Potential for Solar Power Development in Cambridge, MA

Retrofit of Existing Buildings in Cambridge for Solar Photovoltaic Development

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Report Date: September 10, 2014

Version 8

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About This Report

This report was prepared for the Net Zero Task Force, a committee of community members appointed by the City of Cambridge that is charged with the task of finding ways for the City to increase its use of renewable energy sources and increase energy efficiency throughout the community. Its purpose is to provide the City with the current economically feasible amount of solar photovoltaic systems that can be installed on the roofs of Cambridge. This is not intended as a feasibility study of specific buildings or areas within the City, but rather a broad look into the potential for developing solar photovoltaic systems as a source of renewable energy for the city. This report is intended to encourage the Getting to Net Zero Task Force, the City Government, and members of the community to move forward with the development of photovoltaics as a key energy source for the City.

Paul Lyons, the CEO and founder of Zapotec Energy, is a member of the Net Zero Task Force. He is a Registered Professional Engineer in Massachusetts and a NABCEP certified Solar PV System Integrator. He holds a B.S. in engineering from Cornell University and an M.B.A. from the University of New Haven. Working on solar projects for over thirty years in local New England and overseas in Haiti and Mexico, Lyons has extensive experience in solar design, consulting, management, and installation. He has led all of Zapotec's previous and current projects, and continues to play a key role in bringing together communities, developers, and contractors to create a solar future in Massachusetts. He served a term on the Board of Directors of the Solar Energy Business Association of New England (SEBANE), and is a member of the American Solar Energy Society, IEEE, ASHRAE, SEPA, and Northeast Sustainable Energy Association.

Rebecca Kahn worked as a Massachusetts Clean Energy Center Intern at Zapotec Energy this past summer. She is a graduate student at Boston University studying mechanical engineering with a focus on clean energy sources and technology, and is expecting to receive her Master's degree in May 2016. She graduated from Colgate University in 2010 with a B.A. in Geography. Prior to starting at BU, Rebecca worked with GIS (Geographic Information Systems) at FirstSearch Environmental Information in Norwood. She is hoping to combine her newfound engineering skillset with her previous knowledge of GIS and spatial analysis to study and work with renewable energy sources in the future.

Executive Summary

The potential for the development of solar power in Cambridge was investigated for the City's Getting to Net Zero Task Force. The goal was to take the number produced by Mapdwell in their production of the Cambridge Solar Map, 433.3 GWh/year, and trim it down to the realistic and economically feasible amount of solar PV that can be installed in Cambridge at current prices and conditions.

The study takes into account Technical Potential, which eliminates situations in which solar cannot be installed for technical reasons not taken into account in the Cambridge Solar Map, such as having an existing PV array or a certain type of roof. Then, Economic Potential is taken into account, eliminating situations in which the cost of constructing and installing a PV array would be prohibitively high. The results of this analysis found that the current amount of solar PV that can be installed in the City could produce 91.0 GWh/year, accounting for 5.3% of the City's current annual electricity use.

Large scale PV systems were then considered as an option for Cambridge to develop more clean energy. Three parcels of land were considered, and if large scale PV systems were built on each, they could generate 16.3 GWh/year, increasing the overall potential for Cambridge to 107.3 GWh/year. This would account for 6.2% of the City's current annual electricity usage.

If all of the potential PV was installed in Cambridge, the City would be pushing forward towards its goal of becoming carbon neutral, and setting an example for cities throughout Massachusetts and the United States. The investment needed for undertaking this task is roughly $350 million. We recommend that a City of Cambridge Solar Building fund be established into which community members, both individuals and institutions, can invest. Institutions such as Harvard University and MIT should be encouraged to invest in this fund to build solar in their home community. By investing in sustainable energy projects in their community, Harvard and MIT would be contributing to sustainable energy sources and the health of the community which, after all, sustains them.

1 Introduction

The purpose of this paper is to determine the amount of solar electric power that can be realistically developed and produced in the city of Cambridge, Massachusetts. The creators of the Cambridge Solar Map website, Mapdwell, did a groundbreaking study in 2012 using GIS to determine the total physical potential for solar PV development in Cambridge.[4] They created 3D models of buildings in Cambridge and used irradiation data for the City to determine how much sunlight roofs in Cambridge receive, and how much electricity can be generated from this sunlight. The final results of their mapping project show that, in total, 433.3 GWh/year of electricity can be produced on rooftops in Cambridge. Using a specific production estimate of 1057 kWh/kW/year, this is 25.1% of current annual electricity consumption in Cambridge, which is roughly 1723.2 GWh/year.[5] This quantity will be referred to as the total Physical Potential for solar PV power in Cambridge. Though this number and the result of this project is a significant step forward in promoting solar PV development, it does not take into account certain factors that would reduce the potential power that could be produced in Cambridge. These factors include many technical and economic issues that would increase the cost and lower the feasibility of developing solar throughout Cambridge. Our goal is to quantify these factors in order to trim down the Physical Potential and generate realistic estimates for the Technical Potential and Economic Potential for solar power production.

In order to compute the actual, feasible potential for solar in Cambridge, Massachusetts, we used what we call *reduction factors* to trim down the Total Physical Potential as determined by Mapdwell. Reduction factors are the fraction of useable roof area for solar development or solar power production remaining once an obstacle to solar development is accounted for. For example, roofs of certain materials are ill-suited for solar module installation. We identified the fraction of the total number of buildings covered with these materials, and then normalized subsequent calculations to this fraction. Technical Potential takes into account structural and technical issues, whereas Economic Potential takes into account issues that significantly increase the costs of developing solar PV arrays, making it uneconomical at the present time.

1.1 Scope of Report

The scope of this report includes residential, commercial, and industrial structures within Cambridge city limits. Additionally, the potential of multiple large city-owned tracts of land for solar PV installation are also considered.

For the scope of this report, it was not possible to specifically review the feasibility of installing PV systems in carports with canopy arrays. It was also not possible to specifically look at Danehy Park, Alewife, and MBTA property as potential sites for solar PV, as that would require far more detailed analysis than we had the ability to perform with the time and human resources we had. A follow-up feasibility study looking into carports and the aforementioned locations would supplement the information provided in this report, providing specific options for where and how to build up solar PV in Cambridge. Solar thermal for preheated domestic hot water or for space heating is also not included in the scope of this project. This is another great option for increasing the portion of renewable energy used by buildings in Cambridge, but requires a whole different area of

[4] More information at www.mapdwell.com
[5] Source: NSTAR Electric Company

expertise. A study of the potential for solar thermal should be done to supplement this analysis of the potential for solar PV.

1.2 Uncertainty

Ranges of uncertainty have been included on reduction factors that are based, where necessary, on incomplete or extrapolated data. The reduction factors that are based on data from the City, such as Existing PV Arrays, Roof Material, and Roof Height, were calculated based on data from the assessor's database and GIS data of the existing building stock in Cambridge, and contain little uncertainty.

These ranges help display the uncertainty in the analysis performed in this report. They were used to calculate three possible scenarios for the Economic Potential for solar: High, Mid, and Low. The High range uses the higher end of the uncertainty range of reduction factors, the Middle range takes the middle value, and the Low range uses the lower end of the uncertainty range. These help give a range of the current amount of solar PV that is economically feasible, as it is not possible to nail down an exact number right now without some level of uncertainty.

2 Technical Potential Reduction Factors

2.1 Slate and Copper Roofs

The first reduction factor to be taken into account for the Technical Potential is roofing that is unsuitable for solar. In particular, we focus on slate and copper roofs. Slate roofs are unsuitable for solar because of the manner in which the pieces of slate are attached to the sub-roof, making it extremely difficult to overlay a solar panel racking system, which must be secured to the roof joists at 3 to 4 ft intervals. In addition, slate pieces are prone to breaking and dislodging, and a roofer needs access to the roof to replace individual pieces at irregular times, which would involve hiring a trained electrician to first disconnect and remove the solar panels above the section requiring maintenance. Slate roofing material increases the cost of installing and maintaining a PV array beyond the point where the energy cost savings are justified. Copper roofs are unsuitable for solar because copper is an excellent conductor of electricity, and issues arise when grounding a PV system. The racking system for solar PV arrays is usually made of aluminum rails. Aluminum is very susceptible to galvanic corrosion in contact with copper, assuming that the two metals are also in contact with a common electrolyte, such as water – i.e. rainwater and dew on the roof. It is possible to electrically insulate the array from the roof, at an additional cost, but the weight of the array must still be supported by the building's structure. Some installers use brass S-clamps to attach to the standing seam of the copper roof, but the attachment method is only as strong as the weakest link, which is usually the copper nails and cleats. The solar panels may act like a sail during high wind events and exert an excessively strong force on the seams. For these reasons, copper roofs are not compatible with today's solar installation materials and practice.

This reduction factor was estimated using data from the City of Cambridge. The City's GIS department provided us with data on the number of buildings and the total building footprint area for buildings with roof materials unsuitable for solar (i.e. slate and copper) as of July 2014. They also provided us with the total number of buildings in Cambridge, as well as the total building footprint area for the city. To determine the fraction of total buildings with slate and copper roofs, the footprint area for buildings with slate and copper roofs was divided by the total footprint area. This number was subtracted from 1 to get the reduction factor of 0.853.

$$\frac{Footprint\ Area\ of\ Buildings\ w/\ Metal\ or\ Slate\ roof}{Footprint\ Area\ of\ all\ buildings\ in\ Cambridge} = \frac{6{,}406{,}036\ sq\ ft}{43{,}549{,}382\ sq\ ft} = 0.147$$

$$1 - 0.147 = 0.853$$

Equation 1. Calculation of roof material reduction factor

Examples of copper roofs are Kresge Auditorium at MIT and the Greek Orthodox Church in Central Square. Note that the GIS data did not distinguish between galvanized metal roofs and copper roofs, but instead used one classification of "metal roofs". Some galvanized steel metal roofs are suitable for solar arrays. This reduction factor will need to be fine-tuned during future revisions to this report.

2.2 Existing PV Arrays

The second reduction factor to be included in the Technical Potential is existing PV installations. The reason for this is obvious - additional PV cannot be installed on top of systems that already exist. The City provided us with a list of all existing PV arrays as of July 2014, which included the estimated annual power production for each array in kWh.[6] The total power these arrays can produce was calculated by taking the sum of the power production values. The estimated specific production factor used by the City to convert from the DC kW rating of existing systems to kWh/year is 1139 kWh/kW/year, slightly more than the 1057 kWh/kW/yr factor used for the Cambridge Solar Map. The total estimated electricity production from these existing solar installations is 1.76 GWh/year. This value was divided by the Total Potential as calculated by Mapdwell, 433.3 GWh/year, to yield the fraction of this total potential that is covered by existing arrays. It is an extremely small number, 0.407%. This value was subtracted from 1 to yield the reduction factor of 0.996.

There are some arrays which are not included in this list – the actual value is slightly higher, i.e. 0.005, which is approximately 0.50% of solar technical potential and 0.10% of current annual electricity use. The accuracy of this number is not as important as the fact that it is so small as to be far less than the margin of error in some of the other reduction factors. In any case, it is important to track and continuously update all existing PV systems in the City.

$$\frac{Potential\ Power\ Production\ from\ Existing\ Arrays}{Total\ Potential\ Power\ Production} = \frac{1.764\ GWh\ per\ year}{433.3\ GWh\ per\ year} = 0.004$$

$$1 - .00407 = 0.996$$

Equation 2. Calculation of existing PV reduction factor

2.3 Structural Deficiencies

To obtain this reduction factor, we estimated the fraction of roofs that are structurally unable to support solar panels based on our experience in the industry over the last 17 years. The fraction of buildings with structural deficiencies that cannot be corrected through a small additional fee, as part of a solar project, and will have to wait until a major building renovation is undertaken, was estimated to be 10%, plus or minus 2.5%. This yields a reduction factor of between 0.875 and 0.925.

Technical Issue	**Reduction Factor**		
Uncertainty Range	***Low***	***Mid***	***High***
Roof Material – Copper and Slate	0.853	0.853	0.853
Existing Solar Array	0.996	0.996	0.996
Structurally Deficient	0.875	0.900	0.925

Table 1. Technical Potential Reduction Factors

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[6] Sources: MassCEC Rebates, Mass SREC Qualified Systems

2.4 Technical Potential Results

All told, overall Technical Potential for solar PV in Cambridge represents about 18.7% to 19.8% of current annual electricity use, down from the 25.1% described as Physical Potential in Section 1 of this report. The Technical Potential for annual electricity generation by solar PV is 322.1 to 340.5 GWh/year.

Technical Issue	**Reduction Factor**		
Uncertainty Range	***Low***	***Mid***	***High***
Roof Material – Copper and Slate (RFMRF)	0.853	0.853	0.853
Existing Solar Array (ESARF)	0.996	0.996	0.996
Structurally Deficient (SDRF)	0.875	0.9	0.925
Total Tech. Reduction factor (TTRF): RFMRF*ESARF*SDRF	0.743	0.765	0.786
Technical Potential: TTRF*Total Physical Potential (433.3GWh/yr)	322.1	331.3	340.5
% of Total Annual Electr Use (1723.2)	18.7	19.2	19.8

3 Economic Potential Reduction Factors

3.1 Roof Exceeding Three Stories

The first reduction factor to be taken into account for the Economic Potential is buildings that are three or more stories. Taller buildings require more complicated PV construction and installation, which increases costs. A mechanical lift or a crane is required, because a 40 ft extension ladder does not reach above three stories. Many buildings do not have a driveway or open parking lot, so the crane or lift requires a street permit. If the sidewalk is obstructed, a police detail is required. Buildings above 60 ft (five to six stories) are more challenging prospects for solar PV – the wind forces are much stronger above 60 ft, and self-ballasted arrays require more attachments and setbacks from the roof edge, further reducing economic viability of projects. When the cost of design and construction exceeds $5.00 to $6.00 per Watt on these taller buildings, the economics of the individual projects become less attractive, and the potential project does not move forward. So while it is technically feasible to install solar arrays on tall buildings, it is highly probable that it will not be economically viable in 2014.

Along with the data on slate and copper roofs, the City's GIS department also supplied the total number of buildings and total footprint area for buildings that are three or more stories as of July 2014. Similar to the calculation for the slate and copper roofs, this area was divided by the total footprint area for the city to yield the fraction of building area that meet this criteria. This number was then subtracted from 1 to yield the reduction factor of 0.482. Originally, we had wanted to look at roofs greater than 3 stories without roof access, but this level of detail is not possible to obtain this summer. If there is easy roof access on a tall building, it is possible to maintain the PV system for many years without having to rent a lift or a crane every year.

A building roof with a height of three or more stories would complicate the construction and installation of PV, adding to the overall cost enough to include all of these buildings in the reduction factor.

$$\frac{Footprint\ Area\ of\ Buildings\ 3\ or\ more\ stories}{Footprint\ Area\ of\ all\ buildings\ in\ Cambridge} = \frac{22{,}568{,}963\ sq\ ft}{43{,}549{,}382\ sq\ ft} = 0.518$$

$$1 - 0.518 = 0.482$$

Equation 3. Calculation of 3+ stories reduction factor

3.2 Roofs that are 10 to 20 Year Old

Roofs of buildings generally need to be replaced every 25 years. For this reason, we deemed buildings with roofs aged 10-20 years old unsuitable for solar PV development, as their roofs will have to be replaced in 5 to 15 years from today. It does not make economic sense to install solar PV on a roof if it must be removed in 5 to 15 years, since the removal and reinstallation costs will wipe out the energy cost savings of the PV systems. In order to estimate the number of buildings in Cambridge that would meet this criteria, we assumed that over the last 25 years, about 1/25 or 4% of buildings in Cambridge have had their roofs replaced each year, adding up to 100% of buildings in total over 25 years. There is not much new construction in the city, so this figure is included in 20% of buildings with new roofs in the last 5 years (5 yr. x 4%/yr.). To estimate the number of buildings with roofs aged 10-20 years, we multiplied this 4% by 10 years to get 40% of buildings in Cambridge. This estimation yields a reduction factor of 0.60. It is not economical to add solar to buildings in the 10-20 year old roof age range today, but it will be in the next 5 to 15 years.

3.3 Complex Construction for Other Reasons

To estimate the percentage of potential solar that would require extremely complicated construction for various other reasons, we looked at the reduction factors already calculated, the number of buildings in Cambridge, and our knowledge of the city and the building stock. More complicated construction would include situations where 1) unforeseen structural and construction issues arise, 2) historical concerns rule out the addition of PV, and 3) secondary networks owned by NSTAR Electric require complex engineering studies and expensive protective relays. We estimate this number to be quite small, as many other factors have already been accounted for. The percentage of the potential solar within Cambridge deemed to require prohibitively expensive installation and construction is about 5% +/- 2.5%, making the reduction factor between 0.926 and 0.974.

3.4 Economic Potential Results

Economic Issue	Reduction Factor		
Uncertainty Range	***Low***	***Mid***	***High***
Roof 10-20 Years Old	0.600	0.600	0.600
Greater Than 3 Stories	0.482	0.482	0.482
Complex Construction – Other	0.926	0.950	0.974

Table 2. Economic Potential Reduction Factors

In sum, total Economic Potential for Solar PV in Cambridge today represents approximately 5% to 5.6% of current electricity use. To install all of this Economic Potential PV today would cost approximately $311 million to $346 million at an average installed cost of $4/Watt.

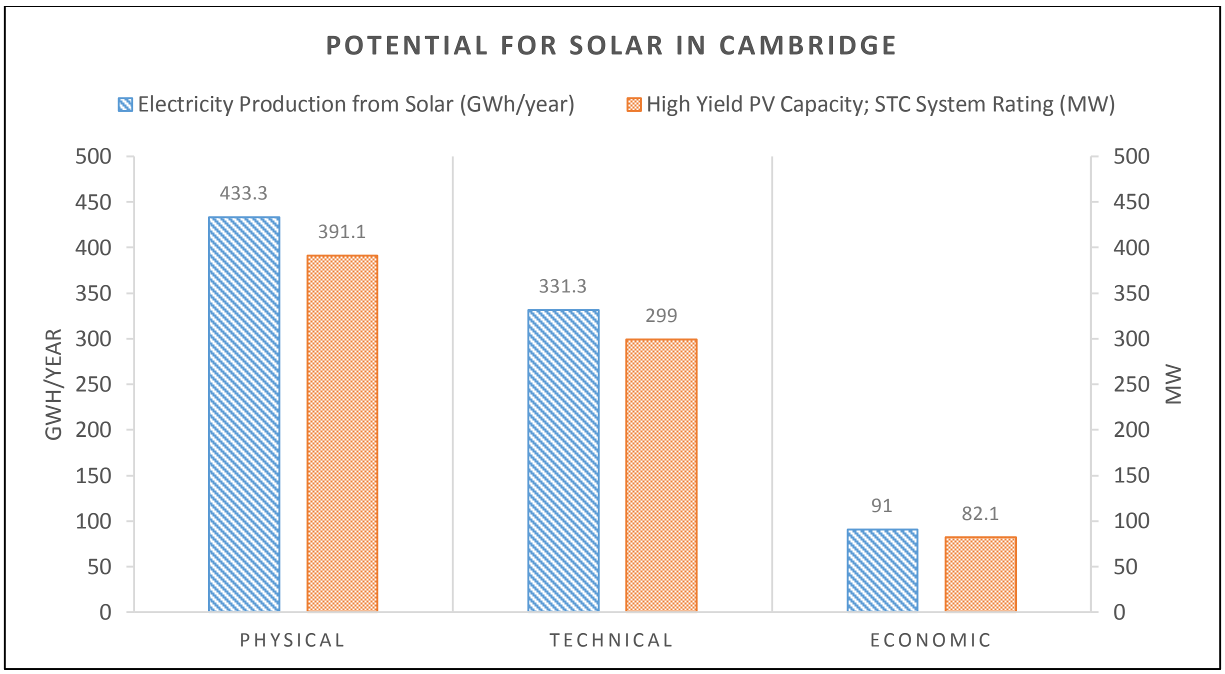

Figure 1. Graph of Mid-Range Results for Technical and Economic Potential PV Power Production

Potential Type	Electricity Production from Solar (GWh/year)	High Yield PV Capacity; STC System Rating (MW)	Percentage of Cambridge Annual Electricity Use
Low			
Physical Potential	433.3	391.1	25.1%
Technical Potential	322.1	290.7	18.7%
Economic Potential	86.2	77.8	5.0%
Mid			
Physical Potential	433.3	391.1	25.1%
Technical Potential	331.3	299	19.2%
Economic Potential	91	82.1	5.3%
High			
Physical Potential	433.3	391.1	25.1%
Technical Potential	340.5	307.3	19.8%
Economic Potential	95.8	86.5	5.6%

Table 3. Results for Technical and Economic Potential PV Power Production showing Low, Mid, and High range scenarios based on the uncertainty of reduction factors

4 Potential for Large Scale Solar PV Development

4.1 Hobbs Brook Reservoir and Surrounding Area

The City of Cambridge owns land in Lincoln and Waltham around two reservoirs used to supply drinking water to the city. There is potential in this land to build a larger scale solar farm that could produce large amounts of electricity for the City of Cambridge. However, most of the land around the Hobbs Brook and Stony Brook Reservoirs is classified as Zone A by the Massachusetts Water Resources Authority (MWRA), which means most uses for the land are restricted. There are still roughly 105 acres of forested land outside of Zone A that could potentially be developed. Many of these 105 acres are in small tracts, because streams feeding the Hobbs Brook Reservoir cut through many of the Cambridge-owned parcels. There are a handful of larger parcels, however, which would be ideal for a larger scale solar PV system.

The two largest tracts of land owned by Cambridge outside of Zone A protection are 20 to 25 acres in size. The largest tract of land is 25 acres of forested land in Waltham, near the Hobbs Brook Reservoir off of Trapelo Road. In order to develop this land, not only would community consent from Waltham residents be needed (there is a residential neighborhood adjacent to this parcel, and the land may be used for recreational purposes), but the conservation restrictions and historical development of the land would need to be studied. If, in the early 1900's, this land was used as agricultural land, then the potential to develop solar increases. This would mean that the forest on the land is relatively young, and the amount of carbon released when cutting down the trees at some future date would be smaller, compared to a more mature, old-growth forest. If restrictions on the land are not an impediment, and the land development shows agricultural development in the past, we recommend that the City consider building a larger scale solar PV system at this location.

The other tract of land is 20 acres off of Mill St in Lincoln, near the Minuteman Regional High School. To develop this land, consent from both Lincoln and Lexington residents would be needed, as the town line is adjacent to the property. Again, it is not known if this land is used for recreational purposes, or what kind of conservation restrictions are in place. Also, as with the above land, a study of the development of the land would need to be completed to determine whether the land was previously used for agricultural purposes. If all of the above factors turn out favorably for the development of renewable energy resources, we recommend the City look into solar development on this 20 acre tract of land.

To estimate the potential PV development possible on this land, we used the rough estimation that a 1 MW system requires 7 acres of land. This yielded that the 20 acre plot could potentially have a 2.86 MW system, and the 25 acre plot could have a 3.57 MW system. These numbers were converted to kWh to show the potential power each could produce per year in Table 4, using a conversion factor of 1300 kWh/kW/year due to the higher efficiency of ground mounted PV systems.

Name of Site	**Size (acres)**	**PV Potential (MW)**	**PV Electricity Generation Potential (kWh/year)**	**Percentage of Cambridge Annual Electricity Use**
Mill St	20	2.86	3,718,000	0.22%
Trapelo Rd	25	3.57	4,641,000	0.27%

Table 4. PV Potential for Cambridge-owned Parcels in Lincoln and Waltham

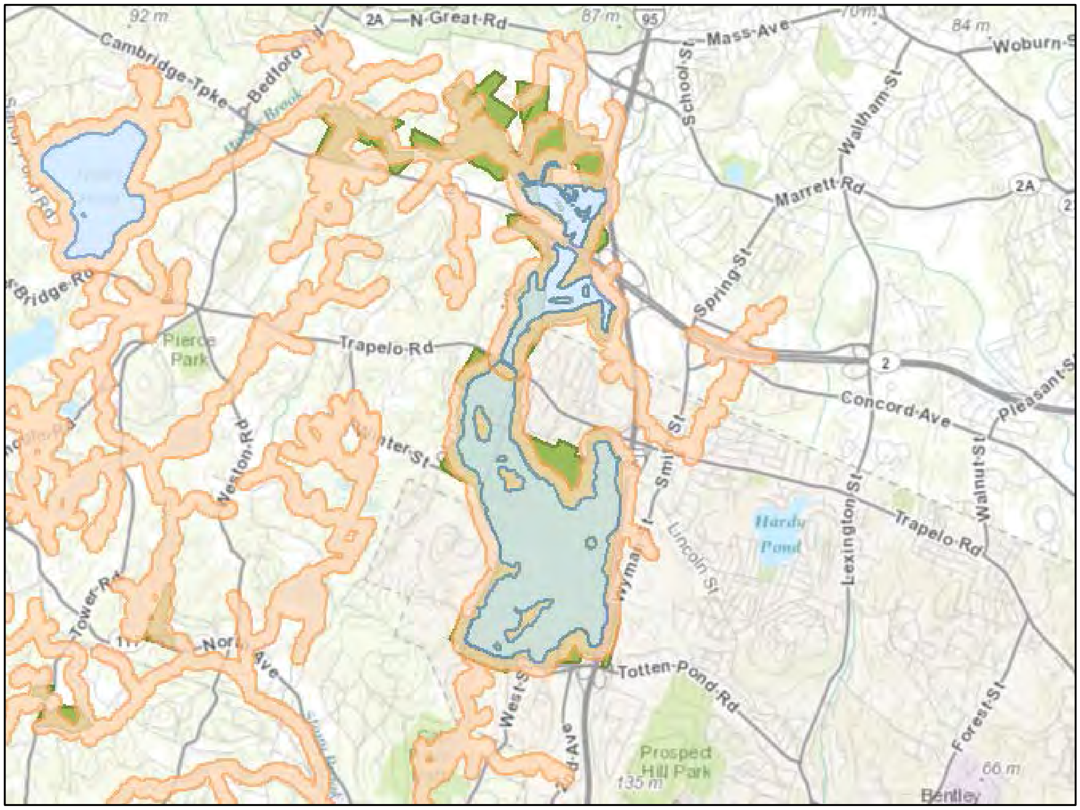

Figure 2. Cambridge Owned Parcels (in green) around Hobbs Brook Reservoir and MWRA Zone A (in orange)

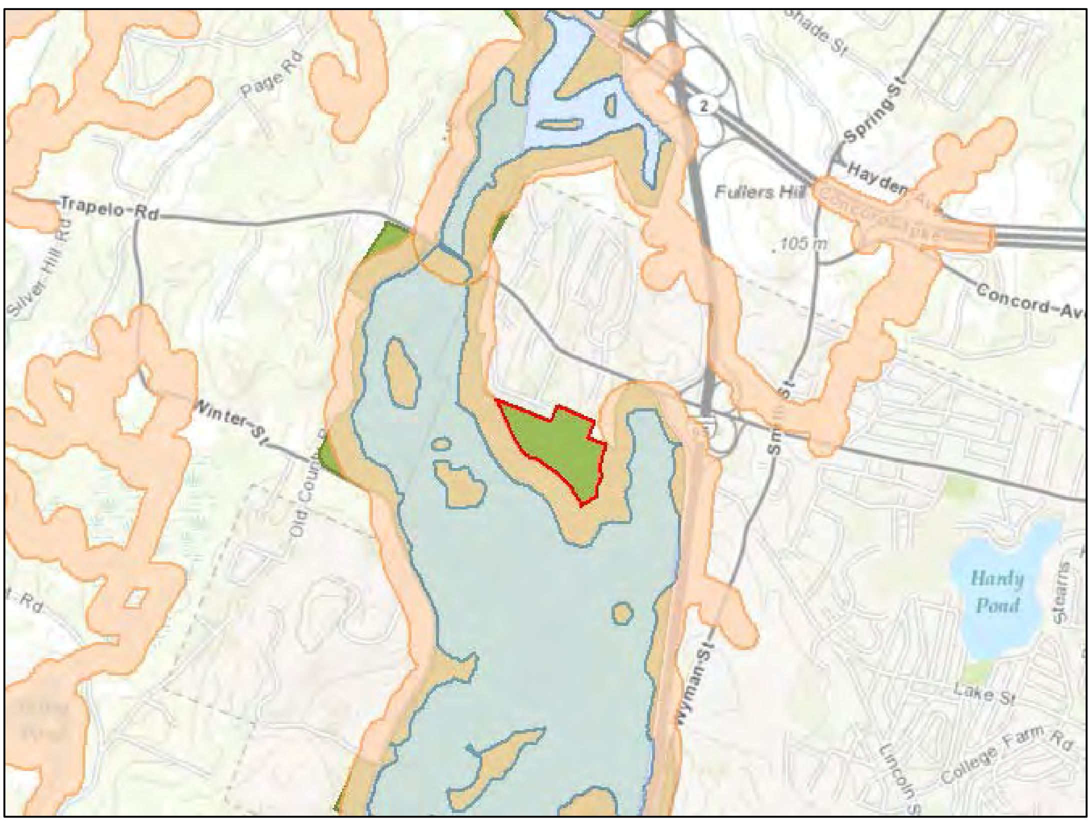

Figure 3. 25 Acre Cambridge-owned tract off of Trapelo Rd, Waltham (in red)

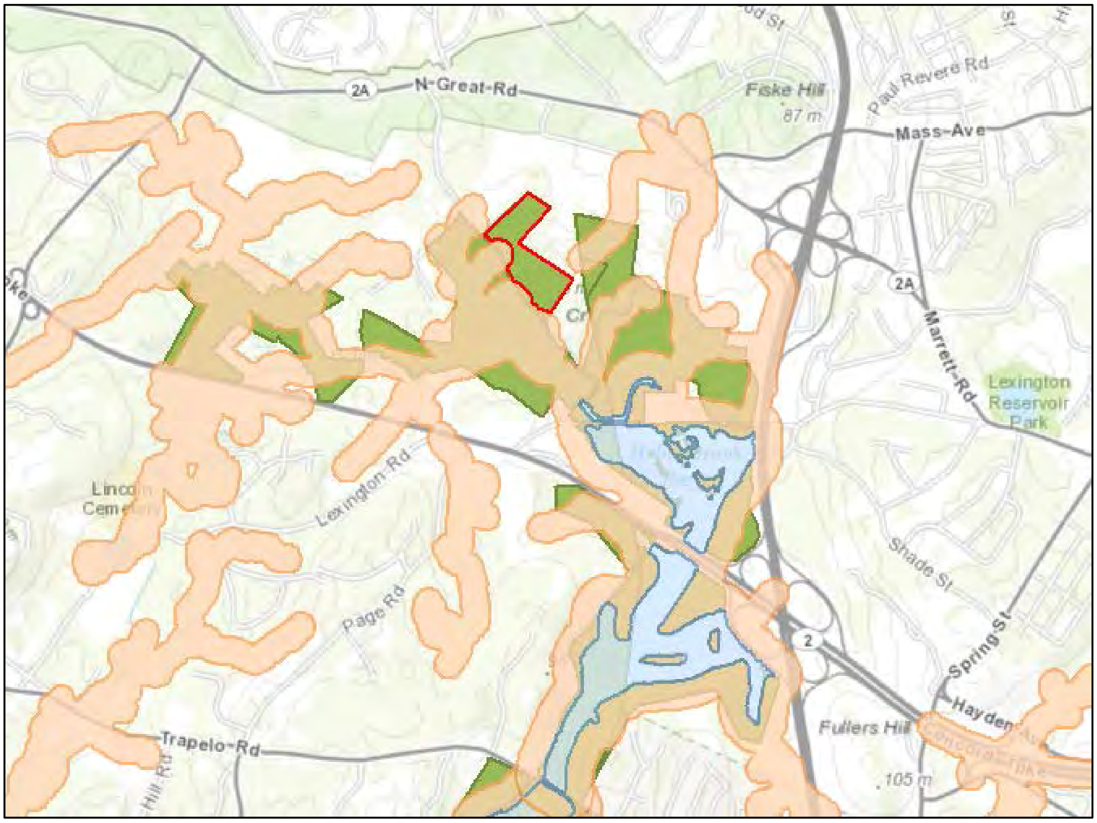

Figure 4. 20 Acre Cambridge-owned tract off of Mill St, Lincoln (in red)

Figure 5. Aerial Photo View of 20 Acre Tract – Mill St

Figure 6. Aerial Photo View of 25 Acre Tract – Trapelo Rd

4.2 Fresh Pond Golf Course

One more potential site for a larger scale solar PV system is the Fresh Pond Golf Course. In total, the area of this parcel is about 84 acres. Taking out the 400 foot buffer around the reservoir, there are roughly 43 acres that can be developed. While the golf course is popular with the community, we argue it should be considered for a potential site for solar power production. The main reason for the proposal of this site is the assumption that chemicals such as fertilizers and herbicides are used to maintain the golf course, which could potentially be running off into the City's drinking water supply. Building a PV system on this site would stop the use of such chemicals, and help protect the City's water supply. Research into how the golf course is maintained and what kind of lawn chemicals are used must be done before making any decisions in the matter. This site is favorable also due to its location within the city limits, and due to the fact that the land is already cleared, which reduces the cost of building a large scale PV system. The 43 acres of land could yield a 6.14 MW system, which could produce around 8 million kilowatt-hours of electricity each year.

Name of Site	Size (acres)	PV Potential (MW)	PV Electricity Generation Potential (kWh/year)	Percentage of Cambridge Annual Electricity Use
Fresh Pond Golf Course	43	6.14	8,021,000	0.47%

Table 5. PV Potential for Cambridge golf course

Figure 7. Fresh Pond Golf Course (in green) and MWRA Zone A (in orange)

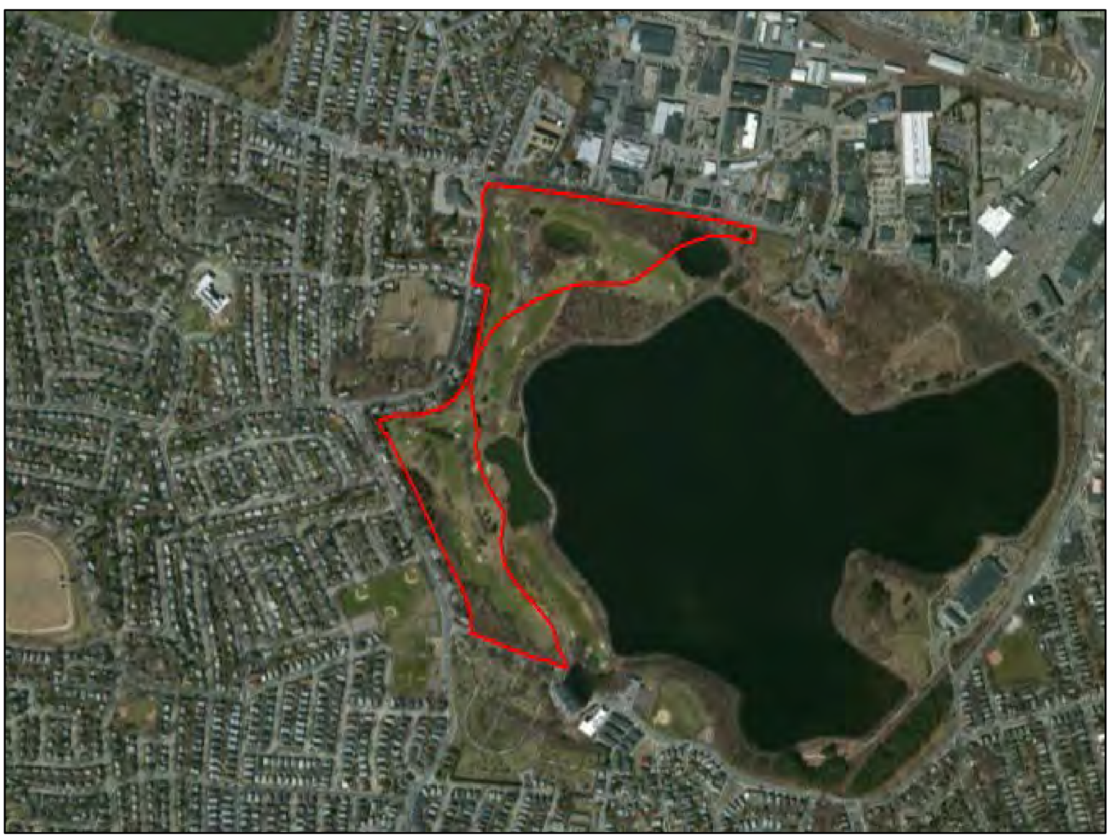

Figure 8. Fresh Pond Golf Course outside of MWRA Zone A (in red)

4.3 Economic Potential with Ground Mount PV Possibilities

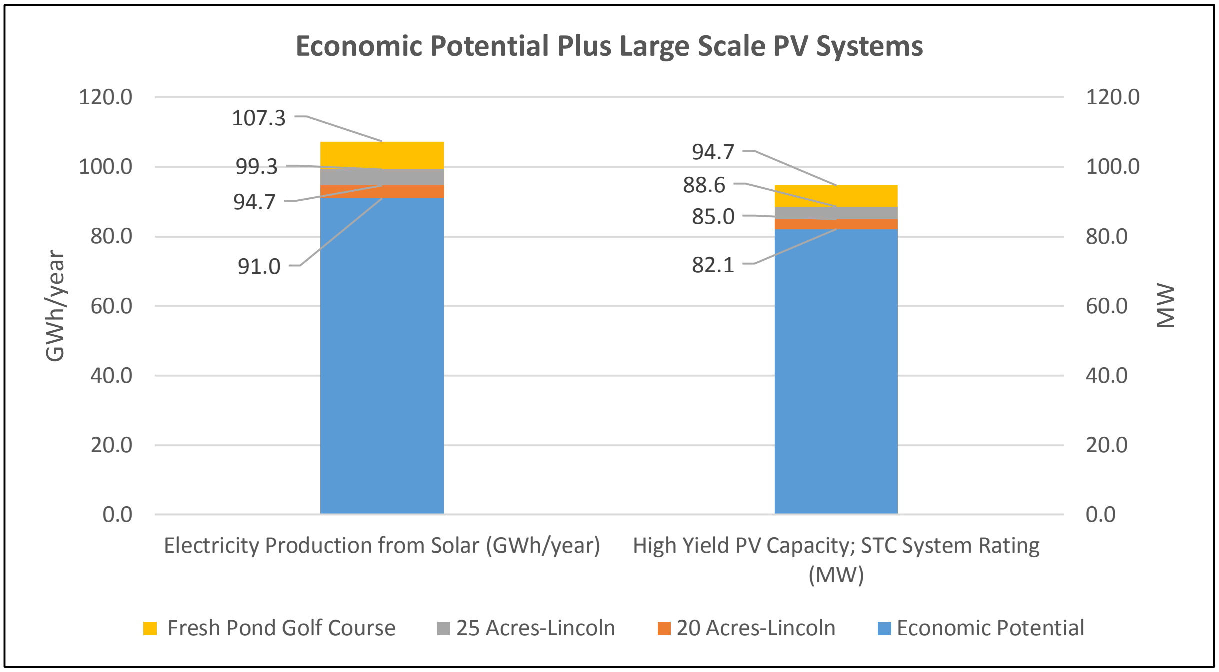

Figure 9. Graph showing how Large Scale PV development can add to Mid-Range Economic Potential

With the potential for installing large scale PV systems on Cambridge-owned land, the total current potential for Solar PV development increases. The amount of electricity that can be produced if all sites are used for Solar PV systems is 107.3 GWh/year, which accounts for about 6.2% of the City's current electricity usage. It would cost $379 million at $4/watt to install all economically viable PV plus the three large scale systems on the land discussed. Although 6.2% of the City's annual electricity use sounds small, it is an important step towards being carbon neutral and decreasing Cambridge's consumption of fossil fuels.

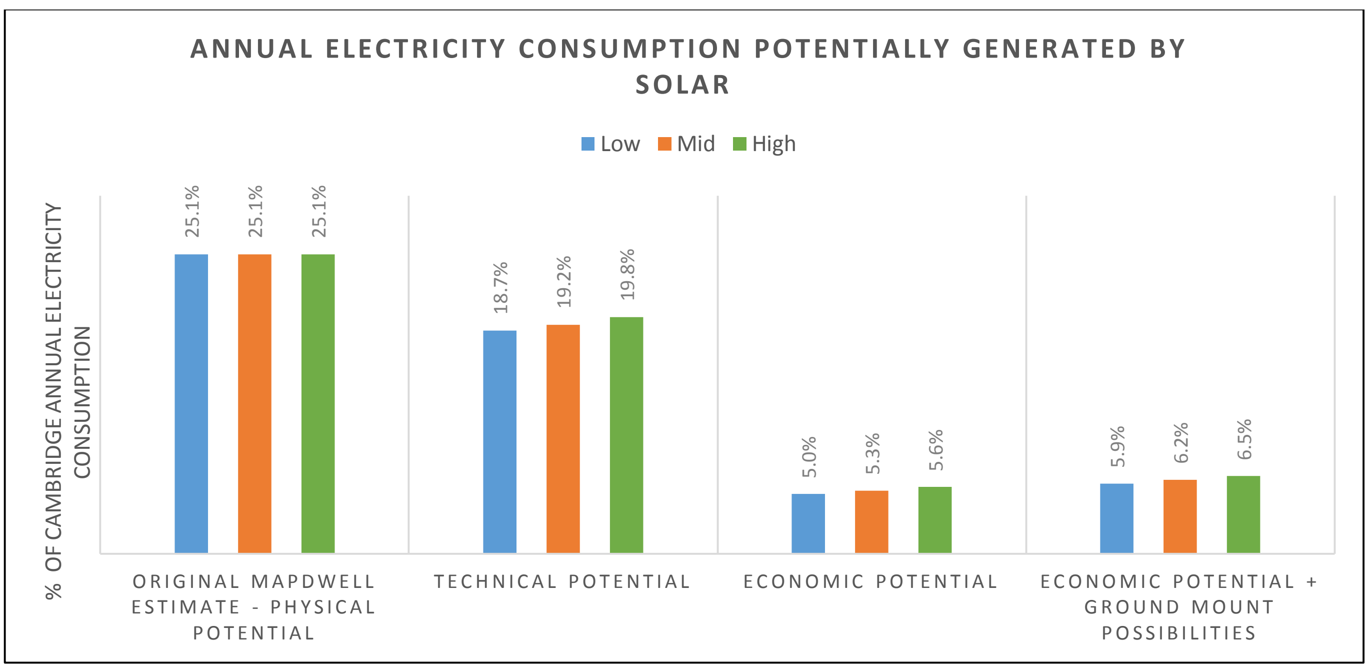

Figure 10. Graph comparing percentage of current annual electricity consumption that could potentially be generated by solar

5 Timeline for Implementation of PV

The timeline for the implementation of photovoltaic systems as a large source of renewable energy within the City of Cambridge is difficult to estimate, as one cannot predict how markets, regulations, stimulus, and taxes may change with growing concern about climate change in Massachusetts and the United States. We have tried to outline three potential scenarios here ranging from 2015 to 2040. The first one is the most favorable estimate in which conditions allow for the rapid increase in the development of solar PV, through market forces causing an increase in cost of fossil fuel and the decline in cost of PV, and through continued government stimulus. This situation predicts the installation of 95 MW (roughly the amount that is currently economically feasible) over the next six years, following with 10 MW being installed each year thereafter, as roofs are being replaced and buildings undergo major renovations. The second is the Business-As-Usual case, which predicts that little will change in the economic or political areas to increase the use of solar PV as a renewable energy source, leaving the cost of PV high and that of fossil fuels low. In this prediction, roughly 1 MW of PV will be installed in Cambridge each year. The third scenario is an average of the two, with a sizeable increase in the amount of PV installed in Cambridge but with slower growth and implementation rates than in the first scenario.

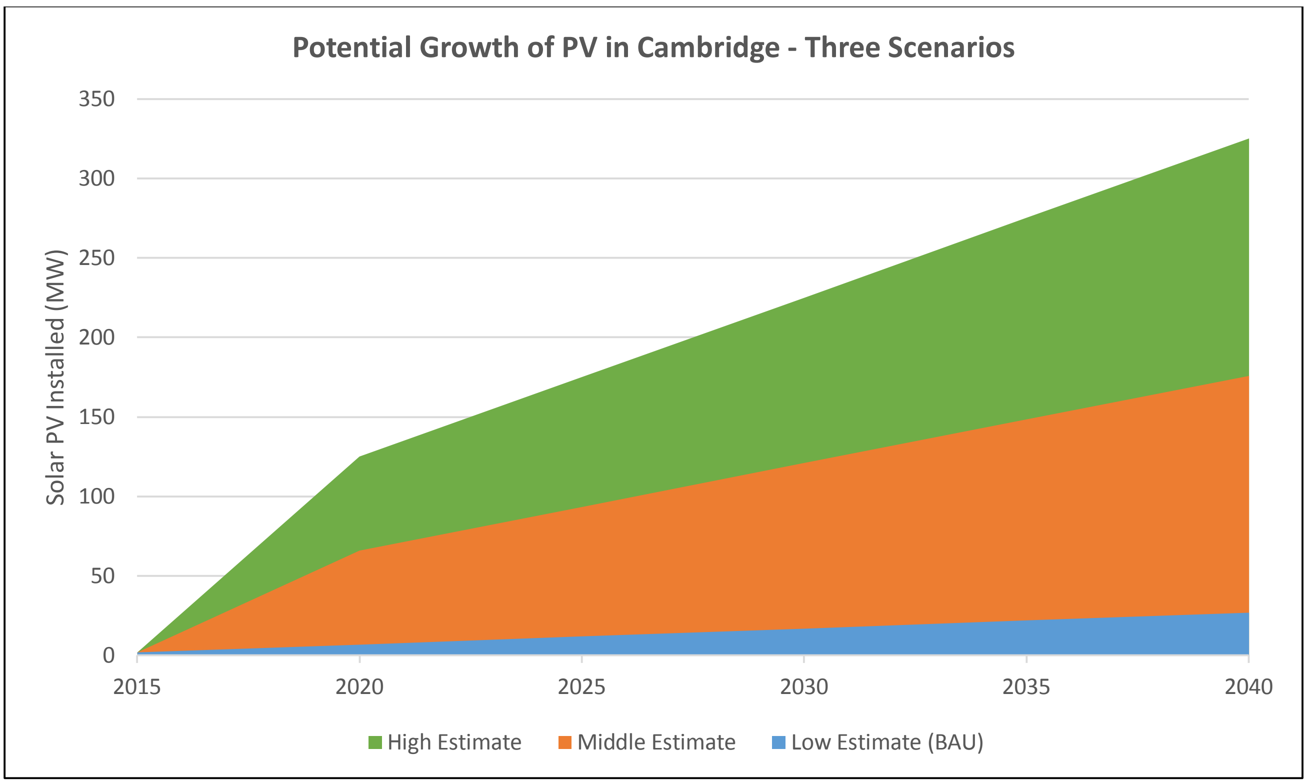

Figure 11. Graph showing three possible implementation scenarios

6 Recommendations for Funding

The economically and technically feasible amount of solar PV that can be installed in Cambridge at this time (not counting the three large ground-based systems) would produce roughly 91 GWh/year, which represents approximately 5.3% of current electricity use in the City. Installing this amount of solar PV would cost roughly $329 million. It is our recommendation that a City of Cambridge Solar Building fund be established to finance the effort. This fund would be used to facilitate the construction and installation of PV throughout Cambridge, pushing the City towards its goal of being carbon neutral. Larger institutions that are part of this community, such as Harvard University and the Massachusetts Institute of Technology, should be encouraged to invest in this fund to install solar PV systems throughout Cambridge.

Harvard University and MIT, leaders in this community and throughout the world, have a responsibility to use their resources to promote renewable energy solutions and slow climate change. They already do so through their research and academic programs, and could do even more by helping to expand the use of solar PV as a renewable energy source in their home community. Harvard University has the largest endowment of any academic institution in the world, at $32.7 billion. Of that, $32.6 million is directly invested in fossil fuel companies. [7] MIT also has a sizeable endowment at $11 billion, of which the exact amount invested directly in the fossil fuel industry is not available. [8] These institutions could cover a large fraction of the investment required to install the $350 million of solar PV by investing some of their large endowments into a fund for use in the City. The two institutions could receive an estimated 6% to 8% return on their investment in this fund to build solar, depending on how it is structured. NSTAR Electric would greatly facilitate the process by allowing solar loans to be repaid in its monthly electric billing system.

Should the City facilitate the set up the City of Cambridge Solar Building fund, and Harvard and MIT choose to invest, constructing all of the 82.1 MW of PV that is currently economically feasible would be a realistic goal. And, with smaller institutions throughout Cambridge also investing, such as Lesley University, Cambridge College, and the many companies that call Cambridge home, it would be possible to raise the funds necessary to accelerate the installation of these 82.1 MW of PV systems throughout the City.

The organizational and legal structure of this fund is beyond the scope of this report. However, this would represent a significant initiative towards sustainability for these educational and research institutions. By investing in sustainable energy projects in their community, Harvard and MIT would be contributing to the health of the community which, after all, sustains them.

[7] http://divestharvard.com/updates/
[8] http://www.fossilfreemit.org/the-200-companies/