SOLAR@SCALE

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

SOLAR @SCALE

Second Edition

About Solar@Scale

American Planning Association

Creating Great Communities for All

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.

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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

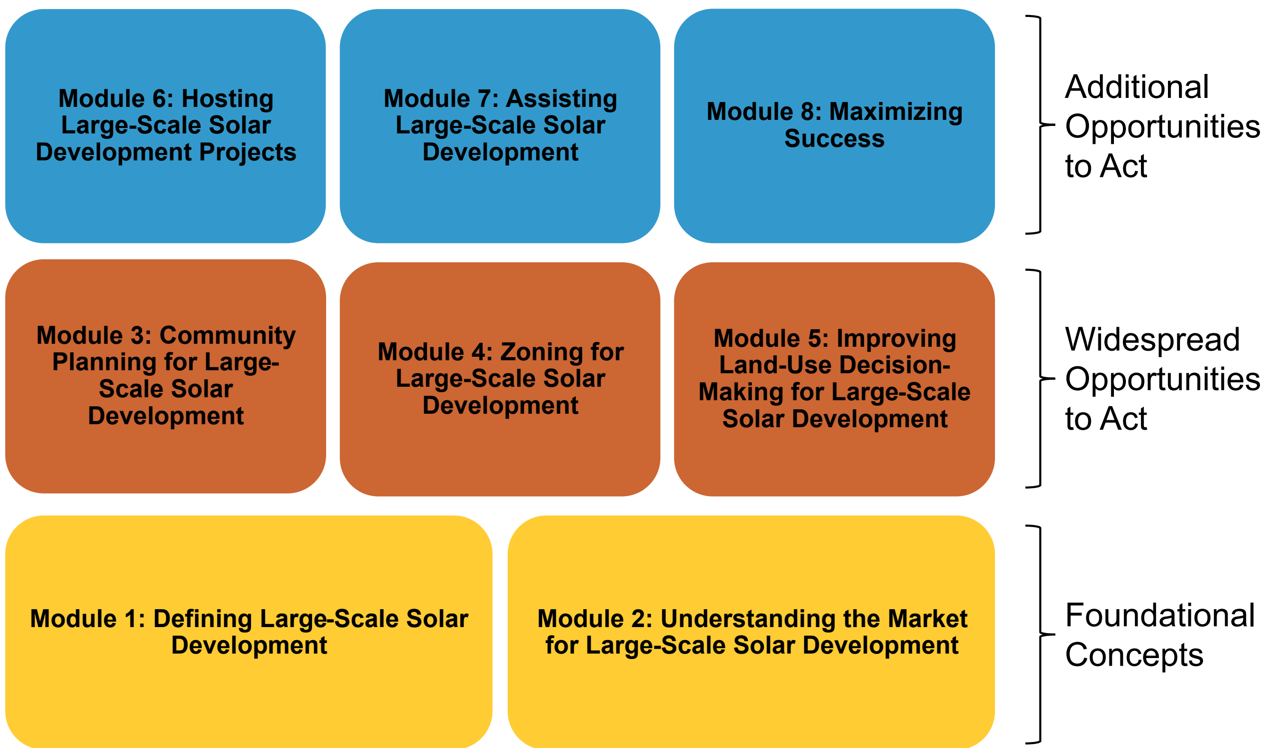

Figure A. Overview of guidebook

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

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.

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 solar radiation to efficiently produce electricity from CSP technology.

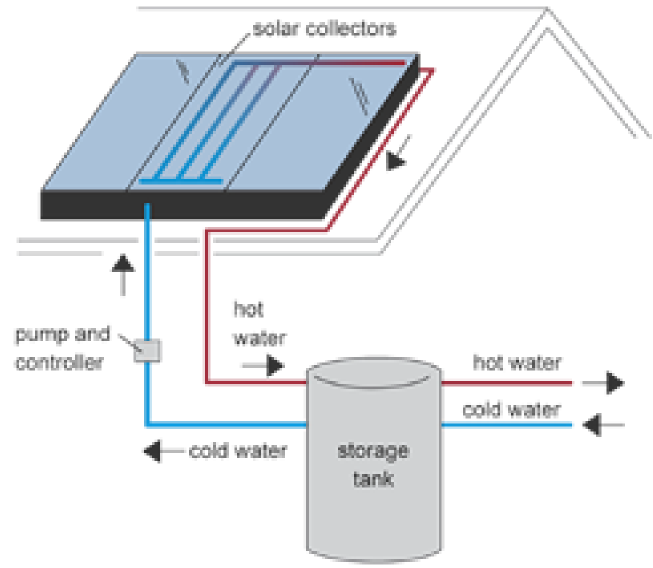

Figure 1-1. Components of a solar thermal system (Source: U.S. Energy Information Administration)

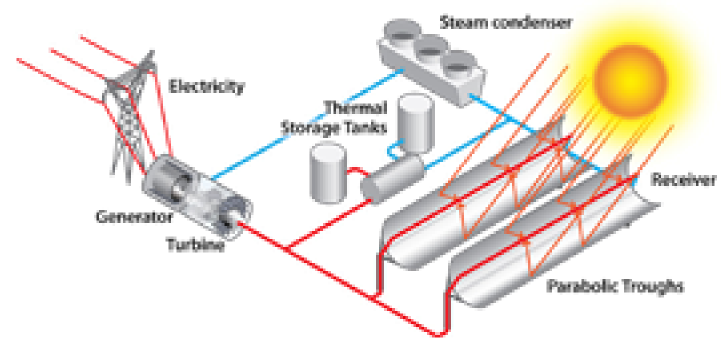

Figure 1-2. Components of a concentrating solar power (CSP) system (Source: U.S. Department of Energy)

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 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).

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. Substations connect and can transform voltage between transmission lines and between transmission and distribution networks. 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 and may include a new, onsite collector substation (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.

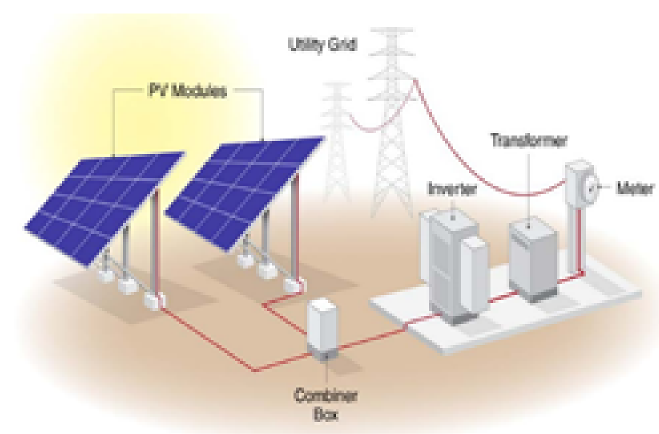

Figure 1-3. Components of a photovoltaic (PV) system (Source: National Renewable Energy Laboratory)

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 solar carports or other 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.

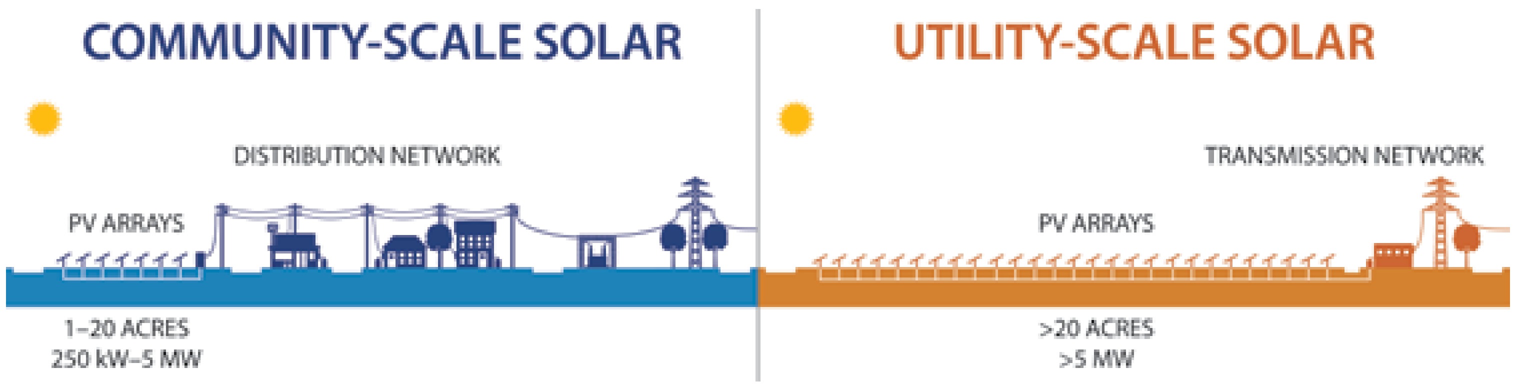

Figure 1-4. Community-scale and utility-scale solar facilities

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

Characteristics	Community-Scale Solar	Utility-Scale Solar
Relationship to the Grid	Connects to the distribution network either behind or in front of the meter	Typically 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 span multiple existing lots or require new roads for site access
Site Area	1–20 acres	>20 acres
Rated Capacity	250 kW–5 MW	>5 MW
Rated Capacity	250 kW–5 MW	>5 MW

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 100–250 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 facility 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 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 and may connect to the grid in front of the meter.

Utility-Scale Solar

For the purposes of this guidebook, a utility-scale solar facility typically 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 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 are typically located near the transmission network. Greater economies of scale mean these facilities are more cost efficient to construct (per MW) than community-scale projects, even after factoring in the higher costs developers typically pay to connect to the transmission network (Gorman, Mills, and Wiser 2019).

Understanding the Benefits of Solar Development

Large-scale solar development confers a mix of benefits. Some of these benefits accrue to individuals, while others accrue to specific communities or whole societies. As trustees of the public good, local officials are primarily interested in maximizing collective benefits to the communities they serve.

There are at least four distinct types of benefits that large-scale solar development can, given the right circumstances, confer on local community members or host communities: expanded access to clean energy, economic development, direct payments to local jurisdictions or community members, and environmental improvements. Each potential benefit depends, in part, on the siting, design, and business model of a solar project.

Clean Energy

Large-scale solar facilities produce electricity without generating air pollution or greenhouse gas emissions—which damage environmental and public health—making these facilities sources of clean energy. Consequently, replacing fossil fuel power plants with new solar facilities has both local and global benefits. The local clean energy benefits are clearest when a facility produces power for the local utility or sells power directly to local utility customers. This is because solar power is the cheapest form of energy in many markets and can, therefore, help lower electricity bills.

For some jurisdictions, solar power produced and sold locally also helps fulfill a commitment to transition to clean energy (see Module 2). Because a facility sited in one community may sell power to a utility or customers in another community, the business model of the facility ultimately determines who claims credit for the clean energy.

Local officials can maximize local clean energy benefits through policies or actions that

- make it easier for projects owned by or selling power to the local utility to locate in the community;
- encourage shared solar projects that sell ownership shares or subscriptions to local utility customers; and
- make it easier for the local government, or other large utility customers, to acquire power from locally sited facilities.

Economic Development

Large-scale solar development generates local economic activity and can improve the health of the local economy. Construction activities often lead to increased spending at local businesses for food, housing, or 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 last throughout the facility'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.

Local officials can maximize local economic development through policies or actions that

- make it easier for large-scale solar projects to locate in the community;
- encourage solar developers to hire and train local workers; and
- encourage large-scale solar projects as a redevelopment strategy for previously developed, but currently vacant or underutilized, brownfield or grayfield sites.

Direct Payments

Most large-scale development projects provide some type of direct payment to the local jurisdiction or to community members affected by the project. These payments can include tax revenue, land rents, or other project-specific income.

Large-scale solar development projects often generate 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). For projects where tax revenue is insufficient to offset collective project impacts, local jurisdictions may be able to collect a payment in lieu of taxes (PILOT) or a host community payment (if permissible under state law).

Additionally, solar developers typically lease, rather than purchase, land for their projects. Consequently, farmers or other local property owners who host projects can collect lease payments to supplement their income

(USDOE SETO 2021). This includes local governments that own sites that would be suitable for large-scale solar development (see Module 6).

Local officials can maximize direct payments through policies or actions that

- make it easier for large-scale solar projects to locate in the community;
- encourage or require PILOT or host-community agreements for projects subject to tax exemptions or abatements; and
- encourage solar developers to negotiate benefits agreements with community-based organizations or individual community members.

Environmental Improvements

In many rural jurisdictions, the most suitable sites for large-scale solar development are often lands currently or recently in agricultural use. However, because conventional farming practices can often degrade soil and water quality, there may be opportunities for carefully designed solar projects to improve environmental conditions and enhance ecological functions (NREL 2022; Randle-Boggis et al. 2020; Ross 2020).

Large-scale solar facilities that establish new native, pollinator-friendly, groundcover can improve water quality by minimizing water use for irrigation and capturing and filtering more runoff onsite (Samuelsen 2021). If developers minimize soil compaction during construction, these facilities can also improve soil quality by giving a chance for overworked agricultural lands to rest and rebuild nutrients. Similarly, dual-use facilities that combine solar energy systems with animal grazing can also help regenerate the soil (ACGI 2021).

Facilities with pollinator-friendly groundcover also provide habitat for native birds and insects. When sited near pollinator-dependent crops, these facilities can help increase crop yields (Siegner et al. 2019). And in hotter, drier areas, dual-use facilities that use solar arrays to shade row crops can also improve crop yields (AGCI 2021).

Local officials can maximize environmental improvements through policies or actions that

- encourage or require large-scale solar projects to incorporate native, pollinator-friendly, groundcover; and
- encourage solar developers to combine solar energy systems with animal grazing or row crops.

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 the natural environment or historic or cultural resources; or changes to existing views or community identity.

Changes to Agricultural or Other Productive Land

As alluded to above, solar developers are often attracted to productive lands currently or recently in use as farms or pasture due to their contiguous nature, limited potential for shading, and proximity to existing transmission infrastructure. These sites can also be less expensive to develop than other options because they are typically large parcels with flat, tilled land or are otherwise nearly ready for solar installations.

While farmland conversion for low-density residential development is far more common, large-scale solar development that replaces existing productive land uses can lead to a long-term, or even permanent, loss of farmland (Hunter et al. 2022). However, solar development can 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 or less-productive land;
- encourage the colocation of PV systems and agricultural activities;
- 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;
- require a decommissioning plan and financial security for all new large-scale solar development; and
- discourage or prohibit large-scale solar development on locally significant agricultural soils.

Effects on the Environment

Large-scale solar development has the potential to disturb wildlands or habitat, which can harm wildlife and impair ecological processes (EPRI 2020; Patton et al. 2013). To prepare land for solar installation, developers may need to grade the site and remove ground cover. They may also need 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 the environment through policies and actions that

- encourage or require the maintenance of vegetated buffers along streams or wetlands within or adjacent to project sites;
- encourage or require native ground cover or pollinator-friendly landscaping;
- discourage or prohibit removing existing trees;
- encourage or require fencing that wildlife can maneuver through; and
- discourage or prohibit projects on sites with documented 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

M1 Defining Large-Scale Solar Development
M2 Understanding the Market for Large-Scale Solar Development
M3 Community Planning for Large-Scale Solar Development
M4 Zoning for Large-Scale Solar Development
M5 Improving Land-Use Decision-Making
M6 Hosting Large-Scale Solar Development Projects
M7 Assisting Large-Scale Solar Development
M8 Maximizing Success

Figure 1-5. PV arrays at the Sunnyside Ranch shared solar facility, adjacent to the former Carbondale, Colorado, landfill (Photo by Dennis Schroeder, NREL 60071)

solar projects can bring unwanted or uninformed visitors to revered or fragile sites. And after construction, fenced-in facilities 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.

Changes to Existing Views

Ground-mounted PV systems consist of dark glass arrays and metal mounting hardware (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). Studies that explore the effects of large-scale solar facilities on property values have mixed findings but suggest that any positive or negative effect on property values is limited in magnitude and geographic extent (ASFMRA 2021; 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 in areas that have not been designated as visually significant;
- 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.

Changes to Existing Identity

People often form attachment to the place where they live based on their perceptions of various physical, economic, and social conditions of the community. An overarching effect of each of the potential tradeoffs above is that large-scale solar development can challenge the perceived identify of a community (Carlisle et al. 2014; Carlisle et al. 2016; Susskind et al. 2022).

Large-scale solar projects can require extensive changes to the visible landscape and, for some community members, may signify broader economic and social changes. For some residents, these changes may enhance or positively reinforce their sense of place. For others, large-scale solar development may have the opposite effect.

Local officials can minimize or mitigate anxiety about changes to existing identity through policies and actions that

- establish a shared vision for large-scale solar development across the community;
- encourage or require solar developers to engage the community before finalizing project designs;
- improve understanding of large-scale solar project benefits and tradeoffs across the community; and
- encourage or require projects to incorporate features valued by the community, such as visual buffers, co-location with agricultural activities, pollinator-friendly groundcover, habitat or wetland restoration, or native grassland carbon sequestration.

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 can—depending on project location, design, and business model—expand local access to clean energy, promote local economic development, improve the fiscal health of local jurisdictions, and enhance the local environment.
- Project location and design affect the magnitude and extent of local tradeoffs associated with large-scale solar development.

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MODULE 2

UNDERSTANDING THE MARKET FOR LARGE-SCALE SOLAR DEVELOPMENT

M1 Defining 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 2021, the estimated total installed capacity of all grid-connected PV systems in the U.S. increased from 16.0 to 92.5 gigawatts (GW) (Table 2-1). During this period, the total number of grid-connected PV facilities with rated capacities of at least one megawatt (MW) grew from 1,034 to 4,884 (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 2050 the total installed capacity of these larger PV systems will be 541.4 GW, if current tax incentives stay in place (USEIA 2022a).

Two related trends underpin the recent rapid expansion of the market for large-scale solar development: declining costs for solar energy systems and 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 2021, the median lifetime costs of PV systems with rated capacities of at least five MW decreased by 87 percent (Figure 2-2). Furthermore, systems with rated capacities of at least 50 MW cost 21 percent less than those with rated capacities of 20 MW or less (Berkeley Lab 2022). Technological improvements, economies of scale, and incentives have all contributed to declining costs (Green 2019; Kavlak, McNerney, and Trancik 2018; Roser 2020). Today, these systems produce electricity at prices competitive with all other forms of energy generation (Berkeley Lab 2022; SEIA 2021a; USEIA 2021a).

Table 2-1. Estimated Net Summer Capacity (in MW) from Grid-Connected PV Systems in the U.S., 2014–2021 (USEIA 2022b)

Year	PV systems < 1 MW	PV systems ≥ 1 MW	Total
2014	7,326.6	8,656.6	15,983.2
2015	9,778.5	11,905.4	21,683.9
2016	12,765.1	20,192.9	32,958.0
2017	16,147.8	25,209.0	41,356.8
2018	19,547.1	30,120.5	49,667.6
2019	23,213.6	35,710.2	58,923.8
2020	27,584.8	46,306.2	73,891.0
2021	39,972.3	59,534.5	92.506.8

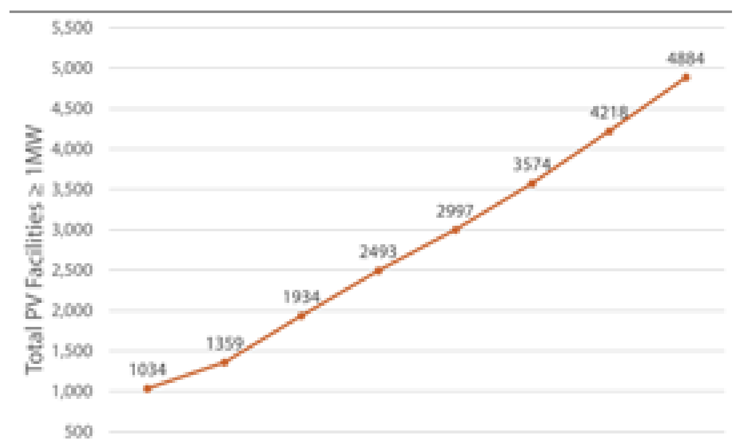

Figure 2-1. Total number of grid-connected PV facilities with rated capacities ≥ 1 MW in the U.S., 2014–2021 (USEIA 2022c)

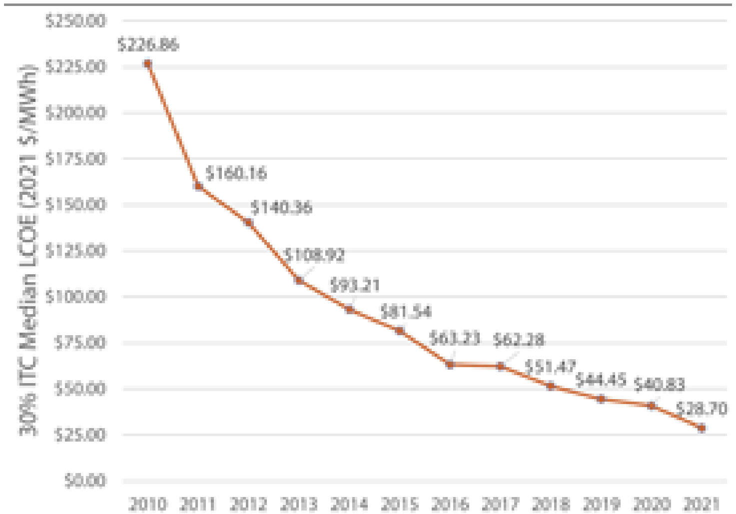

Figure 2-2. Median levelized cost of energy (LCOE) with 30% federal investment tax credit (ITC) for grid-connected PV systems with rated capacities ≥ 5 MW, 2010–2021 (Berkeley Lab 2022)

Declining costs will lead to a substantial increase in large-scale solar development over the next couple of decades. Even though a modest number of communities currently host a large-scale solar project, this increasing demand for solar development will likely affect every community in some way within the next decade or two (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 (CESA 2022; NRDC 2022). Most states now have renewable portfolio standards (RPS) or clean energy standards (CES), which require utilities to increase energy production from renewable or nonpolluting sources (NCCETC 2022). Even in states without these standards, many publicly and privately owned utilities have committed to expanding clean power production.

Climate change mitigation (through 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 footprints, have also played a small role in increasing demand for clean energy (Trumbull 2019; NRDC 2022; see Major Corporation Interests).

Growing Demand for Space

Large-scale PV facilities are land-intensive. On average, these facilities require about 7.5 acres per MW (Bolinger and Bolinger 2021; Hartmann et al. 2016; Ong et al. 2013; Walston et al. 2021). Based on this average, the U.S. will likely need to devote between 4.0 and 10.3 million acres to solar development by 2050 to accommodate projected demand (USDOE 2021a). While this is a large number, it is less than one percent 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.

Figure 2-3. The Desert Sunlight Solar Farm, a 550 MW PV and 220 MW energy storage facility sited over more than six square miles in Riverside County, California (Credit: Bureau of Land Management)

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 there has been steady growth in demand for both community- and utility-scale facilities, the average PV facility size has increased by nearly 150 percent over the past 10 years. In 2012, there were only two operational facilities with rated capacities of at least 100 MW, and by 2021, this number had increased to 143 (USEIA 2022c).

Most new utility-scale systems incorporate tracking systems (Berkeley Lab 2022). Holding other factors equal, facilities that use tracking systems require slightly more land per MW. Similarly, facilities that combine PV systems with battery storage require more space than PV-only facilities (see Module 8, Energy Storage). More than a quarter of all new utility-scale facilities include battery storage (Feldman et al. 2022; Figure 2-3).

Although 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.

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 2-2).

The 26 USC §48 Investment Tax Credit (ITC) provides a dollar-for-dollar reduction in the income taxes owed by large-scale system owners (Blumenstein and Schlusser 2019; SEIA 2021b). The Inflation Reduction Act of 2022 reinstates a 30 percent tax credit for solar facilities that start construction before September 30, 2031 and extends this credit to standalone energy storage facilities. 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).

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

Policy	Potential Effect on Local Demand
Adoption of 26 USC §48 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

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.

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 2-3).

Table 2-3. 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

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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 solar energy 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.

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).

Local Policy and Action

Local government officials can affect local demand for large-scale solar development through the policies they

Table 2-4. 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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adopt and the strategies they use to implement those policies (Table 2-4). 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).

Utility Plans and Programs

Utilities affect local demand for large-scale solar development through their system-planning and power-purchasing decisions (Table 2-5). These decisions are tied to the local utility's business model and governance structure.

Table 2-5. 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 (i.e., shared) solar programs	Can increase demand for community-scale projects in the utility's service area

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 utilities. 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.

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 2-4). 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 regula-

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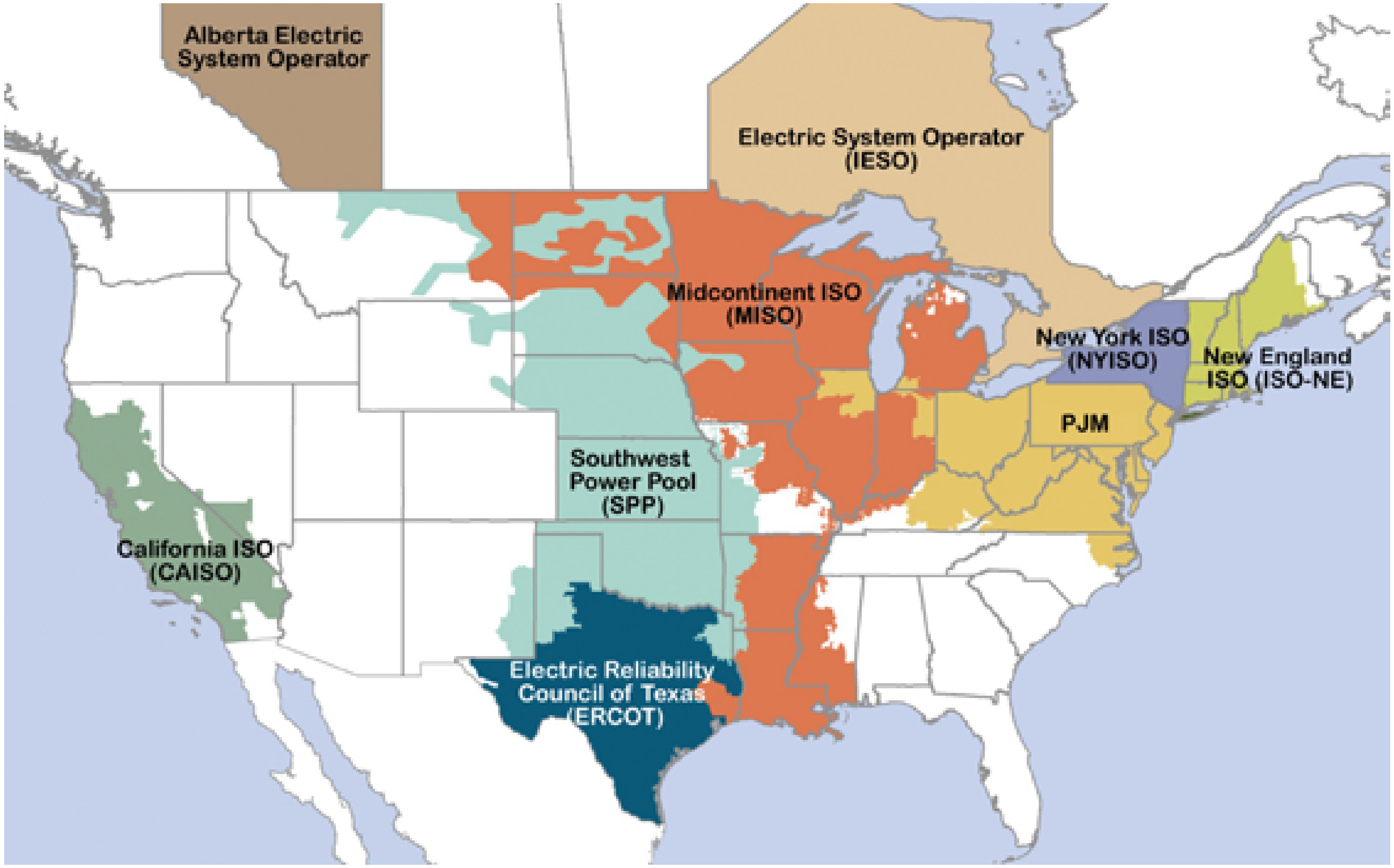

Figure 2-4. The nine regional transmission organizations that operate across North America (Source: BlckAssn, Wikimedia)

Table 2-6. 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

tory 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 2-6).

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.

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, Meta, 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 or otherwise support large-scale solar development.

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

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Table 2-7. 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 402	Projects that disturb over one acre
Clean Water Act, Section 404	Projects that deposit dredge or fill material into "Waters of the U.S." (i.e., navigable waters and associated wetlands)

Table 2-8. 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 402 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 Administers Resource Conservation and Recovery Act; Comprehensive Environmental Response, Compensation, and Liability Act; and other brownfields-related laws by developing and interpreting policy and guidance for projects on potentially contaminated sites
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

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may oppose projects in specific locations if they perceive those projects would conflict with other priorities.

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 (Tables 2-7 and 2-8). 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.

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 environmental review of proposed actions, especially if project applicants are receiving any state funding (or, in some cases, state permits or licenses). Most 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.

Typically, state agencies establish permit requirements for all projects subject to the National Pollution Discharge

Elimination System (NPDES) program under the Clean Water Act. Additionally, outside of areas with municipal storm sewer systems, state agencies generally review stormwater pollution prevention plans for solar projects to ensure they meet the general permit requirements (EPRI 2020).

Local Governments

Outside of states that preempt local siting control, 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).

Key Takeaways

- Between 2014 and 2021, the total number of grid-connected PV facilities with rated capacities of at least one megawatt (MW) grew from 1,034 to 4,884.
- In many parts of the country, producing power from large-scale solar facilities is cheaper than from all other sources of energy.
- 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 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.

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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	§40-360.06
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)	Energy Facility Licensing Process Developers Guide of Practices & Procedures	None
Colorado	Local government	None	None
Connecticut	Local government (< 1 MW); Connecticut Siting Council (≥ 1 MW)	Filing Guides	None
Delaware	Local government	None	None
Florida	Local government (< 75 MW); Florida Siting Board (≥ 75 MW)	Electrical Power Plant Sites and Associated Facilities Application Instruction Guide	§403.509(3)
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	Administrative Code §199.24.10
Kansas	Local government	None	None
Kentucky	Local government + Kentucky State Board on Electric Generation and Transmission Siting (≥ 10 MW)	None	§278.710
Louisiana	Local government	None	None

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)	Technical Guidance for Utility-Scale Solar Installation and Development on Agricultural, Forested, and Natural Lands	38 MRS §484
Maryland	Local government (< 2 MW); Maryland Public Service Commission (≥ 2 MW)	Solar Facility Siting Guidance	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)	Commercial Solar Siting Guidance	§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)	Siting for Large-Scale Renewables	19 NYCCR §900
North Carolina	Local government	None	None
North Dakota	Local government + North Dakota Public Service Commission (≥ 50 MW)	None	§49-22-09

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

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 (≥ 100 MW)	None	§196.491(3)(d)
Wyoming	Local government (≤ 30 MW or 100 acres); Wyoming Industrial Siting Council (> 30 MW or ≥ 100 acres)		§35-12-113(a)

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 hard 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.

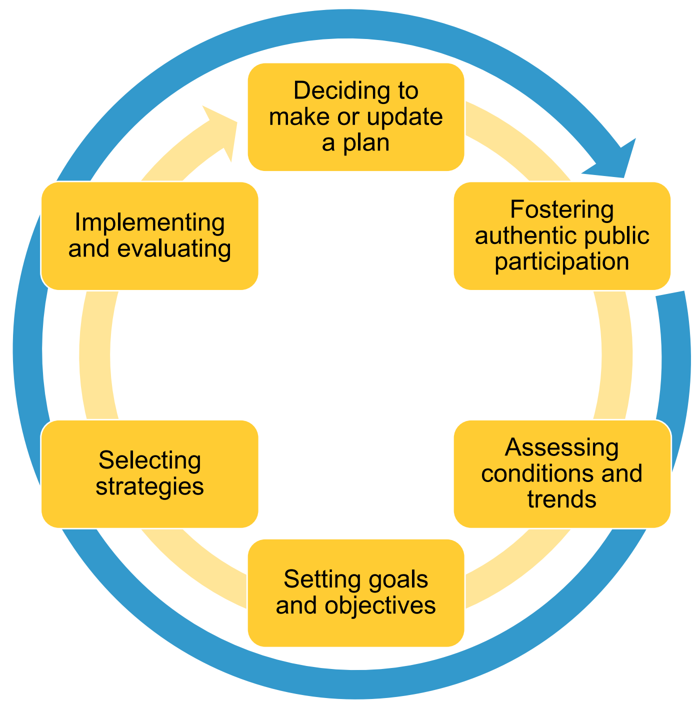

Figure 3-1. The community planning process, rooted in authentic public participation

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

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

Jurisdiction	Policy	Key Features
Butte County, CA	Utility-Scale Solar Guide Vision Statement and Guiding Principles (2017)	Presents a vision for the role of large-scale solar development in the county Lists 14 guiding principles for implementation
Multnomah County, OR	Resolution 2017-046 (2017)	Sets a goal of meeting 100% of communitywide energy needs through renewable sources by 2050 Sets a target of supplying 2% of all energy needs with community-based renewable energy projects by 2035 Prioritizes projects that will provide local benefits to communities of color, women, tribes and native communities, and low-income utility customers
St. Lawrence County, NY	Resolution 132-2020 (2020)	Encourages solar development on marginal farmland and the co-location of sheep grazing and apiaries Encourages community-serving solar projects Requires payment in lieu of taxes for projects that sell electricity to the grid

the community. Then, it can outline the specific policies, plans, programs, and land-use regulations that the jurisdiction might implement to guide large-scale solar development in line with the community's goals and expectations.

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,

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

Jurisdiction	Plan	Key Features
Franklin County, VA	Comprehensive Plan (Updated 2022)	Public Utilities policy recommendations include a clear objective to support solar development at all scales (36.0) and strategies to minimize land-use impacts of large solar facilities
Johnson County, KS	Rural Comprehensive Plan (Updated 2022)	Land Use Plan includes special land-use considerations for Utility-Scale Solar Facilities (9.1)
Pinal County, AZ	Comprehensive Plan (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	Countywide Plan (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	Shape Stearns: 2040 Comprehensive Plan (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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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;
- identifying potential benefits the community hopes to receive from large-scale solar development;
- describing large-scale solar development opportunities and conflicts; and
- 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.

Table 3-3. Examples of Functional Plans That Address Large-Scale Solar Development

Jurisdiction	Plan	Key Features
Boise, ID	Boise's Energy Future: A Community-wide Energy Plan (2019)	Recommends increasing community-scale shared solar installations as a short-term strategy Recommends supporting utility-scale solar projects as a long-term strategy
Raleigh, NC	Community Climate Action Plan (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	Strategic Energy Plan (2019)	Analyzes total solar power potential Discusses opportunities and obstacles for utility-scale solar projects Recommends sites for utility-scale solar development

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.

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	Carillon-Edgemont Neighborhood Plan (2018)	Recommends reusing the site of a former factory for a large-scale solar installation
Pinellas County, FL	Pinellas Gateway/Mid-County Area Plan (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	Sullivan's Gulch Neighborhood Plan (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

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Development Moratoria

A development moratorium is a local law suspending applications for one or more types of land-use approvals. State statutes governing the use of moratoria vary across the U.S., but the general purpose of a moratorium is to provide time for a local jurisdiction to study land-use issues and thoughtfully craft plans and development regulations that address those issues.

A moratorium is a relatively common response to a new form of development, including large-scale solar development. However, this approach can threaten the viability of projects that have secured private commitments based on the existing development policies in the jurisdiction. To be legally defensible, local officials must apply a moratoria as narrowly as possible to address an immediate threat to public health, safety, or welfare and set a specific expiration date (St. Amand and Merriam 2003).

Proactive community planning is often the best strategy for avoiding a moratorium. If a comprehensive plan or zoning code is currently silent on large-scale solar development, including projects that integrate energy storage, local officials should roll this into the next plan or regulatory update.

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 be, ideally, a continuous process.

The planning process will vary based on who leads and participates in it, but the purpose remains the same: including as many people as possible to represent multiple segments of the community and, as a result, ensuring an equitable distribution of benefits and tradeoffs. Three essential questions can guide local officials when planning for large-scale solar development (Ezell 2022):

- Who is helped?
- Who is harmed?
- Who is missing?

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 or desires about how solar development might affect their quality of life (Table 3-5).

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 and business owners	May be interested in how solar development could affect electricity costs, property values or rents, the local economy, community appearance, or various other issues
Farmers and other large landowners	May be interested in hosting a large-scale solar project on their land for income diversification or a retirement strategy or how solar development could affect the local agricultural economy, cash rents, future ability to farm, 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	Interested in participating in large-scale solar development and providing information about industry standards and practices
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

The most straightforward way to identify potential stakeholders is to begin by asking "who is helped?" The users or beneficiaries of any proposed large-scale solar development project should be easily identifiable. The more complicated aspect is figuring out those who may be negatively affected. When asking "who is harmed?", planners should consider various types of harm—financial, physical, cultural, psychological, or harm by being left out of the process—and mitigate negative impacts by engaging with those who already have concerns and those who may be unaware of potential harm.

And by asking "who is missing?" planners can review the inclusivity of their efforts. Planners should engage those with an interest in the subject matter, inside and outside the jurisdiction, who have a stake in the area being affected. This includes those with different abilities and health needs, who, in aggregate, are diverse in a variety of ways, and groups that are traditionally underrepresented or otherwise disproportionately left out of planning conversations (Ezell 2022).

Process Design

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.

Inclusivity in planning means that all community members feel welcome to participate and are confident that their participation can positively affect outcomes. The three essential questions should promote inclusivity in initial stakeholder engagement, but inclusivity is also important during planning activities.

Perspectives on the benefits and tradeoffs of large-scale solar development are bound to differ across stakeholder groups. Inclusive public participation does not end at ensuring all groups get their voice heard. The end results should be equitable and evidence-based policies. Dispelling misinformation may be a key part of the continuous process of engaging all segments of the community.

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.

Process leaders should provide multiple ways for community stakeholders to participate in all stages of the planning effort. They can do so by selecting appropriate tools and methods based on the purpose of each planning activity (Table 3-6).

Process leaders should also make efforts to reduce barriers to participation for traditionally marginalized or underrepresented segments of the community. These 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).

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There are several potential strategies leaders may be able to use to broaden participation (NYSERDA 2021):

- 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.

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

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.

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 typically 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 Modules 2, 6, and 8).

Planners and local government managers can use Argonne National Laboratory's Energy Zones Mapping Tool or 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

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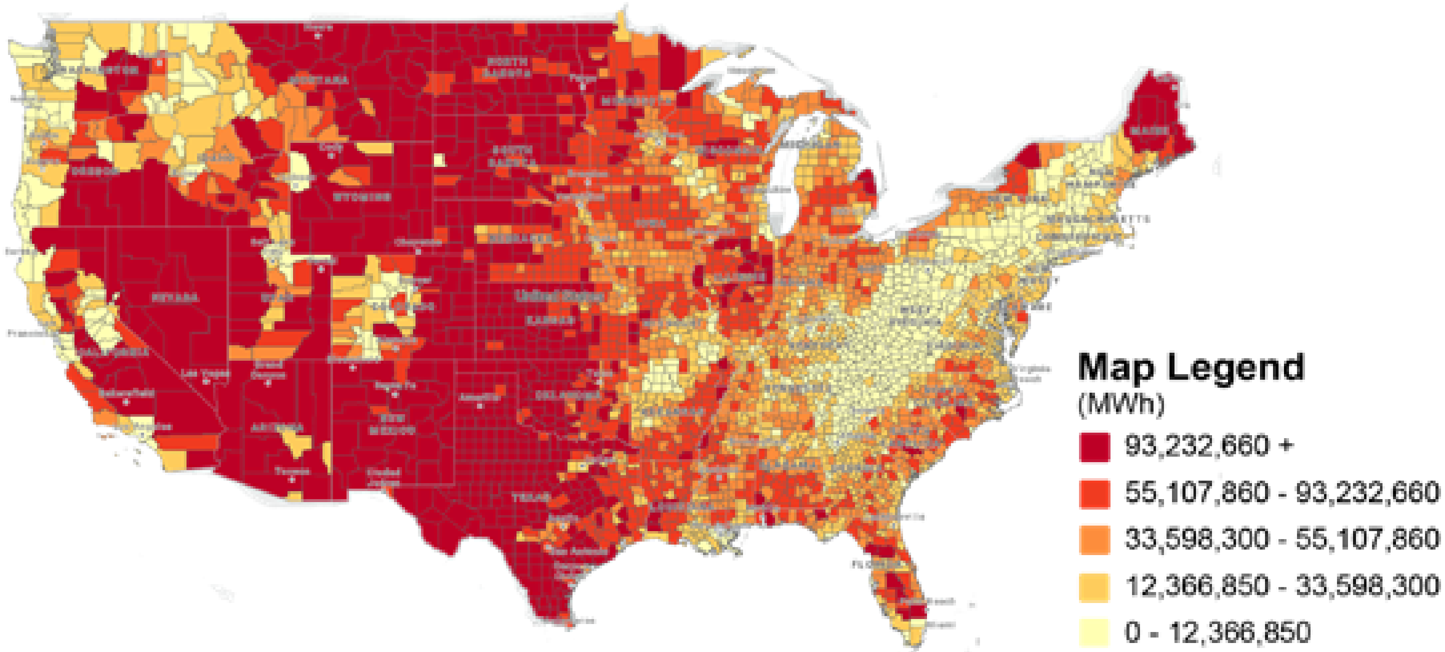

Figure 3-2. Modeled annual technical generation potential by county for utility-scale PV systems from the State and Local Planning for Energy *(SLOPE) Platform (Source: NREL)*

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.

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?

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- What are some strategies for overcoming these concerns?
- What other land uses may wish to locate on sites that could host large-scale solar facilities?
- How do the potential land-use impacts of those other uses compare to large-scale solar development?

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 (NYSERDA 2021). 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. When development does occur on lower-priority sites, they want to ensure it preserves or enhances ecological functions, such as promoting healthy watersheds and providing 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 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; Figure 3-3).

Figure 3-3. A solar-powered microgrid owned by the Snohomish County Public Utility District (PUD) in Washington (Credit: Snohomish County PUD)

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

Table 3-7. Potential Zoning Updates to Advance Broader Goals

Broader Goal	Potential Zoning Updates
Clean Energy Transition	Designate large-scale solar facilities as permissible uses, subject to reasonable standards and development charges
Low-Impact Siting and Design	Adopt standards that incentivize or require large-scale solar facilities to establish native, pollinator-friendly groundcover or combine solar power production with agricultural activities Adopt standards that incentivize solar facilities on previously developed sites
Equitable Development	Designate community-scale solar facilities as permissible or potentially permissible uses, subject to reasonable standards and development charges Adopt standards that incentivize shared solar projects
Community Resilience	Designate solar facilities that include energy storage as permissible or potentially permissible uses, subject to reasonable standards and development charges Adopt standards that incentivize microgrid projects

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partnerships, and technical or financial assistance programs (NYSERDA 2021).

Zoning Updates

Local officials can use zoning to designate permissible locations and site design features for community- and utility-scale solar development in furtherance of broader shared goals (Table 3-7). 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 in furtherance of broader shared goals (Table 3-8). 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).

Process improvements that decrease the average time it takes for developers to secure approval for large-scale solar projects can help accelerate a clean energy transition. Local officials can advance low-impact siting and design goals by pursuing development agreements and imposing conditions of approval that ensure that developers minimize and mitigate any site-specific land-use impacts of large-scale solar projects. They can pursue equitable development goals by carefully considering how specific solar development proposals are likely to benefit or negatively impact different segments of the community and, when necessary and permissible, negotiating for specific community benefits. And they can promote community resilience by improving coordination with public safety staff and utility stakeholders when projects incorporate energy storage or microgrid features.

Table 3-8. Potential Process Improvements to Advance Broader Goals

Broader Goal	Potential Process Improvements
Clean Energy Transition	Ensure each step in the development review process for large-scale solar facilities adds value
Low-Impact Siting and Design	Pursue development agreements and impose conditions of approval that minimize site-specific land-use impacts of large-scale solar facilities
Equitable Development	Evaluate the likely impacts of each solar development proposal on different segments of the community Negotiate for specific community benefits to offset negative impacts that cannot be otherwise mitigated
Community Resilience	Seek additional input from public safety and emergency management staff and utility stakeholders when development proposals include energy storage or microgrid features

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 (Table 3-9). 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 (Table 3-10). Strategies that include technical or financial assistance programs may address eligibility, assistance options, or funding sources, among other topics (see Module 7).

Table 3-9. Potential Development Partnership Approaches to Advance Broader Goals

Broader Goal	Potential Financial or Technical Assistance Approaches
Clean Energy Transition	Create educational materials that highlight solar development opportunities and explain permitting processes
Low-Impact Siting and Design	Create a siting tool that helps developers identify preferred locations for large-scale solar facilities Offer a tax incentive for projects sited on previously developed land
Equitable Development	Serve as an anchor subscriber for a shared solar project seeking to broaden access to solar energy for low-income households Offer a tax incentive for shared solar projects serving low-income households
Community Resilience	Offer a tax incentive for solar facilities that include microgrid features

Table 3-10. Potential Technical or Financial Assistance Approaches to Advance Broader Goals

Broader Goal	Potential Development Partnership Approaches
Clean Energy Transition	Issue a request for proposals for large-scale solar development on underutilized local government land Establish clear system size or performance goals in requests for proposals
Low-Impact Siting and Design	Establish clear environmental protection or enhancement objectives in requests for proposals and mandatory beneficial project design features in partner agreements
Equitable Development	Establish clear project participation goals in requests for proposals for large-scale solar development on underutilized local government land
Community Resilience	Establish clear energy storage or microgrid-related objectives in requests for proposals for large-scale solar development on underutilized local government land

Key Takeaways

- Community planning for large-scale solar development begins with a commitment to make a new plan or to update an existing plan.
- Proactive community planning is often the best strategy for avoiding a moratorium on large-scale solar development.
- 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.

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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.

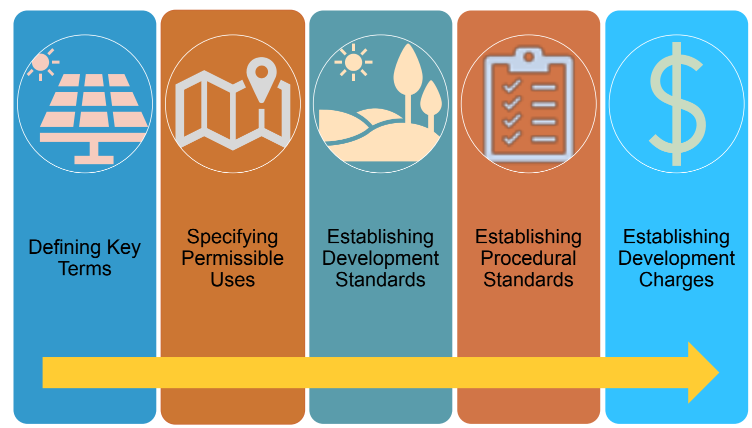

Figure 4-1. Opportunities to address large-scale solar development through zoning

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, which may result in unpredictable outcomes.

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. But some standards, such as lot coverage, might be difficult to interpret for a solar project. Alternatively, officials may decide that solar development is unlike any land use defined or referenced in existing regulations. In this instance, they may determine that solar development is prohibited altogether or that it is subject to an unpredictable discretionary review process.

Officials can avoid both of these scenarios by regulating large-scale solar development as a distinct land use, which 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 differentiate 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 diffi-

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

Use	Definition
Solar energy system, roof-mounted	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. (Grow Solar Model Ordinances 2020)
Solar energy system, building-integrated	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. (Grow Solar Model Ordinances 2020)
Solar energy system, ground-mounted	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. (Grow Solar Model Ordinances 2020)
Solar energy system, small-scale	A ground-mounted solar energy system with a footprint of less than [1–5] acres. (Georgia Model Solar Ordinance 2018)
Solar energy system, community-scale	A ground-mounted solar energy system with a footprint of between [1– 5] and [15–50] acres. (Georgia Model Solar Ordinance 2018)
Solar energy system, utility-scale	A ground-mounted solar energy system with a footprint of more than [15–50] acres. (Georgia Model Solar Ordinance 2018)

cult 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 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, often with vegetated groundcover underneath, jurisdictions should not apply traditional definitions of lot coverage to these systems. If lot coverage is important to the community, officials should 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 colocation of solar development and agricultural activities or pollinator habitat may choose to define *agrivoltaic* (Figure 4-2) or *pollinator-friendly solar energy system*. And

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 64426)

jurisdictions that want to promote solar development on previously developed and potentially contaminated sites may choose to define *brightfield*.

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

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

Term	Definition
Battery energy storage system	An electrochemical device that charges (or collects energy) from the electrical grid or an electricity generating facility, such as a Large-Scale Ground-Mounted Solar Photovoltaic Installation, and then discharges that energy at a later time to provide electricity or other grid services when needed. (Cape Cod Commission Model Large-Scale Solar Bylaw)
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. (Model Site Plan Regulations and Conditional Use Permits to Support Solar Energy Systems in Maine Municipalities 2020)
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. (Georgia Model Solar Ordinance 2018)
Solar land coverage	The land area that encompasses all components of the solar [energy] 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. (NHSEA Model Solar Zoning Ordinance 2018)
Solar energy system, agrivoltaic	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. (Grow Solar Model Ordinances 2020)
Solar energy system, pollinator-friendly	A community- or [utility]-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. (Model Solar Ordinance for Indiana Local Governments 2020)
Brightfield	A brownfield site that is redeveloped through the incorporation of one or more solar energy technologies. (42 USC 3154d(a))

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 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.

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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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.

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 achieving water quality goals, such as limiting stormwater runoff. Coverage ratios assume that impervious surfaces are analogous to rooftops, parking areas, or driveways.

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. While solar arrays do alter the flow of stormwater, they do not prevent infiltration. Solar panels are impervious but should not count as coverage if the project establishes self-sustaining deep-rooted vegetation under and between the arrays. 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 and soils are not compacted (GPI 2021; see Site Conditions).

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 maximum 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.

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 limit disturbance of prime agricultural soils or historic sites can help preserve farmland or historic resources in the case of solar development. Agricultural protection should not, however, be applied only to solar facilities and not to other development forms that also convert farmland.

In other cases, these standards promote multiple site-specific benefits. For example, standards that require developers to plant sites with perennial native vegetation can provide habitat for bees and other pollinators or meet other habitat objectives supported in the local comprehensive plan. Perennial native vegetation or pollinator-friendly ground cover also provide significant improvement in long-term water quality outcomes (NREL 2022a). 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. In fact, limiting internal access roads or parking may promote more ecological function and limit soil compaction. 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, particularly for solar projects where the primary (post-construction) impact to nearby properties is visual. 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

Table 4-4. Select Model Codes with Reasonable Site Conditions Standards

Model Code	Publisher	Target Audience
Georgia Model Solar Ordinance	Emory University Turner Environmental Law Clinic; Georgia Tech Strategic Energy Institute; University of Georgia Agriculture Technical Assistance Program	Counties and municipalities in Georgia
Minnesota Solar Model Ordinance	Midwest Renewable Energy Association	Counties and municipalities in Minnesota
Model Solar Energy Local Law	New York State Energy Research and Development Authority	Municipalities in New York
Model Solar Ordinance for Indiana Local Governments	Indiana University Environmental Resilience Institute	Counties and municipalities in Indiana
Sample Zoning for Solar Energy Systems	Michigan State University Extension; University of Michigan Graham Sustainability Institute	Counties and municipalities in Michigan
Solar Energy Systems Ordinance Template	Rhode Island Division of Statewide Planning	Municipalities in Rhode Island

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community, and increased development costs are frequently offset by lower long-term maintenance costs. Pollinator-friendly projects have been successfully developed in most states (USDOE 2022)..

The References and Resources section below includes several model codes with specific suggestions for reasonable standards (Table 4-4).

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.

In applying existing development or environmental standards to solar development, however, officials should take care to recognize how solar development differs as a land use from other forms of development. For stormwater mitigation, large-scale solar facilities are distinct from other development in that solar panels, while impervious, do not limit the ground under the solar array from being used for stormwater infiltration. If solar projects adopt water quality best practices for compaction, soil depth, groundcover, and disconnection, the site can infiltrate most design storms with minimal additional infrastructure (NREL 2022a).

For maintaining watershed function, officials can refer to the solar runoff calculator and best practice guidance developed in NREL's Photovoltaic Stormwater Research and Testing (PV-SMaRT) project. Officials and solar developers can use the calculator to input site-specific characteristics and select design storms to estimate runoff amounts.

The References and Resources section below includes several model codes that emphasize environmental performance (Table 4-5).

Table 4-5. Select Model Codes with an Emphasis on Environmental Performance

Model Code	Publisher	Target Audience
Kentucky Model Solar Zoning Ordinance	Kentucky Resources Council	Counties and municipalities in Kentucky
Model Large-Scale Solar Bylaw	Cape Cod Commission	Municipalities in Barnstable County, Massachusetts
Model Site Plan Regulations and Conditional Use Permits to Support Solar Energy Systems in Maine Municipalities	Maine Audubon	Municipalities in Maine
Renewable Solar Energy Systems Model Ordinance	Iowa Environmental Council; The Nature Conservancy	Counties and municipalities in Iowa

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 (Figure 4-3). 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-specif-

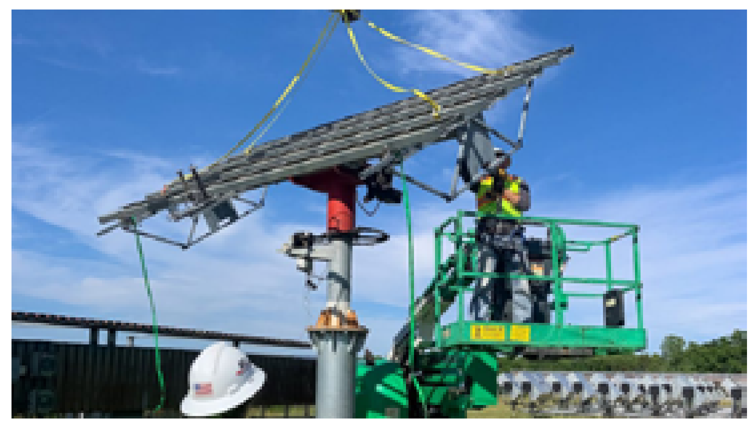

Figure 4-3. Workers decommissioning a solar facility in Catawba County, North Carolina (Credit: RCI Construction Group)

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ic standards for solar energy systems. For projects that are subject to a discretionary review and approval, local jurisdictions should consider requiring a decommissioning plan (Kolbeck-Urlacher 2022; NYSERDA 2020). For by-right projects, it is a good idea to specify 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.

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.

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 preapplication 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.

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 4-6). 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 Offering Development Incentives for a possible exception to this principle). This includes meeting space rental fees in cases where interest in public hearings exceeds the capacity of the local jurisdiction's regular meeting facilities. 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 effective to outsource parts of the review process and pass these costs on to developers.

Table 4-6. 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))

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.

Offering Development Incentives

Some local zoning codes incentivize certain types of development by relaxing development standards, streamlining application requirements or review processes, expediting final decisions, or discounting or waiving permitting or impact fees. For large-scale solar development,

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Table 4-7. Examples of Zoning Incentives for Large-Scale Solar Development

Jurisdiction	Eligible Projects	Potential Incentives
Douglas County, KS	"Agrivoltaics" and solar energy systems designed to "accommodate slopes without grading"	Exemption from height limit (§12-306-49.05.c)
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)

such incentives could include reduced setbacks, additional height allowances, or relaxed buffering or screening requirements (Table 4-7).

Few local zoning codes include incentives for community- or utility-scale solar energy systems.

Local officials should only offer development incentives if the community benefits are likely to outweigh any potential negative effects.

For example, it may make sense to relax development standards or waive or discount permitting fees for solar projects that involve the cleanup and reuse of brownfield sites or shared solar projects that target traditionally underserved utility customers (Figure 4-4). These projects confer specific local benefits and may not happen without some local assistance (see Module 7).

Figure 4-4. A 39 MW shared solar project on Imperial Irrigation District (IIR) land in Imperial County, California, which provides discounted power to income-qualified IIR residential customers.

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.

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MODULE 5

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

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.

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

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

Jurisdiction	Resource	Type
Butte County, CA	Butte Utility-Scale Solar Guide	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	Utility-Scale Solar	Informational web page about application and review process
Pima County, Arizona	Commercial Solar Farm Fees and Permitting Guidelines	Brief guide outlining permitting fees and necessary permits
Prince George County, VA	Solar Energy Facility Information & Projects	Informational web page with details on approved and proposed facilities, policy updates, and links to application materials
Weld County, CO	Use by Special Review for Solar Energy Facility Supplement	Brief guide providing application instructions

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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).

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).

Figure 5-1. A 25 MW solar facility on the former Combe Fill North Landfill Superfund site in Mount Olive Township, New Jersey (Credit: CEP Renewables)

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.

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 (Module 2, 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 (Figure 5-1), the establishment or expansion of pollinator habitat (Figure 5-2), or colocation with agricultural activities (Figure 5-3).

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.

Figure 5-2. Pollinator-friendly ground cover at the Aurora Solar Project in Chisago, Minnesota (Photo by Dennis Schroeder, NREL 53020)

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 or value 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

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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.

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

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

Jurisdiction	Development Agreement	Local Benefits
Riverside County, CA	Development Agreement No. 86: A Development Agreement Between County of Riverside and Renewable Resources Group, Gila Farm Land LLC, and A&F Growers LLC (2017)	Annual public benefit payments, sales and use taxes, and impact fees
Saratoga, WI	Solar Generating Facility Development Agreement Between the Town of Saratoga and Wood County Solar Project, LLC (2021)	Annual utility aid payments, vegetated buffer, visitor area and tours, pollinator-friendly ground cover, and local employment and training
Weber County, UT	Development Agreement Between Weber County, Utah and Little Mountain Solar, LLC (2020)	Fire protection measures, pollinator-friendly ground cover, and wildlife-friendly equipment and site design

Figure 5-3. An agrivoltaic solar facility in Brookfield, Massachusetts (Credit: AgriSolar Clearinghouse, Flickr*)*

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).

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

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(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.

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.

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Inspecting Approved Projects

Local jurisdictions typically require multiple field inspections before an approved large-scale solar facility can begin operations (Figure 5-4). 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 5-4. Inspectors at the Long Island Solar Farm at the Brookhaven National Laboratory in Upton, New York (Source: Brookhaven National Laboratory, Flickr)

Internal Coordination

At a minimum, local jurisdictions typically require at least two inspections for community- and utility-scale solar facilities. 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.

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.

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MODULE 6

HOSTING LARGE-SCALE SOLAR DEVELOPMENT PROJECTS

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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 support solar development. Leasing local-government-owned property for large-scale 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.

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

Identifying Project Goals

Local government officials should establish clear project 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 are 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—such as transitioning to clean energy, low-impact siting and design, equitable development, and community resilience—that were set during the community planning process. 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, or those that want to prioritize the use of some types of land over others and achieve community goals related to low-impact siting and design.

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, which can contribute to community goals related to equitable 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 can tie performance-based goals directly to community goals related to local resilience to climate change and extreme weather events. They may also use performance-based goals to achieve broader community goals related to clean energy transition. For example, if a community's goal is to decrease reliance on power from nonlocal and nonrenewable sources or to demonstrate a commitment to climate change mitigation or sustainability goals, then performance-based goals for a solar energy system can be appropriate.

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.

Project goals related to participation should build on the principles of inclusivity. Local officials can establish goals to increase the participation of specific groups, such as those they have identified as being at risk of being left out of, or potentially harmed by, the solar development process (see Module 3).

Co-Benefits

When hosting projects on public land, local governments can center community members as the beneficiaries of large-scale solar projects. Local officials can return to the three essential questions for planning—Who is helped? Who is harmed? Who is missing?—when developing co-benefits goals (see Module 3).

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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-government-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. Co-benefit goals, thus, can assist in bringing positive impacts to groups harmed by past policy decisions or those previously left out of community planning processes. Reinvestment in these properties may also increase local revenue, create jobs, and ease development pressure on farmland or other productive lands—which can contribute to broader community goals of equitable development and low-impact siting and design.

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.

Figure 6-2. Wildlife-friendly fencing at a solar facility in Moore County, North Carolina (Credit: Liz Kalies, The Nature Conservancy)

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 facilities can serve as green infrastructure that pro-

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vides 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. Existing large-scale solar facilities, such as Maces Pond Agrivoltaic Project in Maine, have been co-located with agriculture to improve crop production. Other facilities, such as the Aurora Solar Project in Minnesota use pollinators to meet sustainability goals and improve water quality. The Aurora Solar Project also accommodates grazing livestock to assist with landscape maintenance, while NREL's Flatirons Campus in Colorado encourages wildlife grazing for the same purpose. And wildlife-friendly fencing at a Pine Gate Renewables site in North Carolina is an example of low-impact design that is unobtrusive to local ecology (Figure 6-2).

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, adhere to broader community 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 economically feasible for development. There are several online tools officials can use to help identify and analyze potential project sites (Table 6-1).

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

Tool	Description
Rocky Mountain Institute's Municipal Solar Site Selection Tool	An Excel workbook designed to help local officials identify promising sites for PV systems; includes screening criteria for open fields, brownfields, and landfills
U.S. Environmental Protection Agency's RE-Powering America's Land Electronic Decision Tree	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
U.S. Environmental Protection Agency's RE-Powering Mapper 2.0	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.

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 areas near existing electricity grid infrastructure. However, brownfields with subsurface contamination may require costly soil removal and replacement or the use of ballasted 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. While local officials may be able protect solar access by negotiating easements and agreements that limit vegetation growth or the height of future development adjacent to a project site, they should consider the climate benefits of trees and urban densification before pursuing this approach.

Network Access

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.

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).

Selecting Development Partners

After a local government has set clear project goals and has an 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.

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 6-3).

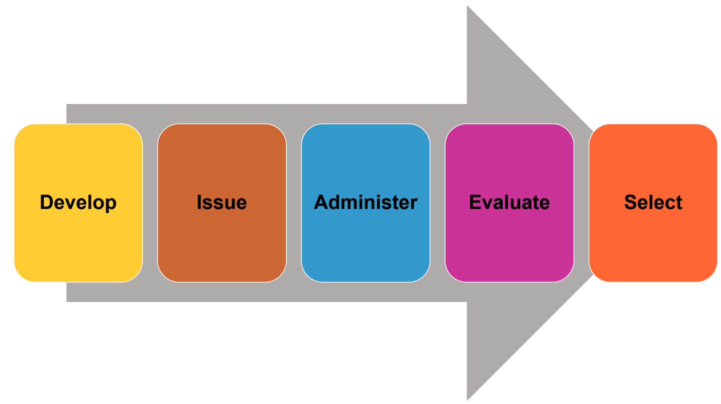

Figure 6-3. Steps in a request for proposals (RFP) process.

To develop a successful RFP, local officials will need to communicate project goals, 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 applicants according to their eligibility and capabilities to meet these expectations. Early in the RFP process, local officials should summarize terms, conditions, and responsibilities that might exclude certain development partners. Clearly listing the community's non-negotiable requirements, such as low-impact or environmentally friendly design or preparation of brownfield sites for installation, will discourage unqualified development partners from sending in proposals.

The RFP should provide as much information on potential sites as possible, including topographic maps or aerial photography. Local governments unable to provide these resources can offer to 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 qualifications, 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; this also reflects the ability of the proponent to meet performance- and size-based project goals. 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 participation and co-benefit goals, such as local hiring or training capabilities or how they plan to communicate with community members about participation opportunities, as well as any general 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.

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 respon-

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

Jurisdiction	RFP
Coatesville, PA	Request for Proposals RFP 1-2020: Land Lease of City-Owned Location (120 Pratts Dam Road) For Solar Photovoltaic Projects (2020)
Charlotte, NC	Request for Proposal: For Partnering with The City of Charlotte in the Development Services for Duke Energy Green Source Advantage Program RFP #2019-407 (2019)
Concord, NH	RFP 01-20: Ground-Mounted Solar Photovoltaic Systems on City-Owned Parcels (2019)
Farmers Branch, TX	Request for Proposals RFP#22-02: Lease of Municipally-Owned, Closed Landfill for Solar Development City of Farmers Branch, TX (2022)
Marshfield, MA	Request for Proposals: Lease of Real Property to Use Site for Construction, Operation, & Maintenance of Renewable Energy Facilities, Large Scale Ground Mounted Solar Photovoltaic Installation (2019)
Norfolk, VA	RFP 9214-0-2022/MS RFP 9214-0-2022/MS: Environmentally Beneficial Land Lease Solution for Campostella Landfill (Solar or Other) (2022)
Sacramento Regional County Sanitation District, CA	Request for Proposals for Solar PV PPA Project (2015)
Urbana, IL	RFP #1718-08: Request for Qualifications for a Landfill Solar Developer (2017)

sibilities 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

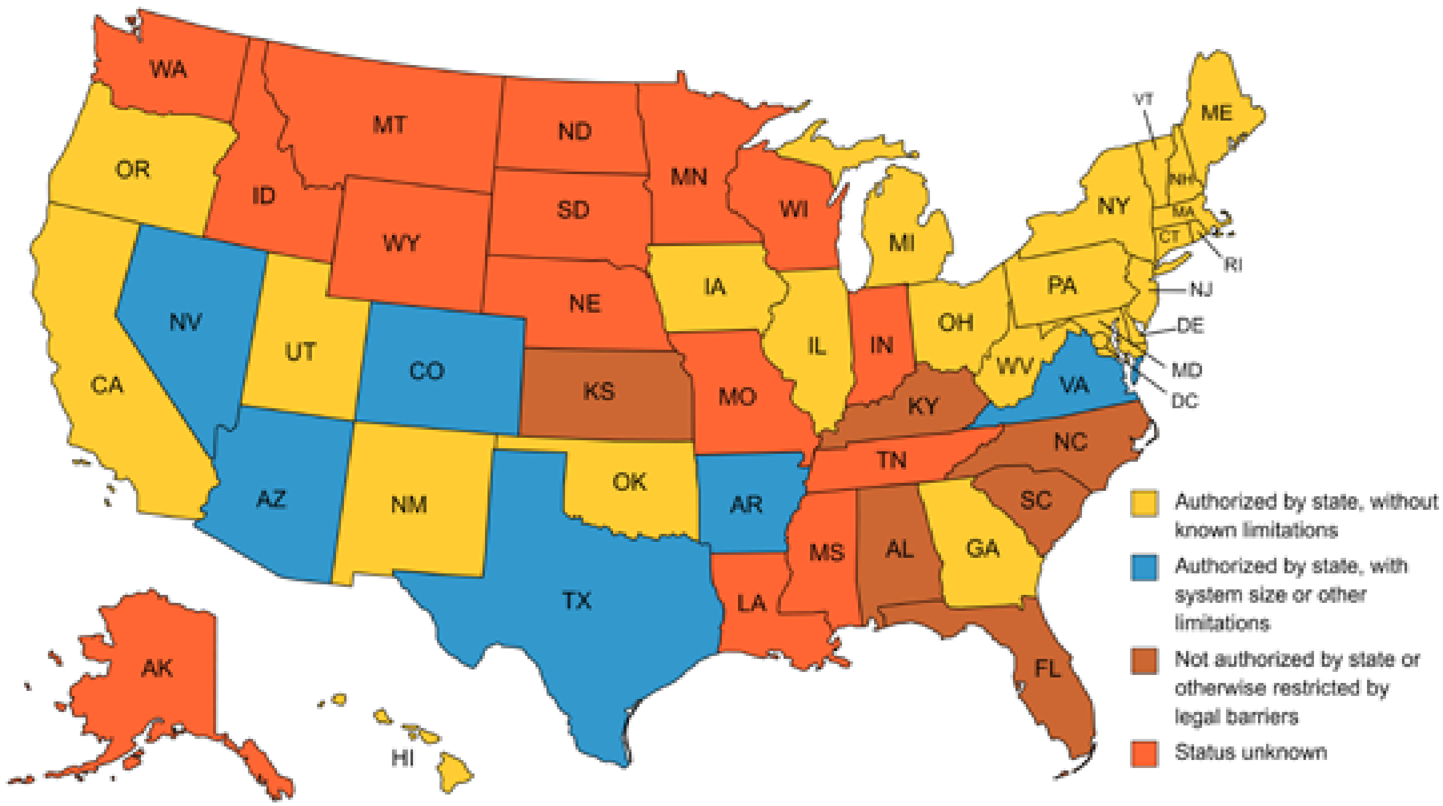

Figure 6-4. State-level authorizations for third-party solar PV power purchase agreements (Source: DSIRE)

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.

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 6-4), and there is no guarantee that the electricity price will be competitive with retail pricing.

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.

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MODULE 7

ASSISTING LARGE-SCALE SOLAR DEVELOPMENT

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. Providing technical assistance reflects the continuous nature of an authentic public participation process, which should be inclusive and equitable (see Module 3).

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. 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. Educational events give potential development partners the chance to make initial connections with property owners or pass along contact information to allow for future conversations.

Local officials should return to the three essential questions for planning—Who is helped? Who is harmed? Who is missing?—when supporting educational events (see Module 3). 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 the shared solar programs or jobs. Educational events that are robust and far-reaching are a necessary part of an authentic public participation process. And local officials can also facilitate the achievement of broader community goals, such as equitable development, by ensuring that all segments of the community are aware of the local opportunities created by large-scale solar development.

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 site design alternatives (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 developers evaluate the development opportunities that are appropriate for their land or projects. Local officials can facilitate the achievement of broader community goals, such as low-impact siting and design, by contributing to or developing site assessment tools.

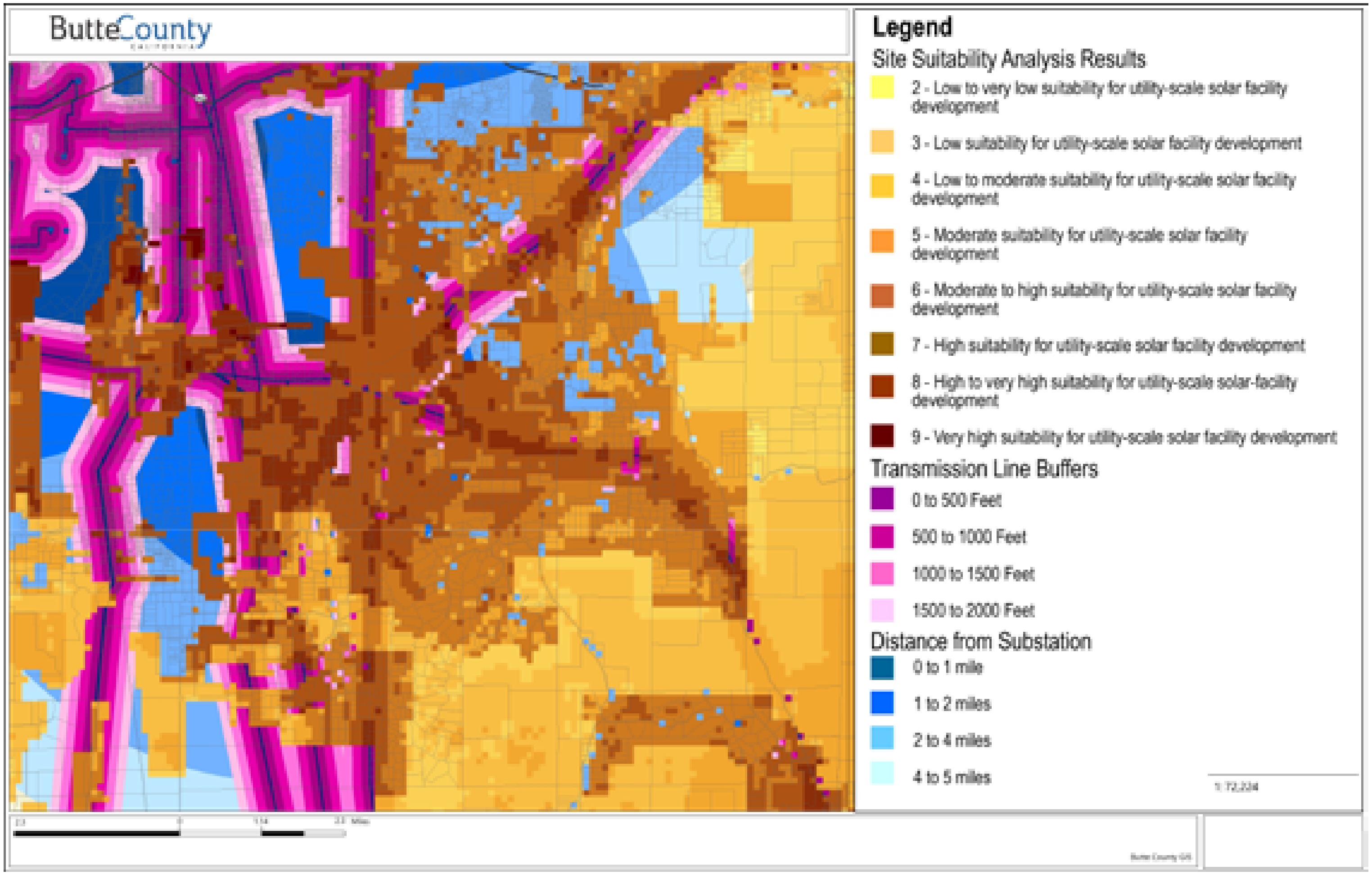

Figure 7-1. An exported image from Butte County, California's PowerButte Utility-Scale Solar Guide Mapping Tool (Source: Butte County GIS)

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 either 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

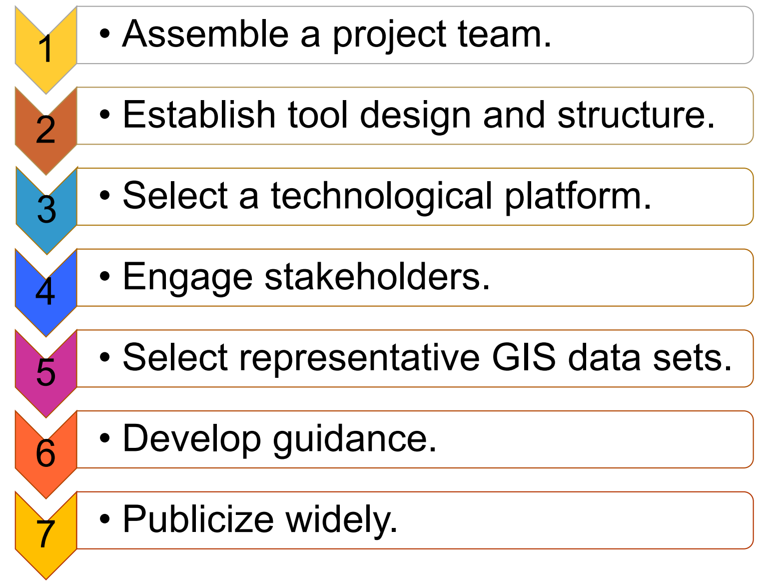

Figure 7-2. Scenic Hudson's seven-step process for developing a local solar mapping tool to identify and prioritize locations for large-scale solar development (2021)

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.

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 (Paulos 2019).

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; Hintz et al. 2021).

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

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

Jurisdiction	Agreement
Greenville County, SC	Fee in Lieu of Tax Agreement Between Greenville County, South Carolina and White Horse A Solar, LLC (2019)
Klamath County, OR	Payment in Lieu of Taxes Agreement by and Between Chiloquin Sollar LLC and Klamath County, Oregon (2018)
Laconia, NH	Payment in Lieu of Taxes Agreement Between the City of Laconia and Laconia Town Solar, LLC (2018)
Marlborough, NY	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 (2019)
Swisher County, TX	Tax Abatement Agreement between Swisher County, Texas, and Swisher Solar Energy LLC (2020)

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. However, 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 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 (Gold 2021a; Hintz, Uebelhor, and Gold 2021; Table 7-1; Table 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 jurisdictions should reference 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 equitable development goals might want to 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.; DenHerder-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

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

Jurisdiction	Project Participation
Ann Arbor, MI	Serves as an anchor subscriber for a shared solar project on a capped landfill owned by the city (DTE Energy 2021)
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)

serve as backstop purchasers, which agree to purchase the generated energy that the main subscriber base does not use (Figure 7-3).

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.

Figure 7-3. A 618 kW shared solar project in Edina, Minnesota, for which the city serves as a backstop subscriber (Credit: Impact Power Solutions)

Key Takeaways

- Through technical and financial assistance, local jurisdictions can uplift broader community goals for large-scale solar development.
- 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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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

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 (§701A.360 et seq.)	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 (§54:4-23.3)	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 (RPT §487)	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 (RPT §487)
North Carolina	Exempts supply-side solar energy systems from 80% of personal property taxes (§105-275(45))	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 (§5727.75)
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 (§285C.350 et seq.)
Pennsylvania	None	None
Rhode Island	None	Authorizes municipalities to exempt solar energy systems from personal property taxes (§44-3-21)
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

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 (see 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.

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 total 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.

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 development, 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 iden-

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

Performance Area	Potential Indicators
Clean energy transition	Total installed capacity of large-scale solar facilities Percentage of local electricity consumption offset by locally produced solar power
Low-impact siting and design	Percentage of total installed capacity of large-scale solar facilities sited on previously developed lands Percentage of total installed capacity associated with agrivoltaic or pollinator-friendly large-scale solar facilities
Equitable development	Percentage of low- and moderate-income utility customers receiving power or utility credits from a shared solar project Percentage of large-scale solar facilities subject to community benefits agreements
Community resilience	Total installed capacity of solar-powered battery storage facilities Percentage of local utility customers served by solar-powered microgrids

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tified 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.

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 purchasers. 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). Local governments with more resources can represent the interests of neighboring jurisdictions. These local governments should be proactive in addressing the indirect and direct effects of large-scale solar development.

There are many ways that local government officials can ensure a path to meaningful engagement in regula-

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.

tory 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.

Regional Transmission Organization Engagement

Regional transmission organizations (RTOs) administer wholesale energy markets and are the regional planning authorities for transmission planning (see Module 2, Regional Transmission Organization Plans and Policies). 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 between 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).

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 (Figure 8-1).

Additionally, increased demand for energy coupled with increased intensity and frequency of adverse weather due to climate change has revealed the vulnerability

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.

and fragility of our energy grid during normal operations as well as during isolated incidents. Battery energy storage, either standalone or coupled with solar, can increase grid resilience and stability.

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 (IRENA 2019; NREL 2017a; NREL 2022).

Local government officials can align goals and policies that address the installation, operation, maintenance, and 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 solar facilities that incorporate energy storage systems (see Module 4) and for standalone energy storage facilities.

Battery storage facilities have special public safety considerations (NFPA 2022). Depending on their chemical makeup, and under extreme conditions, batteries can explode, catch fire, and, potentially, release toxic gases. Once ignited, they are also susceptible to burning intensely for a prolonged period (i.e., thermal runaway). Consequently, local officials should ensure that all battery storage facilities are in compliance with the National Fire Protection Association's NFPA 855 standard.

Figure 8-1. The AES Lawai Solar Project in Kauai, Hawaii, which consists of a 28 MW PV system and 100 MWh battery energy storage system and can restart the island's electricity grid in case of an outage (Photo by Dennis Schroeder, NREL 57998)

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. 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 opera-

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 (§56-14; §56-3-307; §56-8-824)
Johnson County, KS	Defines and regulates *battery energy storage facilities* associated with small and large solar energy systems (Resolution No. 038-22)
King George County, VA	Defines and regulates *battery energy storage facilities* as a distinct use (Appendix A §1.9; §2.12; §4.19)
Pueblo County, CO	Defines and regulates *battery energy storage facilities* associated with large-scale solar facilities (§17.168)
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 (Ordinance PCO-6-20)

tors 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).

Currently, few states have a clear regulatory framework for microgrids (Shea 2022). However, several pioneering states have taken steps to clarify regulations and create financing tools and many other states are exploring options for removing regulatory and financial barriers.

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 high engineering and construction costs as compared to ground-mounted PV.

In general, developers 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, as this technology matures, local officials may need to define and regulate floating solar energy systems as a distinct use to unlock development potential.

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 53975)

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 (Figure 8-3). 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. Additionally, a company in Massachusetts is exploring putting solar panels on highway sound barriers (Lewis 2022b).

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 Daejon and Sejong (Sorrel 2015).

Figure 8-3. A one MW PV system at Exit 14 along Interstate 85 in West Georgia (Credit: Ray C. Anderson Foundation*)*

Installing PV canopies over waterways is another promising approach. Researchers at the University of California have estimated that covering all 4,000 miles of California's public water delivery canals would produce 13 GW of power annually and prevent 63 billion gallons of water from evaporating in transit (McKuin et al. 2021). The Turlock Irrigation District's Project Nexus is testing the feasibility of this approach at three sites along its canal system. The $20 million project will break ground in early 2023, with funding and technical assistance from the California Department of Water Resources (Lewis 2022a; TID 2022).

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.

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