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UNIVERSITY OF MICHIGAN

PLANNING & ZONING FOR SOLAR ENERGY SYSTEMS

A GUIDE FOR MICHIGAN LOCAL GOVERNMENTS

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Cover image: Ground-mounted SES with pollinator garden. Photo by Rob Davis.

BACKGROUND & PURPOSE

Lapeer Solar Park. Photo by Bradley Neumann.

Michigan's diverse energy future is set in motion. Utility companies have bold plans to expand solar options and other forms of renewable energy over the next two decades and beyond. By 2040, DTE Energy[1] expects to have over 10 million solar panels generating power for its customers. Consumers Energy also announced[2] plans to build roughly 8,000MW of solar energy by 2040. Regional electric cooperatives and municipally owned utilities are following suit, with plans to expand solar energy production. Michigan has 65 utilities across two peninsulas.

The shift in the utility sector from centralized power generation (e.g., a large coal plant) to a higher number of accessory and principal use solar energy systems (SES[3]) means Michigan communities should plan for renewable energy development within their jurisdictions. According to a 2019 study of solar ordinances in Michigan, fewer than 20% of Michigan communities have zoning regulations in place to address all scales of SES.[4] These scales are defined further in Section 3 of this guide.

The purpose of this guide is to help Michigan communities meet the challenge of becoming solar-ready by addressing SES within their planning policies and zoning regulations. This document illustrates how various scales and configurations of photovoltaic SES fit into landscape patterns ranging between rural, suburban, and urban.

1 Our Bold Goal for Michigan's Clean Energy Future. DTE. (2020). https://dtecleanenergy.com/

2 Consumers Energy. Consumers Energy Announces Plan to End Coal Use by 2025; Lead Michigan's Clean Energy Transformation. (2021). https://www.consumersenergy.com/news-releases/news-release-details/2021/06/23/consumers-energy-announces-plan-to-end-coal-use-by-2025-lead-michigans-clean-energy-transformation

3 Michigan Office of Climate and Energy. (2019). Michigan Zoning Database. Available at https://www.michigan.gov/climateandenergy/0,4580,7-364-85453_85458-519951--,00.html

4 Ibid.

Planning and Zoning for Solar Energy Systems: A Guide for Local Governments in Michigan was developed by experts within Michigan State University Extension (MSUE) and Michigan State University's School of Planning, Design and Construction in partnership with faculty at the University of Michigan Graham Sustainability Institute. Further review of this document was completed by content experts from local units of government, legal counsel, energy-related non-profits, utility experts, and members of academia. Its intent is to help Michigan communities make public policy decisions related to solar energy development.

This guide is written for use by local planners, officials, legal counsel, and policymakers within the State of Michigan. It first presents the current context for solar in Michigan, describes the various components and configurations of SES, and provides principles for how SES might fit within various land-use patterns across the state. Then, starting on Page 22, the guide presents sample language for including SES into a community's zoning ordinance. The findings and recommendations in this document are based on university peer-reviewed research (whenever available and conclusive) and on the parameters of Michigan law as it relates to the topic(s) in Michigan. The zoning and regulatory rules and concepts discussed here may not apply in other states. This guide will be updated as solar technology evolves and as we learn more from the deployment of existing technology.

Preparing a zoning ordinance and master plan are only two aspects of being solar-ready. More information on how communities can plan for, regulate, and reduce barriers for SES—through meaningful public engagement, clarifying building/electrical permit processes, reducing permit fees, and evaluating placement of SES on or near municipal buildings, to name a few—is available through numerous Michigan agencies, universities, and organizations, and through the SolSmart[5] program. Additional resources on solar energy (and renewable energy) planning and zoning in Michigan are available from MSU Extension[6] and the Michigan Department of Environment, Great Lakes, and Energy[7] in partnership with University of Michigan Graham Sustainability Institute[8] faculty.

Ground-mounted SES, Grand Traverse waterfront. Photo by Mary Reilly.

5 SolSmart. (2021). Program Guide. Available at: https://solsmart.org/resources/solsmart-program-guide/

6 MSU Extension Outreach. Michigan Station University. https://www.canr.msu.edu/outreach/

7 Community Energy Management. Office of Climate and Energy. https://www.michigan.gov/climateandenergy/0,4580,7-364-85453_98214---,00.html

8 Graham Sustainability Institute. University of Michigan. http://graham.umich.edu/

SOLAR ENERGY IN MICHIGAN

O'Shea Solar Park, Detroit. Photo by DTE Energy.

While the solar resources in Michigan and other Midwestern states are not as abundant as in the Southwest,[9] over the course of one year, a solar panel in a typical Michigan location produces approximately 70% of the energy as the same solar panel in Phoenix, Arizona.[10] Furthermore, technology advancements have led to rapid cost reductions at all levels of solar development, making solar an increasingly cost-competitive option, both nationally and in Michigan specifically.[11] As a result, utility companies in Michigan have plans to significantly increase the amount of power generated from solar energy. This shift is evidenced by the amount of utility-scale solar energy development currently under construction or in the development queue,[12] along with expanding installations of smaller on-site solar energy systems.[13]

As the demand for clean energy sources continues to grow, Michigan communities are being approached with development proposals for new SES. It is vital that communities have planning and zoning in place to address these proposals. By doing so, communities have the opportunity to proactively determine how SES can fit into their landscape through master planning and zoning ordinance development.

MASTER PLANNING AND ZONING

Solar energy systems can serve as a method to help reach several different goals that a community may identify, including those focused on resiliency, economic development, farmland preservation, climate action, energy generation, and more.

A community's master plan sets the vision and high-level goals for the community. Local policy related to renewable energy generation is established first in the master plan, with an explanation of how SES could fit into the unique landscapes and character of the jurisdiction. In addition to the master plan, goals related to SES are established in other local plans, which could include district or sub-area plans, resiliency plans, climate action plans, or renewable energy plans. Here, specific geographical areas are designated as ideal for SES development. Including SES in local plans supports the establishment of related zoning regulations, consistent with the requirement of the Michigan Zoning Enabling Act (MZEA).[14] A community-supported vision, followed by the adoption of reasonable zoning standards, together establish a successful framework for SES in a community.

9 Solar Resource Data, Tools, and Maps. National Renewable Energy Laboratory. https://www.nrel.gov/gis/solar.html.

10 Solar Resource Data. NREL PVWatts Calculator. Available at: https://pvwatts.nrel.gov/pvwatts.php.

11 Lazard. (2020). Levelized Cost of Energy and Levelized Cost of Storage – 2020. Available at: https://www.lazard.com/perspective/levelized-cost-of-energy-and-levelized-cost-of-storage-2020/; Solar Technology Cost Analysis. NREL. https://www.nrel.gov/solar/solar-cost-analysis.html.

12 Midcontinent Independent System Operator, Inc. https://www.misoenergy.org/planning/generator-interconnection/GI_Queue/.

13 MPSC. (2020). Distributed Generation Program Report for Calendar Year 2019. https://www.michigan.gov/documents/mpsc/DG_and_LNM_Report_Calendar_Year_2019_711217_7.pdf

14 Michigan Zoning Enabling Act, Public Act (PA) 110 of 2006, as amended. http://legislature.mi.gov/doc.aspx?mcl-Act-110-of-2006.

Incorporating renewable energy into the master plan is a logical place to start before drafting zoning regulations. The MZEA requires that all zoning be based on a plan. The master plan therefore establishes the community's formal policy position on solar energy development. For example, the master plan might set a goal that permits accessory SES throughout the jurisdiction. For principal-use SES, it might define what scale is appropriate as a permitted use (i.e., use by right) or determine appropriateness based on the location of marginal lands, soil types, or steep slopes. It could document community attributes or characteristics that are important to consider and/or protect when siting solar energy development. A master plan ideally includes a spatial analysis of land-use suitability and incorporates community engagement to establish formal guidance for the zoning regulations.

Accessory ground-mounted SES powering remote meteorological and communications equipment. Photo by Bradley Neumann.

COMMENTARY: A request for solar energy development may land on the doorstep of a community that has no mention of solar in the zoning ordinance or master plan. While neither ideal nor recommended, communities sometimes zone first and plan second.[15] Amending the zoning ordinance first without planning for solar is a relatively common course of action, especially when there is a sense of urgency to the permit request. If a community cannot avoid amending the zoning ordinance without first amending the plan, they should work closely with a qualified planner or municipal attorney to perform a master plan review in order to find elements that support or contradict a solar energy zoning amendment. Master plan elements to consider in this review:

- **Vision statement:** How do these broad community statements align with or contradict the contemplated ordinance amendment? Does the vision include renewable energy?
- **Goals and objectives:** If the solar amendment includes multiple scales of SES, then review the goals, objectives, and policies for all relevant land-use classifications on the future land-use map, such as agricultural, residential, commercial, forestry, industrial, etc.
- **Brownfields or grayfields:** Review plans, policies, and maps for recommended zoning approaches.
- **Future land-use map:** Review the map for projected areas of growth (infrastructure extension, type of growth or change in land-use) or areas with goals, objectives, and policies to preserve or maintain a unique community asset.
- **Zoning plan:** While not required as a precursor to a zoning amendment, a statement in the zoning plan[16] affirming the preferred scope and/or location of SES relative to other land-use classifications and zoning districts may be sufficient to show the community anticipated the solar zoning amendment but had not yet taken action to amend the ordinance. [End of commentary]

15 All zoning must be based on a plan. MCL 125.3203(1). http://legislature.mi.gov/doc.aspx?mcl-125-3203

16 Michigan Planning Enabling Act, MCL 125.3833 (2.d)

After a community has incorporated solar development into its master plan, the zoning ordinance can be amended to include regulations for the various configurations and scales of SES. The zoning regulations protect the community's health, safety, and welfare, and are based on policies outlined in the master plan. Zoning regulations define the location, scale, and form or configuration of SES allowed in the community and establish the permits and processes by which solar energy is allowed and even incentivized.

COMMENTARY: According to a review of Michigan zoning ordinances,[17] large-scale solar energy systems (see Section 3) tend to be allowed as principal land uses of property and authorized by special land-use permit in certain zoning districts within a community. Accessory structures, where the electricity generated is used by the principal land use on the property, are generally allowed in more or all zoning districts as accessory uses by right. Furthermore, roof-mounted systems are generally permitted in more zoning districts within a community than ground-mounted systems. In fact, it is quite common to see roof-mounted systems allowed in all zoning districts.

Some communities also permit ground-mounted systems in all districts, though this is less frequently the case than with roof-mounted systems. More specifically, ground-mounted systems tend to be allowed in lower-density districts where there is likely to be larger parcels with larger yards that can accommodate the accessory structure on-site. [End of commentary]

PUBLIC ACT 116—FARMLAND DEVELOPMENT RIGHTS PROGRAM

The Michigan Department of Agriculture and Rural Development (MDARD) administers the Michigan Farmland and Open Space Preservation Program, which includes the Farmland Development Rights Program, commonly referred to as PA 116 (Public Act 116 of 1974). The PA 116 program allows a landowner to voluntarily enter into an agreement with the State to retain their land in agriculture in exchange for certain tax benefits and exemptions from various special assessments.

Prior to 2019, principal-use solar was not permitted on land enrolled in the PA 116 Farmland Preservation Program. The policy has since changed to allow landowners to put their PA 116 agreements on hold to pursue solar development if specified conditions are met.[18] For example, among the conditions in PA 116 are those that require the developer to maintain existing field tile, plant a cover crop that includes pollinator habitat, and post a surety bond or letter of credit with the state to ensure that solar panels will be removed, and the land will be returned to a condition that enables farming at the end of the project life. This allows farmers to take advantage of the economic opportunity presented by solar development while preserving the long-term viability of growing crops or raising livestock on that land. Under the terms of the Farmland Development Rights Agreement, it is the landowner's responsibility to work with the solar energy developer to ensure that all conditions associated with PA 116 are satisfied. Therefore, a landowner will need to address such conditions in the solar energy lease, easement, or other agreement with the developer. In some counties, as much as 80% of farmland is enrolled in PA 116.[19] It is important for municipalities to understand the scope of PA 116 lands within their jurisdiction.

17 Derry, J., & Gilbert, E. (2020). Primary Research on Planning and Zoning for Solar Energy Systems in the State of Michigan. https://www.canr.msu.edu/resources/primary-research-on-planning-zoning-for-solar-energy-systems-in-the-state-of-michigan

18 The Farmland and Open Space Preservation Act, being PA 116 of 1974, now codified in Part 361 of the Natural Resources and Environmental Protection Act, PA 451 of 1994. http://legislature.mi.gov/doc.aspx?mcl-451-1994-III-1-LAND-HABITATS-361. Also see: https://www.michigan.gov/mdard/0,4610,7-125-1599_2558---,00.html

19 MDARD Farmland Preservation Program (PA116) Percentage of Farmland Enrolled by County. https://www.michigan.gov/documents/mdard/PA116_Enrollment_Map_531166_7.pdf

Rooftop SES, Petoskey, Michigan. Photo by Richard Neumann.

PRIVATE RESTRICTIONS

Private restrictions, such as homeowners' association (HOA) rules, deed restrictions, or architectural standards within a subdivision or condominium development, can limit the installation of SES regardless of local government plans and ordinances. Local governments can work with neighborhood associations, sharing sample rules that allow for SES on individual properties and attempting to align the goals of the association with existing local policy. An additional possibility would be to include a requirement in one's zoning ordinance that all new residential developments must allow rooftop solar as a permitted use in the development.

ZONING FEES AND ESCROW POLICY

The local resolution governing permit fees and review costs should be updated to include SES upon adoption of a zoning amendment regulating the use. The Michigan Zoning Enabling Act authorizes the legislative body to adopt reasonable fees for zoning permits.[20] The permit fee amount must be set by the legislative body to cover anticipated actual cost of the application review and not more.

To encourage the adoption of solar energy, some communities waive or reduce zoning fees for some types of systems. Within the SolSmart certification program, for example, communities can earn points toward certification by waiving or exempting fees for residential solar permit applications.

For large utility-scale SES, though, a community might consider using escrow funds deposited by the applicant to recover the expense of hiring outside reviewers, such as an attorney, engineer, or planning consultant. An escrow policy provides a mechanism for the community to anticipate the costs associated with reviewing a complex application. Prior to requiring escrow funds for a zoning application review, the legislative body must first adopt an escrow policy by resolution.[21,22] Among other things, an escrow policy establishes administrative guidelines for spending, replenishing the escrow below a certain balance, and returning remaining funds.

20 Michigan Zoning Enabling Act, Act 110 of 2006, MCL 125.3406, http://legislature.mi.gov/doc.aspx?mcl-125-3406

21 Forner v. Allendale Charter Twp. Court: Michigan Court of Appeals, 2019 Mich. App. LEXIS 576, 2019 WL 1302094 (March 21, 2019, Decided), Unpublished Opinion No. 339072, http://www.michbar.org/file/opinions/appeals/2019/032119/70094.pdf

22 Charter Township Act, PA 359 of 1947. http://legislature.mi.gov/doc.aspx?mcl-Act-359-of-1947. Revised Statutes of 1846. http://legislature.mi.gov/doc.aspx?mcl-R-S-1846-41-1-16

Langeland Farms SES. Photo by M. Charles Gould.

OTHER PERMIT PROCESSES

The planning commission can serve in a coordinating role to ensure additional required permits are obtained before planning commission review and approval. For example, the application may include mitigation measures to minimize potential impacts on the natural environment, including but not limited to wetlands and other fragile ecosystems, historical sites, and cultural sites. In addition to local zoning permits, solar energy developments may require permits from other agencies, including:

- **Department of Environment, Great Lakes, and Energy (EGLE)** if the project affects waters of the state, such as wetlands, streams, or rivers.[23]
- **U.S. Fish and Wildlife Service (USFWS)** for the Endangered Species Act or migratory flyways.[24]
- **Federal Aviation Administration (FAA)** for projects on or within the vicinity of an airport to determine if any safety or navigational problems are present.[25]
- **Municipal or County Soil Erosion Permitting Agency** if the project is one or more acres in size, or is within 500 feet of a lake or stream.[26]
- **Tax Assessor** or zoning administrator for land division approval if leasing less than 40 acres or the equivalent for more than one year.[27]
- **Building Department** for required building, electrical, and mechanical permits.[28]
- **Local Airport Zoning**, for projects within 10-miles of a local airport.[29,30]

23 Parts 301 and 303 of the Natural Resources and Environmental Protection Act, PA 451 of 1994. http://legislature.mi.gov/doc.aspx?mcl-451-1994-III-1-INLAND-WATERS

24 Federal laws administered by the USFWS: Endangered Species Act (ESA); Bald and Golden Eagle Protection Act (BGEPA); Fish and Wildlife Coordination Act (FWCA). See: https://www.fws.gov/ecological-services/energy-development/laws-policies.html

25 Part 77 (Airspace Review) of Title 14 of the Code of Federal Regulations. https://www.faa.gov/airports/environmental/policy_guidance/media/FAA-Airport-Solar-Guide-2018.pdf

26 Soil Erosion and Sedimentation Control. https://www.michigan.gov/egle/0,9429,7-135-3311_4113-8844--,00.html

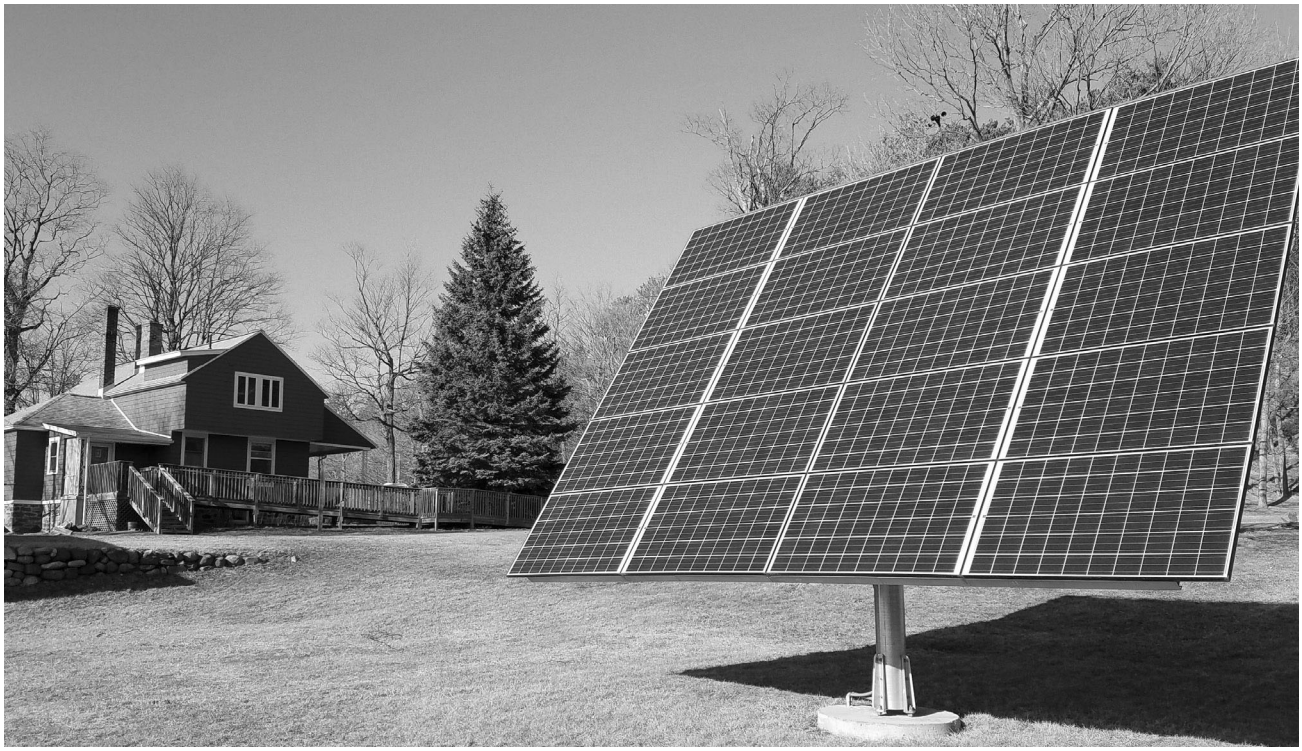
27 Michigan Land Division Act, PA 288 of 1967, definition of 'Division' – MCL 560.102(d). http://legislature.mi.gov/doc.aspx?mcl-560-102

28 When a project is developed or owned by a private entity, local construction permits are required. If the project is owned by a regulated utility, then local building and electrical permits may not be required but projects are instead regulated by the Michigan Public Service Commission. See Stille-Derossett-Hale Single State Construction Code Act, PA 230 of 1972, MCL 125.1502a(1)(bb), http://legislature.mi.gov/doc.aspx?mcl-125-1502a; and 2015 Michigan Building Code, 1.105.2.3 Public Service Agencies, https://www.michigan.gov/lara/0,4601,7-154-89334_10575_17550-234789--,00.html

29 Airport Zoning Act, Act 23 of 1950. http://www.legislature.mi.gov/documents/mcl/pdf/mcl-act-23-of-1950-ex-sess-.pdf

30 Michigan Zoning Enabling Act, Act 110 of 2006, MCL 125.3203, http://legislature.mi.gov/doc.aspx?mcl-125-3203

SCALES & COMPONENTS



Ground-mounted monopole SES. Photo by Bradley Neumann.

This section discusses SES across a range of sizes, scales, configurations, and related components. SES cannot be treated uniformly by local governments because the scale of installations and energy generation capacity can vary dramatically. For example, a small solar panel powering a streetlight might be exempt from regulation, while a large-scale photovoltaic SES, providing power to the grid through a system of components, likely would require rigorous local review.

TYPES

Solar energy generation for distribution to the grid is a unique land use, at both the large and small scale. As such, these developments should be clearly defined as a separate land use within a zoning ordinance. Treating all scales of SES the same may unnecessarily restrict accessory and small scale installations. In addition, solar developments are scalable and can be sited across many zoning districts. Therefore, in zoning ordinances, SES should be expressly defined as distinct land uses at the different system scales that the community desires (e.g. accessory use vs. principal-use, small SES vs. large SES, ground-mounted SES vs. roof-mounted SES, etc.).

The first distinction to consider for SES is accessory use versus principal use.

Accessory: These SES are accessory to the primary use of a property, such as a residence or a commercial building, and provide electricity that is intended for use by a primary structure located on the same parcel as the SES. Accessory systems can range in size and configuration. They typically range from being small enough to power an exterior light fixture to being large enough to power electricity for multiple buildings, for instance livestock or equipment barns. On-site (or distributed-generation) systems can be affixed to the roof of a building or can be freestanding, ground-mounted structures.

Principal: Principal-use SES developments generate electricity distributed off-site through the grid and exported to a wholesale utility market. These projects occupy single or multiple large parcels of land and are typically the primary use on the site. These SES vary greatly in size, covering as little as an acre to thousands of acres. In addition, SES have two primary configurations: ground-mounted and roof-mounted.

Roof-Mounted: A roof-mounted SES has solar panels affixed to a racking system on the roof of a building, which may be a residential, agricultural, institutional, commercial, or industrial building. Roof-mounted panels can be installed parallel to the roof surface, like a solar shingle, or protrude from the roof at an angle, like an awning. A roof-mounted SES typically has fixed mounts that do not rotate throughout the day to track the sun. By definition, roof-mounted systems are accessory structures relative to the principal use of the building.

Ground-Mounted: A ground-mounted SES has solar panels affixed to a racking system on support posts. These posts are most commonly driven into the ground, without requiring excavation for a concrete foundation. However, in cases where the soil cannot be penetrated, such as with a brownfield or capped landfill, ground-mounted SES can also be designed with ballasted supports that sit atop the ground. A ground-mounted SES may be fixed (i.e., stationary) or have single- or double-axis trackers to follow the sun throughout the day. While nearly all principal-use SES are ground-mounted, some accessory SES may be ground-mounted, too. For example, solar parking canopies are becoming more common in Michigan and present unique characteristics as compared to a typical ground-mounted SES.

These characteristics include unique panel height, vehicle support-post collision mitigation, lighting, and site configurations. Ground-mounted SES can also be distinguished by scale, which we define in this guide to be 'large' or 'small'.

SCALES

As mentioned, even principal-use SES can vary greatly in size, covering as little as an acre to thousands of acres. Because of this variation in the size and impact on a site, many communities may choose to distinguish between small and large principal-use SES in their ordinances. To be sure, there is no established definition of "small" or "large," and for other industry or taxation purposes, large- and small-scale distinctions may differ.

In assisting a community in making a distinction between scales of SES based on size, Table 1 (below) illustrates common SES outputs measured in megawatts (MW) of direct current (DC)[31] and the average acreage of land required to host an SES of that output.[32] Larger projects have a higher variability in land required per megawatt (5-10 acres per MW DC)[33], depending on how many parcels are involved and the layout of solar panels within them.

Table 1. Comparison Chart: Megawatt Outputs to Acreage Needed

Megawatts (DC)	Acres
1 MW*	5-10
2 MW	10-20
20 MW	100-200
100 MW	500-1,000
200 MW	1,000-2,000

*The current national average (through 2018) number of homes powered by 1 MW of solar is 190. Since SEIA began calculating this number in 2012 it has ranged from 150 - 210 homes/MW.[34]

31 Solar output can also be measured in alternating current (AC), often for taxation or regulatory policies. An SES will have a higher MW DC rating than MW AC rating since there are some losses when inverting power from DC to AC to connect to the grid.

32 Ong, S., Campbell, C., Denholm, P., Margolis, R., and Heath, G. 2013. Land-Use Requirements for Solar Power Plants in the United States. National Renewal Energy Laboratory, Technical Report NREL/TP-6A20-56290. Table ES-1, Page v. Source: https://www.nrel.gov/docs/fy13osti/56290.pdf. Retrieved August 27, 2021.

33 Solar Energy Industries Association (SEIA). (2021). Siting, Permitting & Land Use for Utility-Scale Solar. https://www.seia.org/initiatives/siting-permitting-land-use-utility-scale-solar

34 SEIA. (2021). What's in a Megawatt? https://www.seia.org/initiatives/whats-megawatt

(Clockwise from top right) Ground-mounted SES with grazing (sheep) by Mary Reilly.; park outbuilding, rooftop SES in winter, demonstration array, all by Bradley Neumann.

In this guide, the scale threshold between small and large principal-use SES is 2MW (or approximately 20 acres). Currently, there are dozens of SES projects of 2MW and less being developed in the state.[35] These have largely been well-received by local communities, suggesting they fit within the character of the landscapes in which they are proposed. Small systems 2MW or under (or 20 acres) could be permitted by right after an administrative site plan review (see discussion below). Each community, though, should determine what the right demarcation of scale is between small and large principal-use SES given the community's context. In an urban environment, where parcels are smaller, the threshold to classify as a large principal-use SES may be smaller projects of fewer megawatts. In a community abundant with rural land or experience with expansive developments, a larger MW or acreage threshold for large projects may be more appropriate.

35 Most of these small projects are sized so that they can be considered "qualifying facilities" under PURPA, a federal law enacted in 1978, intended to diversify electricity generation. Specific capacity (MW) thresholds to receive the "standard offer tariff" vary from utility to utility. The current standard offer capacity threshold and more about PURPA can be found on the Michigan Public Service Commission's website: https://www.michigan.gov/mpsc/0,9535,7-395-93309_93439_93463_93723_93730-406273--,00.html

COMMON SOLAR COMPONENTS

All SES require equipment to operate properly, although this equipment may differ based on the scale and configuration of the system. Besides the solar array panels/modules themselves, four common types of equipment are included with an SES: an inverter, a battery system (if in use), racking, and wiring. There are also other 'balance of system' components that may or may not be present: combiner boxes, disconnect switches, a weather station, performance monitoring equipment, and transformers.

Solar Panels: Photovoltaic solar panels convert light (photons) to electricity (voltage). The vast majority of today's solar panels are made of silicon solar cells. An individual solar panel is typically assembled on racking to function with other panels as part of an array. Commercial solar panels are constructed with one or more anti-reflective coatings often made of magnesium fluoride (MgF_2). Anti-reflective coatings have been highly improved in the last 20-30 years to ensure that panels maximize how much light reaches the photovoltaic cells. Glare from modern solar panels is insignificant and local regulation, even adjacent to airports, is not always required.

Inverter: Inverters convert direct current (DC) electricity generated by photovoltaic modules into alternating current (AC) electricity that is compatible with batteries and the electrical grid.[36] Some inverters produce sound when in operation, which can often be managed with proper placement based on the sound pressure they produce. Communities may choose to adopt sound regulations to influence the placement and design of inverters within an SES.[37]

Battery: Some homeowners or solar developers include batteries in their solar installations, allowing the solar energy to be stored and used at later times when it is needed (such as at night). These on-site batteries make solar energy more accessible and reliable as an electricity source, and are becoming increasingly common for all scales of SES as per-unit costs of batteries decline. Batteries can vary in size depending on the level of storage needed and may also vary in their location on the site. For accessory systems, the batteries may be within the residence itself.

Racking: As described above, SES may be ground- or roof-mounted. The frames, support posts, foundations (if required), and hardware used to secure solar panels and other SES equipment is often collectively referred to as "racking."

Wiring: Solar panels are wired together to create an electrical circuit that allows current to flow through the component parts. Wiring extends beyond the panels to inverters, batteries, electronic devices, transformers, and/or distribution lines, depending on whether the SES generates electricity for use on-site or export to the electrical grid. Wiring between solar components may be underground.

Other components related to larger SES include transformers and substations for connecting to transmission lines that serve the electrical grid. Often solar developers connect to existing substations, but sometimes developers propose new or upgraded substations or transmission-line extensions as part of the SES. Transformers in substations increase voltage to higher levels for more efficient transmission over long distances. Transformers may produce low audible noise, so they may be subject to local government regulations applying to substations.

36 U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. Solar Integration: Inverters and Grid Services Basics. https://www.energy.gov/eere/solar/solar-integration-inverters-and-grid-services-basics

37 Kaliski, K., I. Old, and E. Duncan. An overview of sound from commercial photovoltaic facilities. June 29-July 1. NOISE-CON 2020. https://rsginc.com/wp-content/uploads/2021/04/Kaliski-et-al-2020-An-overview-of-sound-from-commercial-photovolteic-facilities.pdf

LAND-USE CONSIDERATIONS

Fig 1. Rural-to-Urban Transect. *Credit: DPZ CoDesign; MSU Extension*

From left to right in **Figure 1**, above, the landscape shifts from a natural zone (T1), which can be wilderness, woodlands, wetlands, or other naturally occurring habitats, gradually transitioning in intensity-of-use to the urban core where we find our large urban centers. The remaining transect zones depicted in Figure 1 include rural farmland and open space areas (T2), suburban developments (T3) and general urban zones (T4, T5, T6), including traditional walkable neighborhoods and smaller historic downtowns. By taking a transect-based view of a community, policymakers can consider SES scales and configurations relative to the development pattern(s) in a community to determine the most appropriate regulation of SES by landscape type (vs. specific individual land use).

Solar energy systems (SES) can be of different scales and configurations within a community. As used in this document, the four basic scales of SES are roof-mounted, accessory ground-mounted, small principal-use, and large principal-use. Ultimately, the compatibility of an SES at a given site depends on its scale relative to the pattern and density of the surrounding physical and built environment. Zoning, as a local regulatory mechanism, can mitigate the impacts of SES if standards are appropriately tailored to the various development patterns of a community.

To better understand how SES can be integrated into existing development patterns in a community, it is helpful to understand and apply the 'transect' to illuminate the multiple intersections of solar configurations and scales possible across a range of natural to urban landscapes. The Rural-to-Urban Transect, depicted in Figure 1, is an urban planning model that defines a series of zones that transition from natural and sparse rural farmhouses to the dense urban core of a large regional city.[38] In the figure, the dark gray boxes are built structures served by light gray roadways and surrounded by green natural open space or trees. There is an elevation or profile view across the top 'horizon' line of each transect and a plan or aerial view of the same landscape just below.

38 For more background on the Rural-to-Urban Transect, visit the Center for Applied Transect Studies website at: https://transect.org/.

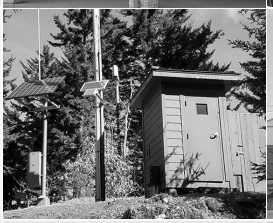
Solar Energy System Type	Natural	Rural	Urban	General Urban
Accessory Roof Mounted				
Accessory Ground Mounted				
Principal Use (Small)				
Principal Use (Large)				

Fig 2. Examples of Solar Energy System Types across the Transect

Figure 2 provides a visual depiction of the type and scale of SES that exhibit predominant factors for compatibility in a given setting. For example, while it's not generally appropriate to develop a large or small principal use SES in a natural wilderness area (T1), it may be more appropriate to allow roof-mounted SES in that transect to serve park structures and accessory equipment within this landscape. Similarly, compatible siting of SES can occur in the suburban transect zone (T3) with a full range of SES types and scales, such as a roof-mounted system on a hotel, an accessory ground-mounted SES carport, or a large or small principal use system at an office park. Regardless of whether a community uses transect-based zoning terminology in the master plan or zoning ordinance, the transect framework is helpful in developing community goals related to the logical placement and installation of SES across varying landscapes of a community.

Table 2 – SES Scale and Type as applied to Example Zoning Districts

Example Zoning District:	Resource Production / Agricultural	Low-Density Residential	Commercial / Office	Industrial	Medium-Density Residential	Mixed Use
Roof-Mounted	P	P	P	P	P	P
Accessory Ground-Mounted	P	P	P	P	P	P
Principal Use (Small)	SPR	SLU	SPR	SPR	SLU	SPR
Principal Use (Large)	SLU	X	SLU	SLU	X	X

P = Permitted Use (zoning standards apply); SPR = Site Plan Review; SLU = Special Land Use; X = Not Permitted

Understanding that various types of SES can exist (or not exist) compatibly within natural, rural, suburban, and urban land-use transects, communities with conventional, use-based zoning ordinances will need to determine the SES type and scale that best fits in each zoning district. This determination must include the approval mechanisms by which the types of SES will be allowed. See Table 2 for one approach to applying SES types and scales across a range of six common zoning districts and the zoning approval processes that might be used. Table 2 suggests permitting processes for the four main SES types. For instance, roof-mounted and accessory ground-mounted systems are likely appropriate across the transect and can be allowed as a use by right in all zoning districts. Small principal-use SES are similarly permitted across the transect, but the approval process varies depending on the context. In zoning districts where there is concern about compatibility with existing land uses, a special land-use (SLU) permit issued after planning commission review provides the most protection for existing and adjacent land uses. However, small principal-use SES might also fit within certain zoning districts without much concern and therefore can also be permitted through site plan review (SPR) performed by the zoning administrator. Lastly, large principal-use SES are permitted by SLU in many, but not all, zoning districts due to compatibility concerns with existing land uses and development patterns. For instance, it could be counter to the master plan and intent of the zoning district for a large principal-use SES to be sited in a walkable, mixed-use district. Each community, though, should tailor the SES type and scale to its own development patterns, transect zones, or zoning districts and assign the appropriate zoning approval process to each.

Overlay zoning is an optional approach to proactively establish the potential location of small or large principal-use SES.[39] Overlay zoning is often used to create a standard set of regulations to address unique needs of one type of land use by placing a second regulatory zoning district on top of the existing zoning map. This approach might be useful if the majority of the land in the community is under the same zoning designation (e.g., agricultural or ag-residential), and the community finds SES are appropriate in some, but not all, areas of that district. For example, the community may determine an SES overall to be most appropriate near existing electrical transmission lines or substations, or in sections of an ag-residential district without substantial residential development. In addition to defining the regulations for the overlay district within the zoning ordinance text, communities who opt to use overlay zoning to regulate SES should also proactively apply the overlay district to their zoning map. The boundaries of the overlay should be supported by the master plan with analysis of the solar resource, location of

39 American Planning Association. Property Topics and Concepts. https://www.planning.org/divisions/planningandlaw/propertytopics.htm

existing energy infrastructure, slopes, unique natural features, capabilities of the land/soil, current development patterns, and more.

COMMENTARY: Ethics and Conflict of Interest: Because large principal-use SES may cover hundreds of acres of land, it is not unusual for local elected officials or planning commission members' properties to be included in a project. The legislative body or planning commission may have existing rules or bylaws on what constitutes a conflict of interest for its members and how a conflict of interest is handled. Planning commissions are required to have bylaws with rules on handling conflict of interest.[40] If no such rules or bylaws are in place, they should be established and would apply to all matters before the board or commission. Involvement of the community's attorney that is experienced in municipal (planning and zoning) law is advised when a conflict of interest issue presents itself for one or more board members or planning commissioners. [End of commentary]

FARMLAND CONSIDERATIONS

When a large principal-use SES is proposed on agricultural land, there are sometimes concerns about whether the operation is a wise use of farmland and whether the land will be able to be farmed during or at the end of the solar project's life. While this question is rarely asked of other land uses in farming communities (for example, residential subdivisions are often allowed in agricultural districts and that land would not be readily farmed again), given the scale of solar projects on the horizon and that prime farmland and other important farmlands are a limited commodity,[41] it is a reasonable concern.

There is nothing inherent in solar development that would make the land unfarmable: the panels and support posts can all be removed. Driving paths between arrays or concrete pads on which the inverters sit will result in soil compaction and should be mitigated upon decommissioning, but these tend to be relatively small percentages of land area for an SES. A bigger concern for returning a solar site to crop production is site design standards, such as the choice of stormwater management practices, the extent and type of landscaping, and the use of berms as a screening mechanism. Movement of topsoil or planting of trees may jeopardize the ability to farm the land in the future. The guidelines outlined in this sample ordinance and also presented in PA 116—to maintain the field tile and plant pollinator habitat—help ensure that the land can be farmed again the future.

Some local governments have proposed going even further, prohibiting solar energy development on particular classes of farmland. The U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) uses eight categories to classify the suitability of soils to grow most kinds of field crops. In general, Class I through Class IV are suitable for cropland use while Class V through Class VIII are suitable for permanent vegetation (i.e., no tillage).[42] However, if land is predominantly Class III or higher, it might be considered marginal farmland, and therefore could be considered less valuable for long-term agricultural use—raising fewer concerns about the appropriateness of solar energy development. In communities where prohibitions based on soil classification extend to other land uses (e.g., residential developments, golf courses, airstrips), this may be reasonable based on a master plan that includes farmland preservation goals and recommends farmland protection zoning techniques and other farmland preservation tools, such as Michigan's farmland purchase of development rights program. However, if soil classification-based prohibitions only apply to large principal-use SES, this approach may be vulnerable to legal challenges.

40 MCL125.3815. http://legislature.mi.gov/doc.aspx?mcl-125-3815. Also see MSU Extension Sample Bylaws for a Planning Commission: https://www.canr.msu.edu/resources/sample_1e_bylaws_for_a_planning_commission

41 Other farmland classifications to consider include: farmland of statewide importance, farmland of local importance, unique farmland, and prime farmland if drained. https://websoilsurvey.sc.egov.usda.gov

42 USDA NRCS. Land Capability Class, by State. 1997. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/?cid=nrcs143_014040

AGRICULTURE DUAL USE

"Dual use" is the integration of solar panels in an agricultural system in a way that enhances a productive, multifunctional landscape.[43] Dual use can take many forms in agricultural areas, and while there are numerous examples of successful co-located projects, it isn't the default practice for every solar development, and may not always be possible or desired by property owners. Perhaps the most overt combination of solar and agriculture working together is through an "agrivoltaic" system that combines raising crops for food, fiber, or fuel, and generating electricity within the project area to maximize land use. Careful planning and evaluation is needed when designing the configuration of solar arrays for specialty crop production.

Grazing animals under and around solar arrays is another example of dual use. Grazing sheep is a practice that keeps land in active agricultural production and effectively manages vegetation.[44] A 2018 report from the David R. Atkinson Center for a Sustainable Future at Cornell University concluded that utilizing sheep for site vegetation management resulted in, "2.5 times fewer labor hours than mechanical and pesticide management on site."[45] Tampa Electric reported a 75% cost savings over traditional mowing at its solar sites.[46] However, grazing sheep requires careful site design (to ensure that livestock is compatible with project infrastructure), as well as vegetation planning (so that the right forages are planted and the proper rotational grazing system is implemented).[47,48,49] Done successfully, solar grazing can support the livelihoods of veterinarians, feed suppliers, and other parts of the rural agriculture economy.

Agrivoltaics and grazing are not the only ways that SES can support agricultural landscapes and economies.[50] Another dual use is planting groundcover that is compatible with solar panels and provides a variety of other ecosystem services of value. Examples include planting vegetation that provides food sources for pollinators or selecting plant species that provide ecological services, such as carbon sequestration, increased soil health, habitat preservation, or water quality improvements.[51] Though some existing solar projects may already provide stacked ecological services, research is just now underway to quantify some of these co-benefits. In the interim, SES systems that integrate plant species and practices compatible with conservation-cover standards should be treated as dual use, as they provide the ecological benefits of these farm management practices along with clean energy.

43 Low-Impact Solar Development Basics. Innovative Site Preparation and Impact Reductions on the Environment. https://openei.org/wiki/InSPIRE/Basics

44 Hartman, David. (2021). Sheep Grazing to Maintain Solar Energy Sites in Pennsylvania. Penn State Extension. https://extension.psu.edu/sheep-grazing-to-maintain-solar-energy-sites-in-pennsylvania

45 Kochendoerfer, N., Hain, L., and Thonney, M.L. (2018). The agricultural, economic and environmental potential of co-locating utility scale solar with grazing sheep. David R. Atkinson Center for a Sustainable Future, Cornell University. https://cpb-us-e1.wpmucdn.com/blogs.cornell.edu/dist/f/6685/files/2015/09/Atkinson-Center-report-2018_Final-22l3c5n.pdf

46 Utility Dive Does a Deep Dive on Solar Grazing. (2020). ASGA. https://solargrazing.org/utility-dive-does-a-deep-dive-on-solar-grazing/

47 Agricultural Integration Plan: Managed Sheep Grazing & Beekeeping. (2020). https://www.edf-re.com/wp-content/uploads/004C_Appendix-04-B.-Agricultural-Integration-Plan-and-Grazing-Plan.pdf

48 Cassida, K. and Kaatz, P. (2019). Recommended Hay and Pasture Forages for Michigan. Extension Bulletin E-3309. Michigan State University. https://forage.msu.edu/wp-content/uploads/2019/11/E3309-RecommendedHayPastureForagesForMichigan-2019.pdf

49 Undersander, D., Albert, B., Cosgrove, D., Johnson, D., and Peterson, P. (2002). Pastures for Profit: A Guide to Rotational Grazing. Extension bulletin A3529. University of Wisconsin-Extension and Minnesota Extension Service. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1097378.pdf

50 A Guide to Solar Energy in Vermont's Working Landscape. (2020). The University of Vermont Extension. https://www.uvm.edu/sites/default/files/The-Center-for-Sustainable-Agriculture/resources/solar_energy_vt_working_landscape.pdf

51 Steinberger, K. (2021). Native Plant Installation and Maintenance for Solar Sites. The Nature Conservancy. https://www.nature.org/content/dam/tnc/nature/en/documents/Native-Plant-Management-at-Solar-Sites.pdf

Ground-mounted SES with grazing (sheep). Photo by M. Charles Gould.

COMMENTARY: As of January 1, 2021, the sheep and lamb inventory in Michigan was 87,000 head.[52] Of that 87,000 head, 47,000 are ewes.[53] By 2024, there will be a total of 1,188 megawatt (MW) of solar online.[54] Assuming a principal-use SES requires eight acres per MW of generating capacity, 9,504 acres could potentially be grazed.[55] At a stocking rate of three mature ewes per acre, 28,512 ewes would be needed to manage the vegetation of all solar projects currently online or going online through 2024.[56] While there are more than enough ewes to service these solar projects, the sheep inventory in the state is at grazing equilibrium. Solar projects that are suitable for grazing could spur an increase in the sheep and lamb inventory in Michigan. Because ewes can have multiple lambs, the state's sheep industry has the capacity to expand to meet this demand. Furthermore, over half of the lamb and mutton supply is currently imported[57], and with the largest livestock harvesting facility east of the Mississippi in the Detroit area, there are opportunities to replace imported meat with the increased lamb and sheep inventory. [End of commentary]

52 U.S. Department of Agriculture. Sheep and Goat Inventory News Release [NR-21-07]. (February 2021). https://www.nass.usda.gov/Statistics_by_State/Michigan/Publications/Current_News_Release/2021/nr2107mi.pdf

53 USDA NASS Great Lakes Region. 2021. News Release: Sheep and Goat Inventory NR-21-07. Found at https://www.nass.usda.gov/Statistics_by_State/Michigan/Publications/Current_News_Release/2021/nr2107mi.pdf. Retrieved July 28, 2021.

54 Correspondence on March 5, 2021 with Julie Baldwin, Manager, Renewable Energy Section of the Michigan Public Service Commission.

55 SEIA. Siting, Permitting & Land Use for Utility-Scale Solar. https://www.seia.org/initiatives/siting-permitting-land-use-utility-scale-solar.

56 U.S. Department of Agriculture. Grazier's Math, With Apologies. https://app.box.com/s/x9zv3yvili2w0l7xbh8lcl2cgn71meh6

57 USDA Economic Research Service. https://www.ers.usda.gov/topics/animal-products/sheep-lamb-mutton/sector-at-a-glance/. Retrieved July 28, 2021.

SOLAR ON BROWNFIELDS AND GRAYFIELDS

A recommended practice is to use regulation to encourage the siting of SES on land that is difficult to develop or marginal for other uses. Examples of marginal land include brownfield sites, capped landfills, grayfield sites (previously developed property), and required safety buffer areas around industrial sites. On brownfields or capped landfills, solar development can allow productive use of land that might be compromised or have other development challenges. Solar arrays can be designed to avoid penetrating the ground and don't require as much remediation as other kinds of development. In a similar vein, development of solar on grayfield sites can provide an economic development opportunity for land that is otherwise disadvantaged from a redevelopment perspective.

While the use of marginal land for solar energy development is recommended, it is not a common practice, particularly among large SES, for a range of reasons.[58] One reason is that most of these marginal lands are smaller than the preferred 100+ acres for a more typical SES, and these smaller sites typically do not allow for achieving economies of scale. Even when solar developers are building a smaller-scale project, developing on a brownfield site may require using ballasted support structures (rather than driven posts), which can be more expensive, or may require a less-than-ideal panel layout. Communities wanting to attract solar development to marginal lands may need to reduce other costs or barriers to development, such as expediting review and permitting, providing land at low or no cost, decreasing required setbacks, or providing other incentives, including offering property tax incentives where that is allowed. While Michigan has seen modest development of solar on brownfields to date, other states (for example, Massachusetts and New York) are purposely targeting such development as a land-use and local economic development strategy.[59]

CO-LOCATION WITH OTHER LAND USES

When evaluating how SES might fit into a community, one important consideration is how compatible an SES would be with the surrounding landscape and existing land use. Solar co-location is a signature concept for local regulation. The notion of co-location allows for solar energy production to be in parallel with another use.

For example, parking lots may be outfitted with solar carports as accessory structures (see extended commentary for some case studies). Other examples of co-location of SES include siting solar arrays at public school sites or other institutional grounds and in highway rights-of-way and the open space at airports. With the road network, an SES within a highway or freeway right-of-way might be deployed to power a specific piece of equipment, such as a sign, light, or meteorological station. Given their ample landholdings, airports may be ideally poised for solar installation, and have successfully installed SES as both ground-mounted and roof-mounted systems. The three primary issues regulated by the Federal Aviation Administration (FAA) are reflectivity and glare, radar interference, and the physical penetration of panels into airspace. Guidance provided by the FAA helps airport operators understand the considerations they should make in deploying solar, including when glare studies are required.[60]

Coldwater Solar Field Park.
Image courtesy of City of Coldwater, MI.

58 Schaap, B., Dodinval, C., Husak, K., & Sertic, G. (2019). Reducing Barrier to Solar Development on Brownfields. Retrieved from: http://graham.umich.edu/product/reducing-barriers-solar-development-brownfields.

59 See: Solar Massachusetts Smart Target Program. https://www.mass.gov/info-details/solar-massachusetts-renewable-target-smart-program and NYSERDA Solar Guidebook for Local Governments.

60 Federal Aviation Administration. (2018). Technical Guidance for Evaluating Selected Solar Technologies on Airports. https://www.faa.gov/airports/environmental/policy_guidance/media/FAA-Airport-Solar-Guide-2018.pdf

COMMENTARY: The use of parking lots for co-location of solar energy systems is a growing trend around the country. These dual-use situations provide unique opportunities and challenges to local governments interested in encouraging their installation.

In many situations, regulations are silent on co-location opportunities. Communities sometimes struggle to identify the land-use regulations that should apply. The following examples, which come from three different underlying land uses, show how co-location opportunities can be encouraged on surface parking infrastructure for existing uses. These summaries are based on personal interviews related to MSU research.

Case Study—Michigan State University (MSU), East Lansing, MI | Michigan State University (49,000 students) has the largest solar carport development project in the state (2020). Over 5,000 parking spaces across five large commuter parking lots (34 acres total) are fitted with ground-mounted solar carports. These lots provide students, faculty, and visitors with covered space to leave their cars as they walk, bike, or use public transit to traverse the campus.

The project can generate up to 10MW—nearly 20% of total campus electricity generation. It is a key part of the university's Energy Transition Plan, a process by which MSU reduces its dependency on fossil fuels and expands its renewable energy portfolio. According to MSU director of Planning, Design, and Construction John LeFevre, preserving green space was a large selling point for the project.

The solar carports advance land-use and energy goals by increasing the utility of existing developed sites with enough structural repetition to allow for an efficient solar-panel layout. This approach to SES development applies to universities, as well as to other larger commuter parking lots and developed grayfield sites present in many communities.

Case Study—USA Hauling & Recycling, East Windsor, CT | East Windsor, a town in northern Connecticut with 11,375 residents, is home to USA Hauling & Recycling, a local waste management firm. In 2018, the company requested and received permission to enact a site-plan change for their industrial property, whereby they installed two solar carports of 25,000 and 45,000 square feet. They now operate their large compressors and recycling processes through 743kW of solar energy and protect their truck fleet with carport canopies.

The company received a prompt review from the town after amending their site plan, gaining final approval in just months. East Windsor town planner and consultant Mike D'Amato, AICP, CZEO, attributes the town's efficient approval process to how they regulate carports—as a class of accessory structures. Within this framework, solar carports are permitted in all zoning districts that allow accessory structures. A key provision of carports is that they are exempt from setbacks and lot coverage. The net result is an abundance of community locations where solar carports are now permitted.

Case Study—Fairbanks Museum & Planetarium, St. Johnsbury, VT | St. Johnsbury is a town of 5,685 residents in northeastern Vermont, home to the Fairbanks Museum & Planetarium. The museum undertook an energy efficiency campaign in 2015, resulting in the installation of a 27.36kW solar car-port over an auxiliary parking lot, connected to underground batteries, in December of 2020. The project marks the end of their renewable energy transformation. According to museum director Adam Kane, energy costs have decreased from around $15,000 per year in 2010 to $0 in 2020.

Both Kane and St. Johnsbury zoning administrator Paul Berlejung make special mention of the town's flexible solar regulations. There are no "restricted" or specifically permitted zoning districts in the town's section on solar collectors. Instead, solar collectors are defined as accessory uses, with a few clearly defined provisions pertaining to setbacks, build heights, and burial of utility lines. Kane and Berlejung both noted that interactions between solar suppliers and the town are remarkably smooth, concluding that municipalities looking to incentivize solar carport construction should consider reducing the barriers to entry at the local level. [End of commentary]

SOLAR AND HISTORIC OR CULTURALLY SIGNIFICANT SITES

Solar panels can have a variety of impacts on character-defining features of historic or culturally significant structures or sites. Solar collectors can obscure character-defining features of a structure, or be incompatible with a structure's roofline, exterior color, and the texture or shape of building materials. Despite these potential impacts, many Michigan communities allow for and regulate SES in historic districts and on other significant sites. It is important to allow SES on historic sites and structures in a context-sensitive way, granting the use while preserving the integrity of site aspects deemed historic or culturally significant.

Newer photovoltaic systems, including building-integrated SES, may be appropriate on the street-facing side, even in historic districts. New technology such as solar shingles can be designed and mounted to match the shape, materials, and proportions of a structure. For ground-mounted SES at a historic or culturally significant site, placement of the SES should be context-sensitive with respect to significant areas of the property.

Communities with historic district ordinances should update their ordinance to address roof and ground-mounted SES. The cities of Grand Rapids, Ypsilanti, and Manchester are a few examples that provide for regulations that address these issues. For state or federally designated historic structures, applicants should review the U.S. Secretary of the Interior's Standards for Rehabilitation.

DECOMMISSIONING AND REPOWERING

A question that commonly arises when communities are considering solar as a primary land use is what happens at the end of the solar project's life. Most solar panels are designed to operate for 25-40 years, so it is not uncommon for solar developers to have a lease or easement of roughly this length with a landowner. However, many landowner agreements include the option to extend, sometimes because there is still life left in the original panels and sometimes because the developer hopes to repower the project.

It's important to note the distinction between the two primary options at the end of a solar project's life: decommissioning and repowering. Decommissioning is the process of removing the equipment and other infrastructure associated with the project. While decommissioning is commonly a provision in a landowner's agreement with a solar developer, many communities also require review of a decommissioning plan that includes a financial commitment as part of the approval process. The decommissioning plan

Rooftop SES, Petoskey, Michigan. Photo by Richard Neumann.

details how the project equipment will be removed and the land restored when the contract for the SES expires, and the financial commitment guarantees there will be funding to implement the plan.

Before reaching the end of its useful life, sometimes a solar project is repowered. Repowering an SES involves refurbishing or replacing system components to allow the SES to continue operation. The expectation associated with repowering is that much of the original infrastructure (e.g., racking, access roads, wiring, etc.) may still have useful life and may be reused, even if other components have reached the end of their useful life.

COMMENTARY: Fundamentally, zoning approvals and permits are permanent and run with the land. A solar power project could be a temporary land use decommissioned at the end of the solar project's life, or it could be repowered through maintenance and installation of new technology. Generally, maintenance of real property is allowed within the terms of a zoning permit. What constitutes system maintenance versus work that triggers a new permit might vary from community to community. Advances in technology will certainly create circumstances in which the SES owner will be compelled to replace equipment in order to continue to efficiently produce electricity relative to project costs. Therefore, the zoning ordinance should specify if repowering triggers a review. A municipal attorney with experience in planning and zoning can help define a process to repower an SES to extend the life of the project. [End of commentary]

MICHIGAN EXAMPLE: Gaines Charter Township requires the following of a decommissioning plan:

"**Decommissioning:** A decommissioning plan signed by the responsible party and the landowner (if different) addressing the following shall be submitted prior to approval:

1. Defined conditions upon which decommissioning will be initiated (i.e. end of land lease, no power production for 12 months, abandonment, etc.)
2. Removal of all non-utility owned equipment, conduit, structures, fencing, roads, solar panels, and foundations.
3. Restoration of property to condition prior to development of the system.
4. The timeframe for completion of decommissioning activities.
5. Description of any agreement (e.g. lease) with landowner regarding decommissioning, if applicable.
6. The entity or individual responsible for decommissioning.
7. Plans for updating the decommissioning plan.
8. A performance guarantee shall be posted in the form of a bond, letter of credit, cash, or other form acceptable to the township to ensure removal upon abandonment. As a part of the decommissioning plan, the responsible party shall provide at least two (2) cost estimates from qualified contractors for full removal of the equipment, foundations, and structures associated with the facility. These amounts will assist the township when setting the performance guarantee valid throughout the lifetime of the facility. Bonds and letters of credit shall be extended on a bi-annual basis from the date of special use permit approval."

– *Gaines Charter Township Zoning Ordinance (Kent Co.), Section 4.18 [End of example]*

SAMPLE ZONING FOR SOLAR ENERGY SYSTEMS

The proposed sample zoning language is meant to be a starting point for dialogue between officials, staff, and residents before or during a zoning amendment process related to SES. Communities can (and should) work with their municipal attorney and a knowledgeable planner to modify the proposed sample zoning language in this document to further refine and develop regulations that fit identified community goals and are tied to master plan objectives, upon which zoning must be based.[61]

DEFINITIONS

Add to the Definitions article of the ordinance the following terms and definitions, or modify existing related definitions for consistency. Not all ordinances will require all of the following terms. Municipalities should tailor definitions to terms used in their ordinance.

Accessory Ground-Mounted Solar Energy System: A ground-mounted solar energy system with the purpose primarily of generating electricity for the principal use on the site.

Building-Integrated Solar Energy System: A solar energy system that is an integral part of a primary or accessory building or structure (rather than a separate mechanical device), replacing or substituting for an architectural or structural component of the building or structure. Building-integrated systems include, but are not limited to, photovoltaic or hot water solar energy systems that are contained within roofing materials, windows, skylights, and awnings.

Dual Use: A solar energy system that employs one or more of the following land management and conservation practices throughout the project site:

- Pollinator Habitat: Solar sites designed to meet a score of 76 or more on the Michigan Pollinator Habitat Planning Scorecard for Solar Sites.[62]
- Conservation Cover: Solar sites designed in consultation with conservation organizations that focus on restoring native plants, grasses, and prairie with the aim of protecting specific species (e.g., bird habitat) or providing specific ecosystem services (e.g., carbon sequestration, soil health).
- Forage: Solar sites that incorporate rotational livestock grazing and forage production as part of an overall vegetative maintenance plan.
- Agrivoltaics: Solar sites that combine raising crops for food, fiber, or fuel, and generating electricity within the project area to maximize land use.

Ground-Mounted Solar Energy System: A solar energy system mounted on support posts, like a rack or pole, that are attached to or rest on the ground.

Invasive Plant: Non-native (or alien) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health.[63]

Maximum Tilt: The maximum angle of a solar array (i.e., most vertical position) for capturing solar radiation as compared to the horizon line.

61 MCL 125.3203(1) of the Michigan Zoning Enabling Act, PA 110 of 2006, as amended.

62 Michigan State University Department of Entomology. Michigan Pollinator Habitat Planning Scorecard for Solar Sites. https://www.canr.msu.edu/home_gardening/uploads/files/MSU_Solar_Pollinators_Scorecard_2018_October.pdf

63 USDA U.S. Forest Service. What is an Invasive Plant Species. https://www.fs.fed.us/wildflowers/invasives/index.shtml

Minimum Tilt: The minimal angle of a solar array (i.e., most horizontal position) for capturing solar radiation as compared to the horizon line.

Non-Participating Lot(s): One or more lots for which there is not a signed lease or easement for development of a principal-use SES associated with the applicant project.

Participating Lot(s): One or more lots under a signed lease or easement for development of a principal-use SES associated with the applicant project.

Photovoltaic (PV) System: A semiconductor material that generates electricity from sunlight.

Principal-Use Solar Energy System: A commercial, ground-mounted solar energy system that converts sunlight into electricity for the primary purpose of off-site use through the electrical grid or export to the wholesale market.

Principal-Use (Large) Solar Energy System: A Principal-Use SES generating more than ___ [e.g., 2] MW DC for the primary purpose of off-site use through the electrical grid or export to the wholesale market [see discussion in "Land-Use Considerations" on why this number is suggested, and why it might warrant tailoring to your community's land-use typologies].

Principal-Use (Small) Solar Energy System: A Principal-Use SES generating up to and including ___ [e.g., 2] MW DC for the primary purpose of off-site use through the electrical grid or export to the wholesale market.

Repowering: Reconfiguring, renovating, or replacing an SES to maintain or increase the power rating of the SES within the existing project footprint.

Roof-Mounted Solar Energy System: A solar energy system mounted on racking that is attached to or ballasted on the roof of a building or structure.

Solar Array: A photovoltaic panel, solar thermal collector, or collection of panels or collectors in a solar energy system that collects solar radiation.

Solar Carport: A solar energy system of any size that is installed on a structure that is accessory to a parking area, and which may include electric vehicle supply equipment or energy storage facilities. Solar panels affixed on the roof of an existing carport structure are considered a Roof-Mounted SES.

Solar Energy System (SES): A photovoltaic system or solar thermal system for generating and/or storing electricity or heat, including all above and below ground equipment or components required for the system to operate properly and to be secured to a roof surface or the ground. This includes any necessary operations and maintenance building(s), but does not include any temporary construction offices, substation(s) or other transmission facilities between the SES and the point of interconnection to the electric grid.

Solar Thermal System: A system of equipment that converts sunlight into heat.

Wildlife-Friendly Fencing: A fencing system with openings that allow wildlife to traverse over or through a fenced area.

GENERAL PROVISIONS

Add to the General Provisions article of the ordinance, as a separate section, the following provisions for Roof-Mounted SES, Accessory Ground-Mounted SES, and Building-Integrated SES as permitted by right in all districts and do not require a special use permit.

Roof-Mounted SES, Accessory Ground-Mounted SES, and Building-Integrated SES are permitted in all zoning districts where structures of any sort are allowed, and shall meet the following requirements:

A. ROOF-MOUNTED SES

1. **Height:** Roof-Mounted SES shall not exceed __ [e.g. 5-10] feet above the finished roof and are exempt from any rooftop equipment or mechanical system screening.
2. **Nonconformities:** A Roof-Mounted SES or Building-Integrated SES installed on a nonconforming building, structure, or use shall not be considered an expansion of the nonconformity.
3. **Application:** All SES applications must include ___ plan [e.g., plot or site, whichever is required for a zoning compliance review]. Applications for Roof-Mounted SES must include horizontal and vertical elevation drawings that show the location and height of the SES on the building and dimensions of the SES.

MICHIGAN EXAMPLES:

"**Solar Energy System:** An aggregation of parts including any base, mounts, tower, solar collectors, and accessory equipment such as utility interconnections and solar storage batteries, etc., in such configuration as necessary to convert solar radiation into thermal, chemical or electrical energy."

– *Royal Oak Zoning Ordinance (Oakland Co.), Section 770-8*

"**Solar Energy System (SES):** A system consisting of a device or combination of devices, structures or parts thereof, that collect, transfer or transform solar radiant energy into thermal, chemical or electrical energy. An SES may be mounted on a roof (roof-mounted SES) or be supported by posts or other support structures extending into the ground (ground-mounted SES)."

– *Greater Thompsonville Area Zoning Ordinance (Benzie Co.), Section 18.23*

"**Solar Energy System:** A passive design using natural and architectural components to collect and store solar energy without using any external mechanical power or an active mechanical assembly that may include a solar collector, storage facility, and any other components needed to transform solar energy for thermal, chemical, or electrical energy. Examples include a solar greenhouse, solar panels, solar hot water heater, photovoltaic panels, passive solar panels, and a large, clear south-facing expanse of windows."

– *Bessemer Township Zoning Ordinance (Gogebic Co.), Section 15.22 [End of examples]*

COMMENTARY: Because of concerns over wind load, most roof-mounted systems are not the same dimensions as ground-mounted SES. Given current SES design considerations, 10 feet is sufficient to accommodate most roof-mounted systems.

If a zoning ordinance has height exceptions for other mechanical equipment, it might alternatively just include roof-mounted SES in this exception. In addition to listing this in the section of your ordinance with those exceptions, you could also use the following language in this section of the solar provisions:

A Roof-Mounted SES, other than building-integrated systems, shall be given an equivalent exception to height standards as building- or roof-mounted mechanical devices, chimneys, antennae, or similar equipment, as specified in Section __ [height exceptions] of the ___ [municipality name] Zoning Ordinance. [End of commentary]

Ground-mounted SES feedlot. Photo by M.Charles Gould.

B. ACCESSORY GROUND-MOUNTED SES

1. **Height:** Ground-Mounted SES shall not exceed __ [e.g. 20] feet measured from the ground to the top of the system when oriented at maximum tilt.

COMMENTARY: Height of a Ground-Mounted SES can vary from four to 15 feet, depending on how many rows of panels are installed and the maximum tilt height, if applicable. If the SES is co-located with an active agricultural operation, such as livestock grazing and crop production, it may need as much as eight feet of clearance, which can increase the overall height to up to roughly 20 feet. Similarly, a solar carport would need additional clearance to accommodate vehicle access. The carports at Michigan State University are 14'6" to accommodate snow removal and paving trucks. A relatively straightforward way to regulate the height of SES and account for this range of applications is to apply the same height standard as other accessory buildings or structures within the zoning district. [End of commentary]

2. **Setbacks:** A Ground-Mounted SES must be a minimum of __ [e.g., 5] feet from the property line or __ [e.g., ½] the required setback that would apply to accessory structures in the side or rear yard in the respective zoning district, whichever is greater. Setback distance is measured from the property line to the closest point of the SES at minimum tilt.
3. **Lot Coverage:** The area of the solar array shall not exceed __ [e.g., 50] % of the square footage of the primary building of the property unless it is sited over required parking (i.e. solar carport), in which case there is no maximum lot coverage for the Ground-Mounted SES. A Ground-Mounted SES shall not count towards the maximum number or square footage of accessory structures allowed on site or maximum impervious surface area limits if the ground under the array is pervious.

4. **Visibility** (Residential)**:** A Ground-Mounted SES in residential districts [list districts here] shall be located in the side or rear yard to minimize visual impacts from the public right-of-way(s).
    a. Ground-Mounted SES may be placed in the front yard with administrative approval, where the applicant can demonstrate that placement of the SES in the rear or side yard will:
        i. Decrease the efficiency of the SES due to topography, accessory structures, or vegetative shading from the subject lot or adjoining lots;
        ii. Interfere with septic system, accessory structures, or accessory uses; or
        iii. Require the SES to be placed on the waterfront side of the building housing the primary use [where applicable].

MICHIGAN EXAMPLES: Some communities apply screening standards to Accessory Ground-Mounted SES. Here is an example:

Ground Mounted SES shall be reasonably screened from the view of the surrounding streets and roads to the maximum extent practicable by garden walls, fences, hedges, landscaping, earth berms, or other means, except to the extent that such screening is either impracticable or would result in ineffective solar access on the lot in question. Ground Mounted SES that are visible from a road or adjacent properties shall, to the maximum extent feasible, and without compromising the ability to effectively use solar collectors on the lot in question, use materials, textures, screening, and landscaping that will screen the Ground Mounted SES from view, and blend with the natural setting, existing environment, and neighborhood character. All Ground Mounted SES that rely on landscaping or a vegetative buffer for screening shall maintain a minimum opacity of at least eighty percent (80%), and a mature height of not less than the greater of (x) six (6) feet or (y) sixty percent (60%) of the height of the Ground Mounted Solar Energy System when oriented to maximum tilt.

– *Webster Township Zoning Ordinance (Washtenaw Co.), Section 12.110 [End of example]*

5. **Exemptions:** A SES used to power a single device or specific piece of equipment such as a lawn ornament, lights, weather station, thermometer, clock, well pump or other similar singular device is exempt from Section ____ [Ground-Mounted SES provisions].
6. **Nonconformities:** A Ground-Mounted SES installed on a nonconforming lot or use shall not be considered an expansion of the nonconformity.
7. **Application:** All SES applications must include a ___ plan [e.g., plot or site, whichever is required for a zoning compliance review]. Applications for Ground-Mounted SES must include drawings that show the location of the system on the property, height, tilt features (if applicable), the primary structure, accessory structures, and setbacks to property lines. Accessory use applications that meet the ordinance requirements shall be granted administrative approval.

Off-grid device power. Photo by Bradley Neumann

Dual-use ground-mounted SES and blueberry farm. Photo by Mary Reilly.

MICHIGAN EXAMPLES: Many Michigan communities with both small-scale and large-scale solar regulations have zoned on-site solar energy systems as accessory uses. The City of Bay City (Bay Co.), Lyon Charter Township (Oakland Co.), and Almont Township (Lapeer Co.) all permit roof-mounted systems as an accessory use in all districts. Van Buren Charter Township (Wayne Co.), Albert Township (Montmorency Co.), and Chester Township (Ottawa Co.) all expand this provision (e.g. permitting roof-mounted systems as an accessory use in all districts) by permitting both on-site roof-mounted and ground-mounted systems in all districts as an accessory use. [End of example]

C. BUILDING-INTEGRATED SES

1. Building-Integrated SES are subject only to zoning regulations applicable to the structure or building and not subject to accessory ground or roof-mounted SES permits.

In addition to the General Provisions (above), also add the following standards for Small Principal-Use SES to the General Provisions article of the zoning ordinance. Also add 'Small Principal-Use SES' to the list of permitted uses in all zoning districts (or where desired). A community will need to decide whether a Small Principal-Use SES application is reviewed solely by the zoning administrator, reviewed and approved by the planning commission, or a hybrid, wherein the zoning administrator has the option to review/approve or advance the application to the planning commission for review/approval.

D. SMALL PRINCIPAL-USE SES: A Small Principal-Use SES is a permitted use in ____ [e.g., all, non-residential] zoning districts subject to site plan review and shall meet all of the following requirements:

1. **Height:** Total height shall not exceed __ [e.g. 20] feet measured from the ground to the top of the system when oriented at maximum tilt.
2. **Setbacks:** Setback distance shall be measured from the property line or road right-of-way to the closest point of the solar array at minimum tilt or any SES components and as follows:
   a. A Ground-Mounted SES shall follow the setback distance for primary buildings or structures for the district in which it is sited.
   b. A Ground-Mounted SES is not subject to property line setbacks for common property lines of two or more participating lots, except road right-of-way setbacks shall apply.
3. **Fencing:** A Small Principal-Use SES may [shall] be secured with perimeter fencing to restrict unauthorized access. If installed, perimeter fencing shall be a maximum of __ [e.g. something greater than or equal to 7] feet in height.____ [Barbed wire is prohibited.] Fencing is not subject to setbacks.

Ground-mounted SES in rural setting. Photo by Bradley Neumann.

COMMENTARY: Principal-Use SES may be subject to regulations, such as those of the National Electrical Code (NEC), that require a perimeter fence. The current NEC standards call for a 6-foot fence with three lines of barbed wire, or a 7-foot fence with no barbed wire. A community could ban the use of barbed wire at an SES and still allow for compliance with the NEC, so long as the fencing is allowed to be at least 7 feet. If an SES is not subject to the NEC, wildlife-friendly fencing, commonly made of smooth wiring to prevent injury with openings that allow wildlife to move through, should be used where appropriate. A community may choose to be less prescriptive in fencing requirements so long as the requirements do not conflict with NEC requirements (e.g. by limiting fence height to 5 feet). [End of commentary]

4. **Screening/Landscaping:** A Small Principal-Use SES shall be designed to follow the screening and/or landscaping standards for the zoning district of the project site. Any required screening and landscaping shall be placed outside the perimeter fencing.
    a. In districts that call for screening or landscaping along rear or side property lines, these shall only be required where an adjoining non-participating lot has an existing residential or public use.
    b. When current zoning district screening and landscaping standards are determined to be inadequate based on a legitimate community purpose consistent with local government planning documents, the Zoning Administrator [or Planning Commission] may require substitute screening consisting of native deciduous trees planted __ [e.g. 30] feet on center, and native evergreen trees planted __ [e.g. 15] feet on center along existing non-participating residential uses.
    c. The Zoning Administrator [or Planning Commission] may reduce or waive screening requirements provided that any such adjustment is in keeping with the intent of the Ordinance and is appropriately documented (e.g. abutting participating lots; existing vegetation).
    d. Screening/landscaping detail shall be submitted as part of the site plan that identifies the type and extent of screening for a Small Principal-Use SES, which may include plantings, strategic use of berms, and/or fencing.
5. **Ground Cover:** A Small Principal-Use SES shall include the installation of perennial ground cover vegetation maintained for the duration of operation until the site is decommissioned. The applicant shall include a ground cover vegetation establishment and management plan as part of the site plan.

a. An SES utilizing agrivoltaics is exempt from perennial ground cover requirements for the portion of the site employing the dual-use practice.

b. Project sites with majority existing impervious surface or those that are included in a brownfield plan adopted under the Brownfield Redevelopment Financing Act, PA 381 of 1996, as amended, are exempt from ground cover requirements. These sites must comply with the on-site stormwater requirements of the ordinance.

6. **Lot Coverage:** A Small Principal-Use SES shall not count towards the maximum lot coverage or impervious surface standards for the district.

COMMENTARY: One of the reasons to exempt large and small principle-use SES from maximum lot coverage or impervious surface standards is because there are practical challenges to measuring the overall footprint of principal-use systems, since they may include tilting panels and access drives. Communities who choose not to include this exemption must decide which elements of an SES count/do not count toward lot coverage and make clear how lot coverage should be calculated for co-located systems. If the community's intent is to minimize a development's impervious surface area, consider using the ground cover provisions within this sample language instead. They serve the same purpose and avoid unnecessary limitations and ambiguities. [End of commentary]

7. **Land Clearing:** Land disturbance or clearing shall be limited to what is minimally necessary for the installation and operation of the system and to ensure sufficient all-season access to the solar resource given the topography of the land. Topsoil distributed during site preparation (grading) on the property shall be retained on site.

8. **Access Drives:** New access drives within the SES shall be designed to minimize the extent of soil disturbance, water runoff, and soil compaction on the premises. The use of geotextile fabrics and gravel placed on the surface of the existing soil for temporary roadways during the construction of the SES is permitted, provided that the geotextile fabrics and gravel are removed once the SES is in operation.

9. **Wiring:** SES wiring (including communication lines) may be buried underground. Any above-ground wiring within the footprint of the SES shall not exceed the height of the solar array at maximum tilt.

10. **Lighting:** Lighting shall be limited to inverter and/or substation locations only. Light fixtures shall have downlit shielding and be placed to keep light on-site and glare away from adjacent properties, bodies of water, and adjacent roadways. Flashing or intermittent lights are prohibited.

11. **Signage:** An area up to ___ square feet [should be consistent with the district or sign type standard] may be used for signage at the project site. Any signage shall meet the setback, illumination, and materials/construction requirements of the zoning district for the project site.

12. **Sound:** The sound pressure level of a Small Principal-Use SES and all ancillary solar equipment shall not exceed __ [e.g. 45] dBA (Leq (1-hour)) at the property line of an adjoining non-participating lot. The site plan shall include modeled sound isolines extending from the sound source to the property lines to demonstrate compliance with this standard.

13. **Repowering:** In addition to repairing or replacing SES components to maintain the system, a Small Principal-Use SES may at any time be repowered by reconfiguring, renovating, or replacing the SES to increase the power rating within the existing project footprint.

a. A proposal to change the project footprint of an existing SES shall be considered a new application, subject to the ordinance standards at the time of the request.

COMMENTARY: The goal of the above sample sound regulation for both small and large principal-use SES is to determine compliance with the sound standard during site plan review, as opposed to long-term monitoring or enforcement by staff. Predicting noise levels and mitigating through site design is more efficient and cost-effective than mitigating an issue after the project is complete. During the site plan phase, applicants have more options to reduce noise impacts on adjoining property owners, such as by placing inverters closer to the center of the project or covering axis motors. Sound isolines on a site plan would show predicted sound levels, typically in 5 decibel increments, starting at the sound source and extending to or beyond the property line. Sound isolines are similar to contour lines on a topographical map and provide helpful information to the approving body and adjoining property owners. [End of commentary]

14. **Decommissioning:** Upon application, a decommissioning plan shall be submitted indicating the anticipated manner in which the project will be decommissioned, including a description of which above-grade and below-grade improvements will be removed, retained (e.g. access drive, fencing), or restored for viable reuse of the property consistent with the zoning district.
    a. An SES owner may at any time:
        i. Proceed with the decommissioning plan approved by the Zoning Administrator [or Planning Commission] under Section ___ [of local government ordinance] and remove the system as indicated in the most recent approved plan; or
        ii. Amend the decommissioning plan with Zoning Administrator [or Planning Commission] approval and proceed according to the revised plan.
    b. Decommissioning an SES must commence when the soil is dry to prevent soil compaction[64] and must be complete within __ [e.g., 18 months] after abandonment. An SES that has not produced electrical energy for __ [e.g., 12] consecutive months shall prompt an abandonment hearing.

64 The "ribbon test" is a simple in-field test that can be used to make a rough determination if the soil is too wet to work without a high risk of compaction. Conducting the ribbon test involves digging down four inches into the soil, grasping a handful of soil, and squeezing it tightly in your hand. If the soil forms a "ribbon" when squeezed between the thumb and forefinger, it is in a condition for compaction to occur. See Iowa State University Extension & Outreach article Soil compaction may be cutting into your yield (https://crops.extension.iastate.edu/encyclopedia/soil-compaction-may-be-cutting-your-yield) and Colorado State University Cooperative Extension Bulletin Estimating Soil Texture: Sandy, Loamy or Clayey? (https://culter.colorado.edu/~kittel/SoilChar(&RibbonTest)_handout.pdf).

SPECIAL LAND-USE STANDARDS

Add to the Special Land Uses article of the ordinance, as a separate section, the following provisions for large principal-use SES. Also add 'large principal-use SES' to the list of special land uses in the zoning districts where appropriate. See discussion on the Rural-to-Urban Transect above.

A. LARGE PRINCIPAL-USE SES: A large principal-use SES is a special land use in the zoning districts specified and shall meet the following requirements:

1. **Height:** Total height for a large principal-use SES shall not exceed the maximum allowed height in the district in which the system is located [or a lesser height, such as __ [e.g., 20] feet].
2. **Setbacks:** Setback distance shall be measured from the property line or road right-of-way to the closest point of the solar array at minimum tilt or any SES components and as follows:
   a. In accordance with the setbacks for principal buildings or structures for the zoning district of the project site [or __ [e.g. 50] feet from the property line of a non-participating lot].
   b. __ [e.g., 100] feet from any existing dwelling unit on a non-participating lot.
   c. A Ground-Mounted SES is not subject to property line setbacks for common property lines of two or more participating lots, except road right-of-way setbacks shall apply.
3. **Fencing:** A large principal-use SES may [shall] be secured with perimeter fencing to restrict unauthorized access. If installed, perimeter fencing shall be a maximum of __ [e.g. something greater than or equal to 7] feet in height. [Barbed wire is prohibited.] Fencing is not subject to setbacks.
4. **Screening/Landscaping:** A large principal-use SES shall follow the screening and/or landscaping standards for the zoning district of the project site. Any required screening and landscaping shall be placed outside the perimeter fencing.
   a. In districts that call for screening or landscaping along rear or side property lines, these shall only be required where an adjoining non-participating lot has an existing residential or public use.

Lapeer Solar Park. Photo by Bradley Neumann.

b. When current zoning district screening and landscaping standards are determined to be inadequate based on a legitimate community purpose consistent with local government planning documents, the Planning Commission may require substitute screening consisting of native deciduous trees planted __ [e.g. 30] feet on center, and native evergreen trees planted __ [e.g. 15] feet on center along existing non-participating residential uses.

c. The Planning Commission may reduce or waive screening requirements provided that any such adjustment is in keeping with the intent of the Ordinance.

d. Screening/landscaping detail shall be submitted as part of the site plan that identifies the type and extent of screening for a large principal-use SES, which may include plantings, strategic use of berms, and/or fencing.

COMMENTARY: Zoning requirements may impact the ability for the land to be returned to its original use. For example, required berming, substantial vegetative screening, or on-site stormwater detention/retention (which may be regulated by the Drain Commissioner, for example) may need to be removed or altered in order to return the land to its previous use. In considering whether to reduce, waive, or expand vegetation and screening standards, communities should take landowner considerations relating to reuse into account. [End of commentary]

5. **Ground Cover:** A large principal-use SES shall include the installation of ground cover vegetation maintained for the duration of operation until the site is decommissioned. The applicant shall include a ground cover vegetation establishment and management plan as part of the site plan. Vegetation establishment must include invasive plant species [and noxious weed, if local regulation applies] control. The following standards apply:

   a. Sites bound by a Farmland Development Rights (PA 116) Agreement must follow the Michigan Department of Agriculture and Rural Development's Policy for Allowing Commercial Solar Panel Development on PA 116 Lands.

   b. Ground cover at sites not enrolled in PA 116 must meet one or more of the four types of Dual Use defined in this ordinance.

      i. Pollinator Habitat: Solar sites designed to meet a score of 76 or more on the Michigan Pollinator Habitat Planning Scorecard for Solar Sites.

      ii. Conservation Cover: Solar sites designed in consultation with conservation organizations that focus on restoring native plants, grasses, and prairie with the aim of protecting specific species (e.g., bird habitat) or providing specific ecosystem services (e.g., carbon sequestration, soil health).

      iii. Forage: Solar sites that incorporate rotational livestock grazing and forage production as part of an overall vegetative maintenance plan.

      iv. Agrivoltaics: Solar sites that combine raising crops for food, fiber, or fuel, and generating electricity within the project area to maximize land use.Project sites that are included in a brownfield plan adopted under the Brownfield Redevelopment Financing Act, PA 381 of 1996, as amended, that contain impervious surface at the time of construction or soils that cannot be disturbed, are exempt from ground cover requirements

   c. Project sites that are included in a brownfield plan adopted under the Brownfield Redevelopment Financing Act, PA 381 of 1996, as amended, that contain impervious surface at the time of construction or soils that cannot be disturbed, are exempt from ground cover requirements.

COMMENTARY: The Michigan Department of Agriculture and Rural Development policy for allowing commercial solar energy development on PA 116 lands requires that any portion of the site not included in pollinator plantings must maintain U.S. Department of Agriculture, Natural Resources Conservation Service Conservation Cover Standard 327. Standard 327 reduces erosion, enhances wildlife, pollinator, and beneficial organism habitat, and improves soil health. Standard 327 can be implemented to support grazing animals with the right mix of forage crops. However, if grazing is the primary forage management practice, Prescribed Grazing Standard 528 may be a more useful standard to follow. Standard 528, however, does not apply to solar projects on land enrolled in PA 116 because the policy specifically recommends using Standard 327. There is flexibility within each standard to develop site-specific seed mixes. Private consultants as well as local NRCS staff can help develop a plan to implement these standards in a solar project. [End of commentary]

COMMENTARY: As discussed on Page 15, if a community's existing master plan and ordinance include farmland preservation provisions, it may make sense to extend them to large principal-use SES. In that case, signal your community's desire for development that minimizes impacts to locally important soil classifications through language such as:

Agricultural Protection: For sites where agriculture is a permitted use in a district, a large principal-use SES may be sited to minimize impacts to agricultural production through site design and accommodations including [select those most applicable to your community]:

a. The ground mounting of panels by screw, piling, or a similar system that does not require a footing, concrete, or other permanent mounting in order to minimize soil compaction, [and/or]
b. Siting panels to avoid disturbance and compaction of farmland by siting panels along field edges and in nonproduction areas to the maximum extent practicable and financially feasible, [and/or]
c. Maintaining all drainage infrastructure on site, including drain tile and ditches, during the operation of the SES, [and/or]
d. Siting the SES to avoid isolating areas of the farm operation such that they are no longer viable or efficient for agricultural production, including, but not limited to, restricting the movement of agricultural vehicles/equipment for planting, cultivation, and harvesting of crops, and creating negative impacts on support infrastructure such as irrigation systems or drains, or
e. Voluntarily purchasing agricultural conservation easements from an equivalent number of prime farmland acres consistent with a purchase of development rights ordinance adopted under state law in ____ [local unit of government].

The above list is presented as a menu of sample standards and is neither a comprehensive list nor intended to be adopted in its entirety or verbatim. A local government that wishes to protect agricultural land from future development should work with a qualified planner and attorney to develop a comprehensive approach in the master plan and zoning ordinance that addresses threats to farmland from all types of development pressure. [End of commentary]

Aerial view of Tecumseh solar farm. Photo by Harvest Solar.

MICHIGAN EXAMPLES: Communities in Michigan have differing approaches to the compatibility of solar energy and agriculture. Here are some examples:

"Solar energy equipment shall only be located in an area determined to be "not prime farmland" by the U.S. Department of Agriculture (USDA), per the USDA's Farmland Classification Map as of the date of Special Use Application for a Utility-Scale Solar Energy Collector System."

– *Chester Township Zoning Ordinance (Ottawa Co.), Section 1912*

"All solar arrays greater than ten (10) acres in area must include one or more of the following amongst the panels of the solar array: Crop cultivation; Livestock grazing, with the panels raised to allow an eight (8) foot clearance for animals to pass underneath; or Pollinator fields, including milkweed and other native plantings."

– *Grand Haven Charter Township Zoning Ordinance 2020 (Ottawa Co.), Section 3.03*

"Solar energy systems in Oliver Township are considered a compatible use in the Agricultural Preservation District. The siting of a ground mounted solar energy system is permitted in the Agricultural Preservation District (Chapter 5) and must conform to the front, rear, and side yard setback requirements described in Section 504."

– *Oliver Township Zoning Ordinance (Huron Co.), Section 1305 [End of example]*

COMMENTARY: Some communities require a performance guarantee for small and large principal-use SES for the cost of grading and on-site ground cover establishment in the form of a bond, letter of credit, or establishment of an escrow account. The rationale is that if a site is cleared of vegetation and graded, but the project is not completed, there is a financial guarantee that the site will be stabilized. Such a provision may be redundant with Soil Erosion and Sedimentation Control (SESC) bonding requirements for projects larger than one acre, or for land enrolled in the Michigan Department of Agriculture of Rural Development's (MDARD) PA 116 Farmland and Open Space Preservation Program.

Regarding decommissioning guarantees, MDARD, as mentioned above, requires a surety bond or irrevocable letter of credit for solar development on PA 116 land to cover the cost of the removal of the solar facility and the restoration of the land to agricultural use. A community may wish to tailor the sample standard below based on this requirement by MDARD or provide an exception from the local government decommissioning guarantee for land enrolled in PA 116.

A periodic review (such as every 3-5 years) of the decommissioning guarantee will ensure adequate funds are available to cover decommissioning costs 20-30 years down the road. A review might also be triggered if there is a change of ownership. The ordinance should specify which body is responsible for approving the amount of the performance guarantee; the planning commission could recommend an amount, but the legislative body should make the final decision. When considering this language, a community could review how performance guarantees are handled for other types of developments, such as landscaping guarantees, and discuss how this could be the same or different. The amount of the guarantee for an SES may prompt a different level of review. [End of commentary]

6. **Lot Coverage:** A large principal-use SES shall not count towards the maximum lot coverage or impervious surface standards for the district.
7. **Land Clearing:** Land disturbance or clearing shall be limited to what is minimally necessary for the installation and operation of the system and to ensure sufficient all-season access to the solar resource given the topography of the land. Topsoil distributed during site preparation (grading) on the property shall be retained on site.
8. **Access Drives:** New access drives within the SES shall be designed to minimize the extent of soil disturbance, water runoff, and soil compaction on the premises. The use of geotextile fabrics and gravel placed on the surface of the existing soil for the construction of temporary drives during the construction of the SES is permitted, provided that the geotextile fabrics and gravel are removed once the SES is in operation.
9. **Wiring:** SES wiring (including communication lines) may be buried underground. Any above-ground wiring within the footprint of the SES shall not exceed the height of the solar array at maximum tilt.
10. **Lighting:** Large principal-use SES lighting shall be limited to inverter and/or substation locations only. Light fixtures shall have downlit shielding and be placed to keep light on-site and glare away from adjacent properties, bodies of water, and adjacent roadways. Flashing or intermittent lights are prohibited.
11. **Signage:** An area up to ___ square feet [should be consistent with the district or sign type standard] may be used for signage at the project site. Any signage shall meet the setback, illumination, and materials/construction requirements of the zoning district for the project site.
12. **Sound:** The sound pressure level of a large principal-use SES and all ancillary solar equipment shall not exceed __ [e.g. 45] dBA (Leq (1-hour)) at the property line of an adjoining non-participating lot. The site plan shall include modeled sound isolines extending from the sound source to the property lines to demonstrate compliance with this standard.

13. **Repowering:** In addition to repairing or replacing SES components to maintain the system, a large principal-use SES may at any time be repowered, without the need to apply for a new special land-use permit, by reconfiguring, renovating, or replacing the SES to increase the power rating within the existing project footprint.
    a. A proposal to change the project footprint of an existing SES shall be considered a new application, subject to the ordinance standards at the time of the request. [Expenses for legal services and other studies resulting from an application to modify an SES will be reimbursed to the ____ [local unit of government] by the SES owner in compliance with established escrow policy.]

COMMENTARY: A fundamental zoning concept is that a zoning ordinance must allow for nonconformities—that is, the continuation of a land use or structure that was legally established before a change in zoning that no longer permits the use or structure location. Zoning ordinances have standards for replacement, reconstruction, and expansion of nonconformities. For example, the decision could be centered around the replacement components' monetary value—a new investment of 50% or more of the value of the project is a typical threshold for nonconformities. The zoning board of appeals or the planning commission, whichever is charged with making decisions on nonconformities, would decide the fate of the project based on the nonconforming standards in the ordinance, rather than following the original special land-use permit review process. A proposal to expand the footprint of the system could be at odds with ordinance rules for enlarging nonconformities. In that case, the ordinance may dictate that the proposal must be scaled back to meet the rules for replacing nonconformities, otherwise decommissioning may be the only option. If decommissioning is not the intended or desired outcome, a community has the option to amend the ordinance to allow for SES again, thereby releasing the project from nonconforming status. Communities should work with a municipal attorney to explore preferred options for the SES and how SES will be treated under an application to repower the system. [End of commentary]

14. **Decommissioning:** A decommissioning plan is required at the time of application.
    a. The decommission plan shall include:
        i. The anticipated manner in which the project will be decommissioned, including a description of which above-grade and below-grade improvements will be removed, retained (e.g. access drive, fencing), or restored for viable reuse of the property consistent with the zoning district,
        ii. The projected decommissioning costs for removal of the SES (net of salvage value in current dollars) and soil stabilization, less the amount of the surety bond posted with the State of Michigan for decommissioning of panels installed on PA 116 lands,
        iii. The method of ensuring that funds will be available for site decommissioning and stabilization (in the form of surety bond, irrevocable letter of credit, or cash deposit), and
    b. A review of the amount of the performance guarantee based on inflation, salvage value, and current removal costs shall be completed every __ [e.g., 3 or 5] years, for the life of the project, and approved by the _____ [legislative body] board. An SES owner may at any time:
        i. Proceed with the decommissioning plan approved by the Zoning Administrator [or Planning Commission] under Section ___ [of local government ordinance] and remove the system as indicated in the most recent approved plan; or
        ii. Amend the decommissioning plan with Zoning Administrator [or Planning Commission] approval and proceed according to the revised plan.
    c. Decommissioning an SES must commence when the soil is dry to prevent soil compaction and must be complete within __ [e.g., 18 months] after abandonment. An SES that has not produced electrical energy for __ [e.g., 12] consecutive months shall prompt an abandonment hearing.

Consumers Energy - Western Michigan University, Business Technology and Research Park solar garden. Photo by Mary Reilly.

SITE PLAN REVIEW

Add to the Site Plan Review article of the zoning ordinance, as a separate section (or to the section of the ordinance with site plan requirements), the following provisions for Principal-Use SES. Consider using the following checklist to determine if the application is complete. In this sample, a large principal-use SES is proposed to be reviewed as special land use. A Small Principal-Use SES is proposed to be reviewed as a permitted use with a required site plan. When reviewing a Small Principal-Use SES, a community will need to choose one of the following approaches:

- **Administrative:** *The Zoning Administrator reviews and approves or denies a Small Principal-Use SES when following the site plan review requirements below.*
- **Administrative/Planning Commission:** *The Zoning Administrator could perform site plan review with the option to send the application to the Planning Commission for site plan review. This option could be utilized to provide greater public input and shared responsibility, such as for a high-interest or high-visibility application.*

Site Plans and supporting application materials for a Principal-Use SES shall include a detailed site plan including all applicable requirements found in Article XX, Section XX [the section of the ordinance with general site plan standards] of this ordinance, except that site plans for large principal-use SES shall be submitted at a scale of 1" = ___ [e.g., 200] feet, plus the following site plan requirements:

SITE PLAN REQUIREMENT (X = Required, NA = Not Applicable)	Small Principal-Use	Large Principal-Use
The location of all solar arrays, including setbacks, the width of arrays and distance between arrays plus total height and height to the lowest edge above grade, ancillary structures and electric equipment, utility connections, and dwellings on the property and within __ [e.g. 150] feet of the property lines, participating and non-participating lots, existing and proposed structures, buried or above ground wiring, temporary and permanent access drives, fencing detail, screening/landscape detail, berm detail, and signs.	X	X
Plans for land clearing and/or grading required for the installation and operation of the system, and plans for ground cover establishment and management.	X	X
Sound modeling study including sound isolines extending from the sound source(s) to the property lines of adjoining non-participating lots.	X	X
A Decommissioning Plan as applicable: • For a Small Principal-Use SES, a decommissioning plan including a description of which above-grade and below-grade improvements will be removed, retained, or restored for viable reuse of the property consistent with the zoning district.	X	N/A
• For a large principal-use SES, 1) a decommissioning plan including a description of which above-grade and below-grade improvements will be removed, retained, or restored for viable reuse of the property consistent with the zoning district, 2) the projected decommissioning costs for SES removal (net of salvage value in current dollars) and soil stabilization, less the amount of the surety bond posted with the State of Michigan for decommissioning of panels installed on PA 116 lands, and 3) the method of ensuring that funds will be available for site decommissioning and stabilization (in the form of surety bond, irrevocable letter of credit, cash deposit).	N/A	X
The location of prime farmland [and/or farmland of statewide importance, farmland of local importance, unique farmland, and prime farmland if drained] as defined in the U.S. Department of Agriculture, Natural Resources Conservation Service - Web Soil Survey.	N/A	X [only if Ag Protection is part of the ordinance]
Completed copy of Michigan Pollinator Habitat Planning Scorecard for Solar Sites (when applicable).	N/A	X

SITE PLAN REQUIREMENT (X = Required, NA = Not Applicable)	Small Principal-Use	Large Principal-Use
Additional studies may be required by the Planning Commission if reasonably related to the standards of this ordinance as applied to the application site, including but not limited to [*select those most applicable to your community; these do not directly link to standards in the sample language, but may be helpful in evaluating conformance with other ordinance standards*]: • Visual Impact Assessment: A technical analysis by a third party qualified professional of the visual impacts of the proposed project, including a description of the project, the existing visual landscape, and important scenic resources, plus visual simulations that show what the project will look like (including proposed landscape and other screening measures) a description of potential project impacts, and mitigation measures that would help to reduce the visual impacts created by the project and documented on the site plan. • Environmental Analysis: An analysis by a third-party qualified professional to identify and assess any potential impacts on the natural environment including, but not limited to wetlands and other fragile ecosystems, wildlife, endangered and threatened species, historical and cultural sites, and antiquities. If required, the analysis shall identify all appropriate measures to minimize, eliminate or mitigate adverse impacts identified and show those measures on the site plan, where applicable. • Stormwater Study: An analysis by a third-party qualified professional that takes into account the proposed layout of the SES and how the spacing, row separation, and slope affects stormwater infiltration, including calculations for a 100-year rain event (storm). Percolation tests or site-specific soil information shall be provided to demonstrate infiltration on-site without the use of engineered solutions. • Glare Study: An analysis by a third-party qualified professional to determine if glare from the SES will be visible from nearby residents and roadways. If required, the analysis shall consider the changing position of the sun throughout the day and year, and its influence on the SES.	N/A	X

Dual-use ground-mounted SES with conservation plantings. Photo by M. Charles Gould.

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