Solar Resource and Infrastructure Assessment for the Town of Wendell

Dwayne Breger,[1] Zara Dowling,[1] River Strong,[1] and Alison Bates[2]

1 UMass Clean Energy Extension
2 Colby College

NREL Technical Monitor: Sara Farrar

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REVIEW DRAFT

Solar Resource and Infrastructure Assessment

for

the Town of Wendell

June 30, 2020

Prepared by

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Clean Energy Extension

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Executive Summary

This report is a solar resource and infrastructure assessment for the town of Wendell, Massachusetts. The assessment was funded through the National Renewable Energy Laboratory, Solar Energy Innovation Network (NREL SEIN) Solar in Rural Communities Program, as part of a project to develop a Community-Informed Proactive Solar Siting and Financing Model. As a first step, the project lead organization, UMass Clean Energy Extension prepared an assessment of existing infrastructure, resources, and potential solar development opportunities in participating municipalities, including Wendell. This assessment was 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 reviewed existing electricity grid infrastructure, and the potential to interconnect additional solar facilities. At the present time, both distribution lines providing electricity to Wendell are over-saturated with authorized and proposed solar projects, and cannot accommodate additional solar projects to interconnect to the grid. It appears that National Grid is planning an upgrade to the Wendell Depot substation, which might then allow in-process projects are to proceed, and potentially free up additional capacity for new, large projects. Meanwhile, most three-phase lines could likely accommodate additional small-to-medium scale projects (under 200 kW), and most single-phase lines could likely accommodate additional 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 locations preferred by the community. Future scenarios may also include the addition energy storage and other "non-wires alternatives."

The Town Center has a cluster of residences and municipal buildings, including the Town Library, which already has a solar array, the Town Offices, and the Town Hall, which is intended to serve as an emergency shelter. This area could benefit from a solar array coupled with energy storage, with solar sited on municipal roofs, parking lots, or other impervious surfaces, such as the paved area surrounding the town Highway Garage. Other potential sites to consider for solar coupled with energy storage systems include the Swift River Elementary School and Kemsley Academy. Additional potential sites for solar identified in this report include the municipal landfill, the D&B landfill, and Scott's Garage.

There is also significant potential for additional solar arrays on residential rooftops and properties, businesses, small parking lots, and farms.

Depending on the restrictions imposed, there are still a number of large parcels in Wendell which could be appropriate for large-scale, commercial development of solar. Given the extent of forest land cover throughout the town, it may be difficult to identify sites where large arrays could be built without significant clearing of trees, or replacement of agricultural production.

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

This draft report will be made available to NREL SEIN and the full project team for feedback and revision, before a final public version of the document is issued.

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
NREL - National Renewable Energy Laboratory
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
SEIN - Solar Energy Innovation Network, a program of the National Renewable Energy Laboratory
sf - square feet

1. INTRODUCTION

This report is a solar resource and infrastructure assessment for the town of Wendell. Wendell is a small, rural community located along the eastern edge of Franklin County in Massachusetts. The town has a total land area of 20,646 acres (32.3 square miles). Estimates based on the 2010 census would suggest the town currently has a population of approximately 850 residents, living in a total of 395 households. Wendell became a designated Green Community in 2012, joining other municipalities across the state in setting ambitious goals for energy use reduction and encouraging renewable energy development[1].

This assessment was funded through the National Renewable Energy Laboratory Solar Energy Innovation Network (NREL SEIN) Solar in Rural Communities Program, as part of a project to develop a Community-Informed Proactive Solar Siting and Financing Model. The overall goals of the project include development of actionable, site-specific solar development plans for three rural municipalities, as well as development of a series of clear protocols, tools and templates to support implementation of this model in rural communities across the Northeast. The project team includes UMass Clean Energy Extension (CEE), the UMass Department of Environmental Conservation, the Massachusetts Department of Energy Resources (DOER), the Massachusetts Department of Agricultural Resources (MDAR), the Pioneer Valley Planning Commission (PVPC), the Franklin Regional Council of Governments (FRCOG), the Western Massachusetts Community Choice Energy Task Force, UMassFive College Credit Union, Northeast Solar, PV Squared, Co-op Power, and the Towns of Blandford, Wendell and Westhampton.

As a first step, the project lead organization, CEE, prepared an assessment of existing infrastructure, resources, and potential solar development opportunities in each participating municipality, in consultation with a subset of project partners (DOER, PVPC, FRCOG, municipal representatives). This assessment was 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 and the solar overlay district
- Town conservation priorities and conservation land
- Existing renewable energy facilities
- Priority energy storage sites
- Sites with potentially moderate to heavy electricity use
- Areas available for development on:
    - Residential rooftops and properties
    - Medium to large-scale rooftops
    - Parking lots
    - Landfills and brownfields
    - Other previously developed sites
    - Farms
    - Undeveloped land suitable for commercial development

This draft report will be made available to NREL SEIN and the full project team for feedback and revision, before a final public version of the document is issued.

[1] For more information, see the DOER Green Communities Division website (https://www.mass.gov/green-communities-designation-grant-program).

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 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.

It is important to note that while existing grid infrastructure may currently constrain the types of solar projects that can be developed cost-effectively 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 electricity 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 **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.

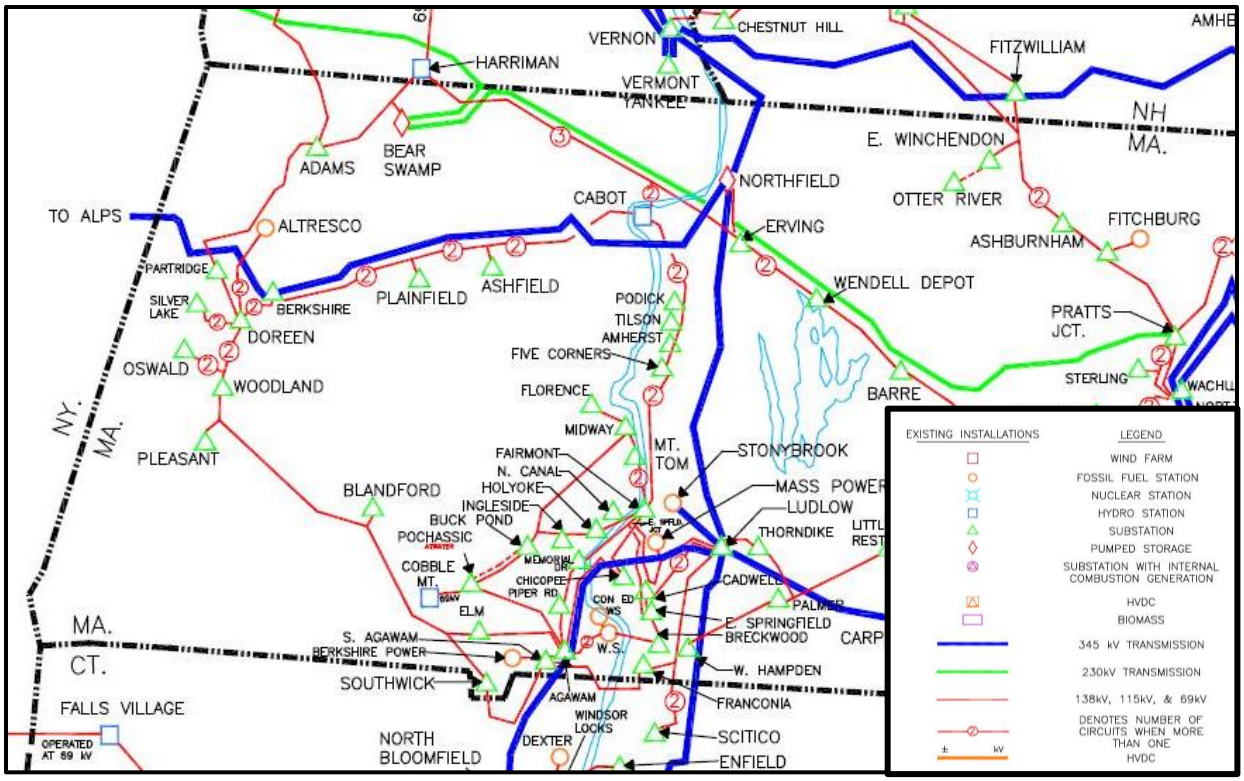


Figure 1 Major electricity transmission lines and substations in western Massachusetts.
Source: ISO New England 2019

2.3 Existing Grid Infrastructure

Wendell is served via a 115 kV transmission line, which connects to the Northfield pumped storage facility at its northwestern terminus, and to a 345 kV line at its southeastern terminus in Millbury, MA. A 230 kV transmission line also runs an adjacent route through the town, but does not provide electricity to the town.

A 13.8 kV distribution line, known as 09-705W3, runs along the Millers River on the northern edge of town. This three-phase line connects to the Wendell Depot substation on the south side of the Millers River, near Kentfield Road. From there, a 13.8 kV three-phase line, known as 09-705W1, covers Sears Road, and also runs down Wendell Depot Road, through the center of town, and south along Locke Hill Road as far as the intersection with Stage Road. The reminder of town is served by single-phase lines connecting to this line (**Figure 2**).

There is a second, temporary substation along the 09-705W1 line, just north of the intersection of Wendell Depot Road with Farley Road. The temporary substation is on a municipally-owned, 12-acre parcel, 3 acres of which is leased to National Grid. National Grid uses the temporary substation during periods when the Wendell Depot substation is being worked on. Substantial upgrades to the Wendell Depot substation are planned for Fall 2020, which would necessitate use of the temporary substation during this period.

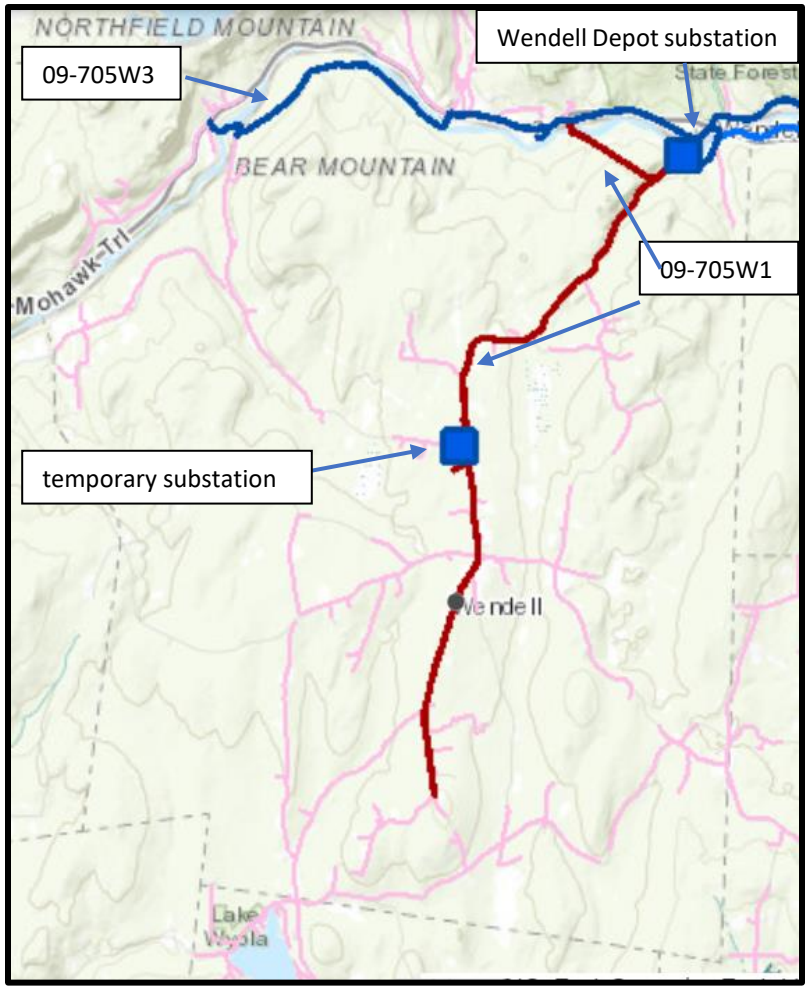


Figure 2 Wendell substations (blue boxes), three-phase distribution lines (red and blue lines), and single-phase distribution lines (pink lines).
Source: Distributed Generation Hosting Capacity Map, National Grid 2020

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 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.

A listing of distributed generation projects authorized or in process on Wendell feeder circuits is provided in **Table 1**.

The 09-705W3 feeder circuit serving the northern edge of Wendell has a total potential hosting capacity of 3,000 kW (3 MW) to interconnect distributed generation electricity sources. Of that total capacity, 1,452 kW has already been authorized, associated with five medium-to-large scale (70-920 kW) solar facilities in Orange and Athol. An impressive additional 22,970 kW (23 MW) of large-scale solar projects are in process, planned for Orange and Erving. Interconnecting all of these projects would likely require major upgrades to existing infrastructure.

The 09-705W1 feeder circuit has a total potential hosting capacity of 3,000 kW (3 MW). This potential capacity is over-saturated with authorized projects, totaling 7,620 kW, associated with two natural gas facilities in Erving (5.6 MW and 0.65 MW respectively), and a 1 MW solar array in Wendell. There are an additional two large solar facilities (2.8 MW and 3.1 MW) in process along this circuit. These projects have held up interconnection of a medium-scale, community-shared 220 kW project proposed for the 09-705W1 feeder circuit.

Circuit Name	Municipality	Capacity (kW)	Facility Type	Status of Project	Complete Application Date	Interconnection Agreement Sent Date	Authorization to Interconnect Date	Expedited/ Standard / Complex Project	Device Type
09-705W1	Erving	5600	Natural Gas	Authorized	10/22/2014	11/30/2015	11/30/2015	STD	Vacuum Ckt Bkr.
	Wendell	1000	Solar	Authorized	12/26/2012	2/6/2015	12/28/2018	STD	Vacuum Ckt Bkr.
	Erving	650	Natural Gas	Authorized	5/23/2013	12/9/2013	5/17/2019	STD	Vacuum Ckt Bkr.
	Wendell	220	Solar	In Process	7/3/2018			EXP	Vacuum Ckt Bkr.
	Wendell	2791	Solar + Battery Add-On	In Process	10/24/2017			STD	Vacuum Ckt Bkr.
	Wendell	3100	Solar	In Process	12/3/2018			STD	Vacuum Ckt Bkr.
09-705W3	Orange	142	Solar	Authorized	10/20/2010	2/2/2011	6/3/2011	EXP	Vacuum Ckt Bkr.
	Orange	70	Solar	Authorized	7/10/2014	9/11/2014	12/16/2016	EXP	Vacuum Ckt Bkr.
	Orange	80	Solar	Authorized	12/17/2015	1/29/2016	12/29/2016	EXP	Vacuum Ckt Bkr.
	Orange	920	Solar	Authorized	2/5/2015	9/10/2015	5/30/2017	STD	Vacuum Ckt Bkr.
	Athol	240	Solar	Authorized	7/20/2018	8/13/2018	7/12/2019	STD	Vacuum Ckt Bkr.
	Orange	3000	Solar	In Process	5/7/2018			STD	Vacuum Ckt Bkr.
	Erving	4990	Solar	In Process	4/2/2018			STD	Vacuum Ckt Bkr.
	Erving	4990	Solar	In Process	4/5/2018			STD	Vacuum Ckt Bkr.
	Orange	4995	Solar	In Process	6/2/2017	1/8/2018		STD	Vacuum Ckt Bkr.
	Orange	4995	Solar	In Process	6/2/2017	1/8/2018		STD	Vacuum Ckt Bkr.

Table 1 Medium and large-scale (> 25 kW) distributed generation projects authorized or in process on the feeder circuits which serve Wendell. Source: DOER Circuit Analysis Pre-Screen Tool, April 2020.

In summary, the primary feeder circuits serving Wendell are over-saturated with authorized and in-progress projects. For the immediate future, any new large-scale projects to be proposed would likely require significant upgrades to grid infrastructure. Meanwhile, most three-phase lines could likely accommodate additional small-to-medium scale projects (under 200 kW), and most single-phase lines could likely accommodate additional 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:

- The town does not have a Master Plan.
- The town is currently in the process of completing the Municipality Vulnerability Preparedness (MVP) process, for which it was awarded state funding in FY2019.
- The town's zoning bylaws include a section which specifically addresses solar development. Wendell's zoning bylaws were updated in October 2019. The changes included a temporary moratorium on large ground-mounted solar arrays, while the bylaws are further updated. The moratorium is in effect through December 2020. The content of these bylaws is addressed below under Section 3.2 *Solar Zoning Bylaws*.
- The town has a municipal wetlands bylaw, which is summarized below under Section 3.3 *Wetlands Bylaws*.
- The town has an Open Space and Recreation Plan (OSRP), which was completed in 2010. A summary of town conservation priorities from the plan is briefly outlined in Section 3.4 *Open Space and Recreation Planning.*

3.2 Solar Zoning

Wendell's current solar zoning bylaw categorizes solar PV arrays into four types:

1. Building-mounted
2. Small-scale ground-mounted (10 kW or less)
3. Large-scale ground-mounted (10 kW to 2 MW, no more than 10 acres of land)
4. Extra-large-scale ground-mounted (greater than 2 MW, or more than 10 acres of land)

No solar systems are addressed as an allowable use in the Historic Institutional District, which is comprised of a single parcel in the center of town (Assessor's Map 407, Lot 69). Building-mounted and small-scale ground-mounted systems are allowed by right in the Rural Residential and Agricultural district, which constitutes the remainder of the town. There are no explicit commercial or industrial zones in town. There is a solar overlay district which covers two inactive landfill sites: the former municipal landfill at 331 New Salem Road (Map 411, Lot 24), and the D & B landfill at 202 Mormon Hollow Road.

Historically, large-scale and extra-large-scale ground-mounted solar arrays in Wendell have required special permit approval, with site plan review by the Planning Board, except in the solar overlay district, where development is allowed by right, with site plan review by the Planning Board. Currently, new large-scale and extra-large-scale ground-mounted systems (types 3 &4) are not allowed per the Town's temporary moratorium, which is set to expire December 30, 2020. The one exception to the moratorium on large ground-mounted systems is for the solar overlay district.

Location considerations identified in the solar bylaw include topography, wetlands, NHESP priority habitat areas, floodplains, inundation areas for moderate or high hazard dams, local or National Historic Districts, water provision opportunities (for fire protection), and stormwater drainage. In order to minimize environmental impacts, the bylaw calls for proposed projects to avoid land clearing, avoid fragmentation of open space, and preserve natural habitat.

The setback distance from the property line for all large and extra-large ground-mounted projects is required to be 100 feet on all sides.

3.3 Wetlands Bylaws

Wendell's wetland bylaw extends Conservation Commission oversight beyond the state's Wetland Protection Act requirements, more explicitly extending limitations on development into the wetland buffer zone, as well as buffers around riverfront areas and vernal pools.

Lands within 100 feet of specific resource areas protected by the bylaw are presumed to be important to the protection of adjacent resource areas, and are protected by the bylaw as a resource area, presumed to provide or promote resource area values. Except as permitted by the Conservation Commission and described in the bylaw, construction within the riverfront area, 100 feet of any wetland, bank, or riverfront area, or 200 feet of a vernal pool, is prevented. The Commission requires that a fifty foot wide strip of undisturbed soil and native vegetation, called the Conservation Zone, be maintained adjacent to any freshwater wetland, isolated wetland, marsh, wet meadow, spring, bog, swamp, or bank, but not including riverfront area. No work, structures, disturbance or alterations are allowed within the Conservation Zone, except for minor activities, such as mowing, gardening, and pruning within existing lawn, garden or landscaped areas.

The bylaw further presumes that all areas meeting the definition of "vernal pools," and the adjacent 200 foot upland area, perform essential habitat functions. This presumption may be overcome only by the presentation of credible evidence. The Conservation Zone for vernal pools is a 100 foot setback of undisturbed native vegetation 100 feet outward from the mean annual high-water line defining the depression.

The land within the Swift River watershed that is regulated by DCR includes land associated with surface water or tributaries. All land within 400 feet of a tributary or surface water, within its floodplain or area of bordering vegetated wetlands (BVWs), and lands above aquifers are under DCR's jurisdiction. No alterations of the land are allowed within 200 feet of the bank of any tributary or surface water.

3.4 Open Space and Recreation Planning

Wendell has an Open Space and Recreation Plan (OSRP) which was compiled in 2010. The plan was developed based on solicitation of public comments, including a survey of town residents and extensive public meetings.

Like many of the hilltown communities found along the western and the eastern edges of Franklin County, Wendell has had a relatively low level of pressure to develop its open spaces for residential development. According to the OSRP, over half of Wendell's land area is permanently protected open space. This designation includes land owned by state conservation agencies, nonprofit conservation organizations, and the town of Wendell; as well as privately-owned land subject to a conservation restriction. In 2010, an additional 13% of the land was under temporary protection through a Chapter 61, 61A, or 61B program, or had limited protection as town-owned land managed as a cemetery, or otherwise managed by the Conservation Commission.

The OSRP noted that the town may want to prioritize the protection of accessible recreation land and open agricultural fields, given that much land had already been protected for wildlife habitat. Protecting the town's very limited prime agricultural soils was a primary concern.

Concerns regarding conservation of natural landscapes focused on unfragmented forest blocks, important watershed areas, and wetlands. Contiguous forests within Wendell were in many cases already protected: either as part of Wendell State Forest (owned by DCR), which includes part of Bear Mountain, and the Metacomet-Monadnock (M&M) Hiking Trail, as part of the Whetstone Wood Wildlife Sanctuary (owned by Mass Audubon), or the town's Fiske Pond Conservation Area.

Sections of the OSRP discussed extending the large block of land protected around the Quabbin Reservoir, as well as the watershed of the Swift River, which flows through the southeastern portion of Wendell, and into the Quabbin Reservoir. There is a circular belt of permanently protected open space that stretches northwest from the 60,000-acre Quabbin Reservation through New Salem, Wendell, and western Orange into Warwick. The eastern half of the circular belt continues up to the state line through Royalston, and then extends south to Tully Mountain in North Orange, Tully Lake, Birch Hill and Harvard Forest in Petersham. Another network connects the western part of the belt in Erving and western Orange through Wendell, Montague, and Sunderland to the Connecticut River. Within these networks of open spaces there are eleven state forests or reservations.

The town owns a section of land along the Millers River, and also identified unbroken forest along this watershed as a conservation priority.

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:

- A brief survey of municipal representatives involved in this project
- Municipal planning documents
- Department of Energy Resources databases of renewable energy generation facilities
- Reference USA database of businesses by zip code
- 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

Currently, the grid-connected renewable energy facilities located in Wendell are all solar arrays. Of the 52 systems identified in Department of Energy Resources (DOER) databases, 51 are residential-scale systems (2.5-13.25 kW). This includes a small-scale system installed on the town library. These systems combined total 322 kW (0.32 MW) of solar capacity.

In addition to residential-scale systems, there is one large ground-mounted solar array in town, which began operation in 2019. This 1.4 MW facility is located near the intersection of Farley Road and Wendell Depot Road.

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 economical, where cost is the sole consideration. However, these systems can provide energy reliability during outages, which means that they also provide additional value in terms of public safety and health.

Wendell does not have large commercial or industrial development. Most buildings in town are residences. The largest electricity users in town are likely high-use municipal buildings (e.g. the town library), schools, and commercial establishments.

In this section, we briefly review sites where considering energy storage possibilities may be worthwhile.

4.3.1 Town Hall

The municipally-owned Town Hall at the center of town serves as Wendell's emergency shelter. It currently has no energy storage system.

4.3.2 Schools and Institutions

Swift River Elementary School is a regional elementary school which straddles the town line between Wendell and New Salem, and serves approximately 150 students from the two towns, in pre-kindergarden through grade 6.

The school has a large roof (36,600 sf), and approximately 3.6 acres of paved area, including a parking lot and driveway. This building has also been discussed as a potential emergency shelter for Wendell and/or New Salem. The school has a back-up generator, but no energy storage system. This school likely is one of the highest electricity users in town; however, it is important to note that electricity use drops significantly during the summer months. CEE will review Mass Energy Insight data to quantify electricity use at the elementary school.

Kelmsley Academy is an institution which provides a summer boarding school experience for Chinese students in Massachusetts. Buildings located in Wendell include dorms, classrooms, and office space, with a total roof area of at least 43,700 sf. Paved areas surrounding the buildings total approximately 3.3 acres. This organization likely is one of the highest electricity users in town. As with Swift River School, electricity use is likely to change seasonally, with higher use in the summer months.

4.3.3 Town Center

The largest density of housing is in the town center, where a number of municipal buildings, including the Town Hall, Town Offices, and Town Library, are also located.

4.3.4 Businesses

Commercial establishments 'could' have higher electricity use than single-family residences. Businesses in town include Diemand's Farm (126 Mormon Hollow Road), the Wendell Country Store (57 Lockes Village Road)/Deja Brew (57A Lockes Village Road), and Scott's Garage (178 Mormon Hollow Road).

4.4 Other Relevant Infrastructure

4.4.1 Parking Lots

There are several parking lots on municipal property. These include paved lots at Swift River School (201 Wendell Road, New Salem), the Town Offices (9 Morse Village Road) and the Highway Garage (29 Wendell Depot Road).

4.4.2 Landfills and Brownfields

The Massachusetts Department of Environmental Protection does not list any identified brownfields within the town of Wendell.

There are two inactive landfill sites in Wendell, the municipal landfill and the D&B landfill. The two properties comprise the town's solar overlay district. These parcels are listed in tax assessment records as 12.6 and 21 acres respectively.

4.4.3 Farms

There are a number of farms in town, which could be approached regarding their interest in agriculturally-related energy projects. As noted in the town's OSRP, preservation of existing farmland is of primary concern to town residents.

The town's website includes a list of active farms in town. These include:

- Diemand Farm – 126 Mormon Hollow Road
- Fallen Oak Farm – 11 Stone Cut Off Road
- New Wendell Farm – 254 Lockes Village Road
- Sugarbush Farm – 47 Davis Road
- Senn Farm – 2 Center Street – Note that a 7.95 kW solar array is already located on a barn on the farm.
- Wild Browse Farm and Sustainability Center - 87 Bullard Pasture Road

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 Wendell. 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 land
- Undeveloped land suitable for 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, 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

We are currently working with National Renewable Energy Laboratory (NREL) experts on a detailed analysis of rooftop solar potential on small buildings in Wendell. This nuanced analysis will be based on lidar (light detection and ranging) data, a remote-sensing technique that uses laser light to densely sample surfaces, providing detailed information about roof pitch, aspect, and shading by trees. This analysis will be included in the final report to the town. In the current analysis, we 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 Wendell has a total of 950 small buildings, totaling 955,024 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 248,306 sf available, equivalent to 3,973 kW (4.0 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]. In Wendell, approximately 67% of small buildings have some roof space suitable for solar. Of small buildings in western Massachusetts with some potential for solar, approximately half have at least 10 m^2 (roughly 100 sf) of roof available for solar. If we assume 67% of small buildings in Wendell have some space available for solar, and 50% of those have at least 10 m^2 available, we can estimate that about 318 buildings could support at least 10 m^2 of solar (at least 1.75 kW). Let us consider this the maximum number of buildings which could economically

[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).

support solar in town. The average roof area of a small building in Wendell is 1,005 sf. If we assume half of that roof space has the proper aspect for solar, and multiply the average roof space by the number of buildings, we arrive at a slightly more conservative estimate of residential solar potential – 2,741 kW (2.7 MW).

A third, 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. Wendell has a total of about 395 households. If 67% of them were able to install solar at their residences, either on a rooftop, or as a ground-mounted system, the town would ultimately have 265 residential systems. The average size of a residential solar system in Wendell currently is 6.30 kW. By this method, we can estimate a potential residential solar capacity of 1,641 kW (1.6 MW).

5.3 Medium to Large-Scale Rooftops

Table 2 provides a list of the 11 medium to large (>5,000 sf) roofs in Wendell. This list includes three municipally-owned buildings (Swift River Elementary School, the Highway Garage and Town Offices), two buildings at Diemand Farm, four Kemsley Academy buildings, Pine Brook Camp, and the Wendell Country Store/Deja Brew/Post Office complex.

As described above, we are currently working with NREL on a more detailed analysis of rooftop solar potential using lidar data. The numbers provided in the table reflect a rough estimate of technical potential, based on nationwide data from NREL. 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]. 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 an on-the-ground assessment would need to be conducted. Note, for example, that our analysis suggests a 287 kW system could be installed on Swift River School. A recent on-site evaluation suggested that due to structural issues in certain portions of the school roof, roof pitch, and shading, the roof would best support an approximately 30 kW array.

Our estimate of total technical potential on medium to large-scale roofs is 1,083 kW (1.1 MW).

Structure	**Street Address**	**Total Roof Area** (sq ft)	**Estimated Technical Solar Potential** (kW)
Swift River School	201 Wendell Road, New Salem	36,616	287
Kemsley Academy	0 Franklinia Way	23,833	187
Diemand Farm	114 Mormon Hollow Road	17,585	138
Pine Brook Camp	346 Lockes Village Road	10,487	82
Diemand Farm	114 Mormon Hollow Road	8,975	70
Deja Brew/Wendell Country Store/Post Office	57 Lockes Village Road	8,194	64
Highway Garage	0 Jackie Lane	6,880	54
Kemsley Academy	0 Franklinia Way	6,719	53
Kemsley Academy	0 Franklinia Way	6,602	52
Kemsley Academy	6 Farley Road	6,539	51
Town Offices	9 Morse Village Road	5,650	44

Table 2 A list of the 11 medium to large roofs identified in Wendell.

5.4 Parking Lots

There are a number of paved areas on municipal property. These include Swift River School (201 Wendell Road, New Salem), the Town Offices (9 Morse Village Road) and the Highway Garage (29 Wendell Depot Road). The Swift River School parking lot and driveway has been previously evaluated, and could host an approximately 80 kW system, covering two parking areas. The Town Offices have an approximately 0.35 acre paved area for parking. The Highway Department has a total of about 0.75 acres of paved area. Solar canopies could potentially be installed over portions of this site, providing protection from the elements for municipal vehicles when not in use.

In addition to municipal properties, Scott's Garage in the northwest section of town has a large, unpaved lot that is largely filled with old cars. The area covers approximately 1.75 acres. Kemsley Academy and Diemand Farm

have significant areas of impervious surfaces, but these are largely taken up with driveways, and may not be suitable for solar canopies.

Potential sites for parking canopies are summarized in **Table 3**. Parking lots can have a packing density of approximately 263 kW per acre[3], but because the paved areas noted here in many cases include driveways, estimates of technical potential based purely on acreage would likely be inaccurate.

Location	**Approximate Area of Pavement or Parking** (acres)
Swift River Elementary School	0.75
Town Offices	0.35
Highway Garage	0.75
Scotts Garage	1.75
Kemsley Academy	3.3
Diemand Farm	2.7

Table 3 Parking lots and paved areas identified in Wendell.

5.5 Landfills and Brownfields

As previously noted, there are no identified brownfields in Wendell.

There are two inactive landfill sites in Wendell, the municipal landfill and the D&B landfill. The two properties comprise the town's solar overlay district. These parcels are listed in tax assessment records as 12.6 and 21 acres respectively. If these two parcels were to be fully developed for solar (excluding the municipal transfer station area), the maximum capacity would be approximately 6.6 MW.

5.6 Agricultural Resources

Wendell has a number of active farms, and significant acreage in agricultural production. Based on MassGIS Land Cover data, some 491 acres are in pasture, hay production, or cultivation. Six properties totaling 57 acres currently are included in the Chapter 61a program for the purposes of agricultural production (this figure does not include productive woodlots). No lands are currently under an Agricultural Preservation Restriction.

Opportunities are available to site solar projects on barn roofs. Other types of solar development – such as systems designed to support on-farm electricity use, solar parking canopies to protect farm equipment, or dual-use systems developed to allow continued use of the land underneath the panels for agriculture – may be appropriate for some sites. On-farm solar potential can be further explored in conjunction with the Massachusetts Department of Agricultural Resources.

5.7 Commercial-Scale Development Sites

As a final step in this analysis, we explored the potential for large-scale commercial solar development. Significant portions of the town are currently undeveloped. Mass Audubon's analysis[4] indicates 19,881 acres (96%) are in a "natural" condition, 508 acres (2.5%) are "open" land, and 163 acres (1%) are developed. Thirty-five acres were developed over the 5-year period between 2012 and 2017 – relative to its land area, Wendell ranked 281 out of

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

[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.

351 Massachusetts municipalities in terms of its pace of development over that time period. Between 2005 and 2013, 17 acres were developed (rank, 299 out of 351). Between 1999 and 2005, 33 acres of natural land were converted to development, and the town ranked 337 out of 351, again, relative to its size.

A total of 12,286 acres (60%) of land in town are permanently conserved, placing Wendell 6th in the state in terms of conserved land, relative to its size. A total of 669 acres were conserved in Wendell between 2012 and 2019, including 124 acres of BioMap2 Core Habitat, 259 acres of BioMap2 Critical Natural Landscape, and 69 acres of land ranked by The Nature Conservancy as "resilient."

For our analysis, we considered properties with a minimum lot size of 5 acres – equivalent to approximately 1 MW of solar development. In Wendell, there are 502 "large" parcels with an area of 5 acres or more, totaling some 17,696 acres. After removing permanently protected land, and land unlikely to be developed (e.g. cemeteries), 384 large parcels, totaling 9,104 acres, remain. Further removing wetland areas, and a minimum 25 ft buffer zone around them, yields 316 parcels with 5 acres or more available for development, at a total area of 6,227 acres (Scenario 1).

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, and BioMap2 habitat on developable parcels, yields a total of 189 parcels with at least 5 acres available for development, totaling 3,116 acres (Scenario 2).

Eliminating locations with a steep grade (greater than 35%), while still maintaining at least 5 acres available for development, yields a total of 179 parcels, totaling 2,911 acres (Scenario 3).

Eliminating properties on which a structure worth more than $25,000 currently sits leaves a total of 74 parcels available for development, totaling 1,434 acres (Scenario 4).

In sum, approximately 8% of all land contained in large (> 5 acre parcels) is available for development, once legal protections, habitat protection standards, slope considerations, and siting off of properties that may already contain houses, are considered.

These values do not include the town's Conservation Zone around wetlands and vernal pools, which would decrease available land slightly, or restrictions within the riverfront area of streams and rivers. Nearly 90% of the land within Wendell is forested, which means development at any undeveloped site would likely require significant forest clearing.

5.8 Summary

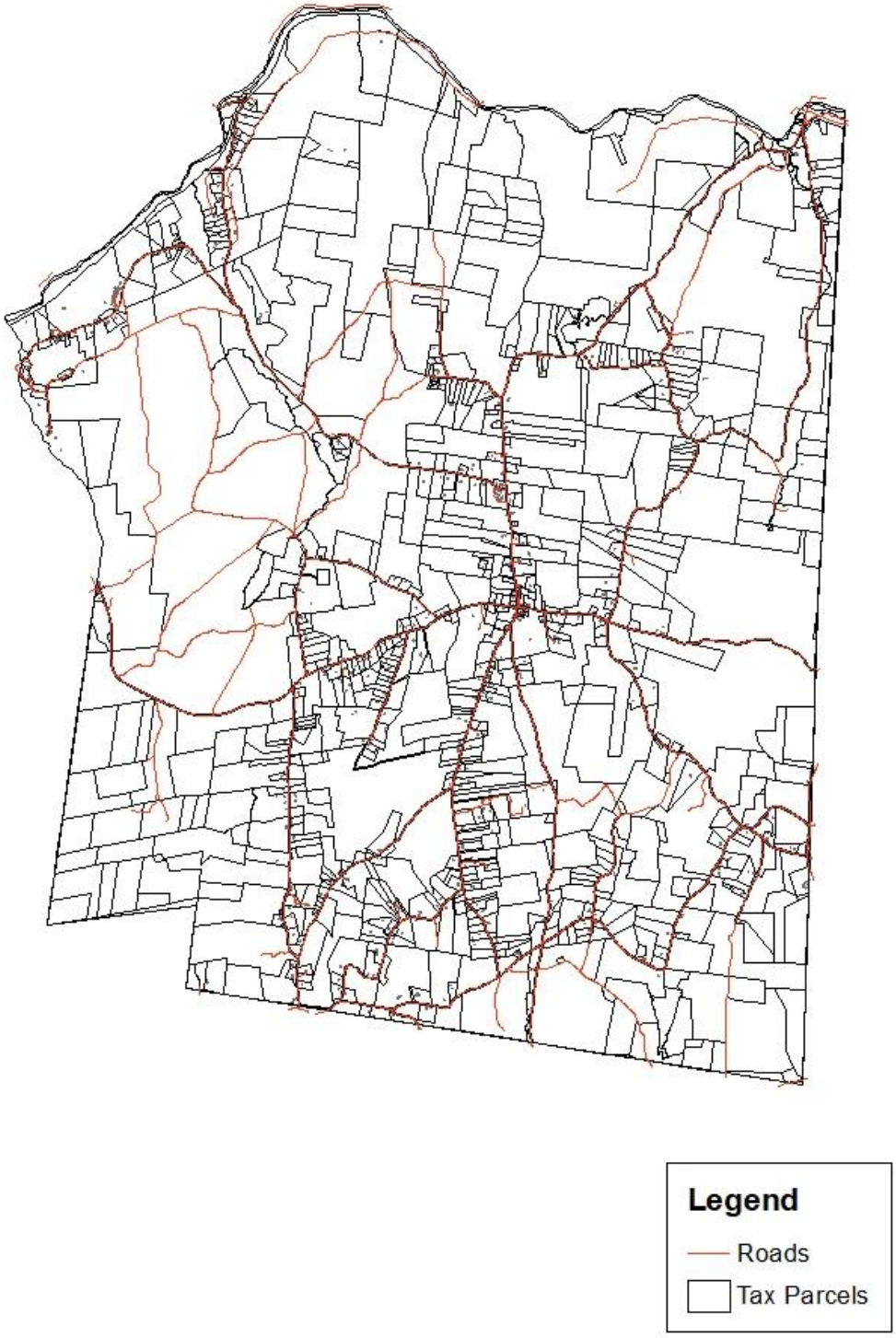
Table 5 below provides a summary of solar resources identified in this assessment.

Resource Type	**Available Resources**	**Estimated Technical Potential**
Residential-Scale Solar	- Estimated 248,300 sf of small building roof space suitable for solar - Estimated 636 buildings (67%) could support some solar - Estimated 318 buildings (34%) could support at least 1.75 kW of solar	At least 1.7 MW, if 67% of households can install a roof or ground-mounted system* **More detailed assessment forthcoming*
Medium to Large Scale Roofs	-Estimated 67,700 sf of roof space suitable for solar	Estimated at 1.1 MW
Parking Lots & Impervious Surfaces	- 1.85 paved acres on municipal property (Swift River School, Highway Garage, Town Offices) -1.75 acre lot at Scott's Garage -2.7 gravel or paved acres at Diemand Farm -3.3 paved acres at Kemsley Academy	-TBD -Potential for 80 kW system at Swift River School, based on on-site evaluation
Landfills and Brownfields	- two landfill properties, 12.6 and 21 acres respectively	Maximum of 6.6 MW
Agricultural Resources	- Multiple active farms - Barns with large roofs - Estimated 491 acres in agricultural production - Approximately 57 acres in Chapter 61a program for agriculture	Dependent on project type
Undeveloped Land	- 74 large land parcels have at least 5 acres that are not protected, meet current state solar incentive criteria, municipal slope requirements, and do not have a structure worth more than $25,000 on the property = 1,444 acres - development of most large land parcels would require significant forest clearing	Approximately 1 MW per 5 acres: 1,434 acres =287 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

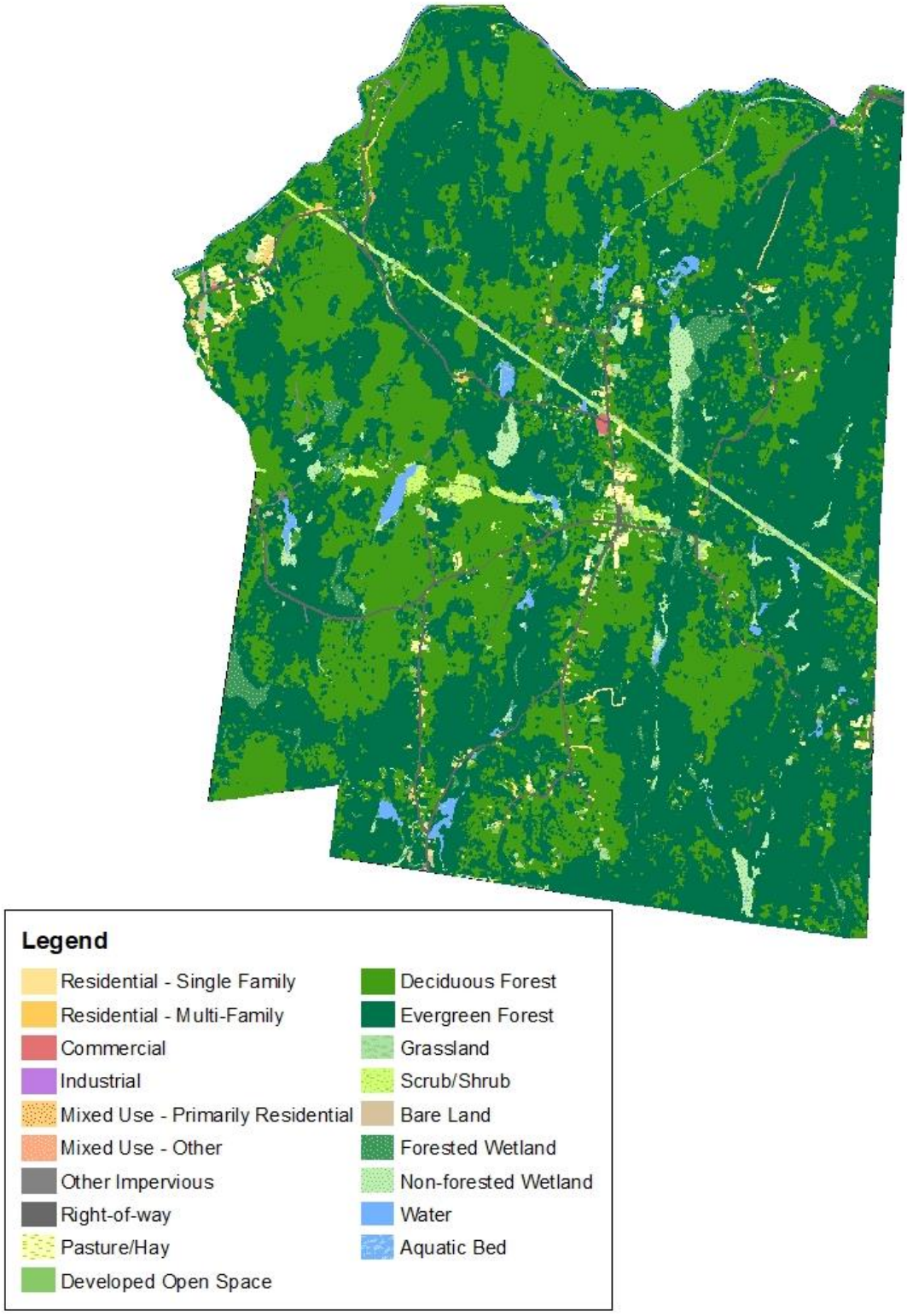
A.1 Roads and Property Lines

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).



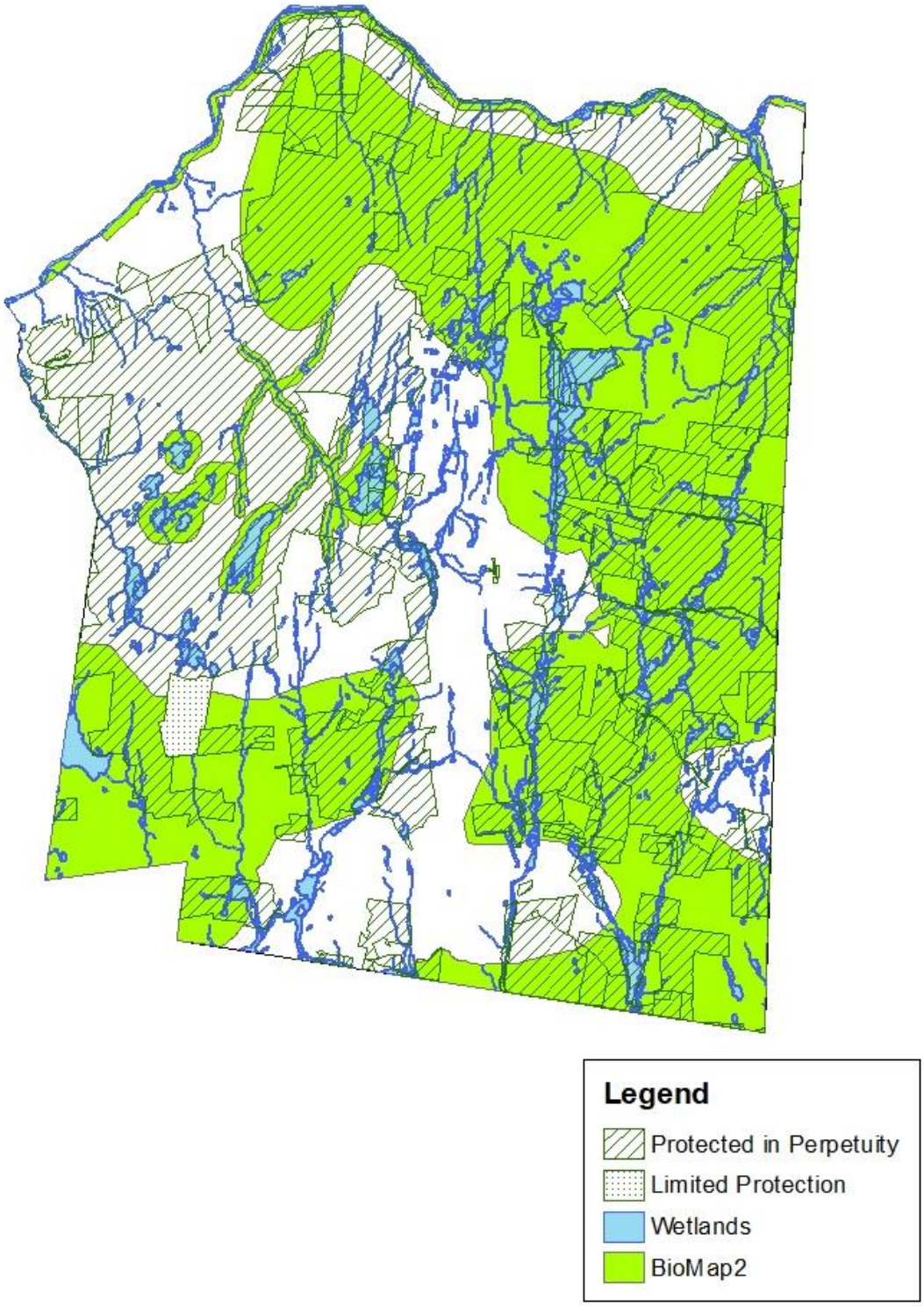
A.2 Land Cover

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).



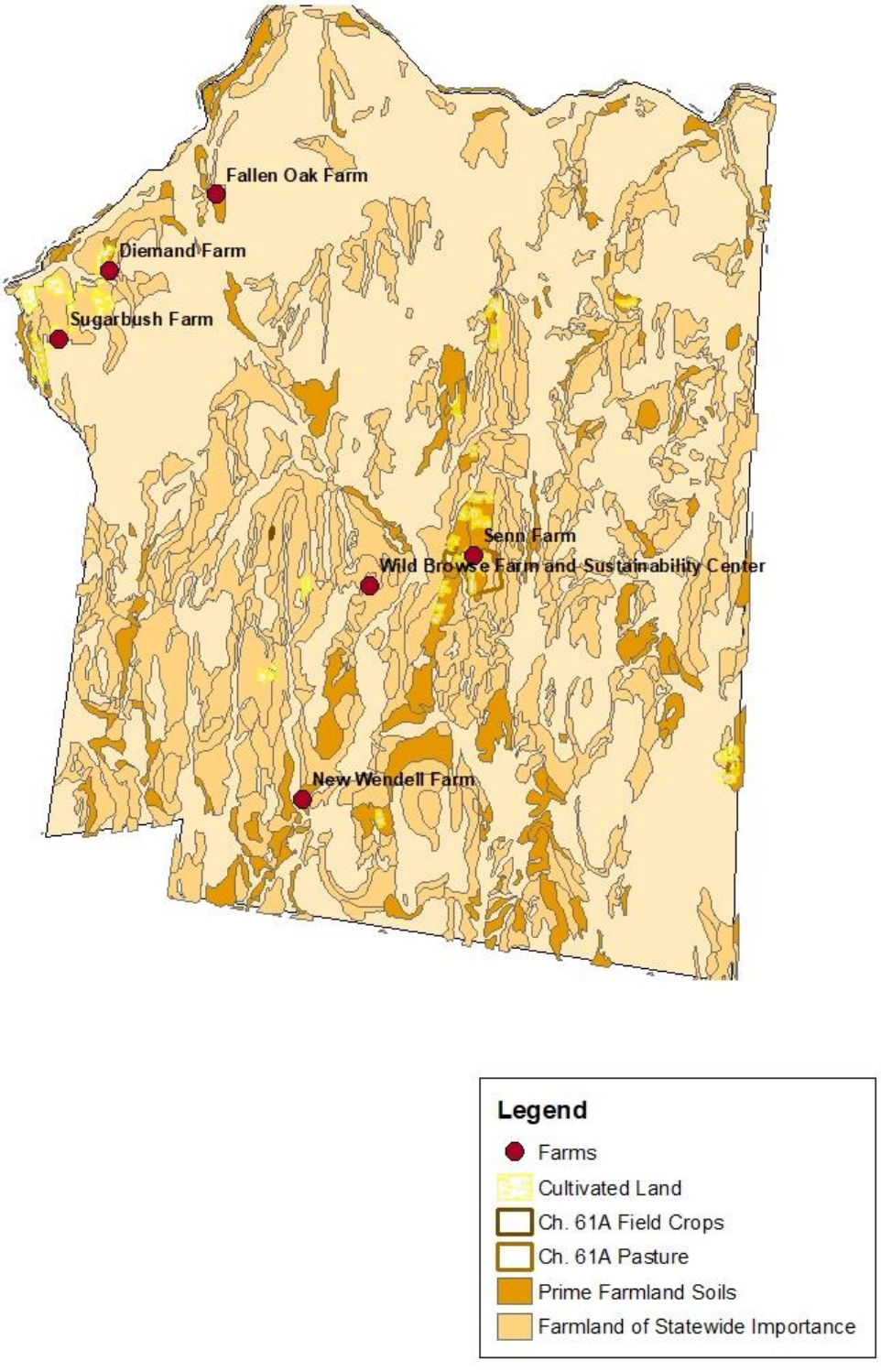
A.3 Conservation Land

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).



A.4 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.5 Parcels available for Commercial-Scale Development

Map represents a compilation of data drawn from the sources listed for maps A1-A4. Please see Section 5.7 for an explanation of the Scenarios depicted.