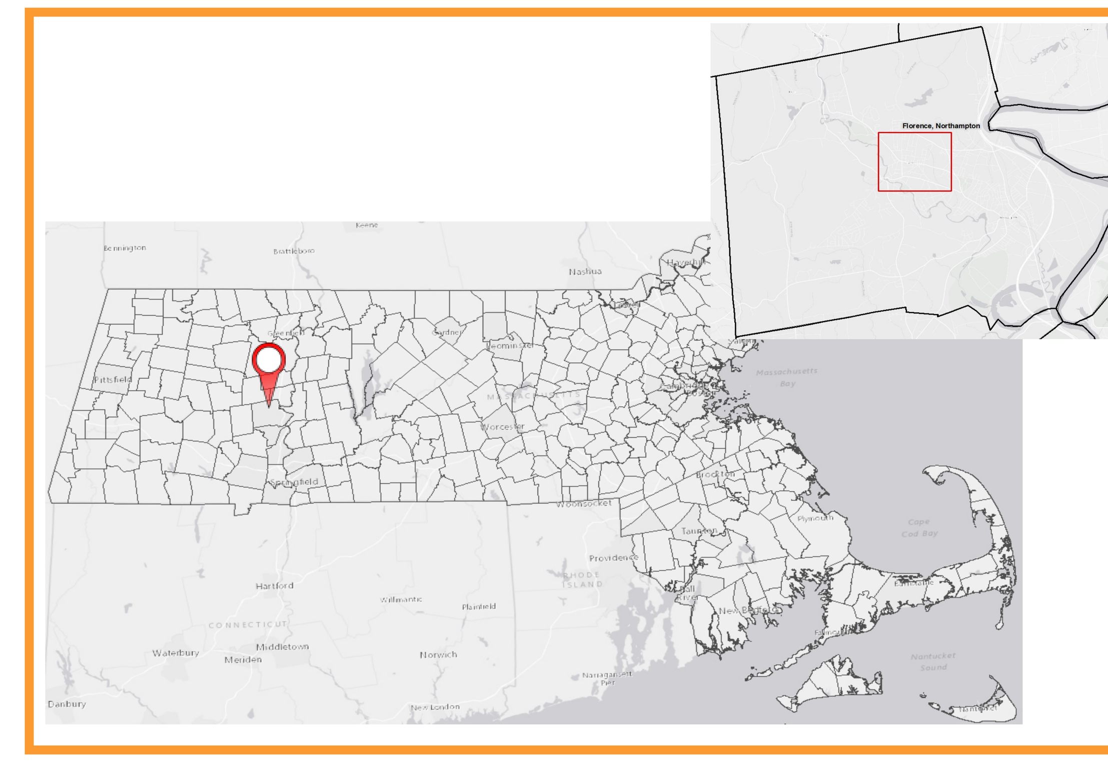
Residential Rooftop Solar PV Potential in Northampton, MA

POTENTIAL FOR RESIDENTIAL ROOFTOP SOLAR PV INSTALLATION BASED ON INSOLATION, ROOF SLOPE, AND ROOF ORIENTATION

Overview

Massachusetts historically has prioritized the development of renewable energy, evidenced by its national top-ten ranking for solar photovoltaic (pv) installations. The Commonwealth boasts support for solar via its net metering and solar renewable energy credit programs, which have encouraged rapid development across the state. Despite rapid development, there are incredible inefficiencies throughout the process. Not only is the state policy only ten years old, but geographic information systems (GIS) software is novel, and public data centers remain in early stages of accessibility. Therefore, instead,solar companies in the residential sector have had to rely on efforts of mass customer outreach, including manual identification of customer eligibility via analysis of satellite imagery and site visits. Clearly, this is an expensive and inefficient method.

In the past three years, Massachusetts has devoted more resources towards expanding public databases, which has significant implications for the future of the solar industry in terms of cost and efficiency. This analysis will identify how GIS methods can be applied to filter residential rooftops eligible for solar photovoltaic installations. Results will indicate households that are able to host panels, and will identify the annual photovoltaic kilowatt hour potential. As software processing is time intensive at high resolution, this poster focuses only on the village of Florence, in Northampton, MA, though this framework can be extrapolated and applied elsewhere.



Methodology

Massachusetts LiDAR data for Florence was converted into a raster, which contains surface elevation data for the study region. This elevation data was clipped to the building footprints within residentially zoned land use portions of the village. The study region is represented in *Figure 1 and Figure 3.*

Overall, there are two integral considerations for solar panel siting. Rooftops must face southeast, south, or southwest, and the slope of the rooftops must be less than forty-five degrees, in order to reach a baseline of energy production. In this analysis, both orientation and slope were analyzed, smoothed for outliers, coded for eligibility, and then combined. *Figure 2* is a sample window of the results, with final eligible roofspace area coded in yellow. Finally, as residential solar panels are typically 1 by 1.65 meters square in size, and can produce 1 kilowatt of power, this roofspace area was divided by 1.65 meters^2 to determine rooftop power capacity.

Next, the portions of rooftops receive different quantities of solar energy over time based on several factors. Therefore, it is necessary determine the kilowatt hour potential for eligible roofspace per meter^2 per year. The rooftop area solar radiation toolset takes into calculation account, including the slope and orientation of the rooftops, in addition to direct, reflected and diffuse radiation, over a specified time period. Further, given that panels have an average conversion rate of 16%, the final value is indicative of the energy each household is expected to reap from their panels each year. *Figure 4* is a sample portion of results, indicative of the total kilowatt hours per meter^2 per year for the rooftops. Overall, it is possible to select any rooftop in this study region to identify the number of panels it can host, and the quantity of energy those panels can produce, if at all.

Figure 1. Eligible panel placement areas based on ideal orientation and slope

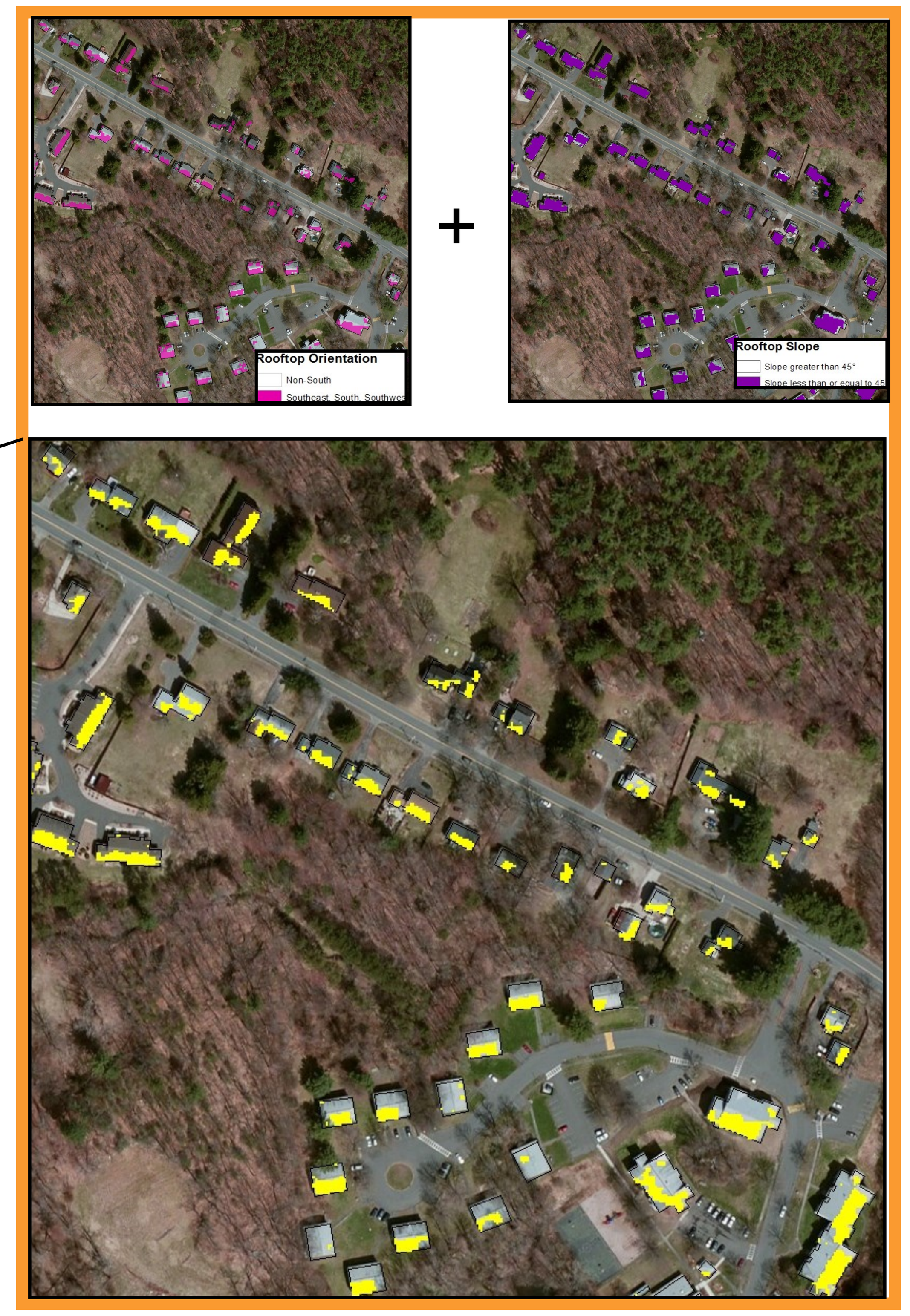


Figure 2. Sample portion of eligible panel placement areas. 1:1800 scale

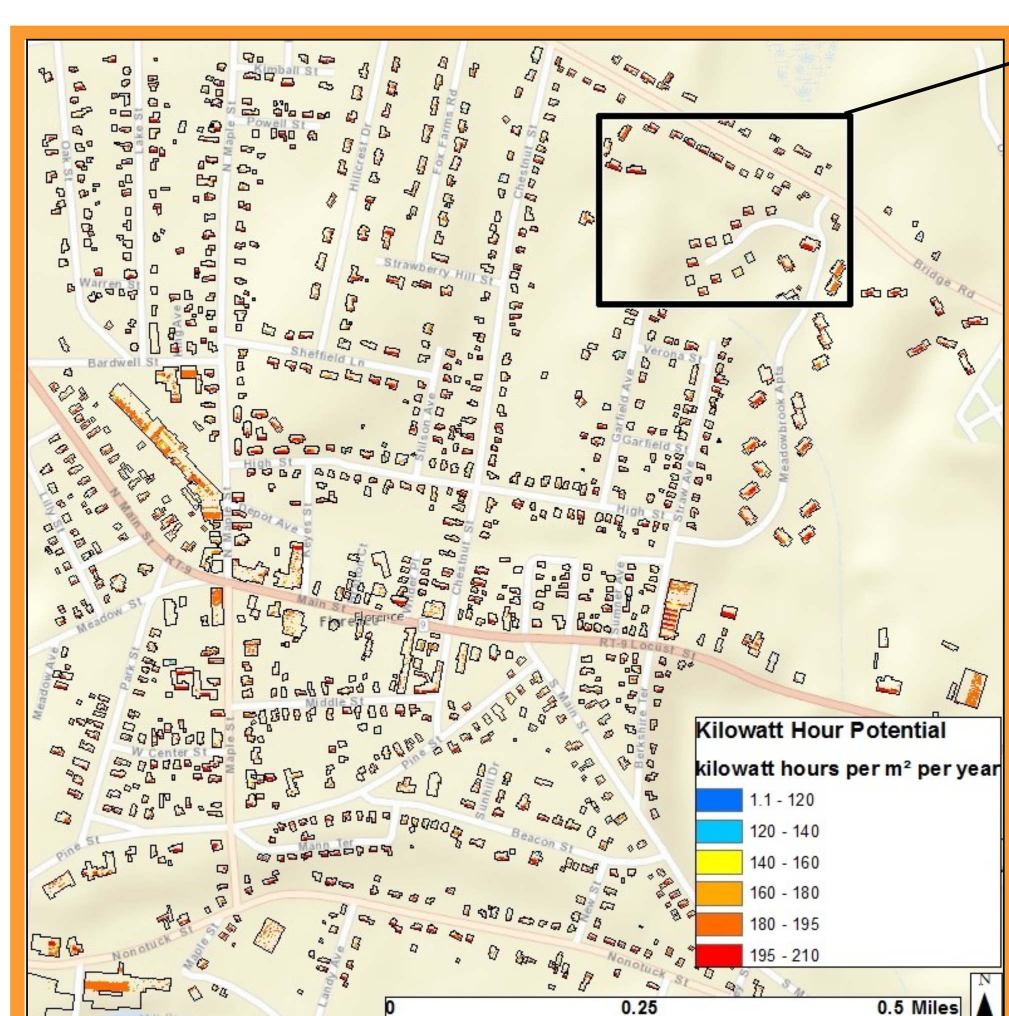
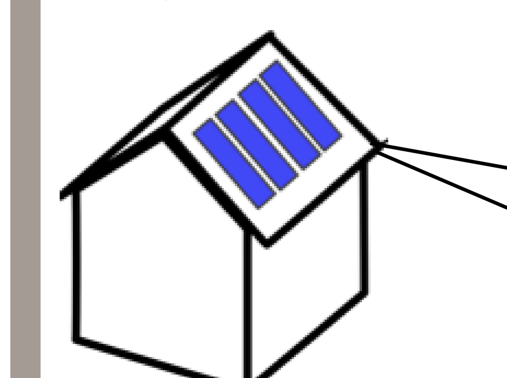


Figure 3. Estimated kilowatt hour potential

Figure 4. Sample portion of estimated kilowatt hour potential, 1:1800 scale

Results

This analysis is not a comprehensive analysis of solar potential, but instead one to identify and filter residential rooftops that receive optimal insolation and have the area to take advantage of this by installing solar panels. The results, sampled in the table below, show that in the village of Florence, almost every house has the ability to host solar panels. This ranges from an impossible 0.6kW hosting capacity, to nearly 1700kW on one roof. Given a National Renewable Energy Lab's summary of the literature, GIS-based methods typically estimate that a range of 6.5% to 59% of households are eligible to host panels, based on slope, orientation, roof stability, shading, and amount of insolation. The estimate within this analysis is beyond that range, as results indicate that 83% of rooftops in Florence can feasibly host panels. There are several reasons as to why this might have occurred. Overall, this is small study region, which makes it difficult to even compare to published ranges. Next, the data was processed at a one meter resolution, which increased processing speed, but limited the accuracy and prompted more estimation. Then and most importantly, this estimate only partially considers shading as a factor. While LiDAR data typically allows for the ability to take tree-shading into account, this analysis clipped the LiDAR data early on minimize lengthy data processing. Finally, while processes were run to smooth the data and remove outlier cells, there are still outlier cells included in eligible roofspace, and thus the estimated kilowatt hosting capacity. Should this work be further refined, processes must be executed to require cell contiguity. Despite limitations, the results still indicate it is possible to identify and filter eligible rooftops with GIS software. Looking at the figures and tables, it is clear that it is possible to filter and identify the kilowatt capacity and the kilowatt hour potential for any home in the study region.



Roof Identification	Total Roofspace, m^2	Eligible Roofspace for Panels, m^2	Kilowatt Hosting Capacity	Kilowatt Hours per m^2 per Year
1	117.6	12	7.3	2146.8
2	76.1	9	5.5	986.2
3	341.8	75	45.5	11929.8
4	131.0	41	24.8	8151.7
5	161.8	25	15.2	3566.7

Conclusions

The results prove the ability to identify and isolate residential roofspace for the purpose of greater solar deployment in Massachusetts and beyond. Though it is clear that the methodology needs fine-tuning, overall concepts are illustrated by the imagery and the numbers.

These processes have significant implications for efficiency of time and money, and would allow the mid-sized companies that comprise the bulk of the solar industry, to target marketing and outreach strategies, evaluate broad regions of customers at a time, and maintain a working database of leads. As renewable energy policy develops, as GIS modeling processes improve over time, and as states expand LiDAR datasets, these practices can be implemented on a broader scale. Given the resources, possibilities are endless.

Data Sources

NAD 83, UTM 18N Projection
MASS GIS: LiDAR Terrain Data (2014), Building Structures- 2D from Orthoimagery (2016), Land Use (2005),

National Renewable Energy Lab
National Oceanic and Atmospheric Administration
LASzip, Martin Isenburg (2014)

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