Community Solar Potential Analysis for Lawrence, Massachusetts

Walter Poulsen,[1] River Strong,[2] and Dwayne Breger[2]

[1] *Clark University*
[2] *University of Massachusetts Amherst Clean Energy Extension*

NREL Technical Monitor: Elizabeth Gill

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Subcontract Report
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June 2024

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List of Acronyms

CEE	Clean Energy Extension
UMass	University of Massachusetts Amherst
LSC	Lawrence Stakeholder Coalition
CS	Community Solar
GIS	Geographic Information Systems
NREL	National Renewable Energy Laboratory

Executive Summary

This report was prepared as part of the U.S. Department of Energy's Communities Local Energy Action Program (Communities LEAP) pilot competitive technical assistance for the Lawrence Massachusetts Stakeholder Coalition (LSC). The coalition is composed of The City of Lawrence, All In Energy, MassDevelopment, Mill City Community Investments, BlocPower and Groundwork Lawrence, and led by Browning the Green Space. The LSC identified investigating community solar opportunities as a priority for this technical assistance opportunity.

In accordance with Technical Assistance Area 1 (*Community Solar Analysis*) and in coordination with the Lawrence Stakeholder Coalition (LSC), the UMass Clean Energy Extension (CEE) research team conducted a high-level geographic information system (GIS) evaluation of potential community solar (CS) development sites within Lawrence, and its three bordering towns of Andover, North Andover, and Methuen. A specific 25-acre former landfill site located in Andover was initially identified by the LSC as a potential pilot CS site. Subsequent research revealed that the landfill site was not suitable for solar development at the time of this analysis. CEE subsequently broadened the boundaries of analysis to include the potential for (1) ground-based CS development sites in Lawrence, Methuen, Andover, and North Andover, and (2) building-mounted (i.e., rooftop) and landfill CS development sites in Lawrence.

These analyses considered the following criteria for evaluating potential CS sites:

- Buildings with 5,000 square feet or more of roof space
- Open land parcels of five acres or more
- Distance to likely grid interconnection points of one mile or less
- Available grid hosting capacity (i.e., the ability of proximal grid circuits to accept solar system interconnections)

The resulting analysis revealed that there are 472 potential open parcels of land that fit the above criteria across the four cities. However, it should be noted that not all identified parcels will be suitable for solar installations due to topographical challenges, the presence of existing structures, conservation restrictions, ownership issues, and other factors that could interfere with solar development efforts. The analysis also identified 637 structures with footprints of 5,000 square feet or greater within Lawrence's city limits. Again, it's likely that only a subset of these areas will ultimately have solar development potential.

The LSC expressed an interest in better understanding the potential to utilize rooftops for CS projects within Lawrence city limits. The LSC and the UMass research team collectively settled on buildings with a 5,000 SF footprint as a lower threshold to consider. Buildings of this size may be able to host a 25-kW installation. While it is technically possible to aggregate two or more discrete CS installations (located within a single utility service area) into a single CS project through a utility accounting mechanism known as Virtual Net Metering, it might be more financially challenging to develop several rooftops rather than developing a single ground-mounted parcel or large rooftop. For reference, a 1-MW solar installation would require approximately 40 buildings with a footprint of 5,000 SF or a single building with a footprint of 200,000 SF.

To support the LSC's investigations into potential Community Solar locations, CEE has developed the following publicly available, interactive GIS maps for the study areas:

- Ground-based CS development sites in Lawrence, Methuen, Andover, and North Andover
- Building-mounted (i.e., rooftop) and landfill CS development sites in Lawrence

A user guide for navigating the mapping platform (ArcGIS Map View) for the above maps is provided here: ArcGIS Map View user guide

Readers should note that this assessment was performed as a desktop analysis, incorporating publicly available geospatial data layers downloaded from MassGIS, the state's Bureau of Geographic Information.[1] It is important to recognize that information contained within these data sources may be out-of-date, inaccurate, or include irregularities that reduce the accuracy of this analysis. This assessment should be considered as a preliminary analysis, providing direction regarding where more in-depth site assessments can be conducted.

For sites determined to have solar development potential in this study, more detailed site assessment steps should include further research into site ownership status and uses, as well as consultations with professional solar installers and/or developers. Selected factors to consider for both building-mounted and ground-mounted sites include:

Building-mounted Sites:

- □ Building type (e.g., agricultural, commercial, industrial, etc.) and current use(s)
- □ Electrical service levels and site proximity to three-phase distribution lines
- □ Roof construction, age, design, condition, orientation, pitch, rooftop equipment, etc.
- □ Historic building or historic district restrictions/concerns (e.g., national registry listing)

Ground-mounted Sites:

- □ Land ownership status, use(s), and type (e.g., brownfield, agricultural, recreation)
- □ Proximity to three-phase distribution lines
- □ Conservation status and presence of wetlands
- □ Land orientation, grade, and topography
- □ Activity of adjacent tenants/owners (e.g., agriculture, roadways, recreation areas)

Should Lawrence's solar stakeholders be interested in engaging in a comprehensive CS planning process, the city could consider exploring the UMass Clean Energy Extension's *Community Planning for Solar* Toolkit.[2] Further details regarding the Toolkit are provided in **Appendix C**.

[1] https://www.mass.gov/orgs/massgis-bureau-of-geographic-information
[2] https://ag.umass.edu/solarplanning

Table of Contents

1. Introduction

To understand the potential for community solar in Lawrence, the UMass Clean Energy Extension (CEE) research team, who were brought in to provide local expertise for the analysis, focused this analysis on a high-level GIS evaluation of potential community solar (CS) development sites in the greater Lawrence area, including and surrounding the city of Lawrence, Massachusetts. The GIS analysis will be a starting point for evaluating diverse sites for community solar in the area and enable the coalition to evaluate tradeoffs. Lawrence is located in Essex County and is part of the Merrimack Valley. It has an area of 6.93 square miles, a population of 87,954, and a population density of 12,861 people per square mile, which is 15 times the state average.[3] The median income in 2021 was $47,542, which is 53% of the state median income of $89,026. The home-ownership rate is 29.1%, less than half of the statewide rate.[4] Various studies show that existing rooftop solar in the U.S. are primarily installed on owner-occupied units, leading to racial and income disparities in access to renewable energy electricity subsidies.[5]

Given the relative lack of open space in Lawrence, the Lawrence Stakeholder Coalition (LSC) requested that the GIS-based *Lawrence Community Solar Potential Analysis* (1) focus on potential rooftop and landfill sites within Lawrence city limits, and (2) that the open land parcel analysis include the somewhat less-densely developed surrounding cities of Andover, North Andover, and Methuen for potential ground-mounted or canopy solar sites. Methodologies and data sources associated with these analyses are outlined in Section 2 below.

Figure 1 below illustrates the *Lawrence Community Solar Potential Analysis* study area.

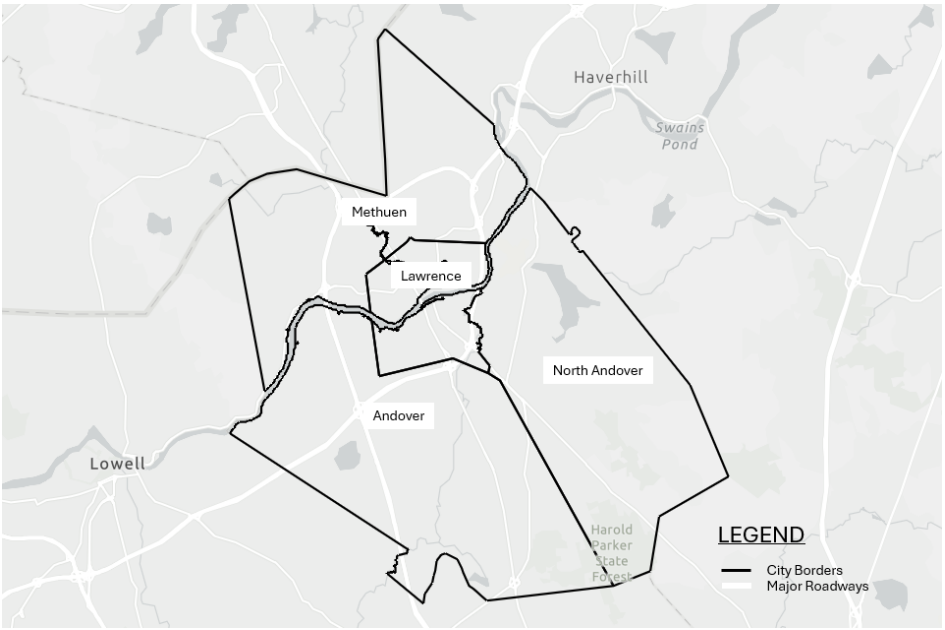

Figure 1 *Community Solar Potential Analysis for Lawrence, Massachusetts* study area

[3]U.S. Census Bureau QuickFacts: Lawrence City, Massachusetts." 2022. https://www.census.gov/quickfacts/fact/table/lawrencecitymassachusetts/PST045222

[4] DataUSA. n.d. "Lawrence, MA | Data USA." Accessed December 6, 2023. https://datausa.io/profile/geo/lawrence-ma/

[5] Sigrin, Benjamin O., and Meghan E. Mooney. 2018. "Rooftop Solar Technical Potential for Low-to-Moderate Income Households in the United States." NREL/TP--6A20-70901, 1434891. https://doi.org/10.2172/1434891

2. Methods & Data Sources

The LSC and the UMass research team initially identified three types of solar configurations that may be appropriate for development of CS installations to serve Lawrence's solar goals: *Ground-mounted*, *Building-mounted* (i.e., rooftop) *and Landfill.* To assess their potential, each installation type required an analysis of different Geographic Information System (GIS) land cover types, specifications, and GIS datasets. *Canopy* solar (e.g., elevated solar installations above parking lots, walkways, agricultural operations) extended beyond the scope of this project due to time limitations, though Lawrence may wish to pursue the investigation of potential *Canopy* sites as a future research step.

For the *Building-mounted* analysis, buildings with a minimum footprint of 5,000 square feet (SF) or greater were examined. For the *Ground-mounted* analysis, the analysis examined open land parcels of five acres or more. These minimum dimensions were determined to serve as baseline values necessary for the site to accommodate at least a 1-megawatt (MW) solar installation, which is the minimum capacity likely to ensure economic viability of a CS project. For reference, in Massachusetts, a 1-MW solar installation can power approximately 160 average homes[6]. A ground-mounted solar installation of 1 MW typically requires 5-7 acres, depending on the land's topography, orientation, and surrounding structures and a 1-MW rooftop solar installation would require approximately 100,000 SF of available rooftop space.

Regarding the *Building-mounted* analysis, it should be noted that a building's *footprint* is considered the ground area that the building occupies and the *available rooftop space* is the amount of roof area able to accommodate a solar PV installation. Available rooftop space in commercial buildings is typically less than a building's footprint due primarily to the presence of rooftop equipment. An analysis from the National Renewable Energy Laboratory suggests that most buildings with a footprint greater than 5,000 SF may have a roof plane suitable for solar, and, that on average, approximately 49% of the roof area may be available (due to the presence of rooftop equipment and other factors).[7] Therefore, a 1-MW solar installation may require a building footprint of up to 200,000 SF. The GIS-based Lawrence Building-Mounted rooftop map indicates that there are six buildings with footprints of 200,000 SF or larger within city limits.

The *Building-mounted* analysis examined buildings with a minimum footprint of 5,000 SF because the LSC highlighted a desire to understand the technical solar development potential of smaller buildings within Lawrence regardless of their economic viability. A building with a 5,000 SF footprint may be able to host a 25-kW installation (this potential capacity depends on available rooftop space and assumes an estimated availability of 49%), though an installation of this size may not be economically viable as a CS project without funding for state or philanthropic sources. However, a smaller CS project that demonstrates local ownership by a disadvantaged community may be attractive as a pilot project for funds from government or foundations. With such funds, a smaller commercial rooftop project may be economically viable and less technically complex. As such, the development of a smaller installation (e.g., 25-kW) as an initial pilot project with adequate funding might be considered as a strategy to gain early public support for the CS concept.

Due to a predominance of rooftop space within Lawrence's city limits, the LSC requested that the UMass research team focus its analysis on *Building-mounted* and *Landfill* sites within the city itself. In addition to analyzing the city's landfill sites and buildings, the research team identified sites within one mile of three-phase distribution lines and with available hosting capacity (i.e., the ability of local

6 https://www.seia.org/initiatives/whats-megawatt

7 Gagnon, P., Margolis, R., Melius, J., Phillips, C. and Elmore, R., 2016. *Rooftop solar photovoltaic technical potential in the United States. A detailed assessment* (No. NREL/TP-6A20-65298). National Renewable Energy Lab.(NREL), Golden, CO (United States).

grid circuits to accept solar system interconnections). Three-phase distribution lines, which are typically needed for solar installations of 50-kW or greater, are not available in all areas. Where they are available, solar systems of up to 200-kW can typically be interconnected without significant technical challenges. However, for systems greater than 200-kW, it is important to first confirm that the distribution lines (1) are near enough to the proposed project site to ensure the economic viability of the system, and (2) have sufficient hosting capacity available before these facilities are designed and built.

A variety of data sources from MassGIS were utilized in this analysis, including tax parcel vector data, 2016 land use classification data, data related to K-12 schools and places of worship, and Town Survey vector data.[8] Descriptions and data source links for the GIS datasets used in this report are provided in Appendix A. Utility hosting capacity data from the *National Grid Massachusetts System Data Portal* was also utilized.[9]

The *Ground-mounted* analysis examined open land sites within the cities of Lawrence, Methuen, Andover, and North Andover. The following land cover classifications were included in this analysis: *Bare Land*, *Cultivated*, *Developed Open Space*, *Grassland*, *Impervious*, *Palustrine Scrub/Shrub Wetland*, *Pasture/Hay*, *Scrub/Shrub*, and *Water* as classified in the 2016 Land Use/Land Cover Classification for Massachusetts as the primary land cover. Definitions of these land cover classifications are provided in Appendix B. Both capped and uncapped landfills were also examined. Uncapped landfills may be active or inactive and are likely not candidates for solar development until they are further addressed. Capped landfills are those that have been covered with a layer of clay or plastic to prevent rain from entering the site. Capped status generally indicates that the landfill is no longer active and thus may be a candidate for the development of solar, wildlife habitat, parks and golf courses, or other uses.

[8] https://www.mass.gov/orgs/massgis-bureau-of-geographic-information
[9] https://systemdataportal.nationalgrid.com/MA/

3. Findings

According to the criteria and data sources listed in Section 2, outlined below are (1) the results of the *Ground-mounted* site analysis in Lawrence, Methuen, Andover, and North Andover, and (2) the results of the *Building-mounted* and *Landfill* site analysis in Lawrence. Key findings include:

- The *Ground-mounted* site analysis identified 472 potential parcels of five acres or larger across the four cities. All of the identified parcels are within one mile of 3-phase distribution lines.
- The *Building-mounted* and *Landfill* site analyses for Lawrence identified 637 structures of 5,000 SF or greater, and two capped landfills within city limits. All of the identified locations are within one mile of 3-phase distribution lines. However, only six buildings were 200,000 SF, the general scale for

More detailed information from the findings are provided in the sections below. Links to publicly available, interactive GIS maps for the study areas, as well as a user guide for navigating the map platform (ArcGIS Map View) are available below:

- Ground-based CS development sites in Lawrence, Methuen, Andover, and North Andover
- Building-mounted (i.e., rooftop) and landfill CS development sites in Lawrence
- ArcGIS Map View user guide

3.1 Ground-Mounted Analysis

The *Ground-mounted* site analysis identified 472 potential parcels across the four cities. Figure 2. below illustrates the resulting map showing individual parcels color-coded by land cover type. Note that the map shows all tax parcels greater than five acres that are classified as the GIS land classifications of *Bare Land*, *Cultivated*, *Developed Open Space*, *Grassland*, *Impervious*, *Palustrine Scrub/Shrub Wetland*, *Pasture/Hay*, *Scrub/Shrub*, and *Water* as classified in the 2016 Land Use/Land Cover Classification for Massachusetts as the primary land cover. Definitions of these land cover classifications are provided in Appendix B.

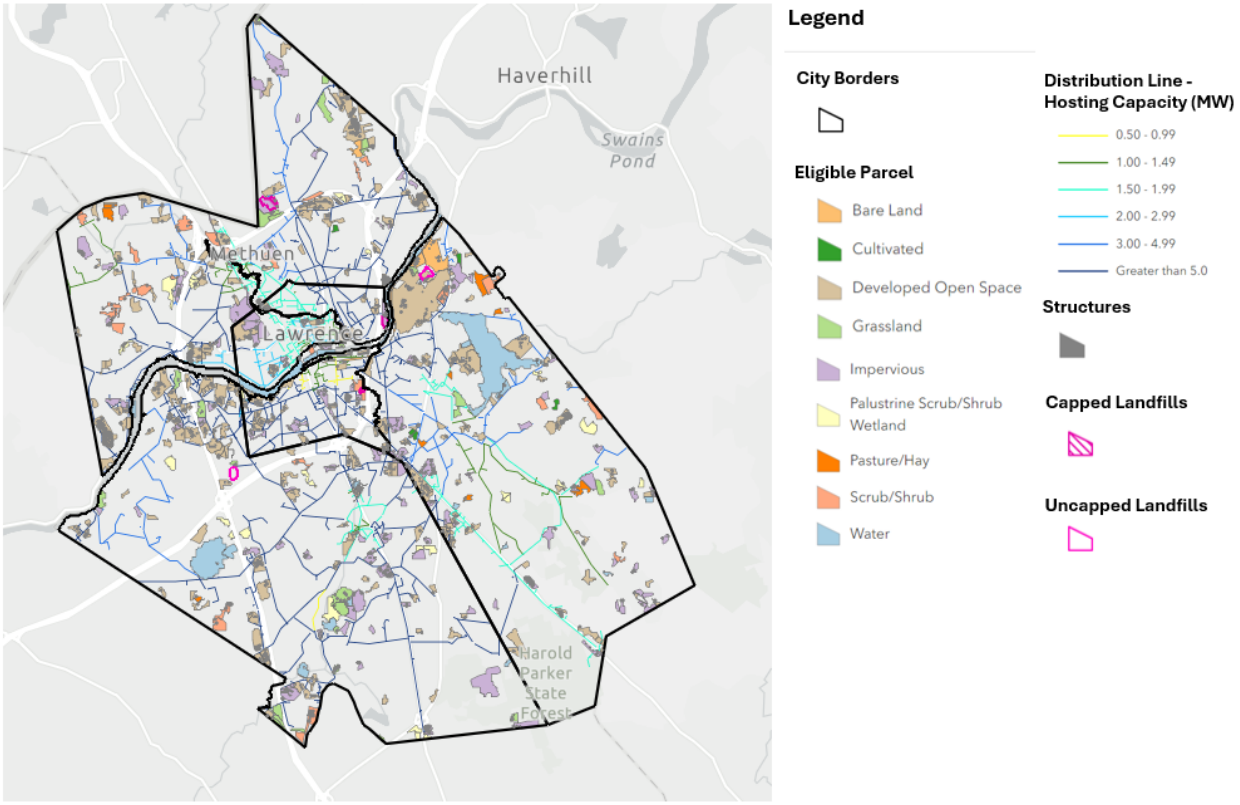

Figure 2. Potential ground-mounted community solar sites in Lawrence, Methuen, Andover, and North Andover

The suitability of sites identified in Figure 2. for solar development will depend on many factors such as solar exposure, current land activities and site topography; any conservation restrictions; the presence of trees or buildings surrounding the site that could cause shading, etc. Although all identified parcels in Figure 2. are located within one mile of at least one 3-phase distribution line, other parcels of interest may not meet this criterion, potentially making them financially unfeasible and, hence, requiring careful evaluation for solar development based on its specific context, location, and site characteristics.

The hosting capacity of area distribution lines are also indicated by color in Figure 2. For example, yellow lines indicate a lower circuit hosting capacity range of 0.5 – 0.99 MW. Lighter blue lines indicate a greater hosting capacity range of 1.50 – 1.99 MW. It should be noted that these values are estimates only and are likely to change over time as grid circumstances change. Existing grid infrastructure plays a major role in where large solar arrays are built. The cost of connecting these facilities to the grid varies widely in different locations, and hence is a primary decision-making factor in where solar developers propose to site projects. The solar development process requires more precise and updated hosting capacity data and interconnection approvals from the local utility.

Those exploring the potential for solar development on specific ground-mounted sites should reference the publicly available, interactive GIS maps linked here: Ground-based CS development sites in Lawrence, Methuen, Andover, and North Andover

Figure 3. illustrates a close-up view of a parcel in Methuen, provided here as an example of a site that may warrant further investigation for ground-mounted solar potential.

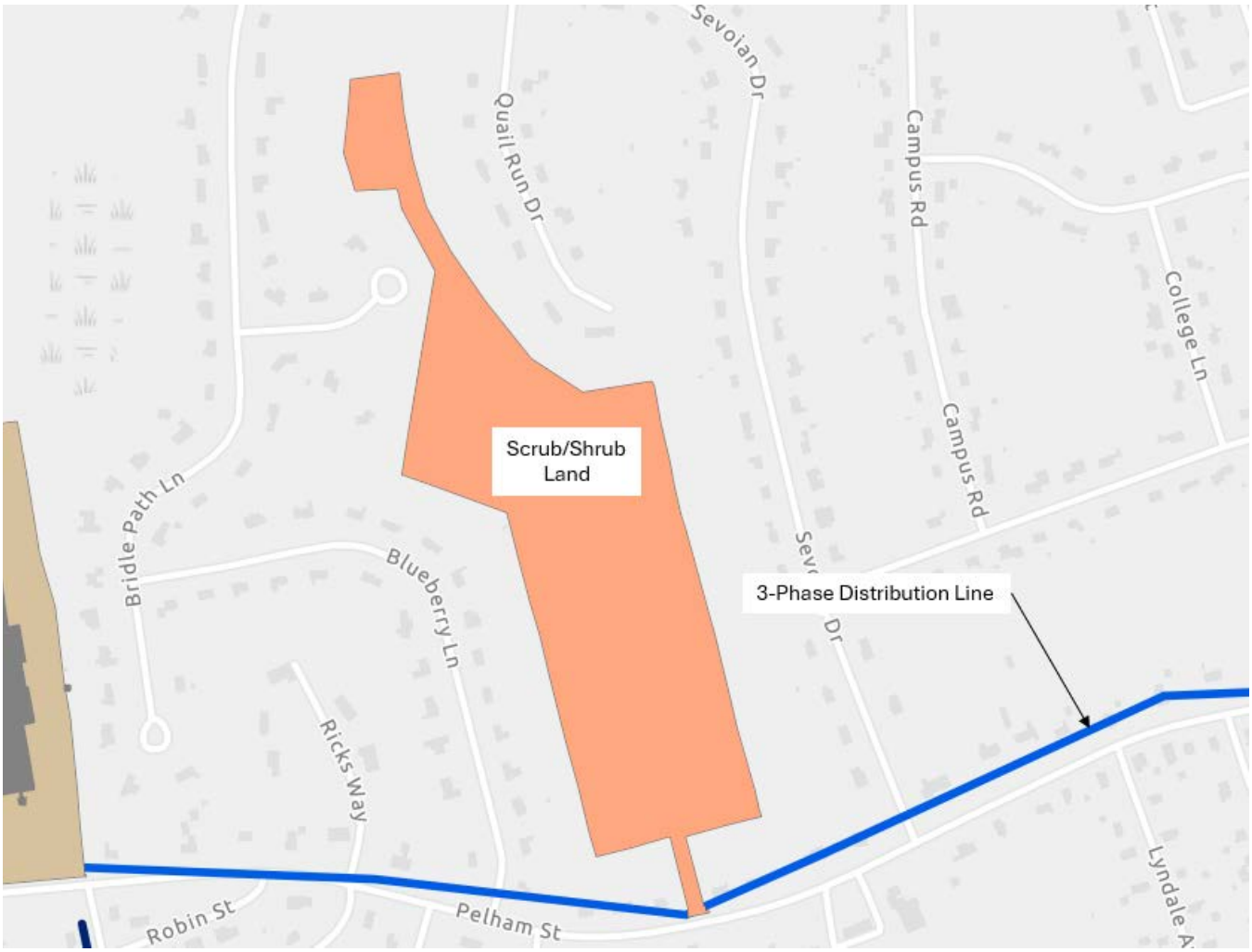

Figure 3. Example of a Methuen parcel classified as Scrub/Shrub land and nearby 3-phase distribution line

The parcel shown in Figure 3 is in close proximity to a 3-phase distribution line, which features 3.00 – 4.99 MW of hosting capacity. Further investigative steps for evaluating the parcel's solar development potential may include identifying additional details such as the site address, the parcel's owner, an assessment of the owner's interest in exploring a solar development, current land use and topography, existing structures, solar exposure, any conservation restrictions, and area available for solar development. This level of information is often gathered in partnership with a solar installer and/or consultant familiar with the solar development process.

Figure 4. below provides summary statistics for the *Ground-mounted* analysis and indicates that the majority of the area of eligible parcels are categorized as *Developed Open Space* and *Impervious Surfaces*. A possible future research step would be to determine specifically what types of surfaces are included in the *Developed Open Space* category.

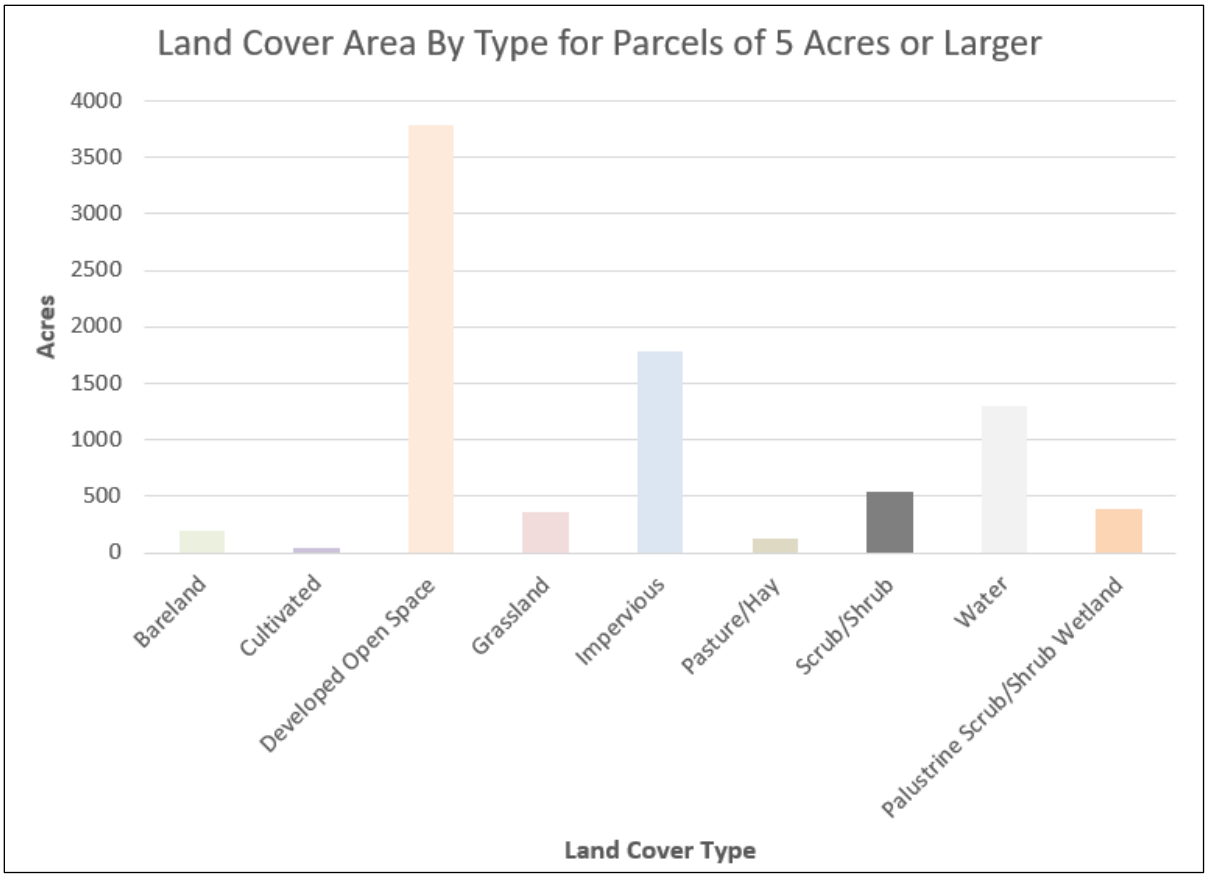

Figure 4 Summary of potential solar installation land cover area by land cover type in Lawrence, Methuen, Andover, and North Andover

Following *Developed Open Space* and *Impervious Surfaces*, land cover classifications of *Water*, *Grassland*, and *Scrub/Shrub* were most prevalent across the four cities. The *Water* land cover classification was included in the analysis due to an expressed interest in opportunities for floating solar installations. *Grassland* and *Scrub/Shrub* land cover classifications may have potential for hosting ground-mounted solar installations, assuming that they are not under any conservation restrictions. Definitions of land use types listed in Figure 4. are provided in Appendix B.

3.2 Building-Mounted and Landfill Analyses

The *Building-mounted* and *Landfill* site analyses for Lawrence identified 637 structures with footprints of 5,000 SF or greater, and two capped landfills within city limits. Of the identified buildings, only six have footprints of 200,000 SF or greater. Of the identified building locations, five sites are *Places of Worship*, 22 are *Schools*, 114 are on *Industrial* parcels, and 496 were *Undefined* (i.e., does not feature a GIS classification). Figure 5. below illustrates the resulting map showing individual buildings color-coded by building type.

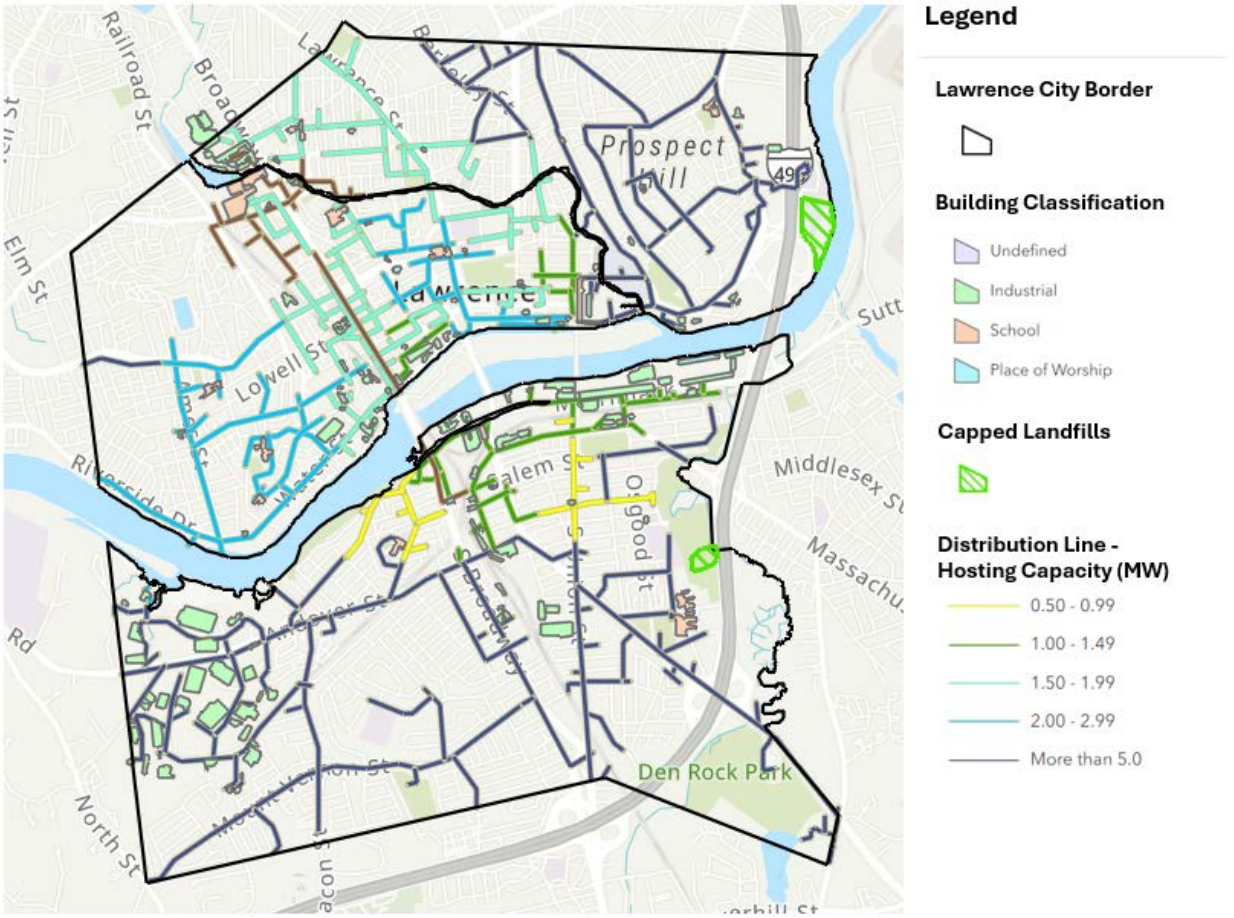

Figure 5 Potential building-mounted solar sites in Lawrence

As noted above, all identified structures in Figure 5 are within a mile or less of at least one three-phase distribution line.

The LSC expressed an interest in better understanding the potential to utilize rooftops for solar within Lawrence city limits. The LSC and the UMass research team collectively settled on buildings with a 5,000 SF footprint as a lower threshold to consider. Buildings of this size may be able to host a 25-kW installation. While it is technically possible to aggregate two or more discrete solar installations (located within a single utility service area) into a single CS project through a utility accounting mechanism known as Virtual Net Metering, it will likely be more financially challenging to develop several rooftops rather than developing a single ground-mounted parcel or large rooftop. For reference, a 1-MW solar installation would require approximately 40 buildings with a footprint of 5,000 SF or a single building with a footprint of 200,000 SF.

The analysis also identified two capped *Landfill* sites in Lawrence: the Incinerator Road Municipal Landfill (13.7 acres) and the South Lawrence East School Landfill (4.4 acres). A capped landfill is a landfill that has been covered with a layer of clay or plastic to prevent rain from entering the site. Capping generally indicates that the landfill is no longer active and thus may be a candidate for the development of solar, wildlife habitat, parks and golf courses, and other uses.

The hosting capacity of area distribution lines is also indicated by color in Figure 5. For example, yellow lines indicate a lower circuit hosting capacity range of 0.5 – 0.99 MW. Lighter blue lines indicate a greater hosting capacity range of 2.00 – 2.99 MW. It should be noted that these values

are estimates only and are likely to change over time as interconnection circumstances change. The local utility will be able to provide more precise hosting capacity estimates.

Those exploring the potential for solar development on specific building-mounted sites should reference the interactive GIS map linked here: [Building-mounted (i.e., rooftop) and landfill CS development sites in Lawrence]

Figure 6. below illustrates a close-up view of an industrial building in Lawrence, provided here as an example of a site that may warrant further investigation for rooftop solar potential.

Figure 6 Example of a Lawrence industrial building site and nearby 3-phase distribution line

The building shown in Figure 6. is in close proximity to a 3-phase distribution line, which features more than 5.0 MW of hosting capacity. Further investigative steps for evaluating the building's solar development potential may include identifying additional details such as the site address, the building's owner, and an assessment of the owner's interest in exploring a rooftop solar installation. Important follow-on information will include the roof dimensions, age, and design, solar exposure, and rooftop space available for solar development. This level of information is often gathered in partnership with a solar installer and/or consultant familiar with the solar development process.

Figure 7. below illustrates a close-up view of the Incinerator Road Municipal Landfill mentioned site in Lawrence, provided here as an example of a capped landfill site.

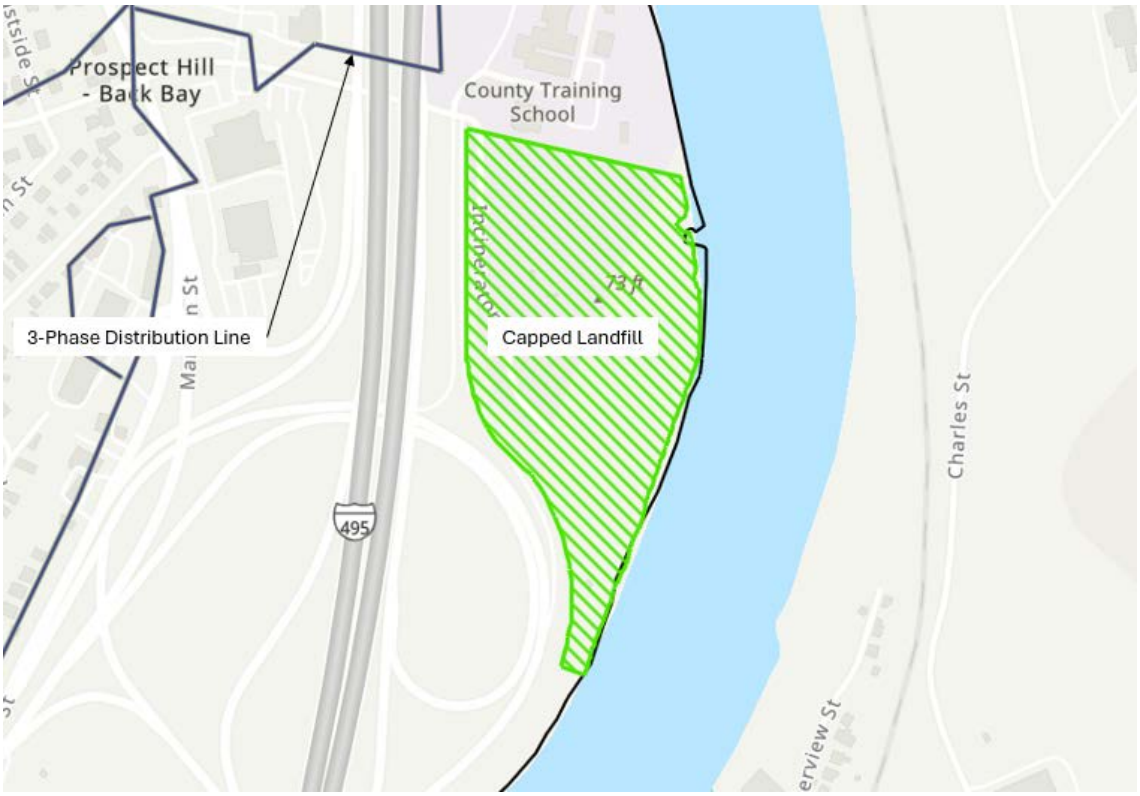

Figure 7 Example of a Lawrence capped landfill site and nearby 3-phase distribution line

This 13.7-acre site is in close proximity to a 3-phase distribution line, which features more than 5.0 MW of hosting capacity. Review of area satellite imagery reveals that the site is currently developed and used for parking and recreational purposes, making it an unlikely candidate for solar development. However, in general, further investigative steps for evaluating capped landfill sites for solar development potential may include gathering additional details such as the site address, the parcel's owner, and an assessment of the owner's interest in exploring a solar development, current land uses and topography, existing structures, solar exposure, any conservation restrictions, and area available for solar development. This level of information is often gathered in partnership with a solar installer and/or consultant familiar with the solar development process.

4. Future Directions

While this study provides a high-level examination of potential *Ground-mounted*, *Building-mounted*, and *Landfill* solar sites in Lawrence and adjacent cities, further analysis is required to determine whether the sites identified are truly viable candidates for development of CS installations. Detailed site assessment steps should include further research into site ownership status and uses, as well as consultations with professional solar installers and/or developers. Selected factors to consider for building-mounted and ground-mounted sites include:

Building-mounted Sites

- □ Building type (e.g., agricultural, commercial, industrial, etc.) and current use(s)
- □ Electrical service and proximity to three-phase distribution lines
- □ Roof construction, age, design, condition, orientation, pitch, rooftop equipment, etc.
- □ Any historic building or historic district issues/concerns (e.g., listed on national registry)

Ground-mounted Sites

- □ Land ownership status, use(s), and type (e.g., brownfield, agricultural, recreation)
- □ Proximity to three-phase distribution lines
- □ Conservation status and presence of wetlands
- □ Land orientation, grade, and topography
- □ Activity of adjacent tenants/owners (e.g., agriculture, roadways, recreation areas)

Should Lawrence's solar stakeholders be interested in engaging in a comprehensive CS planning process, the city could consider exploring the UMass Clean Energy Extension's *Community Planning for Solar* Toolkit.[10] Further details regarding the Toolkit are provided in Appendix C.

[10] https://ag.umass.edu/solarplanning

Appendix A. GIS Data Source Summary Table

Appendix A contains descriptions and data source links for the GIS datasets used in this report.

Table 1. General definitions of the land cover types used in this report

GIS Dataset	Summary	Projected Coordinate System	Link
MassGIS Land Use Classification 2016	This statewide dataset contains a combination of land cover mapping from 2016 aerial imagery and land use derived from standardized assessor parcel information for Massachusetts.	NAD, 1983 State Plane Massachusetts FIPS 2001 (Meters)	https://www.mass.gov/info-details/massgis-data-2016-land-coverland-use
MassGIS Tax Parcels	MassGIS standardized assessors' parcel mapping data set contains property (land lot) boundaries and database information from each community's assessor.	NAD, 1983 State Plane Massachusetts FIPS 2001 (Meters)	https://www.mass.gov/info-details/massgis-data-property-tax-parcels
MassGIS Structures	This dataset consists of 2-dimensional roof outlines ("roofprints") for all buildings larger than 150 square feet for all of Massachusetts.	NAD, 1983 State Plane Massachusetts FIPS 2001 (Meters)	https://www.mass.gov/info-details/massgis-data-building-structures-2-d
National Grid Hosting Capacity	National Grid's hosting capacity mapping data for all 3-phase distribution lines	NAD, 1983 StatePlane Massachusetts FIPS 2001 (Meters)	https://systemdataportal.nationalgrid.com/MA/
MassDOT Major Roads	This layer is the official state-maintained street transportation dataset available from MassGIS. It represents all the public and many of the private roadways in Massachusetts and includes designations for Interstate, U.S. and State routes.	NAD, 1983 StatePlane Massachusetts FIPS 2001 (Meters)	https://www.mass.gov/info-details/massgis-data-massachusetts-department-of-transportation-massdot-roads

Appendix B. Land Cover Classification Definitions

Table B.1 below contains general definitions of the land cover types used in this report as classified in the 2016 Land Use/Land Cover Classification for Massachusetts as the primary land cover.[11]

Table 2. General definitions of the land cover types used in this report

Land Cover Category	General Definition
Bare Land	Contains areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earth material. Generally, vegetation accounts for less than 10 percent of total cover. This category may include permanently unvegetated features but also often capture features in states of transition, such as exposed soil at construction sites (such as new development) or in recent forest clear cuts. This category can also include unpaved, infrequently traveled roads; recently tilled areas of exposed soils in agricultural settings; and railroad features.
Cultivated	Contains areas intensely managed for the production of annual crops, all land being actively tilled, orchards, vineyards, nurseries, cranberry bogs, and aquaculture.
Developed Open Space	Contains grass and other vegetation that is not woody and is associated with developed areas or recreation, mostly managed grasses or low-lying vegetation planted in developed areas for recreation, erosion control, or aesthetic purposes. These areas are maintained by human activity such as fertilization, irrigation, or mowing and often occur in locations that are within or adjacent to other developed features (i.e., neighborhoods, golf courses, airports, cemeteries, sports fields, etc.).
Grassland	Contains areas dominated by graminoid or herbaceous vegetation, generally greater than 80 percent of total vegetation. These areas are not subject to intensive management such as tilling but can be utilized for light grazing.
Impervious	Anthropogenic features which do not allow infiltration from precipitation. This includes buildings, parking lots, and roads developed from asphalt, concrete, or other constructed surfaces. Impervious can also include unpaved roads and similar features (driveways, parking areas, etc.) that are highly trafficked and often compacted, leading to their functioning like a paved, impervious surface.
Palustrine Scrub/Shrub Wetland	Includes tidal and nontidal wetlands dominated by woody vegetation less than 15 ft (5 meters) in height, and all such wetlands that occur in tidal areas in which salinity due to ocean- derived salts is below 0.05 percent (0.5 parts per thousand). Total vegetation coverage is typically greater than 20 percent.
Pasture/Hay	Contains areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops. This cover type is expected to be

[11] https://www.mass.gov/info-details/massgis-data-2016-land-coverland-use

Land Cover Category	General Definition
	perennial (i.e., not tilled on an annual basis) but is generally more intensively managed than natural grasslands.
Scrub/Shrub	Contains areas dominated by woody vegetation that is less than 15 feet (5 meters) tall. This class includes woody vegetation that consisting of shrub species, and tree species that are in early successional stages of regrowth or that are stunted from environmental conditions.
Water	Open water surface features include water-covered areas with less than 25 percent vegetation cover.

Appendix C. Community Planning for Solar Toolkit

Should Lawrence's solar stakeholders wish to undertake a comprehensive CS planning process, the city could consider exploring the UMass Clean Energy Extension's *Community Planning for Solar* Toolkit, which is designed to help municipalities in Massachusetts and throughout the Northeast proactively plan for solar development in their communities. The Toolkitallows community residents and officials to take a proactive approach to solar development by providing communities with the resources that can help them to:

- □ Assess their community's unique resources, solar development options, goals, and preferences.
- □ Identify and prioritize locations in the community for solar development.
- □ Evaluate various solar financing options and pursue financing that best fits community goals.
- □ Develop a Community Solar Action Plan with clear steps for community outreach and education, engaging with potential solar developers and financiers, and aligning municipal bylaws related to solar development with community preferences.

The *Community Planning for Solar* Toolkit can be found at https://ag.umass.edu/solarplanning. Development of this Toolkit was funded in part by the U.S. Department of Energy through the National Renewable Energy Laboratory's Solar Energy Innovation Network cohort program for Solar in Rural Communities, as part of a multi-stakeholder team project to develop a community-informed proactive solar siting and financing model.

For more information about
Communities LEAP, visit:
energy.gov/CommunitiesLEAP

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