December 2017

Stimulate the Adoption of Solar PV on Nantucket

Connor H. O'Neill
Worcester Polytechnic Institute

John Kirwan
Worcester Polytechnic Institute

Nathan A. Pietrowicz
Worcester Polytechnic Institute

Zachary Ryan Boyer
Worcester Polytechnic Institute

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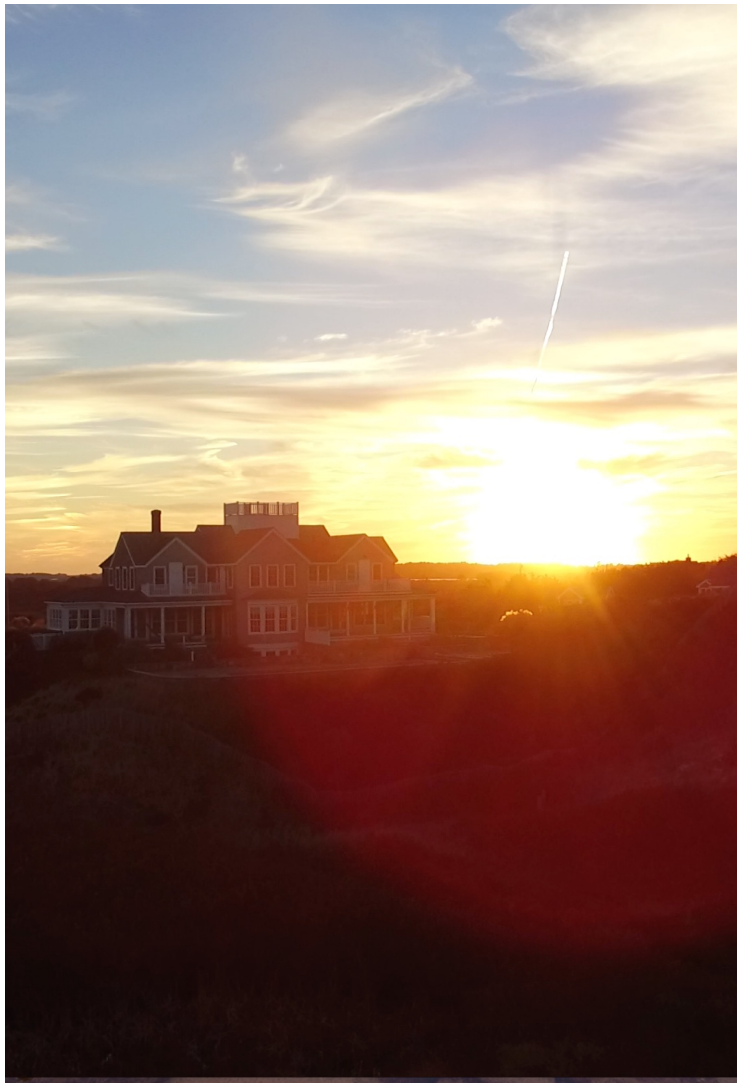

Team Members

Zachary Boyer

John Kirwan

Connor O'Neill

Nathan Pietrowicz

Sponsoring Organization

Town of Nantucket Energy Office

Sponsor Liaison

Lauren Sinatra

Advisors

Dominic Golding

Richard Vaz

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Abstract

Two undersea cables provide Nantucket with electricity, but a third cable may be needed in the future to accommodate peak summer demands. To avoid this eventuality Nantucket is exploring a variety of options, including the adoption of renewable energies in conjunction with energy storage systems to enhance energy independence. The goal of our project was to assist the Nantucket Energy Office in promoting the adoption of photovoltaics on Nantucket. We conducted research, interviewed stakeholders, and distributed a survey to local residents to identify the current barriers to solar PV on Nantucket. We developed web-based promotional materials, including an interactive map, solar PV owner profiles, and a comprehensive list of FAQs, and recommended improvements to the permitting process.

Acknowledgements

We would like to acknowledge and thank several individuals for their contributions to this project including:

Our sponsor Lauren Sinatra from the Town of Nantucket Energy Office

The representatives from the Nantucket Historic District Commission who provided insight to their rules and guidelines relating to solar PV

All of the solar PV owners who graciously took time out of their day to speak with us about their experiences owning a solar PV system

Our advisors Dominic Golding and Richard Vaz

Executive Summary

The demand for electricity on Nantucket has been growing at more than five times the Massachusetts state average and current electricity prices on Nantucket are significantly higher, at 21.5 cents/kWh, than the national average of 13.19 cents/kWh. (Regular Residential Rates, 2017; Basic Service Rates, 2017; Electric Power Monthly, August 2017). The Town of Nantucket Energy Office has been engaged in a variety of activities to reduce electricity consumption and costs for Nantucket residents.

These activities start with educating the public on how to be energy efficient as well as how to conserve energy. The Town of Nantucket Energy Office is also in the process of applying for the MassCEC's HeatSmart Program, increasing clean heating and cooling installations, which will help lower resident's cost of electricity. Education programs and incentives like net metering, income tax credits, Massachusetts Solar Renewable Energy Certificates (SREC-II), tax exemptions and the Mass Save program, along with other small efforts, are great ways to save money and make residents aware of the energy problem. The Town of Nantucket Energy Office is hoping to promote greater use of residential solar PV on the island with its recently launched SOLAR Rebate Program for residents. This offers rebates up to a maximum of $2,500, as a way to reduce the initial cost of a solar PV system (Sinatra, 2017). Additionally, the Town of Nantucket Energy Office's newly approved grant will soon add more than 200 of Tesla's Powerpacks. These will give Nantucket a 48 MWh battery system, hopefully reducing the long-term price of electricity as well as the lowering the possibility of brownouts in the summer months.

Promoting the adoption of solar PV should impact the current problem Nantucket is facing in a positive way. Our project aims to stimulate the interest and adoption of residential solar photovoltaic energy on the island.

The goal of our project was to provide recommendations to the Nantucket Energy Office (NEO) on ways to promote the adoption of solar PV systems on Nantucket. To accomplish this, we established the following objectives:

1. Identify opportunities for and barriers against the adoption of solar PV.

We created and distributed a survey aimed at gauging public awareness of solar PV on the island. We also conducted one-on-one interviews with current owners, representatives of the Historic District Commission (HDC), and on-island and off-island solar PV installers.

2. Determine the current installed capacity of solar PV.

We consolidated information from several databases including the Massachusetts Department of Revenue SREC-II database, the Massachusetts Clean Energy Center database, HDC permitting and inspection files, building permits and Nantucket's Geographic Information System, GIS, in addition to Google Maps.

3. Develop new approaches to promote the adoption of solar PV.

We developed an interactive map depicting each residential and commercial installation as well as specific information for each system. We also wrote three in-depth profiles on three solar PV owners to spread awareness on the process of installing solar PV and their experiences with owning a solar PV system. Lastly, we created a webpage that displays all of the above information as well as Frequently Asked Questions regarding solar PV and a flowchart describing the town permitting processes specific to solar PV.

Stakeholder Opinions on PV Permitting and Installation

Historic District Commission Perspectives

- The HDC does not want solar PV installations installed in the Historic Cores if they are visible from the street.
- The HDC will allow solar PV to be installed outside the Historic Cores with more leniency than inside the Cores.
- HDC members are aware of the energy problems the island is facing.
- The HDC may allow Tesla roof tiles inside the Historic Cores when they become available to the consumer market.

Homeowners Perspective

- The HDC was not perceived to be an impediment to the installation of solar PV systems with any of the homeowners we interviewed
- The homeowners payed little or nothing for electricity after the installation of their solar PV systems
- Most if not all homeowners installed their PV systems for environmental concerns rather than financial reasons.

Installer Perspectives

The interviews with on-island and off-island installers shed light on the specifics of the permitting process. When interviewing the one on-island installer, ACK Smart, we found that many interested owners look at them first, as they want to go with someone local. The on-island installer also has a lot of experience and knowledge of the solar PV application process. Interviewing the two primary off-island installers, Cotuit Solar and SunWind LLC, revealed the difficulties installing solar PV systems on an island thirty miles off the cape. It also showed us that although the owners we interviewed did not have any significant problems with their HDC applications, the installers had instances where their projects required multiple revisions, often delaying the job by a few months. For off-island installers this is very costly, as it means that they have to make more trips back to the island to submit another revision to the HDC. In addition to this, off-island installers have the costs that come with bringing their team to and from the island as well as housing them on-island. Shipping the materials required to build and install a solar PV system also adds to this costs. To accommodate these expenses, it can cost off-island companies $3,500 to $5,000 extra to install solar PV systems on Nantucket. In terms of cost differences between on-island and off-island installers, we learned that although off-island installers have the costs of bringing everything here, on-island installers have to account for the costs of living on island.

Installed PV Capacity on Nantucket

After consolidating information, there are forty installed solar PV systems on Nantucket. Thirty of these systems are residential, with the ten other systems being commercial systems, two of which account for the majority of on-island solar PV generation. In addition to this, there are five residential systems which are still in the process of being built and should be completed by the end of 2017 or early 2018. The number of installed systems has been increasing rapidly over the past few years, as shown in Figure A, with nine

residential systems having been installed this year alone. Bartlett Farms, a commercial system generating over .5MW, is also looking to triple its size, which will add a significant amount to Nantucket's installed PV capacity.

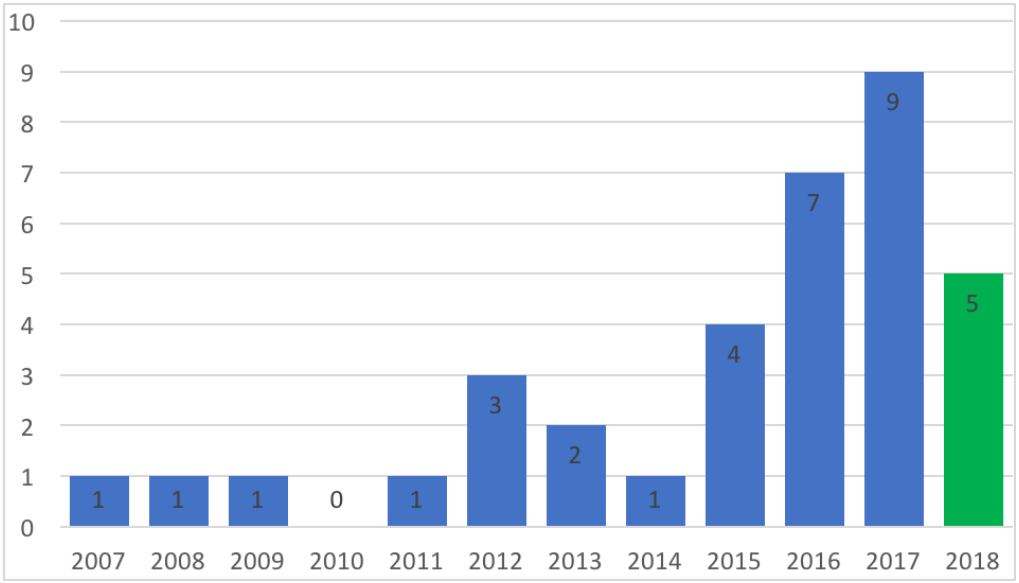

Figure A: Residential Installed Systems on Nantucket Since 2007

Public Attitudes and Awareness about PV

Our survey revealed residents awareness and knowledge of solar PV in addition to any of their perceived opinions and misconceptions. Our survey findings conclude:

- There needs to be better and more easily available information to inform the public on the topic of solar PV.
- Much can be done to increase Nantucket resident's awareness on solar PV, which our project deliverables aim to target.
- When considering installing solar PV, the top three primary concerns were with local permitting, finding a trustworthy installer, and the initial upfront cost.
- When considering installing solar PV, the top three primary benefits were battery storage and backup power, innovative technology, and saving money and reducing electric bills.

Project Deliverables

Based on our research and findings, we developed a set of deliverables to aim the Town of Nantucket Energy Office promoting the adoption of PV on Nantucket. These deliverables include:

- An interactive online map (as seen in Figure B) that shows the location and specifications of residential and commercial solar PV and solar hot water systems.
- Three owner profiles showcasing each owner's motivations, the installation and application process, and the basic system specifications.
- A flow chart outlining the permitting process for a residential PV system installation.
- A webpage on the Nantucket Town website that displays all of the deliverables.

Findings and Conclusions

The permitting process for the installation of PV on Nantucket presents difficulties for some homeowners and installers. Accordingly, we recommend that:

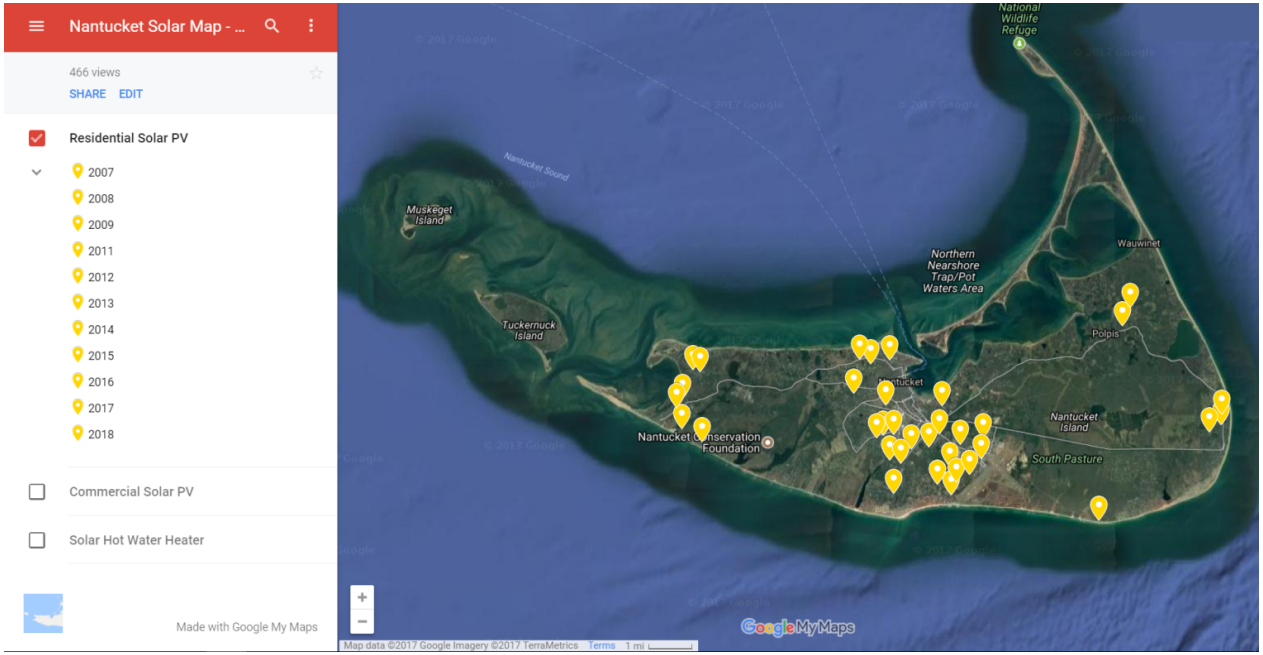

Figure B: Online Interactive Solar PV Map

- The Nantucket Historic District Commission revise its application form to include renewable energies, such as solar PV, either through the inclusion of a few checkboxes regarding renewable energies or by providing more in-depth instructions on the process to apply
- The HDC reconsider and clarify their position on where solar PV can be installed outside of the Historic Cores.
- The Historic District Commission develop a clear set of guidelines for homeowners and installers regarding the installation of PV systems within

and outside the historic districts of Nantucket.

The Town of Nantucket Energy Office should continue to promote the adoption of solar PV on the island. To enhance the likely success of these efforts we recommend that the Nantucket Energy Office:

- Take the lead in establishing better communication with the Historic District Commission to gather data on solar PV installations.
- Use the tools we developed to continue to promote and educate residents on solar PV.
- Update the owner database and interactive map with new solar PV installations using the directions given in Appendix F.

With continued promotion of the local rebate program and using the tools we have provided on the Town of Nantucket Energy Office's website, we anticipate that the number of installed systems on island will continue to grow rapidly over the next several years.

Authorship

Section	Author	Editor 1	Editor 2
Abstract	**Connor**	**John**	**Zach**
Acknowledgements	**Zach**	**All**	**All**
Executive Summary	**All**	**John**	**Zach**
Introduction	**All**	**Zach**	**All**
History of Energy on Nantucket	**John**	**All**	**Zach**
United States Solar PV Policy	**Zach**	**All**	**All**
Comparing MA to the US	**Connor**	**All**	**Zach**
PV Installation Trends across the US	**Zach**	**All**	**All**
Comparing MA to the rest of NE	**Connor**	**All**	**Zach**
Incentive Programs in MA	**Zach, John**	**All**	**All**
Effects of MA Incentive Programs	**Zach**	**All**	**All**
Nantucket SOLAR Rebate Program	**Zach**	**All**	**All**
Methodology (Introduction)	**All**	**Zach**	**All**

Identify opportunities for and barriers against the adoption of solar PV	**Nathan, John**	**Zach**	**All**
Determine the current installed capacity of PV	**Zach**	**All**	**All**
Develop approaches to promote the adoption of PV	**Connor**	**Zach**	**All**
Findings and Analysis (Intro)	**Zach**	**All**	**All**
Payback Period	**Connor**	**Zach**	**All**
Cost of Systems	**Connor**	**Zach**	**All**
Solar PV Awareness	**Connor**	**Zach**	**All**
HDC Guidelines	**Connor**	**Zach**	**All**
HDC Process	**Connor**	**Zach**	**All**
Current Installed Capacity	**John**	**Zach**	**All**
Approaches to the Promotion of PV	**Nathan**	**Zach**	**All**
Conclusions and Recommendations (Intro)	**Nathan**	**Zach**	**All**
Recommendations for the HDC	**Connor**	**Zach**	**All**
Recommendations for NEO	**Connor**	**Zach**	**All**
Appendix A	**Zach**	**All**	**All**

Appendix B	**Zach**	**All**	**All**
Appendix C	**All**	**Zach**	**All**
Appendix D	**Zach**	**All**	**All**
Appendix E	**Connor**	**Zach**	**All**
Appendix F	**Nathan**	**Zach**	**All**
Appendix G	**Nathan, John**	**Zach**	**All**
Appendix H	**All**	**All**	**All**

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Introduction

The goal of the sustainability movement is to "[meet] the needs of the present without compromising the ability of future generations to meet their own needs" (Lemaire, 2010). Fossil fuels are not sustainable long term. BP's statistical analysis of world energy in 2016 states that these fuels are almost depleted. The world has a coal supply of around 114 years, a natural gas supply of 53 years, and an oil supply of 51 years (Ritchie, 2017). Not only are these supplies dwindling, their continued use only adds to problem of climate change. By promoting the adoption of renewable resources such as PV systems, the United State is aiming to reduce its dependence on fossil fuels; decrease environmental impacts on future generations; and begin to reverse the impact of carbon emissions on the planet. Electricity prices in the residential sector of the United States are increasing. From 2000 to 2017, electricity prices increased by 158% (Short-Term Energy Outlook Data Browser, 2017). This increase was one of many that led policy-makers and utility companies to begin to research the promotion of alternative energies including solar photovoltaic (PV) systems. The Energy Independence and Security Act of 2007 was the first step in passing legislation that would promote the adoption of this technology throughout the country not only to reduce electric prices, but to spark a wave of innovation that would begin to decrease the environmental impacts currently hurting the planet. As of October 2017, Massachusetts was the third ranked state, behind California and New Jersey, for overall installed PV capacity with a sum of 1941.27 MegaWatts (MW) (Open PV State Rankings, n.d.). Massachusetts' success is due to the multiple incentive programs and policies that have been implemented over the past two decades including the MassSave effort, MassCEC (Massachusetts Clean Energy Center), and tax exemptions for the installation of PV.

Nantucket faces particularly acute problems regarding electricity costs and supply. Residents pay some of the highest average electricity prices in the country and these prices are rising more rapidly than elsewhere in the state. Furthermore, peak demand is increasing each year and the island is quickly reaching the capacity of its two undersea electric cables. In 2013 the island reached a peak load of 45 MW, about half the capacity of the two cables, and, since then, that number has only increased. Currently, if one cable were to fail the other would not have the capacity to sustain the island (Brief History of Energy on Nantucket, n.d.). The Nantucket Energy Office has been researching and promoting various solutions to delay the installation of the third cable, including the

addition of solar PV systems and energy storage systems.

To promote the adoption of solar PV, the Nantucket Energy Office has developed a local rebate program, the SOLAR Rebate Program, to offset the cost of new residential solar PV systems. Additionally, the Nantucket Energy Office has collaborated with National Grid to explore different approaches in reducing the required amount of energy Nantucket uses with the intention to forestall the construction of a third cable (Brief History of Energy on Nantucket, n.d.). Previous efforts have found that some Nantucket residents are inclined to adopt solar PV; however, the problems Nantucket now face are promotion and the limited information regarding the effectiveness of solar PV on Nantucket. In order to promote solar PV effectively, the Nantucket Energy Office should teach residents about the technology and aid the Historic District Commission in the revision of their application form to include sustainable energies. Currently, the island has less than 40 residential PV installations. If the Nantucket Energy Office can expand the adoption of PV systems and storage systems through education and promotion, there is the possibility that a third cable will not be needed and, in doing so, will continue its mission to empower a more sustainable energy future for Nantucket.

In order to aid the Nantucket Energy Office, our project's purpose was to create promotional tools for the adoption of solar PV systems. We began by identifying particular barriers and opportunities for the adoption of these systems. While on island, we developed a singular database that consolidated location and technical data of each system, such as installed capacity, in addition to contact information for the owner of each system. This information was displayed in an interactive map as well as on a webpage located on the Nantucket Town website, specifically the Nantucket Energy Office page. To complete these objectives, we conducted interviews with stakeholders, assessed existing databases, and visited installations to observe their effectiveness.

History of Energy on Nantucket

Nantucket's demand for electricity has been growing over the past few decades. Since the installation of the first underwater cable in 1996, energy demand has been increasing rapidly (National Grid, 2015). In 2006, National Grid installed a second undersea cable at a price of $41million as a way to meet the island's growing demand. Figure 1 depicts the rough geographic location of these cables from the mainland to the island.

The demand for electricity on Nantucket has grown at more than five times the Massachusetts state average and current electricity prices on Nantucket (21.5 cents/kWh) are substantially higher than the national average (13.19 cents/kWh) (Regular Residential Rates, 2017 ; Basic Service Rates, 2017 ; Electric Power Monthly, August 2017). While the need for a third cable is still uncertain, there is still much that can be done to reduce electricity costs and improve the overall energy efficiency of the island's residences and businesses. (Brief History of Energy on Nantucket, n.d.).

Increased adoption of solar PV might be one solution to help reduce the amount of backup diesel generation, used to supplement the island's electric needs during times of increased peak demand and in the case of cable failure, needed. As can be seen from Figure 2, Nantucket has been steadily approaching the combined cables' peak load of 74 MW. Furthermore, the island has already exceeded the peak load of each individual cable, meaning that if one of these cables were to have a disruption in service, the other cable would not be able to carry enough power to sustain the island's energy demand, especially during the summer months.

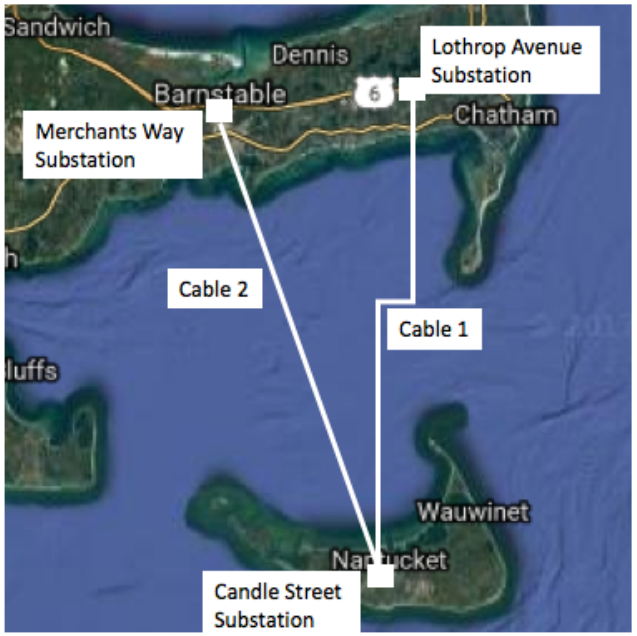

Figure 1: Undersea Transmission Cables (National Grid PDF, 2017)

An energy storage solution in conjunction with solar PV is one of several possible solutions for the residents of Nantucket. Without the use of a battery to store excess energy, solar PV does not help

reduce Nantucket's peak load. According to Ahmad Zahedi, an associate professor and department head of the Electrical and Computer Engineering of James Cook University, "the intermitt[ent] nature of the solar energy is considered as one of the weaknesses of utilization of this technology." (Zahedi, 2010). Scientists, engineers and scholars agree that solar PV's weakness is the off-time when it is not generating electricity. This is a problem for most energy users, as the peak demand in a given day is from 5pm to 10pm (U.S. EIA 2011). During this time solar systems are not effective since there is little to no sunlight to stimulate the panels, but with a battery system attached, energy could be stored for use during these evening hours of high demand. Although these residential battery storage systems can cost upwards of $20,000 in addition to the solar PV system, they can be a fair investment and might help decrease peak energy load.

Nantucket has looked at possible solutions to the peak load problem in the past. Many of these solutions start with educating the public on how to be energy efficient as well as how to conserve energy. The Town of Nantucket Energy Office is also in the process of applying for the MassCEC's HeatSmart Massachusetts Program pilot, which "aims to help drive down the installation costs and increase deployment of clean heating and cooling installations through a group purchasing model." (Energy Efficiency, n.d.). These education programs and incentives along with other small efforts are good ways to involve residents and make them aware of the energy problem, but are not long term solutions.

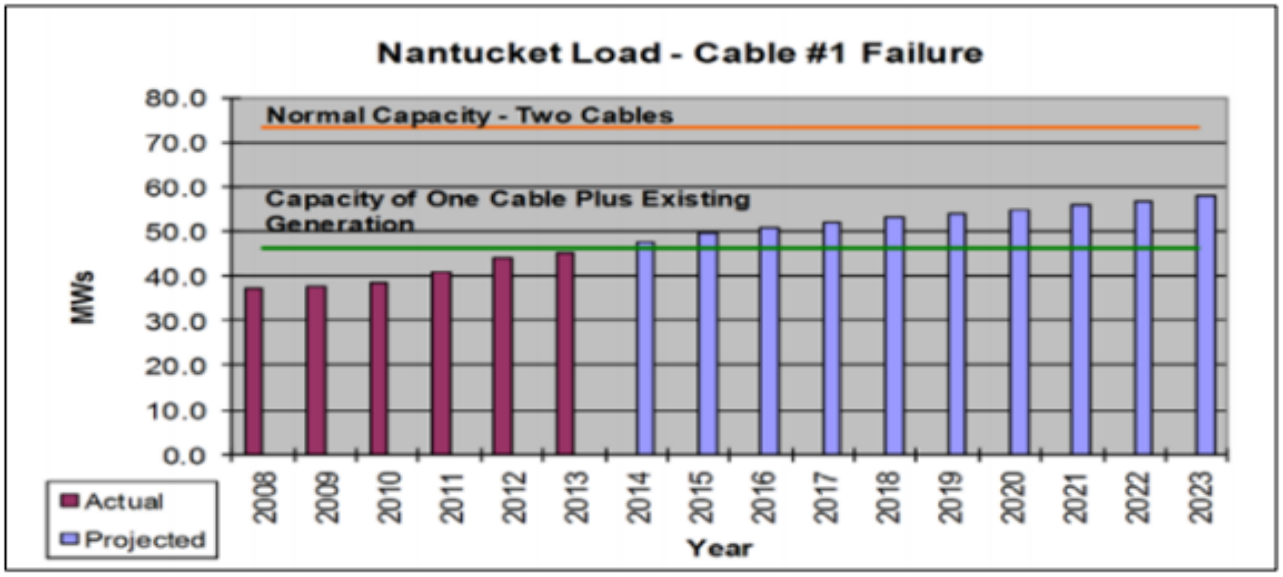

Figure 2: Nantucket Energy Load on Cable 1 (Burgwardt, Maynard, & Sickles; 2015)

While many of these education programs are helping in small ways or are still in the process of being adopted, increasing the on-island generation of electricity by promoting the adoption of solar PV should impact the current problem facing Nantucket in a positive way. Our project aims to stimulate the interest and adoption of residential solar photovoltaic energy on the island. This, along with a storage solution, will eliminate some of the load on the underwater transmission cables, thereby reducing mainland dependency.

United States Solar PV Policy

The United States House of Representatives enacted the Energy Independence and Security Act of 2007 as an initial step to increase the nation's energy independence and security. The act provisioned numerous advisory councils to promote the research and development of next-generation energy sources in addition to decreasing the amount of energy current buildings were consuming. In particular, Title Four of the act "[r]equires the Secretary to study and report to Congress on methods to : (1) integrate concentrating solar power and utility-scale photovoltaic systems into regional electricity transmission systems" (Energy Independence, 2007). In addition, the act created a federal grant program to strengthen the installation, operation, and maintenance of solar energy products and a strong research and development program to assist in the promotion of solar energy sources (Energy Independence, 2007). This act not only served as a basis for the adoption of solar PV systems in the United States, but it also began to reform the electric grid in order to prepare for the adoption of solar.

Two years after the Energy Independence and Security Act of 2007, President Obama signed into law the American Recovery and Reinvestment Act of 2009, also known as the Recovery Act of 2009. This act appropriated resources to expanding the smart grid and extending tax credits for renewable resources such as solar PV. Specifically, the Recovery Act "[e]xtend[ed] for three years the tax credit for producing electricity from wind, biomass, geothermal or solar, solid waste, and qualified hydropower facilities" (American Recovery, 2009). This act was the second step in moving the United States closer to independence from non-renewable resources by expanding tax credits.

PV Installation Trends across the US

The past decade has shown tremendous growth in the number of PV systems installed throughout the United States. As shown in Figure 3, the number of installed PV systems grew from 250,000 in 2011 to more than 1 million in 2016. This is what the Energy Independence and Security Act of 2007 as well as the Recovery Act of 2009 were designed to do. By offering rebates and incentives for the installation of PV in America, citizens pay less for energy in the long term and the country as a whole begins to reduce its dependence on fossil fuels.

Since the implementation of its own incentive and rebate program, Massachusetts has risen to the third ranked state in terms of installed PV capacity. Figure 4 shows that as of December 2016,

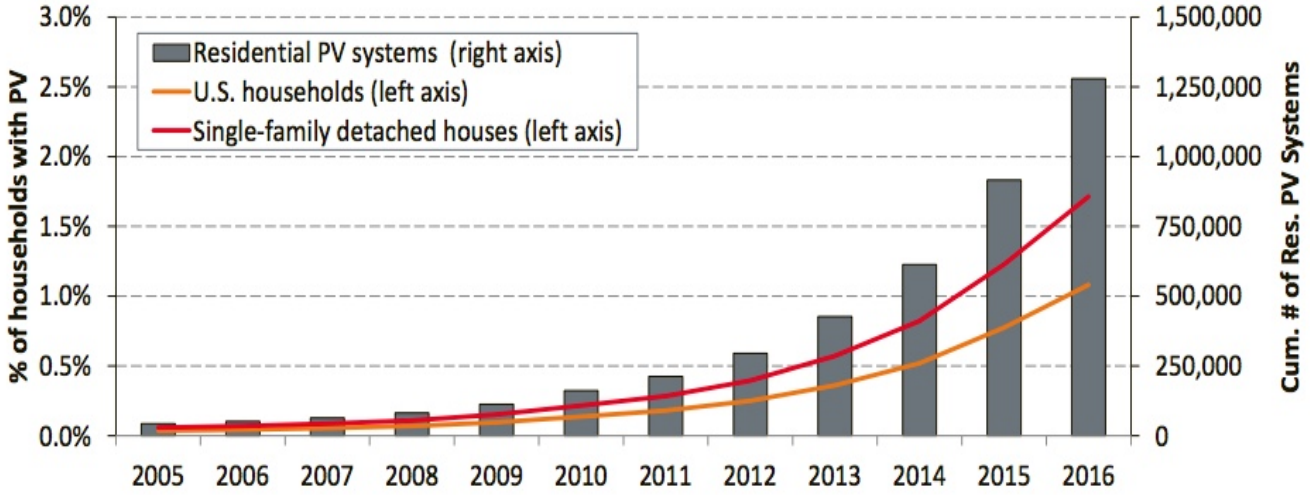

Figure 3: Trends in Installed Residential PV Systems (Margolis, Feldman, & Boff, 2017)

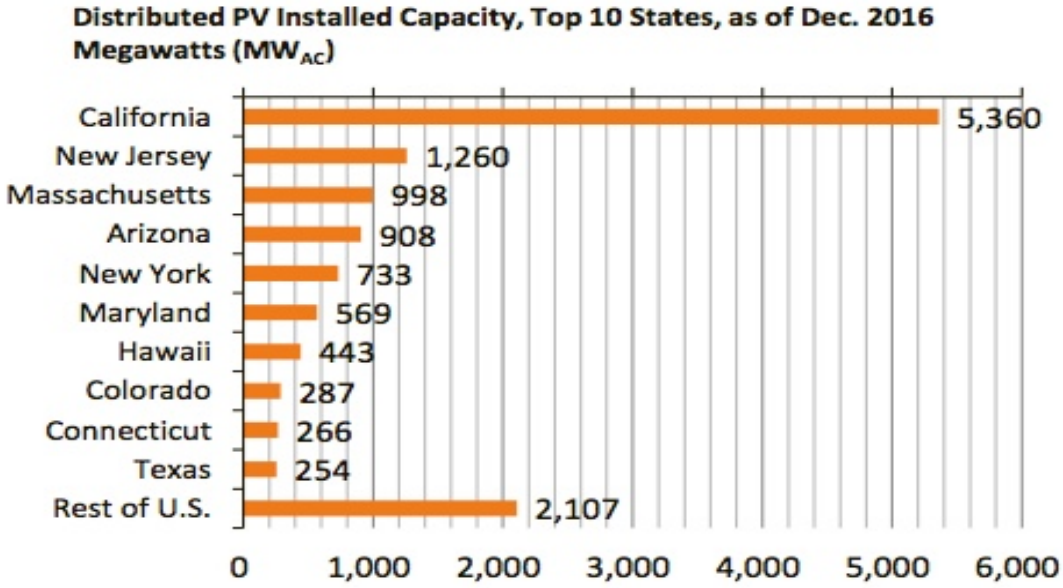

Figure 4: Top 10 US States with PV Installations (Margolis et al., 2017)

Massachusetts had a total PV capacity of 998 MW, only 262 MW short of New Jersey (which holds the second position behind California). Currently, Massachusetts has a total PV capacity of 1941.27 MW (Open PV, 2017). In less than a year, Massachusetts has increased its PV capacity by 943 MW which would appear to indicate the incentive and rebate programs are working. Furthermore, as the cost of PV installations continue to decrease (shown in Figure 5), it is likely that more homeowners will install systems and that the total capacity will only continue to rise.

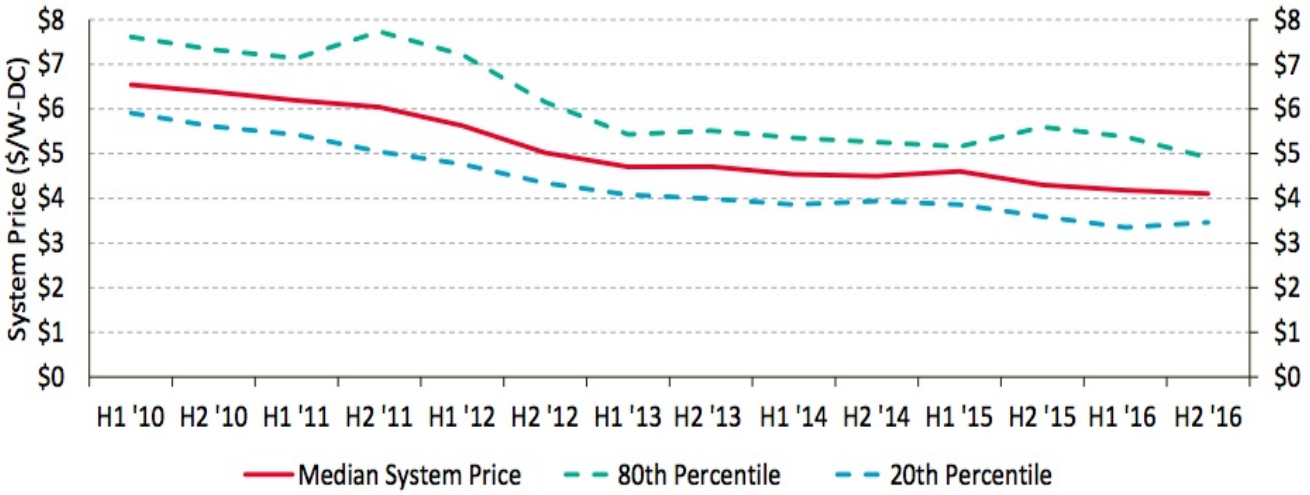

Figure 5: Price of Installed PV Systems (Margolis et al., 2017)

Comparing Massachusetts to the US

Compared to its New England counterparts, Massachusetts has developed a more complex collection of state incentive programs. This correlates with the installed capacities of New England States, as shown in Table 1. Massachusetts does have the highest installed capacity and number of installations out of any other New England state and is ranked third in both regards when compared to all fifty states. Only California and Nevada have a greater number of installations. (NREL, n.d.).

Looking again at the data in Table 1, however, there is no correlation between the average cost of a system and the installed capacity. The cost per Watt of solar PV in Vermont, New Hampshire, and Rhode Island is less than the cost per Watt in Massachusetts. Additionally, when the Watt per capita is calculated to factor in the population of each New

England state, there is still no correlation that the financial piece of solar PV is the primary factor in successful adoption.

Table 1: New England Solar PV Statistics (Open PV State Rankings, n.d.)

State	Cost/ Watt	2017 Capacity (MW)	Installations	Population	Capacity per Capita w/ Person
ME	4.08	7	702	1328302	5.27
RI	4.34	18.81	583	1051511	17.91
NH	4.61	27.95	3501	1323459	21.17
MA	5.27	1941.27	71421	6692824	290.17
CT	5.35	248.61	23643	3596080	69.14
VT	6.69	39.39	1642	626630	62.52

Comparing Massachusetts to other New England States

With New England having a homogenous climate, the six states' residential PV incentives can be studied to find a possible correlation with their success in solar energy adoption. From here, effective ways of promoting solar PV from a financial standpoint can be discovered. Moreover, we can see how Massachusetts' incentive programs for solar PV differ from and compare to those methods employed by the other New England States.

The New England states have all seen an increase in installed PV capacity between 2013 and 2016. These increases have been insignificant in Maine, New Hampshire, and Rhode Island while PV capacity in Vermont and Connecticut have seen substantial increases relative to their installed capacity in 2013. Over this three-year period, Massachusetts stands out among the New England states, as seen in Figure 6, due to its large increase in PV capacity (Final PV Forecast, 2017).

There are several possible reasons why Maine and Rhode Island have been less successful at increasing the installed capacity of PV (Final PV Forecast, 2017). Maine, for example, has only a single incentive program. This program, a PACE loan program, disburses low interest rate loans ranging from $6,500 to $15,000 for a solar PV system. Rhode Island has put more programs in place to promote solar PV, although it has had only modest success so far. Rhode Island has a PACE program similar to that in Maine, but has also exempted PV owners from paying property and sales tax on solar PV systems, no matter their size. In addition, Rhode Island also implemented a Feed-in-Tariff (FiT) for small scale systems. The rates can be seen in Table 2 (Renewable Energy Growth Program, 2017). Although Rhode Island has more incentives in place than Maine, it has not seen substantial growth in PV yet.

Connecticut offers a wide range of incentive programs including loans with

varying interest rates depending on household income. This incentive gives low-income citizens the ability to invest in clean energy. For instance, the lowest bracket has zero interest rate and a 15 year payback period. Connecticut also offers a PACE program and a yearly FiT program with rates between 40 and 48 cents per Watt, depending on the size of the system. Like Rhode Island, it exempts solar PV owners from paying property and sales tax on their PV systems.

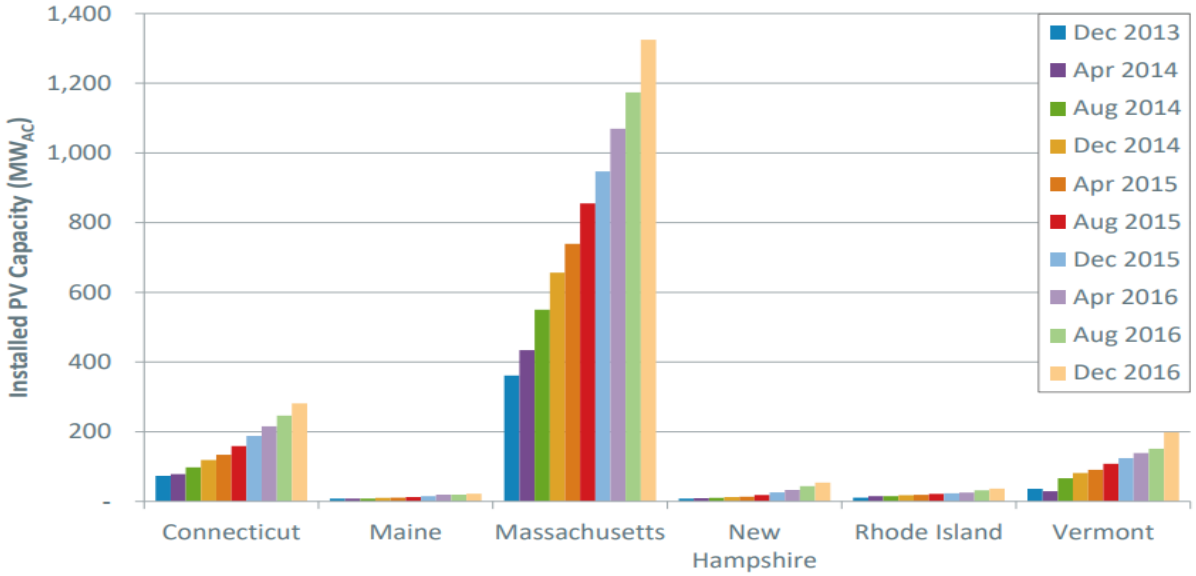

Figure 6: New England Installed PV Capacity (Final PV Forecast, 2017)

New Hampshire's situation does not compare well with the other states because it has seen a modest uptake of PV but has few incentive programs. The state allows sales tax exemption on renewable energies and has a rebate where the solar PV owner can earn back $2,500 of the cost of their system at 50 cents per kWh. The only additional incentive they give is grant funding ranging from $150,000 to $1,000,000, however, it only has a yearly budget of $1,000,000, therefore it will not affect many residents (DSIRE, n.d.).

Vermont offers relatively small incentives as well. Solar PV owners are exempt from property and sales tax relating to their systems. Owners can also apply for a PACE loan of up to $30,000. Vermont

Table 2: Rhode Island FiT Rates (Renewable Energy Growth Program, 2017)

Renewable Energy Class (Nameplate kW)	Annual Enrollment Target (Nameplate MW)	Ceiling Price/Standard PBI (cents/kWh)
Small-Scale Solar – Host Owned (1-10 kW DC)	5.5	37.65 (15-yr Tariff)
Small-Scale Solar – Host Owned (1-10 kW DC)		33.45 (20-yr Tariff)
Small-Scale Solar – 3rd Party Owner (1-10 kW DC)		28.35 (15-yr Tariff) 24.70 (20-yr Tariff)
Small-Scale Solar (11-25 kW DC)		24.90 (20-yr Tariff)

has a Feed-in-Tariff of 13 cents per kWh for 25 years after the installation. This incentive type allows the government to support clean energy, however does not bind the government to a permanent payment plan.

Incentive Programs in Massachusetts

While the initial, upfront cost of a PV system can be quite large, Massachusetts offers numerous incentive programs to both help alleviate the financial burden and to promote the adoption of these systems. Figure 7 depicts how these incentive programs work to lessen the initial cost of PV systems. Over time, conventional electricity (from the grid) will continue to increase in price while the cost of PV systems decrease as PV technologies become more efficient.

Incentive programs bring the cost of PV systems down during this period in order to promote the increased adoption of these systems (shown by the installed PV capacity bar graph in Figure 7). After the grid parity, the point at which the cost of PV is equal to the cost of conventional electricity, incentive programs will be phased out as the market for PV is self-sustaining and will no longer require external incentives to encourage its adoption.

Net Metering

National Grid defines net metering as a way to "financially balance out the total amount of energy imported with the total amount of energy exported over the course of a billing period (typically about a month). Then, the customer is only billed (or credited) for the net difference between these two amounts" (Net Metering, n.d).

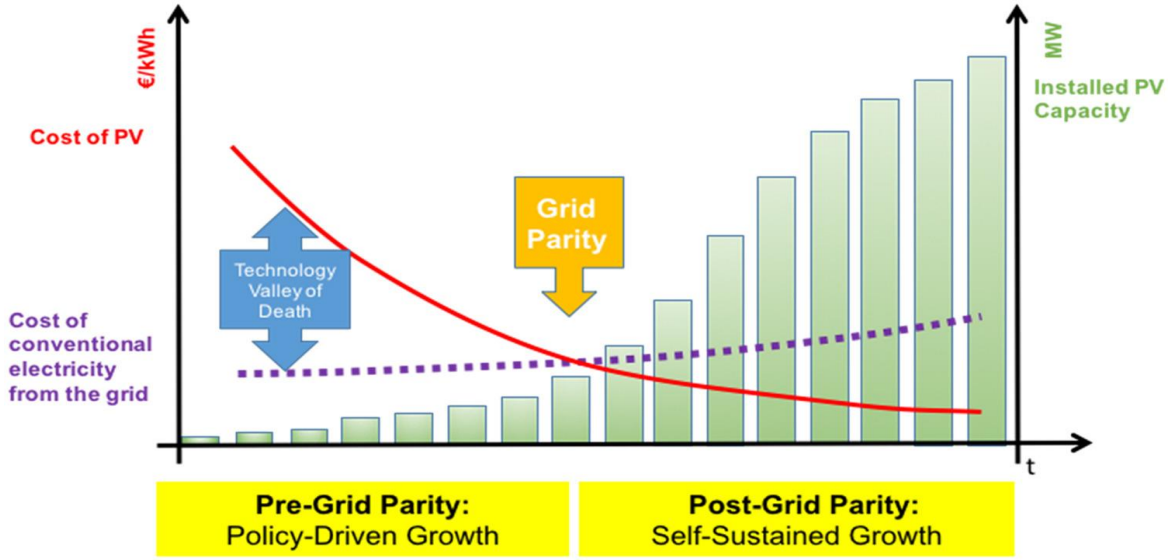

Figure 7: Use of Energy Incentives over Time (Karneyeva, 2017)

In most systems, this difference is usually in favor of the customer and, as a result, National Grid is able to buy back, in the form of credit, the excess energy that the customer's PV system generates.

There are limits to net metering, however. As defined by the Massachusetts Department of Public Utilities, net metering is limited to " 7% of a utility's historical peak load for private customers and 8% for public entities". On Nantucket specifically, this equates to a limit of 3.183 MW private and 3.638 MW public per year. In other words, the maximum amount of electricity private customers collectively can push back into the grid is 3.183 MW. For public entities, this number is 3.638 MW (Net Metering, n.d).

In terms of monetary value, National Grid calculates a credit based on the sum of the applicable charges and multiplies that value by the net exported energy. This results in a dollar amount that is then credited to a customer's account.

Income Tax Credit

In addition to net metering, the State of Massachusetts offers a personal income tax credit of 15%, up to $1000, including the net cost of systems that stay in operation for at least five years (Residential Renewable, 2017).

This type of rebate is ideal for new PV systems because of its immediate nature. Whereas net metering can take at least a month to start deferring the cost of the system, this rebate is offered as soon as the system is installed, thus reducing the immediate financial burden.

Massachusetts Solar Renewable Energy Certificates (SREC-II)

In April of 2014, Massachusetts enacted the Solar Carve-Out II Program in which residents with qualified PV installations, installed after 1/1/2010, would generate Solar Renewable Energy Certificates, or SREC-IIs, "which represent the renewable attributes of solar generation, bundled in minimum denominations of one MWh of production" (Solar Renewable Energy Certificates, 2017). In other words, home owners who generate one MWh of electricity through their PV systems will receive the equivalent of one SREC-II. From this point, the homeowner can sell that SREC-II on the open market through the Massachusetts

Department of Energy Resources (DoER) to electric utility companies for a fixed rate. As of 2017, this rate is $350 per MWh through the open market and $285 through the DoER.

In addition, each qualified installation is given an SREC Factor based on the type of installation it is. For example, a residential system with a capacity of less than 25 kW DC would have a factor of one. In other words, for each MWh produced, that system would receive one SREC, whereas a commercial system would have an SREC factor of 0.9. (Solar Renewable Energy Certificates, 2017).

Tax Exemptions

Homeowners who install PV systems as a "primary or auxiliary power system for the purpose of heating or otherwise supplying the energy needs of property taxable under Chapter 59 [of the Property Tax Bureau Informational Guideline]" are eligible for a tax exemption on the additional value of the property added by the system for a period of twenty years from the installation date (Property Tax Exemptions, 1984). Other tax exemptions require an annual application, whereas this property tax exemption is an easy way to add value to an existing home while only applying once. Here, the customer does not need to worry about the increased property tax that would normally come with building an addition such as a PV system and thus, they only need to worry about paying the initial purchasing and installation fees for the system.

Similarly the property tax exemption that PV systems qualify for can also be exempt from sales tax. According to the Massachusetts Department of Revenue, "[e]quipment directly related to solar, wind-powered or heat-pump systems is [sales tax] exempt if the system is used as a primary or auxiliary power system …" (A Guide to Sales and Use Tax, n.d). Therefore, not only is the customer exempt from twenty years of property tax on the system, they also do not need to pay sales tax further supporting the state's obligation to the promotion and adoption of PV systems.

Mass Save

Another aid to the promotion of energy savings that has been successful in other communities in Massachusetts is Mass Save. Mass Save is a residential energy program sponsored by National Grid. Its main purpose is to offer incentives to homeowners for improvements to their

homes to reduce their energy consumption and energy costs. Residents on island can utilize incentives included with Mass Save, the primary being a "no-cost home energy assessment" (What is a Home Energy Assessment?, n.d.). The program also offers free LEDs to replace ordinary incandescent bulbs, subsidized insulation, and rebates on space heating and water heating equipment (Mass Save, n.d.). Mass Save also offers "Heat Loan Eligibility Services" for residents that are interested and qualify for Solar Hot Water Systems. These rebates will continue to aid residents in reducing energy consumption and assist them in utilizing solar PV more effectively.

Massachusetts Incentive Program Results

In the period between late 2013 and mid-2016, Massachusetts increased its solar PV capacity "from 362 megawatts to 1,174 megawatts" and the various state incentives and programs were one factor that encouraged this growth (Shemkus, 2017). The rebates and tax incentives can reduce the costs of installing a PV system substantially.

For example, new solar systems typically cost around $30,000, or about the price of a new car. These incentives can typically reduce the cost of a new system to $20,000 and, through the Mass Save program, customers can expect to pay anywhere from $14,000 to $16,000 with an average payback period of 7 years (Shemkus, 2017).

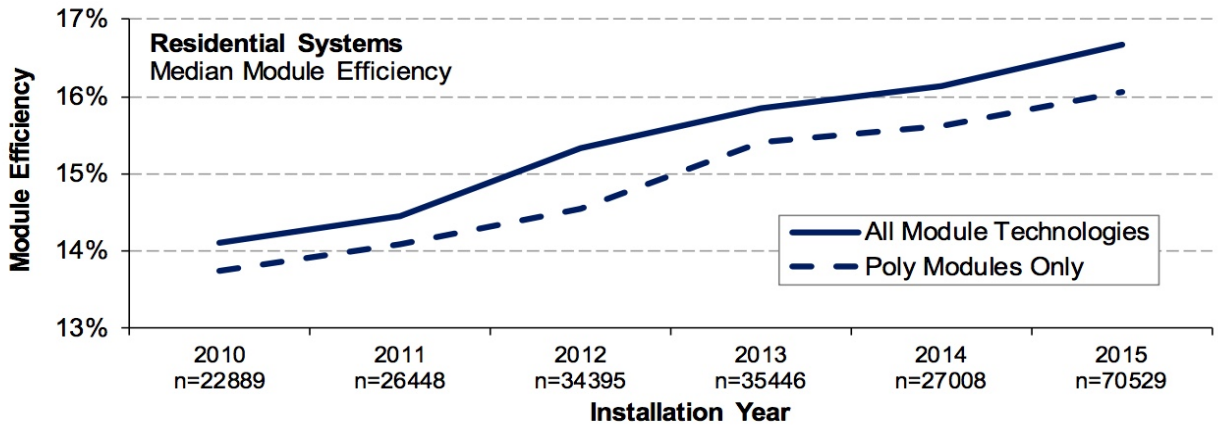

Figure 8: Solar Panel Efficiency (Barbose & Darghouth, 2017)

While still a large amount, this number can easily be lessened through net metering and, in the long run, will actually save the customer money on their electric bill. These programs are working and, as PV technology becomes increasingly efficient (shown in Figure 8) and less expensive (shown in Figure 5), more people will likely start to adopt PV.

Nantucket SOLAR Rebate Program

In July of 2017, the Town of Nantucket Energy Office launched its SOLAR Rebate Program for residents. The program offers rebates up to a maximum of $2,500 as a way to reduce the initial cost of a solar PV system (Sinatra, 2017). The rebate is being made available to encourage the adoption of PV systems on Nantucket.

As climate change and dependence on fossil fuels continue to impact the global biosphere, thereby directly impacting environmental preserves such as Nantucket, and electricity prices continue to rise, the need for renewable energy adoption is becoming a larger topic than it once was. Since the adoption of federal policies in 2007, many states have greatly increased their installed capacity of PV systems both through education programs and through state incentives. Massachusetts has become one of the top states in the country to lead these efforts. Nantucket unfortunately lags behind the rest of the state in terms of PV adoption despite its high energy costs and access to federal and state incentives. In an effort to encourage the increased adoption of PV systems, the Nantucket Energy Office created the Nantucket SOLAR rebate program and, furthermore, is currently looking to explore more innovative ways of promoting energy awareness and adoption of PV.

Methodology

The purpose of this project was to assist the Nantucket Energy Office in promoting the adoption of solar PV on Nantucket. In order to achieve this, we developed the following objectives:

1) Identify opportunities for and barriers to the adoption of PV on Nantucket.

2) Determine the current installed capacity of PV on Nantucket.

3) Develop approaches to promote the adoption of PV on Nantucket.

These objectives required a variety of tasks including interviews with stakeholders, the assessment of existing databases, and site visits and observations, as illustrated in Figure 9. We describe these tasks in more detail below and a timeline for accomplishing them is shown in Appendix D.

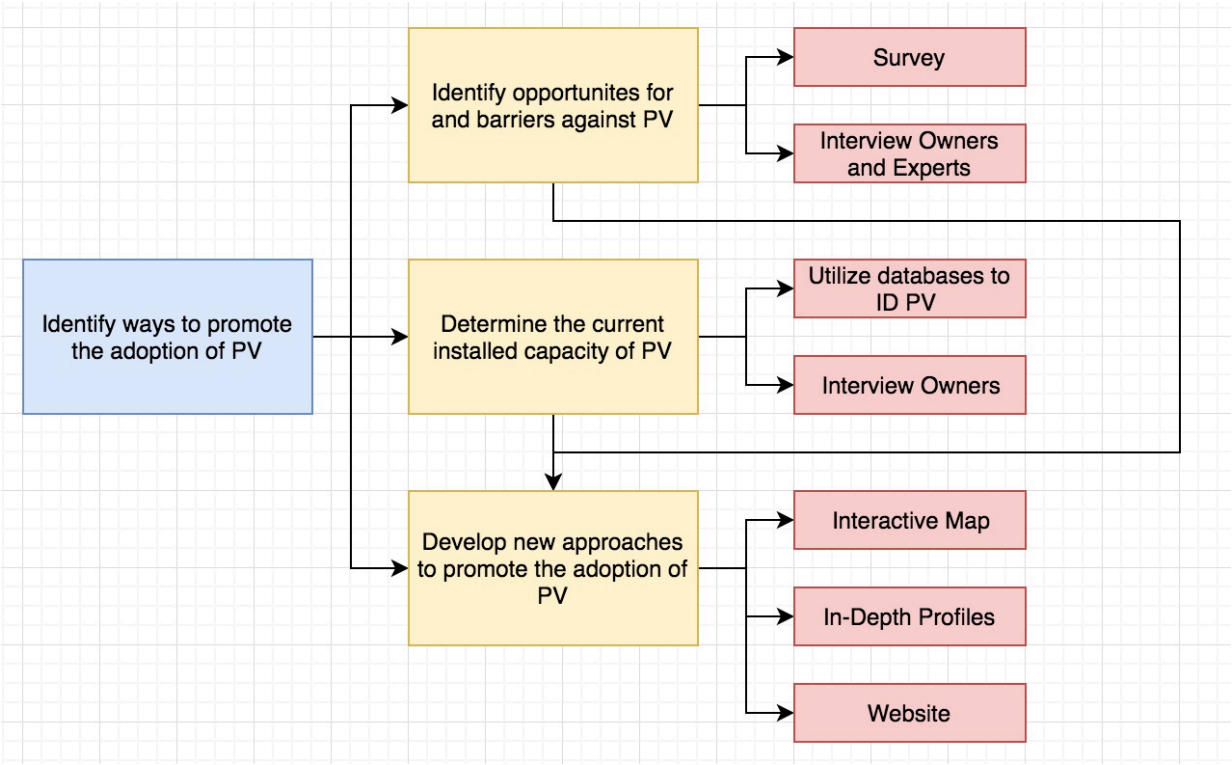

Figure 9: Project Goals and Objectives

Identify Opportunities for and Barriers Against the Adoption of PV

We utilized numerous tools to identify opportunities for and barriers against the adoption of PV on Nantucket including a public survey and interviews with solar PV installers, regulators, and selected solar PV system owners.

Stakeholder Interviews

In collaboration with Lauren Sinatra from the Nantucket Energy Office, our team set up and conducted interviews with energy specialists and industry experts to aid in our research. One of these experts was Tim Holmes, owner and operator of SunWind LLC; a solar installation company operating on Nantucket. We also interviewed experts from companies such as Cotuit Solar, specifically Conrad Geyser and Diane Mahoney, to get a rounded perspective of the solar PV industry on the island. These interviews, in addition to others, were designed to provided deeper understanding of the opinions and knowledge of these specialists with regards to solar PV.

In developing interview scripts for these energy experts, as well as for on-island stakeholders, mentioned below, our team looked at previous interviews given on island and the data collected from those interviews. This gave us a better understanding of the information we wanted to collect and showed us what information we already possessed. Appendix A describes the questions we asked installers and other experts. Because the flow of interviews (order of questions) cannot always be anticipated and conducted in the same way, each session was done differently and thus, the results obtained were not always directly comparable. All of the questions were asked; oftentimes in different orders and to varying degrees of success. These interviews were conducted by at least two team members, one being a designated recorder and the other being the lead interviewer. In addition to notes, each interview was recorded audibly to ensure that if quoted in the final deliverables, the interviewee was quoted accurately. Each interviewee was also read our preamble, described in detail in Appendix A, to ensure they knew the terms of the interview and could consent to being recorded and/or quoted in the final report.

In order to find out more information about current solar PV and any particular problems they may have, lack of

incentives; laws regarding its installation; or general obstacles, we interviewed solar PV owners on Nantucket. To learn more about the HDC permitting process, we spoke with Compliance Coordinator John Hedden, Chairman Ray Pohl, and Board Member Val Oliver regarding their opinions of the solar PV being installed on the island. We also gauged their outlook on solar PV installations within the Historic District Cores in 'Sconset and downtown. We followed the same general interview protocols as those above; using slightly different questions (shown in Appendix B).

Interviews with current solar PV owners allowed us to ask how they became aware of the possibilities of solar PV and the rebates that Massachusetts and the town of Nantucket offers. We also identified any problems that those owners had regarding the permitting process and overall system operation. This was intended to give us an idea of the overall process of getting a solar PV system installed on Nantucket; allowing us to develop an online flowchart that residents could reference to educate themselves on the process. Installation companies were asked about how many solar PV systems are installed on island, the installation process from their point of view, and whether they see an increasing trend of installations on the island.

When interviewing solar PV owners and installers we wanted to get a better understanding of the existing opinions and knowledge on and surrounding solar PV. We spoke about the costs of owning PV and the payback period that comes with owning a system. In addition to this, when conducting interviews with solar PV owners as well as members of the Historic District Commission, we wanted to know their perceptions on the aesthetics and effectiveness of PV specifically on Nantucket in order to identify ways that residents could make the Historic District Commission permitting process easier. The HDC provided us insight as to what restrictions there are on PV placement both within, and outside of, the historic core districts on Nantucket. These interviews with solar PV experts, owners and the HDC were intended to give us a better understanding of the various perspectives of solar PV on Nantucket to help us develop solutions to promote the adoption of solar PV.

Public Survey: Solar Energy

We, with the help of the Nantucket Energy Office, developed a survey to gauge public opinion on the adoption of solar PV on Nantucket. Using feedback from our interviews with homeowners and also a previous survey that was given to the public on Nantucket as well as another survey that was distributed to residents of San Diego, California, we developed the survey to gauge public awareness about solar PV. Over numerous weeks we met with Lauren Sinatra of the Energy Office to finalize a list of 16 survey questions, shown in Appendix C, that would identify public opinion of solar PV adoption and current public awareness of Nantucket incentive programs and financing options for solar PV systems. Once complete, the survey was distributed through Google Forms to a list of Nantucket residents who participated in prior green energy initiatives endorsed by the Nantucket Energy Office such as the Mass Save Home Energy Assessment as well as town employees. As a result, the data collected from the survey had a slight bias, as each respondent was already interested in renewable energy technologies such as solar PV.

Determine the Current Installed Capacity of PV on Nantucket

Our second project objective was to determine the current installed capacity of PV on Nantucket and develop a comprehensive database of residential and commercial PV and thermal solar systems. Before determining the current installed capacity of PV on Nantucket, we needed to find the number of solar PV systems installed on Nantucket. The real question here was how to resolve this number without searching through Nantucket's Graphical Interface System (GIS) and Google Maps extensively.

Our initial plan was to investigate Nantucket's Building and Zoning Department for permits relating to PV installations on the island. Since a building and wiring permit is required for installations such as this, there would be a record of all installations. This would yield the data we were looking for such as; name of the owner, installation date, installation company, possible number of panels, and the system's overall total capacity. However, once on island, we realized that this was not feasible. Nantucket's Building Inspector, who held records of these installations, was unavailable and the Wiring Inspector was often times too busy to provide us with

the information we needed. In light of this, we altered our plan. We utilized databases such as the Massachusetts System of Assurance of Net Metering Eligibility and the Massachusetts Clean Energy Center to collect this data. We were also pointed towards the town Historic District Commission permit files as well as the HDC final inspection book which held contact information, installation date and cost, installation company and much more which helped us verify the data from these databases.

We also asked the Nantucket Energy Office for additional residents to contact who have installed PV systems on their homes. Since the Energy Office has better contacts throughout the island, this yielded a list of residents that we had missed in addition to further verifying those that we acquired through the above databases.

To further verify our findings and find potential installations the databases had missed, we utilized Nantucket's GIS. GIS holds information regarding plot owner and time stamps regarding its aerial photography layers that we used to retrieve owner contact information and an estimate for when the system was installed. If GIS did not yield a good quality image of the install, we attempted to verify with Google Maps.

From the data we collected, we reached out to about 25 system owners to set up in-person interviews to collect data on their experiences with PV. We did not interview all of these individuals due to scheduling conflicts as well as some installations not being installed at the time we were on Nantucket. In addition to the protocols described above, we were interested in the incentives and rebates the owner used, which installation company they used, and, to aid in the profile, sought to take photos of the installation from both the street and the air. This information was included in the interactive map described below in addition to an in-depth profile of some owners on the island that other residents could look at if and when they decide to install PV on their homes.

Develop Approaches to Promote the Adoption of PV on Nantucket

To promote solar PV on Nantucket, we wanted to take into account all of the factors that influenced a resident's decision to purchase a system. We worked to develop resources such as an interactive map, a webpage devoted to solar PV

included on the Nantucket website, and a set of in-depth profiles that would educate the public on the positive effects that solar PV has on the environment and how it can help homeowners financially.

Education about Incentives

A major factor that influences solar PV adoption is the financial savings generated from installing a solar PV system. Solar PV has an average national payback period of 6-8 years (Karneyeva, 2017). After this period, the household that owns the PV system begins to accrue net financial benefits since the household no longer needs to pay off the initial investment. To display this information, we created a new webpage on the Nantucket town website. It contains the interactive solar map in addition to three in-depth owner profiles: one ground-mounted system and two roof-mounted systems. We included a few pictures of each system, from GIS; a drone; and the street, with the owner's permission. In addition, the profiles give the capacity of each system and the initial and ending cost of the system. The idea of these profiles was to educate those interested in implementing solar PV and highlight the personal experiences of those who have gone through the process themselves. While the map simply presents this information, the website relays the more useful and comprehensive information that residents, we hope, will be able to utilize to their advantage and implement these systems.

Solar PV Map

Research suggests that the most effective way to promote renewable energy to a homeowner is to make owning solar PV a trend. Conniff noted (2009) "People don't just want to conserve energy … they want to be acknowledged for conserving energy"; it has been suggested that a person is more likely to invest in renewable energy with the knowledge that their neighbor owns it (Conniff, 2009). In promoting solar PV, one deliverable was an interactive map that displayed each solar PV system installation. This map would be easily accessible to the public so that they can see where solar PV has been implemented.

In preparation for creating the solar PV map, we studied a past research project done on Nantucket, where streetlamps were mapped out and could be marked by the public if they required maintenance (Evaluating LED, 2014). The mapping

software used, Google My Maps, was user-friendly and easy to update, which was a key consideration for the Nantucket Energy Office. This map is shown in Figure 10, where the lightbulbs are shown to represent streetlamps, and the color depicts what form of maintenance is needed. We appreciated the simplicity of the interface but added more detail to each marker (representing a solar PV installation site) including the installation capacity, date of installation, owner name, as well as which installation company installed the system. Different markers for future renewable technologies and, in the case of a solar PV in a construction phase, were made through the addition of multiple map layers. An additional consideration to the map was the ease of use and maintenance. We wanted it to be easily readable by the public and updatable by the Town Energy Office.

This interactive map is intended to be embedded on the Nantucket Energy Office webpage on the Town website where the public can access it to see where solar PV has been installed.

Figure 10: LED Street Lamp Map (Hunt, Potter, Vu, & Waldo, 2014)

Findings and Analysis

The following chapter discusses our major findings resulting from the research done on behalf of the Nantucket Energy Office. Specifically, we speak towards the barriers and opportunities particular to the adoption of solar PV, the current installed capacity of solar PV, and approaches to the promotion of solar PV on Nantucket. We then detail the results of our public survey, stakeholder interviews, and database research to present an overall generalization on the current status of PV on Nantucket from which we can begin to make recommendations and conclusions to aid the Nantucket Energy Office in the promotion of PV on the island.

Payback Period

Payback period is the amount of time needed to pay off the total cost of the system. A low payback period generally correlates to a better investment. Of the solar PV owners we interviewed, the Nantucket average estimated payback period is 6.5 years. We were able to interview nine of the thirty-six current Nantucket solar PV owners. Of those nine, six were able to provide details on costs and payback periods. These solar PV owners had not paid off their systems yet as they had all recently installed (within the last three years generally). Their estimates were based on the time given to them by their installers and the current data extrapolated from the production of their solar array. This is comparable with the national average of 6-8 years (Shemkus, 2017) but longer than the state of Massachusetts average of 4.5-5.5 years (Massachusetts Solar PV, 2017). Only one of the solar PV owners we interviewed, used the Nantucket SOLAR Rebate of $2,500 as it was introduced very recently. Incorporating this rebate takes about half a year off the payback period. By reducing the initial costs and payback periods, the Nantucket Energy Office expects more residents may be encouraged to install PV even though it does not reduce payback periods to the state average.

> *" [Solar PV] is easy, it's quick, it's not as expensive as you'd think"*
>
> *-Jack Weinhold*

Cost of Systems

The cost of systems on Nantucket are higher than the rest of Massachusetts. The

data in Figure 11 shows the date each residential PV system was installed over the past 10 years on Nantucket and their cost per watt. Over the past decade, the cost per watt has decreased significantly, with Nantucket averaging $4.81 per watt in 2017; however, this is still higher than the Massachusetts state cost of $5.27 per watt. From conversations with off-island solar PV installers, we found that the increase in the cost is largely due to transportation of materials and labor to the island, in addition to the lower solar panel efficiency on island. For instance, SunWind LLC installer Tim Holmes stated that as an installer based off-island, a Nantucket solar PV project costs an additional $3500 - $5000 depending on transportation costs. The electricity savings is more on Nantucket; however, this only accumulates on average to $240 per year. This does impact the additional costs of installing on Nantucket; however, does not negate the additional costs of using an off-island installer.

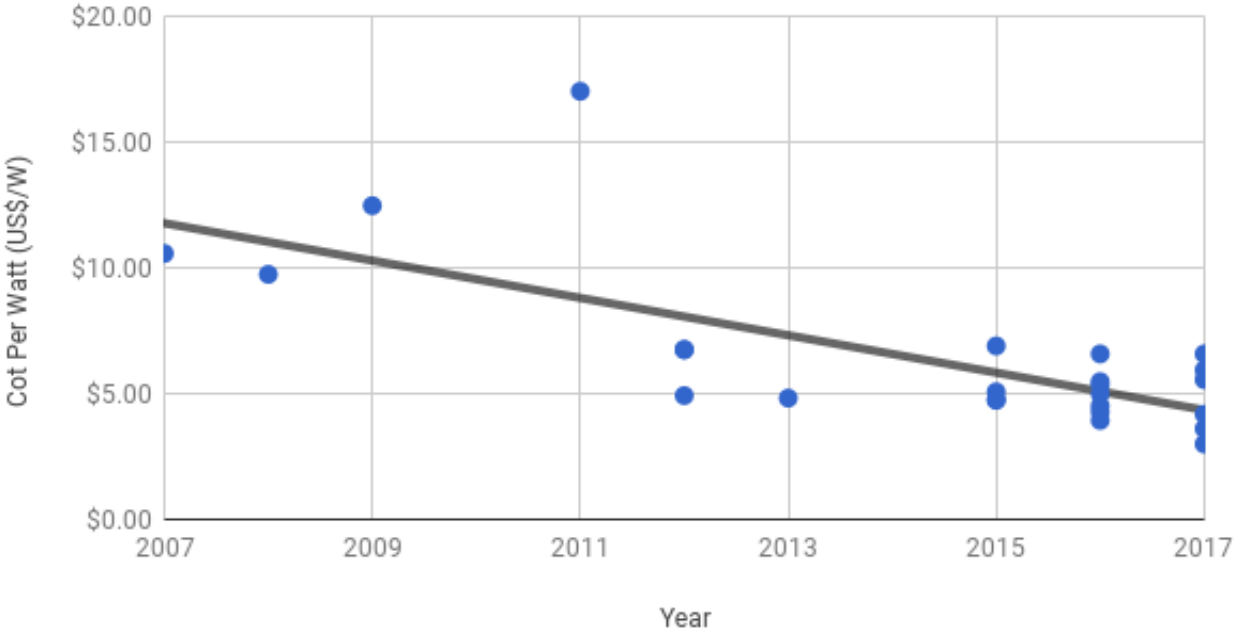

Figure 11: Cost per Watt of Solar PV on Nantucket

Solar PV Awareness

More needs to be done to inform Nantucket residents on solar PV and its benefits. We developed a survey that was sent out to Nantucket residents who are either government workers or were involved in a Mass Save Energy Audit. Of those surveyed, 27.7% indicated they did not know anything about solar PV and 33.7% knew about solar PV but not any details as shown in Figure 12. This data illustrates that the public should be

more informed on solar PV by the town. Additionally, as shown in Figure 13, more than half of the respondents were unsure on whether they could install solar PV where they live. Reasons for not being able to install could be roof orientation, available land, or Historic District Commission regulations. With most respondents being unsure, the population should at least be further informed on these factors that determine whether their property is suitable for a solar PV system.

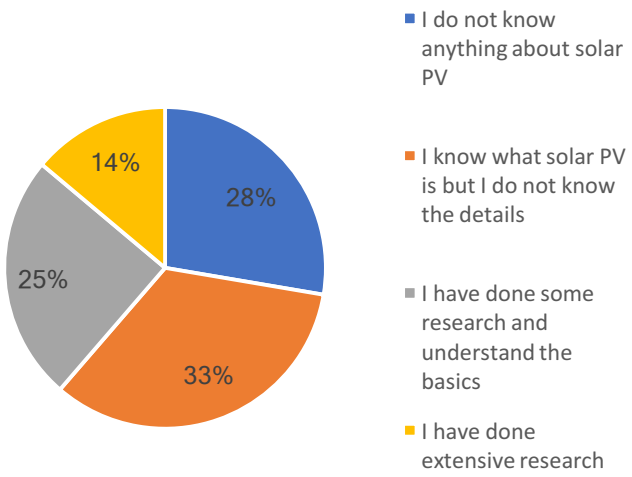

Figure 12: Public Knowledge of PV

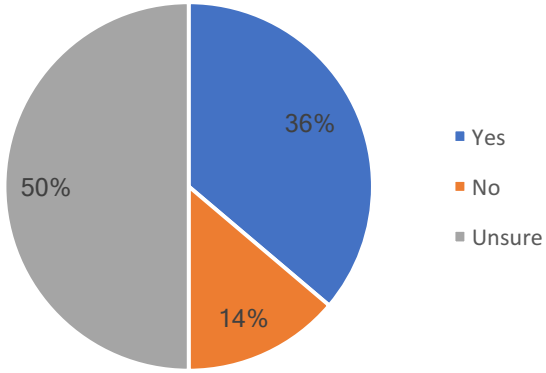

Figure 13: Public Knowledge on PV Installation Location

HDC Guidelines

Through research and interviews with members of the Historic District Commission, we discovered that there is not an updated, agreed upon set of guidelines regarding the installation of solar PV.

The current HDC guidelines were written in 2009 and are both incomplete and out of date in terms of advice for homeowners. It contains a set of recommendations, not rules to follow, on where their solar panels should be placed in order to limit public visibility of the installation. Appendix E is an example from the 2009 guidelines where it recommends incorporating solar panels into a trellis. Doing this would minimize the efficiency of the solar PV panels as they would not be angled properly. Additionally, all three HDC members we interviewed stated that they did not know that the 2009 guidelines existed. Acknowledging this, the 2009 guidelines are thereby out of date and are not being

followed by the Nantucket Historic District Commission. Regarding the two Historic Cores, the HDC would like solar PV to not be seen at all, from any view. This makes the installation of solar panels difficult in these areas since they need to be angled south and not laid flat on the top of a building. There is interest in future use of solar shingles in the Historic Cores. If solar shingles can blend in on roofs and be aesthetically appealing, they could be considered for use in these areas since they would not impede the historic nature of these locations. For the rest of the island, the Historic District Commission has legal jurisdiction over anything visible to the public. If solar panels have the capability of being visible from the road, the HDC can deny the application. After interviewing HDC members and solar PV installers, we found that the HDC has not outright denied a solar application; rather, the HDC has sent the application out for revisions, which in some cases, calls for modification to the solar PV plan that make it economically impracticable. Overall, the HDC is a barrier to the adoption of solar PV on island, limiting the number of usable sites.

HDC Process

The process of filling out an HDC application for solar PV is confusing for homeowners and installers. The Historic District Commission is the first step in applying for permits to install a solar PV system and generally the longest portion of the permitting process. The application not only adds time and difficulty to this process by not including fields related to renewable energies, it creates an unnecessary barrier. After interviewing three HDC members, all agreed that the application was confusing and that changes should be made to the application. One of the members we interviewed even stated that they have developed multiple revisions to the application that make it easier for those applying for solar PV and that the board had been unable to discuss for a long period of time. Having to go through the HDC to install a solar PV system is a process, that most other locations do not have to deal with. The Historic District Commission, has their purpose in maintaining the historical integrity of Nantucket; however, decreasing unnecessary additions to the permitting period, like changing the application, can positively impact the adoption of solar PV on island.

Finding a trustworthy and reliable installer can be a large barrier when looking to install solar PV. While interviewing homeowners, many detailed that finding a trustworthy installer was paramount to the overall enjoyment of the installation process. Solar PV is a large investment and many owners stated that while they wanted to give their business to a local company, it was more important to choose a company that they could depend on and trust. One owner, for instance, stated that she reached out to a few different installers before deciding on which company to hire. Responses from our survey on solar energy also emphasized that this was a major concern when thinking about installing solar PV (as seen in Figure 14).

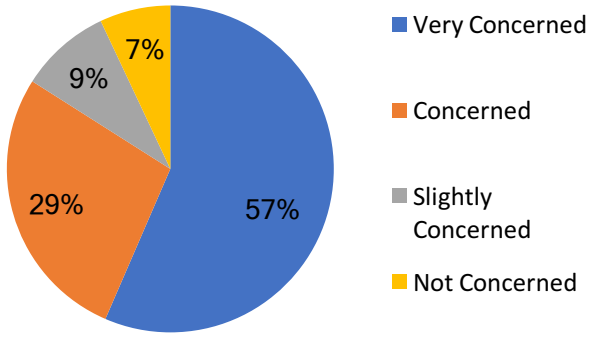

Figure 14: Concerns Regarding Finding a Trustworthy Installer

Current Installed Capacity

There are currently thirty-four residential solar PV systems installed and connected to the electrical grid on Nantucket. Before arriving on the island, our data from NREL and other databases seemed to indicate that there were twenty-five installations around Nantucket. Upon further investigation, we found this data to be inaccurate. After developing a database of all solar installations on Nantucket, there was a clear trend in the number of installed systems over the past decade. As shown in Figure 15, there is an exponential trend showing the growth of solar installations, with a substantial jump in the number of installed systems over this past two years. Solar installations will continue to grow and follow this trend, as solar PV promotion and awareness increases.

Out of the twelve systems that were installed this year, five of them have been approved and are currently being installed over the course of the past few months. These systems are planned to be completed by the end of the year and show the potential increase in adoption for solar PV moving forward. Four out of five of these systems are being installed by one installer. This shows that one installer

alone can install four systems in a span of three months. At this rate, one installer alone could install twelve new systems a year.

There are currently three installation companies that operate on Nantucket, including one on-island and two off-island companies.

Based on the data shown in Figure 15, we can infer that going forward, the exponential trend in solar PV installations each year will continue.

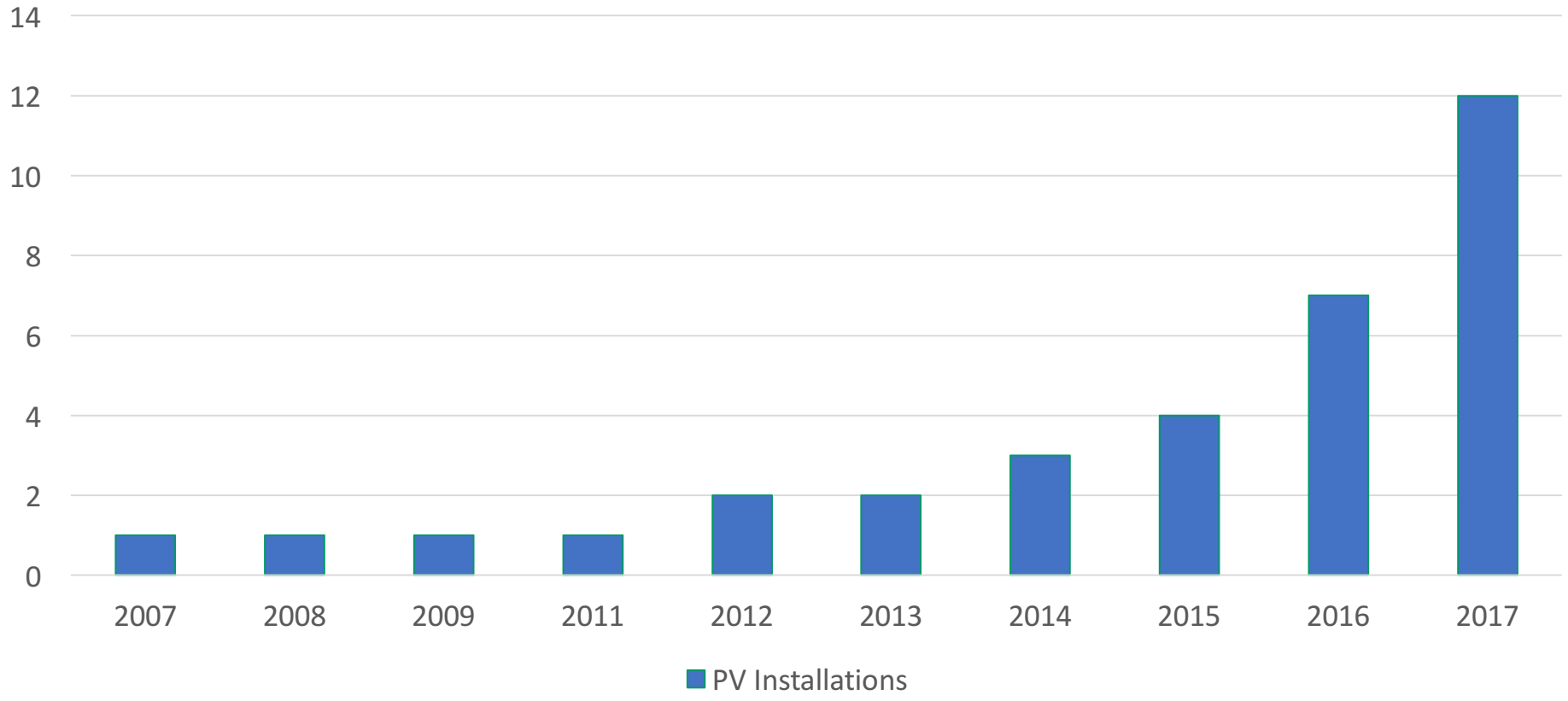

Figure 15: Installed Solar PV Systems per Year

The current total installed capacity of residential solar PV systems on Nantucket totals 232.103kW. In addition to this, 36.06kW will be added to the total from those systems still being installed that will be finished by the end of this year. Together this will total 268.163kW, or approximately 0.27MW. For only thirty-four systems, 0.27MW is a significant impact on the island.

Commercial solar PV systems also make a notable impact on the islands installed capacity. Currently, commercial systems total 1048.06kW or just about 1MW. Comparing this to the summer months where electricity can peak upwards of 45MW, commercial systems are generating more than 2% when compared to what is being used by the whole island. Out of the eleven commercial solar PV systems that account for this 1MW capacity, two of them generate the majority of it. The Nantucket Ice Rink and Bartlett's Farm solar installations make up 0.9MW of this 1MW generation. Bartlett's Farm alone accounts for more than half of this commercial output. In addition to this, Bartlett's Farm plans to expand its solar capacity, tripling the size of the current installed solar PV. After this expansion the installation will have an output of more than 1.7MW. These commercial solar PV installations, especially with the additional expansion of Bartlett's Farm, will contribute significantly toward on-island solar electric generation.

Approaches to the Promotion of PV

This section describes the various tools developed to help promote the use of solar PV on Nantucket. These tools include an interactive solar PV map, three in-depth owner profiles, and a webpage on the Nantucket Town website to house all of the deliverables previously mentioned as well as additional information about the solar PV installation process and a number of frequently asked questions specifically aimed toward solar PV on Nantucket. There is a very large opportunity to increase the promotion of solar PV due to a general lack of information provided by local sources and we believe that the tools mentioned above will help to better inform potential solar PV adopters.

There is a large opportunity to promote solar PV on Nantucket. Using results gathered in owner interviews and a survey sent out to residents involved in the Mass Save Energy Audit as well as town employees, it was determined that there is

a general lack of information about solar PV on Nantucket.

The website is the platform on to which the deliverables developed for this project will be placed to help inform local residents on the current solar PV situation. This will be on the Town of Nantucket Website under the Nantucket Energy Office webpage and will contain the tools developed for this project to help promote the adoption of solar PV.

The main deliverable for this project is an interactive solar PV map, that has every residential system currently installed on the island and the information about each system. The map is the main deliverable because it describes many key points about solar PV through user friendly graphics. The map is sorted by initial operation date to show the growth in

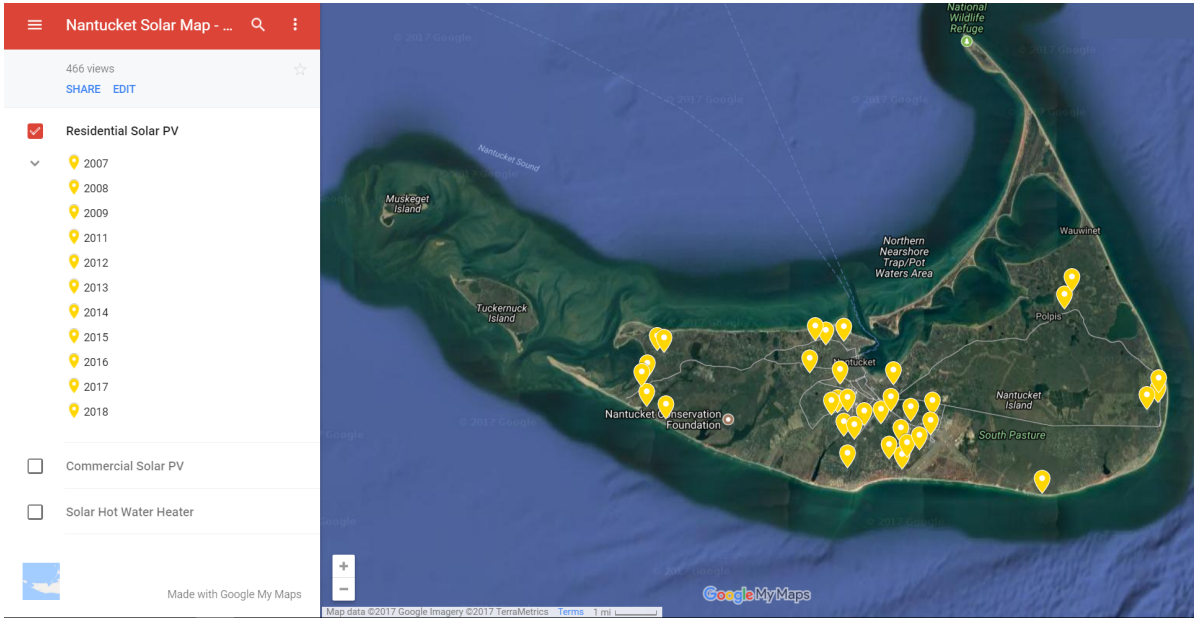

Figure 16: Solar PV Map

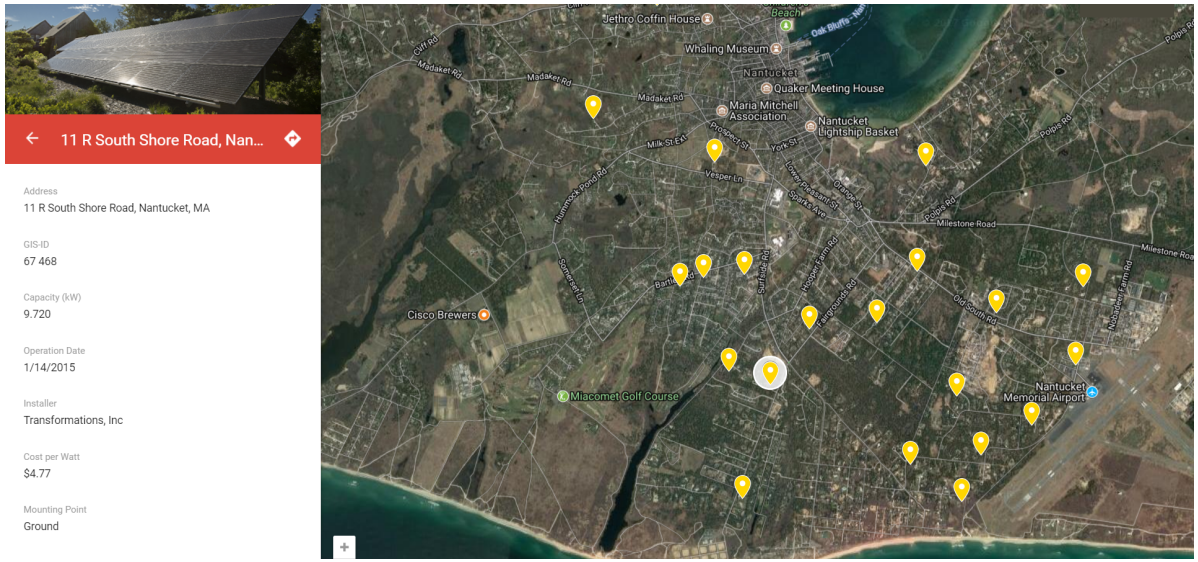

Figure 17: Detailed View of Solar PV Map

number of installations over the years. This also allows people to see who owns solar PV around them, which might push them into installing solar.

Additionally, owner profiles were developed in conjunction with system owner interviews on three different systems that were installed within the past two years. These profiles include:

- System Pictures
- Cost of the system
- Number of panels
- Date of installation
- Total capacity of the system
- System owner experiences with the solar PV installation process
- Other green initiatives that the owners have participated in

These profiles will allow people to see how certain financing options affect the overall system cost and how they might afford a system. They can also show that although there are barriers to the installation of PV, they can be overcome easily. These profiles are included in Appendix G.

After interviewing local solar PV owners and installers, and reviewing the HDC application process with HDC officials, we determined that the process of installing solar PV can be confusing. We developed a flowchart outlining each step of the process from filling out the HDC application and the permits required to build a solar PV installation to installing the system, and the final inspections. The flowchart is included in Appendix G and is also embedded on our webpage.

We also developed about twenty frequently asked questions, pulled from our survey comment sections as well as other popular solar PV information sites. These can also be reviewed in Appendix G as well as on our webpage.

Conclusions and Recommendations

Based on our research and findings, we conclude that:

1. The permitting process and guidelines for solar PV installations present obstacles to the adoption of PV on Nantucket.
2. The number of PV systems on Nantucket is growing exponentially, but enhancing public awareness and understanding of PV will be essential to increase the installed capacity on Nantucket.

From these two major conclusions, we can make several recommendations to both the Nantucket Historic District Commission as well as the Nantucket Energy Office.

Recommendations for the Historic District Commission

We conclude that the HDC could make a few minor adjustments that would greatly increase the adoption rate of solar PV on Nantucket.

Firstly, we recommend that the Nantucket Historic District Commission revise its application form to include renewable energies, such as solar PV, either through the inclusion of a few checkboxes regarding renewable energies or by providing more in-depth instructions on the process to apply for an HDC permit regarding renewable energy. Their current application is confusing for installers and owners as most of the information is written in open space on the application because the current form does not have a specific section to address the addition of renewable energies.

Next, we suggest that the HDC reconsider and clarify their position on where solar PV can be installed outside of the Historic Cores. The number of properties that can have solar are already limited due to roof orientation and lack of yard space to place arrays.

Prohibiting arrays from being seen from a public way, when outside of the Residential Old Historic Core and 'Sconset Old Historic Core, is detrimental to the promotion of solar PV by the Town of Nantucket. We understand that Nantucket is home to the largest collection of pre-civil war era buildings, which is why we respect the HDC's opinion when it comes to renewable energies in the Historic Cores; however, outside of those core districts, if the guidelines are more lenient towards solar

PV systems, the number of PV installations should increase.

We propose that the Historic District Commission develop a revised set of guidelines that clearly describe HDC rules and expectations regarding solar PV installations. The most up-to-date guidelines are from 2009. Since then, solar PV technology has changed in efficiency and aesthetics due to new technologies. These current set of guidelines push for a solar PV system to have a low visual impact and give recommendations, however fail to set any distinct rules for installers and owners to follow. We recommend that rules are set in place so that decisions on whether or not to install a solar PV system is not decided based on the HDC's subjectivity, but because the installed system fails to follow these set rules.

Recommendations for the Nantucket Energy Office

We conclude that there is a lack of communication between town permitting bodies and the Nantucket Energy Office.

We recommend that the Town of Nantucket Energy Office take the lead in establishing better communication with the Historic District Commission to gather data on solar PV installations. Currently, the town's records are mostly paper files. Changing to a digital file system would help significantly, however we realize that this may not be an option. With that consideration, we propose that the Town Energy Office use the HDC final inspection data to confirm sites to add to the owner database and update the solar map.

This will require the HDC to communicate with the Energy Office to acknowledge when an installation's final inspection has been passed.

We also conclude that there is a lack of awareness regarding PV and the process of permitting and installation on Nantucket.

We advise that the Town of Nantucket Energy Office utilize the enhanced efforts of public outreach developed in the course of this project. During our project we produced an interactive map that shows where each solar installation is on the island. Additionally, we created solar PV owner profiles and built an FAQ section that are on a web page located on the Town of Nantucket's website. This information is available to the public and, with the distribution of its existence to local residents, will become a useful tool.

We recommend the Town of Nantucket Energy Office update the owner database and interactive map with new solar PV installations using the directions given in Appendix F. With the data obtained from the HDC inspections, the Energy Office will be able to keep the solar map and owner database up-to-date with new installations making full use of the tool.

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Appendix A: Owner Interview Questions and General Interview Protocols

PREAMBLE:

We are students from Worcester Polytechnic Institute working with the Nantucket Energy Office on a project to assist the promotion of solar PV on the Island of Nantucket. We would like to conduct an interview that should last about 20 minutes. All information and quotations from this interview will only be used to aid us in our project. The interview will be kept anonymous unless you give us permission to use your name in our report. If we use any information or quotations from this interview we will send you a copy of our report via email to review. In addition, would it be acceptable if we record this interview for future reference? During the interview, you may skip any questions you do not wish to answer and can end the interview at any time. Do you have any questions or concerns before we begin?

Solar-PV Owner Interview:

1) How many years have you lived on this property?
    a. Pre-Install?
2) What were the primary factors that influenced your decision to use solar?
    a. Reduce energy bill
    b. Live green and/or reduce carbon footprint
    c. Reduce dependence on outside energy sources
3) What kind of solar PV system do you have?
    a. Ground mounted or roof mounted?
    b. Why did you decide to install this type?
4) What is the installed capacity of your system?
    a. What is the date of your installation?
5) Can you tell us about your process of finding and selecting your installation company?
6) How was your experience with the solar installation process?
7) Did you encounter any specific barriers during the installation process?
    a. Installation
    b. Permitting
    c. Cost
    d. Inspections
    e. Availability of Materials

f. Shading
g. Roof Orientation
h. Installer
i. Electric Panel
j. Homeowner's Association (HDC)
k. Inverter

8) Have there been any unexpected problems that have come up since installing solar on your property?
9) What can be done to make it easier/faster for someone interested in solar to install it?
10) What was/were the most important rebates toward your financial savings?
11) Do you have any other technologies that were installed either before or in conjunction with your solar installation?
    a. Home Energy Assessment (MassSave)
    b. Electric Vehicle
    c. Solar Hot Water
    d. Energy Efficient Appliances
    e. Insulation
    f. Tankless Water Heater
    g. HVAC
    h. Shade Trees
    i. Water Conservation Measures
    j. Electrical Upgrades
    k. Battery Storage
12) Are you more conscious of your energy use after installing your solar system? Do you actively monitor the performance of your system?
13) What kinds of questions/comments/concerns have you received from neighbors/friends/family?
14) Do you feel you are saving money on your electric bill as a result of your solar installation?
    a. What was the cost of your system?
    b. What financing plan did you use?
    c. What is your expected payback period?
15) Would you expect your solar installation to change the value of your home?
16) What do you think are the misconceptions about solar-energy on Nantucket?

Appendix B: Installer Interview Questions

1) How, why, for how long did you get into the business?
    a. Tell us a little about yourself and your company
2) How many systems have you installed on Nantucket, and how long have you been working on Nantucket?
    a. When did you install your first system?
    b. How have things changed?
        i. Local permitting
        ii. Incentive programs
3) Are there specific challenges that come with being a solar installer on the island?
4) What barriers prevent or discourage people from putting in solar? Have these changed over time?
    a. Permitting issues and experiences
    b. Customer motivations
    c. Cost
    d. Regulations (Panels on buildings in-town)
5) What were the primary factors that influenced your customers' decision to use solar?
    a. Reduce energy bill
    b. Live green and/or reduce carbon footprint
    c. Reduce dependence on outside energy sources
6) How do you market your services locally?
7) Financing plans
    a. How does 100% financing work with no out of pocket costs?
8) How would you encourage the adoption of more PV on Nantucket?
9) How will the new rebate programs impact your business?
10) How many revisions do you go through with the HDC on average to fulfill their opinions?
11) Have your clients hear of the SOLAR Rebate program? Has it resulted in more sales calls?

Appendix C: Survey Questions

Public Survey: Solar Energy

We are students from Worcester Polytechnic Institute working with the Town of Nantucket Energy Office on a project to gauge public opinions of solar photovoltaic (PV) systems on Nantucket. This survey should take less than 5 minutes.

* Required

1. **I understand that participation in this survey is voluntary and my responses will be completely anonymous.** *
   Mark only one oval.
   - ◯ I understand and agree

2. **What is your residential status?**
   Mark only one oval.
   - ◯ I own a home and live there year-round.
   - ◯ I own a home but only live there seasonally.
   - ◯ I rent a home/apartment and can make improvements to the property.
   - ◯ I rent a home/apartment but cannot make improvements to the property.
   - ◯ Other: _____

3. **What is the approximate value of your property (in $)?**
   _____

4. **What is your approximate average monthly electric bill?**
   Mark only one oval.
   - ◯ $0 - $150 (0-700 kWh)
   - ◯ $150 - $220 (701-1000 kWh)
   - ◯ $220 - $330 (1001-1500 kWh)
   - ◯ $330 - $440 (1501-2000 kWh)
   - ◯ $440 - $880 (2001-4000 kWh)
   - ◯ $880+ (4000+ kWh)

5. **How many people live in your household?**
   _____

6. **What is the year of your birth?**
   _____

7. **Are you retired?**
   Mark only one oval.
   - ◯ Yes
   - ◯ No

8. **What Nantucket neighborhood do you live in?**
   _____

9. **Can you install solar where you live?**
   Mark only one oval.
   - ◯ Yes
   - ◯ No
   - ◯ Unsure

10. **If no, why not?**

11. **How knowledgeable are you on the topic of solar PV?**
Mark only one oval.

- I do not know anything about solar PV.
- I know what solar PV is but I do not know the details.
- I have done some research and understand the basics.
- I have done extensive research.

12. **Have you considered installing a solar PV system on your house in the past?**
Mark only one oval.

- No
- Yes
- I have already installed solar PV

13. **How concerning are the following if you were to consider solar PV for your Nantucket property?**
Mark only one oval per row.

	Very Concerning	Concerning	Slightly concerning	Not concerning
Initial cost/ obtaining a competitive price				
Finding a trustworthy contractor				
Local permitting (HDC)				
Solar PV efficiency in Nantucket climate/fog				
Reliability/ maintenance				
Technology may become obsolete too quickly				
Unsuitable roof/ ground space				

14. **Other concerns that were not listed above:**

15. **How important are these potential benefits if you were to consider installing solar PV?**
Mark only one oval per row.

	Very Important	Important	Slightly Important	Not Important
Reducing electric bills and saving money	◯	◯	◯	◯
Environmentally responsible	◯	◯	◯	◯
Battery storage/ backup power	◯	◯	◯	◯
Self-sufficiency	◯	◯	◯	◯
Long-term financial investment	◯	◯	◯	◯
Using latest and most innovative technology	◯	◯	◯	◯
Set an example/ local benefits: defer 3rd cable	◯	◯	◯	◯

16. **Please indicate how strongly you agree or disagree with the following statements:**
Mark only one oval per row.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
My electric bill is too high.	◯	◯	◯	◯	◯
Solar panels should not be publicly visible.	◯	◯	◯	◯	◯
It is more expensive to install solar PV on Nantucket than on the mainland.	◯	◯	◯	◯	◯
The HDC is reasonable when approving solar panels.	◯	◯	◯	◯	◯
Nantucket is not sunny enough for solar PV to be viable.	◯	◯	◯	◯	◯
There should be more solar installations on Nantucket.	◯	◯	◯	◯	◯

17. **Local residents are now purchasing solar PV systems through a low-interest loan, for up to 100% of the total system cost. Does this financing option change your opinion about the affordability of installing solar PV?**
Mark only one oval.

◯ Yes
◯ No
◯ Other: _____

18. **The Town of Nantucket is now offering local residents a $2,500 rebate to install solar PV. With this incentive, simple payback periods for Nantucket PV systems are reduced to as little as 5 years. How does this extra incentive change your opinion about installing solar PV?**

Mark only one oval.

- ◯ The incentive definitely makes solar PV more appealing.
- ◯ The incentive isn't enough to make the economics achievable for me.
- ◯ I am not concerned with system cost.
- ◯ Other: _____

19. **Do you have any final thoughts regarding solar PV or this survey that you'd like to share with us?**

_____

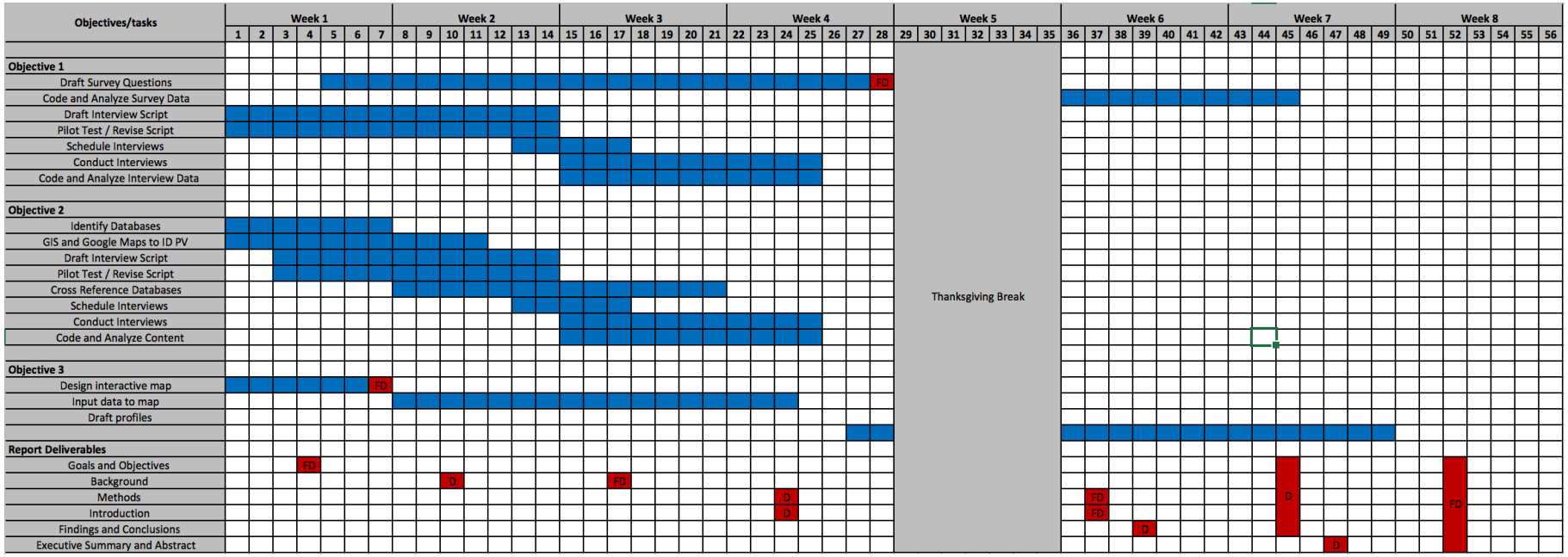
_____

_____

_____

_____

Appendix D: Timeline for Project Completion



Please note that the last three weeks of the term was mainly used to edit and write major sections of the report as well as the final presentation. All three objectives and their respective tasks were finished before Thanksgiving break with minor changes to the final deliverables (such as the profiles and interactive map) were made in the week and a half after the break.

Appendix E: 2009 Historic District Commission Guidelines

Solar Technologies

Photovoltaic Systems

At the time of publication of this addendum, there are only two prevailing types of photovoltaic (PV) collectors: photovoltaic panels and building integrated photovoltaics (BIPV). Both systems exist to convert the sun's energy into electricity. BIPV can be considered because it typically makes less of a visual impact on a structure. Unfortunately, this technology is currently not as efficient as photovoltaic panels. The following guidelines should therefore be applied to any style of PV system that has been deemed appropriate according to each building owner's unique circumstances, keeping in mind that it is always preferable to use the least visible technology.

Solar Thermal Systems

Solar Thermal refers to any system that harnesses the power of the sun to heat a liquid medium for specific applications such as domestic hot water, space heating, and pool heating. As of the publication of this addendum, there are a number of different technologies that are designed to help lower energy bills by utilizing solar thermal systems. Some technologies are available that allow collectors to be hidden entirely within the roof structure, and should be considered (especially for new construction) because of their minimal visibility. However, this guideline will primarily focus on technologies incorporating collectors (whether evacuated tubes or panels) that require direct sunlight.

Figure 7: Photovoltaic Ground Array

Placement & Design of Photovoltaic and Solar Thermal Systems

The utilization of "energy producing" technologies, such as photovoltaics and solar thermal, should only be considered after every effort to reduce a structure's energy consumption have been made. It is appropriate to consider placement of PV or solar thermal arrays elsewhere on the property before considering mounting this technology onto the primary structure. This is especially important in Nantucket's Old Historic District, in Siasconset's Old Historic District, on contributing buildings or in historically important landscapes, where the use of this technology may have a higher degree of visual impact. When determining where to place PV or solar thermal collectors, it is important to attempt to minimize any adverse effects upon a structure's existing fabric, as well as to mitigate the visual impact these panels and all of their supplementary equipment may have upon the surrounding area. As eventual wearing out of parts is expected with these technologies it is important to note that equipment must be replaced with like kind. The HDC will consider any replacement that is not exactly like the original to be a change in design, which requires a new application of appropriateness.[13]

Recommended

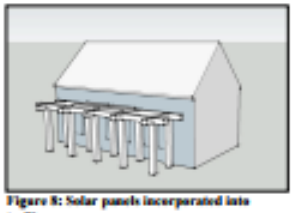


Figure 8: Solar panels incorporated into trellis

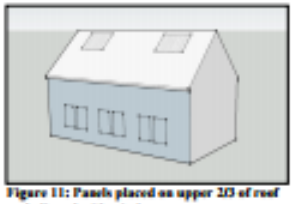


Figure 11: Panels placed on upper 2/3 of roof and aligned with windows.

Not Recommended

Figure 10: Panels on lower 2/3 of roof.

Figure 9: Panels located on primary facade and highly visible.

When beginning an investigation regarding where best to incorporate PV or solar thermal collectors onto a property, the owner of any structure should always fully consider the principles of *minimum intervention* and *reversibility*.* The entire site must be fully examined for its potential to accommodate these technologies effectively. The most preferable placements for these technologies will have no physical impact on the primary structure and have negligible visual impact upon the site as a whole. Therefore whenever possible, the least visible installation of ground arrays is preferred. If it is necessary for an array to be placed on a structure, it is encouraged that the array to be placed somewhere other than on the primary structure. For example, placement on any non-contributing ancillary structures (such as detached garages or sheds) would stand a greater chance of approval than an installation proposed only on the primary

* Minimum intervention is the principle that the less change or alteration done to a historic resource the more integrity that resource retains. Reversibility is the principle that nothing should be done to a historic resource that can cannot be undone or reversed without permanent damage to the resource.

building.* The creative placement of PV and solar thermal collectors may be encouraged, if such placement limits any adverse impact of the array (e.g. in an existing skylight).

Because the sloped roofs typical of Nantucket's built environment are such a character-defining feature of the island's cultural heritage, rooftop equipment installations should be carefully designed and positioned on any roof. The basic elements of design to consider are: balance, proportion, color, rhythm, and scale. Additionally, PV and solar thermal collectors should be kept on the same plane as the roof, with the color of the panels in keeping with the surrounding roofing materials.

Recommended

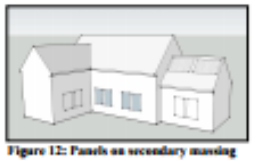


Figure 12: Panels on secondary massing

Figure 13: Panels placed with minimal visual impact.

Figure 14: Panel placed on non-contributing ancillary structure

* A non-contributing structure is defined as a building, which is not an intrusion but does not add to a historic district's sense of time, place and historic development.

Photovoltaic and Solar Thermal Guidelines

Applications for Photovoltaic and Solar Thermal systems in the Old Historic District, Siasconset Old Historic District, and those on contributing properties are likely to attract a higher level of scrutiny. This also is true for installations on contributing buildings, and where lack of vegetation makes an installation visible from surrounding areas.

Existing Buildings and New Construction:

- The least visible application of technologies and their supplementary equipment is recommended. If the array is located on the ground, appropriate screening may be necessary.
- Applications of these systems as a ground array or on non-contributing ancillary structures (as opposed to on the primary structure) are encouraged.
- The appropriateness of a photovoltaic or solar thermal system will be based upon the historic character and architectural significance of the individual structure and its relation to its surroundings.
- Photovoltaic and solar thermal installations need to be designed carefully and positioned to be in scale with the structure's roofline, while maintaining a balance, scale, proportion, and rhythm with other features of that elevation.
- Systems should be on the same plane as the roof with the color of the panels in keeping with the surrounding roofing materials.

Recommended Application Materials:

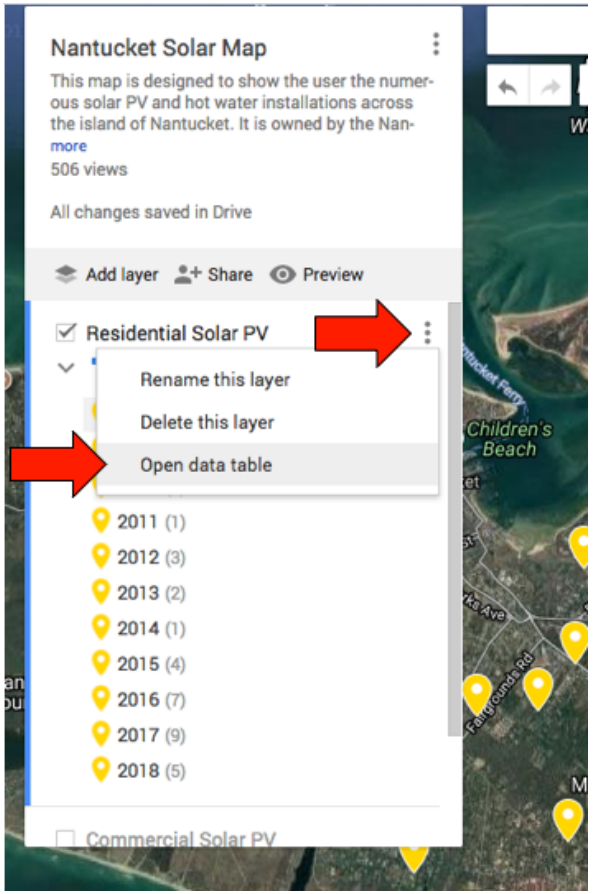
Applications for renewable energy systems should include materials adequate to describe the proposed equipment, the structure, and the surrounding area. These may often include:

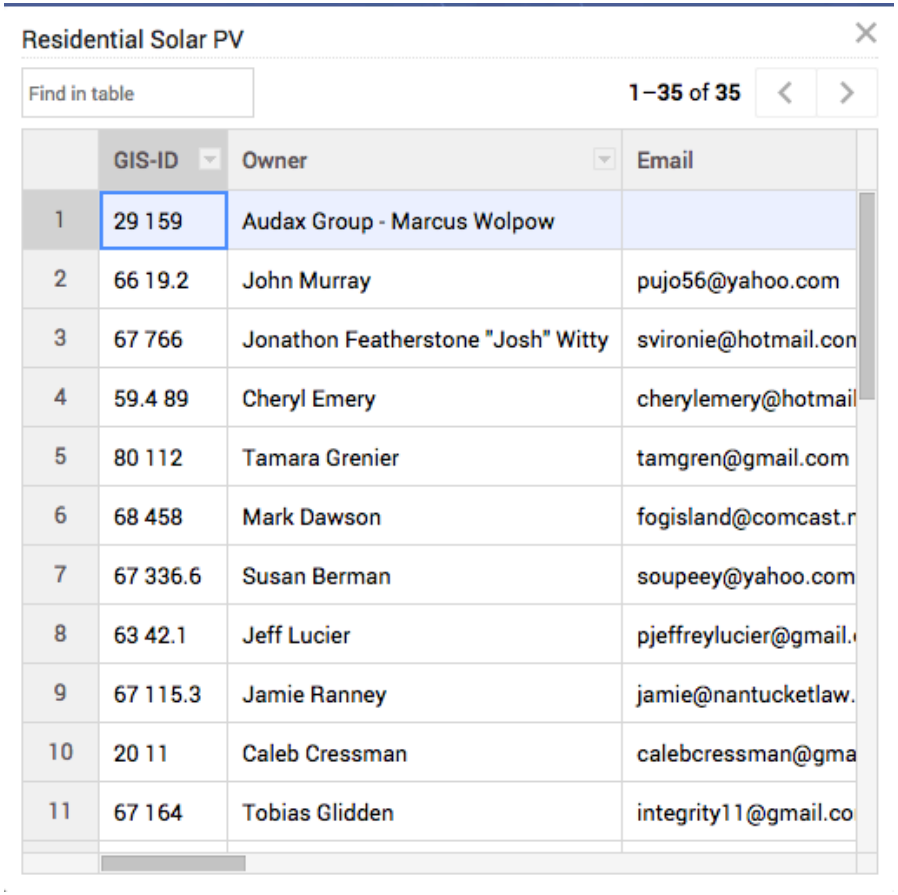
- A sample of the product and supporting documentation if available.
- Photographs of the installation site and surrounding area.
- A scaled drawing of the proposed system including all supplementary equipment.
- If the system is being proposed on the primary structure the applicant should be prepared to discuss why placements with less visibility or less impact were not used.

Appendix F: Instructions for Updating the Interactive Solar Map

Adding a Row to the Data Table

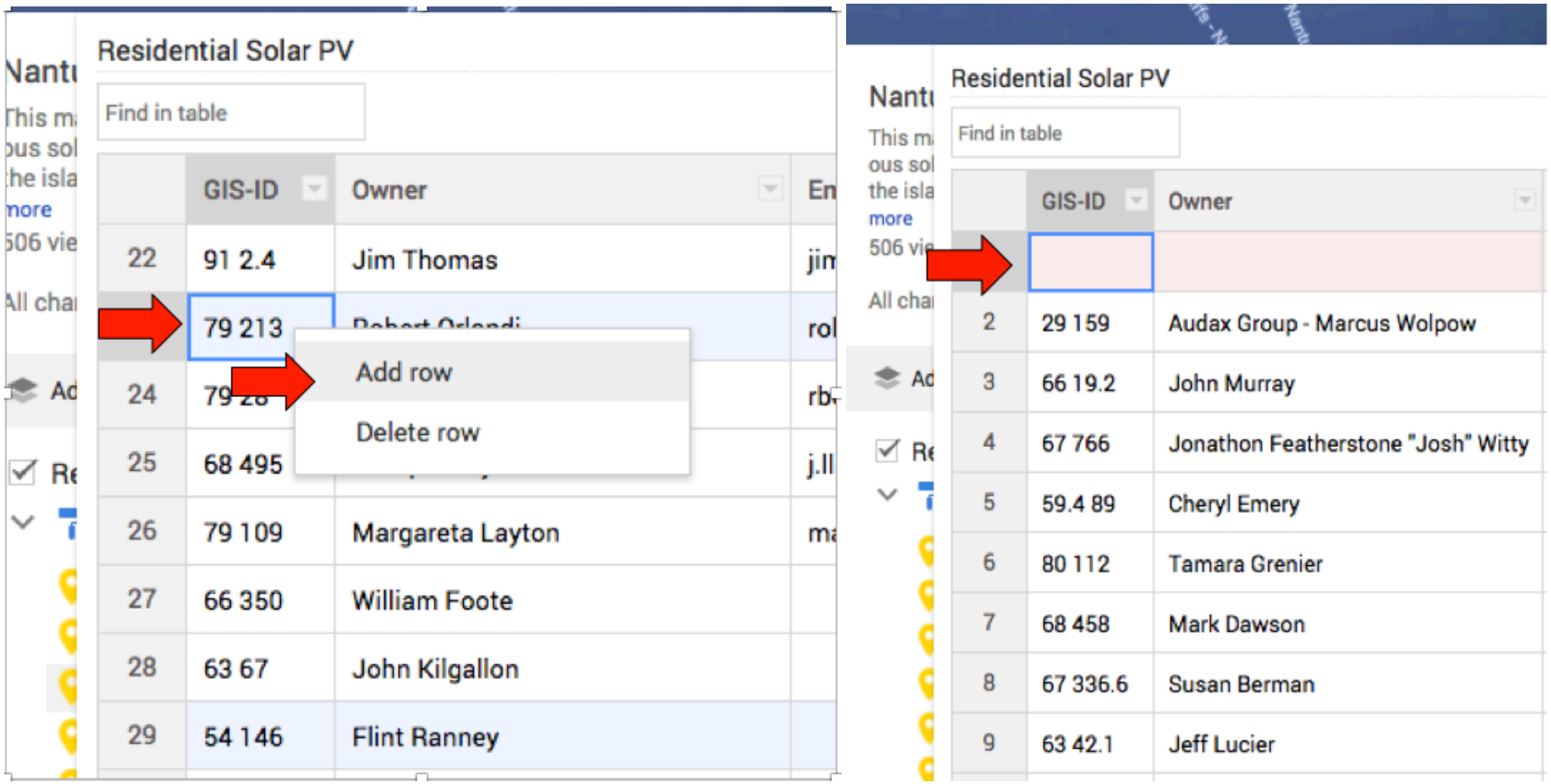
1. Left click on three vertical dots next to the layer you want to add a point to and then left click on "Open data table".





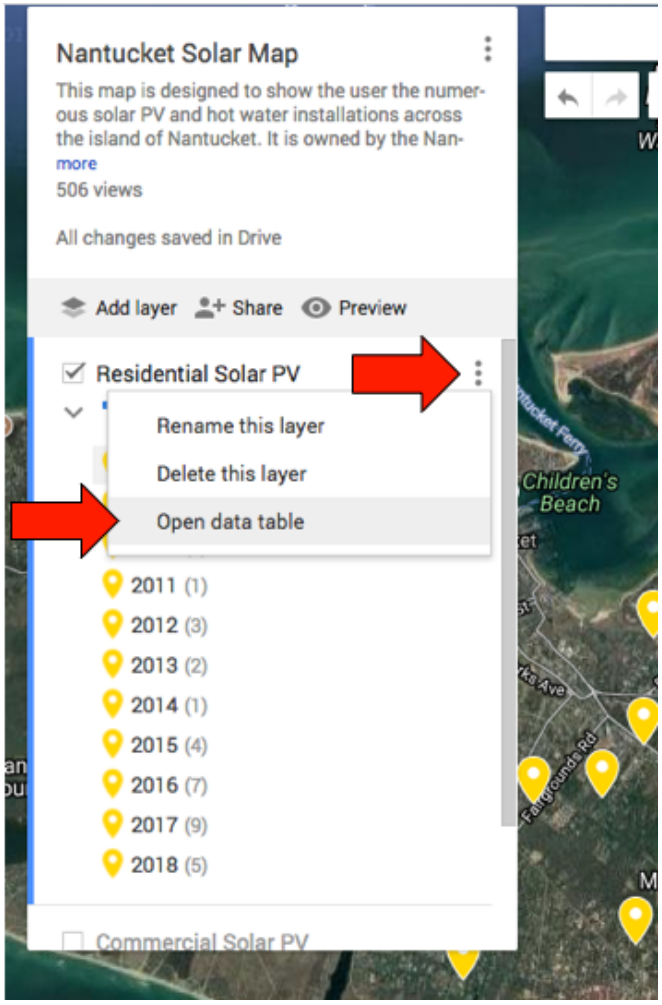
	GIS-ID	Owner	Email
1	29 159	Audax Group - Marcus Wolpow	
2	66 19.2	John Murray	pujo56@yahoo.com
3	67 766	Jonathon Featherstone "Josh" Witty	svironie@hotmail.con
4	59.4 89	Cheryl Emery	cherylemery@hotmail
5	80 112	Tamara Grenier	tamgren@gmail.com
6	68 458	Mark Dawson	fogisland@comcast.r
7	67 336.6	Susan Berman	soupeey@yahoo.com
8	63 42.1	Jeff Lucier	pjeffreylucier@gmail.
9	67 115.3	Jamie Ranney	jamie@nantucketlaw.
10	20 11	Caleb Cressman	calebcressman@gma
11	67 164	Tobias Glidden	integrity11@gmail.co

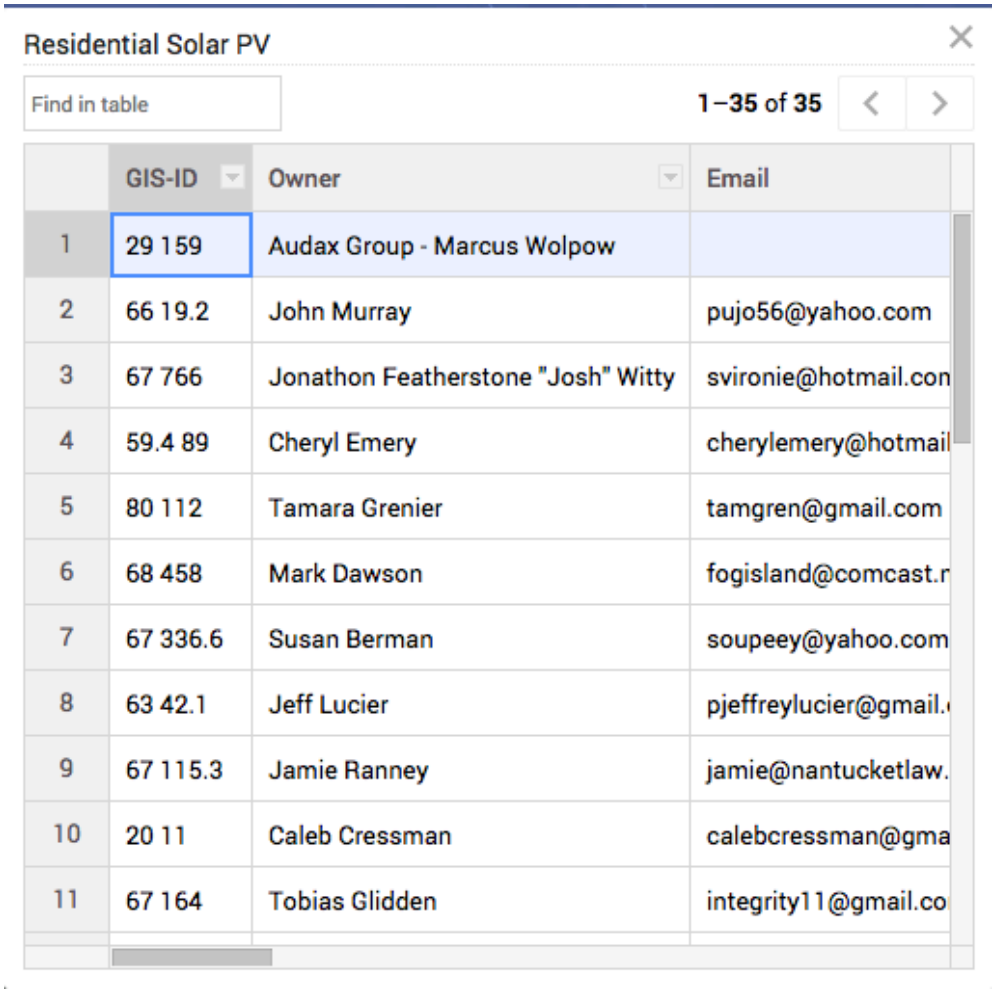
2. Right click on any data box and then left click on "Add row". This will add a row to the data table and you can fill in the appropriate data, and once you add in the address it will add a point to the corresponding address.



Adding a Column to the Data Table

1. Left click on three vertical dots next to the layer you want to add a point to and then left click on "Open data table".





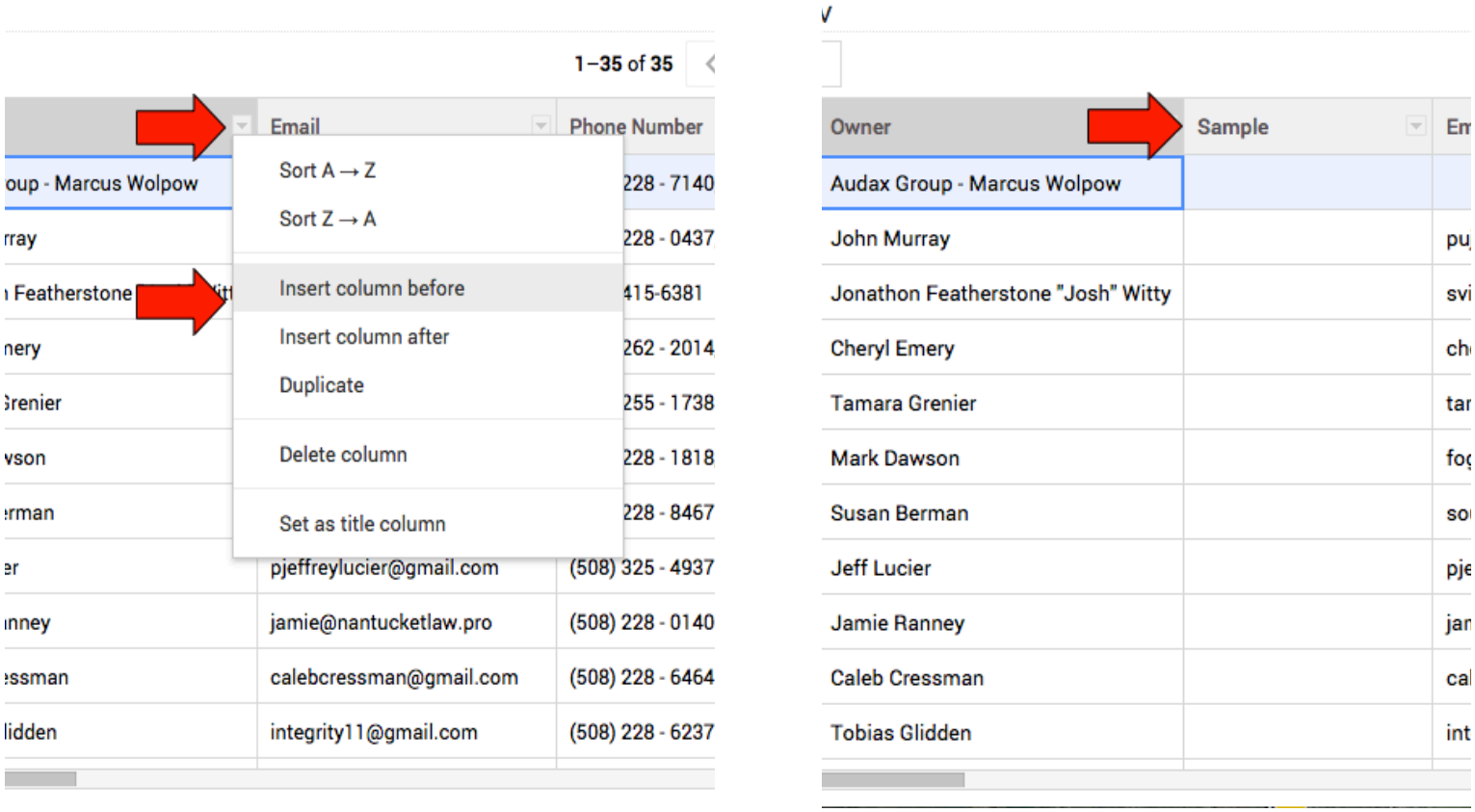
Residential Solar PV

Find in table

1–35 of 35

	GIS-ID	Owner	Email
1	29 159	Audax Group - Marcus Wolpow	
2	66 19.2	John Murray	pujo56@yahoo.com
3	67 766	Jonathon Featherstone "Josh" Witty	svironie@hotmail.con
4	59.4 89	Cheryl Emery	cherylemery@hotmail
5	80 112	Tamara Grenier	tamgren@gmail.com
6	68 458	Mark Dawson	fogisland@comcast.r
7	67 336.6	Susan Berman	soupeey@yahoo.com
8	63 42.1	Jeff Lucier	pjeffreylucier@gmail.(
9	67 115.3	Jamie Ranney	jamie@nantucketlaw.
10	20 11	Caleb Cressman	calebcressman@gma
11	67 164	Tobias Glidden	integrity11@gmail.co

2. Left click on the arrow next to a column name header and left click on either "Insert column before" or "Insert column after".

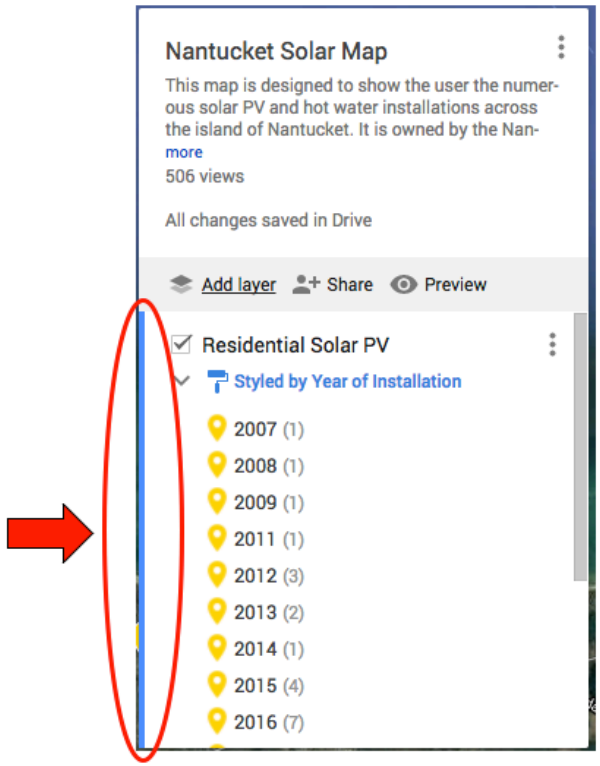


Adding a Point to the Map from Data Table

1. When adding a row to the data table, once you add an address to the address column, it will generate a point at that address.

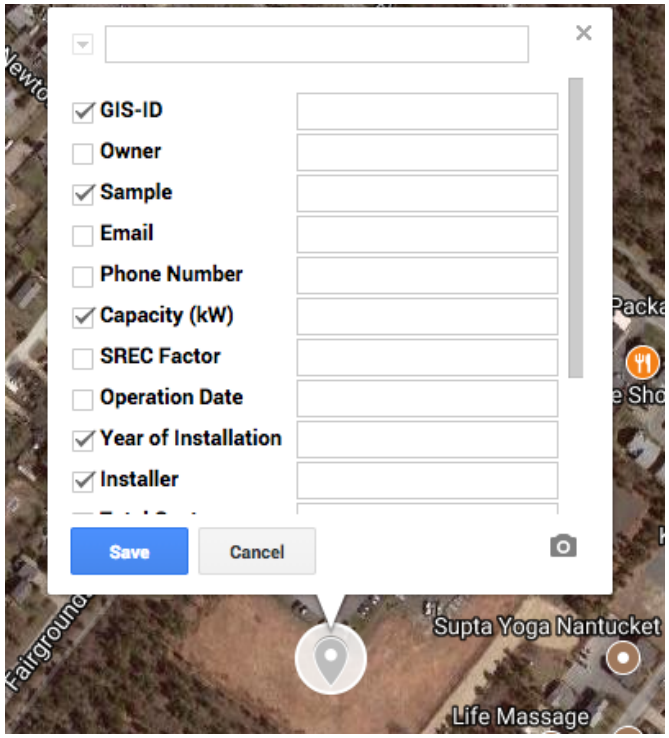
Adding a Point to the Map from the Map

1. Left click on the layer you want to add the point to. Make sure the layer has a blue line running down the side (this means it is selected).



2. Then left click the marker point next to the hand icon near the top of the page. This will change your cursor to a plus sign.

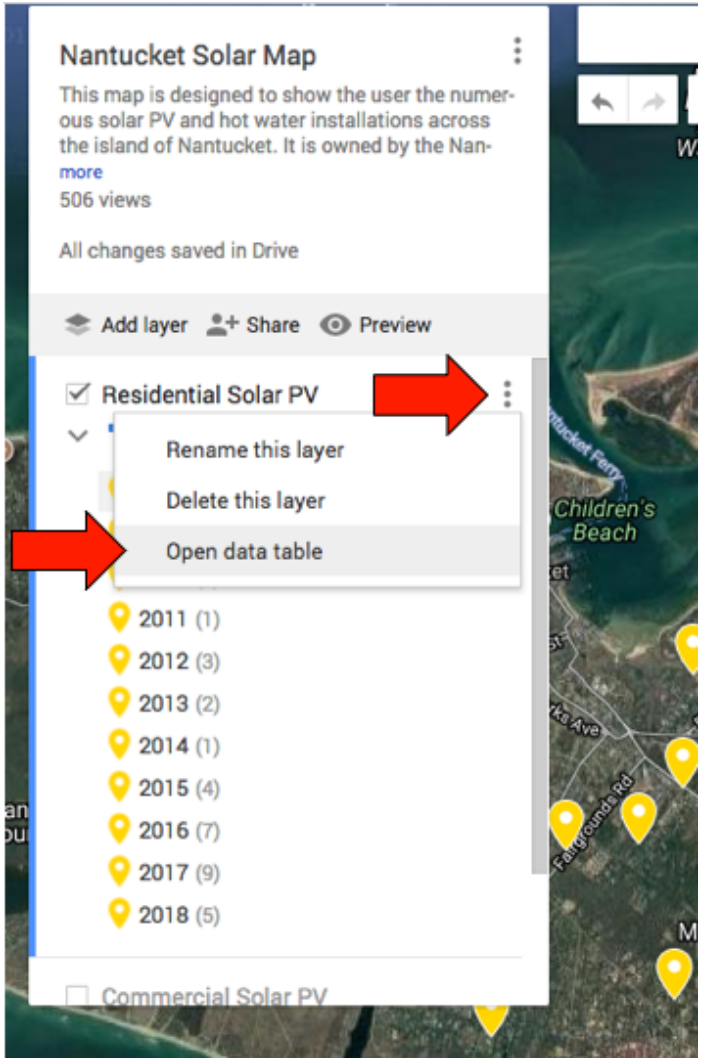
3. Left click on the spot you want to add the point and it will give you a text box with fields to input the appropriate information.

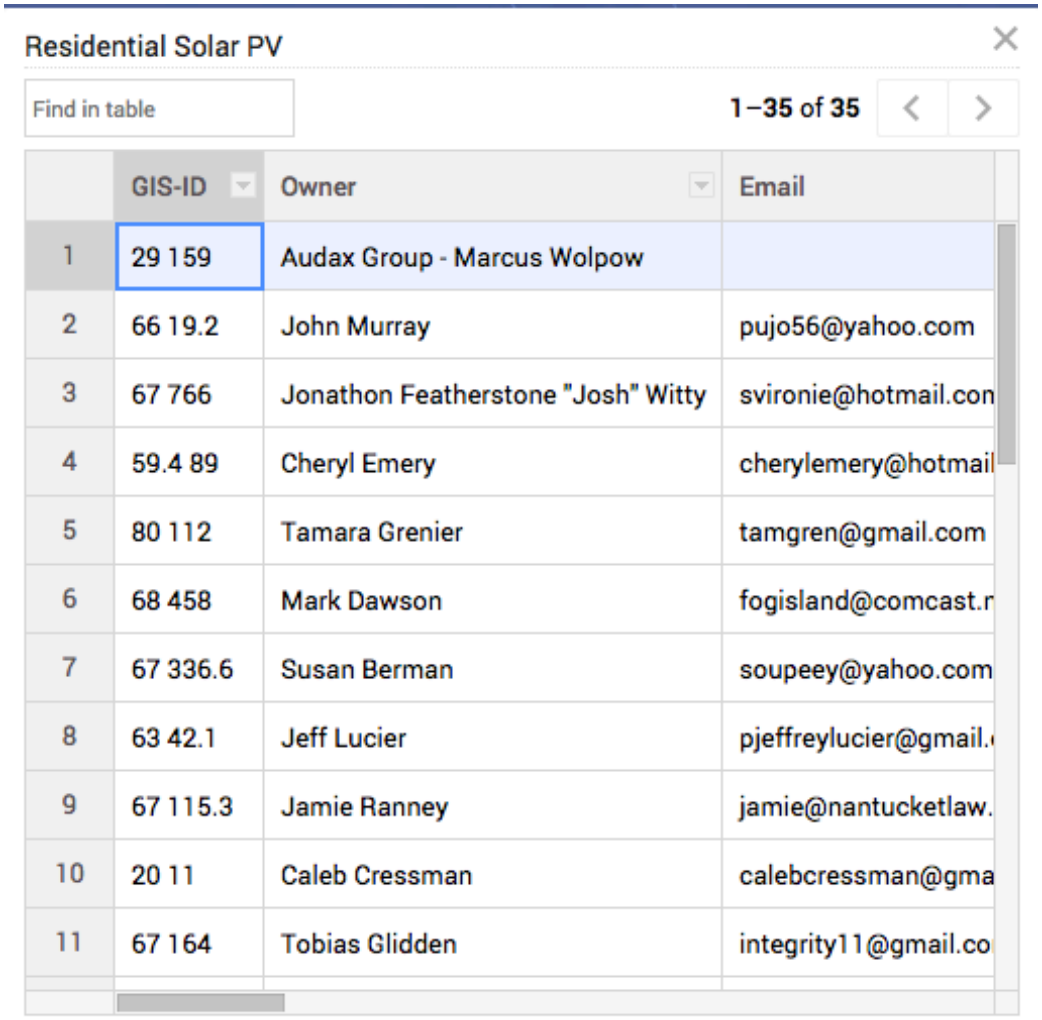


Adding a point into the data table will automatically update the map, and visa versa.

Changing Header Name in Data Sheet

1. Left click on three vertical dots next to the layer you want to change header name and then left click on "Open data table".





Residential Solar PV

Find in table

1–35 of 35

	GIS-ID	Owner	Email
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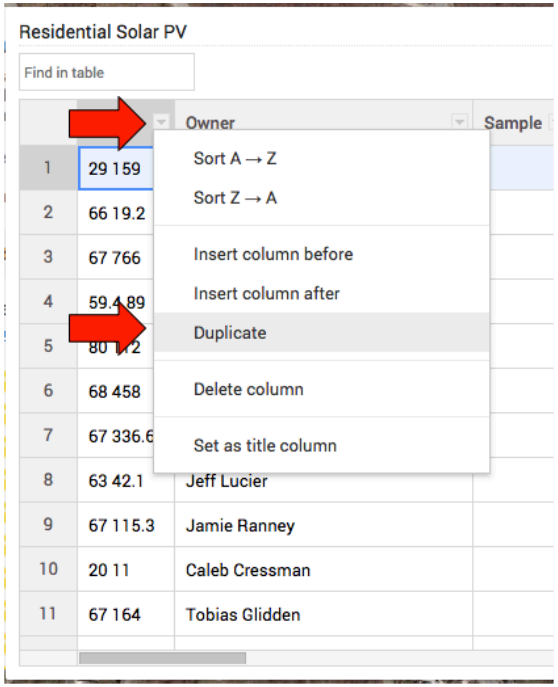
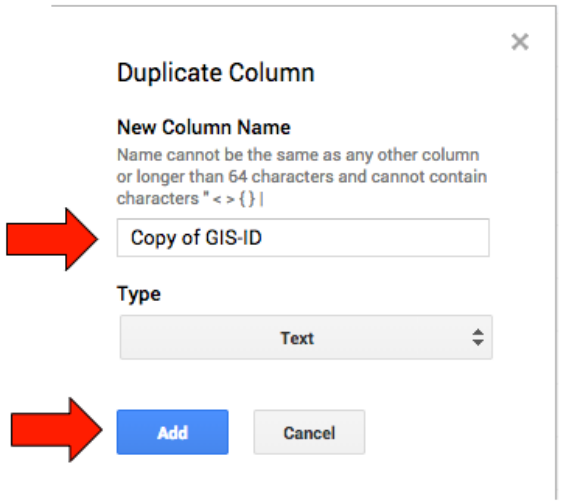
2	66 19.2	John Murray	pujo56@yahoo.com
3	67 766	Jonathon Featherstone "Josh" Witty	svironie@hotmail.con
4	59.4 89	Cheryl Emery	cherylemery@hotmail
5	80 112	Tamara Grenier	tamgren@gmail.com
6	68 458	Mark Dawson	fogisland@comcast.r
7	67 336.6	Susan Berman	soupeey@yahoo.com
8	63 42.1	Jeff Lucier	pjeffreylucier@gmail.(
9	67 115.3	Jamie Ranney	jamie@nantucketlaw.
10	20 11	Caleb Cressman	calebcressman@gma
11	67 164	Tobias Glidden	integrity11@gmail.co

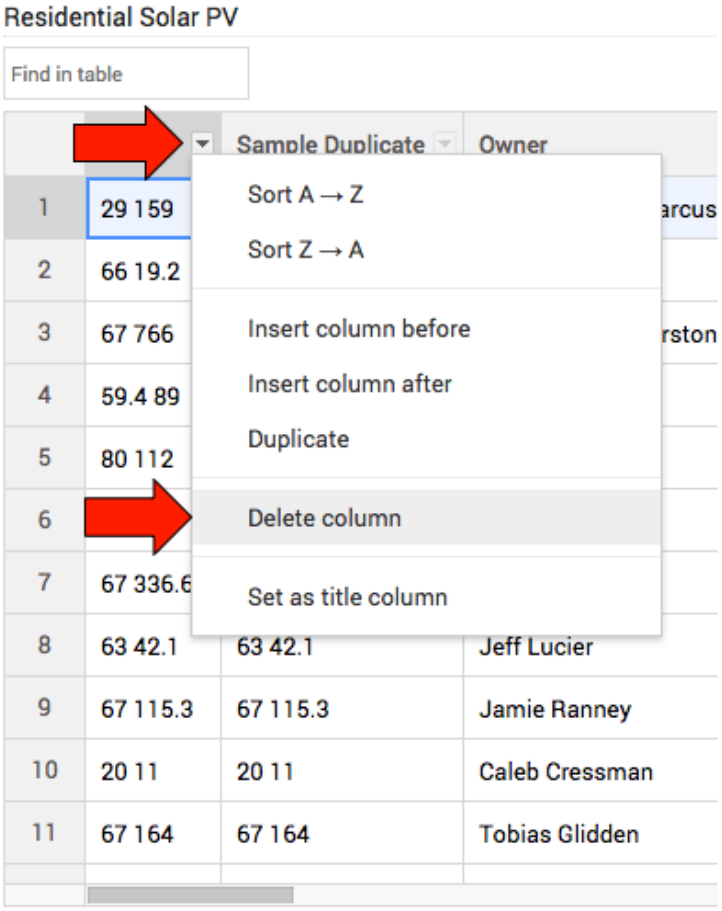
2. Next to the header name left click the drop-down arrow and select "Duplicate".



3. You can change the name in the box under "New Column Name". Then select the "Add" button.

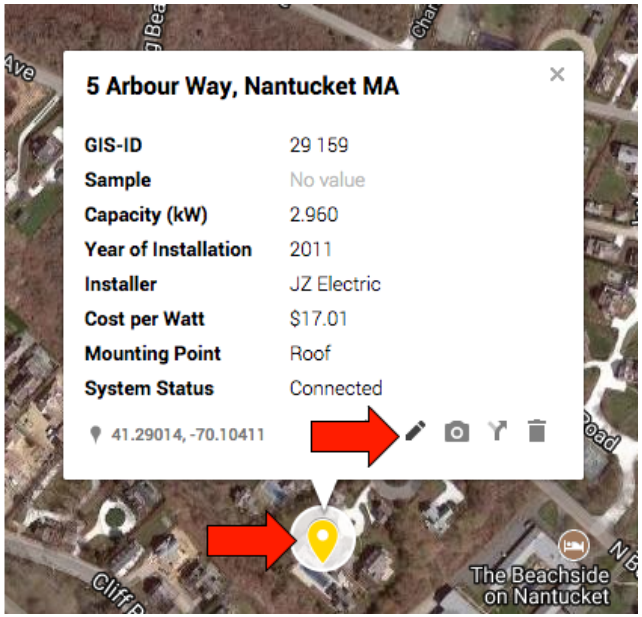


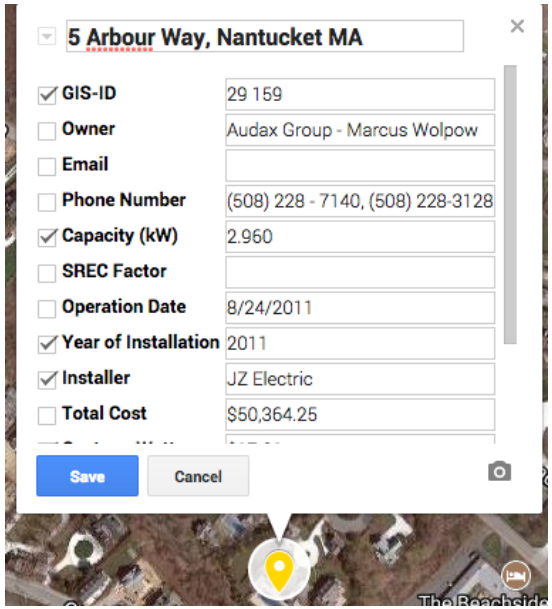
4. Once the new column has been added you can delete the original column.



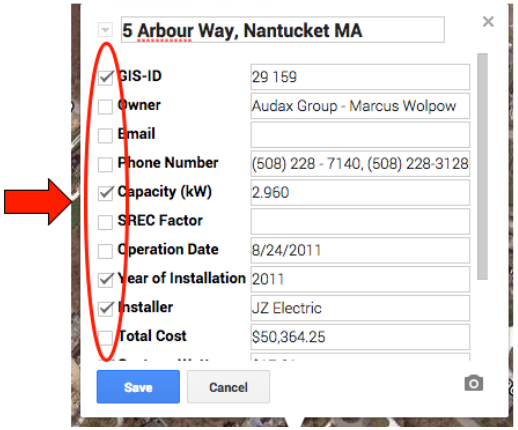
Public Viewable Information vs. Private Viewable Information

1. Left click on a point on the map to bring up the information box. Then left click the "Pencil" icon to edit the information.

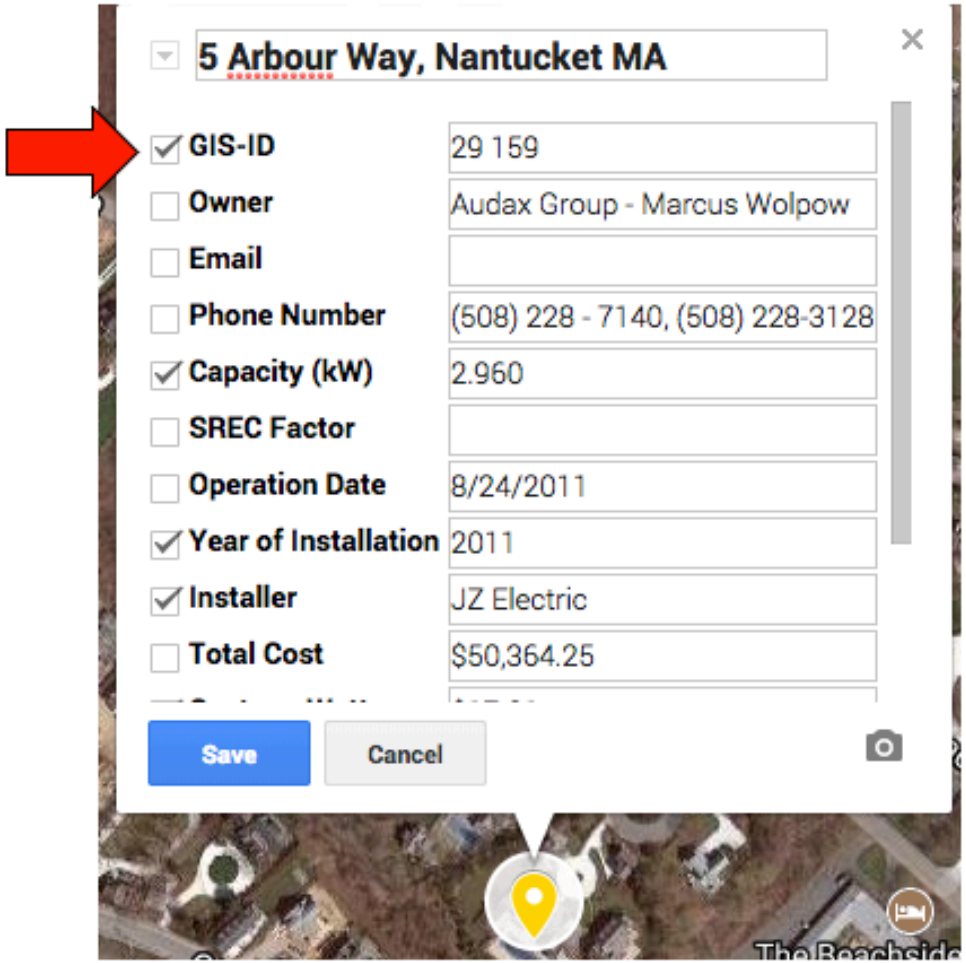




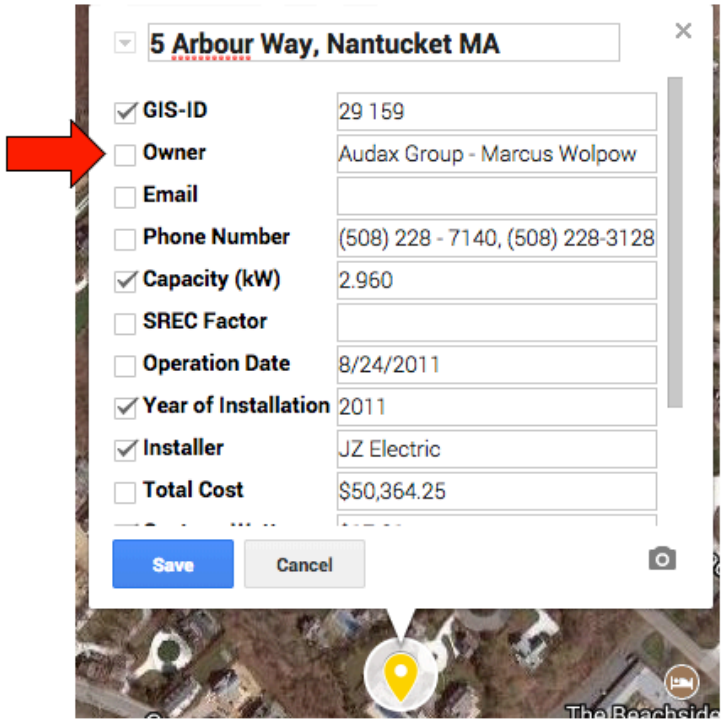
2. To the left of the data fields there are checkboxes. Checking or unchecking a box will update all data points in the layer.



3. All points checked will be viewable to the public.



4. If a point is unchecked then it will only be viewable in private to the owner/updater of the map.



Important Information

RGB Colors for data points

1. Residential (255, 214, 0)
2. Commercial (249, 168, 37)
3. Solar Hot Water (2, 136, 209)

Appendix G: Project Deliverables

In-Depth Profiles

Nantucket

75 Pochick Ave

Mark and Barbara White are retired teachers who have lived on their property for thirty-nine years. They have always been conscious about the environment. Twenty years ago, they looked into going green by installing solar PV on their home, but both unreliability and the very high cost of technology back then put renewable energy on the back burner. As time went on, solar PV technology changed, becoming much more reliable and affordable, allowing them to install.

System Specs:

Price: $34,092
Number of Panels: 24
Capacity per Panel: 300W
Total Capacity: 7.2kW
Installer: ACK Smart

Mark and Barbara decided three years ago that they would install solar PV on their property. They attended a workshop to explore the possibilities and options for solar PV at the time. They visited Jack Weinhold's home and discussed the various installers and different ways they could install on their property. After exploring all the options, Mark and Barbara decided to use an on-island local installer, ACK Smart, to install their system. Looking into different places to install solar, there was not enough land space to install a ground mounted system, however, their roof is South facing, which is the ideal roof direction for solar panels.

The process of installing the solar PV system took very little time, although they decided to wait a couple of months for new panel technology to come out that would increase their efficiency by about 15%. Installation only took two days and the permitting process was completed soon afterwards.

Like many people, the Whites were worried about how they were going to pay for the system because although it helps save money in the long run, it does have a large upfront cost. The Whites explored the rebate options provided by state and federal entities, and decided to install their system, knowing they would receive the $1,000 state rebate, 30% federal tax credit, and SREC payments.

Overall, the Whites have had a very positive experience with their solar PV system. Their system produces about 140% of their electric bill, which they use to net meter to their cottage next door. They want to see more solar PV installed on the island, to be more green and to be more self-sufficient.

Nantucket

4 Jennifer Lane

Cary Hazlegrove has lived in her home in Siasconset since 1980. It is a single-family, Colonial-style home built in 1984. Cary choose to install a roof mounted solar PV system over a ground mounted system. This is partly due to the fact that she did not have much ground space, but also because, like many other homes on Nantucket, her roof was ideal for solar panels. The south side of Cary's roof is facing away from the street. This is great for solar PV as it allows for her panels to be hidden from view of the main road.

System Specs:

Price: $41,888
Number of Panels: 35
Capacity per Panel: 320W
Total Capacity: 11.2kW
Installer: Cotuit Solar

Cary's primary motivation behind installing solar PV was reducing her environmental impact. Cary also composts and collects rainwater, as well as participated in a Mass Save home energy assessment. As a result, they replaced old incandescent light bulbs with energy efficient and long lasting LED light bulbs as well as installed new smart thermostats.

While looking into different solar system installers, Cary chose to use Cotuit Solar as her installer. Like anyone who is making a big investment, she wanted to use an installer that was trustworthy and dependable. To finance her system, Cary was pointed toward a low interest loan for 100% of the cost offered through BlueWave, a Massachusetts bank. With the financing, she was able to keep her initial expenses low, and pay back her loan after her system started saving her money. The payback period of her system is projected to be only five and a half years, which is less than the national average of six to eight years. This is great, as her system will basically pay for itself after that five and a half year period.

When asked about the installation process, Cary told us that it was easy and convenient. The whole installation process took only a couple of days to complete and was "clean and quiet with awesome people." Cotuit Solar brought their own electricians and carpenters and managed all of the paperwork. The only work Cary had to do was go to an HDC meeting for the approval of her HDC application.

Cary has only had her system installed for a few months and is already very pleased with the savings she is seeing. Since installing, her electric bill has been reduced from over $200 to less than $20 a month. She anticipates little to no maintenance moving forward and is excited to see more local residents adopt solar PV.

Nantucket

11 R South Shore Road

Jack Weinhold, a respected and outspoken resident of Nantucket, has lived at 11 R South Shore Road in the heart of Nantucket for twenty-five years. During that time he has become a model for energy sustainability. Jack is one of the island's most vocal residents regarding energy sustainability, not only embracing Nantucket's famous landscape through photography but also trying to protect the environment through renewable energies.

System Specs:

Price: $45,000
Number of Panels: 36
Capacity per Panel: 270W
Total Capacity: 10kW
Installer: ACK Smart

Jack began investing in sustainable energy starting in January of 2015 with the completion of his solar PV system. Using an on-island installation company, ACK Smart, Jack installed a 10kW solar PV system on a large ground mounted array. By installing a ground mounted system, Jack was able to receive energy savings and enjoy ease-of-access for maintenance. In addition, he installed a moderate-sized solar hot water system that harnesses the power of the sun to heat his home's supply of hot water. In 2016, Jack purchased a Nissan Leaf, further reducing is carbon footprint.

Jack's main motivation for installing these systems was the environment. The environment is a large aspect of the community here on Nantucket and as such, residents like Jack desire to reduce their impact on it through the adoption of technologies like solar PV and solar hot water.

Like many, Jack was concerned with how long it would take to recover his solar investment. Low interest financing options were not available at the time. Prospective owners had two options: pay for the system out of pocket, or obtain a bank loan. Nowadays, owners have numerous options including a zero money down, 100% loan.

Jack's installation is far enough from the public view that the HDC had little issues and approved it almost immediately. As long as the public cannot see the panels and the installation looks sleek and professional, the HDC is usually quick to approve. His system heats and cools his house and studio, supplements the solar hot water system and charges his Nissan Leaf. Jack is very enthusiastic about solar PV and residents like him will start a wave of adoption on Nantucket. According to Jack, "Solar PV is easy, it's quick, and it's not as expensive as you'd think."

Frequently Asked Questions

1. Does solar PV system require snow removal?

   With the amount of snowfall on Nantucket, as long as panels are on a roof or high enough off the ground for ground-mounted systems, snow should not need to be removed. The solar panels do a good job of naturally melting any snow that doesn't slide off of them.

2. Do I have to clean my solar panels?

   Cleaning solar panels is not regularly needed. A good rain should clean them off with no problem. If they do get dirty enough to affect their efficiency, they can be cleaned with a non-abrasive wash just like you would clean your windows.

3. How much money is it annually to maintain my system?

   As long as your solar PV system is under warranty, replacement parts should be of no cost to you. With modern solar technologies systems rarely have issues with components, so any maintenance should be uncommon.

4. Will a roof mounted system cause leaks?

   If installed properly, roof mounted systems will not cause roof damage that could potentially cause leaks.

5. How long until the technology becomes obsolete?

   Technology is constantly evolving, and solar panels will inevitably become more efficient in the future. Current solar technology is efficient enough for people to greatly reduce their electric bills to a few dollars a month to even no cost per month.

6. How long do warranties last?

   The solar panels themselves have a manufacturer warranty generally around 20-25 years, while Installers have a labor warranty around 5 years. Both of these warranties are dependent on manufacturer and installer and need to be taken into consideration when investing in a solar PV system.

7. What solar energy rebates and incentives are available?

   Currently there is a federal tax rebate of 30% off of your system cost.

   There is a state rebate of 15% up to $1000.

   There is a Nantucket Town SOLAR Rebate of $2500.

   Quarterly net-metering payments called SRECS.

8. What is the payback period for solar PV on Nantucket?

   Average payback period of a system on Nantucket is around 6.5 years. This means that on average the solar PV system will pay for itself in, on average, around 6.5 years.

9. Is it more expensive to install solar PV on the island of Nantucket than the mainland?

   Like many other things on Nantucket, it is more expensive to install solar PV on Nantucket due to cost of transportation of materials and additional labor costs. The $2500 SOLAR Rebate was created to help alleviate these extra cost. But even though the system is more expensive, it is still an economically viable option to saving money.

10. Does Nantucket get enough sun for solar photovoltaics to work?

    Although Nantucket may not get as much sun as mainland areas, these systems do generate enough electricity for owners to greatly reduce their electric bills without having to install more expensive systems.

11. Is my roof suitable for solar PV?

    The optimal roof orientation for installing solar PV is 180 degrees due south. Roof pitch can be accounted for with the system mounting brackets. Although asphalt shingles are prefered when installing roof mounted systems, roofs with cedar shingles can still be used.

12. How easy is it to monitor my system's electrical generation?

    Many installers use smart apps that communicate to your solar PV system through wifi or ethernet that allow you to manage and track your system output in real time.

13. Can I install solar PV on my property in the Historic Core Districts?

    Rarely can solar panels be installed inside the Historic Cores on Nantucket. Like any home improvement inside the Historic Cores, projects need to contribute to keeping these zones historically accurate. Systems can't be visible from any view, and can't impact the historical integrity of the building.

14. Can I install solar PV on my property outside the Historic Core Districts?

    Yes, as long as the solar panels are visibly hidden from public view or are considered to not make a negative visual impact, they can be installed on your property.

15. Do I need to get HDC approval even if I don't live in a Historic Core?

    Yes, you do need HDC approval before installing solar PV outside of a Historic Core, but they are more lenient when it comes to the aesthetics of the system, as long as it is not in view of a public way.

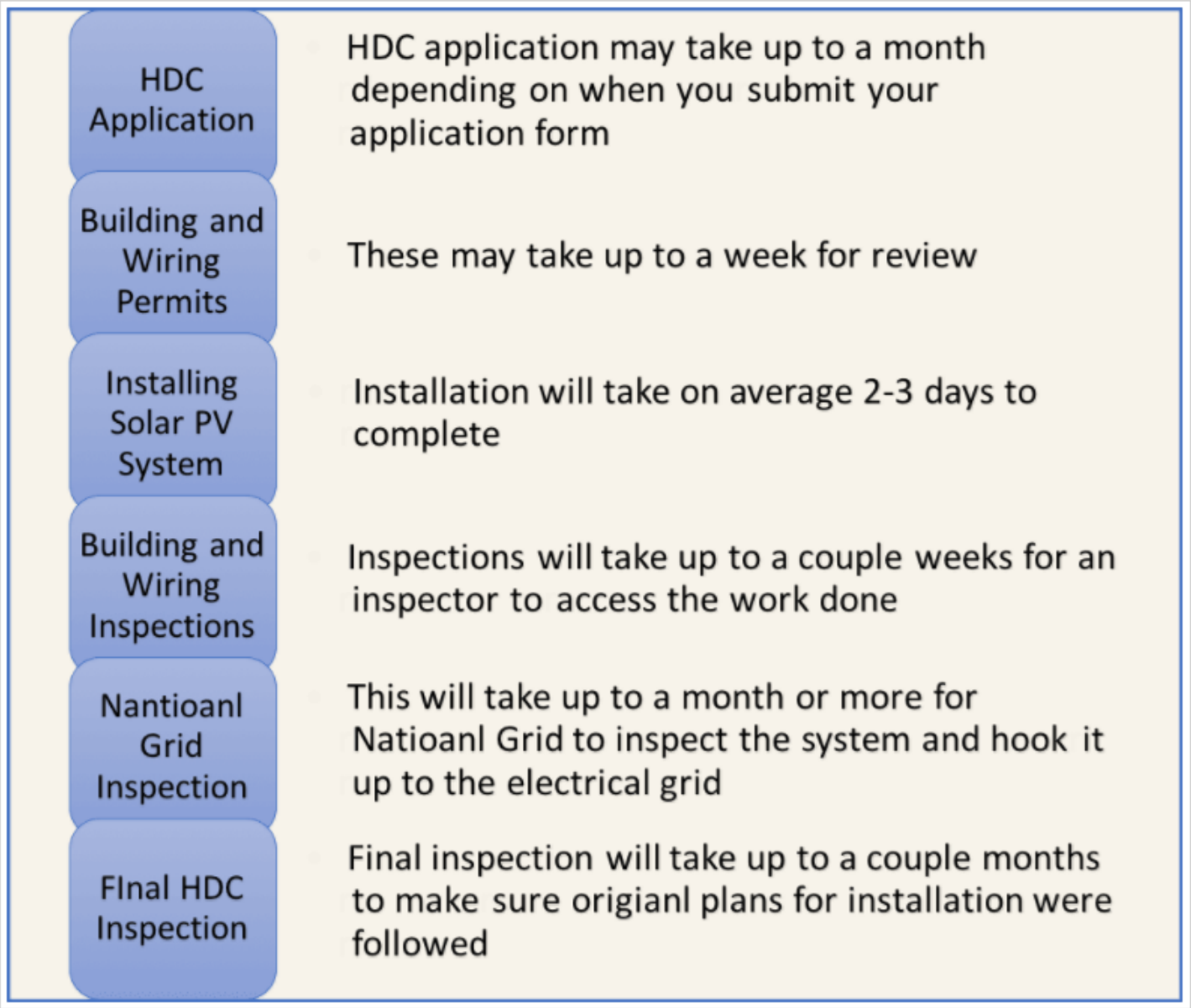
16. Do I have to talk to my local Homeowners Association when considering installing solar PV?

    It's recommended that you talk to your local Homeowners Association before talking to the HDC when looking to install solar PV. You won't have to fill out and pay for an application before finding out whether or not you are allowed to install solar PV where you live.

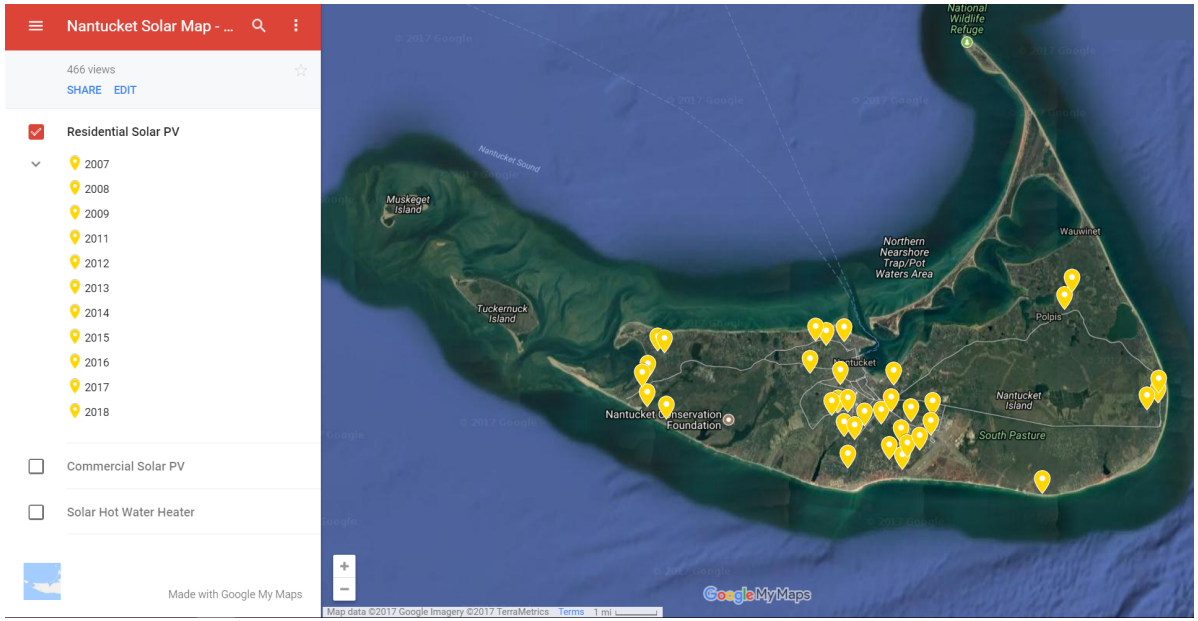
17. How do I choose an installer?

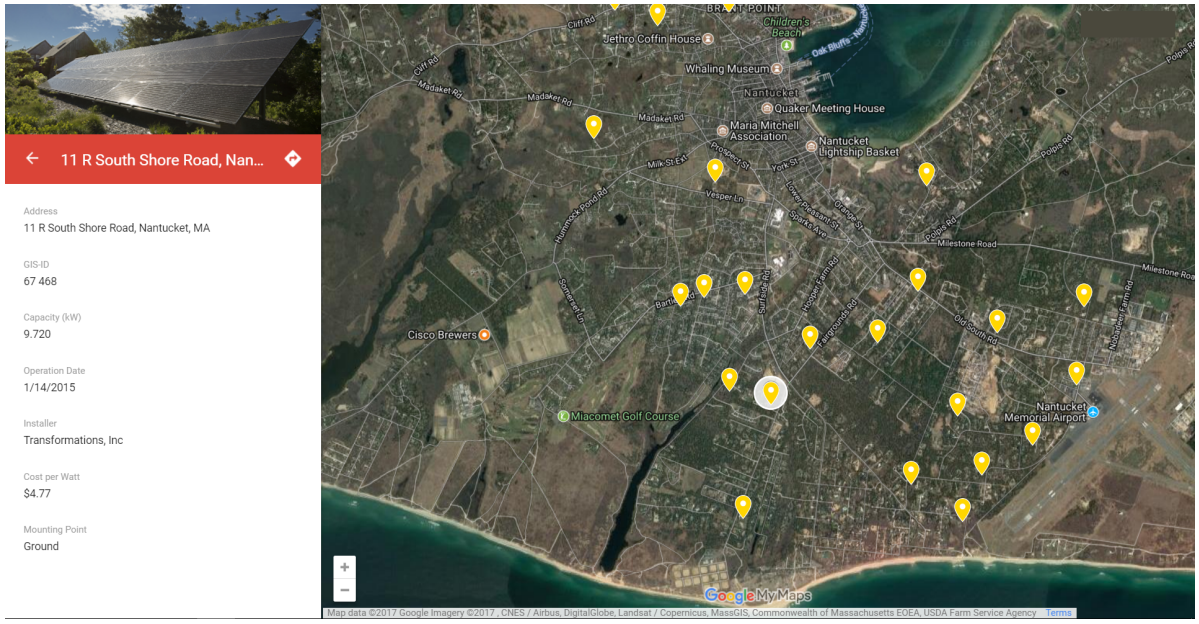
    When looking to install a system on island it is important to talk to multiple installers to get a system and company that works well for your situation. Make sure to consider the overall cost of the system, the expected payback period, system and labor warranties, and how well they communicate.

HDC Permitting Process Timeline



Interactive Map Example





Appendix H: Summative Team Assessment

Team Monitoring

Throughout the semester our team worked effectively for the majority of the time. Before writing a new section, or developing a deliverable, we would brainstorm the main ideas or actions needed as a group. Whenever we needed to make a decision on a matter or an argument in our paper, we took into account each other's opinions and thoughts so that we came to an agreeable conclusion together. To maximize efficiency, we would make a weekly agenda at the beginning of each week and followed it closely to stay on schedule. This was very helpful with keeping us on task during the week and also let our advisors and sponsor know our plans for the week. In addition, to keep track of interviews, meetings, and assignment deadlines, we created an excel sheet that was setup to be a schedule. This had dates as well as time slots for each day and allowed us to keep track of our schedule and, at a glance, see what times we were available.

At first, we would distribute each assignment into four equal or so parts; however, as the term went on, we learned each other's strength and were able to split work up accordingly. This was especially helpful when more work was to be done in areas outside the physical report such as conducting interviews, various meetings, emails, scheduling, and working on our project deliverables.

Toward the end of project, tensions tended to run high causing us not to be as respectful to each other as we were earlier in the project. This did not get in the way of productivity or our relationship as a team, however. We were all stressed, like many teams are at the end of their IQPs, and we think we did a great job of pushing through. At times there would be banter between all group members, but it was never anything that anyone took personally.

Team critique and conflict identification

We are pretty open to one another when it comes to criticizing each other's effectiveness. We try to keep one another on track and constantly update one another on the progress of our sections. Additionally, we set due dates for project work that wasn't given a due date by our advisors. We did a good job all semester on keeping each other productive.

Although we have worked well as a group communicating individual opinions and ideas, for the first three weeks on Nantucket, we had some problems communicating with our advisors. We would receive edits on our report, and if we did not agree with a comment, we would leave the original and not discuss the problem with the advisor who made the edit. Later on, we fixed this by communicating our concerns in a cover letter outlining the edits we made as well as discussing specific comments we disagreed with. After our Thanksgiving break, we all reflected on our midterm reviews and increased our communication with our advisors. Specifically, if we had questions or concerns on report comments, we would ask to meet with our advisors to discuss them. This worked very well and helped us get a clear understanding of any comments or concerns.

In addition, our communication could have been better with our sponsor. We worked in the same office building so we met and emailed quite a bit; however, we had problems communicating objectives and opinions to one another. Looking back, we think that both our group and our sponsor could have taken initiatives to increase our communication especially in regards to our survey.