies (as well as other previously identified key stakeholders).

### Development Potential

Documenting the potential for large-scale solar development in a jurisdiction can help planning process participants understand practical limitations on the number, size, and types of projects that the community could accommodate.

This potential starts with an assessment of the quality of the local solar resource, which is the amount of solar insolation, or the amount of sunlight per square meter per day, available across the community. While latitude and average cloud cover are the base conditions for this resource, topography and shading from trees or buildings affect the solar potential for specific sites. Apart from the quality of the solar resource, the location and capacity of the local power distribution and transmission network and the amount of available land near this network also constrain the total potential for large-scale solar development (see [Module 2](#), [6](#), and [8](#)).

Planners and local government managers can use the National Renewable Energy Laboratory's [State and Local Planning for Energy](#) (SLOPE) Platform to help assess the local solar resource and solar development potential ([Figure 3-2](#)). Beyond this, many state energy offices, regional planning agencies, and colleges and universities have expertise in geographic information systems, generally, or solar mapping, specifically, that planning process leaders can draw on, if necessary, to help refine assessments based on local conditions.

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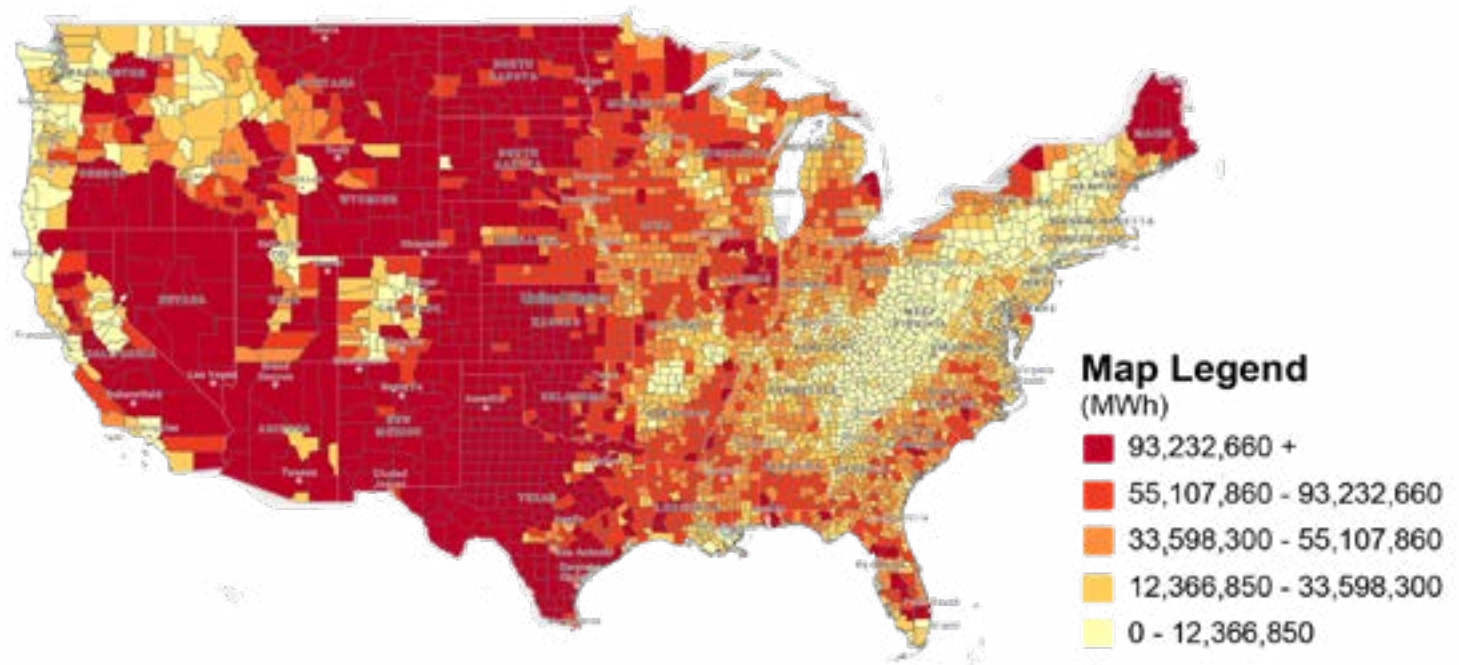


Figure 3-2. Modeled annual technical generation potential by county for utility-scale PV systems from the [State and Local Planning for Energy \(SLOPE\) Platform](#) (Source: NREL)

**Issue Identification and Prioritization**

Before planning process participants can agree on shared goals and objectives for large-scale solar development, they must share an understanding of the relative importance of different solar development issues. Often, these issues relate to the benefits and tradeoffs highlighted in [Module 1](#).

The following questions may help process leaders and facilitators begin to draw out the most significant issues for stakeholders in their community (Bacher, Nolon, and Zezula 2015):

- How might large-scale solar development benefit you, your organization, or the community?
- What are your biggest concerns about large-scale solar development?
- What are some strategies for overcoming these concerns?

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## Setting Goals and Objectives

After participants identify and prioritize large-scale solar development issues and explore relevant conditions and trends, process leaders should shift the focus to setting goals and objectives. In this context, a goal is a general statement about a desirable future condition, while an objective is a measurable outcome in furtherance of a certain goal. Together, goals and objectives define what the local jurisdiction aims to achieve with respect to large-scale solar development.

Potential themes for these goals and objectives include—but are not limited to—transitioning to clean energy, low-impact siting and design, equitable development, and community resilience. The specific goals and objectives in the plan should reflect the shared values and priorities of the community.

### *Clean Energy Transition*

For some local jurisdictions, community- or utility-scale solar development is one component of a broader commitment to mitigate climate change by producing or purchasing enough clean power to offset total electricity demand (see [Module 2](#)). Planning process participants can advance clean energy goals by formulating an objective to offset a specific percentage of their jurisdiction's electricity demand through local large-scale solar development.

### *Low-Impact Siting and Design*

Many local jurisdictions want to prioritize new development on infill and previously developed sites over development on previously undeveloped (i.e., greenfield) and culturally or historically significant sites. And when development does occur on lower-priority sites, they want to ensure it preserves

or enhances ecological functions, including stormwater infiltration and wildlife habitat. Furthermore, many rural jurisdictions and jurisdictions on the urban fringe want to minimize the impacts of new development on working farms or locally significant agricultural lands.

Collectively, these priorities fit under the wider concept of low-impact siting and design. Planning process participants can advance low-impact siting and design goals by formulating objectives that encourage large-scale energy development that is compatible with land preservation and environmental performance targets.

### *Equitable Development*

A growing number of local jurisdictions are making a commitment to ensure that all segments of the community have a voice in and benefit from decisions related to growth and change. This commitment acknowledges a legacy of inequitable development outcomes, which occur when neighborhoods or population groups are under-resourced due to past policy and investment decisions and under-represented during planning and development processes. These neighborhoods or population groups often bear a disproportionately large share of the harmful effects of new development projects instead of capturing the benefits of those projects.

Planning process participants can advance equitable development goals by formulating objectives that encourage large-scale development projects that benefit all segments of the community.

### *Community Resilience*

Many local jurisdictions have identified a need to enhance local resilience to climate change and extreme



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weather events as a priority planning issue. Planning process participants can advance community resilience goals by formulating objectives encouraging large-scale solar development projects that incorporate energy storage or function as components of microgrids (see [Module 8](#)).

### Selecting Strategies

The final step in creating a new or updated plan to manage large-scale solar development is connecting each objective to an implementation strategy. Potential strategies may include—but are not limited to—a mix of zoning updates, process improvements, development partnerships, and technical or financial assistance programs.

### Zoning Updates

Local officials can use zoning to designate permissible locations and site design features for community- and utility-scale solar development. Zoning updates may focus on defining key terms, specifying permissible uses, or establishing development and procedural standards and development charges (see [Module 4](#)).

### Process Improvements

Local officials can use discretionary land-use decision-making processes to increase the benefits and reduce the tradeoffs of specific community- or utility-scale solar projects. Process improvements may focus on the quality of applicant submissions, development review procedures, community benefit negotiations, staff reports and written decisions, or project inspections (see [Module 5](#)).

### Development Partnerships

Local jurisdictions may have opportunities to help meet large-scale solar development objectives by hosting community- or utility-scale projects on local government land. Strategies that include hosting projects may address project goals and selecting potential sites and development partners (see [Module 6](#)).

### Technical or Financial Assistance

In some cases, local officials may choose to create technical or financial assistance programs to help meet large-scale solar development objectives (see [Module 7](#)). Strategies that include technical or financial assistance programs may address eligibility, assistance options, or funding sources, among other topics.

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## KEY TAKEAWAYS

- Community planning for large-scale solar development begins with a commitment to make a new plan or to update an existing plan.
- At a minimum, the local comprehensive plan should provide clear policy direction about which areas of the jurisdiction are appropriate for large-scale solar development.
- Local officials can foster authentic public participation by engaging key stakeholders as soon as possible and designing the planning process in a way that upholds principles of inclusivity.
- Collecting and analyzing baseline and trend data relevant to local large-scale solar development helps ensure that local elected officials and planning process participants have the best available information to guide planning efforts.
- Plan goals and objectives may address transitioning to clean energy, low-impact siting and design, equitable development, community resilience, or other themes of local interest.
- Potential plan implementation strategies include zoning updates, process improvements, development partnerships, and technical or financial assistance programs.

## References and Resources

American Planning Association. 2021. “[Research KnowledgeBase: Online Public Engagement](#).”

———. 2021. “[Research KnowledgeBase: Solar Energy](#).”

Arigoni, Danielle, William Armbruster, Melissa Stanton, Mike Watson, Rebecca Delphia, Victoria Lemley, and Patricia Oh. 2018. *Roadmap to Livability: Community Listening Session Toolkit*. Washington, D.C.: AARP.

Bacher, Jessica, John Nolon, and Tiffany Zezula. 2015. *Land Use Planning for Solar Energy: Resource Guide*. White Plains, N.Y.: Pace University Land Use Law Center.

Baker, Shalanda, Subin DeVar, and Shiva Prakash. 2019. *The Energy Justice Workbook*. Boston: Initiative for Energy Justice.

Bryson, John M., Kathryn S. Quick, Carissa Schively Slotterback, and Barbara C. Crosby. 2012. “[Designing Public Participation Processes](#).” *Public Administration Review* 73(1): 23–34.

Calvert, Kirby. 2019. *Mapping Opportunities for Land-Based Renewable Energy Generation in Ontario: A Guidebook for Local Planners and Analysts*. Guelph, Ontario: Community Energy Knowledge and Action Partnership.

Coffey, Darren. 2019. “[Planning for Utility-Scale Solar Energy Facilities](#).” *PAS Memo*, September/October.

Curti, Julie, Farrah Andersen, and Kathryn Wright. 2018. *A Guidebook on Equitable Clean Energy Program Design for Local Governments and Partners*. Waltham, Mass.: Cadmus Group.

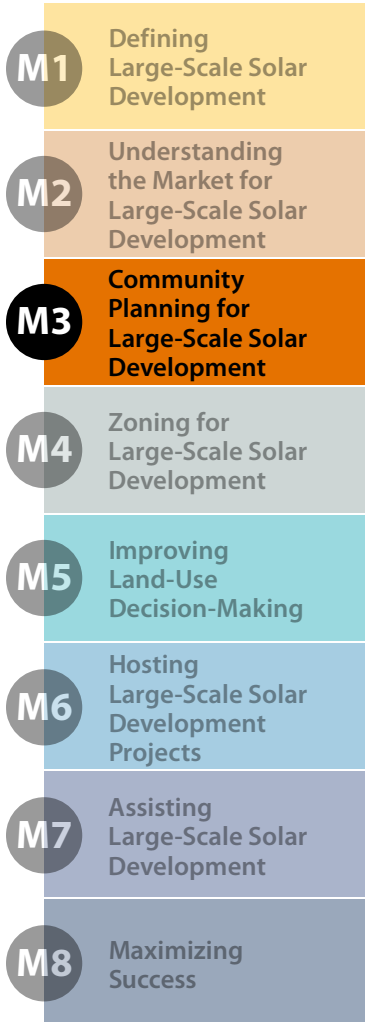
García, Ivis, Andrea Garfinkel-Castro, and Deirdre Pfeiffer. 2019. *Planning With Diverse Communities*. Planning Advisory Service Report 593. Chicago: American Planning Association.

Gilliland, Ed, and Avery Palmer. 2020. *Large-Scale Solar Development: A Playbook for Southwest Virginia*. Washington, D.C.: The Solar Foundation.

Great Plains Institute. 2020. “[Grow Solar Toolkits](#).” Custer, Wis.: Midwest Renewable Energy Association.

Godschalk, David, and David Rouse. 2015. *Sustaining Places: Best Practices for Comprehensive Plans*. Planning Advisory Service Report 578. Chicago: American Planning Association.

Gonzalez, Rosa. 2017. *Community-Driven Climate Resilience Planning: A Framework*. Oakland, Calif.: National Association of Climate Resilience Planners.



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Holley, Kip. 2016. *The Principles for Equitable and Inclusive Civic Engagement*. Columbus, Ohio: Kirwan Institute.

Institute for Local Government. 2015. "Inclusive Public Engagement."

Metropolitan Council. 2015. "Solar Resource Development Requirement." In *Local Planning Handbook*.

Michigan Economic Development Corporation (MEDC). 2019. "Six-Step Guide to Public Participation: An Outline for How a Community May Organize Its Public Participation Strategy."

Miskowiak, Douglas. 2004. "Crafting an Effective Plan for Public Participation." Stevens Point, Wis.: Center for Land Use Education.

Morley, David, ed. 2014. *Planning for Solar Energy*. Planning Advisory Service Report 575. Chicago: American Planning Association.

National Renewable Energy Laboratory. 2021. "SLOPE: State and Local Planning for Energy."

Ramanan, Abbe, Shauna Beland, Yasmin Yacoby, and Nicole Hernandez Hammer. 2021. *Community Outreach and Solar Equity: A Guide for States on Collaborating With Community-Based Organizations*. Washington, D.C.: Clean Energy States Alliance.

Rhode Island Office of Energy Resources and the Division of Statewide Planning. 2019. *Comprehensive Plans & Solar Energy Systems*.

Scenic Hudson. 2020. "Solar Mapping Tool Replication Guide."

Sen, Basav, Griffin Bird, and Celia Bottger. 2018. *Energy Efficiency with Justice: How State Energy Efficiency Policy Can Mitigate Climate Change, Create Jobs, and Address Racial and Economic Inequality*. Washington, D.C.: Institute for Policy Studies.

SolSmart. 2019. "Tools to Help Local Governments With Solar Planning & Deployment."

———. 2021. "Stakeholder Engagement." In *Solar Energy: SolSmart's Toolkit for Local Governments*.

Spalding, Kristen Snow. 2020. "Practices for Just, Equitable and Sustainable Development of Clean Energy." Boston: Ceres.

Yuen, Tina, and Jessica Nguyen. 2020. *The Planner's Playbook: A Community-Centered Approach to Improving Health & Equity*. Oakland, Calif.: ChangeLab Solutions.

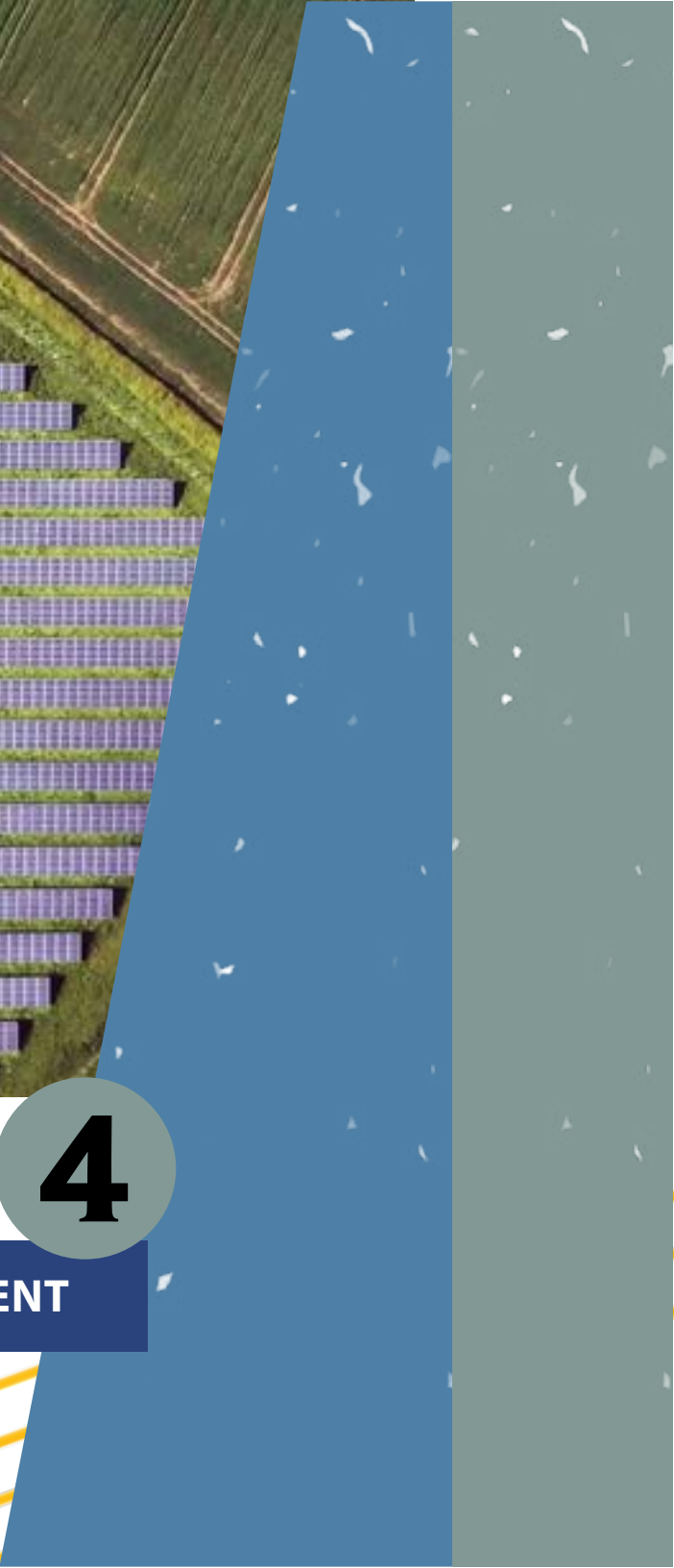




# MODULE

# 4

## ZONING FOR LARGE-SCALE SOLAR DEVELOPMENT



Zoning and other land-use and development regulations are perhaps the most powerful tools that local jurisdictions have at their disposal to help implement community plans. Local land-use and development codes that explicitly acknowledge large-scale solar development as a distinct, permissible, land use can help local officials maximize the benefits and minimize the tradeoffs of community- and utility-scale solar projects.

Local officials can use explicit regulations to ensure solar projects are consistent with the community’s vision and goals for large-scale solar development, as expressed in the local comprehensive plan (or other official plans) (see [Module 3](#)). Furthermore, explicit regulations for solar development provide a degree of certainty to community members and solar developers about local requirements for different types of solar development.

The following sections highlight the importance of defining key terms, specifying permissible uses, and establishing appropriate standards and development charges for large-scale solar development ([Figure 4-1](#)). While this discussion references zoning as the primary regulatory tool, most jurisdictions without zoning should still be able to address these issues through a standalone ordinance governing solar energy systems.

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Figure 4-1. Opportunities to address large-scale solar development through zoning



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## Defining Key Terms

Local zoning codes define key terms to clarify the meaning of regulatory provisions and to improve the consistency of development review processes. Without clear, solar-specific definitions, planning officials typically make ad-hoc determinations about how specific provisions relate to a large-scale solar development proposal.

Officials may decide that large-scale solar development is analogous to an existing defined or referenced use and apply existing use permissions and standards for that existing use to new applications for large-scale solar development. Alternatively, they may decide that solar development is unlike any land use defined or referenced in existing regulations. In this instance, officials may determine that solar development is prohibited altogether or that it is subject to an unpredictable discretionary review process.

Regulating large-scale solar development as a distinct land use starts with clear definitions of different sizes and types of solar energy systems. Furthermore, defining related terms can make it easier to promote specific development outcomes and avoid legal disputes.

### *Systems of Different Types and Sizes*

The foundational component of all large photovoltaic installations is the solar energy system. A solar energy system consists of solar collectors and all associated mounting hardware and equipment.

There are at least three common approaches to defining solar energy systems as distinct land uses based on the following factors:

- The relationship of the system to other structures
- The relationship between the system and any other land uses on the same parcel
- The size of the system

Many local zoning codes define both roof-mounted (or rooftop) and ground-mounted (or freestanding) solar energy systems ([Table 4-1](#)). Some of these also define building-integrated systems as a third category. Rooftop and building-integrated systems fit within the building footprint of structures designed for, or dedicated to, other purposes. In contrast, freestanding systems require land not occupied by other structures.

In zoning, a principal use is the primary or predominant use of a lot, and accessory uses and structures must be customarily associated with and subordinate to a principal use. While virtually all zoning codes differen-

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**Table 4-1. Examples of Use Definitions for Solar Energy Systems**

Use	Definition
Roof-mounted solar energy system	A solar energy system mounted on a rack that is fastened to or ballasted on a structure roof. Roof-mounted systems are accessory to the principal use. ( <a href="#">Grow Solar Model Ordinances 2020</a> )
Building-integrated solar energy system	A solar energy system that is an integral part of a principal or accessory building, rather than a separate mechanical device, replacing or substituting for an architectural or structural component of the building. ( <a href="#">Grow Solar Model Ordinances 2020</a> )
Ground-mounted solar energy system	A solar energy system mounted on a rack or pole that rests or is attached to the ground. Ground-mounted systems can be either accessory or principal uses. ( <a href="#">Grow Solar Model Ordinances 2020</a> )
Small-scale solar energy system	A ground-mounted solar energy system with a footprint of less than [1–5] acres. ( <a href="#">Georgia Model Solar Ordinance 2018</a> )
Medium-scale [or community-scale] solar energy system	A ground-mounted solar energy system with a footprint of between [1–5] and [15–50] acres. ( <a href="#">Georgia Model Solar Ordinance 2018</a> )
Large-scale [or utility-scale] solar energy system	A ground-mounted solar energy system with a footprint of more than [15–50] acres. ( <a href="#">Georgia Model Solar Ordinance 2018</a> )

tiating between accessory and principal uses, few define the accessory and principal versions of a use as distinct land-use categories. Solar energy systems are noteworthy exceptions in some local zoning codes.

When local codes use definitions to distinguish between accessory and principal-use (or primary-use) solar energy systems, they often include references to the intended recipient of the power produced by the system. Furthermore, many codes seem to use distinctions between accessory and principal systems as a proxy for system size. In practice, it’s prohibitively difficult for local jurisdictions to monitor or enforce restrictions on where power from grid-connected systems travels, and system size has no inherent relationship to other uses on the same lot.

Consequently, planning officials should define

ground-mounted systems of different sizes as distinct land uses, rather than relying on distinctions between accessory and principal systems. Some local codes that define systems by size reference the rated capacity of the system to determine whether a particular system is small or large (or in between). Others use the site or surface area required to host the system.

Generally, definitions tied to site or surface area are preferable to those tied to rated capacity since area has a direct relationship to potential land-use impacts. However, because some states preempt local permitting authority for systems over a certain rated capacity (see [Module 2, Table 2-9](#)), there can be benefits to referencing both in size-based definitions. When officials base the thresholds for different sizes on average lot or block

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sizes in different parts of the community, it can help them establish use permissions that better protect the existing development pattern.

### *Other Solar-Related Terms*

Definitions for other solar-related terms can reduce ambiguity in development standards for large-scale solar projects. Additionally, local jurisdictions can use supplementary definitions to lay the foundation for regulations that advance specific policy goals (Table 4-2).

Many local zoning codes include definitions for different components of solar energy systems, such as solar collector, array, inverter, solar mounting devices, and solar storage battery. Some also define related equipment and facilities that are separate from the system itself, such as interconnection, transmission equipment, and substation. These terms can help users better understand what constitutes a solar energy system and how a large system relates to a wider network of utility infrastructure.

Some local zoning codes define terms that can help users understand the effects of specific development standards. These terms include tilt and footprint or solar land coverage. Solar energy systems with tracking devices have different heights at different times of the day and year because their solar collectors tilt up and down as they track the sun across the sky. By defining tilt in this context, planning officials can specify that systems at maximum tilt must satisfy height limits. Similarly, because large systems typically include spaced rows of separately mounted arrays, jurisdictions should not apply traditional



Figure 4-2. A farmer tilling soil at Jack's Solar Garden, a five-acre community-scale agrivoltaic installation in Longmont, Colorado (Photo by Werner Slocum / NREL)

definitions of lot coverage to these systems. Officials can define footprint or solar land coverage to clarify how lot coverage or impervious surface area restrictions apply to these systems.

Finally, some local zoning codes define preferred solar development scenarios as distinct system types or land uses. For example, jurisdictions that want to promote the collocation of solar development and agricultural activities or pollinator habitat may choose to define agrivoltaics (Figure 4-2) or pollinator-friendly solar energy system. And jurisdictions that want to promote solar development on previously developed and potentially contaminated sites may choose to define brightfield.

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**Table 4-2. Examples of Definitions for Other Solar-Related Terms**

Term	Definition
Battery energy storage system	One or more devices, assembled together, capable of storing energy in order to supply electrical energy at a future time, not to include a stand-alone 12-volt car battery or an electric motor vehicle. A battery energy storage system is classified as a Tier 1 or Tier 2 Battery Energy Storage System as follows:  A. Tier 1 Battery Energy Storage Systems have an aggregate energy capacity less than or equal to 600kWh and, if in a room or enclosed area, consist of only a single energy storage system technology.  B. Tier 2 Battery Energy Storage Systems have an aggregate energy capacity greater than 600kWh or [comprise] more than one storage battery technology in a room or enclosed area. ( <a href="#">NYSERDA Battery Energy Storage System Model Law 2020</a> )
Tilt	The angle of the solar panels and/or solar collector relative to horizontal. Tilt is often between 5 and 40 degrees. Solar energy systems can be manually or automatically adjusted throughout the year. Alternatively, fixed-tilt systems remain at a static tilt year-round. ( <a href="#">Model Site Plan Regulations and Conditional Use Permits to Support Solar Energy Systems in Maine Municipalities 2020</a> )
Footprint	The footprint of a ground-mounted solar energy system (SES) is calculated by drawing a perimeter around the outermost SES panels and any equipment necessary for the functioning of the SES, such as transformers and inverters. The footprint does not include any visual buffer or perimeter fencing. Transmission lines (or portions thereof) required to connect the SES to a utility or consumer outside the SES perimeter shall not be included in calculating the footprint. ( <a href="#">Georgia Model Solar Ordinance 2018</a> )
Solar land coverage	The land area that encompasses all components of the solar collection system including but not limited to mounting equipment, panels and ancillary components of the system. This definition does not include access roads or fencing and is not to be interpreted as a measurement of impervious surface as it may be defined in this ordinance. ( <a href="#">NHSEA Model Solar Zoning Ordinance 2018</a> )
Agrivoltaics	A solar energy system co-located on the same parcel of land as agricultural production, including crop production, grazing, apiaries, or other agricultural products or services. ( <a href="#">Grow Solar Model Ordinances 2020</a> )
Pollinator-friendly solar energy system	A community- or large-scale solar energy system that meets the requirements of the 2020 Indiana Solar Site Pollinator Habitat Planning Scorecard developed by Purdue University or another pollinator-friendly checklist developed by a third party as a solar-pollinator standard designed for Midwestern ecosystems, soils, and habitat. ( <a href="#">Model Solar Ordinance for Indiana Local Governments 2020</a> )
Brightfield	A brownfield site that is redeveloped through the incorporation of 1 or more solar energy technologies. ( <a href="#">42 USC 3154d(a)</a> )

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### Specifying Permissible Uses

Zoning codes commonly include one or more agricultural, residential, commercial (or mixed residential and commercial), industrial, and open space zoning districts. Each district has a distinct intent and is governed by a distinct set of zoning standards.

Local zoning codes specify permissible uses by zoning district. Generally, each defined land use is either permitted “by right,” potentially permissible, or prohibited altogether in each zoning district. Many contemporary codes also distinguish between permissible accessory and principal uses.

These lists or tables of permitted uses by district determine where different types and sizes of solar energy systems are, or may be, allowed across the jurisdiction. Furthermore, some jurisdictions have added special-purpose districts to their zoning codes to accommodate large-scale renewable energy development.

### Use Permissions by District

The term “by-right” (or “as-of-right”) use means a use of property that is fully compatible with the intent of the zoning district. If the use satisfies all applicable district- and use-specific zoning standards, the local jurisdiction must permit it. Some jurisdictions issue ministerial (or staff-level) zoning or use permits for these uses. Others simply confirm compliance with applicable zoning standards before issuing a building permit, business license, or certificate of occupancy (for habitable structures).

In contrast, potentially permissible uses are subject to discretionary review and approval by local officials. Local officials must determine whether these uses are compatible with the intent of the zoning district and surrounding land uses on a case-by-case basis, and their final decision typically follows a public hearing. Zoning codes refer to these discretionary uses as “conditional,” “special,” or “special exception” uses.

When defined based on characteristics of the local development pattern, community-scale solar energy systems are compatible, or potentially compatible, with most common zoning districts (Table 4-3). They

**Table 4-3. Example of Use Permissions for Large-Scale Solar Energy Systems (Adapted from Day 2020)**

Type of Solar Energy System	Residential Districts	Commercial Districts	Industrial, Agricultural, Utilities, and Rural Districts	Special Conservation and Historic Districts
Community-scale	Permitted with a discretionary use permit	Permitted by right	Permitted by right	Permitted with a discretionary use permit
Utility-scale	Prohibited	Permitted with a discretionary use permit	Permitted with a discretionary use permit	Prohibited



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are quieter and cleaner and generate less traffic than most agricultural, residential, commercial, and industrial land uses. Local jurisdictions should only prohibit these systems in small-lot districts or districts where any land disturbance would undermine resource conservation goals, such as a heavily forested area.

Similarly, utility-scale solar energy systems are often compatible, or potentially compatible, with zoning districts that permit other large-footprint uses. This includes agricultural and industrial districts, as well as some higher-intensity commercial districts.

### *Special-Purpose Districts*

Local jurisdictions often adopt special-purpose zoning districts to address the unique characteristics of a specific area or to promote unified large-scale development. Local officials may map these districts to specific properties at the time of adoption, or they may hold off on mapping until they approve an owner's request for a rezoning to the special-purpose district. Special districts that are not mapped at the time of adoption are often referred to as "floating" zones.

Additionally, special districts may be base or overlay zoning designations. Once mapped to a specific property, base zoning districts serve as either the primary or only zoning designation for that property. Overlay zoning districts add to or modify the base zoning district standards within a defined area, which need not match base district boundaries.

A mapped special district for large-scale solar development can help local jurisdictions reserve priority areas for community- or utility-scale solar projects and associated transmission infrastructure. Alternatively, local officials can use floating zones to ensure the highest level of scrutiny for large-scale solar development proposals. In either case, the district standards can then focus on the distinct characteristics of these projects.

The potential downside of a mapped special district is that the ideal location for large-scale solar development, from a utility's or solar developer's perspective, may change over time. Factors beyond the local jurisdiction's direct control, such as the available capacity on distribution or transmission lines and the costs associated with interconnection, can impede efforts to steer solar projects to target locations.



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## Establishing Development Standards

Zoning codes also include development standards that define permissible locations and dimensions for structures or activities on a lot. Many contemporary codes also include development standards that relate to site conditions or environmental performance. Each development standard may apply universally across all zoning districts and uses, to all uses within a certain district, or to a specific use (or small group of similar uses).

Because large-scale solar development is often quite different from neighboring land uses, universal and district-specific development standards may not be effective for promoting preferred development outcomes. Consequently, many local jurisdictions have added use-specific development standards to their zoning codes to establish additional requirements or incentives for community- or utility-scale solar energy systems.

## Dimensional Standards

Many local zoning codes include special setbacks, height limits, and lot coverage standards for ground-mounted solar energy systems. Setbacks specify the minimum required distance between a system and the lot lines that define the boundaries of the property hosting the system. Height limits specify the maximum permissible height of a system. And lot coverage standards specify the total area or percentage of the property that a system can occupy.

Planning officials can design dimensional standards to address a variety of local goals, including reducing the visual effects of ground-mounted systems on nearby properties and promoting health and safety. Height standards, for instance, affect how near, tall, or extensive a system appears from nearby properties.

Many local jurisdictions use lot coverage standards to serve the additional purpose of limiting stormwater runoff. However, ground-mounted solar energy systems contain both pervious and impervious features and, therefore, are not analogous to rooftops, parking areas, or driveways.

Generally, there is no reason to require larger setbacks for solar energy systems than for other permissible uses in a zoning district. And in industrial districts that have large setbacks to minimize the potential effects of noise or odors on surrounding properties, it may make sense to reduce the required setback for solar energy systems. It may also make sense to reduce the required setback if the host property provides a landscaped buffer between the system and adjacent roads or surrounding properties (see [Site Conditions](#)).

Ground-mounted solar energy systems typically do not need to be more than 20 feet above the ground at max-

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imum tilt. Because many zoning districts already permit structures this tall, it may be unnecessary to specify a different height limit for ground-mounted solar energy systems.

For lot coverage, local jurisdictions may be better served by explaining how district-specific lot coverage standards apply to ground-mounted solar energy systems, rather than imposing a distinct lot coverage limit on these systems. For example, the zoning code may exempt the surface area of system arrays from impervious coverage requirements, provided the ground under and between arrays has permeable cover (see [Site Conditions](#)).

### *Site Conditions*

Many local zoning codes require all ground-mounted solar energy systems to satisfy specific site-condition standards. These standards may describe conditions that solar developers must establish or preserve, or conditions that may be incompatible with solar development. They include standards related to soil quality, ground cover, historic or cultural resources, and buffering or screening, as well as standards that address site security, access, and parking.

In some cases, these standards support broader community goals. For example, standards that prohibit disturbance of prime agricultural soils or historic sites can help preserve farmland or historic resources.

In other cases, these standards promote multiple site-specific benefits. For example, standards that require developers to plant sites with perennial native vegetation can reduce stormwater runoff and provide habitat for bees and other pollinators, or meet other habitat objectives supported in the local comprehensive plan. Similarly, standards that require developers to plant shrubs or trees between solar energy systems and adjacent roads

or surrounding properties can lessen the visual impact of solar development and may also promote stormwater infiltration or other ecological benefits.

In still other cases, these standards focus on promoting safe operations. For example, standards that require security fencing and warning signs can prevent unauthorized site access and reduce the likelihood of injuries, while standards that require compliance with building and electrical codes can provide a basic level of protection from faulty wiring or hazardous construction (e.g., Article 691 of the National Fire Protection Association’s model [National Electric Code](#) addresses utility-scale systems).

Generally, there is no reason to require permanent off-street parking spaces for community- or utility-scale solar energy systems. Once operational, solar energy systems will have very few visitors, and developers will provide space that can accommodate occasional visits for maintenance or inspections, even if not explicitly required to do so.

As referenced above, standards governing landscaping for buffering or screening should work in concert with setbacks. The greater the setback the less of a need for buffering and screening (and vice versa). Furthermore, buffering and screening for solar energy systems is most appropriate when the development site is visible from existing residences. These standards are, typically, unnecessary if the site adjoins agricultural, industrial, or commercial uses.

Finally, promoting pollinator-friendly ground cover can provide ecological benefits to the site and surrounding community, and there is no evidence that providing this ground cover will substantially increase development or operational costs.

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The [References and Resources](#) section below includes several model codes with specific suggestions for reasonable standards.

### *Environmental Performance*

Some local zoning codes require all community- or utility-scale ground-mounted solar energy systems to meet environmental performance requirements in addition to satisfying dimensional and site-condition standards. Local jurisdictions adopt these environmental performance standards to prevent nuisances that affect neighboring properties, such as noise or light pollution, or to advance wider environmental goals, such as tree, habitat, or water-quality protection.

These standards may establish objective performance measures, such as a maximum number of lumens for outdoor lighting, index of refraction for anti-reflective coatings, or decibels for sounds associated with system operations. Alternatively, they may simply state a subjective performance goal, such as not causing nuisance glare or noise.

For jurisdictions with noise or outdoor lighting standards, there is often no need for use-specific standards for solar energy systems. When set back at least 50 feet from property lines, community- and utility-scale photovoltaic systems are typically quieter than ambient noise levels in residential neighborhoods and reflect less light than most windows (Guldberg 2012; Barrett and Devita 2011).

Similarly, for jurisdictions with tree preservation, habitat protection, and erosion control and stormwater management standards, there is often no need for use-specific standards for solar energy systems. Local jurisdictions should hold these systems to the same standards as other

types of large-scale development. For example, many jurisdictions prohibit widespread tree removal and require post-construction stormwater runoff volume and quality to mimic or improve upon pre-development conditions.

### *Decommissioning*

Many local zoning codes include decommissioning standards that describe actions owners must take once a ground-mounted solar energy system stops producing electricity. Local jurisdictions adopt these standards to minimize the likelihood that they will be stuck with the costs of decommissioning abandoned systems.

These standards often define the maximum period that a system can sit idle before owners must begin the decommissioning process, as well as the deadline for removing all structures and equipment from the site. Many codes require applicants to submit a decommissioning plan that designates responsible parties and describes when and how these parties will remove and recycle or reuse system components and restore the project site. Many codes also require applicants to post a bond at the time of project approval to cover decommissioning costs. However, up-front bonding requirements that exceed the value of the equipment can make large-scale solar development financially infeasible.

Given that solar energy systems, like many electrical appliances, typically contain materials that can be recycled and others that should not be landfilled, it makes sense to address decommissioning in use-specific standards for solar energy systems. For projects that are subject to a discretionary review and approval, local jurisdictions should consider requiring a decommissioning plan. For by-right projects, it is a good idea to specify

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the trigger and timeline for decommissioning and require owners to reuse or recycle system components whenever practical and restore the site to an appropriate condition for its designated use.

**Potential Incentives**

Many local zoning codes incentivize certain types of development by relaxing development standards. For large-scale solar development, such incentives could include reduced setbacks, additional height allowances, or relaxed buffering or screening requirements (Table 4-4). However, few local zoning codes include development incentives for community- or utility-scale solar energy systems.

Relaxed development standards for solar projects can help developers maximize the space devoted to system components and, therefore, the power production potential of a specific site. However, local jurisdictions should only offer this type of development incentive if the community benefits are likely to outweigh any potential negative effects.

**Establishing Procedural Standards**

Virtually all zoning codes include procedural standards that define the application requirements and decision-making process for each distinct type of zoning decision. These standards commonly cover requests for zoning amendments, discretionary use permits (i.e., conditional, special, or special exception uses), site plan review, and variances from zoning standards.

Some local jurisdictions that treat community- or utility-scale solar energy systems as distinct uses in their zoning codes require these uses to satisfy use-specific procedural standards in addition to universal procedural standards related to site plan review or discretionary use permits. These standards may cover preapplication meetings, application materials, and incentives.

Table 4-4. Examples of Zoning Incentives for Large-Scale Solar Development		
Jurisdiction	Eligible Projects	Potential Incentives
Pima County, AZ	“Utility-scale” solar energy systems in Renewable Energy Incentive Districts that meet environmental performance standards (§14.02)	Relaxed development standards, expedited cultural and environmental reviews, and waived permitting and impact fees (§14.03.020)
Sweden, NY	“Solar farms” that provide one or more specific community benefits (§174-8; §175-20)	Relaxed development standards (§175-19)

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### *Preapplication Meetings*

Some zoning codes require or encourage potential land-use applicants to meet with local government staff or community members before submitting their applications. Generally, these standards only apply to zoning amendments and discretionary use permits, or to certain complex or potentially controversial land uses.

Local jurisdictions require preapplication meetings with staff to improve the quality of applications and to increase the likelihood of a smooth decision-making process.

Similarly, preapplication meetings with community members can help potential applicants identify and respond to community concerns before finalizing project details.

Generally, local jurisdictions should only require pre-application meetings with staff or community members when community- or utility-scale solar energy systems require a discretionary review and approval. However, if there is available staff capacity, local jurisdictions should permit potential applicants to request preapplication meetings for any solar energy system.

Procedural standards for mandatory preapplication meetings with staff should specify the purpose of the meeting and the amount of time potential applicants have to submit their applications following the meeting. It can also be helpful to specify optional materials, such as sketch plans, that potential applicants can bring to make meetings more productive. Standards for mandatory preapplication meetings with community members should specify noticing requirements and guidelines for conducting meetings.

### *Application Materials*

Zoning codes that classify community- or utility-scale solar energy systems as distinct uses typically list the materials applicants must submit with their application for a zoning approval or discretionary use permit. Perhaps the most common requirement is a site plan depicting the locations of all existing structures, the proposed solar energy system, property lines, roads and utility rights-of-way, setbacks, and visual buffers or screens.

Other commonly required materials include topographic maps, floodplain and other environmentally sensitive area maps, soil type maps, stormwater management and sediment control plans, decommissioning plans, utility agreements, and verification of insurance coverage. Some jurisdictions also require applicants to submit studies or documentation that address whether the proposed system is likely to have a significant negative effect on wildlife species and habitat (both on-site and on adjoining properties), historic resources, marginalized communities, air traffic safety, or nearby property values.

Application requirements should be driven by use permissions, development standards, and review criteria. For systems permitted by right, a site plan that ties directly to the objective standards in the code should be sufficient to help staff evaluate the application. For systems that require a discretionary use permit or a zoning amendment, local jurisdictions should only require materials that have a direct and clear relationship to applicable development standards and review criteria.

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### *Potential Incentives*

Some local zoning codes incentivize certain types of development by streamlining application requirements or review processes, or by expediting final decisions. Currently, few local zoning codes include similar procedural incentives for community- or utility-scale solar energy systems.

Reducing the volume of application materials or speeding up the review and approval processes for solar projects can reduce overall development costs significantly. However, local jurisdictions should only offer this type of procedural incentive if the community benefits are likely to outweigh any potential negative effects.

### **Establishing Development Charges**

Virtually all local jurisdictions charge administrative fees to cover expenses associated with development review and permitting. Many also require different types of development to pay impact fees to offset the costs of providing or expanding public facilities or infrastructure, such as roads, schools, parks, and fire stations.

Local jurisdictions that treat community- or utility-scale solar energy systems as distinct uses in their zoning codes seldom apply use-specific permitting or impact fees. However, there may be good reasons to do so.

### *Permitting Fees*

Local jurisdictions use permitting fees to pay for their investments of time and materials throughout the development review process. Currently, relatively few local jurisdictions have established standard permitting fees for community- and utility-scale solar energy systems (Table 4-5). Some of these jurisdictions tie fees to a percentage of the estimated value of the project. Others set fees based on the land area or the rated capacity of the system.

Generally, local jurisdictions should seek to recover the full costs they incur to review community- and utility-scale solar applications (see [Potential Incentives](#) for a possible exception to this principle). Standardized permitting fees can help solar developers better plan for project costs. However, inexperienced jurisdictions may have difficulty setting appropriate fee rates.

There can be a steep learning curve in reviewing large-scale solar development projects. Consequently, local jurisdictions should carefully consider whether they need to establish standard permitting fees for solar projects. For some jurisdictions, it may ultimately be more cost ef-



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**Table 4-5. Examples of Solar-Specific Permitting Fees**

Jurisdiction	Permitting Fees
Isabella County, MI	\$5,000 for first 160 acres of project area plus \$50 per additional fractional 40 acres plus escrow fee to cover all review costs and expenses [Application Fees for Solar Farms]
Marlborough, NY	\$1,000 for systems with rated capacities of 101–500 kW \$3,000 for systems with rated capacities of 501–1,000 kW \$5,000 for systems with rated capacities of 1,001–2,000 kW \$7,000 for systems with rated capacities of 2,001–3,000 kW \$9,000 for systems with rated capacities of 3,001–4,000 kW \$12,000 for systems with rated capacities of 4,001–5,000 kW [Building Fees: Solar Farm Fees]
San Bernardino County, CA	Actual cost, with an initial deposit of \$3,910 (§16.0204(k)(6))

fective to outsource parts of the review process and pass these costs on to developers.

**Impact Fees**

Many local jurisdictions use impact fees (also known as system development charges) to mitigate the effects of new development on public infrastructure and facilities. These fees must have a rational connection to the actual anticipated effects of a development project on the specific improvements funded by the impact fees. That is, local jurisdictions can only levy fees that are proportional to project impacts, and every development project that pays impact fees must receive proportional benefits from the fee-funded improvements.

Currently, few local jurisdictions have established specific impact fees for community- and utility-scale solar energy systems. One example is San Bernardino

County, California, which charges a public safety impact fee tied to the land area of the project (§84.29.040(d)). Local jurisdictions without solar-specific fees may use a standard rate based on a broader use category (e.g., industrial or agricultural).

Often, community- and utility-scale solar energy systems have minimal effects on public facilities and infrastructure. Once operational, they generate little traffic and no students for schools and are responsible for few public safety calls. Consequently, local jurisdictions that use impact fees to offset the costs of growth should consider either treating solar projects like agricultural uses or setting a solar-specific impact fee.

**Potential Incentives**

Some local zoning codes incentivize certain types of development by discounting or waiving permitting or

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impact fees. Currently, few local zoning codes include these incentives for community- or utility-scale solar energy systems.

Waiving or discounting development charges for solar projects can reduce overall development costs significantly. However, local jurisdictions should only offer this type of incentive if the community benefits are likely to outweigh revenue losses. Assuming the standard fees are well calibrated, jurisdictions will need to make up for lost revenue through other sources.

For example, it may make sense to waive or discount permitting fees for solar projects that involve the cleanup and reuse of brownfield sites or community solar projects that target traditionally underserved utility customers. These projects confer specific local benefits and may not happen without some local assistance (see [Module 7](#)).

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### KEY TAKEAWAYS

- Definitions for ground-mounted solar energy systems should distinguish between systems of different sizes based on the site or surface area they occupy.
- Community-scale solar energy systems are compatible, or potentially compatible, with most common zoning districts.
- Utility-scale solar energy systems are often compatible, or potentially compatible, with zoning districts that permit other large-footprint uses.
- Many local zoning codes include use-specific development standards to ensure that community- or utility-scale solar energy systems support broader community goals.
- Some local zoning codes include use-specific procedural standards for community- or utility-scale solar energy systems to facilitate efficient development review processes.
- Some local zoning codes have established use-specific permitting or impact fees for community- or utility-scale solar energy systems to ensure that system developers pay their fair share of development-related charges.

## References and Resources

American Battlefield Trust. 2020. “Utility-Scale Solar Facility Development: Recommended Policy Language for Virginia Localities.”

American Farmland Trust. 2019. “Smart Solar Siting Principles and Examples of Local Land Use Laws That Support Renewable Energy While Protecting Farmland.”

American Planning Association. 2021. “Research KnowledgeBase: Solar Energy.”

Barrett, Stephen B., and Philip M. Devita. 2011. *Investigating Safety Impacts of Energy Technologies on Airports and Aviation*. ACRP Synthesis 28. Washington, D.C.: National Academies Press.

California County Planning Directors Association. 2012. “Model Solar Energy Permit Streamlining Ordinance.”

———. 2012. “Renewable Energy Combining Zone.”

Clean Energy NH. 2018. “NHSEA Model Solar Zoning Ordinance.”

Coffey, Darren. 2019. “Planning for Utility-Scale Solar Energy Facilities.” *PAS Memo*, September/October.

Day, Megan. 2020. “Are You Solar Ready?” *Planning*, May.

Emory University Turner Environmental Law Clinic, Georgia Tech Strategic Energy Institute, and University of Georgia Agriculture Technical Assistance Program. 2018. “Georgia Model Solar Ordinance.”

———. 2018. *Georgia Model Solar Zoning Ordinance Guide*.

Gilliland, Ed, and Avery Palmer. 2020. *Large-Scale Solar Development: A Playbook for Southwest Virginia*. Washington, D.C.: The Solar Foundation.

Great Plains Institute. 2020. “Illinois Solar Model Ordinance.” Custer, Wis.: Midwest Renewable Energy Association.

———. 2020. “Iowa Solar Model Ordinance.” Custer, Wisconsin: Midwest Renewable Energy Association.

———. 2020. “Minnesota Solar Model Ordinance.” Custer, Wisconsin: Midwest Renewable Energy Association.

———. 2020. “Wisconsin Solar Model Ordinance.” Custer, Wisconsin: Midwest Renewable Energy Association.

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———. 2020. [“Model Solar Ordinance for Indiana Local Governments.”](#) Bloomington, Indiana: Indiana University Environmental Resilience Institute.

Guldborg, Peter H. 2012. *Study of Acoustic and EMF Levels from Solar Photovoltaic Projects*. Boston: Massachusetts Clean Energy Center.

Kentucky Resources Council Center for Environmental Policy. 2020. [“Kentucky Model Solar Zoning Ordinance.”](#)

Maine Audubon. 2020. [“Model Site Plan Regulations and Conditional Use Permits to Support Solar Energy Systems in Maine Municipalities.”](#)

Massachusetts Department of Energy Resources and Massachusetts Executive Office of Environmental Affairs. 2014. [“Model As-of-Right Zoning Bylaw: Allowing Use of Large-Scale Ground-Mounted Solar Photovoltaic Installations.”](#)

———. 2014. [“Model Zoning for the Regulation of Solar Energy Systems.”](#)

Morley, David, ed. 2014. *Planning for Solar Energy*. Planning Advisory Service Report 575. Chicago: American Planning Association.

Morris, Marya, ed. 2009. “Model Unified Development Permit Review Process Ordinance.” Chapter 4.5 in *Smart Codes: Model Land-Development Regulations*. Planning Advisory Service Report 556. Chicago: American Planning Association.

NC Clean Energy Technology Center. 2016. [“Template for Solar Energy Development Ordinance for North Carolina.”](#)

New York State Energy Research and Development Authority. 2020. *New York State Battery Energy Storage System Guidebook*.

———. 2020. *New York State Solar Guidebook*.

Rhode Island Division of Statewide Planning. 2019. [“Renewable Energy Guidelines: Solar Energy Systems Model Ordinance Templates Zoning & Taxation.”](#)

Smith, Cody. 2020. *Iowa Solar Siting Resource Guide: A Roadmap for Counties*. Nevada, Iowa: Center for Rural Affairs.





## **MODULE**

**5**

**IMPROVING LAND-USE DECISION-MAKING  
FOR LARGE-SCALE SOLAR DEVELOPMENT**



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Local zoning regulations create a framework for evaluating proposed large-scale solar development projects (see [Module 4](#)). However, these regulations typically say relatively little about how local government officials conduct development review and approval processes. Consequently, administrative procedures affect the efficiency and efficacy of local land-use decision-making processes.

Many, if not most, large-scale solar development projects will need one or more discretionary land-use approvals from the local jurisdiction. Through these decision-making processes, local officials can shape community- and utility-scale solar projects in ways that increase benefits and reduce tradeoffs.

This module highlights steps officials can take to improve applicant submissions and review processes, secure community benefits through agreements and written decisions, and ensure compliance through inspections.

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### Improving Applicant Submissions

The development review process for a large-scale solar project does not officially begin until a landowner or developer submits a complete application. By this point, the developer has already invested significant time and money to identify a suitable site, negotiate terms with participating landowners, and create a site plan for the project.

Incomplete applications and applications that fail to meet objective development standards can waste the local jurisdiction’s time and prove costly to correct for applicants. Furthermore, rushed applications that fail to solicit and respond to community input often face an uphill battle to approval.

Two of the most important proactive tools local jurisdictions can use to improve application packages for large-scale solar projects are educational materials and preapplication meetings.

### Educational Materials

Solar developers that work in multiple jurisdictions quickly learn that zoning regulations for large-scale projects can vary considerably from place to place. While they may be adept at finding and interpreting zoning regulations, even experienced developers can benefit from supplemental materials that will help them prepare application packages and plan for public hearings. Beyond this, educational materials can help new developers—who may be unfamiliar with zoning and development review processes—start scoping out a project.

At a minimum, local government officials should consider creating fact sheets, brochures, guides, or web pages that address large-scale solar development as a distinct project type (Table 5-1). These materials can explain the zoning regulations that apply to large-scale solar development projects and the basic steps of the development review and decision-making process. Some officials may also have opportunities to connect these materials to project siting tools or information about available state or local incentives (see Module 7).

**Table 5-1. Examples of Educational Materials for Solar Developers**

Jurisdiction	Resource	Type
Butte County, CA	<a href="#">Butte Utility-Scale Solar Guide</a>	Guide explaining the permitting process for utility-scale solar projects and mapping tool to help developers identify optimal sites for solar development
Linn County, Iowa	<a href="#">Solar Farms</a>	Informational web page about application and review process
Pima County, Arizona	<a href="#">Commercial Solar Farm Fees and Permitting Guidelines</a>	Brief guide outlining permitting fees and necessary permits

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### Preapplication Meetings

Preapplication meetings between potential applicants and local jurisdiction staff provide an efficient means for identifying potential regulatory issues before large-scale solar developers submit project applications. Similarly, developer-led preapplication meetings with community members are an effective way to solicit feedback on project features before finalizing a site plan.

When meeting with potential applicants, planning and building department staff members can answer questions about zoning and building standards or the decision-making process. In cases where a proposed project doesn't fit the community's vision, they can suggest changes that would help the project align with that vision (see [Module 3](#)).

Local staff members serve a very different role in developer-led meetings with community members. Before the meeting, they can help developers connect with neighborhood associations or other community-based organizations, and they can provide guidance on strategies to maximize attendance and participation, including open house-style meetings (see [Module 3](#)). During the meeting, staff members should listen to community concerns and only speak up to clarify the jurisdiction's regulatory approach or refute misinformation.

### Reviewing Proposed Projects

Large-scale solar development projects often represent new land uses, involve new structures, and typically require land disturbance for construction. Consequently, multiple local staff members (or contract consultants) often review applications for these projects, and these reviews may require multiple site visits to verify project details. Additionally, many large-scale solar projects also require local jurisdictions to coordinate their reviews with the local utility or state agencies.

When reviews and site visits run smoothly, staff can efficiently evaluate whether an application complies with all applicable codes and standards and supports the community vision for large-scale solar development. In contrast, poorly coordinated visits and reviews can delay decisions, costing the local jurisdiction and the developer both time and money.

### Internal Coordination

The core principle of development review is that every participant and every step in the process should add value (Van Hemert 2005; Arimes 2012; Blue 2014; Wright 2017). In practice, though, many jurisdictions have gradually expanded the breadth and depth of their review processes over time as new community priorities emerged. Consequently, large or complex projects may go through multiple separate departmental reviews. When this happens, the timeline for completion becomes more uncertain and the probability that applicants will receive confusing or contradictory feedback increases.

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Some solar developers can afford to hire a team of legal and design professionals to help them navigate review processes. However, new developers and those who specialize in community-scale projects may be discouraged by complicated and unclear processes.

Local jurisdictions that have successfully streamlined their development review processes often use one of two approaches. Many jurisdictions have created “one-stop” permitting centers that combine planning, building, environmental, and engineering staff services in one physical location (with or without reorganizing department structures). This encourages smooth handoffs between members of multidisciplinary review teams. Other jurisdictions have switched to a “concierge” approach that designates a single point of contact for each project. This concierge guides the application through all necessary internal reviews.

### External Coordination

Large-scale solar developers are responsible for securing all necessary state and utility approvals for their projects (see [Module 2](#)). However, local reviews often require confirmation of these external approvals. Consequently, local staff can help improve the efficiency of the development review process by building better relationships with their counterparts at the local utility and state agencies that issue certificates of need or siting permits or oversee environmental reviews for power plants.

By establishing and maintaining these relationships, local staff are better equipped to help inexperienced applicants navigate external approval processes. Additionally, good external relationships are essential if the local jurisdiction hopes to advance its large-scale solar development

goals through decision-making processes that are outside of its direct control. This is especially true in states where projects over a certain size must obtain a separate siting permit from a state siting board ([Table 2-9](#)).

By cultivating local staff expertise on utility and state review processes, local jurisdictions may identify opportunities to align local application requirements with external application requirements. This can help developers by allowing them to prepare materials once for multiple reviews. Furthermore, by participating in external planning or policy development processes, local jurisdictions can better prepare for future project applications (see [Module 8](#)).

### Site Visits

Local government staff members that participate in reviewing large-scale solar projects routinely make site visits as part of the application review process. These visits allow staff to check the accuracy of information provided in the application package, evaluate the likelihood of potential land-use conflicts, and to investigate conditions on the site or in the area that merit further analysis (Meck 2005). In some cases, visiting the site will help staff identify opportunities for the project to support specific policy goals, such as brownfield redevelopment, the establishment or expansion of pollinator habitat, or colocation with agricultural activities ([Figure 5-1](#)).

Typically, reviewers summarize notes from these site visits in their staff reports (see [Preparing Staff Reports and Written Decisions](#)). This information may be combined with geographic information systems (GIS) to create a data layer. At a minimum, staff participating in site visits should note existing land uses and structures, topography and vegetation, and visible utility infrastructure.

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Figure 5-1. Pollinator-friendly ground cover at the Aurora Solar Project in Chisago, Minnesota (Photo by Dennis Schroeder / NREL)

In some jurisdictions, planning board members or elected officials participate in site visits. While site visits can help these officials better understand project details, they must be careful to share everything they learned during the visit before the public hearing for the project begins (Dale 2000; Theriaque 2014). To further reduce the appearance of bias in the decision-making process, any site visit attended by local officials should be properly advertised in accordance with any applicable state or local requirement and open to the public.

## Negotiating Community Benefits

Community members often oppose large-scale development projects when they don't understand the benefits and the tradeoffs disproportionately affect the project site and its immediate surrounding area. In cases where land-use impacts are difficult to eliminate or adequately mitigate through zoning standards or conditions of approval (see [Conditions of Approval](#)), some local jurisdictions or community-based organizations negotiate with large-scale project developers to secure additional community benefits.

Successful negotiations typically result in formal agreements. These include development agreements between developers and the local jurisdiction and community benefits agreements between developers and one or more community-based organizations.

### Development Agreements

A development agreement is a contract between a developer and a local jurisdiction that establishes each party's rights and obligations with respect to a proposed development project. Typically, the local jurisdiction agrees to freeze land-use and development regulations in force at the time of the agreement in exchange for the developer agreeing to provide public benefits.

This can be attractive to developers because it gives them assurance that they will be able to proceed with their development plan, even if future regulations would prohibit it. And local jurisdictions can ask for project features or public improvements that are not required by the applicable zoning regulations. For example, a development agreement may require a developer to plant trees offsite or purchase additional land to remain forested to offset tree removal on the project site.

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At a minimum, all development agreements must be consistent with the local comprehensive plan (see [Module 3](#)) and applicable zoning regulations. Several states have explicitly authorized development agreements and established local requirements through state statutes. Some of these enabling laws specify a project size threshold or other limits on the use of development agreements. Local officials in other states should consult with a qualified attorney before negotiating with developers for project features or improvements that are not directly connected to the proportional community impacts of the project.

A development agreement for a large-scale solar project may be beneficial in instances where the local jurisdiction has identified specific desirable features but has not amended its zoning regulations to require these features for all similar projects (see [Module 4](#)). These features may include the colocation of agricultural activities (i.e., agrivoltaics) or pollinator habitat (i.e., pollinator-friendly solar) and solar power production ([Table 5-2](#)).

### Community Benefits Agreements

A community benefits agreement (CBA) is a contract between a developer and one or more community-based organizations or groups of community members affected by a specific development project. They detail benefits the developer will provide to the community in exchange for community support for the development project. Common examples of benefits include local hiring goals, living wage requirements, and job training programs.

Because CBAs are agreements between developers and community groups, they may include benefits beyond what a local government could legally require. Local officials should refrain from negotiating the agreement, because if they participate directly, courts may invalidate specific provisions of a CBA as unconstitutional exactions. Local officials can encourage CBAs, however, by sharing information about development proposals, providing forums for developers and community stakeholders to exchange ideas, and incorporating community benefits provisions into development agreements. Officials can also use evidence of community support as a criterion for discretionary approvals or economic development subsidies (see [Module 7](#)).

**Table 5-2. Examples of Development Agreements for Large-Scale Solar Projects**

Jurisdiction	Development Agreement	Local Benefits
Saratoga, WI	<a href="#">Solar Generating Facility Development Agreement Between the Town of Saratoga and Wood County Solar Project, LLC</a> (2021)	Annual utility aid payments, vegetated buffer, visit or area and tours, pollinator-friendly ground cover, and local employment and training
Weber County, UT	<a href="#">Development Agreement Between Weber County, Utah and Little Mountain Solar, LLC</a> (2019)	Fire protection measures, pollinator-friendly ground cover, and wildlife-friendly equipment and site design



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Negotiations for a large-scale solar project community benefit agreement should start well before the developer submits a land-use application or begins discussing a development agreement with the local jurisdiction. Proactive community planning processes can provide a forum to identify potential community benefits and groups that may be willing to negotiate on behalf of community members for those benefits (see [Module 3](#)).

In July 2021, Connecticut’s governor signed into law [an Act Concerning a Just Transition to Climate-Protective Energy Production and Community Investment](#) (Public Act No. 21-43). This law requires developers of renewable energy projects with rated capacities of five megawatts or more to pursue community benefits agreements that include workforce development programs.

### Preparing Staff Reports and Written Decisions

The discretionary review process for a large-scale solar development project culminates in a final decision, following a public hearing. In advance of this public hearing, planners typically prepare a staff report with a recommended action. While decision makers are not required to follow this staff recommendation, the information in the staff report is designed to help local officials make better decisions.

To comply with procedural due process requirements, local officials must document the reasoning for and terms of their decision in writing. This written decision often repeats findings of fact or conditions of approval from the staff report.

### Findings of Fact

Findings of fact are objective claims about the relationship of a project application to the adopted policies and regulations of the local jurisdiction (Dale 2015; Meck and Morris 2004). They are a crucial component of any staff report and may be repeated verbatim or with modifications in the final written decision. Basing decisions on findings of fact, rather than emotional appeals from applicants or other interested parties, ensures that each application receives fair consideration and can protect local jurisdictions from costly legal challenges.

When drafting findings of fact for large-scale solar projects, planning officials should explain in plain language how the project relates to each relevant zoning standard as well as any relevant language or maps in the local comprehensive plan. They should also clearly state whether project supporters or opponents offered factual support for specific claims of benefits or harm. A claim without evidence is not a defensible reason for a decision.

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### Conditions of Approval

Conditions (or stipulations) of approval are the formal terms of approval for a discretionary land-use decision. They may include modifications to a project’s physical design or operations, provision of offsite improvements or land dedications, or notice of a necessary approval from another permitting authority. All conditions of approval that involve offsite improvements or land dedications must be rationally related and roughly proportional to the anticipated land-use effects of the project.

When drafting conditions of approval for large-scale solar development projects, planning officials should limit stipulations to project features or issues addressed through use-specific development or procedural standards (see [Module 4](#)). Planners can include recommended conditions of approval in their staff reports, and local officials can accept or modify these conditions in their formal written decision.

Conditions of approval must be stated objectively, without room for interpretation. If unanticipated issues surface during the review process or the public hearing, the stipulations that address these issues should be narrowly tailored and must be in conformance with the relevant state zoning enabling law. It is often better to delay action on an application than to approve it based on hastily drafted conditions.

### Inspecting Approved Projects

Local jurisdictions typically require multiple field inspections before an approved large-scale solar development project can begin operations ([Figure 5-2](#)). These inspections verify compliance with zoning standards as well as applicable building, electrical, and fire codes. They are generally separate from field inspections required by utilities or other authorities.

When inspections run smoothly, local staff and officials have assurance that the project complies with all applicable codes and standards. Poorly coordinated inspections can delay operations, however, costing the local jurisdiction and the developer both time and money.



Figure 5-2. Inspectors at the Long Island Solar Farm at the Brookhaven National Laboratory in Upton, New York (Source: Flickr / Brookhaven National Laboratory (CC-BY-NC-ND 2.0))

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### Internal Coordination

At a minimum, local jurisdictions typically require at least two inspections for community- and utility-scale solar installations. The first inspection occurs during construction to allow inspectors to view features that will be concealed once the installation is complete. The second inspection occurs once construction is complete to verify compliance with all applicable codes and standards. Many jurisdictions require additional inspections for stormwater management, erosion and sediment control, landscaping, transportation access, decommissioning, and other issues.

Local jurisdictions that do not have staff with the necessary expertise or enough available time to handle all necessary inspections should contract for inspection services or require applicants to secure and cover the costs of third-party inspectors. Because developers need a clear timeline for inspections, either option is better for the applicant than long wait times for staff visits. Local jurisdictions should negotiate the timing and fees associated with all inspections during the development review process and record all inspections-related obligations in conditions of approval or a separate development agreement.

### External Coordination

Large-scale solar developers are typically responsible for securing all necessary state and utility inspections for their projects. In some cases, these separate inspection processes may present an opportunity to ease local inspection requirements. Local staff can help improve the efficiency of the inspections process by contacting local utility and state agencies that conduct field inspections for large-scale solar projects to learn more about their processes.

Where external inspections duplicate local efforts, the local jurisdiction can narrow the scope of its inspections. Some utilities and state agencies may even be willing to share their inspection reports with affected local jurisdictions. If this isn't possible, local officials could still require developers or operators to provide a copy of these reports in lieu of separate local inspections.

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## KEY TAKEAWAYS

- Two of the most important proactive tools local government officials can use to improve application packages for large-scale solar projects are educational materials and preapplication meetings.
- When development review processes run smoothly, local government staff can efficiently evaluate whether an application supports the community vision for large-scale solar development.
- Local government officials may be able to secure specific local benefits by formalizing development agreements with solar developers or encouraging solar developers to negotiate community benefits agreements with community-based organizations.
- When drafting findings of fact for large-scale solar projects, planning officials should explain in plain language how the project relates to each relevant zoning standard as well as any relevant language or maps in the local comprehensive plan.
- When drafting conditions of approval for large-scale solar development projects, planning officials should limit stipulations to project features or issues addressed through use-specific development or procedural standards.
- Local jurisdictions that do not have sufficient staff capacity to handle inspections should contract for inspections or include third-party inspection requirements in conditions of project approval.

## References and Resources

American Planning Association. 2021. “[Research KnowledgeBase Collection: Improving Development Review](#).”

Arimes, George. 2012. “[Transparent Development Services](#).” *Zoning Practice*, October.

Arsenova, Maria, and Holle Linnea Wlokas. 2019. *Local Benefit Sharing in Large-Scale Wind and Solar Projects*. Washington, D.C.: International Finance Corporation.

Blue, Michael. 2014. “[Development Review as Economic Development](#).” *Zoning Practice*, February.

Butte (California), County of. 2017. “[Butte Utility-Scale Solar Guide](#).”

Dale, C. Gregory. 2000. “[Site Visits: Necessary But Tricky](#).” *Planning Commissioners Journal*, Summer.

———. 2015. “[Findings of Fact for Planning Commissions](#).” *The Commissioner*, April.

Callies, David L., and Julie A. Teppendorf. 2001. “[Unconstitutional Land Development Conditions and the Development Agreement Solution: Bargaining for Public Facilities After Nollan and Dolan](#).” *Case Western Reserve Law Review* 51: 663–96.

Canon, Ramsin G. 2014. “[Participatory Democracy and the Entrepreneurial Government: Addressing Process Efficiencies in the Creation of Land Use Development Agreements](#).” *Chicago-Kent Law Review* 89(2): 781–821.

Coffey, Darren. 2019. “[Planning for Utility-Scale Solar Energy Facilities](#).” *PAS Memo*, September/October.

Frank, Steven P. 2009. “[Yes in My Backyard: Developers, Government and Communities Working Together Through Development Agreements and Community Benefit Agreements](#).” *Indiana Law Review* 42: 227–55.

Easley, Gail. 2006. “[Conditional Uses](#).” *Zoning Practice*, May.

Green, Shelby D. 2004. “[Development Agreements: Bargained-for Zoning That Is Neither Illegal Contract nor Conditional Zoning](#).” *Capital University Law Review* 33: 383–497.

Gross, Julian, Greg LeRoy, and Madeline Janis-Aparicio. 2005. *Community Benefits Agreements: Making Development Projects Accountable*. Washington, D.C.: Good Jobs First.

Higgins, Bill, JoAnne Speers, and Charles Summerell. 2006. *An Ounce of Prevention: Best Practices for Making Informed Land Use Decisions*. Sacramento, Calif.: Institute for Local Government.

Johnson, Bonnie. 2017. “[The Better Staff Report](#).” *Planning*, March.

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Jones, Gregory W. 2017. "Running Efficient, Effective (and Shorter) Meetings." *The Commissioner*, December.

Koviac, Gary A., and Mary L. McMaster. 1992. "Drafting Land Use Findings." *Planning Commissioners Journal*, May/June.

Larsen, David J. 2002. *Development Agreement Manual: Collaboration in Pursuit of Community Interests*. Sacramento, Calif.: Institute for Local Self Government.

Meck, Stuart. 2005. "Site Visits: Purpose, Planning, and Practice." *Zoning Practice*, February.

Meck, Stuart, and Marya Morris. 2004. "Formatting and Writing the Staff Report." *Zoning Practice*, November.

Merriam, Dwight H., and Robert J. Sitkowski. 1998. "Procedural Due Process in Practice." *Planning Commissioners Journal*, Summer.

Partnership for Working Families. 2015. "Policy & Tools: Community Benefits Toolkit."

Read, Anna. 2015. "Community Benefits Agreements." *PAS QuickNotes* 59, December.

Salkin, Patricia E., and Amy Lavine. 2008. "Understanding Community Benefits Agreements: Equitable Development, Social Justice and Other Considerations for Developers, Municipalities and Community Organizations." *UCLA Journal of Environmental Law and Policy* 26: 291–331.

Senville, Wayne. 2010. "Dealing With Contentious Public Hearings." *Planning Commissioners Journal*, Winter.

Swift, Susan. 2011. "Getting the Most Out of Staff Reports." *PAS QuickNotes* 30, February.

Theriaque, David. 2014. "Site Visits Done... Legally." *The Commissioner*, June.

U.S. Department of Energy. 2017. "Guide to Advancing Opportunities for Community Benefits Through Energy Project Development."

Van Hemert, James. 2005. "The Development Review Process." *Zoning Practice*, January.

Wright, Norman. 2017. "Development Review Process Improvement." *Zoning Practice*, May.





# MODULE **6**

**HOSTING LARGE-SCALE SOLAR  
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Both general- and special-purpose local jurisdictions can directly participate in large-scale solar development by hosting projects on local-government-owned land.

Potential benefits for the local jurisdiction include revenue from lease payments by the developer or owner and a predictably priced source of clean electricity for local governmental operations. Local government officials may also be interested in using these projects to model a commitment to broader renewable energy and climate action goals. Local jurisdictions that lead by example can inspire other landowners and actors in the community to sup-

port large-scale solar development. Leasing local-government-owned property for large solar facilities can also help local jurisdictions make progress on secondary goals, such as economic development or environmental restoration.

This module summarizes the key steps for hosting large-scale solar development projects on local-government-owned land: identifying project goals, selecting potential sites, and selecting development partners.

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## Identifying Project Goals

Local government officials should establish clear goals to maximize the usefulness of large-scale installations on public land. This requires them to identify the primary reasons for hosting large-scale solar development. Project goals may serve as a foundation that local officials can return to when prioritizing sites and choosing development partners or proposed projects.

To ensure community buy-in, project goals should be transparent, public facing, and linked to broader community goals. Local government officials can communicate goals to community members and local government staff through press releases, the jurisdiction's website, and through plans and policy documents (see [Module 3](#)).

Local officials can set clear and specific project goals based on system size or performance, a desire for local participation in the project, or an interest in maximizing co-benefits.

### System Size and Performance

Local officials can base project goals on the size or performance of the solar energy system.

Size-based goals establish a target size for the system, typically in terms of rated capacity in megawatts (MW) or power generation in megawatt-hours (MWh). This type of goal might be appropriate for local jurisdictions that want to use their available land as efficiently as possible. If a local jurisdiction has only one or two sites it would like to use for solar development, it may aim to maximize power production on that land by establishing an ambitious but realistic installed capacity or annual power generation goal. Local jurisdictions might also want to use size-based goals if they are aiming to create

a specific number of construction jobs or to otherwise spur economic development.

Performance-based goals establish a target for the effects of a new solar project on community conditions. Common performance-based goals are a percent increase in local installed capacity or power generation; an increase in the percentage of renewable or clean electricity consumption by the local government or the community; or a percent reduction in GHG emissions. Local jurisdictions may use performance-based goals if they are aiming to decrease reliance on power from nonlocal and nonrenewable sources or to demonstrate a commitment to broader climate change mitigation or sustainability goals.

### Participation

Local officials can also set goals that encourage local stakeholders and residents to directly participate in large-scale solar projects located on local government land.

For example, a local jurisdiction may want to host a shared solar project that gives community members an opportunity to subscribe and receive credit on their electricity bills for power produced from the hosted system. Alternatively, local officials may be interested in setting an employment goal that would require a solar developer to hire (and potentially train) local workers to fill a certain percentage of total jobs for the project. In this case, the local workforce must be willing and able to perform these temporary construction jobs.

### Co-Benefits

When hosting projects on public land, local governments can center community members as the beneficiaries of large-scale solar projects.



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Figure 6-1. A 2.3 MW solar energy system sited on top of a closed municipal landfill in Easthampton, Massachusetts (Source: Flickr / Massachusetts Department of Environmental Protection (CC BY 2.0))

The co-benefits approach to solar development emphasizes the importance of direct advantages for the host community. Large-scale solar can do more than produce clean energy and mitigate climate change; local jurisdictions can use siting and project design to deliberately increase local and collective benefits.

Some of the co-benefits that may accompany large-scale solar development include revitalizing underutilized public lands; increasing public awareness of clean energy and climate action; managing natural resources, such as water and soil; and increasing the viability of local food production.

Brownfields, such as closed landfills and wastewater treatment sites, are just some of the local-govern-

ment-owned sites that can support a large-scale solar system (Figure 6-1). Due to possible contamination and the potential need for costly remediation, these sites might be unsuitable for commercial or residential redevelopment. Redeveloping brownfields with solar installations may benefit public health, property values, and local ecology. Reinvestment in these properties may also increase local revenue, create jobs, and ease development pressure on farmland or other productive lands.

The details of each site are important when determining the feasibility and cost for development. Sometimes these lands have higher cleanup costs or special site characteristics that constrain project design, but developers may benefit from nearby existing infrastructure, such as access roads or distribution lines. And since these sites often have fewer potential alternative uses, they are less controversial to develop.

Co-benefit goals that promote siting on brownfields or other previously developed but currently underutilized sites might require developers to spend more money preparing the site for installation. Local jurisdictions will need to balance their desire to site projects on underutilized lands with the necessity of commercial viability.

Developers are increasingly able to intentionally design large-scale solar development to be low impact and ecologically valuable (Ross 2020; NREL 2020). Large-scale solar systems can serve as green infrastructure that provides pollinator habitat, decreases stormwater runoff, and protects or improves water quality, such as by reducing contamination of drinking water or restoring water and soil quality for better food production. Local jurisdictions can set project goals that promote green infrastructure, making the project more appealing to residents and other local stakeholders.

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### Selecting Potential Sites

Not all local-government-owned land is appropriate for large-scale solar development. Local jurisdictions should develop a standardized process for selecting sites that satisfy project goals and meet other practical requirements.

Local officials can start by first identifying a list of local sites that meet the basic physical requirements to support a large-scale solar facility. Then, they can collect further information on the site. Local stakeholders who have ecological, financial, and technical expertise can assist local officials in narrowing down the list to the most promising sites: those that have the best access to existing grid infrastructure (or the best potential for efficiently building new infrastructure), the fewest potential environmental impacts, and the most economic feasibility for development. There are several online tools officials can use to help identify and analyze potential project sites (Table 6-1).

### Site Characteristics

The topography of the site—the slope, size, and shape—largely determines its suitability for large-scale solar development. Developers need relatively flat land to install solar arrays on, so the slope must be low. The size and shape of the site should be able to accommodate the entire solar system, as well as any necessary buffers and accessory structures.

Additionally, ground-mounted systems require compact soils. Ground cover and vegetation should be unobtrusive but has the potential to be ecologically valuable, such as pollinator-friendly or native vegetation, which typically requires low amounts of maintenance. As discussed below, sites that are near distribution or transmission lines and have access or graded roads are more appealing for developers.

When cleared of above-ground structures, remediated brownfields can be attractive sites for large-scale solar development. They often consist of large, flat, and unshaded

**Table 6-1. Screening Tools for Identifying and Analyzing Potential Large-Scale Solar Project Sites**

Tool	Description
<a href="#">Argonne National Laboratory's Energy Zones Mapping Tool</a>	An online decision-support tool that provides data layers to help users analyze the suitability of sites and areas for solar (and other renewable energy) projects
<a href="#">U.S. Environmental Protection Agency's RE-Powering America's Land Electronic Decision Tree</a>	A downloadable application that walks users through a series of questions about potential solar and wind project sites to produce site screening summary and site comparison reports
<a href="#">U.S. Environmental Protection Agency's RE-Powering Mapper 2.0</a>	An interactive map to help users analyze the feasibility of previously identified contaminated lands, landfills, and mine sites for solar (and other renewable energy) projects

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areas near existing electricity grid infrastructure. However, brownfields with subsurface contamination may require costly soil removal and replacement or the use of ballast systems and above-ground wiring.

Sites with land-use exclusions or restrictions, such as environmentally sensitive lands or historical and cultural lands, are not suitable for large-scale solar projects. Development that prevents or disturbs the ecological function of a site can have adverse impacts on wildlife and the environment (both on-site and on adjoining properties). While developers may be able to design systems that complement or enhance natural functions, these designs can be more expensive. Land that serves as critical natural habitat is generally not appropriate for solar development.

The amount of direct solar irradiance and shading both affect the site's access to the solar resource. Trees, adjacent buildings, and utility lines are some features that can reduce how much sun reaches the solar arrays.

Because solar development is a long-term land use, the surrounding features are liable to change over the lifetime of the project. Local jurisdictions will need to guarantee continued solar access for the site, such as by limiting vegetation growth and the height of future development adjacent to the site through easements and agreements.

### Network Access

Because almost all large-scale solar development projects connect to the local power grid, the proximity of grid infrastructure to a site affects its viability to host a large-scale solar energy system. Being near appropriate interconnection points can reduce initial project costs.

The appropriateness of an interconnection point is determined by the rated capacity of the system, its relationship to the grid (behind or in front of the meter), and the degree of PV penetration on the local distribution grid. If grid operators and developers do not prepare for high PV penetration, this can lead to grid instability. Local officials and grid operators can encourage developers to provide additional measures to mitigate instability or to efficiently connect to the transmission grid, but this may be more costly.

The location and capacity of the local power grid is a crucial consideration for site selection. Depending on whether a project will be community- or utility-scale, it will need to connect to either the distribution or transmission grid. Sites closer to an interconnection point will be less costly and more convenient for developers.

Local officials should consult and communicate with utility planners to familiarize themselves with current and future grid infrastructure in their jurisdictions, as well as the impacts of high PV penetration (see [Module 8](#)).



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### Selecting Development Partners

After a local government has set clear goals for its project and has a clear understanding of which sites are appropriate for large-scale solar development, the next step is selecting development partners who can implement a project.

Local officials will need to develop a competitive, fair, and open process for selecting development partners. Solar developers are the most common type of development partner, but local governments could also partner with community-based organizations, special districts, and other entities to implement a large-scale solar project that meets their needs and goals.

Local jurisdictions can issue a request for qualifications (RFQ) to identify potential development partners. Then, they can issue a request for proposals (RFP) to select a partner. Partner agreements are also necessary for active participants in the project beyond solar developers and operators, such as electricity offtakers and contractors.

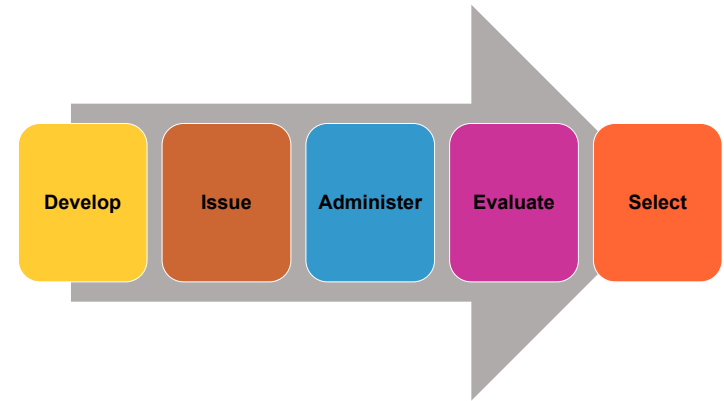


Figure 6-2. Steps in a request for proposals (RFP) process.

### Requests for Proposals

Local jurisdictions issue RFPs to solicit bids from potential partners who can develop, install, finance, interconnect, operate, or maintain a solar energy system (SolSmart 2021; IREC 2015; TSF 2012a). The basic steps of the RFP process include developing the RFP, issuing the RFP, administering the RFP, evaluating submitted proposals, and selecting the final proposal (Figure 6-2).

To develop a successful RFP, local officials will need to start with a clearly defined goal, consult with stakeholders, provide the potential partners with site information, and determine and adhere to criteria to evaluate bids. The RFP outlines expectations and establishes requirements that the local government has for its development partners (Table 6-2).

Providing expectations up front—such as project goals, priorities, and preferences— can narrow the pool of project proponents according to their eligibility and capabilities to meet these expectations. Early in

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**Table 6-2. Examples of RFPs for Large-Scale Solar Development Projects on Local Government Land**

Jurisdiction	RFP
Concord, NH	<a href="#">RFP 01-20: Ground-Mounted Solar Photovoltaic Systems on City-Owned Parcels</a> (2019)
Sacramento Regional County Sanitation District, CA	<a href="#">Request for Proposals for Solar PV PPA Project</a> (2015)
Urbana, IL	<a href="#">RFP #1718-08: Request for Qualifications for a Landfill Solar Developer</a> (2017)

the RFP process, local officials should summarize terms, conditions, and responsibilities that might exclude certain development partners. For example, developers who cannot provide low-impact or environmentally friendly design options or who are not capable of preparing brownfield sites for installation should not apply if these are listed as requirements for the project.

The RFP should provide as much information on potential sites as possible, including topographic maps or aerial photography. If local governments cannot provide these resources, they should grant temporary site access to potential developers.

The RFP should share basic information on the term of the lease, the possibility of extensions, and the process for making payments. This gives potential development partners the opportunity to share questions about terms and conditions.

The RFP should also aim to reveal the capabilities of the development team, its technical and project management approaches, and its proposed timelines. The capabilities of the development team include its qual-

ifications, experience, and proof of financial capacity and insurance coverage. Technical approach details the proposed system design, a proposed site plan, relevant studies on soil suitability and engineering, as well as equipment specifications. Project management approach covers operations and maintenance procedures, as well as the team’s ability to fulfill responsibilities for permitting, interconnection, and decommissioning. It also describes performance monitoring or control systems and performance guarantees. Another common element is a site security plan.

Finally, local governments may wish to have development partners share their plans for local hiring or training, and how they plan to communicate with community members about their options to participate in the project, as well as their concerns.

After finalizing the content of the RFP, local officials can announce the RFP and begin accepting proposals. Local officials will need to decide how they want respondents to submit proposals and ensure there are adequate staffing and resources to answer questions that potential development partners may have.

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Local officials should create criteria that allow them to evaluate submitted proposals in a standardized way. Adhering to evaluation criteria helps to ensure a fair process and increases the likelihood that the proposal selected will meet project goals. Successful review processes should emphasize the importance of a development partner achieving specific outcomes, without placing unnecessary limits on the technical, design, and project management approaches development partners use.

The final step in the RFP process is selecting the “winning” proposal and establishing partner agreements.

### *Partner Agreements*

Local government officials will need to establish agreements with organizations and entities that play an active role in project implementation. Solar developers and operators will typically be the primary development partner. Common partner agreements include site control agreements (such as a license, easement, or lease), solar access agreements, and power purchase agreements (PPAs) (IREC 2015).

A site license grants the large-scale solar system owner the right to use land for installation, operation, repair, and decommissioning. Licenses might be suitable for public land that serves another purpose, such as a parking lot, where system owners might want to have less responsibilities for the security and maintenance of the site. Property owners can revoke or terminate licenses unless development partners negotiate otherwise. Local officials can pair long-term PPAs with site licenses to mitigate the risks for system owners associated with licenses. But this does not always satisfy system owners’ concerns, in which case an easement or lease will be necessary.

An easement is like a license in that both authorize usage for limited purposes (e.g., installing and operating a large-scale solar energy system) without granting ownership. But in addition to allowing for the use of land, an easement allows the easement holder to take from the land and protect it from external interests. An easement requires a written agreement that provides specific details, such as the term period, rights, and purpose. Easements can assign clear responsibilities for security, solar access, and maintenance. Property owners and development partners can negotiate these features based on system characteristics.

A site lease gives a lessee (such as a large-scale solar system owner) possession of a property owned by another person or entity. In addition to allowing the system owner to use the land, it also gives them the ability to exclude other uses. Through a site lease, system owners take on the responsibilities of paying property taxes and insuring and securing the property. A site lease provides the system owner the power to grant sub-rights to other entities who provide interconnection, telecommunication, or other services (IREC 2015). Therefore, a system owner may grant easements or licenses, as well as sub-leases or co-leases.

When choosing a site control agreement, local officials should consider the characteristics of a project and local laws governing local-government-owned property. Officials can design easements to mirror the protections of a lease, but the main difference is that an easement does not allow for anything more than the purpose of operating a large-scale solar system. This may or may not be preferable for the local jurisdiction and can determine whether officials choose an easement or lease.

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Local officials should ensure they retain the right to access the property for inspections, monitoring, or other purposes. They should also use site agreements to establish partner responsibilities that they do not want to (or cannot) handle themselves, such as system removal and decommissioning (see [Module 4](#)).

In addition to site control agreements, local officials should also consider establishing solar access agreements with neighboring property owners. The most common form of a solar access agreement is a solar easement, which is a voluntary agreement that protects access to sunlight on the host site. Solar easements prohibit neighboring property owners from building any structure or allowing trees to grow in a way that prevents sunlight from reaching a solar energy system.

Power purchase agreements (PPAs) are long-term contracts that allow the local jurisdiction to buy power from a third party who owns and operates the large-scale solar system (IREC 2015; NREL 2009). The benefits of a PPA that make them desirable for many local governments' solar projects include low up-front costs and eligibility for federal tax incentives. Local governments can also expect stable electricity prices during the term of the agreement. However, PPAs are not permitted in every state ([Figure 6-3](#)), and there is no guarantee that the electricity price will be competitive with retail pricing.

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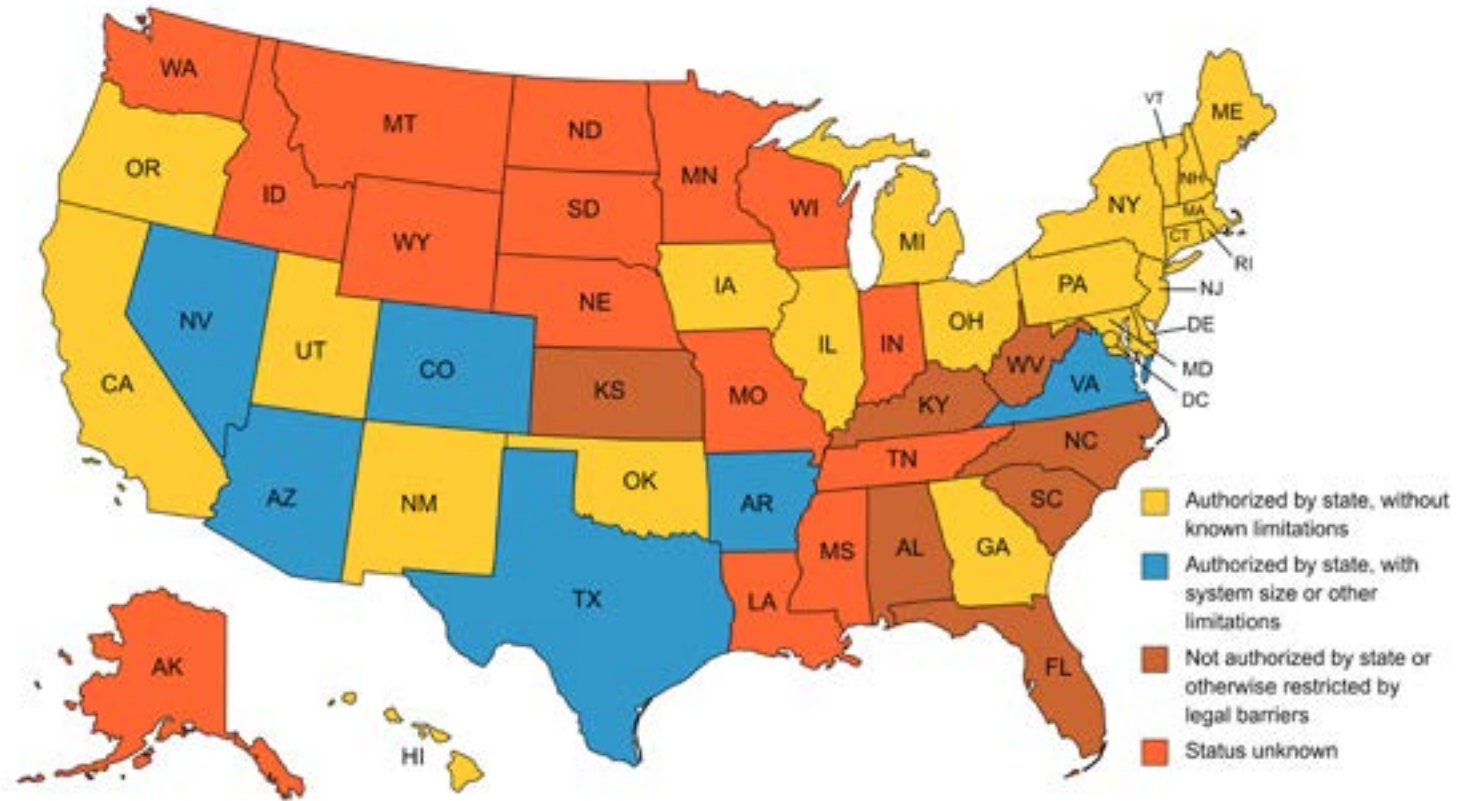


Figure 6-3. State-level authorizations for third-party solar PV power purchase agreements (Source: DSIRE)



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### KEY TAKEAWAYS

- Project goals for hosted solar energy systems should have a clear connection to broader community goals for large-scale solar development.
- Project sites must be relatively flat and unshaded by nearby structures or trees and have convenient access to the electricity grid.
- Local officials can use requests for proposals (RFPs) to identify and select project development partners.
- Local officials can use site agreements to establish access and use rights for development partners.
- Local officials can use solar easements to protect access to sunlight from the project site.
- In most states, local officials can use power purchase agreements (PPAs) to purchase the electricity produced by a hosted system.

## References and Resources

- Argonne National Laboratory. 2021. [“Energy Zones Mapping Tool.”](#)
- Bank, J., B. Mather, J. Keller, and M. Coddington. 2013. [“High Penetration Photovoltaic Case Study Report.”](#) Golden, Colo.: National Renewable Energy Laboratory.
- Brigham Young University, University of Idaho, Idaho National Laboratory, and Boise State University. n.d. [PVMapper.](#)
- Cory, Karlynn, Brendan Canavan, and Ronald Koenig. 2009. [“Power Purchase Agreement Checklist for State and Local Governments.”](#) Golden, Colo.: National Renewable Energy Laboratory.
- Dodson, Emily, Christopher Doyle, and Robert Lockhart. 2014. [Guide to Implementing Solar PV for Local Governments.](#) Washington, D.C.: International City/County Management Association
- ICF Incorporated, LLC. 2019. [“Interconnection: Plugging RE-Powering Sites Into the Electric Grid.”](#) RE-Powering America’s Land Initiative Discussion Paper. Washington, D.C.: U.S. Environmental Protection Agency.
- . 2019. [“The Value of Existing Infrastructure for Renewable Energy Development.”](#) RE-Powering America’s Land Initiative Discussion Paper. Washington, D.C.: U.S. Environmental Protection Agency.
- Interstate Renewable Energy Council (IREC). 2015. [Solar Power Purchase Agreements: A Toolkit for Local Governments.](#)
- Massachusetts Department of Energy Resources. 2016. [The Guide to Developing Solar Photovoltaics at Massachusetts Landfills.](#)
- National Renewable Energy Laboratory (NREL). 2009. [“Power Purchase Agreement Checklist for State and Local Governments.”](#)
- . 2013. [Best Practices for Siting Solar Photovoltaics on Municipal Solid Waste Landfills.](#) Washington, D.C.: U.S. Environmental Protection Agency.
- . 2020. [“Low-Impact Solar Development Strategies Guidebook.”](#)
- NC Clean Energy Technology Center. 2021. [“DSIRE Programs.”](#)
- New York State Energy Research and Development Authority. 2020. [“Municipal Solar Procurement Toolkit.”](#) In [New York Solar Guidebook for Local Governments.](#)
- Ross, Brian. 2020. [“Solar, with Benefits! \(Or, the Co-Benefits Approach to Solar Development\).”](#) Minneapolis, Minn.: Great Plains Institute.

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SolSmart. 2021. [“Solar Development on Public Facilities and Under-Utilized Land.”](#) In *Solar Energy: SolSmart’s Toolkit for Local Governments*.

The Solar Foundation (TSF). 2012. [“Leasing Municipal and Private Property for Solar: Key Steps and Considerations.”](#)

———. 2012a. [“Steps to a Successful Solar Request for Proposal.”](#)

U.S. Environmental Protection Agency. 2016. [“RE-Powering’s Electronic Decision Tree.”](#)

———. 2018. [Local Government Project Portal: Goal-Setting Guidance.](#)

———. 2019. [Interconnection: Plugging RE-Powering Sites Into the Electric Grid.](#)

———. 2021. [“Solar Project Development Pathway & Resources.”](#)



**MODULE**

**7**

**ASSISTING LARGE-SCALE SOLAR DEVELOPMENT**

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Historically, federal and state incentives, such as the federal investment tax credit and state renewable portfolio standards, have contributed to the rapid growth of the large-scale solar market (see [Module 2](#)). Meanwhile, local assistance programs have played much smaller supportive or complementary roles.

This module summarizes how local technical assistance initiatives can improve large-scale solar development outcomes and how local jurisdictions may be able

to use financial assistance programs to facilitate highly desirable large-scale solar projects.





### Providing Technical Assistance

Local government officials can provide technical assistance to help facilitate solar development projects or to connect community members with opportunities associated with development projects. At a minimum, this assistance requires staff time, and it may also require investments in new tools, supplies, or materials. Consequently, local government officials should reserve technical assistance efforts for solar development projects whose local benefits far outweigh tradeoffs.

Informational efforts can build local awareness of the opportunities and benefits of large-scale solar development. And programmatic investments can help landowners, residents, and developers take advantage of and maximize local large-scale solar development opportunities.

### Educational Events

Local jurisdictions can support educational forums, workshops, and open-house-style events initiated or hosted by development partners or industry experts that explain the large-scale solar development process and share specific opportunities for local participation.

Local officials should encourage events that cater to different audiences and their relevant opportunities, such as helping landowners learn the benefits and tradeoffs of hosting large-scale solar projects or informing residents how to apply for shared solar programs or job opportunities. These events give potential development partners the chance to make initial connections with property owners or pass along contact information to allow for future conversations.

Events for property owners can focus on considerations for solar land leases, such as local average lease

rates, conversion penalties, increases in taxable value, tax exemptions, ensuring return to pre-lease condition, and potential options for siting on different parts of property (NYSERDA 2020a).

Educational events should primarily provide information about the process of large-scale solar development, but they can also create opportunities for participants to access information and tools that allow them to weigh all their options, as well as ways to stay in touch with local staff and experts that can guide them through the process.

### Site Assessment Tools

Interactive mapping and assessment tools can help local property owners and prospective large-scale solar devel-

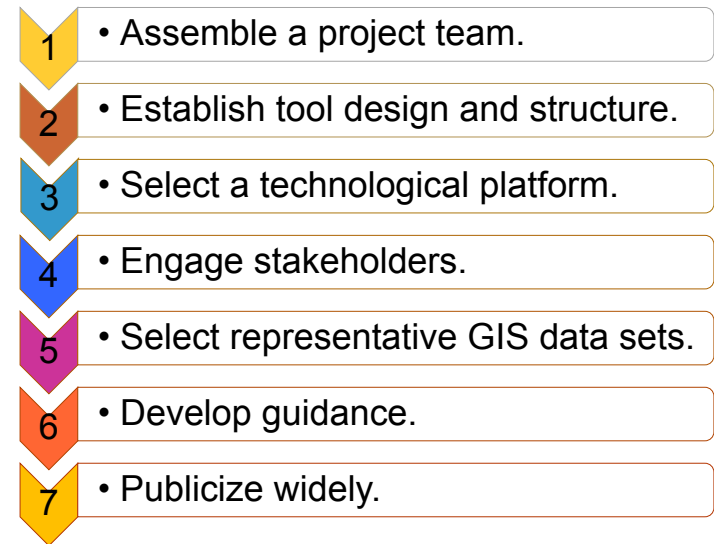


Figure 7-2. Scenic Hudson’s seven-step process for developing a local solar mapping tool to identify and prioritize locations for large-scale solar development (2021)

opers evaluate the development opportunities that are appropriate for their land or projects.

Online solar mapping tools can educate and inform property owners and developers about the estimated solar energy potential of a site and share information about the likely benefits of a large-scale solar project.

In 2017, Butte County, California, developed a solar mapping tool to identify areas that are conducive to utility-scale solar development (Figure 7-1). This tool rates the suitability of potential parcels according to their size and current land-use designation. It determines if a proposed site falls within “opportunity areas,” which the county defines as ei-

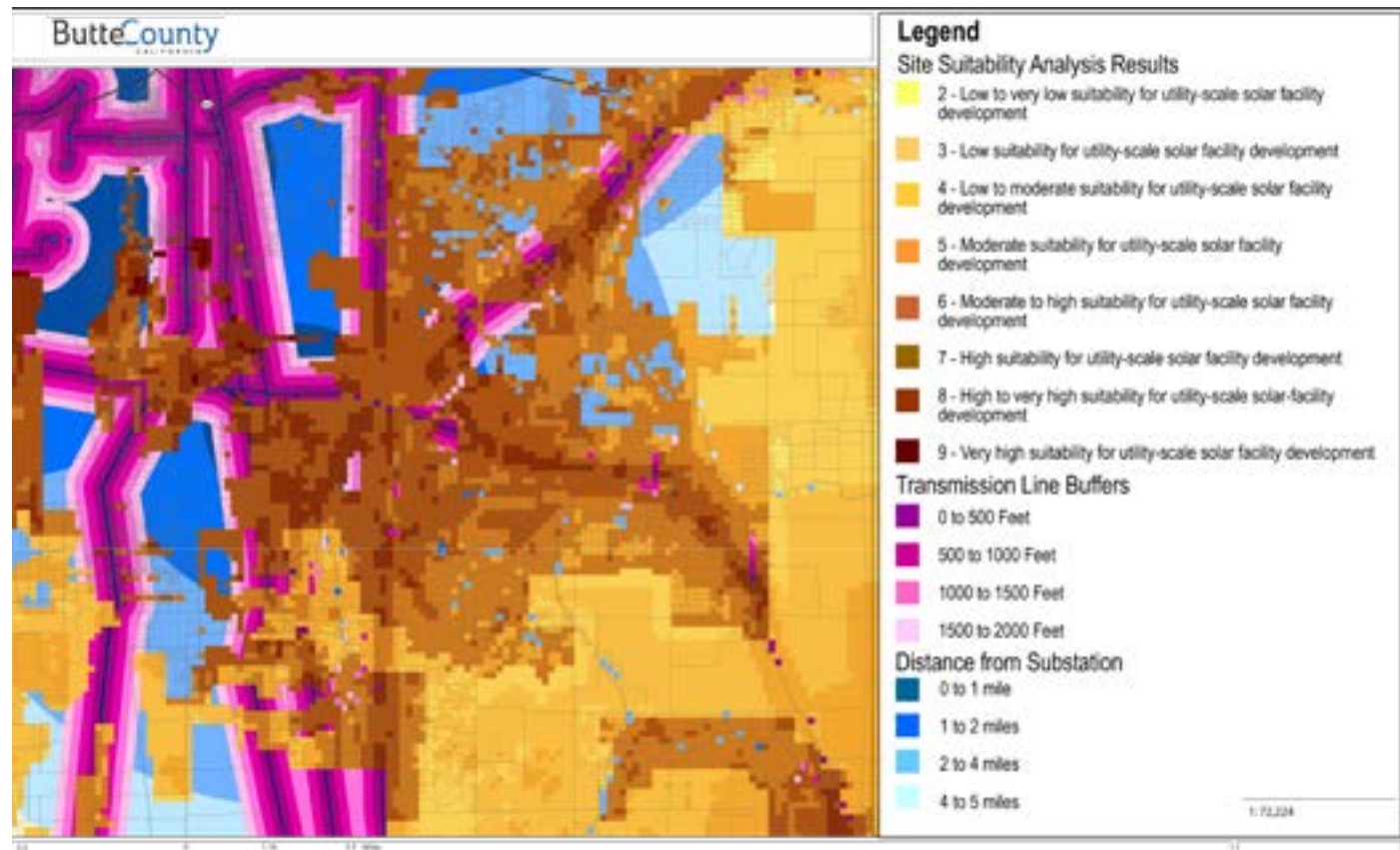


Figure 7-1. An exported image from Butte County, California’s PowerButte Utility-Scale Solar Guide Mapping Tool (Source: Butte County GIS)

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ther areas with limited alternative uses or those in proximity to transmission lines or substations. It also defines areas that may be feasible for utility-scale solar projects, with careful planning and design. Additionally, it identifies areas that are entirely unsuitable because of factors deemed important by the county (land-use compatibility, biological resources, agricultural resources, and natural hazards). This tool integrates a buffer analysis that constrains utility-scale solar development to varying degrees depending on distance from residential areas and scenic highways.

In 2020, Scenic Hudson created a similar mapping tool to help local officials, solar developers, and other community stakeholders in New York’s Hudson Valley identify and prioritize sites for solar development. It also created a seven-step guide to help communities in other regions develop their own mapping tools (2021; see [Figure 7-2](#)).

The first step in creating a local site assessment tool is assembling the project team. Ideally, this team should include staff members and other community stakeholders with expertise in planning, geographic information systems (GIS), renewable energy policy, conservation science, and public engagement. This team can establish the design and structure of the tool, select the platform that will host it, and select relevant datasets as inputs. Engaging with stakeholders throughout this process, especially for testing prototypes, can facilitate improvements based on feedback and build an established group of future users.

After finalizing the online mapping tool, local officials can promote its use by developing user-friendly guidance to help community members and solar developers understand the purpose of the tool, how to use it, and how to interpret the outputs and results.

Publicizing the tool through press releases, social media posts, web pages, and interactive activities can ensure residents are aware that the tool exists (Scenic Hudson 2021).

Local jurisdictions can also connect site assessment tools to local incentives. For example, they can help developers identify preferred locations—such as those that have been pre-screened for suitability—that may be eligible for development incentives (see [Module 4](#)) or direct financial incentives from the state or local jurisdiction.

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## Providing Financial Assistance

Many cities, towns, and counties use financial incentives to attract development projects. Some of these incentives are ad hoc and project specific; others are standardized assistance programs with uniform eligibility criteria.

As with technical assistance efforts, local financial incentives are only appropriate in cases in which highly desirable projects (those that confer local benefits far outweighing tradeoffs) may be financially infeasible or carry high risks. Potential examples include solar projects on brownfield sites, floating solar (see [Module 8](#)), and those designed to maximize co-benefits or benefits for populations that utilities and local governments have historically underserved.

Tax incentives are often the most widely available form of financial assistance as they do not require a dedicated source of local funding. However, programs that support shared solar projects may be the most locally beneficial.

### *Tax Incentives*

Federal tax incentives have been critical to the success of many large-scale solar projects. The necessity of local tax incentives is often less clear, and state laws may constrain local tax incentive options.

There is no consensus method of assessing property taxes on large-scale solar energy systems and project sites. And there is no widespread agreement about what types of property taxes should apply. Some states classify large-scale solar energy systems as real property, while others classify them as personal property (Barnes et al. 2013; Goss and Fazeli 2018).

Accurate and fair tax assessments can reduce tax burden on large-scale solar projects. Most states and local ju-

risdictions base their property tax assessment on the idea that a property's replacement cost will rise every year. This does not always apply to large-scale solar facilities, whose replacement costs may decrease as technologies mature (Bernard and Mason 2018; see [Module 2](#)).

Assessors and elected officials typically oppose reducing the local tax base and might initially be hesitant to make large-scale systems eligible for tax incentives. Local officials will need to reconcile potentially competing policy objectives, such as increasing local revenue or decreasing tax burdens. Elected officials may find providing tax incentives, alongside creating accurate tax valuation models, more reasonable when they understand the potential to meet local economic development and other community goals through large-scale solar development.

The most common types of local tax incentives for development projects are property tax exemptions or abatements and tax increment financing (Kenyon, Langley, and Paquin 2012). Each method has distinct advantages and disadvantages with respect to large-scale solar projects.

Property tax exemptions reduce the taxable value of personal or real property, while property tax abatements directly reduce the amount of personal or property taxes owed over a specified period. Both exemptions and abatements can help solar developers secure financing for large-scale solar projects, and both can increase the profitability of the installation for as long as the incentive remains in effect. They also reduce the local property tax revenue collected by the local jurisdiction.

The impact that property taxes have on the long-term financial viability of large-scale solar projects can be significant. Many states and local governments grant full or partial tax exemptions for property that serves a public or



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**Table 7-1. Examples of Payment in Lieu of Taxes (PILOT) Agreements**

Jurisdiction	Agreement
Klamath County, OR	<a href="#">Payment in Lieu of Taxes Agreement by and Between Chiloquin Sollar LLC and Klamath County, Oregon</a> (2018)
Laconia, NH	<a href="#">Payment in Lieu of Taxes Agreement Between the City of Laconia and Laconia Town Solar, LLC</a> (2018)
Marlborough, NY	<a href="#">Payment in Lieu of Taxes Agreement for Solar Energy Systems Between the Town of Marlborough, County of Ulster, the Marlboro Central School District and Marlborough Solar, LLC</a> (2019)

beneficial purpose—such as solar energy systems. However, most existing local tax incentives for solar focus only on residential installations. The eligibility of large-scale projects for property tax exemptions has been a point of debate as the language of most incentives does not address them (Goss and Fazeli 2018).

Some states exempt or abate personal property taxes for large-solar energy systems, and some of these states authorize local jurisdictions to negotiate payments in lieu of taxes (PILOTs) from tax-exempt property owners to recover some lost revenue (see [Tables 7-1](#) and [7-3](#)). Others explicitly authorize local jurisdictions to offer exemptions or abatements. Local jurisdictions may be able to negotiate PILOTs with developers based on property and system type (e.g., large-scale installations receive different treatments than small-scale ones). Local officials should review their state statutes to see if they allow or require PILOT agreements and specify terms of use.

Tax increment financing (TIF) provides a mechanism to borrow against the future property values of an area to finance capital improvements that will spur development. Where authorized, local jurisdictions can designate TIF districts that allow them to issue bonds to be paid back

as property tax values increase over time. The basic idea behind TIF is that when a developer improves a property, the value of that property rises, and the taxes generated on that site increase. The difference between the pre-improvement taxes and the post-improvement taxes is the “tax increment.”

TIF can help local jurisdictions invest in costly infrastructure upgrades, such as electric transmission or distribution network expansions, that can make solar development projects feasible. However, once the local jurisdiction creates a TIF district, it cannot use the increased tax values to fund local services because this increment is earmarked to pay off the bonds.

*Support for Shared Solar*

Shared solar projects that allow multiple local participants to purchase ownership shares or a percentage of the power produced by the project have proven to be an effective strategy for broadening local access to the direct benefits of solar energy (ACCC n.d.; Cook and Bird 2019; DenHerder-Thomas and Welle 2020; IREC 2016; ISC 2021). Consequently, local jurisdictions with equity-related large-scale solar development goals might want to



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**Table 7-2. Examples of Local Jurisdictions as Anchor Subscribers**

Jurisdiction	Project Participation
Denver Housing Authority, CO	Financed and owns a shared solar project in Watkins, Colorado, that provides on-bill credits to public housing residents (ICMA and Cadmus 2019)
Orlando, FL	Serves as an anchor subscriber for a shared solar project owned by the city’s municipal utility (Lindwall 2020)
Saint Paul Housing Authority, MN	Serves as an anchor subscriber for multiple off-site shared solar projects to offset 100 percent of energy use at 10 high-rise buildings and the authority’s administrative building (Grid Alternatives and Vote Solar 2021)

prioritize assistance for shared solar projects that enroll or hire members of marginalized communities, remove barriers for low- and moderate-income participants, or seek community-based developers as development partners.

Beyond offering property tax incentives, a local jurisdiction can also help shared solar projects secure financing by becoming an anchor subscriber, a backstop purchaser, or by setting up loan loss reserves (ACCC n.d.; DenHerd-er-Thomas and Welle 2020; IREC 2016; USDOE n.d.).

Anchor subscribers reduce costs by helping projects reach economies of scale. They provide assurance to financiers by providing a guaranteed amount of project cash flows. Becoming an anchor subscriber is an opportunity for local governments, who typically have large electric loads, to power their operations through clean energy (Table 7-2). Alternatively, local governments can serve as backstop purchasers, which agree to purchase the generated energy that the main subscriber base does not use.

One tradeoff for local jurisdictions that take on the role of an anchor or backstop purchaser is that they might get locked into a power purchase agreement that might be

more expensive than alternative arrangements, though this is uncommon.

Besides direct participation in a shared solar project, local governments can also set up loan loss reserves, or public funds put aside to pay unmet project obligations, such as those caused by customers in default. These programs offset financial risk, enhance the credibility of the project, and make it possible for low- or moderate-income customers to participate in a shared solar project. However, the local jurisdiction typically pays out of pocket for loan loss reserves, requiring them to prioritize this spending over other activities.

Finally, local jurisdictions may be able to provide direct financial support to shared solar projects through a land disposition agreement. With governing board approval, local governments can donate surplus public land, or sell it at below market value, to a nonprofit organization for use as a shared solar project site. But donating or discounting land for solar projects means the local jurisdiction could lose out on revenue from leasing or selling these lands at market value.

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### KEY TAKEAWAYS

- Local government officials can provide technical assistance to help facilitate solar development projects or to connect community members with opportunities associated with development projects.
- Educational events can help landowners assess opportunities to host a large-scale solar project or utility customers learn more about how they can subscribe to a shared solar project.
- Interactive mapping and decision-support tools can help local property owners and prospective large-scale solar developers evaluate the development opportunities that are appropriate for their land or project.
- Accurate and fair tax assessments can reduce tax burdens on large-scale solar projects.
- Local jurisdictions can help shared solar projects secure financing by becoming an anchor subscriber, a back-stop purchaser, or by setting up loan loss reserves.

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## References and Resources

American Climate Cities Challenge (ACCC). n.d. [“Procurement Guidance: Community Solar.”](#)

Barnes, Justin, Chad Laurent, Jayson Uppal, Chelsea Barnes, and Amy Heinemann. 2013. [Property Taxes and Solar PV Systems: Policies, Practices, and Issues](#). Raleigh, N.C.: North Carolina Solar Center.

Bernard, Tom, and Trevor Mason. 2018. [“Reducing Property Taxes a Key to Profitability of Renewables.”](#) Utility Dive, November 29.

Brigham Young University, University of Idaho, Idaho National Laboratory, and Boise State University. n.d. [“PVMapper.”](#)

Butte (California), County of. 2017. [“Butte Utility-Scale Solar Guide Mapping Tool.”](#)

Cook, Jeffrey J., and Lori Bird. 2019. [Unlocking Solar for Low- and Moderate-Income Residents: A Matrix of Financing Options by Resident, Provider, and Housing Type](#). Golden, Colo.: National Renewable Energy Laboratory.

DenHerder-Thomas, Timothy, and Jonathan Welle. 2020. [Equitable Community Solar: Policy and Program Guidance for Community Solar Programs that Promote Racial and Economic Equity](#). Washington, D.C.: Institute for Local Self-Reliance.

Grid Alternatives and Vote Solar. 2021. [“Low-Income Solar Policy Guide.”](#)

Goss, Stephen, and Sandy Fazeli. 2018. [“Section 4: Property Taxes.”](#) In U.S. Climate Alliance Solar Deployment Guidebook: A Resource for State and Local Governments. Arlington, Va.: National Association of State Energy Officials.

Hackler, Darrene, and Ellen Harpel. 2020. [“A Framework for Responsive Economic Development: Determine, Design, and Evaluate.”](#) In Reflecting Community Priorities in Economic Development Practices. Philadelphia: The Pew Charitable Trusts.

Interstate Renewable Energy Council (IREC). 2016. [“Shared Renewable Energy for Low- to Moderate-Income Consumers: Policy Guidelines and Model Provisions.”](#)

Institute for Sustainable Communities (ISC). 2021. [“Catalyzing Community Solar.”](#)

International City/County Management Association (ICMA) and Cadmus. 2019. [“Solar in Your Community Challenge Case Study: The Community Affordable Renewable Energy \(CARE\) Project.”](#)

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Kenyon, Daphne E., Adam H. Langley, and Bethany P. Paquin. 2012. [Rethinking Property Tax Incentives for Business](#). Cambridge, Mass.: Lincoln Institute of Land Policy.

Lindwall, Courtney. 2020. [“Meet the Sunshine State’s New Clean Energy Darling—Community Solar.”](#) NRDC Dispatch, August 6.

National Aeronautics and Space Administration DEVELOP, Georgia Chapter of the Nature Conservancy, and Georgia Department of Natural Resources. 2020. [“Georgia Low Impact Solar Siting Tool \(LISST\).”](#)

National Renewable Energy Laboratory. 2018. [“Low- and Moderate-Income Solar Policy Basics.”](#)

New York State Energy Research & Development Authority (NYSERDA). 2020a. [“Landowner Considerations for Solar Land Leases.”](#) In New York State Solar Guidebook. Albany, N.Y.: NYSERDA.

———. 2020. [“Solar Payment-In-Lieu-Of-Taxes \(PILOT\) Toolkit.”](#) In New York State Solar Guidebook. Albany, N.Y.: NYSERDA.

Scenic Hudson. 2021. [“How to Solar Now.”](#)

SolSmart. 2021. [“Market Development and Finance.”](#) In Solar Energy: SolSmart’s Toolkit for Local Governments.

Sundberg, Tanya. 2017. [“Memorandum: Weighted Raster Overlay Model for Butte County.”](#) Berkeley, Calif.: PlaceWorks.

U.S. Department of Energy (USDOE). n.d. [“State and Local Solution Center: Loan Loss Reserve Funds and Other Credit Enhancements.”](#)

U.S. Environmental Protection Agency. 2021. [RE-Powering America’s Land Initiative Mapper Tool](#).

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**Table 7-3. Property Tax Incentives and Local Property Tax Incentive Options for Large-Scale Solar Development by State**

State	Property Tax Incentive	Authorization for Local Property Tax Incentive
Alabama	None	Authorizes localities to exempt up to 100% of personal property taxes for up to 10 years (with a possible 10 year extension) (§40-9B)
Alaska	None	None
Arizona	Equipment taxed at 20% of taxable original cost (minus depreciation) (§42-14155)	None
Arkansas	None	None
California	Exempts new solar energy systems from real property taxes (Revenue and Taxation Code §73)	None
Colorado	Community solar gardens exempted from personal property taxes (§39-3-118.7)	Authorizes localities to offer a property or sales tax credit or rebate for the installation of a solar energy system (§30-11-107.3 & §31-20.101.3)
Connecticut	Exempts virtual net metered solar energy systems from real property taxes (§12-81(57)(D))	Authorizes municipalities to exempt up to 100% of real property taxes for any solar energy system subject to a power purchase agreement approved by the Public Utilities Regulatory Authority for the duration of the agreement (§12-81(57)(F))
Delaware	None	None
Florida	Exempts new solar energy systems on nonresidential property from 80% of real property taxes (§193.624)	None
Georgia	None	None
Hawaii	None	None
Idaho	Exempts properties hosting supply-side solar energy systems (other than systems owned by regulated public utilities) from all real and personal property taxes (§63-602JJ); however, solar power producers must pay a 3.5% tax on gross energy earnings (§63-3502B)	None
Illinois	None	None
Indiana	None	None



**Table 7-3. Property Tax Incentives and Local Property Tax Incentive Options for Large-Scale Solar Development by State**

State	Property Tax Incentive	Authorization for Local Property Tax Incentive
Iowa	None	None
Kansas	Exempts new solar energy systems from personal property taxes for 10 years (§79-201(11))	None
Kentucky	None	None
Louisiana	None	None
Maine	Exempts virtual net metered solar energy systems from real and personal property taxes (§36-656.K; §36-655.U)	None
Maryland	Exempts solar energy systems from real property taxes (§7-242)	None
Massachusetts	None	Authorizes municipalities to enter into tax increment financing (TIF) exemption agreements or payment-in-lieu of taxes agreements for qualifying projects (§40-59; §59-38H)
Michigan	None	None
Minnesota	Exempts solar energy systems from personal property taxes (§272.02.24); however, owners of supply-side systems with rated capacities over 1 MW must pay a production tax (§272.0295)	None
Mississippi	None	None
Missouri	Exempts solar energy systems from real and personal property taxes (§137.100)	None
Montana	Exempts solar energy systems with rated capacities of 1 MW or greater from 50% of real property taxes for a period of 5 years, with a decreasing exemption percentage for the next 5 years (§15-24-1401 et seq.)	None
Nebraska	Exempts all solar energy systems with rated capacities of 100 kW or greater from personal property taxes (§77-202(10)); however, owners must pay a nameplate capacity tax (§77-6203)	None

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**Table 7-3. Property Tax Incentives and Local Property Tax Incentive Options for Large-Scale Solar Development by State**

State	Property Tax Incentive	Authorization for Local Property Tax Incentive
Nevada	Exempts supply-side solar energy systems from 55% of real property taxes for a period of 20 years ( <a href="#">§701A.360 et seq.</a> )	None
New Hampshire	None	None
New Jersey	Stipulates that working farms that host solar energy systems with rated capacities of 2 MW or less can continue to be taxed as farms, provided they meet specific conditions ( <a href="#">§54:4-23.3</a> )	None
New Mexico	None	None
New York	Exempts solar energy systems from real property taxes for a period of 15 years, unless localities opt out ( <a href="#">RPT §487</a> )	Authorizes localities to either opt out of a 15-year real property tax exemption for solar energy systems or to negotiate payments in-lieu of taxes ( <a href="#">RPT §487</a> )
North Carolina	Exempts supply-side solar energy systems from 80% of personal property taxes ( <a href="#">§105-275(45)</a> )	None
North Dakota	None	None
Ohio	None	Authorizes counties to exempt solar energy systems with rated capacities of 20 MW or greater from personal property taxes through 2023 and to negotiate payments in-lieu of taxes ( <a href="#">§5727.75</a> )
Oklahoma	None	None
Oregon	None	Authorizes localities to create Rural Renewable Energy Development Zones that exempt properties that host supply-side solar energy systems from real property taxes for a period of 3 to 5 years ( <a href="#">§285C.350 et seq.</a> )
Pennsylvania	None	None
Rhode Island	None	Authorizes municipalities to exempt solar energy systems from personal property taxes ( <a href="#">§44-3-21</a> )
South Carolina	None	None

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**Table 7-3. Property Tax Incentives and Local Property Tax Incentive Options for Large-Scale Solar Development by State**

State	Property Tax Incentive	Authorization for Local Property Tax Incentive
South Dakota	Exempts solar energy systems with rated capacities up to 5 MW from the greater of the first \$50,000 or 70% of assessed real property value from taxation (§10-4-44)	None
Tennessee	None	None
Texas	None	None
Utah	None	None
Vermont	None	None
Virginia	Exempts all solar energy systems with rated capacities of 5 MW or less from 100% of real and personal property taxes and systems with rated capacities up to 150 MW from 80% of real and personal property taxes (§58.1-3660)	Authorizes localities to require owners of supply-side solar energy systems with rated capacities greater than 5 MW to pay a revenue share in exchange for a 100% personal property tax exemption (§58.1-2636)
Washington	None	None
West Virginia	None	None
Wisconsin	Exempts all solar energy systems from personal property taxes (§70.111(18))	None
Wyoming	None	None



**MODULE**

**8**

**MAXIMIZING SUCCESS**

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Solar technology, the modern grid system, and renewable energy policy are all variables that can (and will) change rapidly. The decisions of different groups also influence the future of large-scale solar development ([Module 2](#)). Local government officials that account for this uncertainty can be better prepared to maximize success.

This module highlights the importance of monitoring and evaluating the performance of local plans, programs, and policies that affect large-scale solar development;

aligning local land-use and regional utility plans; enhancing resilience; and preparing for innovation in solar technologies.



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## Monitoring and Evaluating Performance

For local officials, the process of maximizing success begins with monitoring and evaluating the performance of existing plans, policies, and implementation programs. Regular monitoring and evaluation can help staff and elected officials spotlight successes and identify strategies that need adjustment.

Previous modules summarized how local officials can influence large-scale solar development outcomes through community planning, zoning regulations, and land-use decisions; development partnerships; and assistance programs. Each of these activity areas presents distinct performance management challenges and opportunities.

Effective monitoring and evaluation starts with choosing meaningful performance indicators and setting appropriate performance targets. These indicators and targets form the basis for regular performance reports.

### *Indicators and Targets*

Performance indicators are metrics that tell a story about local government or community activities or conditions (Feiden 2016; Phillips 2003; Young 2019). Performance targets are aspirational indicator values that, once met, demonstrate clear progress toward a larger goal (Young 2019).

For indicators to be meaningful, local officials must tie them to the community's vision and long-term goals for large-scale solar development. Meaningful indicators allow local government practitioners to measure progress and assess the well-being of the individuals, groups, and systems within a jurisdiction (Table 8-1). It is unrealistic to select indicators that ask local government practitioners to take responsibility for factors they cannot fully control.

Instead, a holistic set of indicators allows the local jurisdiction to measure specific activities and outputs (such as programs and procedures) and to also identify the relationships among factors within complex systems (such as the economy or ecosystems) it can reasonably influence.

Appropriate targets should reflect a range of time periods, from immediate changes that staff can expect to see within a few years to mechanisms that track long-term changes over many decades.

Local officials should select indicators that meet as many ideal characteristics as possible. This includes the validity, consistency, reliability, and comprehensiveness of data and information. Indicators should also be relevant to the performance area, as well as to various audiences and purposes. They should be financially feasible and practical for local government staff to measure. Finally, whenever possible, officials should select indicators that make it easier to compare similar contexts within or outside of the local jurisdiction.

To assist monitoring and evaluation of the community planning process, local officials should select indicators and targets that measure progress related to procedural goals (such as inclusive public participation) and goals for large-scale solar development found in community plans (see Module 3). To set appropriate targets for public participation, planning officials should start with the level of participation in past planning processes for comparable topics. A realistic target value should also factor in the expected impact of methods that officials are using to remove barriers to participation. The number of policies that address large-scale solar development in local plans can be a relevant indicator, but officials should also consider ways to measure the quality of these policies.

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**Table 8-1. Examples of Performance Indicators for Large-Scale Solar Development by Performance Area**

Performance Area	Potential Indicators
Community planning	Percentage of community members who participated in visioning and goal-setting exercises for large-scale solar development Percentage of comprehensive plan recommendations related to large-scale solar development implemented
Zoning	Percentage of large-scale solar development applicants requesting variances from zoning standards Percentage of large-scale solar development applicants requesting zoning amendments
Land-use decisions	Average number of days between application and decision for large-scale development projects requiring discretionary use permits Percentage of large-scale solar development projects approved
Development partnerships	Percentage of local utility customers participating in large-scale solar development projects on local government sites Percentage of local government electricity consumption offset by large-scale solar development projects on local government sites
Assistance programs	Average return on investment for direct financial incentives claimed by large-scale solar development projects Percentage of technical assistance users who subsequently participated in a large-scale solar development project

Planning officials should review whether zoning regulations adequately address the reoccurring characteristics of proposed large-scale solar projects (see [Module 4](#)). Indicators and targets should assist local officials in monitoring and evaluating the relationship between zoning regulations and the common characteristics of proposed projects. In doing so, they can determine the appropriateness of existing zoning regulations and make reasonable changes that are in line with community goals.

It is important to also measure the effectiveness of decision-making procedures for large-scale solar develop-

ment, particularly for land-use decisions (see [Module 5](#)). Indicators and targets should assist local officials in monitoring and evaluating the relationship between development review activities and large-scale solar development outcomes. Good indicators and targets can help local government managers and planning officials understand the typical experiences of applicants regarding transparency and appropriate response times during decision-making procedures. Furthermore, they can help officials determine if there is consistency and fairness in the decision-making process when compared to the rate of success for other



development applications in the jurisdiction (or the rate of success for large-scale solar development applications in a similar jurisdiction).

Local government managers and elected officials should review the types of development partnerships in the jurisdiction. Indicators and targets should assist local officials in monitoring and evaluating the relationship between the characteristics of large-scale solar projects hosted on local government land and previously identified project goals (see [Module 6](#)). By monitoring and evaluating this performance area, officials can determine if the value and benefits of existing large-scale solar projects hosted on local government land meet stakeholder expectations.

When monitoring and evaluating the efficacy of financial and technical assistance programs, it is important to consider which individuals and groups are taking advantage of these resources (see [Module 7](#)). Indicators and targets should assist local officials in monitoring and evaluating the relationship between assistance program activities and large-scale solar development outcomes, such as local participation. In doing so, local government managers and elected officials can determine the reach and usefulness of assistance programs for large-scale solar development and make necessary changes.

### *Regular Reporting*

Regular reporting on performance measures can keep both local government officials and the wider community informed about progress toward large-scale solar development goals.

Reporting can empower staff to improve processes and activities to achieve results. Internal communication between local staff and elected officials—who are likely

to change over time—will ensure they remain aware of the collective vision.

Reporting is also an important tool for engagement, keeping residents and stakeholders informed, interested, and confident in the work of their local government. Reporting can remind community members of the collective vision that they helped set, as well as show the progress that the local government has made toward achieving that vision.

The frequency of reporting depends on the nature of the indicator. Local officials should establish how often they might expect to see change for certain indicators, then reflect this in the reporting process. For some measures, staff may be able to automate reporting and provide real-time data through an open data portal or dashboard. For other measures, staff will need to choose how often to collect and report data. Local officials can also use these dashboards to share indicators and targets. Periodic reports are typically better for characterizing progress toward performance targets, but they can also communicate the reasoning for selected indicators.

Periodic reports can either be standalone products or integrated into other regular communications, such as news releases, community or constituent newsletters, or social media posts. But reporting requires more than just sharing data tables and target values out of context. Local government officials and the wider community will need to understand the message or story that the indicators and targets tell. Officials might consider developing narratives, visuals, and interactive tools within performance dashboards. Additionally, officials should invite community members to co-create data products that are relevant to them.

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Examples of data that might be appropriate for an open access portal or dashboard are the number of approved and pending large-scale solar development applications by type or the real-time power generation of a solar installation on local government property.

Reporting should communicate the truth instead of trying to make the local government look successful. Performance measurement information that avoids taking responsibility for mistakes or shortcomings might come across as unreliable and biased (NPMAC 2010). While it is often difficult to admit errors, honest and accurate reporting can help local officials fix problems and improve future outcomes.

### Aligning Land-Use and Utility Plans

In most areas of the country, there are few, if any, explicit links between local land-use and state or regional utility plans. This disconnect can frustrate local efforts to steer large-scale solar development to specific areas or to achieve ambitious clean energy goals.

For example, the local government's optimal or preferred locations for solar energy systems may not be near existing or planned transmission infrastructure. Or the optimal routes for transmission infrastructure identified by utilities or grid operators may be incompatible with local land-use plans.

To begin to change the status quo, local government officials will need to foster collaborative relationships with state and regional utility counterparts (Elkind and Lamm 2018). This includes encouraging utility-sector participation in local planning processes and engaging in public utility commission and regional transmission organization planning and decision-making processes.

### Public Utility Commission Engagement

Public utility commissions (PUCs), also known as public service commissions, regulate investor-owned electric utilities. They may also have authority or influence over rural cooperatives and municipal utilities.

PUCs are primarily responsible for ensuring affordable rates and reliable service for utility customers, as well as financial viability for utilities. They also review and approve goals for renewable energy procurement as well as certificates of need and power purchase agreements for large-scale solar projects. Consequently, PUCs have considerable influence over state-level transmission planners, grid infrastructure developers, and power pur-

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chasers. Ideally, PUCs would encourage or require these actors to collaborate with local jurisdictions and incorporate local plan recommendations—such as preferred locations and project designs—into their own planning processes (Elkind and Lamm 2018).

While local governments typically only engage with PUCs about topics such as rate setting, there are a growing number of reasons to go beyond traditional concerns (Duncan and Crandall 2019), including the recent focus on local climate action and the demand for clean energy. By becoming more involved in the regulatory processes of PUCs, local governments can take advantage of valuable opportunities to influence state or utility policy proposals that impact the residents they serve or the economic development and environmental sustainability of their jurisdiction.

Each local government will have varying motivations and different levels of capacity to engage with PUCs

(Table 8-2).

There are many ways that local government officials can ensure a path to meaningful engagement in regulatory processes. First, staff can make a clear case to elected leadership about the connections between local energy goals and local government participation in PUC regulatory processes. After doing so, local officials can start with less resource-intensive participation techniques and slowly ease into deeper engagement over time. Elected officials can also designate funding to hire staff or experts, or collaborate with other stakeholders who have similar interests and motivations to pool resources.

Finally, local officials should ensure two-way communication with PUC staff: not only should they closely follow and participate in PUC proceedings, but they should also provide PUC staff the chance to participate in relevant community planning processes.

**Table 8-2. Potential Ways to Engage With Public Utility Commissions (PUCs) (Duncan and Crandall 2019)**

Engagement Activity	Description
Maintain an informal relationship with PUC staff	Stay informed by following PUC proceedings that are relevant to your jurisdiction.
File public comments	Gain enough familiarity with topics to draft meaningful comments in response to the PUC regulatory process and proceedings.
Join (or form) a coalition of groups with shared interests	Share responsibility with local governments or large electric customers to represent interests at PUC proceedings or through public comments.
Hire expert staff or contract technical and legal experts	Delegate responsibility to specific staff to closely follow and participate in regulatory processes and proceedings.
Participate formally in the PUC regulatory process	Become a formal stakeholder after consistent communication with PUC staff or sustained participation and interest in regulatory processes and proceedings.



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**Regional Transmission Organization Engagement**

Regional transmission organizations (RTOs) administer wholesale energy markets and are the regional planning authorities for transmission planning (see [Module 2](#)). The planning processes of RTOs mainly involve preparing regional transmission plans and selecting transmission projects. The planning process considers and evaluates possible solutions and alternatives that can meet specific regional transmission needs based on reliability requirements, public policy, or economic considerations (Eto and Gallo 2017).

By sharing their goals with RTOs, local governments can reduce the chance that lack of transmission and interconnection points becomes a barrier to preferred siting for large-scale solar development. It may also be relevant for local governments to advocate for better alignment be-

tween local land-use plans and regional transmission plans.

Because each RTO develops its own planning cycles, processes, and stakeholder engagement, local governments will face different issues and conditions related to their RTO. There are multiple ways to engage with an RTO, depending on organizational capacity ([Table 8-3](#)).

**Table 8-3. Potential Ways to Engage With a Regional Transmission Organization (RTO) (Ratz, Roche, and Hutchinson 2021)**

Engagement Activity	Description
Craft public statements	Initiate public dialogue on barriers to clean energy in the regional wholesale market.
File comments (or complaints)	Communicate with the Federal Energy Regulatory Commission (FERC), which provides oversight for RTOs, by learning how to research, draft, and submit comments (or complaints).
Engage with the RTO as a nonmember	Build relationships with RTO staff, such as by participating in RTO outreach events.
Partner with, or form, a coalition of stakeholders	Overcome organizational limitations (e.g., lack of capacity or expertise) by working with other stakeholders, potentially through existing councils of government and regional planning agencies, to engage with RTOs.

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## Enhancing Resilience

Distributed solar power generation is part of the vision for a more resilient grid. However, better technology, planning, and flexibility will be necessary to prepare the existing grid system to better accommodate intermittent power sources, including solar energy systems. Grid operators will need to be able to react quickly to changing conditions that affect generation patterns. If not managed correctly, this could compromise grid stability and lead to power shortages or blackouts.

Recent disasters have shown that the utility industry needs to be proactive by evaluating resiliency options and pursuing new ways to structure and operate the grid sooner rather than later (O'Neill-Carrillo et al. 2017). Large-scale solar facilities that incorporate energy storage and other advanced controls can help to decarbonize the grid to achieve climate goals, as well as improve system reliability and resiliency.

### Energy Storage

The fluctuation of power output that PV systems experience could become a major issue as solar energy generation increases. One way to increase the penetration of PV generation into the grid is to add energy storage devices—such as batteries, compressed air, and pumped storage hydropower—to large-scale solar projects (O'Neill-Carrillo et al. 2017). By doing so, developers can ensure their systems contribute to balanced loads and enhanced grid stability.

At its commissioning in 2019, the AES Lawai Solar Project in Kauai, Hawaii, became the world's largest battery plant paired with solar generation (Spector 2019). It consists of a 28 MW PV system and 100 MWh battery



Figure 8-1. The AES Lawai Solar Project in Kauai, Hawaii (Photo by Dennis Schroeder / NREL)

energy storage system (Figure 8-1). This project not only helps provide clean energy at night, but can also restart the island's electricity grid in case of an outage.

Users can design energy storage for individual loads, but community energy storage that serves multiple customers in a specific distribution area has a better chance of building local resilience. Utility-owned community energy storage can offer greater reliability to utility customers, add the cost of storage into the utility rate, and phase in higher levels of solar energy generation. But state and local policymakers will need to pay close attention to how local utility rate structures and incentives encourage user behavior and usage patterns and collaborate with utilities to find ways that prepare for the solar energy load (NREL 2017a).

Local government officials can align goals and policies that address the installation, operation, maintenance, and

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**Table 8-4. Examples of Local Zoning Codes That Define and Regulate Energy Storage Facilities as a Distinct Use**

Jurisdiction	Zoning Approach
Ellsworth, ME	Defines and regulates accessory and “stand-alone” energy storage systems as distinct uses ( <a href="#">§56-14</a> ; <a href="#">§56-3-307</a> ; <a href="#">§56-8-824</a> )
King George County, VA	Defines and regulates battery energy storage facilities as a distinct use (Appendix A <a href="#">§1.9</a> ; <a href="#">§2.12</a> ; <a href="#">§4.19</a> )
Warwick, RI	Defines and regulates accessory and principal energy storage facilities as distinct uses and establishes overlay districts for principal solar energy systems and energy storage facilities ( <a href="#">Ordinance PCO-6-20</a> )

decommissioning of energy storage systems with goals and policies that guide large-scale solar development (see [Module 3](#)). After doing so, officials can adopt reasonable zoning standards for energy storage systems (see [Module 4](#)).

The New York State Energy Research and Development Authority’s New York State Battery Energy Storage Guidebook includes model zoning regulations that define and regulate large-scale (“Tier 2”) energy storage systems as a distinct use (2020). And a growing number of local jurisdictions have updated their zoning codes to clarify standards for energy storage facilities ([Table 8-4](#)).

**Microgrids**

A microgrid is a small network of electricity users connected to one or more local power sources. Often, microgrids are linked to the wider local distribution and transmission system (the “macrogrid”), but operators can control and operate them independently (in “island mode”).

The key components of a microgrid are electricity generation, control technologies, and energy storage.

The benefits of microgrids include improved reliability and cost-efficiency. Pairing community-scale solar energy systems with battery storage and advanced inverters can create microgrids that enhance community resilience.

Local governments can support microgrid development through local policies, assistance programs, or public investments. For example, local jurisdictions can offer zoning incentives for large-scale solar development projects that include features compatible with microgrids, such as energy storage or intelligent energy management (Vine and Morsch 2017). They may even participate directly in microgrid projects by joining as an anchor subscriber or providing space on local government land. The National Renewable Energy Laboratory provides suggested language for solar project requests for proposals (RFPs) that can encourage developers to design microgrid-ready solar PV systems (NREL 2017b).

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## Preparing for Innovation

Some of the growing demand for large-scale solar facilities may be met by new approaches to solar development. Floating and linear-infrastructure PV installations provide potential alternatives to the dominant approach to the deployment of large-scale PV systems. While there are barriers to widespread adoption, each could prove beneficial in minimizing land-use conflicts.

### Floating Installations

Floating solar or floating photovoltaics (PV) is the installation of a PV system on the surface of a body of water. Existing floating solar installations are commonly found on man-made bodies of water, such as wastewater storage ponds or reservoirs (Figure 8-2). One of the primary benefits of floating installations is that they shift solar energy's increasing demand for land to water, making them potentially more reasonable in areas with high land prices or strong land conservation policies (Spencer et al. 2019).

Solar PV systems can also benefit by locating on water, often experiencing improved performance due to cooling; more direct solar access; less adjacent development, such as buildings and infrastructure, that might limit access to the solar resource or compete for land; and reduced grid interconnection costs when sited near existing hydropower facilities (Spencer et al. 2019). There can also be benefits for the body of water, including reducing water evaporation, improving water quality, and minimizing algal blooming. However, these benefits might not translate to ecologically sensitive bodies of water with fragile ecosystems.

Currently, floating solar makes up a very small percentage of PV installations. This is likely due to relatively



Figure 8-2. A floating PV system on a retention pond at a municipal water treatment facility in Walden, Colorado (Photo by Dennis Schroeder / NREL)

high engineering and construction costs as compared to ground-mounted PV. Developers also must consider the impact of water and moisture on electrical infrastructure, as it can lead to faster degradation of equipment (Agostinelli 2020).

Nevertheless, properly designed floating solar has noteworthy potential when combined with hydropower reservoirs. Since both renewable energy systems can use the same power distribution infrastructure, the cost-effectiveness and economies of scale can be attractive for developers. While floating solar will likely not replace ground-mounted solar, local officials may need to define and regulate floating solar energy systems as a distinct use to unlock development potential.

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### *Linear Infrastructure Installations*

Pairing PV systems with linear infrastructure, such as highways and other public rights-of-way (ROWs), is another strategy for minimizing potential land-use conflicts associated with large-scale solar development. Several state departments of transportation and highway authorities have already piloted solar projects in highway ROWs (Cullen 2018; FHWA 2017). Others are testing methods for integrating PV components into roadway materials and installing PV systems on canopies over roadways.

While many ROWs are too narrow for installations parallel to roadways, areas around highway interchanges and rest areas may be suitable sites for community-scale solar energy systems. Researchers at the University of Texas have estimated that there are more than 200 miles of interstate ROW, totaling over 127,500 acres of land, that could host systems (Beagle et al. 2020). They estimate the total generation potential to be 36,000,000 MW hours per year, or about one percent of total electricity usage in the U.S.

Existing roadway-integrated solar panels are not durable enough to withstand regular traffic and may not be efficient enough to justify the extra maintenance they require (Create Digital 2017; Grimwood 2020). However, this approach could still prove promising for linear infrastructure with less intense usage, such as sidewalks and trails.

Meanwhile, three major European technology research institutions are exploring the feasibility of developing PV canopies over busy highways (Enkhardt 2020). While the project is still in the conceptual stage, there is a potential precedent. In South Korea, a 20-mile-long solar canopy covers a dedicated two-way bike path located in the median of a highway connecting Daejeon and Sejong (Sorrel 2015).



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### KEY TAKEAWAYS

- The process of learning with and adapting to the future begins with monitoring and evaluating the performance of existing plans, policies, and implementation programs.
- Performance indicators should connect to the community’s vision and long-term goals for large-scale solar development.
- Reporting regularly on performance measures can help keep elected officials and the wider community informed about progress toward large-scale solar development goals.
- Fostering collaborative relationships with public utility commissions and regional transmission organizations is important in overcoming the disconnect between local land-use and state and regional utility planning processes.
- Large-scale solar facilities that incorporate energy storage and other advanced controls can help to decarbonize the grid to achieve climate goals, as well as improve system reliability and resiliency.
- Floating PV systems and PV systems installed in public rights-of-way have potential to minimize land-use conflicts associated with large-scale solar development.



## References and Resources

Agostinelli, Guido. 2020. "Floating Solar Photovoltaic on the Rise." Washington, D.C.: International Finance Corporation.

Beagle, Emily A., Kelsey J. Richardson, Joshua D. Rhodes, and Michael E. Webber. 2020. *The Ray Solar Highway Project: Assessment of Solar Potential Installed in ROWs Across the United States*. Austin, Tex.: University of Texas at Austin, Webber Energy Group.

Bunker, Kaitlyn, Kate Hawley, and Jesse Morris. 2015. *Renewable Microgrids: Profiles from Islands and Remote Communities Across the Globe*. Boulder, Colo.: Rocky Mountain Institute.

Cleary, Kathryn, and Karen Palmer. 2020. "Renewables 101: Integrating Renewable Energy Resources Into the Grid." Washington, D.C.: Resources for the Future.

Create Digital. 2017. "Solar Roads: The Way of the Future, or a Path to Nowhere?" Create, October 15.

Cullen, Anna. 2018. "Nation's 1st Pollinator-Friendly Right-of-Way Solar Project Comes to Georgia." Ray C. Anderson Foundation, August 29.

Duncan, Jake, and Kelly Crandall. 2019. "Local Government Engagement With Public Utility Commissions Mini Guide." Washington, D.C.: Institute for Market Transformation.

Elkind, Ethan N., and Ted Lamm. 2018. *A New Solar Landscape: Improving County-Level Landscape Planning for Utility-Scale Solar PV Facilities*. Los Angeles: UCLA School of Law, Emmett Institute on Climate Change and the Environment.

Eto, Joseph H., and Guilia Gallo. 2017. *Regional Transmission Planning: A Review of Practices Following FERC Order Nos. 890 and 1000*. Berkeley, Calif.: Lawrence Berkeley National Laboratory

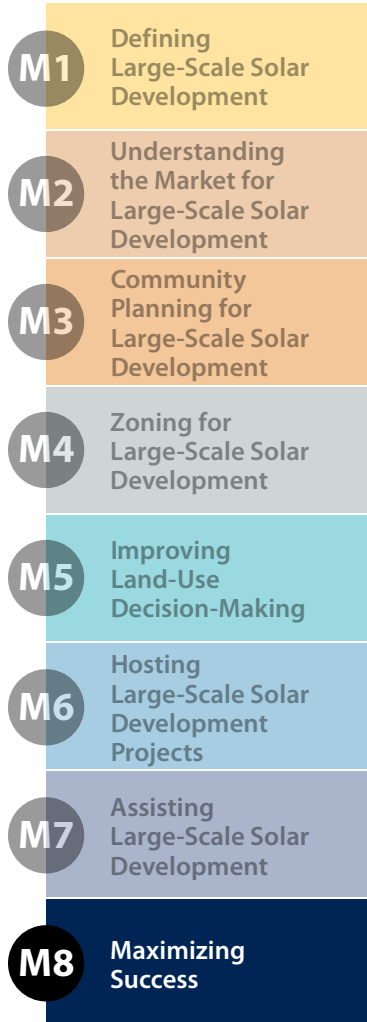
Enkhardt, Sandra. 2020. "Photovoltaics for Highways." *PV Magazine*, September 1.

Federal Highway Administration (FHWA). 2017. "Value Capture Defined: Solar Energy Use."

Feiden, Wayne. 2016. "Metrics and Data." Chapter 7 in *Local Planning Agency Management*. Planning Advisory Service Report 582. Chicago: American Planning Association.

Feiden, Wayne, and Elisabeth Hamin. 2011. *Assessing Sustainability: A Guide for Local Governments*. Planning Advisory Service Report 565. Chicago: American Planning Association.

Grimwood, Mariah. 2020. "Solar Roads: Will They Ever Come?" *Ecavo*.



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Hatry, Harry P. 2014. *Transforming Performance Measurement for the 21st Century*. Washington, D.C.: Urban Institute.

Kavanagh, Shayne. 2013. *Lessons from Performance Management Leaders: A Sample of Larger Local Governments in North America*. Chicago: Government Finance Officers Association.

Massachusetts Department of Transportation. 2021. "MassDOT Renewable Energy Projects."

O'Neill-Carrillo, Efraín, Isaac Jordán, Agustín Irizarry-Rivera, and Rafael Cintrón. 2018. "The Long Road to Community Microgrids." *IEEE Electrification Magazine*, December.

National Performance Management Advisory Commission (NPMAC). 2010. *A Performance Management Framework for State and Local Governments: From Measurement and Reporting to Management and Improving*. Lexington, Ky.: National Association of State Auditors, Comptrollers, and Treasurers.

National Renewable Energy Laboratory (NREL). 2017a. "Distributed Solar PV for Electricity System Resiliency."

———. 2017b. "Microgrid-Ready Solar PV: Planning for Resiliency."

New York State Energy Research and Development Authority. 2020. "New York Battery Energy Storage System Guidebook for Local Governments."

Oregon Department of Transportation. 2016. *Solar Highway Program: From Concept to Reality*.

Phillips, Rhonda. 2003. *Community Indicators*. Planning Advisory Service Report 517. Chicago: American Planning Association.

Ratz, Heidi B., Priyanka Roche, and Norma Hutchinson. 2021. *Local Government Voices in Wholesale Market Issues: Engagement Approaches for Decarbonization*. Washington, D.C.: World Resources Institute.

Sorrel, Charlie. 2015. "This South Korean Bike Highway Has a 20-Mile Solar Roof." *Fast Company*, July 27.

Spector, Julian. 2019. "AES Completes Record-Breaking Solar and Battery Plant on Kauai." *Greentech Media*, January 8.

Spencer, Robert S., Jordan Macknick, Alexandra Aznar, Adam Warren, and Matthew O. Reese. 2019. "Floating Photovoltaic Systems: Assessing the Technical Potential of Photovoltaic Systems on Man-Made Water Bodies in the Continental United States." *Environmental Science & Technology* 53(3): 1680–89.

Steinberger, Harold I. 2009. *State and Local Governments' Use of Performance Measures to Improve Service Delivery*. Alexandria, Va.: Association of Government Accountants.

U.S. Energy Information Administration. 2020. "Battery Storage in the United States: An Update on Market Trends."

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U.S. Environmental Protection Agency. 2019. *RE-Powering Critical Infrastructure*.

Vine, Doug, and Amy Morsch. 2017. *“Microgrids: What Every City Should Know.”* Arlington, Va.: Center for Climate and Energy Solutions.

World Bank Group, Energy Sector Management Assistance Program, and Solar Energy Research Institute of Singapore. 2019. *Where Sun Meets Water: Floating Solar Handbook for Practitioners*. Washington, D.C.: World Bank.

Young, Gerald. 2019. *Getting Started: Performance Management for Local Government*, 2nd ed. Washington, D.C.: International City/County Management Association.



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