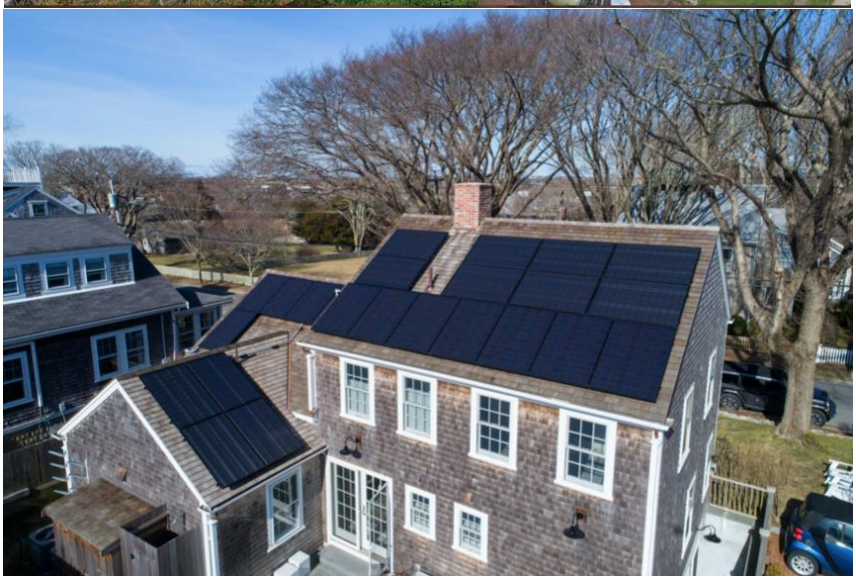
Integrating Solar into Nantucket's Historic Fabric



by
Katharine Miller
Shawn Mills
Morgan Raposa
Benjamin Twombly

Integrating Solar into Nantucket's Historic Fabric

An Interactive Qualifying Project
submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfilment of the requirements for the
degree of Bachelor of Science

by
Katharine Miller
Shawn Mills
Morgan Raposa
Benjamin Twombly

Date:
15 December 2022

Report Submitted to:

Lauren Sinatra
Nantucket Energy Office

Holly Backus
Nantucket Planning Office

Mary Bergman
Nantucket Preservation Trust

Professors Dominic Golding and Bruce Bursten
Worcester Polytechnic Institute

Abstract:

The overall goal of this project was to develop recommendations and resources the Town of Nantucket in collaboration with the Nantucket Preservation Trust may use to encourage and assist in the permitting of solar technologies without compromising the island's historic and architectural character. We evaluated the guidelines in Nantucket and other historic districts, surveyed public opinion, and interviewed officials, solar installers, and homeowners with solar installations. We found strong support for the increased use of solar technology as well as strong support for the maintenance of Nantucket's historic fabric. We recommended ways to improve the public information, outreach, and solar technology application process to achieve these competing demands, including the use of a new online map of solar installations that we designed to be easier to use and manage.

Acknowledgements:

We would like to thank and acknowledge several people for their contributions to our project including:

Lauren Sinatra, our sponsor from the Town of Nantucket Energy Office.

Holly Backus, our sponsor from the Town of Nantucket Planning Office.

Mary Bergman, our sponsor from the Nantucket Preservations Trust.

Nathan Porter, GIS Coordinator, for his help with navigating the Arc-GIS software

Molly Sprouse, IT Technician, for her help with navigating the EnerGov system

The Nantucket Historic District Commission Official who provided insight regarding the guidelines surrounding solar PV.

Peter Morrison, for distributing our survey to the Nantucket Civic League

All the solar installers who took the time to speak with us.

All the Nantucket residents who previously applied for a Certificate of Appropriateness who spoke to us about their experience.

The Nantucket Yacht Club for housing us and Young's Bicycle shop for loaning bicycles to us for our time on island.

Our advisors Dominic Golding and Bruce Bursten.

Executive Summary:

Background Information:

Electricity is supplied to Nantucket Island by two undersea cables constructed and maintained by National Grid. The combined capability of these two cables is 74 MW. Nantucket's electricity demands have continued to grow at a significantly faster rate than that of mainland Massachusetts, especially during tourist season, reaching a peak load of 55 MW. This increasing demand means that if either undersea cable were to fail, Nantucket could be faced with large scale power outages until back-up generation could be implemented. This precarious situation has sparked growing concerns amongst residents and the town government that a third undersea cable may need to be installed which would come at a significant cost to Nantucket electricity rate payers. Due to these concerns, the Energy Office was formed in 2011 to create programs to promote energy efficiency, conservation, and renewable energy. One of the responsibilities of the Energy Office is to help manage the increasing demand for the installation of photovoltaic (PV) solar technologies as a means to decrease dependence on electricity through the undersea cables. Because Nantucket is a designated Historic District, proposals to install solar technologies are subject to guidelines established by the Nantucket Historic District Commission (HDC).

The goal of this project was to develop recommendations and resources to encourage and assist in the solar permitting process. To achieve this goal, we identified three main objectives

- Evaluate current guidance and best practices for the approval of solar technologies in historic districts.
- Identify stakeholder opinions on Nantucket about the current guidelines and approval process for the installation of solar technologies and suggest improvements.
- Update and improve the functionality of the online map of solar installations maintained by the Energy Office.

To complete these objectives, we used a variety of methods including, analysis of the Nantucket HDC and Energy Office records to identify candidates for interviews as well as developing a survey that was distributed to the Nantucket Civic League and a list of approximately 40 residents who had previous solar projects approved. In addition to interviewing

Nantucket residents, we also interviewed the three main solar installers on the island, as well as a Nantucket Official and officials from other historic districts in the Commonwealth and Rhode Island. We also familiarized ourselves with the technology used in the current solar map and the record-keeping for new approved solar projects, as well as learning about newer technologies that will allow the Energy Office to maintain the solar map with greater currency and efficiency.

Deliverables:

For the portion of the project concerning the interactive solar map, the general requirements were two-fold: First we had to recreate the current functionality of the existing Google Maps based solar map in an Arc-GIS based layer. Second, we needed to find a way to automate the process of updating said map layer. To begin, the functionality offered by the Arc-GIS Pro software seemed to be more than sufficient for the purpose of recreating the existing solar map. By working with the town's GIS Coordinator, we developed a method for creating the solar-map layer from a table or spreadsheet of various solar installations. The original map utilized street addresses to provide location to the various entries, but there are two main reasons that this was not possible for the new layer. First, Google Maps provides a base layer containing street layouts and addresses by default, but Arc-GIS does not. Second, some portions of Nantucket do not actually have street addresses in the traditional sense, particularly the island of Tuckernuck located off the western coast of Nantucket. To circumvent these difficulties, we had to find a new method of providing location data for entries. Manual placement of the locations of various entries was not possible due to the automation portion of the requirements. Therefore, we had to utilize data available in the base layer of the Nantucket's GIS system. More specifically, the layer containing the shapes of all the land parcels on Nantucket, as well as their location, which was provided to us by the town's GIS Coordinator. This shape layer can be thought of as a jigsaw puzzle of the island, with each piece being an individual parcel of land, and each parcel of land containing a set of information (attributes) assigned to it.

Records from the EnerGov database were the primary source of information for new entries, with new installations being identified via cross-referencing HDC, electrical, and building permits. This was done because the presence of completed electrical and building permits is almost always an indication of an installation being built. Permit applications on EnerGov always include the parcel number of the property in question, with the parcel number

being a unique identifier for all land parcels on Nantucket. The provided parcel shape layer includes this identifier, so it is possible to match solar installation entries to individual shapes in the parcel layer. By matching installation entries to parcel shapes in this way, the parcel shape layer could be used to provide location data for these entries. The shape layer was then converted to a marker layer, a process which basically just places a marker on a point inside of the corresponding shape. We tested this method with a data set containing all existing solar installations on Nantucket. This data set was created from data sheets of solar-related permits that were provided to us by one of the town's IT specialists. We used a Python script to identify likely installations by cross-referencing the sheets of HDC Certificates of Appropriateness (COAs), electrical permits, and building permits. We then combined existing entries from the old solar map with new installations identified using the method outlined above and filtered for duplicates.

Findings and Recommendations:

Throughout our research process we completed several interviews and distributed a survey. While each method of gathering information was different, all interviewees posed their suggestions for opportunities for improvements in the current guidelines and application process. From our interviews with residents who had previously applied, we found that there was generally a lack of awareness regarding precisely what was considered acceptable in solar installations. This sentiment was largely reinforced by the survey question regarding what potential educational items may be beneficial to the process including a "guide to going solar" webpage and solar permitting checklist. In addition to a lack of awareness, residents also voiced their concern that the current HDC guidelines are not solar-friendly enough with approximately 63% of survey respondents agreeing. Our interviews with two of the three solar installers corroborated this sentiment as they also believed that current guidance was not as fair and reasonable as it could be.

However, approximately 36% of the survey respondents, as well as the Nantucket official we interviewed agreed that the current guidelines are fair and reasonable. In general, though these parties also agreed that having other educational resources would be a beneficial change and would help to increase awareness surrounding the current guidelines and application process.

Based on these findings, we recommend that our project sponsors work together to create some of the following resources:

- An online guide for homeowners considering the installation of solar technologies
- A checklist of steps that will be followed during the application process
- A compilation or slideshow to show the range of installations that the HDC has approved
- Continuing updates of the solar map to display more accurately the current state of solar installations on island

These resources would allow for a more succinct and focused presentation of essential information for those looking to install solar technology.

In addition to the creation of these educational resources, we also found that many of the respondents felt that solar panels should be allowed to be visible from public ways if the property is outside of the Old Historic District or ‘Sconset Old Historic District. This figure included approximately 61% of survey respondents, of which 30% felt strongly that these types of installations should be more permissible. This leads to the recommendation that the town of Nantucket pursue a Survey & Planning Grant from the Massachusetts Historical Commission to help fund an independent third-party review of the current guidelines similar to what the Town of Salem, Massachusetts has done with their guidelines.

Authorship:

Section	Author(s)	Editor(s)
Abstract	Morgan	All
Acknowledgements	Morgan	All
Executive Summary	Morgan	All
Introduction	Benjamin & Katharine	All
History of the Historic District of Nantucket	Katharine	All
Electricity Generation and Consumption on Nantucket	Katharine	All
Solar Technology Installations on Nantucket	Benjamin & Katharine	All
Current HDC Policies on Solar Technologies	Benjamin	All
Attitudes Towards Solar on Nantucket and the HDC Guidelines	Katharine & Morgan	All
Innovations in Solar Technology	Morgan	All
Review of Other Historic Districts	Shawn	All
Objective 1	Shawn	All
Objective 2	All	All
Review Public Opinion	All	All
Survey of Residents	Morgan	All
Stakeholder Interviews	All	All
Objective 3	All	All
Guidelines in Other Historic Districts	Shawn	All
Findings from Interviews of Other Historic Districts	Shawn	All
Stakeholder Opinions	Morgan	All

Perspective of Residents	Morgan	All
Perspective of Installers	Katharine	All
HDC Perspective	Morgan	All
Updating and Improving the Solar Map	Benjamin	All
Conclusion 1	Morgan	All
Recommendation 1	Morgan	All
Conclusion 2	Morgan	All
Recommendation 2	Morgan	All
Conclusion 3	Shawn	All
Recommendation 3.1	Shawn	All
Recommendation 3.2	Shawn	All
Conclusion 4	Benjamin	All
Recommendation 4.1	Benjamin	All
Recommendation 4.2	Benjamin	All
Appendix A	All	All
Appendix B	All	All
Appendix C	All	All
Appendix D	All	All
Appendix E	All	All
Appendix F	Benjamin	All
Appendix G	Katharine	All
Appendix H	Shawn	All

Table of Contents:

List of Figures:

List of Tables:

Introduction:

Nantucket represents one of the best-preserved collections of pre-Civil War buildings in the United States. Because of this unique historic and architectural significance, the Nantucket Historic District was created in 1955 and the Historic District Commission (HDC) was created in 1956 (Lang & Stout, 1992, p. 7-9). The HDC's jurisdiction originally only included the Old Historic Districts of Downtown Nantucket (Town) and Siasconset ('Sconset) but has since expanded to encompass the entire island of Nantucket as well as the islands of Tuckernuck and Muskeget (Lang & Stout, 1992, p. 9). Like other historic districts and towns, Nantucket tries to balance historic preservation with the introduction of new technologies and infrastructure, such as solar technologies. In 1978 the HDC published a set of design guidelines aimed at protecting the historic architecture and landscape of Nantucket titled "Building with Nantucket in Mind" with a second edition published in 1992. In 2009 they published an addendum to these guidelines addressing sustainability including solar technologies (Way, 2009). Since these guidelines were issued the HDC has approved more than 250 applications for the installation of solar technologies, however there is a perception among many Nantucket residents that the HDC requirements are too restrictive.

Several town offices, commissions, and other organizations share the mission of preserving and protecting the historic and architectural integrity of the island. However, this objective invariably needs to be balanced with the reality of Nantucket's distinctive energy situation. The increase in demand for small-scale solar installations on Nantucket has led many residents and companies involved with the installation of these arrays to question the HDC's regulations and guidelines for such solar installations on the island, as well as voicing dissatisfaction with how the current process functions.

The overall goal of this project is to develop recommendations and resources the Town of Nantucket in collaboration with the Nantucket Preservation Trust may use to encourage and assist in the permitting of solar technologies without compromising the island's historic and architectural character. To meet this goal, our group established three main objectives: (1) evaluate current guidance and best practices for the approval of solar technologies in historic districts that have some similarities to Nantucket; (2) identify stakeholder concerns on Nantucket about the current guidelines and approval process for the installation of solar technologies and

suggested improvements; (3) update and improve the functionality of the online map of solar installations maintained by the Energy Office.

To achieve these objectives, we conducted interviews and surveys with residents, installers, and town officials. In addition, based on the findings of our research, we offered the Energy Office, Planning Office, and Nantucket Preservation Trust suggestions on how the solar guidelines and application process may be improved in the future. Lastly, we explored how the town's existing interactive solar map could be improved and created an improved solar map layer based on our findings.

We concluded that there is a desire for more solar on Nantucket. On the other hand, there is also a strong desire to preserve the historic character and aesthetic of the island. Additionally, we concluded that Nantucket's guidelines are on average more elaborate than most other towns in Massachusetts but may need to be revamped.

Finally, we crafted recommendations to balance these conflicting desires. Our primary recommendations are that the Town should consider:

- Consider relaxing the conditions for approval on installations outside of the Old Historic District and 'Sconset Old Historic District.
- Pursuing a Survey & Planning Grant from the Massachusetts Historical Commission to fund an independent third-party review of the current guidelines.
- Decreasing the amount of physical paperwork that is still used by the Town of Nantucket for record keeping regarding and applications for solar installations.
- Update previous graphics showing the HDC's preferred installation methods.
- Developing resources for the residents of Nantucket to improve their awareness of the guidelines surrounding solar installations.
- Utilizing the solar map layer that our team created on the town MapGEO webpage.
- General renewed focus on data entry and organization within the EnerGov system.

Background:

In this chapter we provide a brief history of the historic district of Nantucket. Next, we describe electricity generation and consumption on Nantucket, including a history of energy usage on Nantucket and current energy consumption. From there we discuss the current status, policies, and public attitudes regarding solar installations on the island and review recent developments in solar technology. Finally, we conclude with a brief overview of solar guidelines from other historic districts in Massachusetts and Rhode Island.

History of the Historic District of Nantucket:

Nantucket was once the shining beacon of the American whaling industry, but due to a combination of factors, the whaling industry and Nantucket's economy began to collapse in the 1840s (Stackpole & Harrison, 2022). While the collapse of the whaling industry may have seemed like a death knell for Nantucket at the time, it was ironically a major reason why Nantucket is a thriving tourist destination today. In fact, due to careful preservation, the Town of Nantucket represents "one of the best intact collections of late-17th to mid-19th century buildings in the United States" with almost 800 pre-Civil War buildings whose preservation was facilitated by the economic collapse and subsequent lack of development (Lang & Stout, 1992, p. 7). The Nantucket Historic District was created in 1955 and the Town of Nantucket was designated a National Historic Landmark in 1966 in recognition of the island's historic significance (Lang & Stout, 1992, p. 7).

To protect the architectural and historic integrity of Nantucket, the Historic District Commission (HDC) was created in 1956 (Lang & Stout, 1992, p. 9). The HDC's jurisdiction was originally limited to the two main settlements—Downtown Nantucket and Siasconset ('Sconset), which are shown in Figure 1. After a development boom in the late 1960s, many residents lobbied for similar protections for the rest of the island (Lang & Stout, 1992, p. 9). Thus, in 1971 HDC jurisdiction was expanded to include the rest of Nantucket as well as the islands of Tuckernuck and Muskeget (Lang & Stout, 1992, p. 9). Since then, the HDC's volume of work has grown substantially. For example, in 1989 the Commission reviewed nearly 2000 requests for Certificates of Appropriateness (COA), which is almost double the number reviewed in 1975 (Lang & Stout, 1992). The workload for the HDC has continued to increase with 2,362 COAs

issued in FY2021 including 81 COAs for solar installations (2021 Annual Town report, 2021, p. 81).

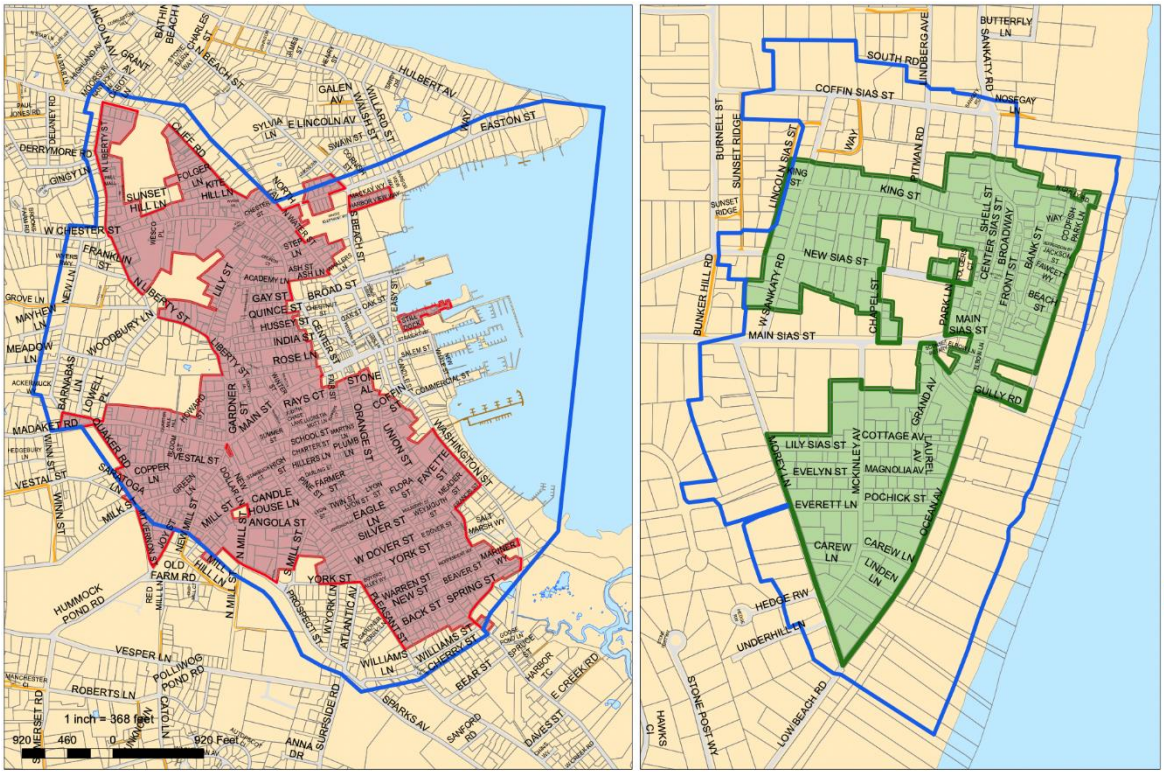


Figure 1: Map of the Old Historic District (Red) and ‘Sconset Old Historic District (Green). Blue lines represent the boundaries of these districts (Town of Nantucket, 2020).

Electricity Generation and Consumption on Nantucket:

Beginning with the electrification of homes in the late nineteenth century until 1996, Nantucket’s electricity needs were met by on-island power generation (Town of Nantucket Energy Office, n.d.). Towards the end of this period, it became clear that power generation on the island could not keep up with demand. Nantucket residents, visitors, and businesses suffered frequent power outages, especially when demand peaked during the summer tourist season. To address the problem, National Grid laid two undersea power cables (Figure 2) that connect Nantucket to the mainland power grid (Town of Nantucket Energy Office, n.d). Cable 1 was installed in 1996 at a cost of $30 million and has a 36-megawatt (MW) capacity; cable 2 was installed in 2006 at a cost of $41 million and has a 38MW capacity (Town of Nantucket Energy Office, n.d.; National Grid, n.d.).

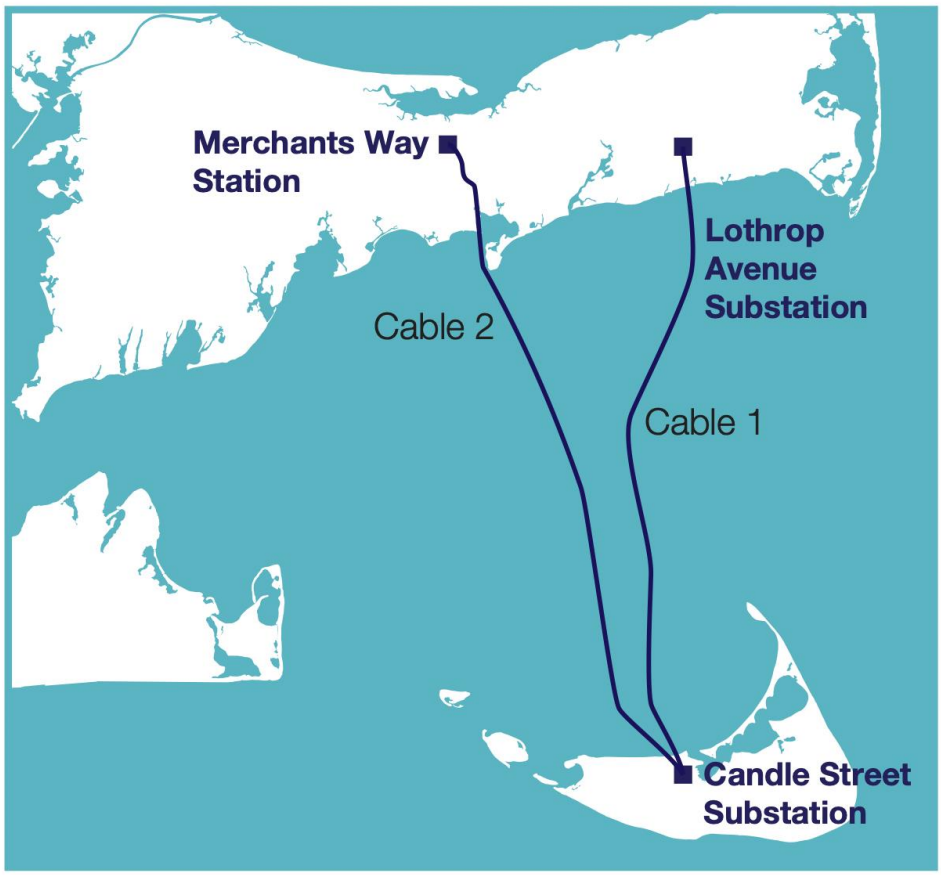


Figure 2: Nantucket's two undersea cables. (National Grid, n.d.)

Nantucket's electricity demands have continued to grow at a significantly faster rate than that of mainland Massachusetts, especially during tourist season; in fact, according to the National Grid, "at its peak in 2015, [electricity] demand was as high as 45MW" (National Grid, n.d.). Figure 3 shows a graph of Nantucket's peak electricity demand by year between 2008 and 2022 which was created using data we received from Lauren Sinatra, the Nantucket Energy Coordinator. As the graph indicates, peak demand reached 55 MW in 2022, a figure which represents an 8.3% increase from the previous year. This increase in demand means that if either cable were to fail during a period of high demand Nantucket could be faced with large scale power outages until back up generation could be implemented. A precarious situation which has sparked growing concerns amongst residents and the town government that a third undersea cable may need to be installed, a costly endeavor which would be paid for by Nantucket energy rate payers (Town of Nantucket Energy Office, n.d). Due to these concerns, the Energy Office

was formed in 2011 to create programs to promote energy efficiency, conservation, and renewable energy (Energy Office, n.d).

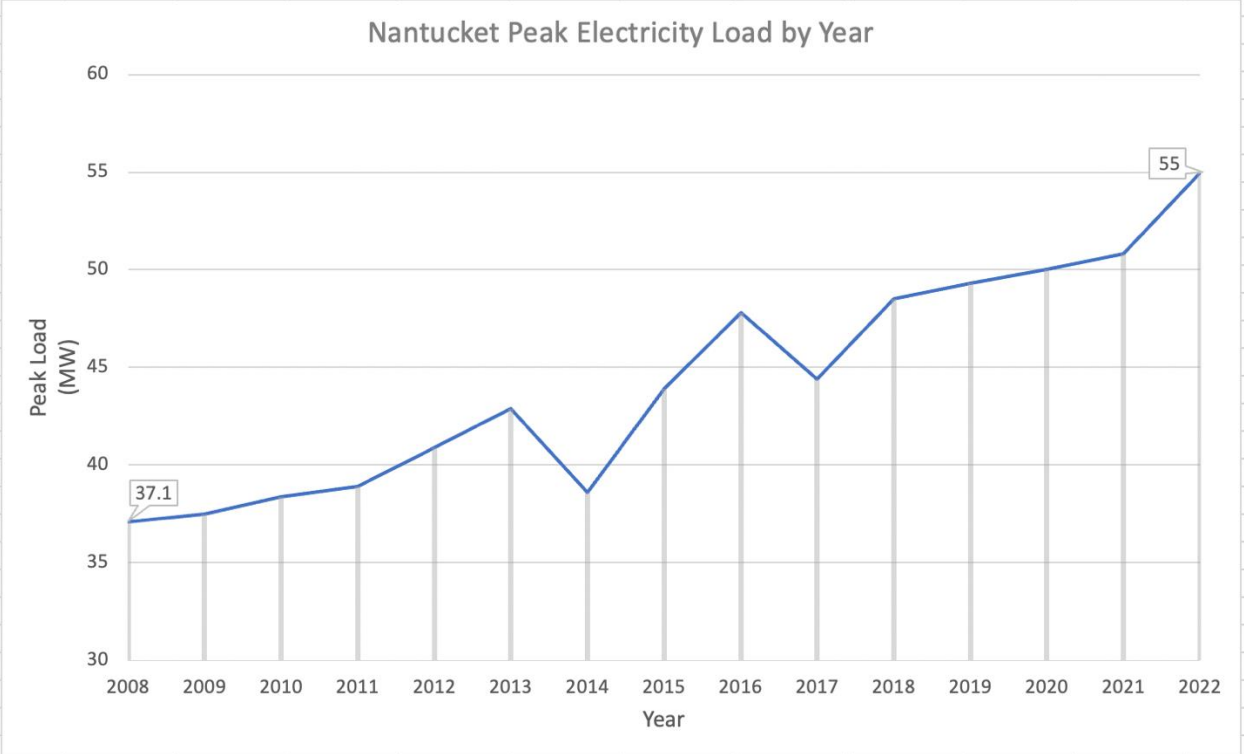


Figure 3: Nantucket's peak electricity demand by year

Solar Technology Installations on Nantucket:

In recent years, Nantucket has seen an increasing interest in solar projects that might help reduce residential energy costs and could delay or prevent the installation of a third cable. In fact, a 2021 survey found that the overwhelming majority of Nantucket residents believe that "the adoption of solar power should be encouraged more on Nantucket" (DeSantis et al., 2021, p. 20-21). Over the course of our background research, we pulled data from the previous solar map to analyze trends in solar installations on Nantucket. Figure 4 is a bar graph depicting the data, which demonstrates how the number of solar installations has been increasing each year. The dips in 2019 and 2020 are due in part to inconsistent updates to the previous map in those years, which we discovered when analyzing the data pulled from our updated version of the map (discussed further in Findings). Despite the yearly increase in installations, Figure 5 indicates

that both photovoltaic (PV) and solar thermal systems are rarely installed in the Old Historic and ‘Sconset Old Historic Districts. (Nantucket Solar Map, 2022).

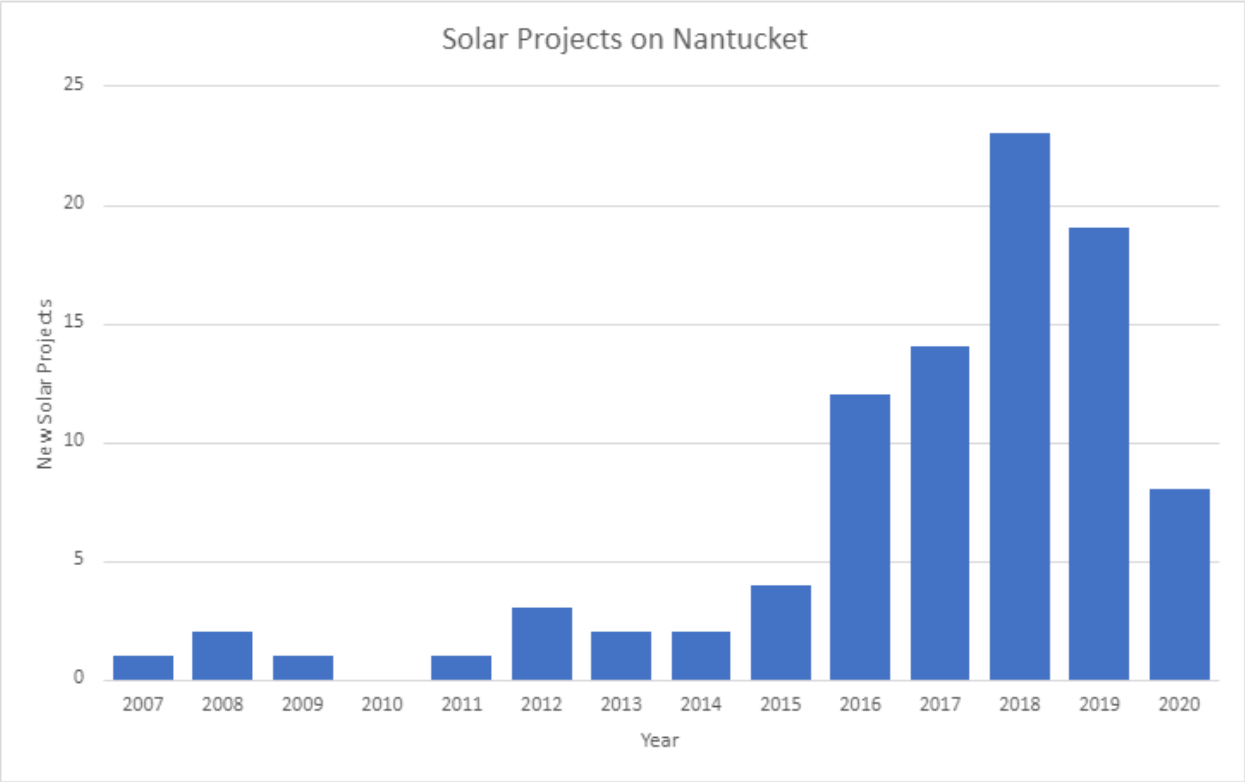


Figure 4: Solar project installations on Nantucket by year (data taken from the prior google-based Nantucket Solar Map)

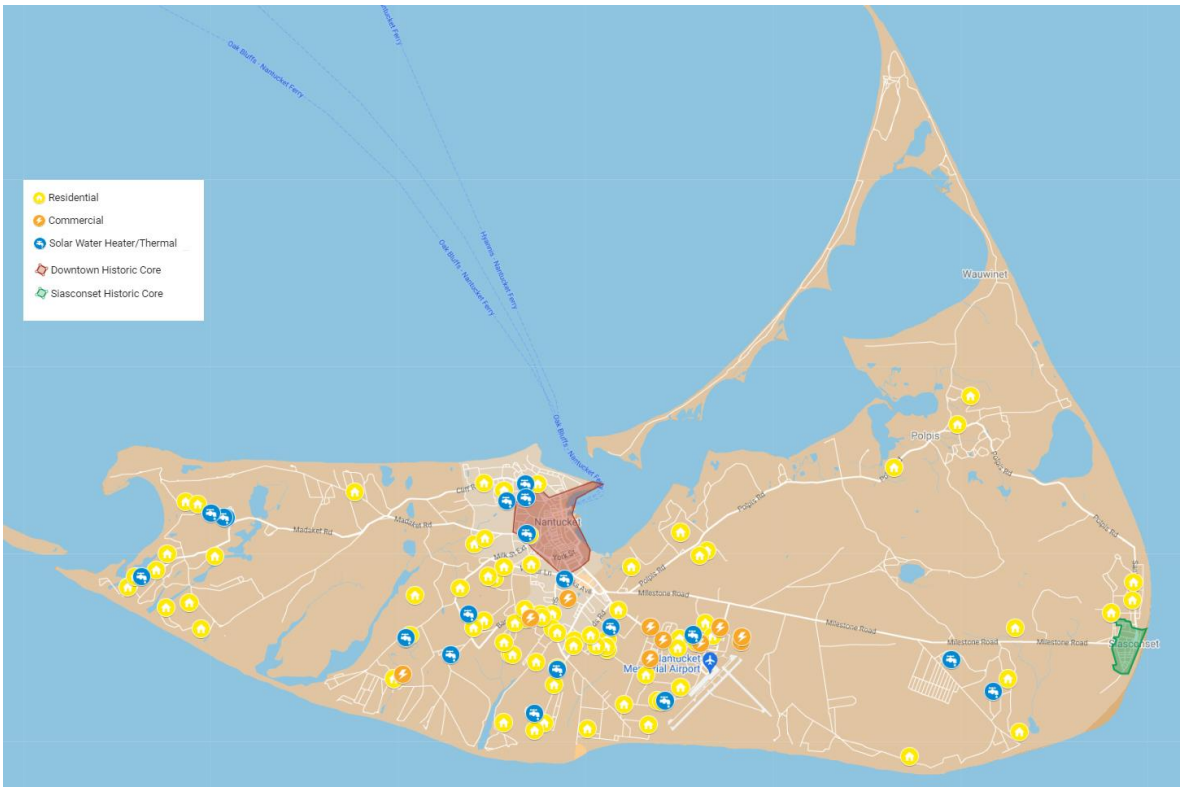


Figure 5: Locations of solar installations as shown on Prior Interactive Solar Map. The red area represents the Old Historic District, and the green area represents the ‘Sconset Old Historic District

According to the data gathered from the Nantucket Interactive Solar Map, there are currently 92 photovoltaic (PV) installations on the island. Eighty-one of these installations are privately owned residential systems and 11 are commercially owned. The residential systems are typically roof mounted rather than ground mounted arrays. The data indicate, however, that installation sites closer to the Old Historic District and ‘Sconset Old Historic District are typically roof-mounted while those further away are more frequently ground-mounted and might even include tracking installations (Nantucket Solar Map, 2022).

Current HDC Policies on Solar Technologies:

The Historic District Commission’s guidelines for protecting the historic architecture and landscape of Nantucket were originally described in detail in the document *Building with Nantucket in Mind* in 1978, with a second edition being published in 1992. The guidelines

govern the exterior details, materials, and aesthetics of all preservation, restoration, reconstruction, renovation, and construction projects on Nantucket. Despite the exhaustive nature of these guidelines, solar technologies were only mentioned briefly, and only to strongly discourage their use (Lang & Stout, 1992). At that time, solar technologies were expensive and inefficient, and the HDC emphasized energy conservation over generation. Since the drafting of the guidelines, solar technology has improved, and the efficiency of solar panels has increased to such an extent that small-scale solar installations now represent a viable avenue for home energy production across the US, including on Nantucket (Han & Mukherjee, 2014). At the same time, electricity consumption has grown so much that there is now a real need for alternative sources of electricity to bolster the energy production capability on the island. As such, in 2009 the HDC released an addendum to their existing guidelines focusing primarily on energy conservation and weatherization, with a section focused entirely on the installation of solar devices (Way, 2009). This addendum is modeled after the *Secretary of the Interior's Standards for the Treatment of Historic Properties*, which are meant to act as general guidance for all work that may be done on historic properties on all Federal, State, and local levels (U.S. National Park Service. 1995). These guidelines recognize that there are several types of solar technologies and distinguish between photovoltaic (PV) systems and solar thermal systems. For photovoltaic systems, the guidelines list the two main types of systems: standard photovoltaic panels and building-integrated photovoltaics (BIPV). As discussed in the following section, many recent BIPV designs (e.g., roof tiles) are notable for their more limited visual impact. Thermal systems are defined as any system that utilizes the heating of a liquid for an application such as water heating or climate control, but the guidelines deal mainly with systems that utilize "collectors" that must be visible as they require direct sunlight. The reasoning behind this guideline is that such systems will inherently have a major visible component to them, with the guidelines regarding placement of PV panels also being applicable to these "collectors." Finally, installations in both the Old Historic District and 'Sconset Old Historic District are subject to greater scrutiny than installations elsewhere on the island.

Despite acknowledging the existence of and differences between solar thermal and PV technologies, the guidelines make no further differentiation between them in terms of regulations. All types of installations are subject to the same regulations regarding placement and design. Since the primary concern of the HDC is the aesthetic impact of systems, the non-visible

portions of building-integrated systems are not of concern. Thus, the “collectors” of thermal systems can be treated similarly to the panels of photovoltaic systems in that they should be concealed from view. Unfortunately, there are no explicit guidelines regarding other components of the devices, such as cables or piping, although these typically are considered by the HDC during the approval process.

The current HDC guidelines treat the use of any solar technologies, both PV and thermal, as options of ‘last resort’, to be considered only after all other options to reduce energy consumption are explored. In general, the guidance encourages devices to be placed in positions that minimize the visual impact on the existing structure. It also suggests that the site be examined in its entirety to ensure that all possible options for device positioning are considered. In most circumstances the detached or standalone solar installation with the least visual impact is the preferred option. However, if a device must be placed on a structure, it is preferential to place it on something other than the main structure, such as a detached garage. It is also suggested that the reversibility of an installation be considered, meaning the ease with which a solar device can be removed, and the structure can be returned to its original form. This means that installations that have any structural impact on the building or are integral to it in any way are heavily discouraged. If a solar device must be placed on a structure, a variety of factors must be considered thoroughly to minimize the impact on the historic integrity of the construction. Given that the vast majority of roofs on Nantucket are angled in design, the guidelines include detailed recommendations on the placement of roof mounted devices. Any PV panels or other collectors should be mounted in-line with the plane of the roof, to avoid any visible protrusion of the device beyond the supporting structure, which would invariably increase the visual impact. The color and general appearance of the panels or collectors should also be carefully considered to minimize their visual distinctness from the surrounding roof surface. Where possible, roof mounted devices should also be placed on “secondary massing,” which refers to any extensions or offshoots from the main body of the structure. Further recommendations are provided in the form of examples of acceptable and unacceptable designs. One of the more helpful of such examples is one that depicts the mounting of a device on the top of a trellis structure, as shown below in Figure 6; this is an example of a creative way to minimize the visual impact of the device as it allows the panels or collectors to be mounted flat on the top of the structure such that it is only visually apparent when viewed from above. Another pair of interesting examples are

two that depict devices placed on a flat sloping roof which, as mentioned earlier, is typical for structures on Nantucket. One of these examples, shown in Figure 7, explains that panels mounted on the upper two thirds of the roof surface are encouraged over panels mounted on the bottom portion of the surface as is depicted in the other example. Lastly, it is recommended that the fact that device components have a limited lifetime should be considered, and that the replicability of the components with identical parts is important. This consideration is important as the replacement of any components with visually distinct parts is viewed as a new design and will be subject to the approval process.

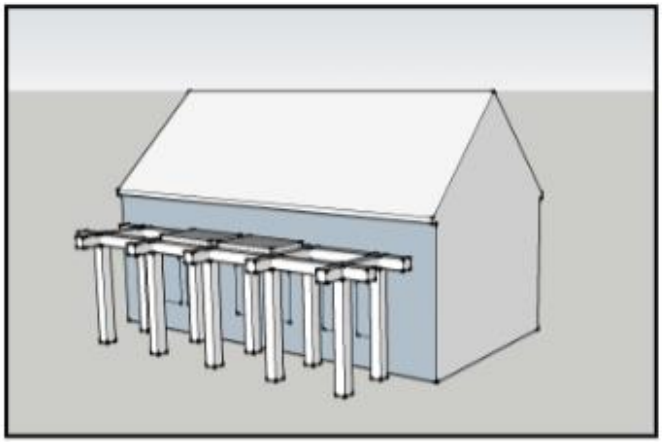


Figure 6: Example of solar panels mounted on the top of trellis (Way, 2009).

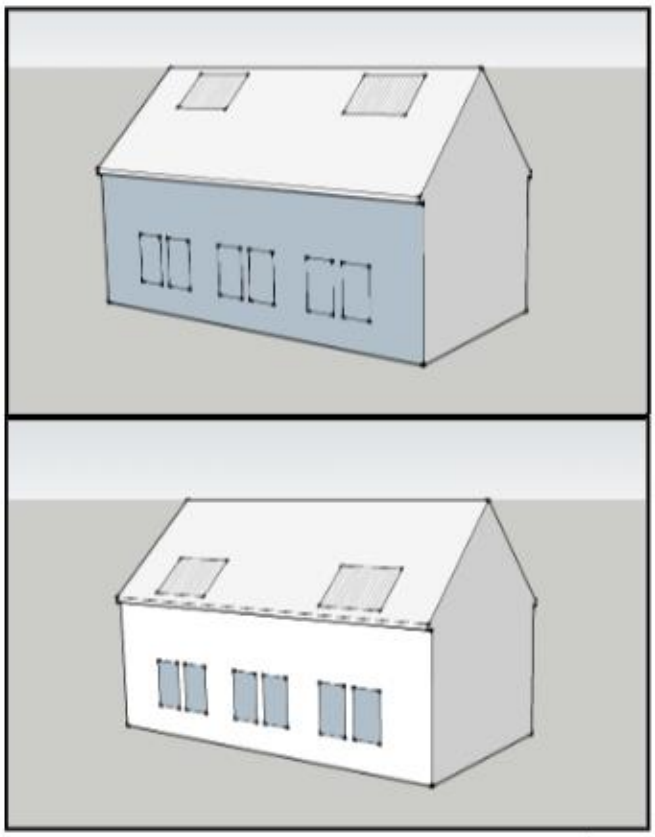


Figure 7: Guidelines encourage placement high on the roof (top) rather than near the eaves (bottom) (Way, 2009).

Attitudes towards Solar Technologies on Nantucket and the HDC Guidelines:

Previous surveys have revealed that Nantucketers are excited about solar technologies. Many want to see more widespread implementation of solar technologies on the island and are not overly concerned about visual impacts. For example, more than 80% of full-time residents and 40% of seasonal residents disagreed with the statement that "solar panels should not be visible outside of the [Old Historic Districts]" (DeSantis et al., 2021, p. 21). Many people on Nantucket have expressed concerns with the way the HDC considers applications and approvals for solar installations. For example, one recent article in The Nantucket Inquirer and Mirror (Bushard, 2021b) claims that some people believe the HDC is overly stringent in its regulation of proposed projects outside the Old Historic District and 'Sconset Historic District, particularly

regarding the placement of solar panels. Some developers and solar installers on the island have expressed concerns that the HDC does not adequately consider the location of the property in many cases, with devices positioned on the front of a remote and isolated home being treated nearly identically to installations in more densely populated residential areas. This belief is reflected in Jeff Booms' citizen article for the Annual Town Meeting, which states that the HDC "shall reasonably allow for the visible integration of solar panels and renewable energy systems" outside of the old historic districts, an article that has since been referred to the HDC to study the issue (Balling, 2022; Bushard, 2022). In fact, there have been multiple recent cases of solar application denials being brought before the Town Select Board with arguments about the HDC arbitrarily denying the applications. One of these appeals resulted in the denial being overturned (Bushard, 2021a; Bushard, 2021b). Meanwhile, members of the HDC dispute this sentiment, claiming that their goal and intention is to work with applicants to integrate solar devices in ways that would not compromise the historic integrity of the island, and that the complaints of developers are largely motivated by financial concerns rather than concerns for the future of Nantucket (Bushard, 2021b).

Innovations in Solar Technology:

Since the 2000s, solar panels have experienced great improvements in their overall efficiency and design. These improvements include the switch from traditional inverters to microinverters. This change allows each panel to individually convert the solar power into electricity rather than having the whole system tied to a single traditional inverter. The newer solar panels with microinverters also eliminate the need to designate a separate space for a traditional inverter with the associated wiring conduits, thus reducing overall visual impact of the system (Encor Solar, 2018).

Other innovations, such as low-profile panels, non-reflective glass, and all black anodized frames and mounting hardware, also help reduce the visual impact of solar PV technology. More radical innovations are allowing the integration of PV systems into the design of the building itself instead of being affixed to the roof during or after construction. Various aspects of these Building Integrated Photovoltaics (BIPVs) can be modified to blend in with building designs and materials, including their color, shape, or transparency. While some of these new designs may reduce the overall efficiency of individual cells, it may be possible to integrate these cells over

much larger surface areas of a building to offset the lower efficiencies (Martín-Chivelet et al., 2022).

One example of BIPV technology is the Tesla Solar Roof which is made using a combination of steel roofing tiles and glass solar tiles (Tesla, n.d.). These solar shingles are installed in place of typical housing shingles to create a minimally intrusive solar installation when compared to installing an array of solar panels. One of these shingles is shown in Figure 8. The shingles are designed to be about the same size as a standard three-tab asphalt shingle. While the Tesla shingles do meet some of the guidelines set in the Sustainable Preservation addendum including the rectangular design and fire resistance, the coloration and reflectiveness of the panels may be a cause for debate during the HDC approval process. Additionally, the Tesla shingles come with fixed dimensions and cannot be cut to size like wooden or asphalt shingles. As a result, flashing must be used to fill in gaps at the roof edges and valleys (Wesoff, 2020), which may be a concern to HDC. Despite these limitations, the Tesla shingles, or other solar shingles that may develop in the future, could find their place on Nantucket provided they met the HDC criteria. Along with the low profile of the shingles, the batteries incorporated in the Tesla Solar Roof system also allows for storage of energy produced during the day, allowing power to be discharged at night or during power outages (Tesla, n.d.). Using this kind of technology would be a proactive measure to defend against brownouts during the peak months of the year.

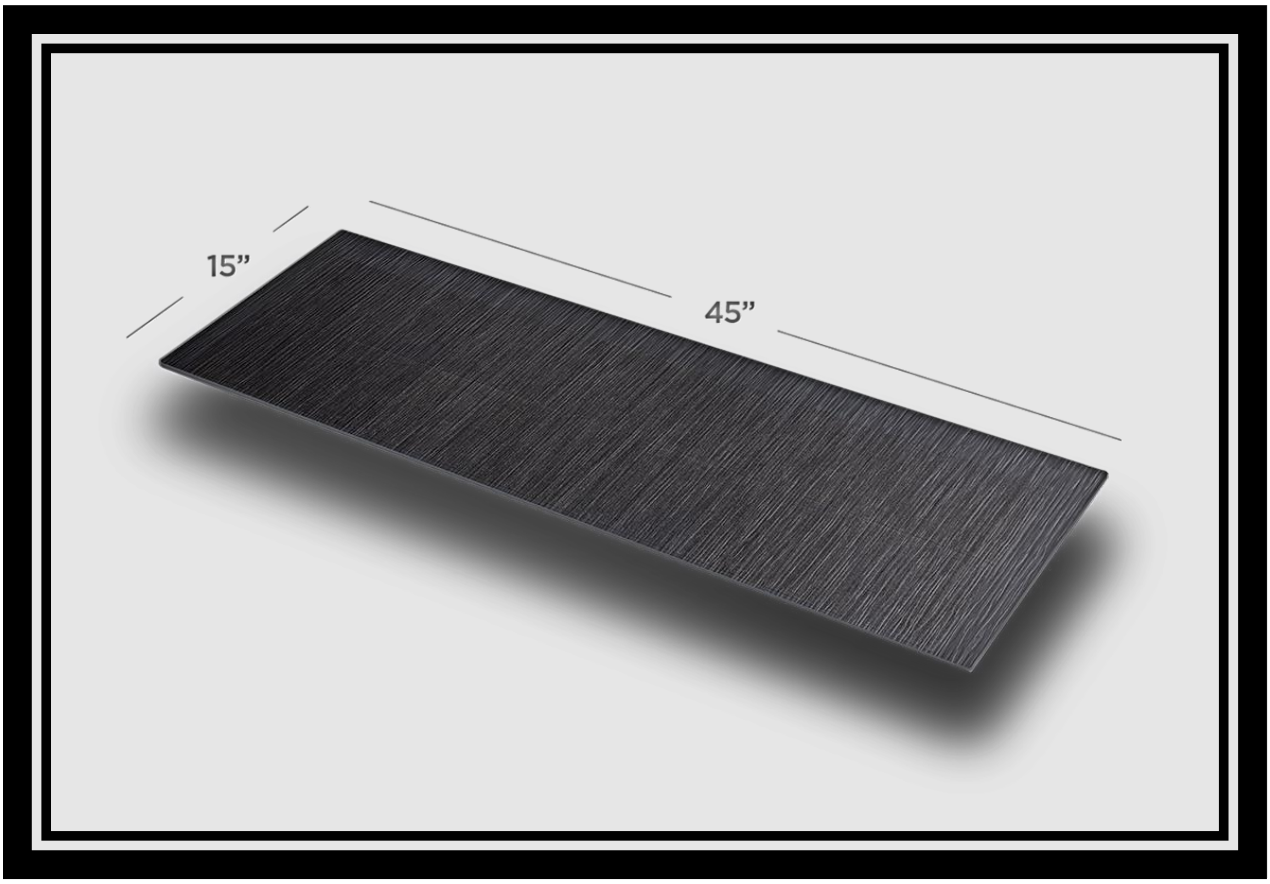


Figure 8: Image of a Tesla Solar Shingle. (Tesla, n.d.)

Tesla is not the only company making low-profile solar roofing tiles. Dyaqua is an Italian based company that creates solar roofing tiles that look like a typical terracotta roof tile (Dyaqua, n.d.). In addition, SunStyle is another company that creates BIPV technologies that replace roofing shingles in a squarer dragon-scale pattern instead of the rectangles that the Nantucket HDC prefers. These technologies are shown in Figure 9 and Figure 10 respectively. While these designs may not meet Nantucket’s current guidelines, these technologies are evolving rapidly, and new designs will be coming to market in the future that may be more attractive and acceptable in Nantucket.

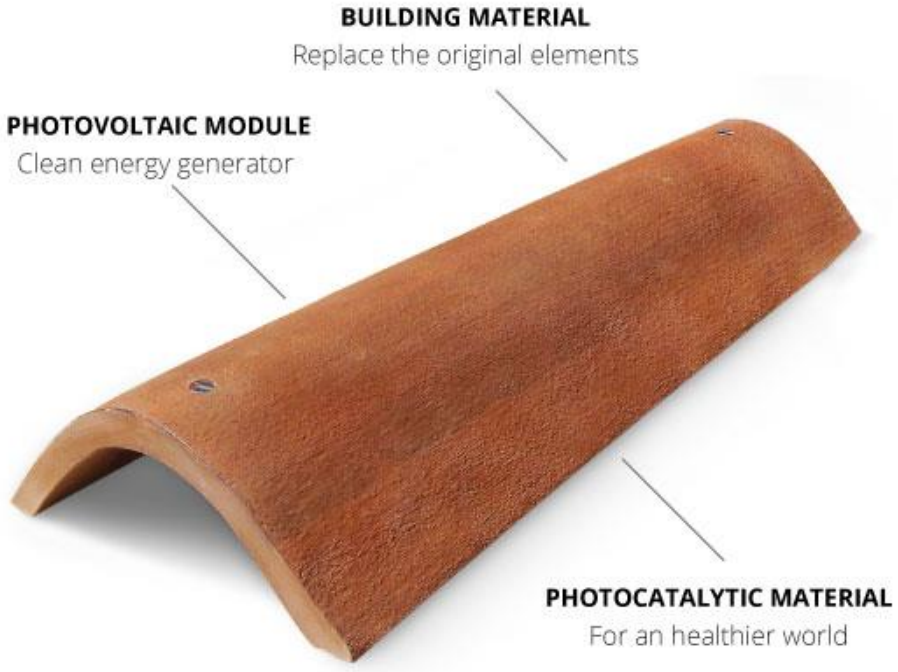


Figure 9: Image of the terracotta style Dyaqua solar tile. (Dyaqua, n.d.)

Figure 10: Images of the SunStyle solar tiles (SunStyle, n.d.)

Because these technologies are still under development and production is still ramping up, they are typically more expensive and less readily available than standard PV cells. However, given the architectural flexibility of BIPV modules, they present tantalizing opportunities for the future once they reach a marketable scale (Martín-Chivelet et al., 2022). Entities like the HDC could begin to draft guidelines that would aim to set out standards for the incorporation of such developing technologies.

These newer BIPV technologies have seen success in European countries. For example, in Norway the 18th century Strand Church in Tau was renovated in 2012 to replace the wooden shingle roof with the tiles shown in Figure 11 (SunStyle, n.d. b). More recently, an 18th century neo-gothic church was renovated in 2019 in Sarpsborg as shown in Figure 12. Using SunStyle solar roof tiles, the 2019 project was able to preserve the architectural aesthetics while also helping provide solar power to the community (SunStyle, n.d. a). In both cases, the renovations satisfied the local regulations on retrofitting historic buildings with solar technology. The guidelines and architectural styles are different in Nantucket, but these examples indicate how new technologies can be tastefully integrated in historic buildings and districts.

Figure 11: SunStyle tiles applied to Strand Church in Tau, Norway. (SunStyle, n.d. b)

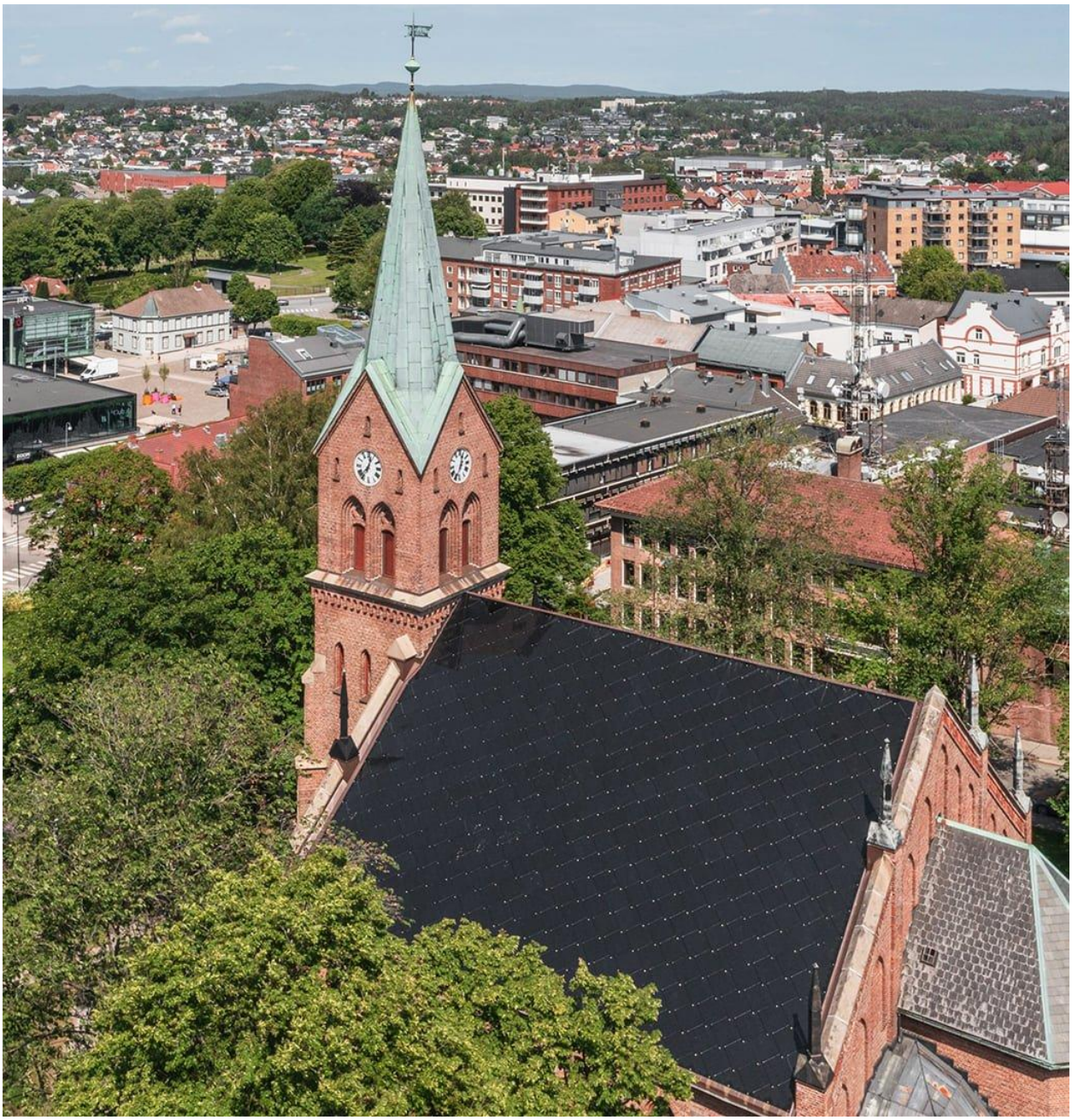


Figure 12: SunStyle tiles on a Neo-Gothic Church in Sarpsborg, Norway. (SunStyle, n.d. a)

Review of Other Historic Districts:

A historic district is an area that has been deemed to be "important in American history, culture, architecture, or archaeology" and can range in size from a small section covering a few buildings to a large area encompassing an entire town (Balzej, n.d.). The state of Massachusetts contains over 220 historic districts across 125 cities, and Rhode Island contains 18 historic districts (Historical Preservation & Heritage Commission n.d.; Preservation Massachusetts, n.d.). Historic District Commissions (HDCs) are established to protect the historic aesthetic and charm of a district. Many commissions in Massachusetts have jurisdiction over multiple historic districts. Usually, a commission protects their historic district by requiring a Certificate of Appropriateness (COA) for any sort of construction or home improvement project ranging from relatively minor renovation, such as repainting a house or replacing windows, to major construction, such as erecting a new building in the district. To obtain a COA from a commission, an applicant needs to complete an application and have a public hearing in which the commission discusses the proposed project and decides whether it is appropriate in the historic district. HDCs have a set of design guidelines to assist people in accomplishing projects without disturbing the district's aesthetic. We thoroughly reviewed the design guidelines established by 62 different HDCs in Massachusetts and Rhode Island, specifically looking at their guidance on solar technology implementation. Because many of the guidelines were created before solar technologies became relatively common, we also checked for an addendum on solar technology for each of the 62 HDCs. The results of this research are given in the Findings section.

Methods:

The overall goal of this project was to develop recommendations and resources the Town of Nantucket in collaboration with the Nantucket Preservation Trust may use to encourage and assist in the permitting of solar technologies without compromising the island's historic and architectural character. To meet this goal, our group established three main objectives:

1. Evaluate current guidance and best practices for the approval of solar technologies in historic districts.

2. Identify stakeholder opinions on Nantucket about the current guidelines and approval process for the installation of solar technologies.
3. Update and improve the functionality of the online map of solar installations maintained by the Energy Office.

We used a variety of methods to achieve these goals based on the information required. These included the analysis of Nantucket HDC and Energy Office records accessed through EnerGov to identify candidates for interviews as well as developing and sending a survey to residents. Figure 13 below shows our overall goal with their associated objectives and tasks.

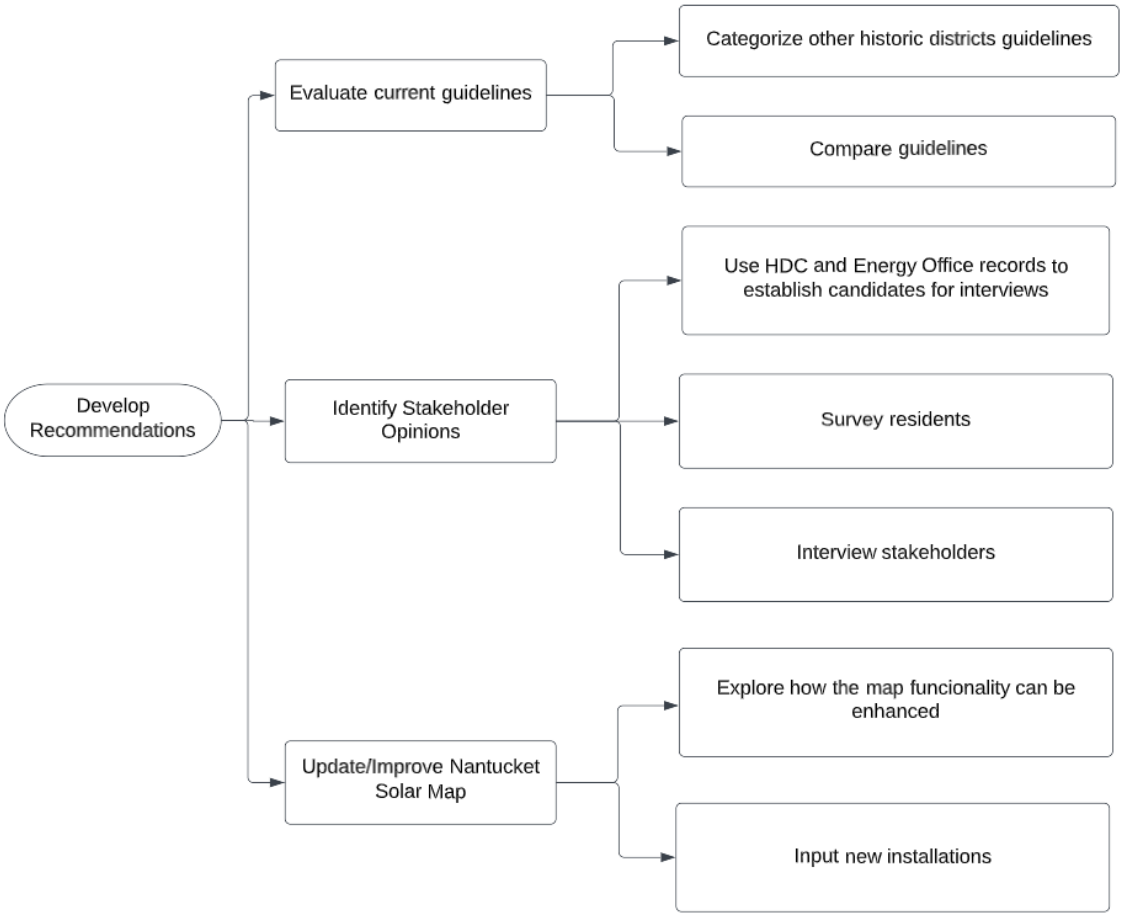


Figure 13: An organizational flow chart depicting the goal, objectives, and tasks.

Objective 1: Evaluate Current Guidance

The first objective was to assess current guidance and best practices for the approval of solar technologies in historic districts.

To achieve this objective, we created a list of 62 Historic District Commissions (HDC) located in Massachusetts and Rhode Island. To make the list, we went through each HDC's website looking for their design guidelines. Once located, we read through the guidelines looking for anything related solar technology. Unfortunately, many of the HDCs' design guidelines were made before solar home installations became common. Therefore, many of the guidelines did not have any specific solar guidance. We also checked for any addenda regarding solar technologies to ensure we reviewed all relevant guidance.

We supplemented our review of materials that are publicly available online by interviewing appropriate officials from selected historic districts (Providence, Sudbury, Salem, Northampton) to gain a better understanding of how and why the guidelines were created, how property owners and installers received the guidelines, and if the guidelines could be modified in the future to accommodate new technologies. A list of questions and the preamble are given in Appendix A. To ensure all pertinent topics were addressed, we consulted with our sponsors to refine our interview questions. We modified the questions according to the respondent's expertise, and our set of questions evolved during implementation. Since the interviewees were not in Nantucket, we conducted the interviews by Zoom or by phone. Finally, we used the insight gained from other districts to inform our recommendations.

Objective 2: Identify Stakeholder Opinions

Our second objective was to identify stakeholder opinions about the current guidelines and approval process for the installation of solar technologies on Nantucket. In addition, we collected suggestions for improvements regarding the process. We accomplished this through the completion of three main tasks:

- Reviewed previous surveys and newspaper articles to identify past public opinions on the current guidelines and approval process
- Conducted surveys of Nantucket community members, including residents who have applied for solar installations.

- Conducted interviews with selected officials and installers. We also conducted interviews with residents who have applied for solar installations in the past to discuss the installation and application process on Nantucket.

Review Public Opinion:

We reviewed previous materials, including surveys and newspaper articles, to identify current and past opinions on solar technologies as well as the HDC guidelines and approval process. This is a process that was mostly completed prior to arriving on the island using the Nantucket Inquirer and Mirror newspaper and previous surveys. Once we arrived on island, we reviewed application and permit records through the Town's record keeping and permitting software EnerGov, in order to create a general list of residents of Nantucket who applied or were applying for a solar installation. We categorized their results to identify different groups including:

- Applications approved and built or under construction
- Applications approved but not being built
- Applications denied

Survey of Residents:

We surveyed Nantucket community members, including residents who applied to the HDC for permits to install solar technology, to gauge their opinions regarding the HDC guidelines, and the application and approval process. This was accomplished through a combination of multiple-choice and open-ended responses depending on the detail required to effectively answer the question. Within the survey, we used a filtering question that asked whether the respondent had solar installed or had previously applied. If the respondent had, they were shown a subset of questions that were dedicated to discussing their experience while applying for a Certificate of Appropriateness. Using Google Forms, we developed a set of questions to effectively gather stakeholder opinions regarding the appropriateness of the HDC guidelines as well as the perceived speed, ease, and clarity of the application process. The survey preamble and list of questions are given in Appendix B. Pretesting the survey was an iterative process that began with having the other WPI students and our sponsors complete the questions

to ensure that they were clear and comprehensible, and to gauge how long it took to take the survey.

We then provided a link to the survey to our sponsors, as well as the Co-President of the Nantucket Civic League, who then sent the survey out to stakeholders on our behalf. In addition, we sent the survey to a list of residents whose contact information was available in the previous interactive solar map. We monitored the responses and asked our sponsor to send a reminder email one week after the initial mailing date.

Stakeholder Interviews:

We interviewed several residents to gather their thoughts regarding the application process and any difficulties they might have faced. We identified these individuals based on information that was provided to us by our sponsors. We then contacted these potential interviewees initially by email to ask if they were willing to complete an interview. This process continued until we were able to schedule interviews with a good mix of interviewees from each of the applicant groups that were mentioned above.

Our team generally used the same questions for each interview with slight variations based on the status of the interviewee's application. For the applicants who had their solar projects approved but have not installed them, we focused on why they had not installed their solar project. This information helped us identify trends among this group and determine potential support to help with encouraging solar implementation once an application has been approved. We developed the interview script through an iterative process in consultation with our sponsors and advisors. The set of interview questions are presented in Appendix C. We continued to update our interview script as additional questions emerged.

Interviews were conducted in person, as well as on Zoom or over the phone. We explained the nature of the research and solicited their consent through the preamble noted in Appendices C, D and E. We asked for permission to quote the interviewee by name, and we explained that we would give them the right to review any materials from the interview that we used in our report prior to publication. We used the information from the interviews to identify trends among the groups and determine common concerns about the current guidelines and approval process.

We also conducted interviews with the three main solar installers who work on Nantucket in the manner outlined above. These installers were key sources of information in our process as they are directly affected by revisions that are made to the guidelines and the application and approval processes. We discussed any trends they may have noticed regarding the solar installation process on the island to determine any perceived issues or barriers in each step. We also asked them about any issues they have seen for applications that incorporate developing technologies, such as those identified in Objective 2.

Lastly, we interviewed a key official on Nantucket to discuss whether they had considered or planned to consider changes to the current regulations. This official was a current Historic District Commission (HDC) Commissioner that uses the guidelines in their decision-making process, so they could provide us with information about any perceived problems with the current guidelines. We conducted the interview in the same manner outlined above.

Objective 3: Update and Improve Online Solar Map

Our third objective was to update and improve the functionality of the online map of solar installations maintained by the Energy Office. To achieve this objective, we identified two main tasks.

First, we explored how the functionality of the solar map could be enhanced. We met with key officials to discuss what additional information they would like to see integrated into the map. We also investigated the feasibility of integrating the solar map with the town's EnerGov database to use HDC records to update the solar map in real time. Through our investigation we determined that full automation is not currently feasible. Furthermore, we investigated whether the current mapping software (Google Maps) met the needs of the town and determined that an Arc-GIS-based map would be preferable based on our sponsor's wishes.

Our second task within this objective was to update and improve the map based on the feedback received. One of the most important factors in the decision to use an Arc-GIS-based system as opposed to Google Maps was the existence of extensive resources in Arc-GIS for Nantucket. The town's existing Arc-GIS infrastructure offered novel ways of managing the display and addition of data to the map. Chief among these was the possibility of partially automating the process of periodically updating the map with new installations and information, as the previous iteration of the map required entirely manual updates. The greater capability of

the Arc-GIS-based system has led to the creation of a new solar map system that better suits the needs of the Town of Nantucket.

Findings:

The following section discusses the major findings from the research, survey, and interviews conducted. Specifically, we evaluate and compare the current guidelines of HDCs in Massachusetts and Rhode Island. We identify concerns about the current guidelines and application process through an island wide survey as well as interviews with people that have installed solar panels on their property, solar technology installers, and an HDC official. Finally, we address the process of updating the solar installation map and the data we collected through the process.

Guidelines in other Historic Districts:

Other historic districts in Massachusetts and Rhode Island have many buildings that are similar in design and materials to most of the buildings on Nantucket. There are over 220 historic districts in Massachusetts, including Nantucket, and Rhode Island has 18 historic districts. Each historic district has its own Historic District Commission (HDC) with its own guidelines. We reviewed the guidelines of 44 of the HDCs in Massachusetts and all 18 in Rhode Island with respect to solar guidelines.

As shown in Table 1, 23 of the 62 towns with historic districts do not mention solar technology anywhere in their guidelines. Fifteen include solar panels in the equipment section of their guidelines, which also focus on satellite dishes and HVAC units. These solar guidelines tend to be minimal and typically state that the equipment should be as minimally visible as possible. The remaining 24 districts have separate standalone sections on solar guidelines, and some of the characteristics of these guidelines are summarized in Table 2. Eight of these HDCs have a very brief paragraph in their guidelines stipulating that solar panels must match the color of the roof, be as low profile as possible, and invisible from the street in front of the house. Five of the remaining 16 historic districts (Acton, Belmont, Concord, Dedham, and Northampton) have longer, more explicit guidelines that stipulate further that the solar panels cannot be permanently installed; there must be at least two feet of visible roofing around the solar panels,

the panels must be the same color as the roof, and the panels must be parallel to the roof and cannot be raised higher than 3 inches. Methuen HDC has similar guidelines that are illustrated with a couple of basic diagrams (Figure 14). The Arlington HDC's guidelines are like the previous five mentioned, but they emphasize preserving the original materials and structures, and include three links to articles from the National Trust for Historic Preservation on integrating solar into old homes. The Framingham HDC also has similar guidelines to the previous five, but they do not specify how far from the edge of the roof the panels must be. The Provincetown HDC has very similar guidelines to Framingham except Provincetown states that the solar panels must be in a rectangular pattern, without any large gaps between the panels.

Table 1: Categorizing the extent of solar panel guidelines for selected HDCs in Massachusetts and Rhode Island

State/Town	Solar Guidelines		
	None	Incorporated into the Equipment Section	Separate Section
Massachusetts:			
Acton			
Andover			
Arlington			
Back Bay			
Bedford			
Belmont			
Boxford			
Brookline			
Cambridge			
Chelmsford			
Concord			
Dedham			
Edgartown			
Framingham			
Gloucester			
Grafton			

Harvard			
Harwich			
Hull			
Hingham			
Holden			
Lenox			
Lowell			
Methuen			
Nantucket			
Newburyport			
New Bedford			
North Reading			
Northampton			
Oak Bluffs			
Old Kings Highway			
Plymouth			
Provincetown			
Reading			
Rowley			
Salem			
Sherborn			
Somerville			
Sudbury			
Topsfield			
Wayland			
Wenham			
West Tisbury			
Westport			
Rhode Island:			
Bristol			
Coventry			
Cranston			
Cumberland			
East Greenwich			

East Providence			
Gloucester			
Hopkinton			
New Shoreham (Block Island)			
Narragansett			
Newport			
North Kingstown			
North Providence			
North Smithfield			
Pawtucket			
Providence			
South Kingstown			
Warwick			

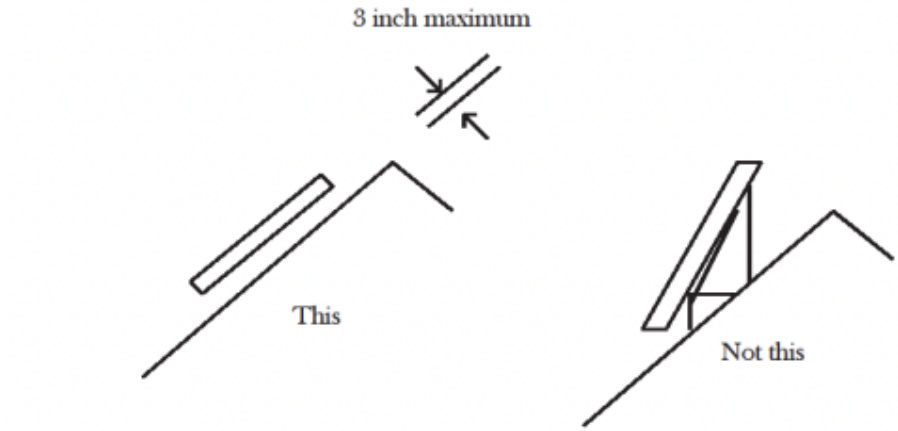


Figure 14: Diagram of solar panel orientation on a roof. (Historic District Commission, City of Methuen Massachusetts, 2016, p. 9)

The Wenham HDC's guidelines evaluate solar installations on five criteria: (1) the panels must be flush to the roof; (2) the homeowner should use the minimum number of solar panels required; (3) the color of the panels must match the existing roof; (4) the panels must be

aesthetically integrated; (5) the geometry and location of the panels relative to the roof should minimize visual impacts. Like Wenham's solar guidelines, the Sudbury HDC's solar guidelines state that panels should be flush to the roof, and the minimum number of solar panels should be used. From there, Sudbury's guidelines differ in focus. They state that the panels must be black, uniform in size, oriented in the same direction, massed into a single group, and the mounting materials should be under the panel.

The last four historic districts (Hingham, Salem, Coventry, and Providence) have more detailed and specific solar guidelines (The Nantucket solar guidelines were extensively covered in the Background section so they will not be covered here). The Hingham HDC's guidelines include an entire page explicitly addressing solar installations, including the panel location on the roof, the color and finish of the solar panels. They emphasize the use of low-profile panels and very briefly mention solar shingles. The guidelines also state that if the panels will not be visible from any public way, then the applicant would need to apply for a Certificate of Non-Applicability, which is similar to a Certificate of Appropriateness, but a public hearing is not required. The Providence and Coventry HDCs' guidelines are identical and have four pages on solar technologies that address all the previously mentioned specifications. These guidelines include one and a half pages on different ways and places to install solar panels on a house depending on the type of roof. The Salem HDC's guidelines are by far the most detailed. They have very similar requirements to those of the Hingham HDC. The guidelines also have a section of tips, such as "use dark panel modules, framing and attachments; black is usually best" (Salem Historical Commission, 2022, p.100) to help applicants effectively integrate solar technology into their home/building. There is also a checklist included in the guidelines, so applicants know what materials need to be submitted to the HDC with their application. Additionally, there are six diagrams and three photos of installations included in the guidelines. Figures 15 and 16 contain examples of the diagrams and photos found in Salem's guidelines. All of the HDC guidelines mentioned are compared in Table 2.

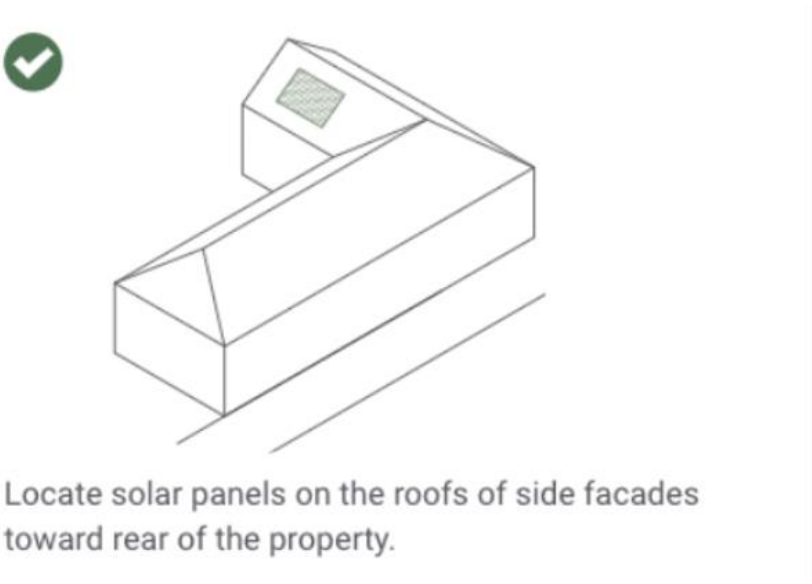


Figure 15: Diagram from the Salem HDC solar guidelines (Salem Historical Commission, 2022, p.100)

Figure 16: Photo of solar installation from the Salem HDC solar guidelines (Salem Historical Commission, 2022, p.10

Table 2: Twenty-Three Historic Districts with Detailed Solar Guidelines

State/Town	Visibility of Solar Equipment	Panel Orientation	Maximum Raise Off Roof	Distance From Edge of Roof	Panel Color	Perminance of Installation	Solar Shingles	Other Solar Technologies	Number of Diagrams and Examples
Massachusetts:									
Acton	Not Visible	Parallel to Roof	3 Inch	Not Specified	NA	Reversible	NA	NA	None
Arlington	Not Visible	Parallel to Roof	Not Specified	Not Specified	Same as Roof	Reversible	NA	Not Allowed in Windows, Walls, Siding, or Shutters	None
Belmont	Not Visible	Parallel to Roof	3 Inch	2 Feet	Same as Roof	Reversible	NA	NA	None
Concord	Not Visible	Parallel to Roof	3 Inch	2 Feet	Same as Roof	Reversible	NA	NA	None
Dedham	Not Visible	Parallel to Roof	3 Inch	2 Feet	Same as Roof	Reversible	NA	NA	None
Framingham	Not Visible	Parallel to Roof	3 Inch	Not Specified	Same as Roof	Reversible	NA	NA	None
Edgartown	Not Visible	Parallel to Roof	Not Specified	NA	Same as Roof	NA	NA	NA	None
Harvard	Not Visible	Parallel to Roof	3 Inch	2 Feet	Same as Roof	Reversible	NA	NA	2 Examples
Harwich	Not Visible	NA	NA	NA	NA	NA	NA	NA	None
Hingham	Not Visible	Parallel to Roof	NA	NA	Same as Roof	NA	Low/Non Reflective	NA	None
Methuen	Not Visible	Parallel to Roof	3 Inch	2 Feet	Same as Roof	Reversible	NA	NA	2 Diagrams
Nantucket	Not Visible	Parallel to Roof	NA	NA	NA	Reversible	NA	Acknowledges Solar Thermal Technology	7 Diagrams
Newburyport	Not Visible	Parallel to Roof	NA	2 Feet	Same as Roof	Reversible	NA	NA	None
New Bedford	Not Visible	NA	NA	NA	NA	NA	NA	NA	None
Northampton	Not Visible	Parallel to Roof	3 Inch	2 Feet	Same as Roof	Reversible	NA	NA	None
Old Kings Highway	Not Visible	Parallel to Roof	NA	NA	NA	Reversible	NA	NA	None
Plymouth	Not Visible	Parallel to Roof	NA	NA	NA	NA	NA	NA	None
Provincetown	Not Visible	Low Profile	3 Inch	Not Specified	Same as Roof	NA	NA	NA	None
Salem	Not Visible	Parallel to Roof	Not Specified	NA	Same as Roof	Reversible	Low or Non Reflective	NA	None
Sudbury	Not Visible	Parallel to Roof	NA	NA	Black	NA	NA	NA	None
Wenham	Not Visible	Parallel to Roof	NA	NA	Same as Roof	NA	NA	NA	None
West Tisbury	Not Visible	NA	NA	NA	NA	Reversible	NA	NA	None
Rhode Island:									
Providence	Not Visible	Parallel to Roof	NA	NA	Same as Roof	Reversible	NA	NA	None

*Not Specified means a word or phrase such as “flush” or “not to the edge” was used instead of giving a specific height or distance.

Findings from Interviews of Other HDCs:

To gain a better understanding of how Historic District Commissions create guidelines on solar panels and provide guidance to the homeowners in the historic districts, we attempted to contact all the HDCs mentioned in Table 2. Unfortunately, we were only able to conduct interviews with four of the HDCs (excluding the Nantucket HDC). We spoke to representatives of the Northampton, Providence, Salem, and Sudbury HDCs, and our key findings are given below.

All four of the HDCs' solar guidelines were created in response to increased demand for panels. The Salem HDC updated their solar guidelines in 2022, funded in part by a Survey & Planning Grant from the Massachusetts Historical Commission. The Northampton updated their solar guidelines around 6 years ago. The Providence HDC updated their guidelines at least 10 years ago. Unfortunately, the representative from the Sudbury HDC was unable to inform us on when their guidelines were created. Additionally, when Salem updated their solar guidelines, they did so by hiring a consultant to overhaul their guidelines to reflect the current realities of solar.

All four representatives indicated that the HDCs did little to educate the public directly about the solar technologies and installations. Rather the guidelines are posted for the public to access as needed, although finding them on the HDC websites is not always easy (access to the materials typically requires between 2 and 5 clicks from the homepage). The four representatives indicated it is the installers who typically inform the residents of the HDCs' guidelines and complete the application process. The representatives stated, however, that they are always looking for better ways to inform the public.

Each HDC we spoke to indicated that there were people with concerns about the guidelines of their district. According to one HDC official, people have expressed concern with the expensive adjustments that their HDC has requested homeowners to make in order to reduce the visual impact of panels from a public way. Another HDC official stated they have received pushback from the public after some of the solar applications were denied.

All four of the HDCs supplied us with rough estimates of the number of applications that they have processed within the last three years. The HDCs in Sudbury, Salem, and Northampton had between three and ten applications before them over the past three years and each has denied

one or two applications. The Providence HDC had far more solar applications. They had between 30 and 50 solar applications, 1 denial, and between 3 and 5 withdrawals over the past three years.

The HDCs had very similar approval processes. All of them require the applicant (usually an installer representing a resident) to give them information regarding the specifics of the proposed installation and how technology is being implemented. The commission will hold a public hearing to decide whether to approve, approve with conditions, or deny the application. If the application is approved with conditions, the applicant is usually asked to reduce the number of solar panels, to change the location of solar panels, or to hide the panels with some form of screening. If an application is denied, the applicant can appeal the decision. In the case of an appeal, the commission board would hold an in-depth evaluation of the application and decide whether to uphold the denial or have the HDC reprocess the application.

Each of the four HDCs stated that their guidelines are open to further change as technology develops. In fact, the representative from providence informed us that they are currently having discussions around revising their guidelines. We also discussed the possibility of solar shingles such as the Tesla Solar Roof being used as an alternative to solar panels. The HDCs that solar shingles are generally less obtrusive when compared to traditional panels. In particular, Sudbury and Providence stated that they preferred the look of the Tesla Solar Roof rather than traditional panels. Salem also expressed an interest in reevaluating the Tesla Solar Roof now that they are more fully developed.

Stakeholder Opinions:

Within this section, we report on the findings from our survey and interviews with residents, installers, and a Nantucket HDC representative.

Perspective of Residents:

The survey that we sent out yielded a total of 208 responses. Some respondents chose to leave some questions unanswered—most of the questions that were a part of the general portion of the survey received around 195-205 responses. Based on the survey responses, most of the respondents were strongly in favor of preserving the historic buildings and streetscapes of Nantucket while also being strongly in favor of more solar installations on the island. As shown in Figure 17, of the 202 responses to the question regarding the need for more solar installations

on the island, 79% of respondents agreed that more installations were needed. Of these, 52% were strongly in favor of this idea. Similarly, as shown in Figure 18, with the question regarding preservation of Nantucket's historic streetscapes and buildings, of 203 responses, 93% agreed that preservation was important, of which 69% strongly agreed.

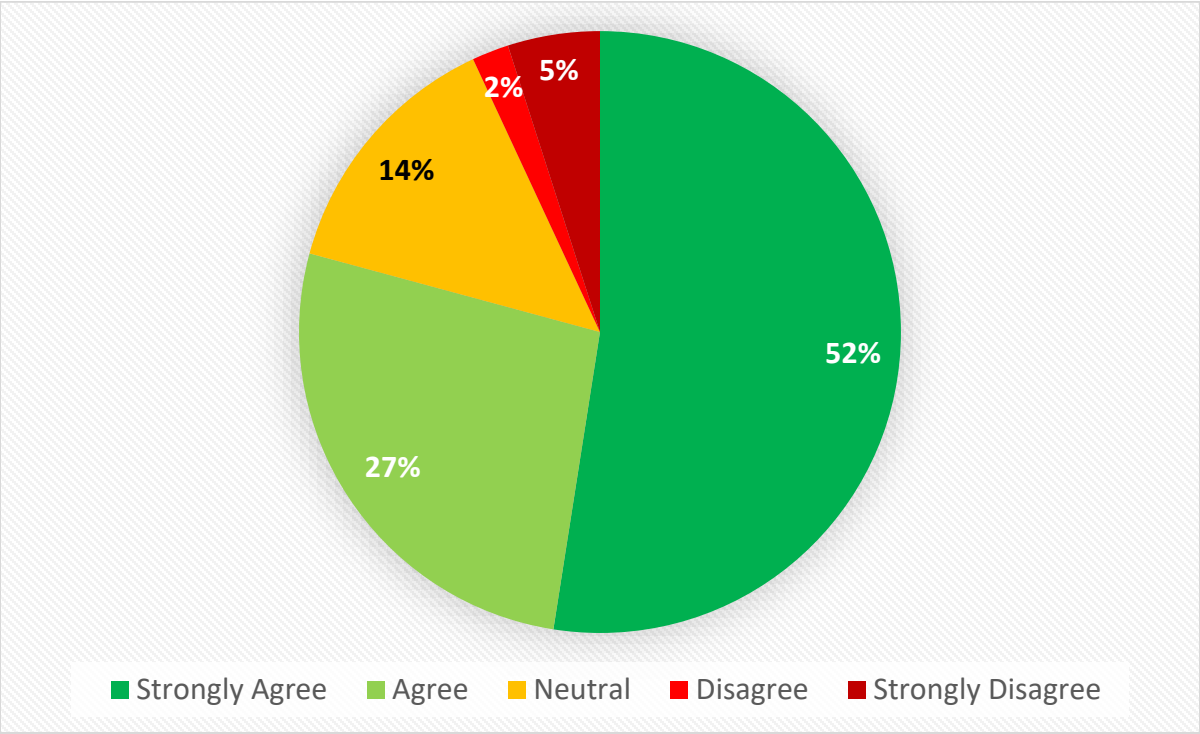


Figure 17: Responses to the statement "There should be more solar installations on Nantucket" N=202.

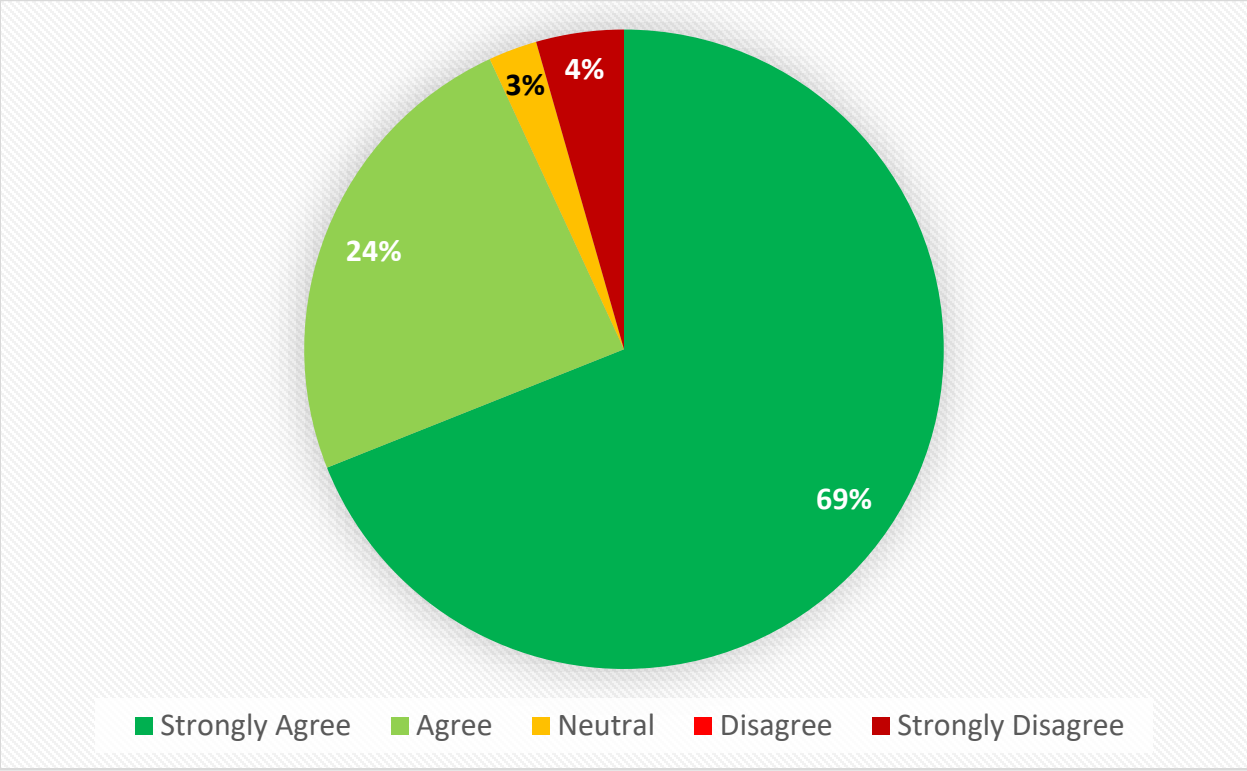


Figure 18: Responses to the statement “The preservation of Nantucket's historic buildings, streetscapes, and aesthetic is important to me.” N=203.

In terms of attitudes towards visibility of solar panels within the Old Historic District and ‘Sconset Old Historic District, opinions were largely split evenly. For both the OHD and SOHD, approximately 45-46% of respondents agreed that panels should not be visible from public ways in either of the historic districts. On the contrary, approximately 38-39.5% of respondents disagreed and felt that panels should be allowed to be visible from public ways in those same old historic districts as shown in Figure 19 and Figure 20.

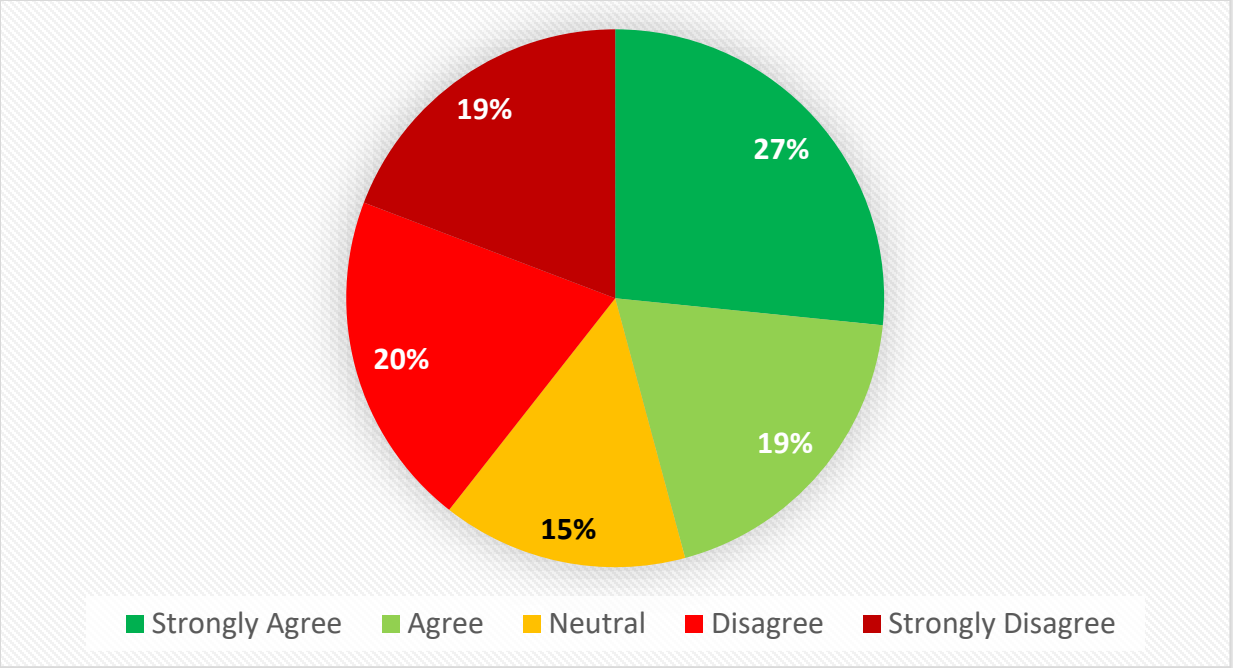


Figure 19: Responses to the statement "Solar panels should **NOT** be visible from public ways in the historic downtown." N=203.

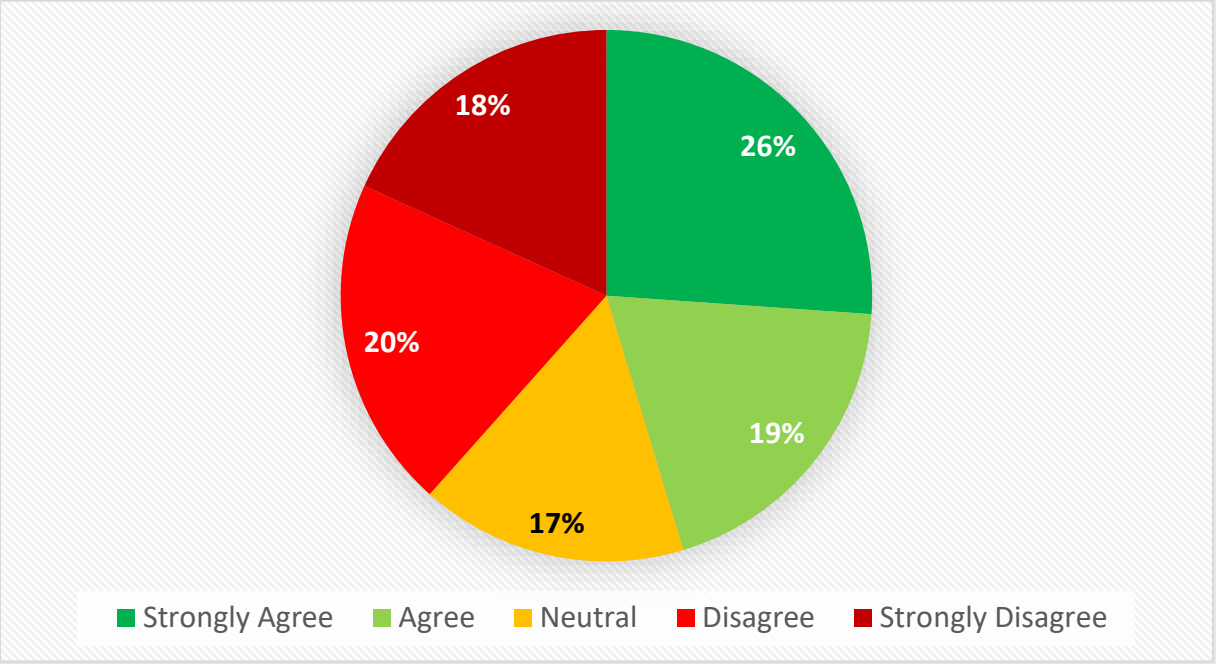


Figure 20: Responses to the statement “Solar panels should **NOT** be visible from public ways in the ‘Sconset historic districts.” N=203

The survey results also showed that 63% of the respondents believed that the current guidelines including: minimizing visibility from a public way and avoiding panels being placed on primary structures, are not solar friendly enough (Figure 21). However, only about 19% of the survey respondents were residents who had applied for solar in the past. Among the respondents who had applied, the open-ended responses regarding their interactions with the HDC were mixed. Some respondents had rather poor experiences trying to apply for a solar installation while others had no problems at all. Notably, some of the respondents who said they did not encounter problems clarified that their project site was not visible from a public street or was outside of the old historic districts.

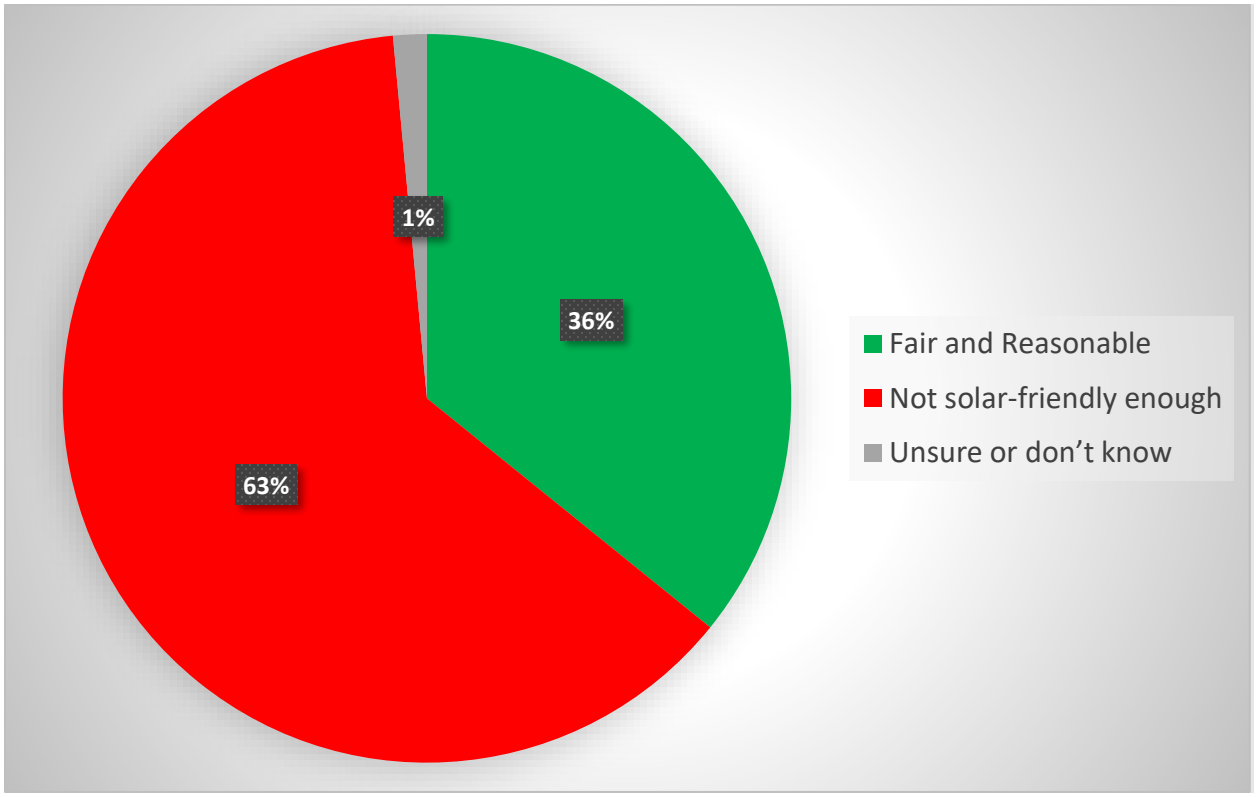


Figure 21: Responses to the question "The current HDC guidelines regarding solar installations have resulted in conditions such as solar panel color needing to match roof color, avoiding placement on a primary structure, and minimizing visibility from a public way. Do you believe these guidelines are:" N=201.

Additionally, we had a subset of questions that were dedicated to residents who had previously applied for a Certificate of Appropriateness. This section yielded 39 respondents.

Within this section, more detailed questions regarding the specifics of the respondent's application were given to gauge their experience with the HDC. We found that of the 39 respondents, 92.3% said that their installation was handled mostly or completely by the solar installer. The responses also showed that of 38 respondents, 73.7% were approved and another 21.1% were approved with conditions, while only 2.6% were denied or withdrawn. Of those who were approved with conditions, we found that approximately half of the conditions were related to the panels being visible from a public way.

Of the 38 respondents, 89.5% had completed and operational installations with another 7.9% in progress. Only one respondent answered that the installation was not proceeding and stated in a follow-up question that it would have been too costly, and the benefits would have been of little value. Ultimately, we found that the applicants had a range of different experiences with the HDC during the application process. Some respondents claimed that the process was irritating or arduous, others said they had no idea due to their installer handling the process for them, and other respondents had an easy time due to the orientation of their property in relation to the public way.

For a more in depth look at the results gained from our survey, please view the Excel spread sheet that is listed on Nantucket Project Center — Worcester Polytechnic Institute (wpi.edu).

In addition to the survey, we reached out to 24 Nantucket residents who had previously applied for a Certificate of Appropriateness. Of the 24 residents, we only interviewed six. During the interviews, we largely reconfirmed the sentiments and trends that were identified when analyzing our survey data. When asked about the fairness of the current HDC guidelines, the interviewees generally thought that the current solar guidelines are not solar friendly enough and need to be modified in some way. Another common theme we identified was that many of the participants stated that they were partially or completely unfamiliar with the application process as it was handled almost entirely or entirely by their selected solar installer.

The opinions of the residents we interviewed differed with respect to the challenges faced during the approval process. This difference in perceptions largely depended on the variation in installation parameters and building site specifications. We found that residents who have a property on the southern side of a road and have a south facing roof generally have an easier time during the application process. In contrast, residents who live on the northern side of the road

often have a much more difficult process given that their south facing roof is generally pointed towards public ways.

There was greater consensus among our six interviewees regarding potential methods to improve the solar application and approval process. In general, all respondents felt that items such as a solar permitting checklist or a "guide to going solar" webpage on the town's website would be useful both before and during the application process. This sentiment is also reaffirmed in the survey responses which showed 69.7% of respondents felt the checklist would be helpful, and 76.3% of respondents felt the webpage would be helpful.

Perspectives of Installers:

We interviewed the three main solar technology installation companies that heavily service the island: ACK Smart Energy, Cotuit Solar, and Sunwind LLC. During our interviews all three installers cited significant changes in solar technology since they started installing solar on Nantucket. One common change that was noted is that solar panels have become more efficient, with panels almost doubling in output for the same size panel according to Tim Holmes from Sunwind. Additionally, on the topic of changing technology, Tim Carruthers from ACK Smart explained that he believes solar technology is currently at the same point as computers were in the 1980s. This is important to note because the field of solar technology is constantly evolving, and it is important to keep an open mind on how new technologies could potentially be integrated into solar guidance on Nantucket.

During our interviews, all three installers noted an increase in demand for solar installations in recent years. One installer told us that demand for solar has been growing steadily for the last five years, with a recent uptick in the last six to twelve months. We also discussed the town's solar rebate, which grants up to $6,000 depending on the size of installation. All three installers agree that the rebate helps increase demand for solar on the island. Because of the reduced payback period and increased return on investment, the rebate provides a tipping point for some customers who are interested in solar but may not be able to afford an installation without the rebate. Other factors that were mentioned in relation to increased demand were high electricity costs, residents wanting to forestall the need for a third undersea cable, and residents seeing impacts of climate change every day (and thus, wanting to help fight it).

Furthermore, all three installers mentioned how they screen potential clients and will not move forward with projects which they believe do not meet HDC design guidance. This is because all three installers try to submit only solar applications to the HDC that they believe are approvable. All three installers told us that visibility is the main factor that inhibits approval—if an installation is visible from a public way, the HDC is unlikely to issue a COA without significant screening measures. This requirement is even more stringent inside the Old Historic Districts, where panels that can be seen at all from a public way are extremely unlikely to be approved. One installer also noted that the visibility of panels automatically rules out most houses with the southern roof plane that faces a public way as candidates for solar. A southern roof plane is by far the most effective location for solar panels. Installing panels on a roof with a different aspect to limit visibility is typically not cost effective given the reduction in energy production.

We also discussed the differences between ground-mounted and roof-mounted solar systems with the installers. We learned that 70-90% of solar systems being installed are roof mounted, depending on the installer. One installer explained that ground-mounted solar systems are typically approved more easily because they are inherently less visible than roof-mounted systems. Unfortunately, ground-mounted arrays are not a viable solution for everyone, especially since ground mounts cost about 15% more than a comparable roof-mounted system. Since most clients are interested in solar for economic reasons, the more expensive ground-mounted systems are less desirable. Furthermore, in our discussion on this topic, one installer noted that ground-mounted systems are limited to seasonal residents with larger properties, as most year-round residents have smaller houses with limited space for a ground-mounted array.

Although all three installers try to submit applications for solar projects they believe will be approved, some projects are either approved with conditions or sent back for revisions. When an application is approved with conditions, the project can move forward without further trips to the HDC if those conditions are met. However, on some projects the conditions may not be financially feasible for the client and thus the project stops without being completed. In contrast, when a project is sent back for revisions, the installer must modify the project proposal and resubmit it to the HDC where it will usually either be approved or sent back for further revisions. One of the installers we spoke with told us that they would only do one revision to an application because further revisions are not worth it financially for the installer or the client due to the labor

that goes into revising a solar application. The other two installers did not limit the number of revisions they were willing to do, however one installer said that by the third revision most clients have abandoned the project. Additionally, one installer told us they felt that the HDC will send a project back for revisions when they know the revisions are infeasible instead of just denying the project. Furthermore, another installer told us that sometimes they will ask the HDC to either approve or deny a project, but the HDC will still send the project back for further revisions.

Finally, we discussed the solar application process with the installers. We learned that with each application the installer needs to file multiple paper copies of the application, which is about eight to nine pages long. One installer also told us that on top of the paper copies of the application, the installers must also file a copy of the application electronically. They also told us that due to the applications being on paper, it is sometimes difficult to know the status of a project. One installer also told us that the typical time from contract to installation was about six months with the HDC application and approval process taking the first two months of that time.

HDC Perspective:

We interviewed one member of the Nantucket HDC who said accommodating solar technologies while preserving the historic character of the island presents an interesting challenge. The official explained that members were generally in favor of alternative energy sources and would like to avoid the installation of a third undersea cable. They added that the town itself also harbors a large desire for alternative energy sources, elaborating that it is very meaningful to residents when they can place an installation on their house, given that it helps to reduce the cost of living on the island.

Additionally, during our discussion, the official explained that the HDC believes their current guidelines are still appropriate and adequately consider the changing technologies. This consideration of changing technologies extended to BIPV's like solar shingles. However, the official explained that current solar shingles still have a reflective surface and therefore look more metallic than shingled, but they are hoping that solar shingles will soon look very comparable to typical wooden shingles. The HDC member also stated that the Commission is willing to review any new BIPV's that come to market and would not be opposed to an alternative that they determined to be viable in terms of their visual impact when installed.

This official also explained that they are in favor of building new structures while considering how solar installations could be implemented on these new structures. This included manipulating the placement of the structure to face solar mounting locations away from the public way. This differs from existing structures since applicants and installers must make the most of the building placement that they have. The official clarified that the HDC does not have jurisdiction over what other property owners are able to see from their property. When asked about how properties that are overlooked by higher elevations are treated, the official explained the 'visibility from a public way' standard is more aimed at closer and more impactful views rather than looking at a vista from a longer distance away. This would mean that looking across the street at an installation on the front of a building would not be permissible, while looking down at Brant Point from Cobblestone Hill would not disqualify an installation from being permitted.

Additionally, the HDC member explained that the color of roof shingles should be considered during replacement or construction to reduce the visual impact of the panels and any discontinuity with the surrounding roof area. This mindset also extended to utilizing 3-D modeling software or the creation of physical frameworks to test the visibility of a solar installation from street level. With this mindful construction mentality, the official also elaborated that they have been in favor of larger solar arrays that are managed on a town level as compared to residential installations. Finally, during our interview, the official also explained that while the Commission still uses paper plans and permitting documents, these are superfluous given current technology. They discussed how a transition to more digital submission has already occurred--plans are now presented as digital presentations, especially after the pandemic forced a transition to remote presentations.

Updating and Improving the Solar Map:

We had two goals in updating and improving the existing solar map: First, we had to recreate the current functionality of the existing solar map that uses Google Maps in an Arc-GIS-based layer; Second, we wanted to automate the process of updating the map directly from town records to minimize data entry in the future.

To begin, the functionality offered by the Arc-GIS Pro software seemed to be more than sufficient for the purpose of recreating the existing solar map. By working with the town's GIS

Coordinator, we developed a method for creating the solar-map layer from a table or spreadsheet of various solar installations. The original map utilized street addresses to provide location to the various entries, but there are two main reasons that this was not possible for the new layer. First, Google Maps provides a base layer containing street layouts and addresses by default, but Arc-GIS does not. Second, some portions of Nantucket do not actually have street addresses in the traditional sense, particularly the island of Tuckernuck located off the western coast of Nantucket. To circumvent these difficulties, we had to find a new method of providing location data for entries. Manual placement of the locations of various entries was not possible due to the automation portion of the requirements. Therefore, we had to utilize data available in the base layer of the Nantucket's GIS system. More specifically, we used the layer containing the shapes of all the land parcels on Nantucket, as well as their location, which was provided to us by the town's GIS Coordinator. This shape layer can be thought of as, in essence, a jigsaw puzzle of the map of the island, with each piece being an individual parcel of land, and each parcel has a set of information (attributes) assigned to it.

Records from the EnerGov database were the primary source of information for new entries, with new installations being identified via cross-referencing HDC, electrical, and building permits. This process was adopted because the presence of completed electrical and building permits is almost always an indication of a solar installation being completed. Permit applications on EnerGov always include the parcel number of the property in question, which is a unique identifier for all land parcels on Nantucket. The provided parcel shape layer includes this identifier, so it is possible to match solar installation entries to individual shapes in the parcel layer. By matching installation entries to parcel shapes in this way, the parcel shape layer could be used to provide location data for these entries. The shape layer was then converted to a marker layer, a process that basically just places a marker on a point inside of the corresponding shape. We tested this method with a data set containing all existing solar installations on Nantucket. This data set was created from data sheets of solar-related permits that were provided to us by one of the town's IT specialists. We used a MATLAB script to identify likely installations by cross referencing the sheets of HDC COAs, electrical permits, and building permits. We then combined existing entries from the old solar map with new installations identified using the method outlined above and filtered for duplicates. The sample map created with the resulting

data can be seen in Figure 22. Additionally, the number of installations per year is shown in Figure 23.

Figure 22: Marker layer created in Arc-GIS Pro with data set of all current solar installations on Nantucket, each orange marker denoting the location of an installation.

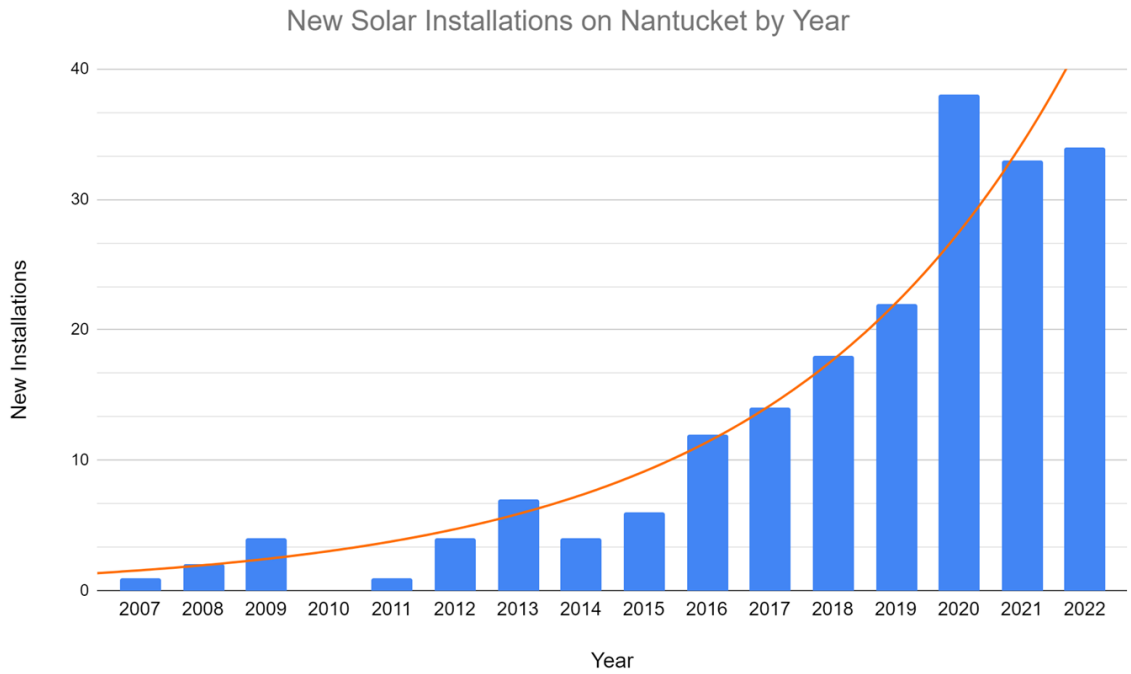


Figure 23: New solar installations per year on Nantucket.

By consulting Nantucket's GIS Coordinator, we learned that fully automating the update process for the solar map layer would not be feasible, primarily due to limitations in how the town's GIS systems are managed. Specifically, the updating of the marker layer with any new entries could not occur automatically and would require manual entry of the new updated layer by appending the installation table with location data pulled from the parcel layer. The actual process of creating the table of installations and updating it with new entries pulled from EnerGov could still be semi-automated with a data-collection script being run periodically. To accomplish this goal, we worked with one of the town's IT Specialists to determine the best way to pull data from the EnerGov database and format it into a table to be added to the map layer.

We were provided with access to the backend of the EnerGov system, which allowed us to utilize the advanced search feature to create and save custom sets of search criteria. We created three such criteria sets, one for searching for solar related HDC Certificates of Approval, one for searching for solar related building permits, and one for searching for solar related electrical permits. These criteria were repeatedly revised to provide better and more complete results, with particular focus on tightening the criteria since the earlier sample data contained quite a few false positives regarding installations that did not actually exist being marked. This issue was a result of peculiarities with how different records were entered into EnerGov, and each of the three searches required multiple revisions to achieve satisfactory results. A detailed explanation on how the EnerGov searches worked and were used for the update process is available in Appendix F.

The results of the searches were saved as .csv files using the "export search" feature in EnerGov. A Python script was then used to identify solar installations from said search results; this was done by cross-referencing the different permit types in a method similar to that which was used in the MATLAB script that had been written for sorting through the initial sample data earlier. The Python script took any identified installations and added them to an existing table of previously identified installations if there were no matching installations already in the table. In the case of there being an already identified installation that matched one that had just been identified, preference would be given to the already existing entry. This was necessary due to the need to allow for and favor any manual revisions to the data. The resulting table of installations could then be sent to the town's GIS coordinator, and the solar layer would be recreated with the most recent data.

The question regarding where the new interactive solar map layer would be available was the next thing we explored. There were already two locations the town had for Arc-GIS based resources, the Map integrated into the EnerGov site and the Nantucket GIS site using MapGEO. The MapGEO site was determined to be the better option for a few key reasons. The first was that the majority of Nantucket's other GIS resources and tools were available on the site. This meant that the solar layer would be accessible alongside of and easy to use in conjunction with all the other layers and assets made for the town. MapGEO also uses a far cleaner and modern user interface than that which is standardly available via Arc-GIS. This would greatly enhance the user experience as the EnerGov integrated map's interface is rather outdated by comparison.

Conclusions and Recommendations:

Based on the findings from our survey and interviews we draw the following 4 conclusions and 7 recommendations regarding the ways in which the Town of Nantucket handles the installation of solar technologies.

Conclusion 1: Guidelines Outside the Two Old Historic Districts

We conclude that most respondents believe that there should be more solar installations on Nantucket. Based on the survey results, of 202 respondents, 51.9% strongly agreed and another 26.7% agreed that the island needs more solar installations. Additionally, most respondents to the survey also stated that the preservation of Nantucket's historic streetscapes and buildings is important to them, thus indicating that the decisions were made with preservation of Nantucket in mind. Of the 203 respondents to the question, 68.9% strongly agreed and another 23.6% agreed that preservation was important to them.

Based on our interviews and surveys, we conclude that 61% of the respondents (n=203) believe visibility from a public way should *not* disqualify a solar installation if it is outside the old historic districts of town and 'Sconset, as shown in Figure 24.

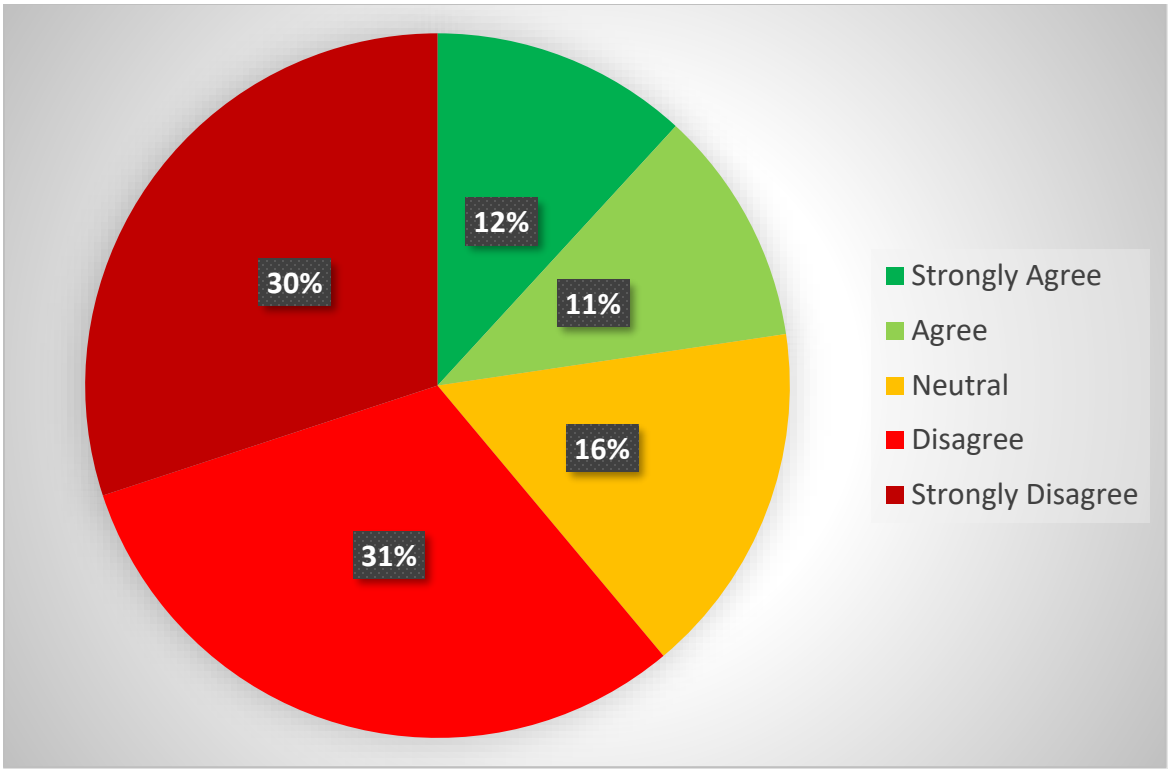


Figure 24: Responses to the statement "Solar panels should **NOT** be visible from public ways outside of the downtown and 'Sconset historic districts."

On the other hand, feelings regarding the visibility of solar installations within the OHD and SOHD were quite split. Based on our survey results, 45.8% of respondents believe that solar panels should not be visible from public ways in the Old Historic District. However, for the same region, 39.4% of respondents believed that installations should be allowed to be seen from public ways. The remaining 14.8% were neutral. Similarly, for the 'Sconset Old Historic District, 45.3% of respondent believe that solar panels should not be visible from public ways, with 38.4% disagreeing and the remaining respondents being neutral.

Recommendation 1.1: Relaxing Conditions

We recommend that the HDC consider relaxing the conditions for approval that are placed on applications for COA's outside of the Old Historic District and 'Sconset Old Historic District. This would allow the OHD and SOHD to retain the same level of scrutiny and preserve their historic integrity. Doing so would allow more residents outside of these districts the

opportunity to successfully apply for a COA, while not compromising Nantucket's unique aesthetic.

Recommendation 1.2: Third-Party Guideline Review

Additionally, we recommend that the current guidelines be reviewed by a professional third-party. To exemplify this, in 2022 the town of Salem had a third party conduct a professional review of the town's solar guidelines using a Survey & Planning Grant from the Massachusetts Historical Commission. We recommend that the Town of Nantucket pursue this grant to fund a better assessment of the state of the current guidelines.

Conclusion 2: Streamlining Process

Both Nantucket installers and the HDC Commissioner that we interviewed indicated that they did not find the process of applying for a Certificate of Appropriateness to be burdensome. However, both had suggestions for improvements to the application process. The first improvement would be updating the graphics showing preferred panel locations to reflect actual installations that have been approved on the island. This goal could largely be accomplished by using photos of approved installations. Also, eliminating the requirement that applications and supporting documents be submitted on paper could lead to an easier and more sustainable process.

Recommendation 2.1: Reducing Paper Requirement

We recommend that the HDC reduce number of required copies of an application that need to be filed on paper to help facilitate a more complete transition to an online format. This would remove the need for redundant copies of the application. Additionally, we recommend that the Town continue to transition to a fully online format for solar permitting applications.

Recommendation 2.2: Updating Previous Graphics

In conjunction with the previous recommendation, we recommend updating the *Sustainable Preservation* addendum's graphics to reflect the HDC's preferred installation designs more accurately. Doing so could help prospective applicants to gauge what are and are

not acceptable installations per HDC guidelines. The Salem Historical Commission has several good diagrams and examples that should be used as a reference for how to effectively implement images and diagrams in solar guidelines.

Conclusion 3: Educational Resources

Based on our interviews and survey, we conclude that some respondents believe that there is currently a lack of information and awareness regarding the application and approval processes. Our survey of 39 applicants and interviews with six residents indicated that many people who have been through the application and installation process are unaware of the HDC guidelines and rely strongly on the installer to recommend installation options and guide them through the process. Many other people who have not been through the application process and generally lack awareness of the guidelines nevertheless believe that the HDC guidelines are not friendly enough to solar. Many survey respondents and interviewees who had gone through the application process never directly interacted with the HDC. The residents we interviewed stated that the installers completed the application documentation and represented them at public hearings.

Recommendation 3: Potential Resources

We recommend that the Nantucket Energy Office and Nantucket Preservation Office work together to increase public understanding and awareness of the current guidelines and application process. This greater awareness would afford residents more opportunities to readily research the relevant guidance based on their location on island. These new resources might include:

- Using the solar map to display the current status of solar installations on island
- A dashboard showcasing the number of applications and installations completed and in process
- Developing an online guide for homeowners considering the installation of solar technologies
- Creating a checklist of steps in the application process
- Compiling a slideshow showing images of installations that the HDC has approved

These new resources would be focused on providing information in a more succinct format to address common questions regarding the application and installation process.

In addition, the Town of Nantucket could continue to look outward towards other historic districts to attempt to gather further ideas for methods of improving public awareness and education surrounding solar installations. To start, we recommend the town of Framingham as an example of methods for raising public awareness about solar technologies and permitting. We also recommend that they look at the Salem Historical Commission Design Guidelines as an example of a well-made, informative solar guidelines that not only set the standard for how solar panels should be installed but also includes tips, a checklist, as well as photos and diagrams for prospective solar applicants to learn and understand how to appropriately integrate solar.

Conclusion 4: Updated Solar Map

The interactive solar map layer on the MapGEO system improves upon the previous iteration of the town's solar map which was on Google Maps. The benefits of switching to an Arc-GIS-based system include an increased level of functionality regarding possibilities for update automation. The use of MapGEO allows for greater integration with the town's other existing GIS based resources and increases the ease of access for users. The implementation of the new script-based data collection method for identifying installations from EnerGov data will aid greatly in the process of continually updating the map with new installations. However, based upon our interactions with Nantucket officials as well as our own experience identifying pertinent data on solar installations, there are some insufficiencies with the current utilization of the EnerGov system for record keeping. There are some instances in which documents are absent or missing from the system, and many entries where significant pieces of information are missing or incomplete. Information such as the size and capacity of a solar installation is necessary in an application for a building or electrical permit for said installation, yet in many cases such information is not transferred to the EnerGov entry for the permit in question. Missing and inaccurate information may limit the accuracy of the data on the solar map and limit the effectiveness of the update automation.

Recommendation 4.1: New Solar Map

We recommend that the town adopt the new Arc-GIS-based interactive solar map layer on MapGEO to replace the current Google Maps based solar map. This should be updated periodically using the method outlined above with the updated installation table being sent to the town's GIS Coordinator so said information can be displayed on the MapGEO layer.

Recommendation 4.2: Data Entry

We also recommend a general renewed focus on data entry and organization practices in the EnerGov system. Staff responsible for making entries regarding HDC certificates of appropriateness, electrical permits, and building permits should be given training or instruction as to how best to utilize the system and make entries. This is because the functionality of the interactive solar map and the continued viability of its partial update automation system is entirely dependent on how relevant permits are entered into EnerGov. Better and more consistent utilization of features such as the "sub-records" system, which would greatly aid in matching certificates of appropriateness to relevant electrical and building permits, should also be considered. Existing problems with data entry and formatting have already and will continue to require manual action to resolve. Consistent high-quality data in EnerGov would open the door to greater possibilities regarding the creation and usage of tools and resources similar to the solar map.

References:

2021 Annual Town report (PDF) - Nantucket. (2021). Retrieved August 30, 2022, from https://www.nantucket-ma.gov/DocumentCenter/View/42103/Annual-Town-Report-2021-Town-of-Nantucket-PDF

Backus, H. E. (2021, September 9). *Renewable Energy & the Nantucket Historic District Commission* (Town of Nantucket, Department of Planning and Land Use Services, Planning and Zoning Office). Retrieved September 8, 2022.

Balling, J. (2022, May 6). *Voters OK topless beaches, ban fertilizers, hot tubs in historic districts and plastic "nip" bottles*. Inquirer and Mirror. Retrieved September 26, 2022, from https://www.ack.net/stories/town-meeting-night-two,28459

Blazej, T. (n.d.). *There's a Difference.* Massachusetts Historical Commission. Retrieved December 5, 2022, from https://www.sec.state.ma.us/mhc/mhcpdf/difference.pdf

Boyer, Z., Kirwan, J., O'Neill, C., & Pietrowicz, N. (2017). *Stimulating the Adoption of Solar PV on Nantucket*. [Interactive Qualifying Project, Worcester Polytechnic Institute]. https://wp.wpi.edu/nantucket/projects/2017-projects/neo/

Building Integrated Photovoltaics (BIPV) | WBDG - Whole Building Design Guide. (n.d.). Retrieved September 25, 2022, from https://www.wbdg.org/resources/building-integrated-photovoltaics-bipv

Bushard, B. (2021a, March 18). *Select Board overturns HDC Solar Denial*. Inquirer and Mirror. Retrieved September 26, 2022, from https://www.ack.net/stories/select-board-overturns-hdc-solar-denial,23665

Bushard, B. (2021b, January 30). *This Week in town government: Select Board upholds rooftop-solar denial*. Inquirer and Mirror. Retrieved September 26, 2022, from https://www.ack.net/stories/this-week-in-town-government-select-board-upholds-rooftop-solar-denial,21937

Bushard, B. (2022, April 25). *Voters to decide on expanded use of solar panels*. Inquirer and Mirror. Retrieved September 25, 2022, from https://www.ack.net/stories/voters-to-decide-on-expanded-use-of-solar-panels,28300

Canada, N. R. (2018, July 17). *Building-integrated Photovoltaics*. Natural Resources Canada. https://www.nrcan.gc.ca/energy/efficiency/data-research-and-insights-energy-

efficiency/buildings-innovation/solar-photovoltaic-energy-buildings/building-integrated-photovoltaics/21280

Cotuit Solar. *Experienced Solar Installer, Solar Cape Cod & Islands, Solar Panels*. (n.d.). Retrieved September 13, 2022, from https://cotuitsolar.com/

DeSantis, K., Devlin, G., Salvalzo, A., & Schroeder, B. (2021). *Feasibility of off-grid solar applications on Nantucket.* [Interactive Qualifying Project, Worcester Polytechnic Institute]. https://cpb-us-w2.wpmucdn.com/wp.wpi.edu/dist/e/127/files/2021/12/ReMain-IQP-Final-Report.pdf

Dyaqua. (n.d.). *Invisible Solar*. Retrieved September 25, 2022, from https://www.dyaqua.it/invisiblesolar/_en/

Encor Solar. (2018, November 13). *How Have Solar Panels Improved in the Last Ten Years?* Encōr Solar. https://encorsolar.com/how-have-solar-panels-improved-in-the-last-ten-years/

Han, A., & Mukherjee, A. (2014, April). Efficiency Of Solar PV, Then, Now and Future. Solar Photovoltaic. Retrieved September 14, 2022, from https://sites.lafayette.edu/egrs352-sp14-pv/technology/history-of-pv-technology/

Historic District Commission, City of Methuen Massachusetts (2016). Retrieved October 5, 2022, from https://www.cityofmethuen.net/sites/g/files/vyhlif886/f/uploads/histdistrules4721.pdf

Historic District Commission, City of Providence (2019). Retrieved October 5, 2022, from https://www.providenceri.gov/wp-content/uploads/2019/12/SolarSGamendment-final.pdf

Historic District Commission, Hingham Massachusetts (n.d.). Retrieved October 5, 2022, from https://www.hingham-ma.gov/DocumentCenter/View/1857/Guidelines-for-work-in-Historic-Districts-PDF

Historical Preservation & Heritage Commission. (*n*.d.). *Local Historic District* Zoning. Retrieved December 5, 2022, from https://preservation.ri.gov/preserve-protect/local-preservation/local-historic-district-zoning

Lang, J. C., & Stout, K. (1992). *Building with Nantucket in Mind*. Building with Nantucket in Mind | Nantucket, MA - Official Website. Retrieved August 30, 2022, from https://www.nantucket-ma.gov/537/Building-With-Nantucket-In-Mind

Martín-Chivelet, N., Kapsis, K., Wilson, H. R., Delisle, V., Yang, R., Olivieri, L., Polo, J., Eisenlohr, J., Roy, B., Maturi, L., Otnes, G., Dallapiccola, M., & Upalakshi Wijeratne, W. M. P. (2022). Building-Integrated Photovoltaic (BIPV) products and systems: A review of energy-related behavior. *Energy and Buildings*, *262*, 111998. https://doi.org/10.1016/j.enbuild.2022.111998

Nantucket Solar Map. (n.d.). Google My Maps. Retrieved September 12, 2022, from https://www.google.com/maps/d/viewer?mid=1yl6T_2TrqKAbQIIts4SgB7AlbdBrw2zE

National Grid. (2020, January). *L8 Distribution Reliability Project - upgrades to existing overhead ...* Retrieved September 25, 2022, from https://www.nantucket-ma.gov/DocumentCenter/View/29915/L8-Distribution-Reliability-Project-Upgrades-to-Existing-Overhead-Distribution-Facilities

National Grid. (n.d.). *Nantucket peak load: Frequently asked questions*. Retrieved September 13, 2022, from https://www.nationalgridus.com/media/pdfs/resi-ways-to-save/0317-ngrid-hes-708459-nantucketfaqs_r2a_web.pdf

Planning & Land Use Services (PLUS). *Planning & Land Use Services (plus)*. Planning & Land Use Services (PLUS) | Nantucket, MA - Official Website. (n.d.). Retrieved August 30, 2022, from https://www.nantucket-ma.gov/230/Planning-Land-Use-Services-PLUS

Preservation Massachusetts (n.d.). *Local Historic Districts in Massachusetts.* Retrieved December 5, 2022, from https://www.preservationmass.org/_files/ugd/04159b_3ea3fab11f144b6683e2ae8340d3e3d3.pdf

Salem Historical Commission. (1984). *Salem Historical Commissions Guidelines Notebook.* Retrieved October 5, 2022, from https://www.salemma.gov/sites/g/files/vyhlif7986/f/uploads/guidelines.pdf

Salem Historical Commission. (2022). *Salem Historical Commission Guidelines Notebook* Retrieved December 12, 2022, from https://www.salemma.gov/historical-commission/links/design-guidelines-updated-guidelines-now-available

Solar Roof Shingles, Residential Solar Roofs. (n.d.). *SunStyle*. Retrieved September 30, 2022, from https://www.sunstyle.com/residential-solar-roofing/

Stackpole, M., & Harrison, M. R. (2022, February 24). *Why did Nantucketers stop whaling?* Nantucket Historical Association. Retrieved September 14, 2022, from https://nha.org/research/nantucket-history/history-topics/why-did-nantucketers-stop-whaling/

SunStyle | Neo-gothic church updated with solar roof. (n.d.). *SunStyle*. Retrieved September 25, 2022, from https://www.sunstyle.com/portfolio/neo-gothic-church-sarpsborg-norway/

SunStyle | Strand Church with solar tiles. (n.d.). *SunStyle*. Retrieved September 25, 2022, from https://www.sunstyle.com/portfolio/strand-church-tau-norway/

Tesla. (n.d.). *Solar Roof*. Retrieved September 25, 2022, from https://www.tesla.com/solarroof

Town of Nantucket. (2020, September 9). *Town of Nantucket - GIS Mapsheet*. Retrieved August 30, 2022, from https://www.nantucket-ma.gov/DocumentCenter/View/11200/Historic-Districts-Map

Town of Nantucket Energy Office. (n.d.). *Brief history of energy on Nantucket*. Retrieved September 13, 2022, from http://www.ackenergy.org/brief-history-of-energy-on-nantucket.html

Town of Nantucket Energy Office. *Energy Office*. Town of Nantucket Energy Office | Nantucket, MA - Official Website. (n.d.). Retrieved August 30, 2022, from https://www.nantucket-ma.gov/136/Energy-Office

U.S. National Park Service. (1995). *The Secretary of the Interior's Standards for the Treatment of Historic Properties—Technical Preservation Services (U.S. National Park Service)*. Retrieved November 1, 2022, from https://www.nps.gov/orgs/1739/secretary-standards-treatment-historic-properties.htm

Way, G. (2009). *Sustainable Preservation*. Nantucket, MA - Official Website. Retrieved September 8, 2022, from https://www.nantucket-ma.gov/DocumentCenter/View/9543/Sustainable-Preservation---Final-PDF?bidId=\

Wesoff, E. (2020, June 8). *First Tesla solar tile roof V3 installed in Massachusetts*. pv magazine USA. https://pv-magazine-usa.com/2020/06/08/first-tesla-solar-tile-roof-installed-in-massachusetts/

What are Building-Integrated Photovoltaics (BIPV)? (n.d.). *SunStyle*. Retrieved September 25, 2022, from https://www.sunstyle.com/perspectives/what-are-building-integrated-photovoltaics-bipv/

Appendix A: Interviews with Other HDCs

Preamble: We are a group of four students from Worcester Polytechnic Institute. We are conducting a research project in collaboration with the Nantucket Energy Office, Preservation Planner, and Nantucket Preservation Trust to identify ways to improve Nantucket's solar installation guidelines and solar application process especially with regard to historic buildings.

Would you be willing to take 15 minutes to answer some questions about the approach to solar installations in your historic district? You may skip any questions that you would prefer not to answer, and you may withdraw at any time. We shall be taking notes during our conversation and may wish to quote you in our final report. Do you mind if we attribute these quotes to you, or would you prefer that we anonymize your responses? We will give you an opportunity to review any quotations prior to publication. If you wish, we will also be happy to provide a copy of our report once it is completed. Thank you for your support in our research.

If you have any questions or concerns after the interview, you can contact us at gr-ack22-solar@wpi.edu or our faculty advisors, Dominic Golding, at golding@wpi.edu, or Bruce Bursten, at bbursten@wpi.edu.

We have reviewed your solar technology guidelines online, but could you tell us:

- How were your solar technology guidelines created?
    - Did you model these guidelines on any other communities?
    - Were they modeled on those of other communities?
        - If so, where, and what aspects of them?
- What is the history of your solar technology guidelines?
    - When were they first created and why were they created?
    - What circumstances led to the need for your community to address regulations on solar technologies.
    - Have they been updated since their creation? If so, how, and how frequently?
- How do you communicate your solar regulations to your residents?
    - How effective have your efforts been at informing those in your community?
- Have homeowners and/or installers expressed any concerns about the guidelines or the process for getting installations approved?

- How many installations have been approved and denied in the past 3 years for the historic district?
- How does the approval process work?
- How does the denial process work?
- Is there any route for appeal if an application is denied?
- Have any approvals or denials been particularly controversial in recent years?
    - Why were they as controversial as they were?
- Does the district anticipate relaxing or changing guidelines to accommodate increasing demand for PV installations in the future?
- Are your guidelines open to future modification?
    - Have you or others considered how the guidelines might need to be modified to accommodate new solar technology, such as building integrated photovoltaics? Would the district be amenable to the installation of 'dragon scale' PV tiles or Tesla tiles, for example?
- What is the dominant architectural style in your community? (Roof shapes/styles)
- Do you know of any other historic districts that have extensive or particularly innovative guidelines or designs?
    - If so, do you know how we can contact them?

Appendix B: Survey Questions

Preamble: We are a group of students from Worcester Polytechnic Institute conducting a research project in collaboration with the Town of Nantucket and Nantucket Preservation Trust to identify ways to improve local solar permitting, including the HDC approval process.

This survey is estimated to take approximately 5-10 minutes. You may skip any questions you prefer not to answer, and you may withdraw at any time. The survey is anonymous – we will not be collecting your name or any personal, identifying information.

Your participation is greatly appreciated. If you have any questions about our research, or would like a copy of the published report, please contact us at gr-ack22-solar@wpi.edu, or our faculty advisors, Dominic Golding, at golding@wpi.edu or Bruce Bursten, at bbursten@wpi.edu.

GENERAL SURVEY QUESTIONS

- Choose which bests describes your residency status on Nantucket
    - I am a year-round homeowner
    - I am a year-round renter
    - I am a seasonal homeowner
    - Other:
- Where is your main property located on the island?
    - Downtown Historic Core
    - ’Sconset Historic District
    - Madaket
    - Mid-Island
    - ‘Sconset
    - Tom Nevers
    - Other: Fill In

- Please indicate how strongly you agree or disagree with the following statements:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The preservation of Nantucket's historic buildings and streetscapes is important to me.					
Solar panels are a visual intrusion.					
Solar panels should **NOT** be visible from public ways in the historic downtown.					
Solar panels should **NOT** be visible from public ways in the 'Sconset historic district.					
Solar panels should **NOT** be visible from public ways outside of the downtown and 'Sconset historic districts.					
The Historic District Commission (HDC) makes reasonable decisions when approving solar PV systems.					
HDC policies are inhibiting the wide-scale adoption of solar technologies on Nantucket.					
There should be more solar installations on Nantucket.					

- The current HDC guidelines regarding solar installations have resulted in conditions such as solar panel color needing to match roof color, avoiding placement on a primary structure, and minimizing visibility from a public way. Do you believe these guidelines are:
    - Fair and reasonable
    - Not solar-friendly enough
    - Other: ____
- Please indicate your level of awareness about solar photovoltaic (PV) systems on Nantucket?
    - I am unfamiliar with solar PV.
    - I am generally aware of what solar PV is, but I wouldn't know how to get started with an installation on Nantucket.
    - I have done some research on solar power and understand the basics, including local permitting requirements, incentives, and rebates available.
    - I am very informed on the topic of installing solar on Nantucket, including the HDC approval process
- Please indicate your personal level of interest in installing PV on your Nantucket property
    - I am not interested.
    - I am interested in installing solar in the future.
    - I am interested but believe the HDC would not allow it.
    - I have already installed solar, or have applied in the past
- What would be your primary motivation for installing solar PV?
    - Economic benefits/Financial Investment*
    - Environmental benefits/Combating Climate Change
    - Energy Independence/Resiliency
    - Other?
    - *There are significant federal, state and local incentives, rebates and tax credits available for installing solar PV, which can reduce the ROI to 5-years or less.

- Other towns provide specific resources to educate their communities about going solar, such as solar permitting checklists, maps, and webpages. Please indicate which resources you think would be helpful for the Town/HDC to offer the Nantucket community:
    - Solar Permitting checklist
    - "A Guide to Going Solar" webpage on the Town's website
    - Interactive solar map displaying the locations of all locally installed solar systems
    - Informational brochure
    - Other: ___

HAVE APPLIED FOR AN INSTALLATION

- In what year did you apply for a HDC Certificate of Appropriateness for your solar installation?
    - 2018 or Earlier
    - 2019
    - 2020
    - 2021
    - 2022
- Did the installer handle all or most of the application process for you?
    - Yes/No
- What is the status of your application?
    - Approved
    - Approved with conditions
    - Pending
    - Denied/Withdrawn
- If approved with conditions, what were the conditions (including design revisions), and do you think they were reasonable?
    - Text Box
- If approved, what is the status of your installation?
    - Completed and operational
    - Installed and awaiting final inspections
    - Installation is in progress
    - Installation is not proceeding

- If the installation was approved but will not proceed, can you explain the reason why?
    - Text Box
- Please indicate the design of your solar system
    - Roof mount
    - Ground mount
    - Solar Pergola
    - Tracker
    - Solar Thermal/Hot Water
    - Other (Specify)
- How would you describe your experience with the HDC during the application process?
    - Text box
- How might the HDC and other departments involved (e.g., Building Inspector, Wiring Inspector, Energy Office, National Grid) improve the solar permitting process?
    - Text Box
- Do you have any additional comments you would like to share about your solar installation experience?
    - Text Box

Thank you for taking the time to complete our survey. The results of the survey will be available through the Town of Nantucket or at the WPI Nantucket Project Center website (https://wp.wpi.edu/nantucket/) in mid-December.

Appendix C: Nantucket Resident Interviews

Preamble: We are a group of students from Worcester Polytechnic Institute. We are conducting a research project in collaboration with the Nantucket Energy Office, Preservation Planner, and Nantucket Preservation Trust to identify ways to improve Nantucket's solar installation guidelines and solar application process.

Would you be willing to take 15 minutes to answer some questions? Your participation in this interview is voluntary. You may skip any questions that you would prefer not to answer, and you may withdraw at any time. We shall be taking notes during our conversation and may wish to quote you in our final report. Do you mind if we attribute these quotes to you, or would you prefer that we anonymize your responses? We will give you an opportunity to review any quotations prior to publication. If you wish, we will also be happy to provide a copy of our report once it is completed. Thank you for your support in our research.

If you have any questions or concerns after the interview, you can contact us at gr-ack22-solar@wpi.edu or our faculty advisors, Dominic Golding, at golding@wpi.edu, or Bruce Bursten, at bbursten@wpi.edu.

- When did you apply for a solar installation?
- Was the application mostly handled by the installer you chose to work with?
- How long after your submission was your application heard?
    - Were you satisfied with this response time?
- If application was approved:
    - Has the installation been completed yet?
    - Were there any conditions to approval?
- If application was rejected:
    - Were you given a reason why the application was rejected?
    - Were suggestions for improvement offered to you?
    - Do you intend to follow these suggestions and apply again?
- If application was approved and has not yet been built:
    - Have there been any obstacles in the installation process?
- Have you installed any other solar technologies such as building integrated photovoltaics (BIPV)?

    - What motivated the inclusion of (relevant developing technologies) in your project?
    - Did you encounter any difficulties in the application or installation process that you feel may have been related to your inclusion of these technologies in your project?
- Do you believe the current HDC guidance is fair and reasonable?
- How would you describe your experience with the HDC during the application process?
- Do you have any suggestions to improve the solar application and approval process?
    - Would a solar permitting checklist be a useful tool during the application process?
    - Would "A Guide to Going Solar" webpage on the Town's website be a useful resource prior to and during the application process?
    - Would an interactive solar map displaying the locations of all locally installed solar systems be useful to see examples of what the HDC has approved?
- Do you have any suggestions for changes that could be made to the existing solar guidelines?

Appendix D: Nantucket Installer Interviews

Preamble: We are a group of four students from Worcester Polytechnic Institute. We are conducting a research project in collaboration with the Nantucket Energy Office, Preservation Planner, and Nantucket Preservation Trust to identify ways to improve Nantucket's solar installation guidelines and application process.

Would you be willing to take 15 minutes to answer some questions? If you agree to participate, you may skip any questions that you would prefer not to answer, and you may withdraw at any time. We shall be taking notes during our conversation and may wish to quote you in our final report. In the event we want to quote a statement from this interview, we will give you an opportunity to review any quotations prior to publication. During the review process, let us know if you would want the quotes to be attributed to you or anonymize the response. If you wish, we will also be happy to provide a copy of our report once it is completed. Thank you for your support of our research.

If you have any questions or concerns before or after the interview, you can contact us at gr-ack22-solar@wpi.edu or our faculty advisors, Dominic Golding, at golding@wpi.edu, or Bruce Bursten, at bbursten@wpi.edu.

- In what year did your company start installing solar technologies on the island?
    - How did you get into this field?
    - Can you tell us about your role in the company?
    - What technologies does your company currently offer (i.e., PV, thermal, batteries) or specialize in?
    - In what ways have solar technologies changed since you have been involved with the industry?
    - How have regulations and requirements surrounding solar technologies changed?
        - Rebates/tax incentives/codes
            - What is the impact of the Town's solar rebate program on residential solar installation?
        - Has the stretch code requirements helped to drive solar sales?
    - How have market conditions changed surrounding solar technology?
- How many PV installations have you been a part of since your company began?
    - How many installations have you been a part of in the last year?

    - How have sales and trends changed in the past 5 years?
    - How many of your installations have been roof arrays?
        - Have you experienced any specific challenges in working with the HDC for these types of installations?
            - Would you suggest any changes to help alleviate these challenges?
    - How many of your installations have been ground arrays?
        - Have you experienced any specific challenges in working with the HDC for these types of installations?
            - Would you suggest any changes to help alleviate these challenges?
    - Have you installed any arrays on or around historic properties (Properties in the Old Historic Districts)?
        - How was the process different, if at all?
        - What have been the biggest hurdles in these installations?
- Do you screen prospective clients for how you anticipate the HDC will vote on the aesthetic appropriateness/visibility of their application?
- Do you expect or have you experienced any complications with these projects?
    - Have you been involved in any projects that required substantial modifications to achieve HDC approval?
        - What kinds of modifications were required?
        - How did that process go?
    - Have you been involved in any projects that will not proceed?
        - Have you been given a reason why the project has not been built yet?
        - Do you expect this issue to be resolved?
- Have you been involved in any solar installation projects that have been proposed but not approved?
- Have you ever escalated an HDC denial to the Select Board? If yes, can you share more about this experience and outcome?
- How many revisions does a typical solar application take for approval? How many rounds of HDC revisions would you/your client consider before giving up
- What challenges have you experienced with the current solar application process?
    - Do you have any suggestions to improve the application and approval processes?

    - Would you find it beneficial to have improved monitoring or visibility of the progress of the application and approval processes?
- We plan on conducting a survey both community as a whole and individuals who have applied for solar projects, to gauge their opinions on this matter. Do you have any suggestions for topics we should address for our survey?
- Before we conclude this interview, is there anything else you'd like to share with us regarding your experience, insights, or suggestions?

Appendix E: Nantucket Official Interview

Preamble: We are a group of students from Worcester Polytechnic Institute. We are conducting a research project in collaboration with the Nantucket Energy Office, Preservation Planner, and Nantucket Preservation Trust to identify ways to improve Nantucket's solar installation guidelines and solar application process.

Would you be willing to take 15 minutes to answer some questions? Your participation in this interview is voluntary. You may skip any questions that you would prefer not to answer, and you may withdraw at any time. We shall be taking notes during our conversation and may wish to quote you in our final report. Do you mind if we attribute these quotes to you, or would you prefer that we anonymize your responses? We will give you an opportunity to review any quotations prior to publication. If you wish, we will also be happy to provide a copy of our report once it is completed. Thank you for your support in our research.

If you have any questions or concerns after the interview, you can contact us at gr-ack22-solar@wpi.edu or our faculty advisors, Dominic Golding, at golding@wpi.edu, or Bruce Bursten, at bbursten@wpi.edu.

Start general!

- Can you tell us about your profession and role on the Nantucket HDC?
- What is your perspective of solar as an architect? Does this differ from your role as an HDC* Commissioner?
- Do you see a rise in interest in installing solar from your clients? How do you advise them?
- In your experience, are abutters typically supportive of solar applicants?

HDC Solar guidelines

- Given that the solar guidelines were developed over 10-years ago, do you feel any of the guidelines or application process are especially in need of modifying, if at all?"
- Do you feel that the current state of the HDC's guidelines regarding solar installations and applications are adequate to effectively promote the general welfare of the town and its inhabitants? (As per the HDC mission statement)

    - Do you feel that the current state of the HDC's guidelines regarding solar installations and applications reflect the policy of the Commonwealth to encourage the use of solar energy systems and to protect solar access?
- Given that solar technologies are constantly developing, such as BIPVs like solar pergolas and Tesla Roofs, do you believe that the HDC's guidelines in their current state are compatible with such developments?
- Many buildings are being elevated in response to concerns about flooding. Would this change the way the HDC evaluates solar installations because roofs will be less visible from street level?
- How does the HDC evaluate 'visibility from a public way' – would this mean that many houses in Brant Point would be by default ineligible for solar because they can be viewed from above (e.g., from Cobblestone Hill)?
- Do you feel there is a false perception from the public about the HDC's attitudes toward solar?
- In your opinion, why was Article-80 at the 2022 Annual Town Meeting proposed, and what was your opinion of it?
- What do you believe should be an outcome of the designated HDC workgroup charged with revising the HDC's sustainability guidelines?
- We understand that the guidelines on solar technologies are posted on the HDC website, but are applicants, installers, and residents in general clear about the guidelines and application process?
- Should the HDC do more to explain the guidelines and application process?
- Do you have any suggestions to improve the application and approval processes, including the existing guidelines?
    - We understand that the applications for solar installations are still required to be filed on paper. Is there a reason that this process has not moved to an online portal instead?
- We are in the process of interviewing other HDCS about their solar guidelines. Are there any questions or information you feel would be important for us to ask or request?

Appendix F: EnerGov System Explanation

The EnerGov search portion of the map update process requires backend EnerGov access, specifically utilizing the advanced search feature. The three saved custom searches “Solar Map Search COA”, “Solar Map Search BLDR”, and “Solar Map Search ELEC” which were created by the account WPI Student01 (wpistudent01@nantucket-ma.gov) should be run and their results each downloaded using the “Export Search” feature. The three searches in question are shown below in Figure F1. The resulting csv files will be utilized as input when using the Python script explained in Appendix G below.

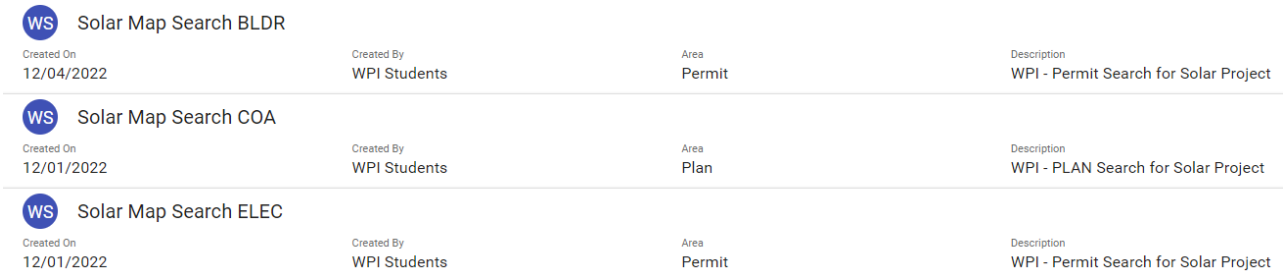


Figure F 1: The three custom EnerGov searches to be utilized for record searches.

The search criteria for all three saved searches are shown in Figures F2-F4 below, and the output fields are shown in Figure F5-F7. The searches can be recreated using these settings and should still work with the cross-referencing Python script, although the ordering of the output fields of all three searches are important for the script to function as intended.

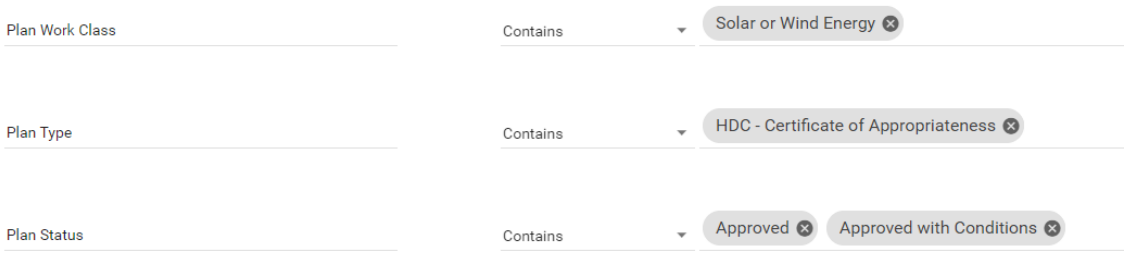


Figure F 2: "Solar Map Search COA" search criteria.

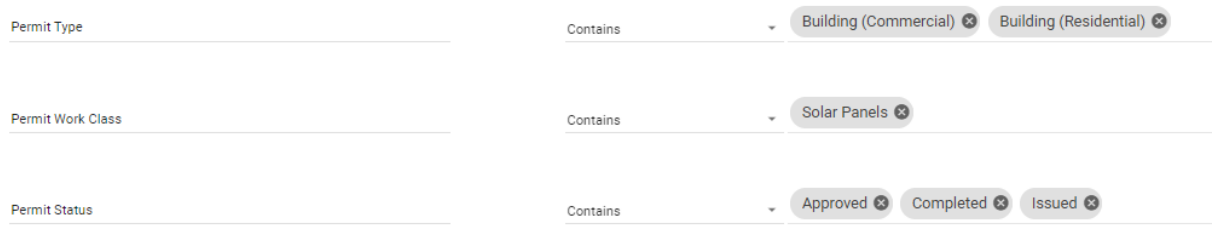


Figure F 3: "Solar Map Search BLDR" search criteria.

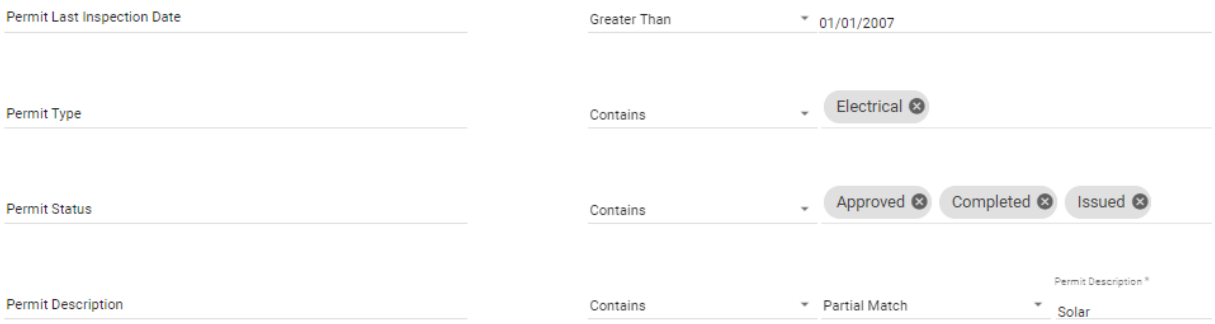


Figure F 4: "Solar Map Search ELEC" search criteria.

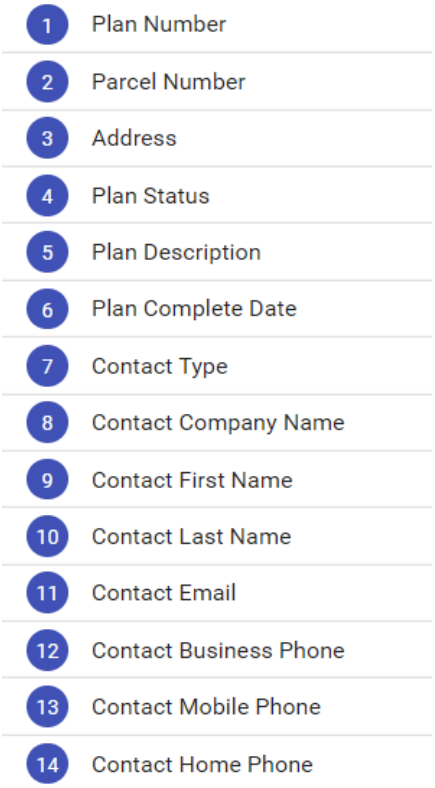


Figure F 5: "Solar Map Search COA" output fields.

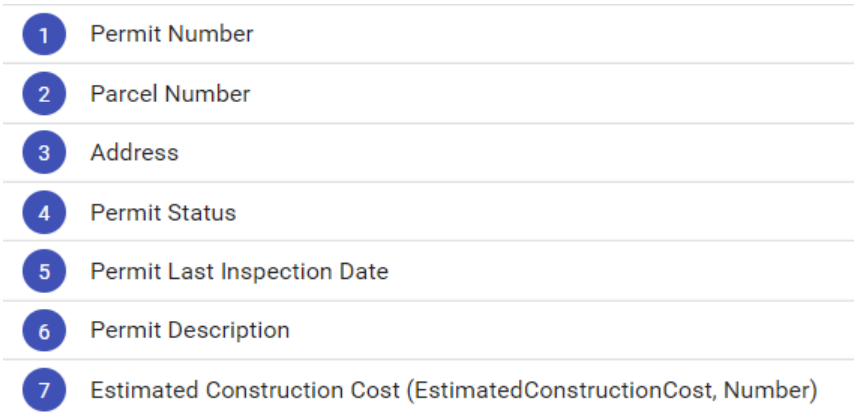


Figure F 6: "Solar Map Search BLDR" output fields.

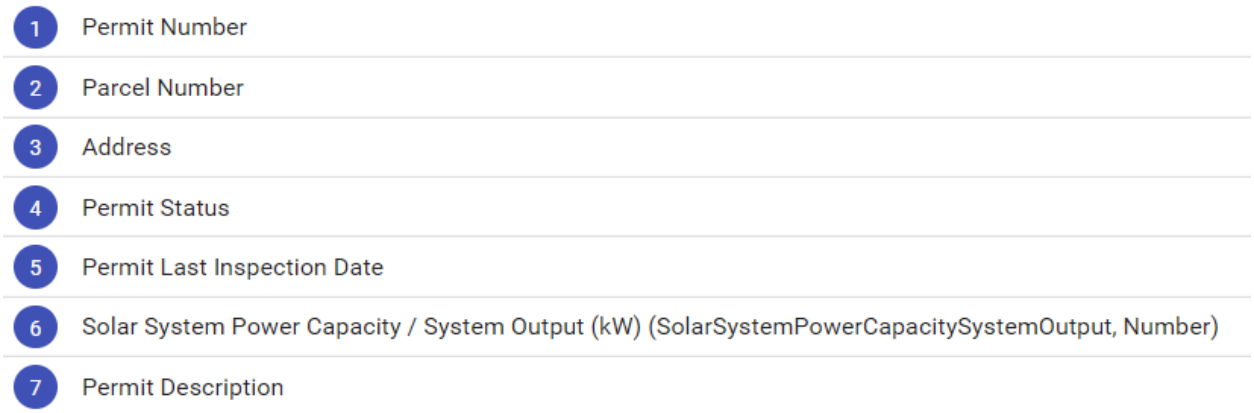


Figure F 7: "Solar Map Search ELEC" output fields.

Appendix G: Python Cross-Referencing Script

The Python cross-referencing script portion of the solar map update process uses a Python 3.9.5 script to take the results of the EnerGov advanced searches and update the list of existing solar installations. The script contains two modules: the Solar Map Updater and crossCheck.py. In order to run the script both modules must be in the same folder and the Python packages of csv and openpyxl must be installed. Additionally, the three csv files that resulted from the EnerGov searches, the properly formatted Excel file containing the most up to date existing solar map installation table, and the properly formatted Excel file containing the blacklist (which is a list of entries which have been manually identified as being false positive results from the EnerGov searches) must also be in this folder.

To update the solar map installation table with new data from EnerGov simply open and run the Solar Map Updater from the folder containing all of the necessary files. The script will prompt input from the user for the necessary file names and will add any new solar installations found to the Excel file containing the existing solar map installation table. The two Python modules, as well as the most up to date solar map installation table (as of the writing of this report) and a sample blacklist can be found on the Nantucket Project Center Website. A more detailed explanation of the two Python modules is below.

If an entry added to the installation table by an EnerGov search is manually determined to be false, then that entry should be removed from the installation table and added in its entirety to the blacklist table. If the entry is not put on the blacklist, then it will be readded to the installation table by any future uses of the EnerGov/Python script update process.

Data can be added, changed, and removed from the installation table manually using Excel. Although care must be taken to respect and follow the existing formatting of said table. Any changes made to the installation table will not be overwritten or removed by running the Python script. Similarly, the data for existing installations will not be changed nor added when running the script. Lastly, since the only way to automatically detect duplicates reliably with the data currently available from EnerGov is comparing parcel numbers, any subsequent solar installations on the same parcel as an already identified installation will not be added and must be added to the installation table manually.

Solar Map Updater:

This module:

- Gets user input
- Reads the csv and Excel files
- Passes the HDC, electrical permit, and building permit data to the cross-check module
- Checks for duplicates between the existing installation table and the cross-checked results
- Adds the new installations to the existing installation table

```
#   This is a program for updating the Nantucket Solar Map
#   based on data pulled from EnerGov advanced searches

import csv
import openpyxl
from crossCheck import *

def main():
    HDC, Elect, Build, Existing, Blacklist = getInput()
    H, E, B, Ex, Bl = readSheets(HDC, Elect, Build, Existing, Blacklist)
    processedList = crossCheck(H, E, B)
    newSolarData = updateExisting(processedList, Ex, Bl)
    fields=['Parcel Number', 'Address', 'Plan Number', 'Contact Type',
'Contact Company Name', 'Contact First Name', 'Contact Last Name',
'Contact Email', 'Phone Number', 'Installation Type', 'Installation Date',
'Year of Installation', 'Capacity (kW)', 'Total Cost', 'Cost per Watt',
'SOLAR Rebate']
    writeData(newSolarData, Existing, fields)



def getInput():
    print("This program is used to update an Excel file containing the
solar installations")
    print("that are currently on the Town's Solar Map with new
installations identified")
    print("through EnerGov advanced searches. To do this we need a few
files:")
    print("the csv files that outputed from the EnerGov searches
containing the HDC COA data,")
    print("electrical permit data, and building permit data; and the Excel
files containing")
    print("the existing solar map data, and the blacklist data (locations
which are false positives for solar)")
    print("Please include the .csv or .xlsx after the file name and make
sure all files are in the same folder as the Python Scripts")
    HDC = input("What is the name of the file with the HDC COA data?")
    Elect = input("What is the name of the file with the electrical permit
data?")
```

```
    Build = input("What is the name of the file with the building permit
data?")
    Existing = input("What is the name of the file with the existing solar
map data?")
    Blacklist = input("What is the name of the file with the blacklisted
data?")
    return HDC, Elect, Build, Existing, Blacklist

def readSheets(HDC, Elect, Build, Existing, Blacklist):
    hdc = open(HDC, 'r', encoding='utf-8-sig')
    H = csv.DictReader(hdc)
    elect = open(Elect, 'r', encoding='utf-8-sig')
    E = csv.DictReader(elect)
    build = open(Build, 'r', encoding='utf-8-sig')
    B = csv.DictReader(build)
    existing = openpyxl.load_workbook(filename=Existing, data_only=True)
    ex_page = existing.active
    Ex = []
    for row in ex_page.iter_rows(min_row=2):
        ex_dict = {}
        for i in range(len(ex_page[1])):
            ex_dict[ex_page.cell(1, i+1).value] = '' if i >= len(row) else
row[i].value
        Ex.append(ex_dict)
    existing.close()

    blacklist = openpyxl.load_workbook(filename=Blacklist, data_only=True)
    bl_page = blacklist.active
    Bl = []
    for row in bl_page.iter_rows(min_row=2):
        bl_dict = {}
        for i in range(len(bl_page[1])):
            bl_dict[bl_page.cell(1, i+1).value] = '' if i >= len(row) else
row[i].value
        Bl.append(bl_dict)
    blacklist.close()

    return H, E, B, Ex, Bl


def updateExisting(processedList, Ex, Bl):
    exist = []
    for row in Ex:
        exist.append(row)
    black = []
    for row in Bl:
        black.append(row)

    new = []
    for row in processedList:
        dupe = False
        for entry in exist:
            if row['Parcel Number'] == entry['Parcel Number']:
                dupe = True
```

```
                break
        if dupe:
            continue

        for item in black:
            if row['Parcel Number'] == item['Parcel Number']:
                dupe = True
                break
        if dupe:
            continue

        new.append(row)
    return new


def writeData(newSolarData, Existing, keys):
    rows = newSolarData

    existing = openpyxl.load_workbook(filename=Existing, data_only=True)
    page = existing.active

    i = 2
    while i < page.max_row and page.cell(i, 1).value is not None:
        i += 1

    for row in rows:
        for j in range(len(row)):
            page.cell(i, j+1).value = row[keys[j]]
        i += 1

    existing.save(filename=Existing)
    existing.close()


if __name__ == '__main__':
    main()
```

crossCheck:
This module:

- Takes the data from the three csv files
- Checks if an entry has a COA, electrical permit, and building permit
- Builds a list with entries that have all three using data from all three csv files to fill out all the necessary fields
- Sets the solar rebate field to N/A because at this moment in time solar rebate data is not in EnerGov
    - Solar rebate data can be manually entered to the completed excel file before it is sent to the GIS coordinator

```
#   This module cross checks the three permit spreadsheets
#   and builds a list of entries that appear on all three sheets
```

```
def crossCheck(H, E, B):
    pL=[]
    elec=BuildElectric(E)
    build=BuildBuild(B)
    for row in H:
        d={}
        addKeyValues(d, row)
        d['check']=0
        for entry in elec:
            if entry['Parcel Number']==d['Parcel Number']:
                d['Capacity (kW)']=entry['Capacity (kW)']
                d['Installation Date']=entry['Installation Date']
                d['Year of Installation']=entry['Year of Installation']
                d['check']=d['check']+1
                break
        for item in build:
            if item['Parcel Number']==d['Parcel Number']:
                d['Total Cost'] = item['Total Cost']
                d['check']=d['check']+1
                break
        if d['check']==2:
            d['SOLAR Rebate']='N/A'

            cW = costPerWatt(d)
            d['Cost per Watt'] = cW

            del d['check']
            pL.append(d)
    return pL

def BuildElectric(E):
    elec=[]
    for row in E:
        e={}
        e['Parcel Number']=row['Parcel Number']
        e['Capacity (kW)'] = row['Solar System Power Capacity / System
Output (kW)']
        e['Installation Date'] = row['Permit Last Inspection Date']
        y = installYear(row)
        e['Year of Installation'] = y
        elec.append(e)
    return elec

def BuildBuild(B):
    build=[]
    for row in B:
        b={}
        b['Parcel Number']=row['Parcel Number']
        b['Total Cost'] = row['Estimated Construction Cost']
        build.append(b)
    return build

def addKeyValues(d, row):
```

```
    d['Parcel Number'] = row['Parcel Number']
    d['Address'] = row['Address']
    d['Plan Number'] = row['Plan Number']
    d['Contact Type'] = row['Contact Type']
    d['Contact Company Name'] = row['Contact Company Name']
    d['Contact First Name'] = row['Contact First Name']
    d['Contact Last Name'] = row['Contact Last Name']
    d['Contact Email'] = row['Contact Email']
    pN = phoneNum(row)
    d['Phone Number']=pN
    iT = installType(row)
    d['Installation Type']=iT
    return d

def phoneNum(row):
    if row['Contact Business Phone']!='':
        pN = row['Contact Business Phone']
    elif row['Contact Mobile Phone']!='':
        pN = row['Contact Mobile Phone']
    else:
        pN = row['Contact Home Phone']
    return pN


def installType(row):
    words = []
    i = ''
    p = row['Plan Description']
    p = p.replace('t', ' ')
    p = p.replace('T', ' ')
    p = p.replace('*', ' ')
    p = p.replace(';', ' ')
    p = p.replace(':', ' ')
    p = p.replace('/', ' ')
    t = p.split()
    for entry in t:
        t=entry.lower()
        if t!='':
            words.append(t)
    for w in words:
        if w == 'roof':
            i = 'roof'
        elif w == 'ground':
            i ='ground'
    if i =='roof':
        iT = 'Roof'
    elif i == 'ground':
        iT = 'Ground'
    else:
        iT = row['Plan Description']
    return iT

def costPerWatt(d):
    cap=float(d['Capacity (kW)'])
```

```
    if cap == 0: return '';

    cos=float(d['Total Cost'])
    cPW = cos/(cap*1000)
    return cPW

def installYear(entry):
    D = entry['Permit Last Inspection Date']
    D = D.replace('/', ' ')
    ND = D.split()
    for item in ND:
        test=int(item)
        if test > 100:
            year=test
    return year
```

Appendix H: List of Other HDCs

This is a list of all the Historic District Commissions researched and links to their respective solar design guidelines. If they read "Page NA" at the time of making this appendix the HDC did not have solar guidelines within their design guidelines or elsewhere on their website.

Massachusetts Historic Districts

Acton – https://www.acton-ma.gov/DocumentCenter/View/6919/HDC-SOLAR-GUIDELINES#:~:text=Any%20solar%20panel%20permitted%20on,distance%20appropriate%20under%20the%20circumstances.- Pages 1- 3

Andover – https://preservation.mhl.org/sites/default/files/files/BVHDC%20Guidelines%20Electronic%20Version%207-08.pdf- Page 11

Arlington – https://www.arlingtonma.gov/home/showpublisheddocument/56715/637577230611600000 - Page 17 - 18

Back Bay - https://www.cityofboston.gov/images_documents/Back%20Bay%20Guidelines%20for%20the%20Residential%20District_tcm3-13458.pdf – Page NA

Bedford - https://bedfordma.gov/DocumentCenter/View/1551/HDC-Guidelines-PDF - Page 17

Belmont - https://www.belmont-ma.gov/sites/g/files/vyhlif6831/f/uploads/hdcdesignguidelines2009.pdf - Page 40

Boxford - https://www.town.boxford.ma.us/sites/g/files/vyhlif321/f/uploads/guide.pdf - Page NA

Brookline - https://www.brooklinema.gov/DocumentCenter/View/11202/Local-Historic-District-Design-Guidelines-Jan-2016?bidId= - Page NA

Cambridge - https://www.cambridgema.gov/-/media/Files/historicalcommission/pdf/historic_brochure.pdf - Page NA

Chelmsford - https://chelmsfordgov.com/CHCwebsite/CHD_files/Review_Standards_2022-05-02.pdf - Page 11

Concord - https://www.concordma.gov/DocumentCenter/View/5806/Historic-Districts-Design-Guidelines---Amended-August-2015 - Pages 28 - 29

Dedham - https://www.dedham-ma.gov/home/showpublisheddocument/1400/636202626188200000 - Pages 12 - 13

Edgartown - https://www.edgartown-ma.us/home/showpublisheddocument/7668/637396393049770000 Page 7

Framingham - https://www.framinghamma.gov/DocumentCenter/View/45434/section-2-draft-guidelines-3-23-2022 - Page 6

Gloucester - https://gloucester-ma.gov/DocumentCenter/View/352/HDCguidelines?bidId= - Pages NA

Grafton - NA

Harvard - https://www.harvard-ma.gov/sites/g/files/vyhlif676/f/uploads/design_guidelines_2020_final.pdf - Pages 20 - 21

Harwich - https://www.harwich-ma.gov/sites/g/files/vyhlif7091/f/file/file/guidelines_notebook.pdf - Page 30

Hull - https://www.town.hull.ma.us/sites/g/files/vyhlif3286/f/uploads/august2015orig.pdf - Pages 42

Hingham - https://www.hingham-ma.gov/DocumentCenter/View/1857/Guidelines-for-work-in-Historic-Districts-PDF - Pages 14 - 15

Holden - NA

Lenox - https://www.townoflenox.com/sites/g/files/vyhlif3341/f/uploads/lenox_historic_district_guidelines.pdf - Pages 13, 18

Lowell - https://www.lowellma.gov/DocumentCenter/View/956/Downtown-Design-Review-Standards-PDF?bidId= - Page 5

Methuen - https://www.cityofmethuen.net/sites/g/files/vyhlif886/f/uploads/histdistrules4721.pdf - Page 9

Nantucket - https://www.nantucket-ma.gov/DocumentCenter/View/29382/Solar-Guidelines - Pages 1 - 4

Newburyport - https://www.cityofnewburyport.com/sites/g/files/vyhlif7106/f/file/file/designguidelines_1.pdf Page 7

New Bedford - https://www.newbedford-ma.gov/historical-commission/wp-content/uploads/sites/43/design-guidelines/Guidelines_Phase_4-Section_3.pdf - Page 21

North Reading – https://www.northreadingma.gov/sites/g/files/vyhlif3591/f/uploads/hdc-designgudelines-08.pdf - Page NA

Northampton - https://www.northamptonma.gov/DocumentCenter/View/1666/Elm-StreetRoundhill-Design-Standards-R9242013?bidId= - Page 38

Oak Bluffs - https://www.oakbluffsma.gov/DocumentCenter/View/1901/Oak-Bluffs-Harbor-District-Design-Guidelines-1997-PDF?bidId= - Pages NA

Old Kings Highway - https://www.town.barnstable.ma.us/BoardsCommittees/OldKingsHighway/Resources/-OKH-Regional-Historic-District-Bulletin.pdf?tm=12/11/2022%2011:53:47%20PM – Page 32

Plymouth - https://www.plymouth-ma.gov/sites/g/files/vyhlif3691/f/uploads/historic_guidelines_3.pdf - Page 32

Provincetown - https://www.provincetown-ma.gov/DocumentCenter/View/13047/HDC---Solar-Exclusion-Policy - Page 1

Reading – https://www.readingma.gov/DocumentCenter/View/1617/Guidelines-for-Historic-District-PDF - Page 5, 7

Rowley - https://www.townofrowley.net/sites/g/files/vyhlif4956/f/uploads/hcdmar2015_district_guidelines_with_pics.pdf - Page 2

Salem - https://www.salemma.gov/historical-commission/links/design-guidelines-updated-guidelines-now-available - Page 99 - 101

Sherborn - https://www.sherbornma.org/sites/g/files/vyhlif1201/f/uploads/guidelines.pdf - Page 9

Somerville - https://s3.amazonaws.com/ifa.somervillema.gov/documents/historic/DesignGuidelines.pdf - Page 2

Sudbury - https://cdn.sudbury.ma.us/wp-content/uploads/sites/302/2014/08/HistoricDistrictsComm_Guidelines.pdf?version=fbd1707f05fb587c0a45a62dea952410 – Page 6

Topsfield - https://www.topsfield-ma.gov/sites/g/files/vyhlif5086/f/uploads/historical_commission_guidelines.pdf - Page 5 - 6

Wayland - https://www.wayland.ma.us/sites/g/files/vyhlif9231/f/uploads/wayland_hdc_guidelines_final_for_posting_-_october_21_2019_0.pdf - Pages 11, 20

Wenham - https://cms4files1.revize.com/wenhamma/HDC%20Guidelines.pdf – Page 9

West Tisbury - https://www.westtisbury-ma.gov/sites/g/files/vyhlif8396/f/uploads/historic_district_commission_design_guidelines.pdf - Page 4

Westport – https://www.westport-ma.com/sites/g/files/vyhlif7356/f/uploads/whc2017guidelinesweb.pdf - Page 12

Rhode Island Historic Districts

Bristol - https://www.bristolri.gov/wp-content/uploads/2021/08/HISTORIC-DISTRICT-COMMISSION.pdf - NA

Coventry - https://coventryri.civicweb.net/document/9686/ - Page 50 - 53

Cranston – NA

Cumberland – https://www.cumberlandri.org/wp-content/uploads/2019/09/Planning_Historic-Guidelines.pdf - Page 24

East Greenwich - http://ri-eastgreenwich.civicplus.com/DocumentCenter/View/49/Standards-and-Guidelines-for-Historic-Properties-PDF - Page NA

East Providence - NA

Gloucester –https://www.glocesterri.org/HDC-Standards-Guidelines.pdf – page 37, 39

Hopkinton - https://www.hopkintonri.org/pdf/Draft-Hopkinton-HDC-Guidebook-final-draft-000ry-013116.pdf - Page 12

New Shoreham (Block Island) - NA

Narragansett - https://www.hopkintonri.org/pdf/Draft-Hopkinton-HDC-Guidebook-final-draft-000ry-013116.pdf - Page 15

Newport - https://www.cityofnewport.com/CityOfNewport/media/City-Hall/Departments/Planning%20Zoning%20Inspections/Historic%20Preservation/Maps%20and%20Info/Design-Guidelines-2016.pdf - Pages 43, 44, 58, 63

North Kingstown - https://www.northkingstown.org/DocumentCenter/View/1159/North-Kingstown-Historic-District-Commission-Rules-and-Regulations-PDF - Page NA

North Providence - https://northprovidenceri.gov/pdf/nphdc/NPHDC_Standards.pdf - Page NA

North Smithfield – https://www.nsmithfieldri.org/sites/g/files/vyhlif3596/f/uploads/nshdc-homeownersguide_11-09-2015-final.pdf - Page NA

Pawtucket - https://pawtucketri.com/sites/default/files/uploads/Historic%20District%20Commission%20Standards%20and%20Guidelines.pdf – Page 29

Providence - https://www.providenceri.gov/wp-content/uploads/2019/12/SolarSGamendment-final.pdf - Pages 1 - 4

South Kingstown - https://www.southkingstownri.com/DocumentCenter/View/11144/Kingston-Homeowners-Guidebook-and-Preservation-Standards--Guidelines-Oct-2022 - Page 12

Warwick – NA