Solar Resource and Infrastructure Assessment

for

the Town of Leyden, MA

Photo Credit: *Town of Leyden Website*

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Executive Summary

This report is a Solar Resource and Infrastructure Assessment for the Town of Leyden, Massachusetts. The assessment was conducted through a joint collaboration among the town, UMass undergraduate students, UMass Clean Energy Extension (CEE), and the UMass iCons program, using CEE's *Community Planning for Solar* toolkit (ag.umass.edu/solarplanning). As Step 2 in the planning process, this assessment details existing infrastructure, resources, and potential solar development opportunities in Leyden. This assessment is designed to describe relevant bylaws and infrastructure within the town, identify the types of solar facilities that could be developed, and quantify the total space available for each type of facility.

A summary of solar technical potential for different types of sites is provided in Section 5.8 of this document.

Terminology

The following terms, abbreviations, and acronyms are used in this report.

Terms

Photovoltaic, or "PV," systems are solar arrays composed of panels that generate electricity from sunlight. These panels are a different type of technology than the types of panels used in "solar hot water" or "solar thermal" systems.

Voltage of an electric power line can be thought of as the equivalent of pressure in a water line. The voltage of transmission and distribution power lines is typically measured in kilo-volts (kV). One kilo-volt is equivalent to 1000 volts (V). In residential use in the United States, electrical wires within a household carry electricity at 120 V.

Capacity of a solar array is a description of the instantaneous power output of the panels at top production (i.e, in full sun). It is typically measured in kilowatts (kW) or megawatts (MW). A residential-size solar system is typically 5-10 kW in capacity. Commercial-scale solar arrays are typically 1 MW or greater in size. An average 1 MW array would cover approximately 4-5 acres of land.

Annual generation of a solar array is a measure of the yearly energy output produced by the panels. It is typically measured in kilowatt-hours (kWh) or megawatt-hours (MWh). In New England, annual generation is approximately equal to the array's capacity (in DC) *14% * 8760 hours per year.

DC is the abbreviation for direct current, the type of electricity produced by solar panels. The DC capacity of a solar array is a good indication of its size, and footprint on the landscape.

AC is the abbreviation for alternating current, the type of electricity flowing into the grid from a solar array, after it has gone through a transformer. In the absence of energy storage, a typical DC to AC ratio for solar array capacity is about 1.25:1. However, with energy storage, that ratio can be significantly higher (close to 2:1), since excess electricity can be stored in batteries during the day, and released into the grid during the night, when the panels are not generating electricity.

Solar facility size terms used in this report are in line with current state solar incentive program categories (not with municipal bylaws). That is:

- **Small** systems are 25 kW or less.
- **Medium** systems are 25-500 kW.
- **Large** systems are over 500 kW (0.5 MW) in size.

SMART is the abbreviation for the current state solar energy incentive program (the Solar Massachusetts Renewable Target program). This program replaced earlier solar incentive programs, commonly known as "SREC" programs, in November of 2018, and was further updated through an emergency regulation in April 2020. The SMART regulation includes incentives for projects up to 5 MW AC in size. Additional incentives are available for projects located on buildings, parking lot canopies, landfills, brownfields, and "dual-use" solar and agriculture projects, as well as certain types of projects that benefit public entities, like municipalities. The updated regulation places restrictions on what types of large, ground-mounted projects can receive incentives, if they are sited on undeveloped land designated as BioMap2 Critical Natural Landscapes or Core Habitat, by the state MassWildlife Natural Heritage and Endangered Species Program.

Abbreviations & Acronyms

CEE - UMass Clean Energy Extension
DOER - Massachusetts Department of Energy Resources
FRCOG - Franklin County Regional Council of Governments, the regional planning authority for Franklin County, MA
kV - kilo-volt
kW - kilowatt
kWh - kilowatt-hour
MDAR - Massachusetts Department of Agricultural Resources
MVP - Municipal Vulnerability Preparedness plan, a municipal planning document
MW - megawatt
MWh - megawatt-hour
OSRP - Open Space and Recreation Plan, a municipal planning document
PV – photovoltaic, the type of solar panels that generate electricity from sunlight
PVPC - Pioneer Valley Planning Commission, the regional planning authority for Hampden and Hampshire Counties, MA
sf - square feet

1. INTRODUCTION

This report is a Solar Resource and Infrastructure Assessment for the Town of Leyden, MA.

Leyden is a small town on the border of Massachusetts and Vermont. The town separated from Bernardston in 1784, but it was not incorporated until February 22, 1809. Since then, it has grown to have a population of around 700 year-round residents and an estimated 259 households.[1] Leyden has an area of 18 square miles, and a population density of 41 people per square mile, significantly below the state average. The town has attempted to gain Green Community status in the past but has yet to complete the process. The town Conservation Commission is actively working to get the town certified.

The assessment was conducted through a joint collaboration among the town, UMass undergraduate students, UMass Clean Energy Extension (CEE), and the UMass iCons program, using CEE's *Community Planning for Solar* toolkit (ag.umass.edu/solarplanning).

As the second step in the *Community Planning for Solar* process, UMass team members prepared this assessment of existing infrastructure, resources, and potential solar development opportunities. This assessment is designed to describe relevant bylaws and infrastructure within the town, identify the types of solar facilities that could be developed, and quantify the total space available for each type of facility.

In this report, we review and describe:

- Existing electricity grid infrastructure, and the potential to interconnect additional solar facilities
- Current municipal solar zoning bylaws
- Town conservation priorities and conservation land
- Existing renewable energy facilities
- Priority energy storage sites
- Businesses and institutions with potentially moderate to heavy electricity use
- Areas available for development on:
    - Residential rooftops and properties
    - Medium to large-scale rooftops
    - Parking lots
    - Landfills, brownfields, and other previously disturbed sites
    - Farms
    - Undeveloped land where large-scale commercial development could be viable

[1] https://data.census.gov/table?q=leyden+ma&tid=ACSST5Y2021.S1101

2. GRID INFRASTRUCTURE ASSESSMENT

2.1 Introduction

In this section, we provide a description of the existing electricity grid infrastructure serving the town, and the potential for new solar arrays to connect to existing circuits. Through this description, we hope to provide a general understanding of how the electricity grid functions, as well as to provide a snapshot of current conditions. Existing grid infrastructure plays a major role in where large solar arrays are built. The cost of connecting large solar 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.

While existing grid infrastructure may currently financially constrain the types of solar projects that can be developed in some locations, the electricity grid is in a constant state of change, and grid components are constantly being upgraded. This description of the current state of the grid may be most relevant to situations in which the town or community members have an interest in the development of a particular site for medium- to large-scale solar in the near future. The current state of grid infrastructure within the town may be less relevant to long-term planning. In fact, we suggest that significant town-level planning around solar energy could potentially drive the location of electric grid upgrades to allow development in places where community members would prefer to see solar facilities sited.

2.2 Grid Infrastructure Basics

The New England electricity grid is overseen by ISO New England, the regional transmission organization that serves the states of Massachusetts, Maine, New Hampshire, Vermont, Connecticut, and Rhode Island. This non-profit organization is charged with ensuring grid reliability – that is, to continuously balance electricity supply and demand, in Massachusetts and throughout the region. The electricity grid consists of transmission lines, high-voltage lines which carry electricity over long distances, and distribution lines, lower voltage lines which distribute power to individual communities and households. Most transmission lines in Massachusetts are owned by the two major electricity utilities which operate in the state - Eversource (formerly NSTAR and WMECO) and National Grid. Distribution lines are typically owned by the local electricity provider, which could be Eversource, National Grid, Unitil, or a municipal utility. Transmission lines range in voltage from 69-345 kV. When these lines reach a substation, electricity is "stepped down" to a lower voltage and distributed along 13-34 kV distribution lines.

The "interstate highways" of the electrical grid are 345 kV transmission lines. In western Massachusetts, one 345 kV line runs north-south, east of, but approximately paralleling, the Connecticut River (see dark blue lines Figure 1, next page). This line connects the pumped storage facility in Northfield with the Stonybrook Power Plant, an oil and natural gas facility, in Ludlow. A second 345 kV line runs west from the Northfield pumped storage facility, through Ashfield, Plainfield, and Pittsfield, and ultimately across the state line into New York.

For a more complete introduction to the electricity grid, please see CEE's Fact Sheet: The Electric Grid, Distributed Generation, and Grid Interconnection.

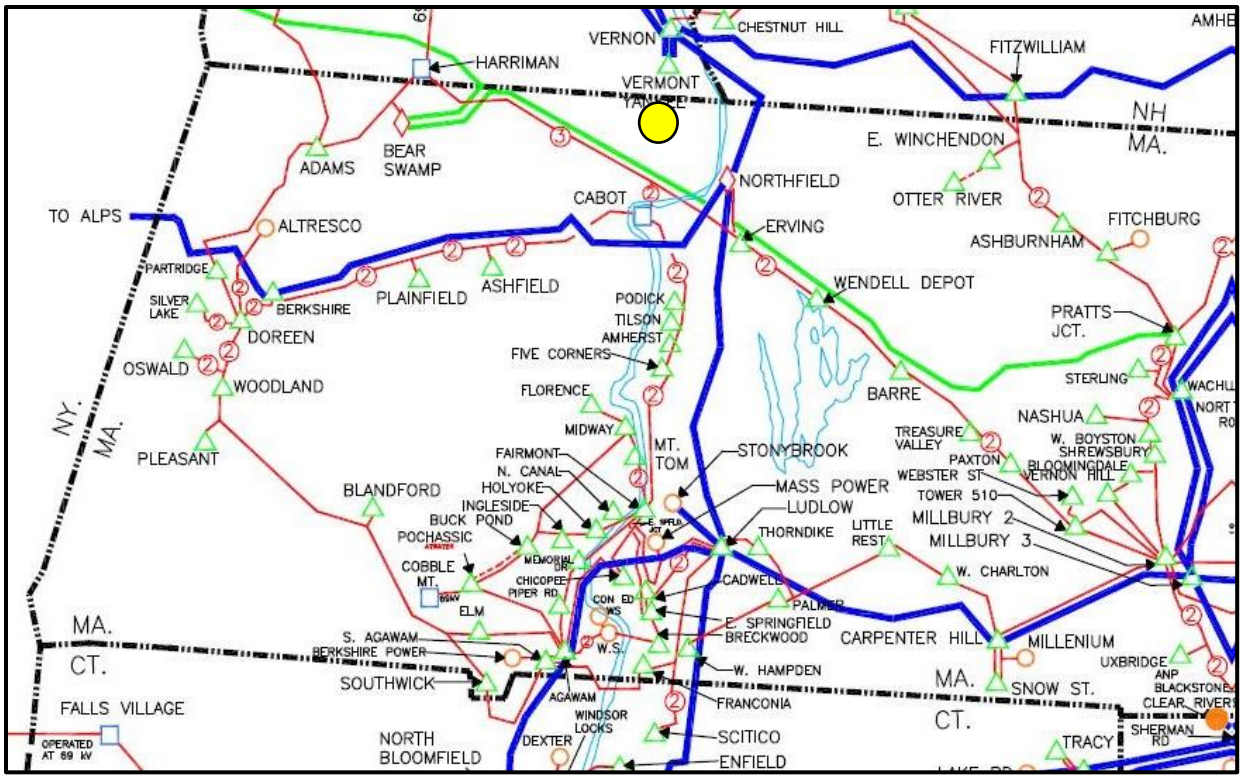


Figure 1 Major electricity transmission lines and substations in western Massachusetts. The location of Leyden is shown as a yellow circle. Source: ISO New England 2019

2.3 Existing Grid Infrastructure

Due to Leyden's small population and lack of industry, the town does not have a large electricity demand. As shown in Figure 2 below, the town is served by one three-phase power line running the length of the town. This circuit is named 22B7 and currently has a hosting capacity of 1,000 kW (1.0 MW).

The distribution line runs north from the southern border of town, following Greenfield Road until it meets South Country Road. The line then curves west and follows South Country Road until it meets back up with Greenfield Road. At the fork of Greenfield Road and Mid Country Road the line splits; one branch continues along Greenfield Road for 0.55 mi, while the other branch follows Mid Country Road until it turns into West Leyden Road. At the end of West Leyden Road, the line follows North Green River Road along the town line for about a mile before coming to an end. The line has an average operating voltage of 13.8 kV; three-phase lines typically have an average voltage level between 11 and 33 kV. As illustrated in Figure 2a below, the 22B7 distribution line is connected to the 22B CUMBERLAND station, located south of Leyden in Greenfield, off Lower St. near the town landfill.

The remainder of town is served by single-phase power lines, which branch off from the three-phase line onto residential streets.

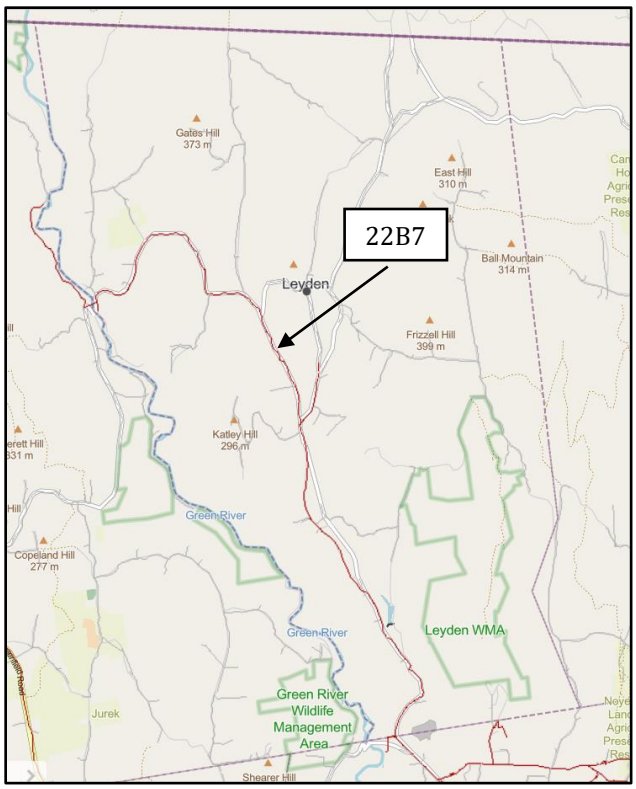


Figure 2a: The major three-phase distribution line (red lines) serving Leyden. Single-phase lines are shown in gray. Source: Eversource DG Hosting Capacity Map, https://eversource.maps.arcgis.com

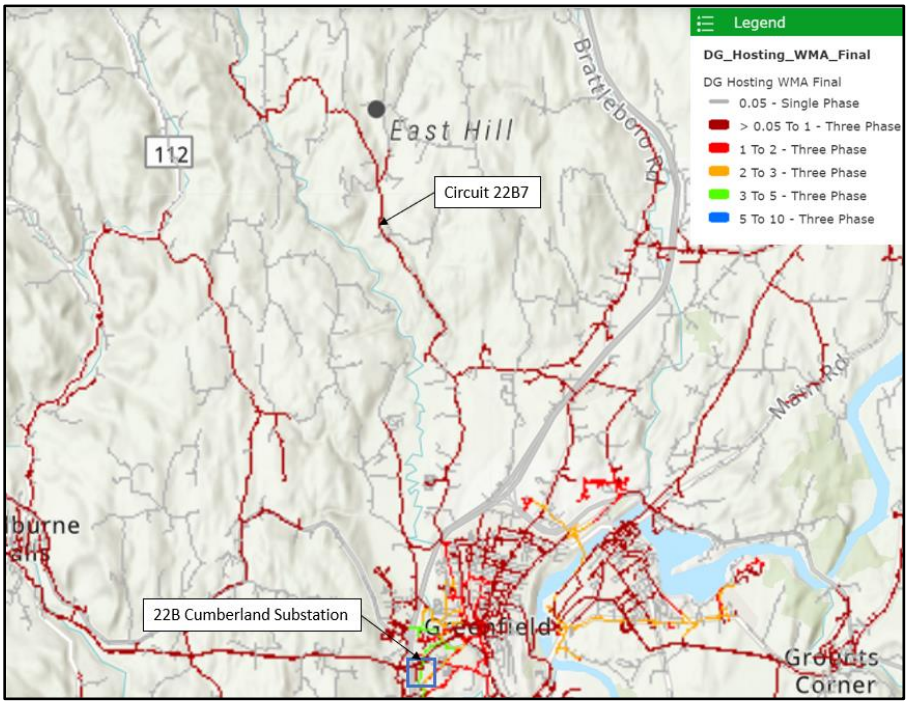


Figure 2b: The 22B CUMBERLAND substation (blue box) and major three-phase distribution lines (red lines) serving Leyden. Single-phase lines are shown in gray. Source: Eversource DG Hosting Capacity Map, https://eversource.maps.arcgis.com

2.4 Existing Hosting Capacity

Historically, distribution lines in the electricity grid were designed as somewhat akin to one-way streets, supplying power to homes and businesses from large power plants connected to high-voltage transmission lines. With the addition of solar and wind resources, there are now many energy-generating facilities that seek to interconnect to the grid via distribution lines. These "distributed generation" electricity sources require that distribution lines act as two-way streets instead, allowing for energy to flow into the grid via distribution lines, while still allowing energy to continue to flow outward into individual homes and businesses. Balancing this two-way flow can represent a challenge for ensuring reliability and safety of the grid. This is especially true where distributed generation electricity sources are renewable sources, such as wind and solar energy, which supply electricity to the grid in an intermittent and variable manner. In order to ensure that generation facilities can be connected safely, developers are required to obtain written permission from the local utility company before interconnecting these systems to the electricity grid.

The "hosting capacity" of an electric power line identifies its ability to incorporate distributed generation electricity sources, such as wind and solar. In most places, including those served by single-phase distribution lines, small solar systems of up to 50 kW can be incorporated without adverse impacts on the grid's reliability. In areas served by three-phase power lines, solar systems of up to 200 kW can typically be interconnected without significant challenges. However, for larger systems, it is necessary to ensure there is sufficient capacity available on the distribution line before these facilities can be built and interconnected. Otherwise, power lines or substations may require upgrades before additional distributed generation sources can be interconnected without compromising reliability. While not true across the board, an industry 'rule-of-thumb' is that 6 MW can be connected safely for every 13.8 kV distribution line. In western Massachusetts, where many towns are served by one or a few low-voltage feeder circuits, the local grid can quickly become "saturated," such that there is not sufficient hosting capacity to incorporate additional medium to large solar arrays.

The state of Massachusetts now requires that utilities provide publicly available maps and data regarding the available hosting capacity of distribution lines, and the level of saturation of individual feeder circuits. This public information lists all projects greater than 25 kW in capacity connected to three-phase lines, and all projects greater than 10 kW connected to single-phase lines. If circuits are currently saturated, it does not mean that no more distributed generation systems can be added to the circuit, but does suggest that upgrades are needed before additional large projects can be interconnected. Upgrades may involve significant costs, which the energy facility developer is typically expected to pay for, as a condition of interconnection. Previously, interconnection applications were considered on a project-by-project basis, but recently, ISO New England has determined that multiple projects may be considered together as one group for the purposes of interconnection, in what are known as "Affected System Operator," or Group, studies. This change is anticipated to streamline the review of interconnection requests for projects "queued" up to connect to each circuit. Even if areas currently appear saturated on the map, they may not remain so. Companies developing large, more lucrative solar projects may be able and willing to support significant upgrades to these circuits (either individually or in groups with cost sharing). New upgrades may then open up new hosting capacity.

Table 1 below provides a listing of distributed generation projects over 25 kW in capacity that are online, authorized, or in process in Leyden, or located in adjacent towns that use the same 22B7 circuit**.** It is not known how many of the projects currently "in process" will ultimately be built and connected to the grid.

City/Town	Design Capacity (kW)	Fuel Type	Date Application Deemed Complete	Date Interconnection Agreement Sent	Authorization to Interconnect	Status of Project
Deerfield	30	Solar	10/19/2011	11/7/2011	2/3/2012	Online
Deerfield	25	Solar	5/7/2019	8/15/2019	12/11/2019	Authorized
Greenfield	50	Solar	1/11/2011	1/12/2011	2/10/2011	Online
Greenfield	83	Solar	7/8/2011	12/13/2011	2/6/2012	Online
Greenfield	600	Diesel	8/26/2014	1/7/2015	4/25/2018	Authorized
Greenfield	44	Solar	10/8/2015	2/17/2016		Cancelled
Greenfield	250	Other	3/1/2017			Cancelled
Greenfield	294	Solar	3/1/2017			Cancelled
Greenfield	995	Biogas	3/20/2017			Cancelled
Greenfield	1,000	Solar	12/21/2017	11/20/2018		In process
Greenfield	500	Solar	12/21/2017			Cancelled
Greenfield	4,998	Solar	7/24/2018			In process
Greenfield	498	Solar	3/9/2020			In process
Leyden	4,980	Solar	2/22/2019			In process
Leyden	38	Solar	9/7/2012	11/6/2012	5/22/2013	Online

Table 1 Distributed generation projects online, authorized, in process, or cancelled in Leyden and adjacent towns that utilize the same circuits. It is unknown how many of the projects currently "in process" will ultimately be built and connected to the grid. Source: DOER Circuit Analysis Pre-Screen Tool, October 2022.

The three-phase distribution line that serves Leyden, 22B7, has a current hosting capacity of 1,000 kW (1.0 MW). This line could handle interconnection of additional solar arrays, but access is limited and any solar projects larger than 1,000 kW on circuit 22B7 may require upgrades to the grid infrastructure. The currently limited hosting capacity of this circuit is likely due to the large projects currently "in process" in Greenfield and Leyden. Meanwhile, most single-phase lines could likely accommodate projects under 50 kW in size.

This description represents the local grid infrastructure as it is – planning for future scenarios of development could include recommendations for areas of grid infrastructure improvement to allow siting of distributed generation in preferred locations. Future scenarios may also include the addition of what are known as "non-wires alternatives," which can reduce the needs for grid upgrades. These are technologies like energy storage, energy efficiency, demand-response, and grid software, which reduce the need for additional power lines to be added to the grid.

3. MUNICIPAL PLANNING DOCUMENTS

3.1 Planning Documents & Bylaw Review

We conducted a brief review of relevant planning documents and municipal bylaws, and identified the following:

- To our knowledge, the Town of Leyden does not have a Master Plan.
- Leyden and Bernardston are collaborating to pursue funding for a Municipal Vulnerability Preparedness (MVP) planning process to address long-term community resilience.
- A Community Resilience Building and Hazard Mitigation Plan is currently being drafted (2022).
- Leyden's Conservation Commission is in the process of drafting a Large-Scale Solar Bylaw.
- The Town of Leyden does not currently have a wetlands bylaw.
- Leyden completed an Open Space and Recreation Plan (OSRP) in 2019.

3.2 Solar Zoning

Leyden's zoning bylaw was updated in May, 2014. A Large-Scale Solar Bylaw is currently being drafted by the town's conservation committee. *Note that this section of the report has been completed based on a past draft of the solar bylaw that is currently being edited*. The draft Large-Scale Solar Bylaw is summarized as follows:

Purpose: The purpose of the Large-Scale Solar Bylaw is to promote the creation of new large-scale ground-mounted solar photovoltaic installations by providing standards for the placement, design, construction, operation, monitoring, modifications and removal of such installations that address public safety, minimize impacts on scenic, natural and historic resources and to provide adequate financial. assurance for the eventual decommissioning of such installations.

Definitions: "Large" ground-mounted arrays are defined as having a capacity greater than 25 kW DC.

Districts & Applicability: The entire area of the Town of Leyden is designated as a "primarily Residential-Agricultural District." In addition, there is a Floodplain Overlay District as defined in Section 5.9 of the zoning bylaws. The draft Large-Scale Solar Bylaw does not discuss a specific Solar Overlay District, but discusses a "Designated Location," which might be considered as equivalent. The location designated by the Leyden Planning Board, in accordance with Massachusetts General Law Chapter 40A Section 5, where large-scale ground-mounted solar photovoltaic installations may be sited as-of-right, is 7.85 acres shown as "Parcel C" on Document No. 1815 in Plan Book 134, Page 40 at the Franklin County Registry of Deeds, owned by the Town of Leyden.

As written, the draft bylaw notes that Site Plan Review is required, but does not specify the conditions under which a Special Permit is required. It is possible the intention is that As-of-Right Siting with Site Plan Review is required in the "Designated Location," and Special Permits are required elsewhere.

Regardless of other requirements, projects must be in compliance with all laws, ordinances, and regulations, and must obtain a building permit and inspection. There also must be a site plan submitted showing all property lines, proposed changes to landscape, blueprints and building plans, electrical diagrams, as well as installation and owner contact information.

All large-scale ground mounted solar projects must be set back 50 feet from the street sideline, and 40 feet from adjacent property lines on the sides and rear. In addition to the setbacks, all structures should be

screened from view by vegetation when possible, to avoid visual impacts. In addition to these visual impacts, all projects must meet the design standards for lighting and signage listed in the (draft) Large-Scale Solar Bylaw section 4.7 1&2.

All projects must provide a copy of the project summary, electrical schematic, and site plan to the Leyden Fire Chief and the Police Chief. Upon request, the owner may have to develop an emergency response plan with the local emergency services.

Note that no mention of roof-mounted solar or small-scale (less than 25 kW) solar projects is made in the town's zoning bylaw.

3.3 Wetlands Bylaw

The Town of Leyden does not currently have a wetlands bylaw. However, the Leyden Conservation Commission is responsible for overseeing the protection and preservation of the town's wetlands and natural resources. Any construction, building, or project which may potentially affect a wetland or natural resource in the town must be approved through the Conservation Commission.

3.4 Open Space and Recreation Planning

The Town of Leyden completed its OSRP in December, 2010. The plan outlines the preservation of the town's natural and recreational resources based off of the feedback received from the 2009 Open Space and Recreation survey. The town's seven-year action plan outlined in the OSRP focuses on protecting local farmlands and forests, as well as discussing the potential for water quality monitoring town-wide. Adjustments to the zoning bylaws are to be made to ensure that new development conserves the town's rural character.

4. COMMUNITY INFRASTRUCTURE

4.1 Introduction

In this section, we briefly review community infrastructure of relevance to solar energy development and energy storage. Information included in this section was drawn from a variety of sources, including:

- Municipal representatives participating in this planning process
- Municipal planning documents
- Department of Energy Resources (DOER) databases of renewable energy generation facilities
- Community Involved in Sustaining Agriculture Farm Finder
- MassGIS geospatial data layers

Associated maps are provided in Appendix A of this document.

4.2 Existing Renewable Energy Infrastructure

Leyden already has a strong residential solar presence. There are 44 residential projects in town, with a total capacity of 355 kW. In addition to the residential projects, there is one larger ground-mounted array. This array is at the Angels Rest Retreat located in the northern part of town. This array has a capacity of 44 kW. At this time, there are no proposed solar projects pursuing permitting through town boards.

4.3 Potential Energy Storage Sites

Energy storage systems help to balance differences between electricity demand and generation and are especially valuable components for intermittent energy sources like wind and solar, which do not produce energy 24 hours a day, and may not be producing during times of peak demand.

Energy storage systems have the potential to allow larger solar facilities to be built in areas where interconnecting a medium or large solar array could otherwise exceed the ability of the local distribution lines to accommodate additional renewable energy capacity. Prices of battery storage are dropping quickly, but energy storage is still a relatively expensive technology. At present, these types of systems typically require loads larger than residential scale to be cost-effective where cost is the sole consideration, but these systems can provide energy reliability during outages, which means that they also provide additional value in terms of public health and safety.

In this section, we briefly review sites where considering energy storage may be of value. Further details on these and other sites may be identified in Leyden's MVP planning process.

4.3.1 Town Offices

Leyden's Town Offices may benefit from energy storage, as it is one of the larger buildings, utilized often, and important to the town's operations.

4.3.2 Bree-Z-Knoll Farm

Bree-Z-Knoll Farm has expressed interest in incorporating solar power in their dairy farm. The farm consumes a relatively large amount of electricity to facilitate its dairy production. As such, it may be another important location to implement energy storage.

4.3.3 Plaza of the Fire Department, Church, and Library

These three large, centrally located buildings represent a potentially important site for energy storage, which could provide resilience to Fire Department as a critical emergency facility in the case of a power outage.

5. SOLAR RESOURCE ASSESSMENT

5.1 Introduction

In this section, we identify, summarize, and attempt to quantify the available solar resources in the Town of Leyden. We identify a number of different types of potential resources in this assessment, including:

- Residential-scale solar resources (roof-mounted and small ground-mounted systems)
- Medium to large-scale roofs (greater than 5,000 sf)
- Parking lots
- Landfills and brownfields
- Other previously developed/disturbed land
- Undeveloped land with the potential for large, commercial-scale solar development

This analysis was a desktop analysis, incorporating publicly available geospatial data layers downloaded from MassGIS, the state's Bureau of Geographic Information. It is important to recognize that information contained within these data layers may be out-of-date, inaccurate, or include irregularities that reduce the accuracy of this analysis. For example, tax parcel data included in this analysis was last updated in 2018. Boundaries of conserved land outlined in the MassGIS Protected and Recreational Open Space data layer do not appear to line up perfectly with tax parcel boundaries. This should be considered as a preliminary analysis, providing direction regarding where more in-depth site assessments can be conducted.

5.2 Residential-Scale Resources

In this analysis, we will provide several rough estimates of solar potential, based on MassGIS structures data, and NREL solar potential estimates for small buildings. For this analysis, we follow NREL's definition of a "small building" as one with a roof area of 5,000 sf or less.

Based on MassGIS Structures data, the Town of Leyden has a total of 751 small buildings, totaling 98,732 sf in roof area. The majority of these buildings are residential structures, including houses, garages, and sheds, although some small businesses and farm outbuildings are included in this total. The National Renewable Energy Laboratory (NREL) estimates that nation-wide, an average of 26% of the roof area of small buildings is suitable for solar[2]. Therefore, we could project a total technical solar resource of 25,670 sf available, equivalent to 381 kW (0.4 MW) of solar. Of course, this is the *technical* resource available. It is not feasible to connect solar panels to electric lines at all locations, some roofs may not have the structural integrity necessary to support solar panels, and it is not cost-effective to install panels in locations where the available space is small.

NREL provides additional data and estimates regarding small building roof space in western Massachusetts[2]. A second, and perhaps more practical, estimate of residential-scale solar potential can be derived by considering the potential for roof-mounted OR small-scale ground-mounted arrays to support residential use. Leyden has a total of about 259 households. Approximately 75.2% of Leyden's small buildings have some roof space suitable for solar, with the most common impediment to development being tree shading on the property. If we assume 75% of households could install solar at their residences, either on a rooftop, or as a ground-mounted system, the town could ultimately have 208 residential

[2] 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).

systems. The average size of a residential solar system in Leyden currently 8.83 kW. By this method, we can estimate a potential residential solar capacity of 1,828 kW (1.8 MW).

5.3 Medium to Large-Scale Rooftops

Leyden has 13 buildings with roofs over 5,000 sf, totaling 100,967sf of roof space. NREL's analysis suggests that virtually all medium and large-scale buildings have a roof plane suitable for solar, and that on average, approximately 49% of area on medium-scale roofs is available[2]. Based on this statistic, an estimated 49,474 sf are suitable for solar. Our estimate of total technical potential on medium to large-scale roofs is 735 kW (0.7 MW). Again, this is the *technical* resource available, and does not reflect structural or financial considerations.

Table 2 provides a list of 13 large roofs in Leyden. This list includes the Town Hall, farms, and large residential homes. The numbers provided in the table reflect a rough estimate of technical potential, based on nationwide data from NREL. Our technical estimates are based on this statistic. As described above, this technical potential is not reflective of roof structural integrity or economic viability, and on-the-ground assessments would need to be conducted.

Structure/Ownership Status	**Street Address**	**Total Roof Area** (sq ft)	**Estimated Technical Solar Potential** (kW)
Barn, Sweet Morning Farm (Noreen Fay Pollen)	1096 GREENFIELD RD	5,079	37
Residence, Fred & Susan Pazmino	185 SOUTH COUNTY RD	5,135	37
Barn, Robert & Lynette Snedeker	170 FRIZZELL HILL	5,293	39
Residence, Jessica & Robert Provost	120 GREENFIELD RD	5,853	43
House + Barn Complex, Ann Zaveruha & Jeffrey Stebbins	45 COATES RD	7,560	55
Barn, Sidney & Jason Herron	85 GLEN RD	7,659	56
Barn, Giard Nominee Trust	39 NORTH BERNARDSTON RD	7,754	56
Barn, Sunny Dell Stables (Edward Glabach)	56 EAST HILL RD	7,893	57
Town Hall, Town of Leyden	7 BRATTLEBORO RD	8,154	59
Barn, Sidney & Jason Herron	85 GLEN RD	8,520	62
Barn, K Kaeleen & William R Butler	148 EAST HILL RD	8,610	63
Barn Complex, Bree-z Knoll Farm	160 N COUNTY RD	8,790	64
Barn, Bree-z Knoll Farm	160 N COUNTY RD	14,667	107

Table 2: A list of 13 large roofs identified in Leyden.

5.4 Parking Lots

We identified three sites with at least 0.5 acres of parking lot or paved area in town. Potential sites for parking canopies are summarized in **Table 3** (next page). Technical estimates are based on a packing density of 263 kW per acre[3]. Our estimate of total technical potential on the listed parking lots is 955 kW (1.0 MW).

Location	**Approximate Area** (acres)	**Estimated Solar Technical Potential** (kW)
Town Hall/Fire/Police Complex	1.16	305
0 Zimmerman Hill Road (Owners Robert & Lynette Snedeker)	1.09	287
Town Offices	0.88	231
100 Alexander Road (Owners John & Barbara Wallace)	0.50	132

Table 3: Parking lots and paved surfaces identified in Leyden.

5.5 Landfills, Brownfields, and other Disturbed Sites

Leyden consists largely of undeveloped land and has few previously disturbed/developed sites. The town has no brownfields as identified by MassDEP. According to assessors' records, there are no properties identified as quarrying, mining, or sand and gravel operations (FY2022). There is one property straddling the southern border of Leyden that appears to include a former gravel pit. This site comprises roughly 15 acres of disturbed land, including land over the line into Greenfield. See Table 4 for this and other potential areas of bare soil that could represent previously disturbed sites. The other sites are smaller and more difficult to identify definitively as previously disturbed areas.

Location	**Approximate Area** (acres)	**Estimated Solar Technical Potential** (kW)
0 Greenfield Road; southern border of Leyden (Owner: Ashley Webb)	15	3,000
51 Brooks Road (Owner Elaine Brooks)	1.75	350
533 West Leyden Road (Owners David & Norma Capparrille)	0.6	120
135 Gates Rd (Owners Jeffrey & Diedrick Neipp)	0.5	100

Table 4: Potential previously disturbed sites in Leyden.

In addition to the disturbed areas noted above, as noted in the grid infrastructure section of this report, there is an electricity transmission line which run through Leyden. The right-of-way (ROW) associated

[3] Krishnan, Ram. 2016. *Technical solar photovoltaic potential of large scale parking lot canopies*. Dissertation, Michigan Technological University.

with this line is maintained as open land by the utility. While not as disturbed as the other types of sites mentioned above, the ROW is partially developed, and include large areas of land. The ROW, which cuts diagonally across town, is cleared to ~80 ft wide and runs roughly 5.2 miles through Leyden, for a total area of about 50 acres. Although much of this area may not be suitable for solar – particularly due to bordering trees providing too much shade on the edges of the ROW through some sections, although also due to steep slopes, portions crossing through or near private property, and viewshed considerations - the ROW could potentially provide significant space for ground-mounted solar development. A major challenge in developing ROWs is that there is not a common practice of developing electricity transmission ROWs for solar. Utility companies typically prefer to keep these areas clear to allow for easy maintenance of transmission lines as well as underlying vegetation. However, this type of land area represents a potential untapped resource for solar across Massachusetts.

5.6 Agricultural Resources

Leyden has a number of farms and significant extent of prime farmland soils. Based on MassGIS Land Cover data, 1,013 acres are dedicated to agriculture in Leyden, including 987 acres in hay/pasture and 26 cultivated acres. **Figure 3** below shows a map of Leyden, with areas of prime farmland highlighted in green.

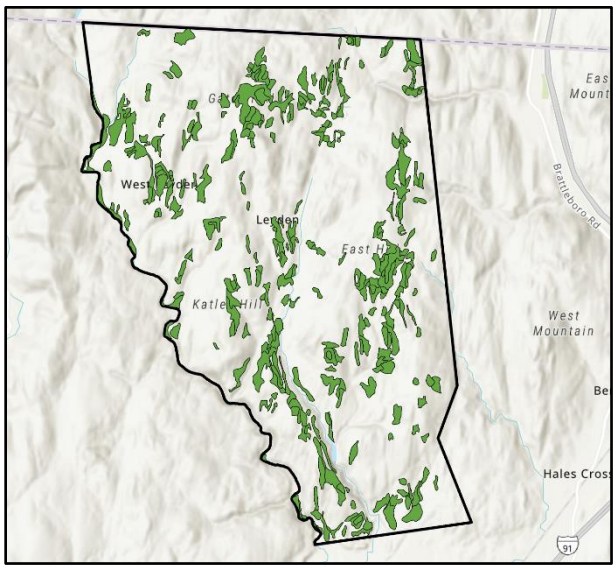


Figure 3: Areas of prime farmland in Leyden (shown in green).

Leyden's 2010 OSRP encourages farmers to use the Agricultural Preservation Restriction (APR) program as a way of ensuring that their land remains in agriculture use. The OSRP lists approximately 3% of Leyden's farmland as "protected", and 87% of Leyden's open space farmland as "temporarily protected". Maintaining and preserving farmland is a priority for the town. Currently, 18 properties totaling 659 acres are permanently protected via an APR. A total of 40 properties are currently (2018) enrolled in the Chapter 61A program for the purposes of agricultural production, totaling 1,138 acres. In addition, there are some mixed-use properties which include land enrolled in Chapter 61A.

The following farms in Leyden could be approached regarding their interest in agriculturally related energy projects:

- Bergeron Sugar House - Brattleboro Road
- Bree-Z-Knoll - 160 North County Road

- Dancing Bear Farm - 181 Frizzell Hill Road
- East Hyland Farm - 85 Glen Road
- Leyden Glen Farm - 31 Glen Road
- Sunny Dell Stables – 56 East Hill Road
- Sweet Morning Farm, LLC - 910 Greenfield Road

At least ten large barn roofs could be potential sites for roof-mounted solar systems (see Section 5.3). Roof-mounted systems designed to support on-farm electricity use, solar parking canopies to protect farm equipment, dual-use systems developed to allow continued use of the land underneath the panels for agriculture, or other types of solar facilities may be appropriate for some of these sites. On-farm solar potential can be further explored in conjunction with the Massachusetts Department of Agricultural Resources, which provides agricultural energy grants to farms across the state

The Town of Leyden has set a goal to refurbish existing large buildings and to repurpose them. It is possible that these buildings could be rebuilt with solar infrastructure in mind.

5.7 Commercial-Scale Development Sites

As a final step in this analysis, we explored the potential for large-scale commercial solar development. When looking for a location to install a solar facility, solar developers typically look for a location near (within 2,000 ft of) a three-phase distribution line because the expense of upgrading single-phase lines to allow interconnection of a solar facility can be cost-prohibitive. In addition, commercial developers typically look for a site where it is possible to install a large facility. For this analysis, we considered a minimum lot size of 5 acres, which could accommodate a solar facility of at least 1 MW.

Table 4 below shows land use in Leyden, based on Mass Audubon's analysis[4]:

Condition Type	Total Acres	% of total town land	Rank in MA
Natural Land	9,933	83%	152nd
Open Land	1,392	12%	152nd
Developed Land	175	2%	333rd

Table 4: Land use in Leyden.

According to Mass Audubon, 6 acres of land were developed in Leyden over the past 10 years, placing Leyden at 334th in the state in terms of land developed. Between 2012 and 2019, 980 acres of land were conserved in Leyden (placing it at 45th in the state), 62 acres of which were BioMap2 Core Habitat (190th in the state), 471 of which were BioMap Critical Natural Landscape (52nd in the state), and 45 of which were ranked as "resilient" lands by The Nature Conservancy (41st in the state).

Because the vast majority of Leyden is undeveloped, properties of a size appropriate for commercial-scale solar development sites are most likely to consist largely of undeveloped land. When evaluating the potential for commercial-scale solar development, it is important to consider what undeveloped areas which may be unsuitable for solar, either because they are legally protected from solar development or because they may be important areas for recreation or wildlife conservation.

[4] Ricci, E.H., J. Collins, J. Clarke, P. Dolci, and L. de la Parra. 2020. Losing Ground: Nature's Value in a Changing Climate. Massachusetts Audubon Society, Inc., Lincoln, Massachusetts, 33 pp.

In Leyden, there are a number of permanently protected properties which are not available for development. These include the Leyden Wildlife Management Area and Leyden Glen (owned by the city of Greenfield). In addition, there are a number of moderately-sized properties permanently protected through Agricultural Preservation Restrictions (as discussed in Section 5.6) and Conservation Restrictions.

Leyden also has a number of properties which are currently enrolled in the Chapter 61, Chapter 61A, and Chapter 61B programs for the purpose of providing timber products, recreation, wildlife habitat, or open space value. Chapter 61 programs act as a financial disincentive for solar development but do not preclude development of these parcels. A total of 54 properties are currently (2018) enrolled in one of these programs, comprising 1,306 acres. In addition, there are some mixed-use properties which include land enrolled in these programs.

The Green River forms the western border of Leyden. The town is home to large swamps and other wetlands, many located along the town's large streams, including Glen Brook, Thorne Brook, and Beaver Meadow Brook. Under the Massachusetts Wetland Protection Act, development in wetlands, lakes, rivers, and perennial streams is prohibited. The Conservation Commission must be consulted regarding any projects proposed within 200 ft of a river or stream or 100 ft of a wetland.

The town also has large areas of BioMap2 habitat, which represent valuable habitat for wildlife. Solar development is not prohibited in these areas but may require review by the state Natural Heritage and Endangered Species Program. In addition, these areas are not currently eligible for state incentives for solar development, due to the values they offer as open land maintained in its natural condition. Much of Leyden is mapped as BioMap2 habitat, although there are portions of the south-central part of town that are not priority wildlife habitat.

As noted above, for this analysis of potential sites for commercial-scale development, we considered properties with a minimum lot size of 5 acres – equivalent to approximately 1 MW of solar development – located within 2,000 feet of an existing three-phase distribution line. Within Leyden, 151 properties meet these criteria, but 26 properties are largely comprised of permanently protected land. This leaves 125 properties with the potential for commercial-scale solar development, totaling some 2,688 acres. However, wetlands comprise a considerable portion of these properties, and are not available for development. Removing wetland areas leaves approximately 2,614 acres available for development across these 117 properties.

The current state solar incentive program does not provide incentives for solar development on land identified in state databases as important habitat conservation land – designated either as BioMap2 Core Habitat or Critical Natural Landscapes – or for development on parcels on which more than half of property receives this designation. Further excluding these parcels, as well as the BioMap2 habitat on developable parcels, 63 properties remain with the potential for large-scale solar development, totaling roughly 973 acres of land that is not comprised of permanently protected land, wetlands, or BioMap2 habitat. Note that this estimate does not take into consideration the current land use at the property, and some of these properties may include commercial enterprises, agricultural land, single-family homes, and residential yards.

See **Map A4** in Appendix A for a map of properties with the potential for large-scale solar development overlaid with constraints on development (i.e., permanently protected lands, wetlands, BioMap2 habitat). Much of Leyden is mapped as BioMap2 habitat, but there are a number of parcels in the south-central part of town which are not permanently protected, do not have large wetlands, and do not consist largely of BioMap2 habitat. Some of these parcels have buildings located on them and others do not.

These values do not include additional considerations regarding existing land cover or the town's expressed interest in preserving Leyden's scenic beauty.

5.8 Summary

Table 5 below provides a summary of solar resources identified in this assessment.

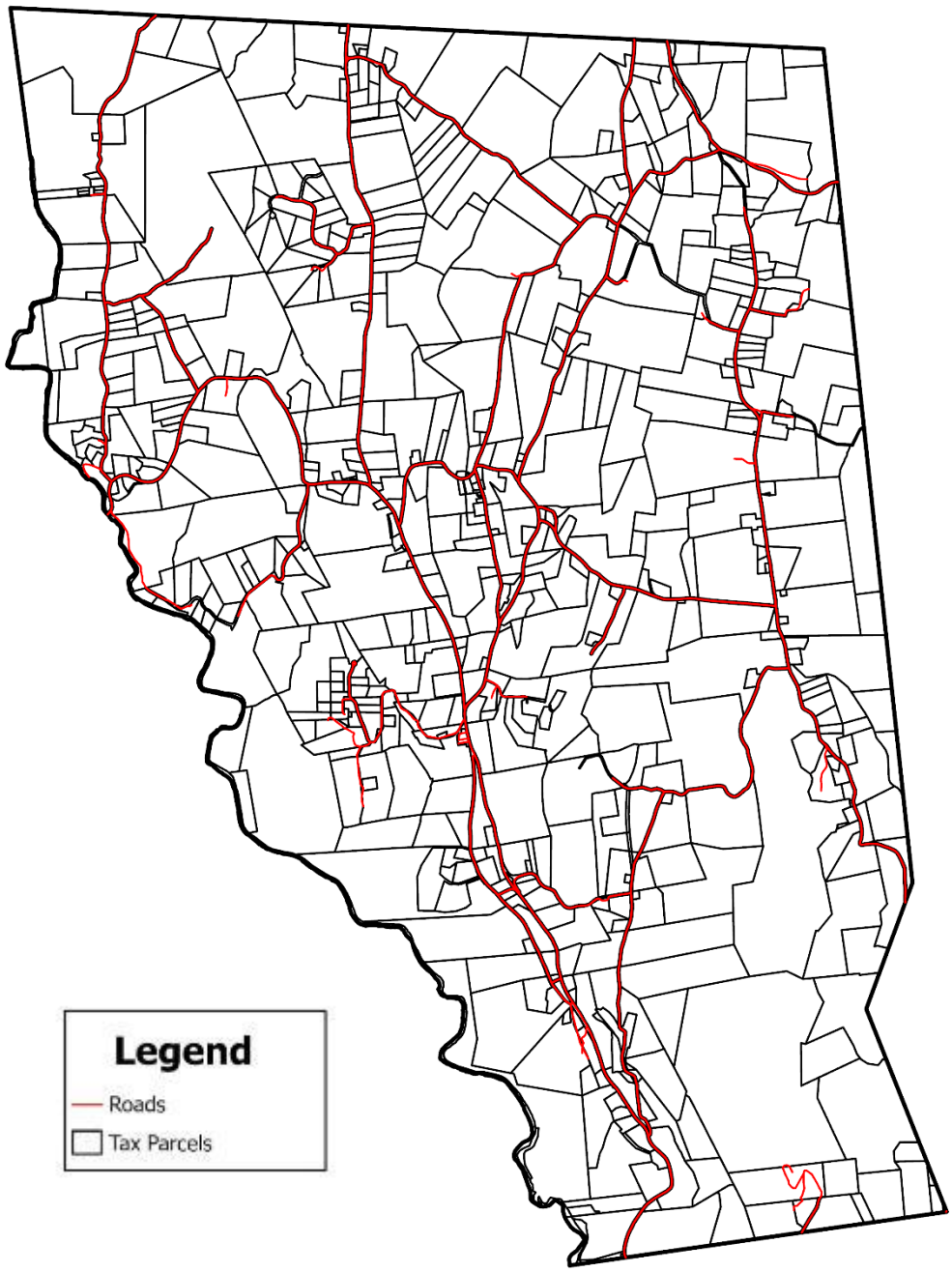
Resource Type	**Resources Available**	**Estimated Technical Potential**
Residential-Scale Solar	- 277 total residential households; estimated 25,670 sf of small building roof space suitable for solar - Estimated 208 residential properties (75.2%) could support some solar -Average size of a residential solar array in Leyden is currently 8.83 kW.	At least 1.8 MW, assuming that 75.2% of households can install a roof or ground-mounted system -381 kW (0.4 MW) if all small building roofs were developed
Medium to Large Scale Roofs	-13 large roofs; estimated 100,967 sf of large building roof spaces suitable for solar	Estimated at 0.7 MW
Parking Lots	Potential parking canopy sites at: - 1.16 acre lot at Leyden Town Hall/Police/Fire complex - 1.09 acre lot on Zimmerman Hill Rd - 0.88 acre lot at Leyden Town Offices -0.50 acre lot at 100 Alexander Rd	1.0 MW, if all sites listed were to be developed
Landfills, Brownfields, and other Previously Disturbed Sites	-15-acre former gravel pit straddling Leyden/Greenfield line -5.2 miles of electricity transmission line ROW -Other areas of bare soil could represent previously disturbed sites, total 2.85 acres	-3 MW at former gravel pit -Feasibility of solar facility in electricity transmission line ROW TBD -Other sites TBD, up to 570 kW if all sites developed
Agricultural Resources	- Active farms and private residences, total of 10 large barn roofs (and likely many smaller barn roofs) - Estimated 1,301 acres in agricultural production - More than 1,138 acres in Chapter 61A program for agriculture	-0.6 MW of large barn roofs -Other capacity dependent on project type (e.g., solar greenhouses, parking canopies for farm equipment, agrivoltaic arrays, solar arrays at field margins)

Undeveloped Land	-117 large land parcels located near three-phase power have at least 5 acres that are not permanently protected, not wetlands, and are near three-phase power = 2,614 acres of non-wetland land -63 large land parcels have at least 5 acres located near three-phase power that are not permanently protected, not wetlands, and not located on properties that are more than 50% BioMap2 habitat, eligible land on these properties = 973 acres	Approximately 1 MW per 5 acres: 2,614 acres = 523 MW 973 acres = 195 MW *It is not expected that all undeveloped land available would be built out for solar development.*

Appendix A – Maps of Solar Resources and Infrastructure

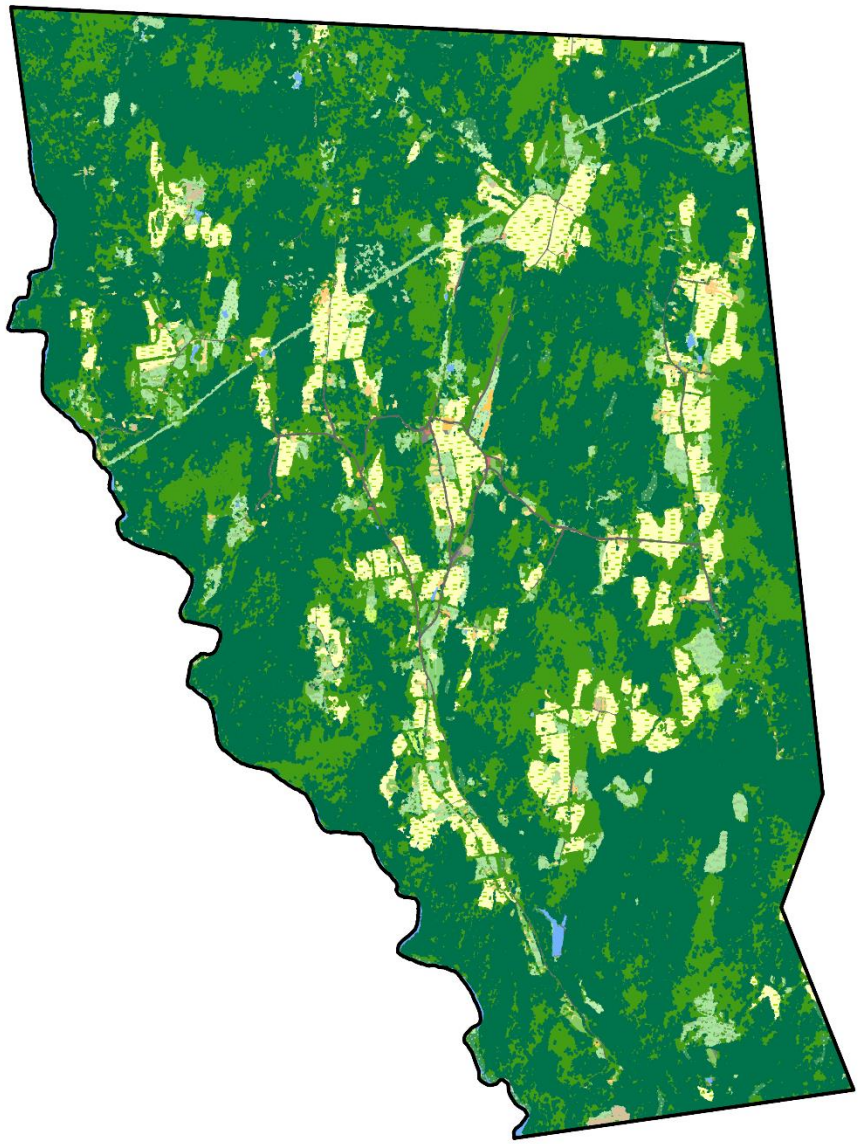
A.1 Roads and Property Lines

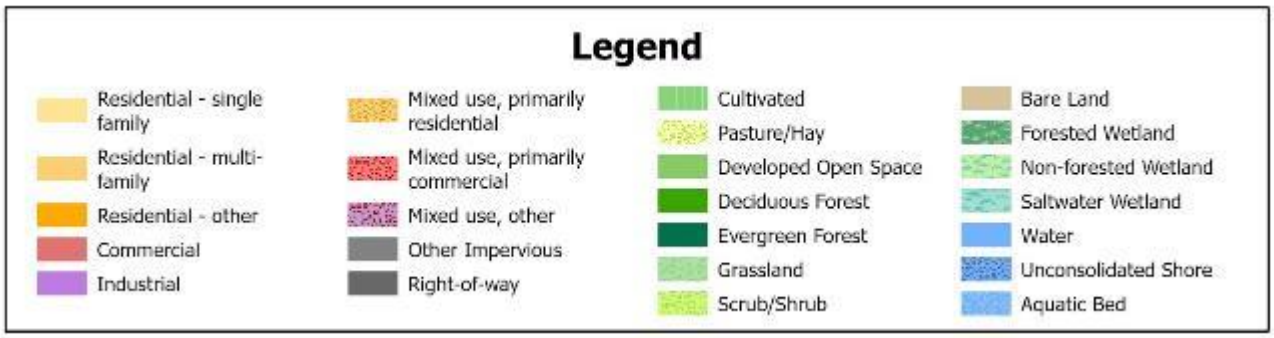
Data from MassGIS Tax Parcel data (https://docs.digital.mass.gov/dataset/massgis-data-standardized-assessors-parcels) and MassDOT roads (https://docs.digital.mass.gov/dataset/massgis-data-massachusetts-department-transportation-massdot-roads).



A.2 Land Cover

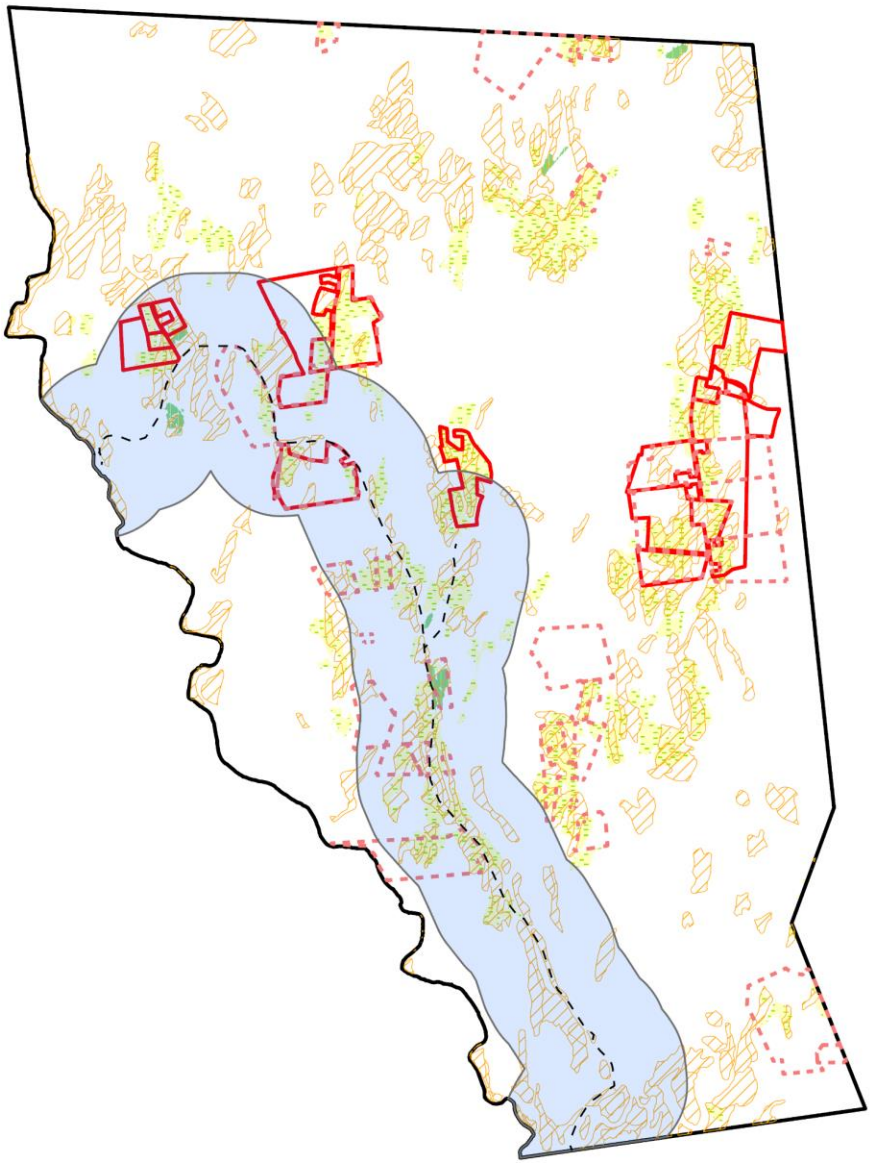
Land cover data from the MassGIS Land Cover/Land Use data layer, updated in 2016 (https://docs.digital.mass.gov/dataset/massgis-data-2016-land-coverland-use).





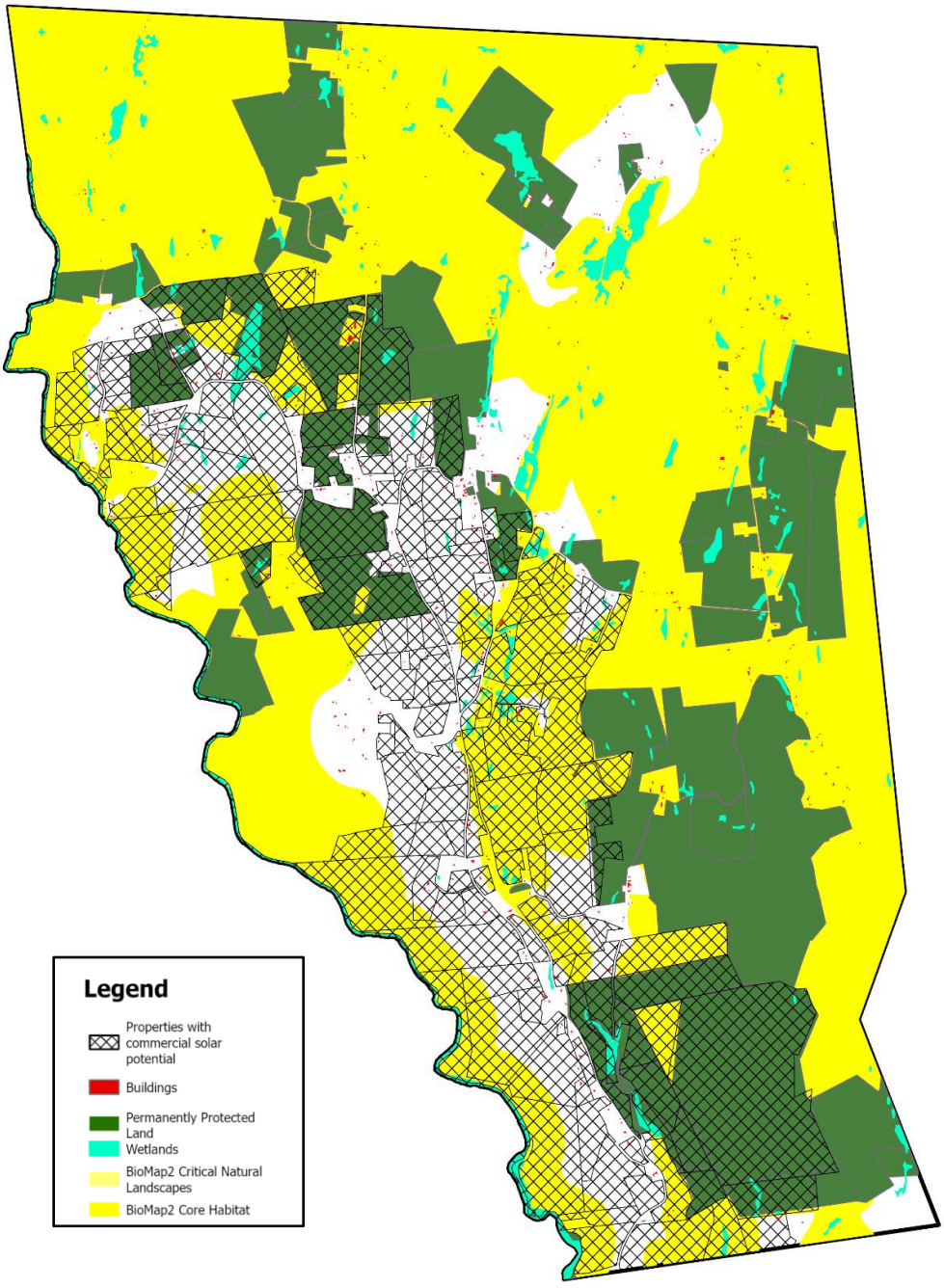
A.3 Agricultural Resources

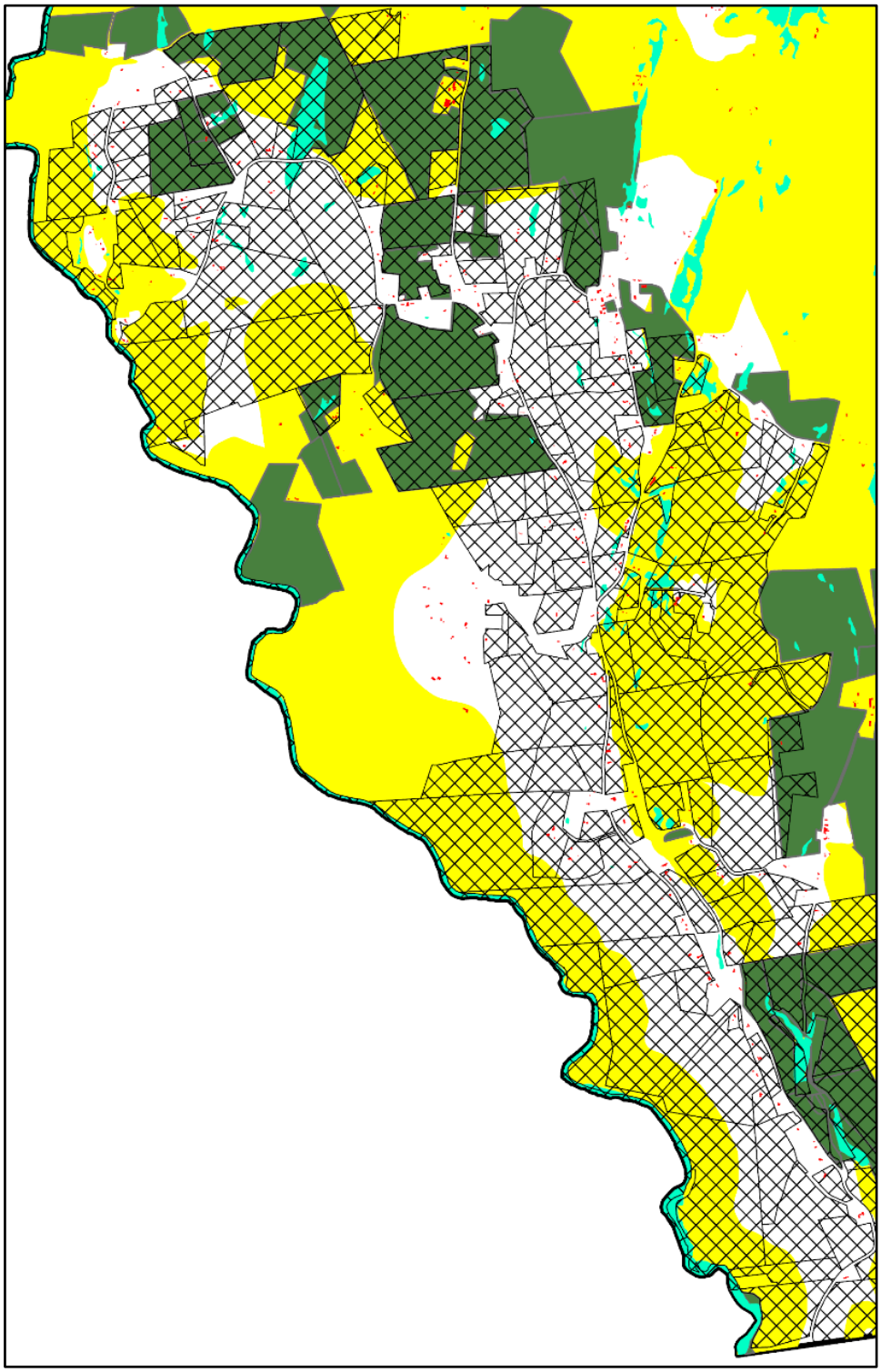
Data from MassGIS Tax Parcel data (https://docs.digital.mass.gov/dataset/massgis-data-standardized-assessors-parcels), MassGIS Land Cover/Land Use data layer (https://docs.digital.mass.gov/dataset/massgis-data-2016-land-coverland-use), and NRCS SSURGO-Certified Soils (https://docs.digital.mass.gov/dataset/massgis-data-nrcs-ssurgo-certified-soils).



A.4 Parcels available for Commercial-Scale Development

This map depicts parcels suitable for solar development due to large size (5 acres or more) and proximity to three-phase distribution lines (within 2,000 ft), as well as several constraints on development, including permanent conservation protections, presence of wetlands, and extent of BioMap2 wildlife habitat. Buildings present on the property could also indicate a competing land use. Data from MassGIS BioMap2 repository (https://docs.digital.mass.gov/dataset/massgis-data-biomap2), MassGIS Protected Land and Recreational Open Space (https://docs.digital.mass.gov/dataset/massgis-data-protected-and-recreational-openspace), and MassGIS OLIVER DEP wetlands data layer (http://maps.massgis.state.ma.us/map_ol/oliver.php).





Close-up of south-central portions of town. Note that some parcels are near three-phase power and include large areas not mapped as priority wildlife habitat or wetlands, and not permanently protected, which means they could be suitable for solar development. However, competing land uses (such as residential or commercial use) are already occurring on some of these properties, which could preclude development for solar.