FEASIBILITY STUDY ON COLLEGE ROOF-MOUNTED SOLAR PROJECTS IN BOSTON

Tufts

Xiaochong Yao, Dec 16, 2012

Class of 2013, Civil & Environmental Engineering

Project Overview

My project intends to identify the most suitable location (s) for solar panel installations on college rooftops in the Boston metro area using ArcGIS 10. Rooftop solar panel installation has been experimented on residential, commercial and public buildings to provide energy for heating and electricity as well as to reduce CO2 emissions. There have been several successful campus solar panel installation projects in the past decade to provide economic, environmental and educational value.

Commonly used parameters employed in previous spatial studies on optimal solar project locations include energy demand of potential installation sites, efficient roof areas, installation costs, elevation of buildings, slope of the roof tops, roof top area of buildings, and solar radiance received in each location.

In Massachusetts, various solar rebate programs have been in place to encourage solar installations. Since 2007, average installed costs in Massachusetts have decreased 35%, with costs under $4.50 per watt for some systems.

The installed capacity of solar PV in Massachusetts has grown rapidly, especially in the past four years. As of mid-2010, more than 2,200 systems were installed. By the end of 2010, there will be more than 2,600 installations statewide, providing more than 45 MW of solar power, which is enough to power almost 7,000 homes.

Methodology

To determine the optimal locations (campuses and specific roofs) to install solar panels on college rooftops in Boston metro area, I used the following key criteria:

1. average installation cost per watt,
2. past solar experience,
3. size of colleges,
4. size of roofs, and
5. orientation of roofs.

I projected the data layer of all colleges in Massachusetts (Mass GIS 2009) to the "NAD 1983 State Plane Massachusetts Mainland FIPS 2001 Feet" coordinate system to match that of the data layer of planning districts in Boston (BRA 2012). I screened for all projects installed in Boston using the spreadsheet with all information on solar installations under Commonwealth Solar Program (CSP) from 2008 to 2012 (MassCEC 2012) to get average installation cost per watt (criterion 1) and total project size (criterion 2) for each district .

I created a feasibility scorecard for all planning districts based on past solar project experience and average cost per watt. I then queried for districts with a feasibility score <6. Within the selected districts, I did a spatial query to identify target colleges.

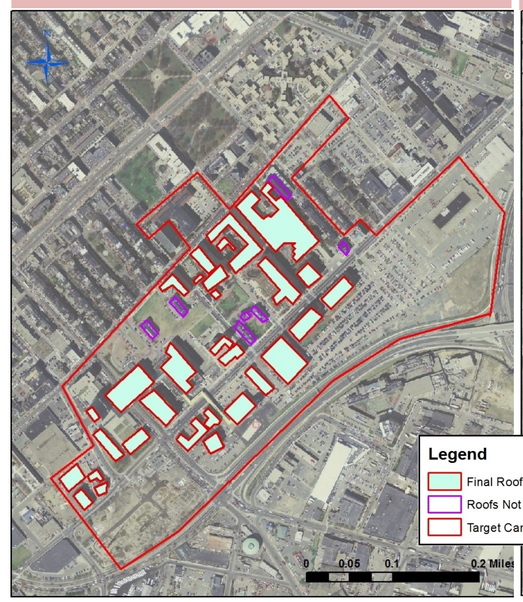
Please note that though West Roxbury was identified as a feasible district and there is one college (Massachusetts School of Professional Psychology) in the district. After verifying with the school website, I realized the school moved to another campus which is no longer in metro Boston. In other words, the Mass GIS 2009 database was not updated to reflect it. Therefore, I excluded that target college.

Larger colleges may have more resources and motivation to fund a solar panel project. I thus further screened target colleges based on enrollment greater than 1000 students and obtained two final target colleges (criterion 3).

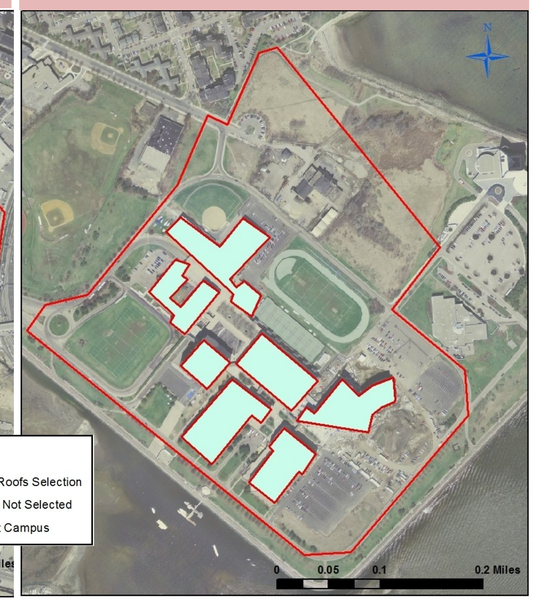
Both campuses and building roofs in the two target colleges were digitized based on information from respective school websites and the layer of labeled roads from MassGIS. The area of each roof and total roof area in each campus were thus obtained. Since the minimum roof area required for mounting photovoltaic (PV) panels is 10'x 15', all the roofs at target colleges have enough area for roof mounted PV system (criterion 4).

Several reports suggested non-south-facing slanted roofs were not effective in receiving sunlight. Therefore, I visually inspected the orientation of roofs based on the Boston raster image (BWSC 2012) and excluded non-south-facing slanted roofs from potential installation sites (criterion 5).

Boston University Medical Campus Roofs for PV Installation



University of Massachusetts Boston Roofs for PV Installation



Results

The two optimal campuses for roof solar project installations are Boston University Medical Campus and University of Massachusetts Boston. Non-flat roofs that were not south-facing were excluded from designated roofs as project sites due to their inefficiency in receiving solar power. Based on our analysis, both campuses will have a payback period shorter than 9 years, a net benefit greater than $30 million after 20 years from electricity bill savings, and tons of emission reductions of NOx, SO2 and CO2.

Table 1. Proposed Project Characteristics, Economic Analysis and Environmental Analysis

	Project Characteristics			Economic Analysis				Environmental Analysis		
Target Campuses	**District**	**Installation Area (ft^2)**	**Mounted PV Size (Watt)**	**Total Cost (mn $)**	**Electricity Savings (mn $/yr)**	**Payback Period (yr)**	**Net Benefit (mn$)**	**Total NOx Offset (ton)**	**Total SO2 Offset (ton)**	**Total CO2 Offset (ton)**
University of Massachusetts Boston	North Dorchester	484,803	4,848,029	$28.4	$ 3.4	8	$ 39.9	7.8	27.0	4.5
Boston University Medical Campus	South End	509,755	5,097,546	$26.0	$ 3.6	7	$ 45.8	8.2	28.4	4.7

Limitations

Actual installation costs depend on site specific conditions, type of equipment specified, and accessories. Only 24% of the projects in our dataset are public ones and all are under CSP but the colleges may be eligible for other rebate programs to lower cost. Maintenance and operation costs were not considered. 100% PV coverage of roofs was assumed without consideration of potential obstructions or safety factors related to roof loading.

Sources

Data:

MassCCE 2010; ESRI 2011; Mass GIS 2009; BRA 2012

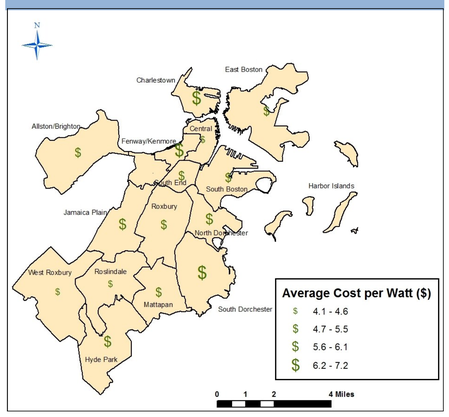
Literature:

Ghosh and Vale 2006; Iler 2012; Gadsden et. al. 2003; Connors et al. 2005; Phillips and Student 2009; Dacanay 2009; Santos et al. 2011; PPL Electric Utilities, unkown date; Lisell, Tetreault and Watson 2009; HGCI unkown date; O'Brien 2006; and Ailworth 2012

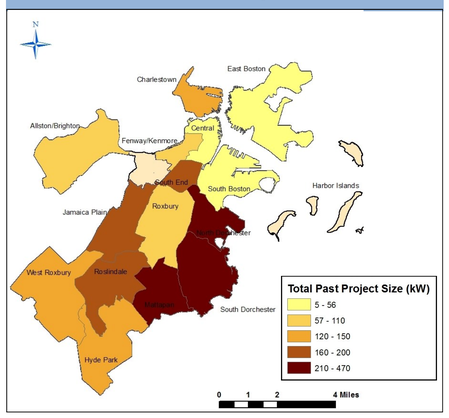
Roof PV Example

Waltham High School Roof-Mounted PV System. http://masselec.com/portfolio/waltham-solar/

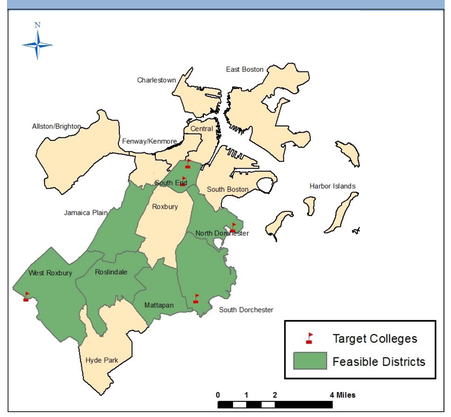
Average Installation Cost



Past Solar Experience



Feasible Districts



Final Target Campuses