



FEASIBILITY OF OFF-GRID SOLAR APPLICATIONS ON NANTUCKET

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Feasibility of Off-Grid Solar Applications on Nantucket

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Abstract

Residential solar photovoltaic systems are becoming increasingly popular on Nantucket as a way to promote sustainability and reduce demands on the electrical grid. However, there has been little attention paid to small-scale, off grid solar systems. [ReMain Nantucket](#) sponsored this project to research the feasibility of small-scale, off-grid solar applications on Nantucket with the goal of increasing public awareness of solar power. We interviewed key stakeholders across the island, researched current practices in solar power, and distributed a public survey to better understand the public's opinion on solar power, as well as several possible solar applications. We conclude by recommending applications and incentives for ReMain to pursue.

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[Nantucket Natural Resources Department](#) Director Jeff Carlson

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Executive Summary

Residential solar photovoltaic (PV) systems are becoming more common on Nantucket as residents and town officials look to make the island more sustainable and avoid the need for a third undersea electric cable. In contrast to the large scale and grid tied systems that have been the focus of the majority of the previous PV systems, the goal of this project was to evaluate the feasibility of small-scale, off-grid solar projects on Nantucket as a potential way to both reduce peak demand and raise public awareness of solar power’s capabilities on island. To achieve this goal we developed these four project objectives:

1. Review the current and best practices for the implementation of small-scale solar PV applications in New England and elsewhere.
2. Evaluate the barriers and incentives to off-grid solar installations on Nantucket.
3. Assess the benefits and limitations of possible applications of small-scale solar on island.
4. Provide promotional and informational guides for the most beneficial off-grid solar applications.

Based on our goals and objectives we developed the subtasks illustrated in Figure A. As can be inferred from this figure, interviews, surveys, site visits, background research and data collection/assessment were the primary tasks associated with addressing the objectives of this project.

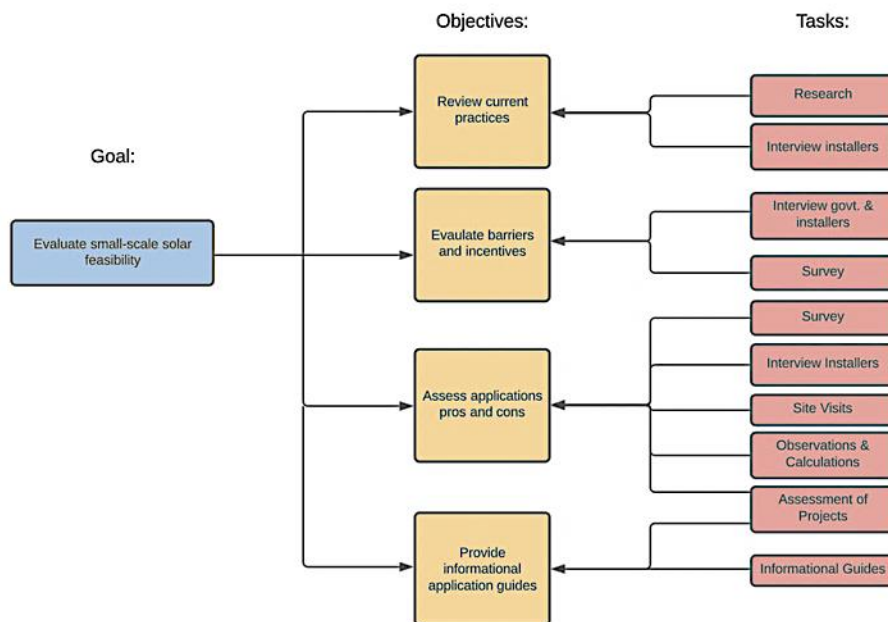


Figure A. Project objectives and tasks

Conclusions, Recommendations, and Key Findings

From the interviews conducted and survey data gathered, we developed the following observations. First, based on background research and previous studies, we concluded that solar PV systems have become increasingly popular on Nantucket with most attention being placed on residential solar installations. Based on our survey results, (Figure B), the public has little to no issue with solar panels being visible outside of Sconset and the downtown, and are a bit more conservative when discussing panels within these areas.

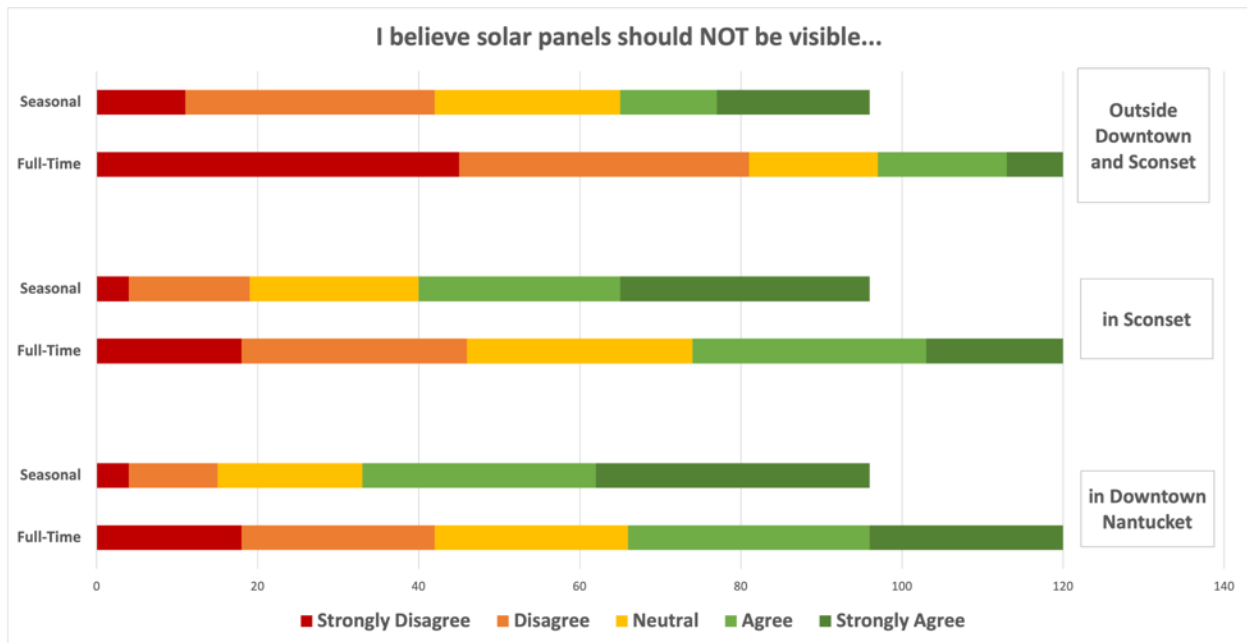


Figure B. Panel visibility concerns

Second, there are many potential small-scale, off-grid applications that could be implemented on Nantucket, though each comes with unique limitations. Based on technical and legal restrictions and public reception, we determined that solar pergolas, trash compactors, and golf cart charging systems were the most feasible applications. Some other applications showed promise but could face much opposition from the community due to concerns about their aesthetic impact. One such application was solar parking kiosks, which could be used in lieu of individual parking meters if paid parking was to be implemented in the downtown area. However, parking is currently free on Nantucket, and the transition to paid parking is a topic of debate.

Third and finally, after discussion with Tim Carruthers of ACK Smart, we concluded that caution must be practiced when pursuing off-grid solar projects on Nantucket. Off-grid solar is a relatively unexplored and unregulated field on the island. The breakthrough projects into the

field must be well-received in order to pave the way for future small-scale, off-grid solar endeavors.

Based on our conclusions, we provided the following recommendations:

- 1. We recommend the DPW continue to apply for grants to replace [Bigbellys](#) on island, and work to install additional compactors at popular public parking lots and other venues outside of the historic cores.**

The DPW has asked for funding to replace the bins at the five locations that have Bigbelly trash compactors on island. The lifespan of the barrels is about 6 to 10 years and the technology of the bins themselves have improved drastically since their initial installation. According to Recycling/Solid Waste Coordinator Graeme Durovich, the DPW has requested \$151,000 to replace all of the existing bins. We feel that the wider deployment of compactors could save the DPW time and money, while simultaneously promoting solar power's usage. Such trash compactors were found to be the most favorable while also having the least negative visual impact on the aesthetic of the island. They were well received by both full time and seasonal residents who took the survey as shown in Figure D. From this data, we concluded that trash compactors will have the least pushback from the public and the most potential to have a positive impact on Nantucket.



Figure C. Bigbelly trash compactors on Nantucket

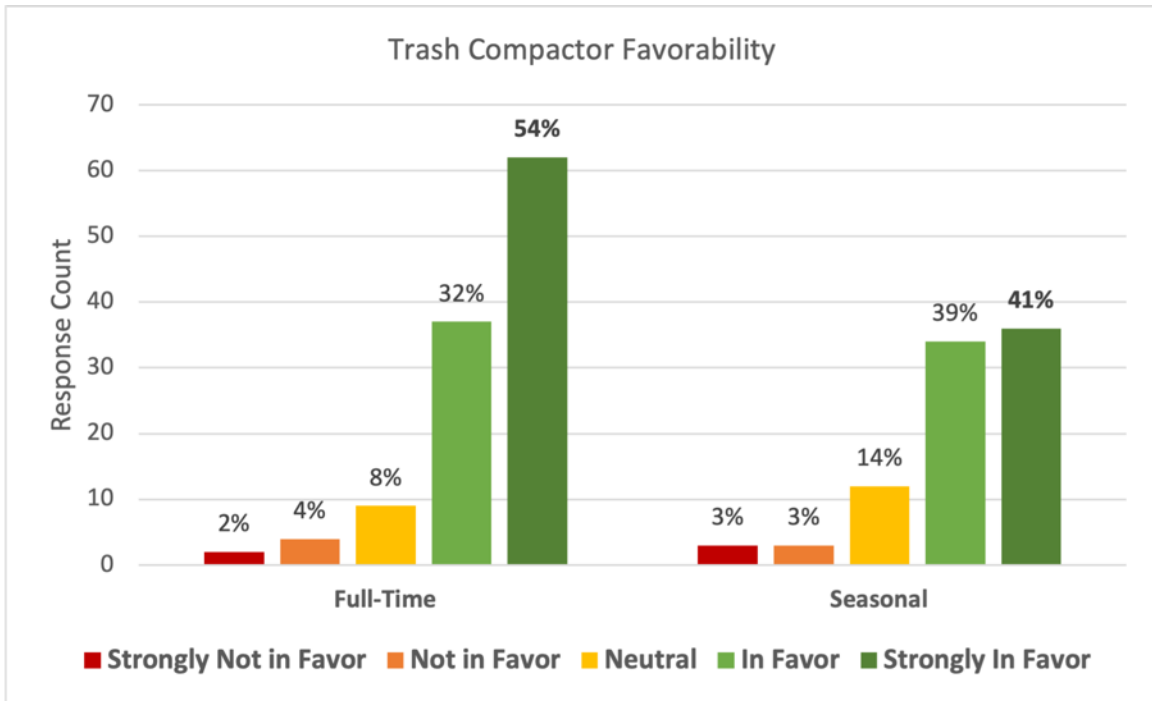


Figure D. Trash compactor favorability by residency

2. **We recommend that ReMain Nantucket publicize the current solar pergola construction at The Corner Table Cafe as an example of the benefits of small-scale solar and identify potential new locations to encourage projects.**

Considering ReMain is already familiar with installing pergolas and have had success with them in the past, we feel that they should promote their installation and use. We know that these pergolas are compliant with HDC regulations as long as they are constructed high enough so the panels are not visible from the street. As solar power has become more popular on the island, many stakeholders agree that the HDC’s approach to applications has evolved, as all parties involved work to find a middle ground between preserving the island’s signature character and moving the community forward in terms of sustainability. Solar pergolas are an aesthetically viable option that would both preserve the island’s aesthetic and encourage solar usage.

3. **We recommend that local golf courses pursue the gradual adoption of charging their golf carts, among other elements such as clubhouses and irrigation systems with solar PV systems.**

The island has several golf courses: Miacomet, Siasconset, Nantucket, and Sankaty Head. Courses could implement pergolas or garages away from the public view and would operate similarly to the pergola at [Wheels of Delight](#) that has a roof-mounted solar array

to charge their bikes. Typically, the HDC reviews and approves or denies all publicly visible solar installations to ensure they do not detract from the island's character. However, their jurisdiction only applies to permanent architectural structures that are visible from a publicly traveled way. The golf courses on the island are relatively secluded from the public eye. Due to this, the level of HDC involvement would most likely be limited, if present at all. This gives golf courses unique potential for solar development.

4. We recommend that the Town of Nantucket conduct further research into the topic of paid parking in the Nantucket downtown area (either seasonal or yearly) and that solar powered parking kiosks be considered in lieu of individual parking meters.

We understand that paid parking currently does not exist on Nantucket and that there is a desire for it to remain this way. However, research could be conducted to better understand if paid parking could help reduce the traffic issue in the downtown area. If so, parking kiosks could help solve the public parking issue while also promoting solar on the island.

5. We recommend that ReMain purchases and lends out a solar generator, similar to ACK Smart's "Solar Flower" for public and private events around town.

A solar generator would be an effective public relation tool for ReMain. The generator would highlight the potential for solar power on the island and could be designed with the ReMain logo to help promote their organization. Based on interviews with members of local solar installer ACK Smart, who had owned and used a similar generator, the device is a powerful public relations tool, generating excitement in the community and finding a surprising amount of uses.

Authorship

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<u>Acknowledgments</u>	All	All	All
<u>Executive Summary</u>	All	All	All
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<u>Background</u>	All	All	All
<u>Electricity Provision on Nantucket and Peak Demand</u>	Keith	Blaise	Garrett
<u>Solar Power on Nantucket and Public Adoption</u>	Keith	Alicia	Garrett
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<u>Wheels of Delight</u>	Alicia	Keith	Blaise
<u>Solar-Powered Trash Compactors</u>	Alicia	Keith	Blaise
<u>The Bigbelly Program</u>	Alicia	Keith	Blaise
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<u>Objective 4: Provide Promotional and Informational Guides</u>	Keith	Blaise	Alicia
<u>Findings</u>	All	All	All
<u>Stakeholder Perspectives</u>	Keith	All	All
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<u>Technical Limitations and Installers</u>	Keith	All	All
<u>Public Survey Results</u>	Garrett & Blaise	All	All
<u>Application Assessments</u>	All	All	All
<u>Solar Pergola</u>	All	All	All
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<u>Towable Solar Generator</u>	Alicia	All	All
<u>Outdoor Lighting for Restaurants and Other Venues</u>	Garrett	All	All
<u>Golf Cart Charging Pergolas</u>	Blaise	All	All

<u>Additional Pergola and Household Applications</u>	Blaise	Alicia	Garrett
<u>Conclusions and Recommendations</u>	Alicia & Keith	Garrett	Blaise
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<u>Appendix B</u>	All	All	All
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Introduction

Nantucket's electricity is provided through two undersea cables owned and maintained by National Grid. Due to the island's increasing peak electrical demand however, there is growing concern that a third cable will have to be installed, coming at a high cost to the town and utility customers. Given this concern, individuals and organizations on island have been involved in multiple efforts to reduce the peak demand on the electrical grid. One electrical energy reduction program has been the encouragement of the construction and installation of solar photovoltaic (PV) systems. In recent years, the number of PV installations on island has increased rapidly, but most of which are roof-mounted and residential.

One application of solar power that will likely have a minimal impact on reducing cable energy usage but could have a significant impact on educating visitors and citizens to the use of solar power is the identification, development and deployment of PV systems to power off-grid applications. [ReMain Nantucket](#), a philanthropic and entrepreneurial organization based on Nantucket, has historically supported off-grid solar by installing PV systems on local bus shelters to power lights. ReMain hopes to continue to promote and expand the use of solar and off-grid power on Nantucket by identifying applications and thus contributing to a "multi-pronged" effort to reduce the strain on the Nantucket electrical grid.

The goal of this project was to evaluate the feasibility of small-scale, off-grid solar projects on Nantucket. To achieve this goal we developed these four project objectives:

1. Review the current and best practices for the implementation of small-scale solar PV applications in New England and elsewhere.
2. Evaluate the barriers and incentives to off-grid solar installations on Nantucket.
3. Assess the benefits and limitations of possible applications of small-scale solar on island.
4. Provide promotional and informational guides for the most beneficial off-grid solar applications.

To achieve these objectives, we conducted interviews with solar power companies, installers, local committee members, and members of the public. In conjunction with ReMain, we also created and distributed a survey for residents of Nantucket to determine public opinion on various small-scale solar applications and to identify areas of need and opportunity. Subsequently, we presented ReMain with a formal assessment of off-grid solar application options. Each assessment included relevant statistics, consideration factors, and figures. Finally, we provided ReMain with a set of recommendations on how to move forward with the adoption of small-scale solar power on the island.

Background

In this chapter, we provide a short introduction to the electrical energy consumption patterns on Nantucket. From there, we discuss the social, legal, and engineering context affecting non-grid tied solar projects and their possible benefits to the island. We conclude with some case studies looking at similar projects in other local communities.

Electricity Provision on Nantucket and Peak Demand

Nantucket's electricity is provided by National Grid, through two undersea cables, the first being a 36MW cable that was installed in 1996. As seen in Figure 1, due to the island's rapidly rising energy needs, a second 38MW undersea cable was installed in 2006 (Sinatra, 2015). As a popular summer resort, Nantucket's population fluctuates dramatically, swelling from around 15-16 thousand in the off seasons to 70-80 thousand in the summer (Graziadei, 2021). Peak demand in the summer tourist season typically occurs in late afternoons and early evenings (Sinatra, 2015). Figure 2 shows that peak demand has been

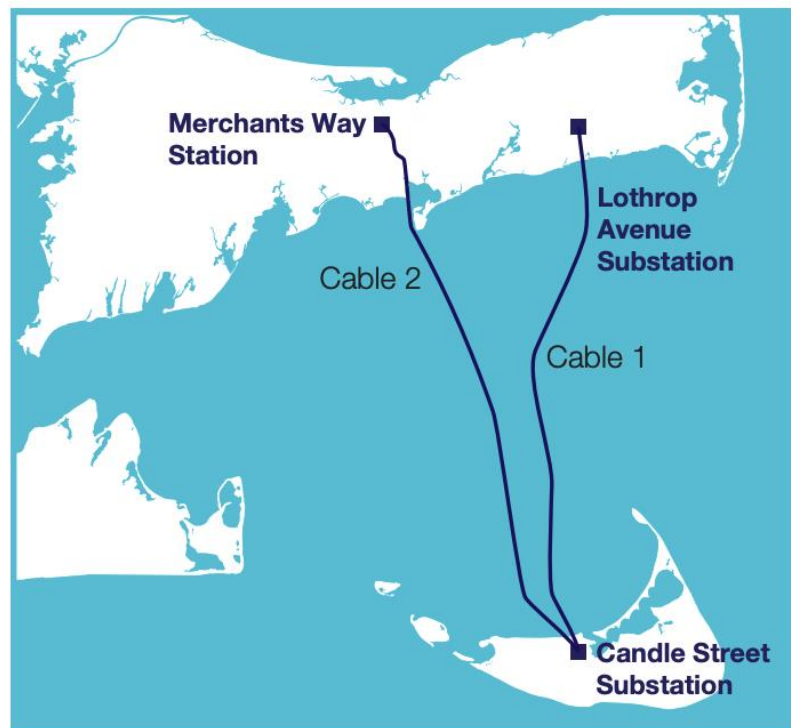


Figure 1. Nantucket's two undersea cables (Nantucket Peak Load, n.d.)

rising over the past decade and now exceeds the capacity of either cable alone. Thus, if one cable were to fail, the island would likely experience power outages until the cable was repaired or generators were used. Furthermore, peak demand has been rising steadily since 2008, aside from a decline in 2014 and 2017 (Figure 2). This has led to a growing concern among the local government officials and residents that National Grid will have to install a third undersea cable to accommodate the island's increasing peak demand which would come at a high cost and most likely be felt directly by the Nantucket utility customers.

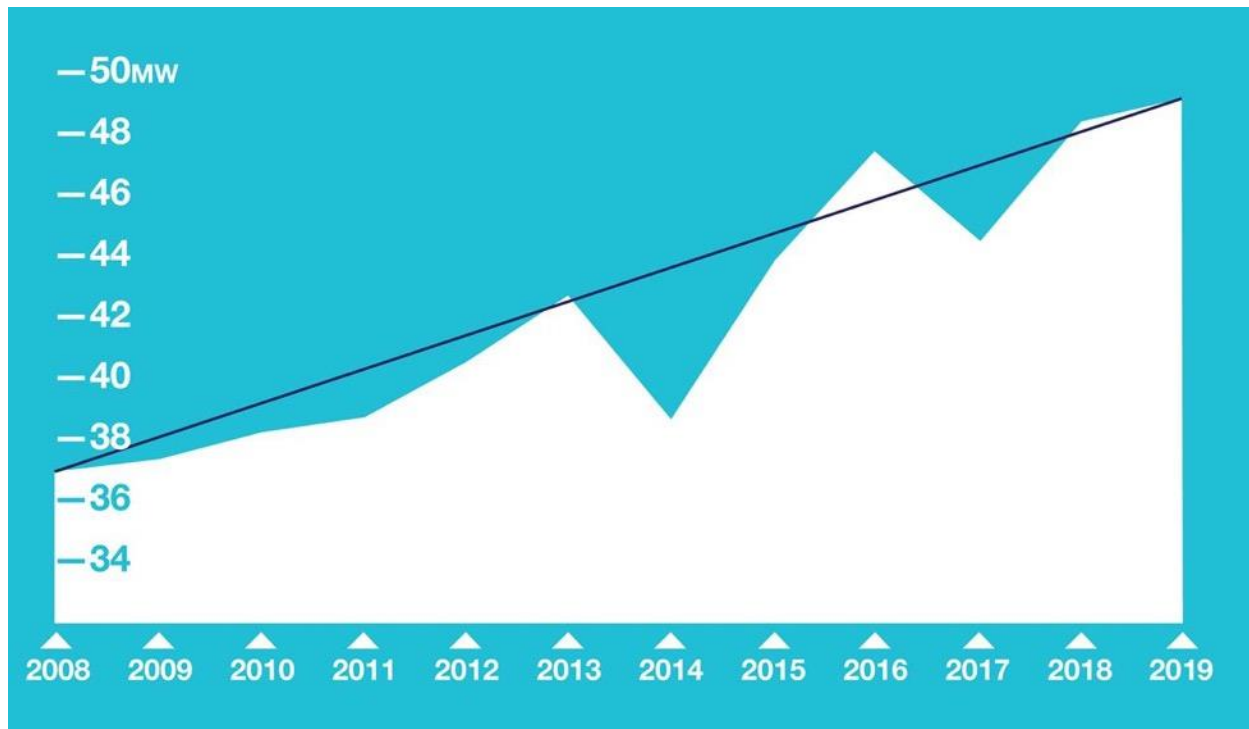


Figure 2. Peak electrical demand in Nantucket (Need & Benefit, 2019).

Given these concerns, many individuals and organizations, including [Nantucket's Energy Office](#) (NEO), have been investigating options to reduce peak load and provide more sustainable energy. In recent years Nantucket has taken on multiple projects to address the issue, building a wind turbine next to the high school, installing generators to provide emergency energy on island, and the recent addition of a Tesla battery system which charges from the grid and discharges during peak demand hours to attempt to alleviate the strain on the cables (Lambert, 2019). Another important sustainable energy source are photovoltaic systems. On island, medium to large scale residential grid-tied PV systems are well regulated by local government offices and maintained by multiple solar installation companies. [ReMain Nantucket](#) has sponsored this research to investigate the lesser-known field of small-scale, non-grid tied solar projects on Nantucket and their possible impact on peak demand, as well as for educating the public about other sustainable energy sources.

Solar Power on Nantucket and Public Adoption

Residential solar PV systems have become increasingly popular in Nantucket over the past decade, although some citizens and officials have expressed concern about their effect on the island’s historic and aesthetic character. The mission of the Nantucket [Historic District Commission](#) (HDC) is “the preservation and protection of historic buildings, places and districts of historic interest” (Historic District Commission: Background, 2020). Pursuant to this mission, the HDC has established guidelines for the installation of solar PV systems in Nantucket and must approve all applications prior to installation. In 2017, a study found the HDC permitting process for solar PV systems was confusing for all parties and an “unnecessary barrier” to installers (Boyer, Kirwan, O’Neill, Pietrowicz, 2017). This is not to say the HDC is against solar PV per se. The commission board’s chair Raymond Pohl said, “there isn’t a person on the board who is against renewable energy,” rather their concern was the visual impact of panels on houses and in public, specifically in the downtown and historic districts (Norton, 2019). Small-scale solar applications might avoid aesthetic concerns by being designed to be more discrete and/or more easily “hidden” to minimize visual impact.

Residential and commercial PV installations on Nantucket have been steadily increasing (Figure 3 and 4). As seen in Figure 3, the number of solar installations on Nantucket has been increasing at an exponential rate, with an average yearly percentage increase of 56%.

Unfortunately, there is no central database for PV installations on Nantucket and the data in Figure 3 was

gathered by cross examining multiple sources. The apparent dip in installations in

2019 is an artifact of the data since the only data currently available through the [Nantucket Energy Office](#) for that year is from a rebate-based incentive program, and therefore may be incomplete (Final_SMART Qualified_Units, 2021). As of this writing, sources disagree on the exact number of installations on the island but there are currently upwards of 90 individual systems. (Nantucket Solar Map, n.d.).

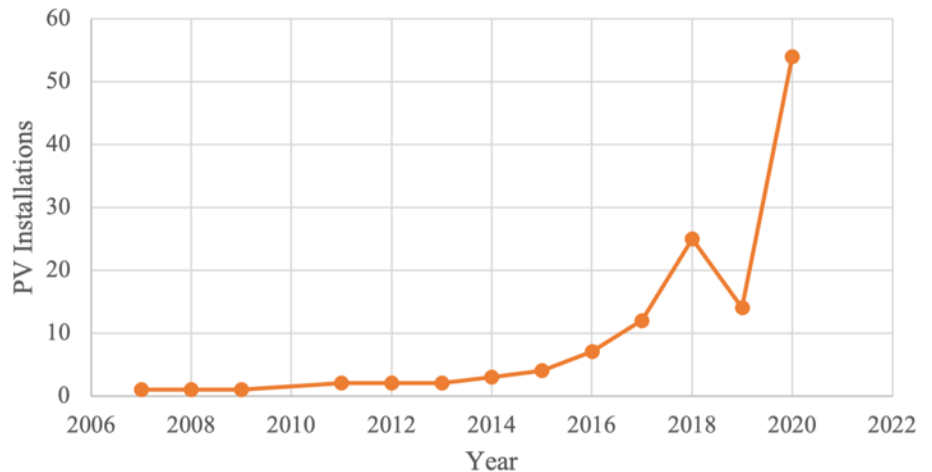


Figure 3. PV installations on Nantucket over time (Boyer, 2017; Data and Reports, 2018; Final_SMART Qualified, 2021)

As PV systems become more common on Nantucket, the town has considered loosening regulations that limit their installation (Bushard, 2021). The island’s grid components, however, are nearing their current capacity for PV systems (L. Sinatra, personal communication, November 10, 2021). While other research projects have found that “large-scale deployment of PV alone will not have a significant impact on Nantucket’s peak electrical demand” based on studies and calculations,

the concept of using solar as one part of a “multi-pronged” approach to promoting sustainability has shown promise (Sinatra, 2015). Part of this approach might be encouraging greater public awareness and adoption of more sustainable practices, by showcasing innovative, small-scale solar systems designed to meet particular

needs. Ultimately, the concept of “snowball sustainability” could contribute to the island’s reduction of peak electrical demand. Snowball sustainability refers to the behavioral-economic observation that individuals tend to engage in sustainable practices when their neighbors and fellow citizens do (Coniff, 2009).

Non-grid tied solar projects may help promote sustainability on the island and contribute to a “multi-pronged” solution to the island’s energy needs. Part of the establishment of this norm, however, is attaining a comprehensive understanding of the current regulations and engineering practices surrounding solar energy systems.

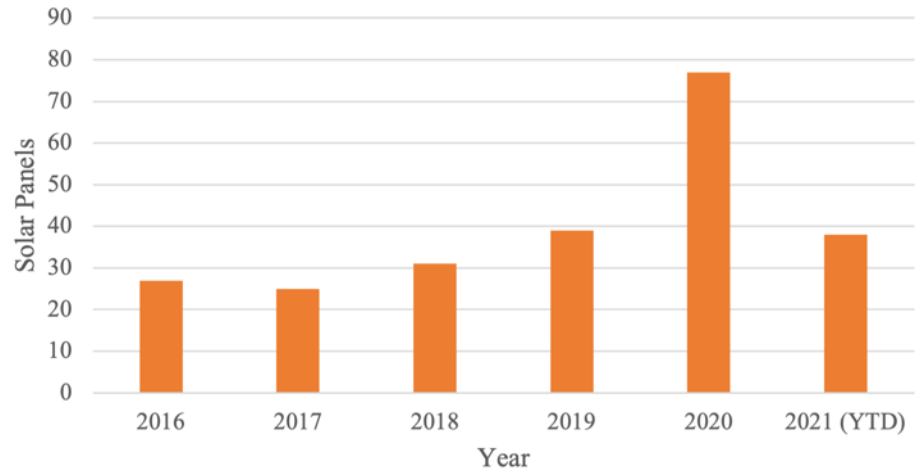


Figure 4. Solar panels installed on Nantucket (HDC Monthly Data, 2021)

Government Involvement in Solar Power: Regulations and Incentives/ Opportunities

On Nantucket, grid-tied solar systems are regulated by the state and local government agencies. Massachusetts is primarily responsible for the building and electrical codes, but the rules are enforced and implemented by the local governments that may have additional planning and zoning restrictions. Additional restrictions may also be imposed from other local entities, such as the HDC and the Conservation Commission. When it comes to incentives, most statewide and local programs apply only to grid connected systems rather than small-scale, non-grid connected solar applications, yet the opportunities that non-grid tied applications could provide may be an untapped market.

Regulations:

Nantucket is generally more restrictive when it comes to solar installations compared to other places in the state. All of Nantucket is a [National Historic Landmark District](#), however some districts such as Downtown and Siasconset are more regulated to preserve their historical nature. In all districts, the HDC oversees solar PV system installations to make sure they follow set guidelines. The primary goal of these guidelines is to ensure solar panels do not detract from the historic and aesthetic character of the town, and the HDC achieves this by regulating where and how a panel can be installed. The HDC prefers that PV and thermal systems be set up either on the ground, or out of the public's view. The Solar Technologies document from the HDC states that "The least visible application of [solar] technologies and their supplementary equipment is recommended. If the array is located on the ground, appropriate screening may be necessary. Applications of these systems as a ground array or non-contributing ancillary structures (as opposed to on the primary structure) are encouraged." (Solar technologies, n.d.) Another preference of the HDC is their support of building integrated photovoltaics (BIPV) over standalone systems. However, these regulations are meant to apply to grid-tied, home-based solar, rather than the smaller applications that are the focus of this project.

Permitting and Installation Process:

Installing solar panels on Nantucket follows a regulated process illustrated in Figure 5. It should be noted that the first and last steps in this Figure are unique to Nantucket, while the others are similar to mainland installations. From Figure 5, the procedure starts with the HDC application (Solar map & resources, n.d.). Next, one will need to get building and wiring permits, and once that is done the actual installation can proceed. Once installed, an inspection to make sure the wiring and construction are secure and follow codes will take place. There will need to be several inspections from both National Grid (if the system will be connected to Nantucket's

energy grid) and the HDC once the structure itself is cleared. The Nantucket Energy Office estimates that this process takes around 4 to 5 months before the solar system is set up and has fully passed inspection (the HDC steps alone add about a month or two to the overall time compared to on the mainland) (Nantucket Energy Office. (n.d.)). An important note is that the installation process outlined by the Nantucket Energy Office is meant specifically for grid connected panels. Because the installations that this project investigates are smaller off-grid applications, this process may be accelerated or even exempt. For example, solar powered trash compactors will not need to have wiring inspections since they operate as standalone units.

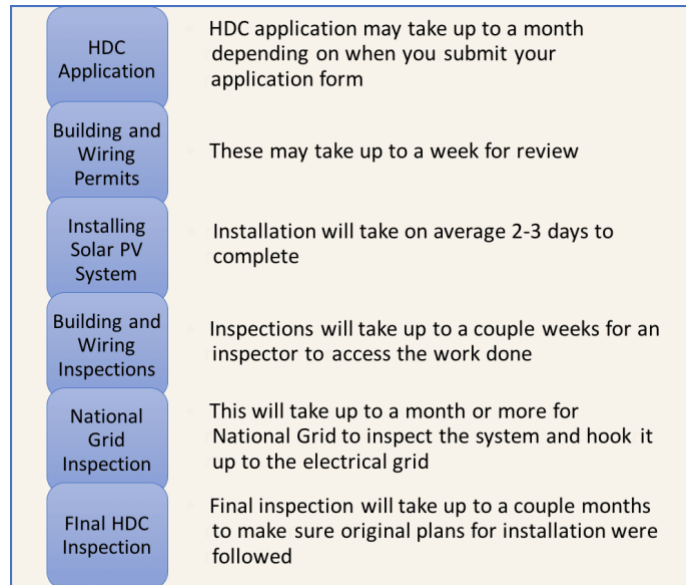


Figure 5. The permitting process for installing a solar system on Nantucket (*Solar map & resources*, n.d.)

Incentives and Opportunities:

One of the most important programs in Massachusetts solar incentives is the SMART program (Solar Massachusetts Renewable Target). The SMART program’s goal is to make solar energy use more widespread throughout the state, and does so by providing incentives such as monthly payments if the system was purchased outright, net metering credits, and tax credits for those who install PV (SMART Incentive Program | Eversource, n.d.). However, the applications we are considering may not be eligible, as Eversource states, “To qualify, your PV solar energy system must be smaller than 5 MW, connected to the Eversource Massachusetts grid and installed after Jan. 1, 2018.”(SMART Incentive Program | Eversource, n.d.). The SMART program also applies to the National Grid system, which is the primary energy provider for Nantucket. However, this project focuses on non-grid tied systems¹, so it is likely no incentives or payback programs will apply.

Despite there being a lack of government incentives for small-scale applications of PV systems, the opportunities presented due to consumer demand for unique PV applications will be

¹ In this report, we will use the terms “small-scale,” “off-grid,” and “non-grid tied” interchangeably.

a driving factor in the selection of projects. For example, while a rebate might not be offered for a solar charging station set up on or near a beach, consider the number of people who might use their cell phones or laptops while there. A charging station set up at a table near a concession stand might be used on a regular basis. A solar powered trash compactor that is emptied five times less than a regular trash bin will reduce labor and fuel costs. In sum, incentives for small-scale PV applications will come not from government rebates, but from the reduction of energy costs and improvement of overall island sustainability.

Variety of Small-Scale Solar Implementations

In order to provide ReMain Nantucket with a list of possible small-scale solar power ideas, we decided the best course of action was to look at current practices of solar on the island and better understand how these practices have made an impact. We then used this understanding of the current state of solar on Nantucket to craft a list of possible applications that could be installed. The possibilities of solar-powered implications are endless; ranging from transportation to charging applications. We describe a few below.

Wheels of Delight:

Nantucket already has some small-scale solar systems. The bicycle rental company, [Wheels of Delight](#), uses a solar-powered pergola to charge their fleet of rental electric bicycles (Figure 6). The pergola is constructed of recycled cedar wood, making the entire structure environmentally friendly. The bicycles sit underneath the pergola to recharge while not in use by a renter.



Figure 6. Solar-powered pergola used at Wheels of Delight (E-Bike Sales Rentals, n.d.)

Wheels of Delight was founded in 2011 when Zach Dusseau, owner of [ACK Smart](#) solar company, and Tobias Glidden, an employee at ACK Smart solar, wanted to find an appealing way for solar power to gain traction on the island in order for the Nantucket community to become more sustainable. These electric bikes did just that. In one summer, the electric bikes logged 14,000 miles. On one charge, an electric bicycle can travel about 40-50 miles at a speed of up to 20 mph. Given that Nantucket is only 14 miles long, the stored charge of these electric bicycles allow users to explore the island for the entirety of a day. Glidden stated that, “The average car trip is less than two miles. If we could use an e-bike for half of these trips, we’d cut our traffic down by fifty percent.” (Nimerfroh, 2019).

Solar-Powered Trash Compactor:

Another idea for how to implement small-scale solar on Nantucket is by utilizing solar-powered trash compactors. This idea was taken from a journal which discussed the design of a solar-powered waste management system. Trash compactors are systems that pack down trash inside of the trash bin so the bin does not need to be emptied as frequently. These systems are often found on beaches or places where it is difficult or too expensive to tap into the electricity

grid. The system itself can store power so that trash compaction can take place on a routine compaction cycle (S.M., 2018).

Public areas with high volumes of pedestrian traffic and limited access to the grid are ideal locations for trash compactors. On Nantucket, trash compactors could be well suited for beaches or bike paths. These locations experience a lot of foot traffic, especially during peak tourism season in the summer.

The Bigbelly Program:

[Bigbelly](#) trash compactors (Figure 7) are the leading solar-powered trash compactors in the industry. Their newest HC5 model compactor holds 5-10x more trash than an average waste bin. The HC5 is equipped with sensors that wirelessly report information back to the owner such as when the trash bin is full and the bin's collection activity. The power generated by the solar panels is stored and used to compact the trash and communicate live data to the operators.

Solar-powered trash compactors similar to the ones mentioned above have been used in the city of Philadelphia to help address their waste management struggles. In 2008, the city of Philadelphia replaced 700 of their generic trash bins with 900 of the Bigbelly solar-powered trash compactors.

This change was implemented “with a goal of making our streets cleaner, saving money, and improving the environment (Bigbelly Smart Waste & Recycling, 2021). The following is a list of how Philadelphia has seen these trash compactors benefit their city:

- ❖ Five times more capacity than regular bins.
- ❖ Saves the city money by:
 - requiring fewer trash collections;
 - lowering truck fuel costs; and
 - conserving landfill space.
- ❖ Reduces greenhouse gas emissions.
- ❖ Sealed to keep trash and odor in, pests out.
- ❖ Sturdy and practically maintenance free.



Figure 7. Bigbelly trash compactors

- ❖ Frees up Streets Department collection units to work on other issues.
- ❖ Inspires everyone to keep city streets free of litter.

The island of Nantucket has also had prior experience with Bigbelly trash compactors. The Department of Public Works (DPW) installed several of these trash bins at Children’s Beach and outside of the Nantucket Cottage Hospital (Figure 7). The Bigbellys efficiently compacted trash as expected; however, they were not operating at their full potential due to the lack of proper software. The DPW, for a number of reasons, never took advantage of the wireless status reporting system of the trash compactors. As a result, the DPW was unaware of when the trash compactors were full except by physically checking on the bins. Unfortunately, this limited the ability of the DPW to minimize service trips for their Bigbelly trash compactors.

Bus Shelter Utilizing Solar Power

ReMain Nantucket worked alongside the Historic District Commission (HDC) and ACK Smart to install solar power at bus shelters along Surfside Road, Milestone Road, Orange Street, and Pleasant Street in Nantucket. These bus shelters are utilized by the Nantucket Regional Transit Authority (NRTA) and their WAVE bus system. The purpose of these shelters is to provide shade, as well as generate solar power that is used to illuminate a shelter at night. The energy generated by the panels during the day is stored in a battery on the back side of the shelter. The battery is enclosed by cedar shingles which keeps it out of the public view. The solar panels on the structure can also not be seen from the street since the panels sit flat on top of the awning that hangs off of the front of the shelter (Figure 8).



Figure 8. Solar-powered bus shelter on Pleasant Street

Solar Consideration Factors

ReMain Nantucket has a history of sponsoring various sustainability projects on the island including recycling and composting initiatives, installation of a wind turbine to reduce a high school's energy costs, and Nantucket Footprints, "a nexus of information and ideas" to maintain and care for the island (Welcome to ReMain Nantucket, n.d.). This project integrates their sustainability goals with the technology of solar PV systems, with a goal of making solar PV systems commonplace on Nantucket. Through this project, we focus on whether small-scale solar PV systems are both feasible and desired. These systems would benefit residents and visitors alike with implementations for public use, private systems to benefit homeowners and businesses, and systems increasing the sustainability of town operations such as transportation and recycling. Three key points that need to be addressed through our research are whether the available solar PV systems can be implemented small-scale, whether their energy yield is sufficient for a particular application, and whether there is demand. The energy yield in tandem with the cost of systems and installation will have an impact on whether the goal of small-scale solar can be implemented and be sustainable on Nantucket.

Installing solar PV systems on Nantucket comes with many questions concerning placement, size, classification, and whether or not a particular system is connected to the grid. Stand-alone systems are connected to batteries for energy storage, and are better suited for implementations such as street lighting, information kiosks/charging stations, electric transportation charging stations, local lighting such as for a gazebo or bus shelter, and so forth. Consumers, both public and private, have to consider whether to connect their system to the grid, or have a stand-alone system based on their needs. When planning for solar PV installation and considering possible designs, key factors to consider include the energy that will be required to power the targeted system, the efficiency of energy collection, the dimensions and shape of the array, and choosing the method of installation (Hankins, 2010).

Conclusion

Based on this background research, we were able to develop a methodological approach to completing project objectives. Once we gathered a collection of possible applications, we were able to filter them using various criteria to determine feasibility. These filters were determined by the data we collected through surveys, interviews, regulations, and research on technical data of applications. These methods allowed us to gain insight into public opinion to understand residents' needs, wants, suggestions and opinions on solar applications on Nantucket. Ultimately, the data we collected and research we performed allowed us to analyze the application options we had, so that we could create a comprehensive assessment of the most feasible applications, including pertinent information, data and diagrams for each application

Methodology

The goal of this project was to evaluate the feasibility of small-scale, off-grid solar projects on Nantucket. To achieve this goal we developed four project objectives:

- 1) Review the current and best practices for the implementation of small-scale solar PV applications in New England and elsewhere.
- 2) Evaluate the barriers and opportunities for small-scale solar installations on Nantucket.
- 3) Assess the benefits and limitations of possible applications of small-scale solar on island.
- 4) Provide promotional and informational guides for the most beneficial off-grid solar applications.

The objectives and associated tasks can be seen in Figure 9. In the following sections, we will discuss our data-gathering and analysis methods to complete these objectives.

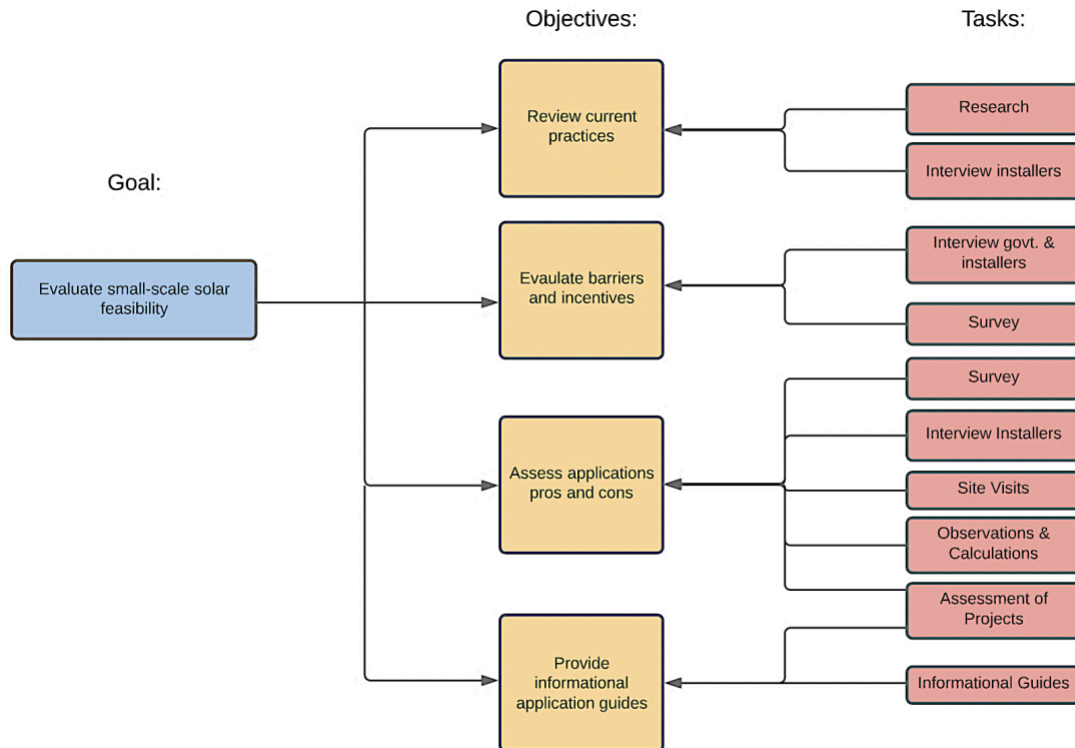


Figure 9. Project objectives and subtasks.

Objective 1: Review of Current Solar Practices

To determine what solar practices would best be suited for the island of Nantucket, we used the information gathered in our background section and searched for additional examples of small-scale, off-grid solar applications and designs. We kept an open mind to every solar application we identified and performed a feasibility analysis to determine which of these applications would most likely be implemented and accepted on Nantucket.

Along with our application research, our group interviewed representatives of local companies and other organizations that have used or are currently using solar panels as an electric grid alternative. The individuals we spoke to are numbered 1 through 4 in **Appendix A**.

Objective 2: Evaluate the Barriers and Opportunities for Small Scale Solar Installations on Nantucket

In order to better understand the field of off-grid solar on Nantucket, we conducted interviews with key stakeholders and developed a survey to gauge public opinion on multiple applications.

Interviews:

We conducted interviews with representatives of town committees and departments, such as Raymond Pohl from the Historic District Commission and Lauren Sinatra from the Nantucket Energy Office, to determine what policies and regulations might apply to the installation of small-scale PV systems in both residential and public settings. We also conducted interviews with select business owners to explore solar PV applications that might be of interest to them (solar charging stations, beach concessions, hotel pool heating, etc.). These interviewees are listed in **Appendix A**. Our interviews were a mix of in-person and virtual meetings, with virtual interviews being conducted on Zoom and Google Meets. Before each interview, we read our preamble which explained our purpose for this research and sought consent from the interviewee to publish information discussed during the interview. We also asked for consent to record during our interviews so that our team could pull direct quotes from the conversation and correctly interpret information that was discussed. Every interviewee consented to us recording the interview. We used an application called [Otter.ai](https://otter.ai) to transcribe the interview as it was recording. Our preamble can be found in **Appendix B**.

Public Survey:

By surveying the public, we sought to understand their opinion on possible off-grid solar applications as well as the community's attitude towards sustainability and historic preservation. We developed the survey instrument in an iterative process of consultation with ReMain to ensure the survey questions adequately covered the public opinion research questions we identified and sought to obtain data on. The set of topics the survey covered were:

1. Public opinion on certain small-scale solar applications on island
 - a. Public concerns about each application
 - b. Likelihood of public use of each application
2. The importance of historical and aesthetic preservation on Nantucket
3. Prevalence and perception of solar power on island

The survey was distributed online through [Qualtrics](#) and consisted of a mix of open and close ended questions (**Appendix C**).

Objective 3: Assessment of Benefits and Limitations of Off-Grid Solar Applications

In order to better understand off-grid solar technology and its capabilities and limitations, we researched systems that are currently available and identified locations on the island that would be feasible for small-scale applications. The research we conducted on current installations provided us with a look into what was feasible to implement on the island based on what was already there. Optimal locations were determined upon shading, ease of installation, and overall need for an application.

When considering location, we took into account factors such as visibility, necessity, and foot traffic. In order to determine ideal locations, we gathered data from research as well as surveys and interviews to determine most frequented locations, locations where residents see need, and locations with unobstructed sunlight. In terms of visibility, we determined the feasibility of locations such as beaches, town sidewalks, pergolas, etc. by discussing what restrictions the HDC will impose on various types of applications and locations with board member Ray Pohl. Necessity of applications was determined by surveying residents and organizations, in order to gather public opinion on what applications are desired, and the benefit they would provide to the community.

Objective 4: Provide Promotional and Informational Guides

Once we had identified projects which we had determined to be possible for ReMain and others to implement on island, we developed detailed yet simplified informational guides for selected applications and systems. We wrote these guides based on a critical analysis and assessment of our research and survey results. The promotional and informational guides were created on the site [Canva](#), structured as an informational handout, and written to include pertinent information on the application and present it in a “public-friendly” way. Each guide included one or more of the following details:

- ❖ Name and description of application;
- ❖ Picture or mockup of application;
- ❖ Succinct pros and cons list;
- ❖ Approximate price ranges or quotability;
- ❖ Proposed locations for installation;
- ❖ “Expected Usage and Popularity” determined by public survey; and
- ❖ Seasonality

Each guide was designed to be presented to the application’s appropriate audience. These guides can be found in **Appendix D**.

Findings

This section addresses the results of our research conducted in conjunction with ReMain Nantucket concerning small-scale, off-grid solar feasibility on Nantucket. We address high level findings from interviews and discussions we held with stakeholders across the island, as well as data analysis from our public survey. We include detailed assessments of multiple off-grid applications which include descriptions and data such as stakeholder opinions, costs, possible locations for installation, and benefits and downsides to each application. Finally, we provide our conclusions and recommendations for ReMain and other relevant organizations on island based on which applications were deemed most feasible.

Stakeholder Perspectives

In this section, we discuss significant findings from the interviews we conducted and provide context to each finding, including explanation and interviewee perspectives. The findings are grouped into three overarching topics: public relations, HDC jurisdiction, and technical limitations.

Off-Grid Solar and Public Relations

Nantucket Energy Office Coordinator Lauren Sinatra indicated that off-grid solar applications “really won’t make that much of an impact” on the island’s peak electrical demand (L. Sinatra, personal communication, November 10, 2021). This concern was one many interviewees shared, including local HVAC specialist Mike Dobbert, because the majority of the applications do not provide enough alternative energy to sufficiently reduce demand on the grid (M. Dobbert, personal communication, November 5, 2021).

This is not to say off-grid solar projects are a futile endeavor. Many stakeholders, including ACK Smart Business and Operations manager Tim Carruthers, explained this point and helped us understand the benefits and limitations of such applications. First, Mr. Carruthers helped us narrow down our initial list of applications as he explained that some applications were not likely because they would not be able to produce enough energy to serve their purpose, such as battery-powered outdoor heaters. When discussing the more feasible applications however, he mentioned that the potential public relations impact that off-grid solar could have on the island is enormous. Small-scale solar could easily act as a “proof of concept” to the public that solar power can be well integrated on Nantucket without creating an eyesore or needing to be hidden on the back of the more remote homes. Nantucket’s community is tightly-knit where, as Lauren Sinatra put it, “nothing spreads faster than word of mouth” (L. Sinatra, personal communication,

Nov. 10, 2021). Should these applications be implemented around island, they could help establish solar as an accepted and acceptable technology on Nantucket. As Mr. Carruthers put it,

“When you go to build a house, everyone knows you're going to put a front door and windows on the house. So the HDC has control over that but they can't tell you can't have a front door. They just tell you that it's got to look nice. And it's got to fit in. And likewise with the windows. And that's where we need to get to with the HDC and solar. It has to be, yes, you're going to have solar and we're going to work with you on making it look nice” (T. Carruthers, personal communication, November 1, 2021).

To this point, [Department of Natural Resources](#) (NRD) Director Jeff Carlson mentioned that, although there has been an increase in residential solar PV system popularity on island (see: [Technical Limitations and Installers](#)), Nantucket is a community where one often hears the phrase “but we’ve always done it this way” (J. Carlson, personal communication, November 18, 2021). That is to say, some changes are an uphill battle on the island, especially those that affect the aesthetic and historic character of the island. Small-scale solar could prove an invaluable tool in the effort to make residential scale solar a standard, and therein lies one of its long-term values.

HDC Jurisdiction and Regulation

From our interview with HDC Chair Raymond Pohl, we developed a better understanding of the Commission’s role and areas of jurisdiction on island. The HDC’s official jurisdiction covers only “architectural features visible from a publicly traveled way,” and does not apply to town property such as sidewalks and roads (R. Pohl, personal communication, November 4, 2021). The distinction between “architectural features” and mobile applications is a very important one, with architectural solar installations being systems more like the typical residential installations, where panels are permanently affixed to structures, and mobile applications consisting of those that are easily moved and do not require architectural integration (e.g. towable generators and some phone charging stations). While this means the HDC has no direct control over mobile applications, the Commission would likely appreciate being consulted as a courtesy.

The members of the HDC are not against solar power on the island, but they must fulfill their mission to preserve Nantucket’s historic character. Lauren Sinatra has worked with the HDC on multiple projects over the years and believes the Commission is now more willing to compromise in an attempt to find a balance between preservation and sustainability (L. Sinatra, personal communication, November 10, 2021). While the design and installation process for

mobile applications would be significantly easier than typical residential systems because HDC approval is not required, that balance of preservation and sustainability should be prioritized when developing and deploying any mobile application.

The NRD may also have to be consulted depending on the application and location. Director of the Department of Natural Resources Jeff Carlson explained how permitting through the NRD would be on a case by case basis. When looking to proceed with a large installation, even seasonally, “it depends upon where they’re going to be situated and where they’re going to be.” Mr. Carlson mentioned that being within 100ft of a “resource area” is a definitive situation where permitting would be required, but any groups looking to install any such devices should still consult with the NRD before each installation to ensure they are following all proper procedures (J. Carlson, personal communication, November 18, 2021).

Technical Limitations and Installers

Based on discussions and site visits with representatives of ACK Smart, powering applications with a constant energy need is simpler than powering applications that drain power less predictably. For example, a pergola with panels and a battery storage system set up outside a restaurant to power lighting during the evenings can be built based around the power needed overnight, since the lights draw a consistent and predictable amount of power. Applications like charging stations however are more complicated, as power is drained sporadically as people plug and unplug their devices. If devices are left plugged in, any battery system connected to the device will “trickle drain” power to it passively. Along with this insight, ACK Smart explained that when installing small-scale solar on pre-existing systems such as outdoor restaurant lighting, it is preferable to install an entirely new system instead of attaching panels to a pre-existing electrical circuit (T. Carruthers, personal communication, November 1, 2021). This is due to the added complexity of rewiring systems that were made to be grid tied into panels or battery storage options. This could increase costs, and while every application’s pricing is unique and changes based on shading, weather, and a myriad of other factors, Zach Dusseau of ACK Smart provided us with some approximate pricing guidelines for solar panels. Currently panel power production is around 1200W per 100 square feet of panel surface and can cost around \$3.75 to \$4.50 per watt depending on the panel and installer, on top of installation fees. ACK Smart has indicated that they would be interested in being hired to consult, provide quotes, and install multiple off-grid solar projects (Z. Dusseau, personal communication, November 17, 2021).

While residential solar is becoming more and more affordable, Lauren Sinatra indicated that Nantucket’s current infrastructure is reaching its solar capacity, due to current limitations at the local substation to prevent surplus energy generated on the island from backfeeding onto the existing undersea cables to the mainland. Since the cables are engineered to only deliver power

one direction: from Cape Cod to Nantucket, a power back feeding scenario could be catastrophic to the island’s welfare and resiliency. (L. Sinatra, personal communication, November 10, 2021). This gives off-grid solar projects a unique advantage, as they could be a way to keep solar development in the public’s view and maintain the increasing momentum of solar installations on the island that Ms. Sinatra and the Nantucket Energy Office have seen over recent years.

Public Survey Results

54% of respondents were full time residents and 43% were seasonal. Respondents answered questions on a scale of 1 (Strongly Disagree/Not in Favor) to 5 (Strongly Agree/in Favor) with the five statements shown in Figures 10 and 11.

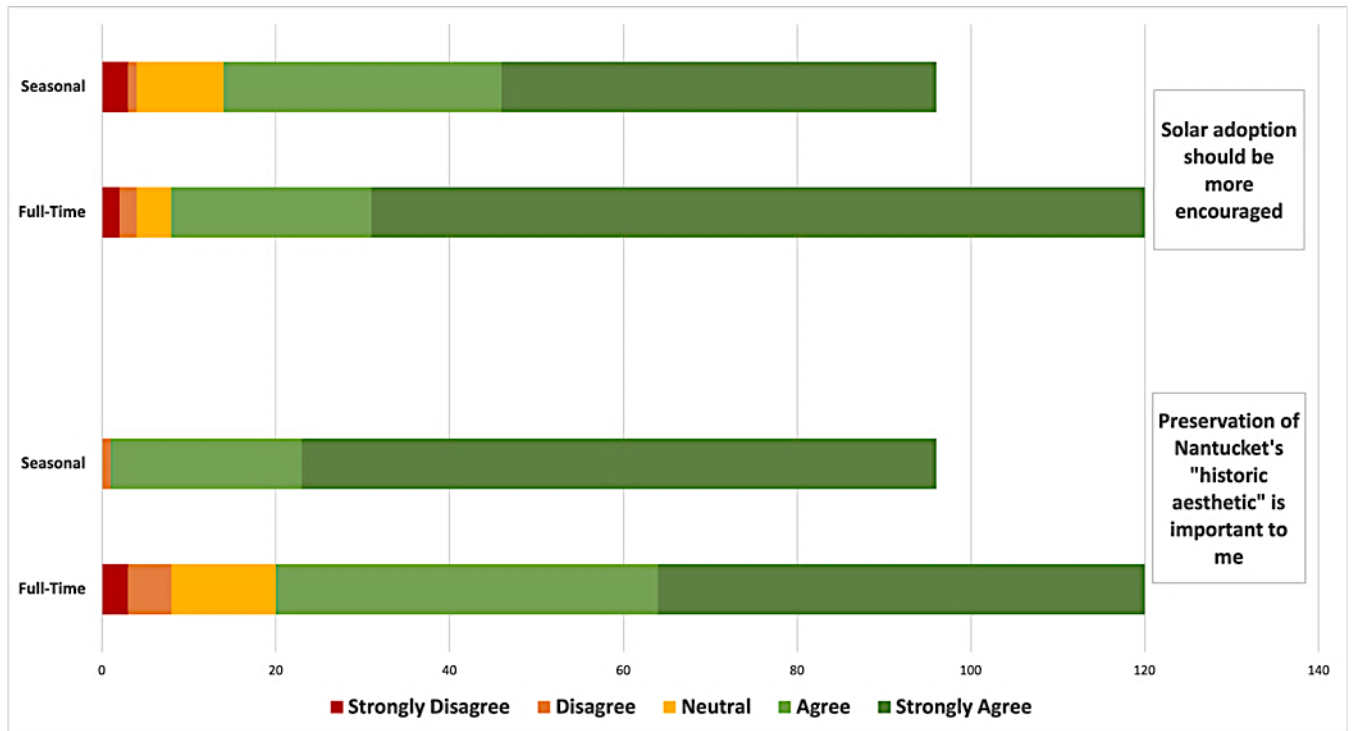


Figure 10. Agreement with solar adoption and aesthetic preservation

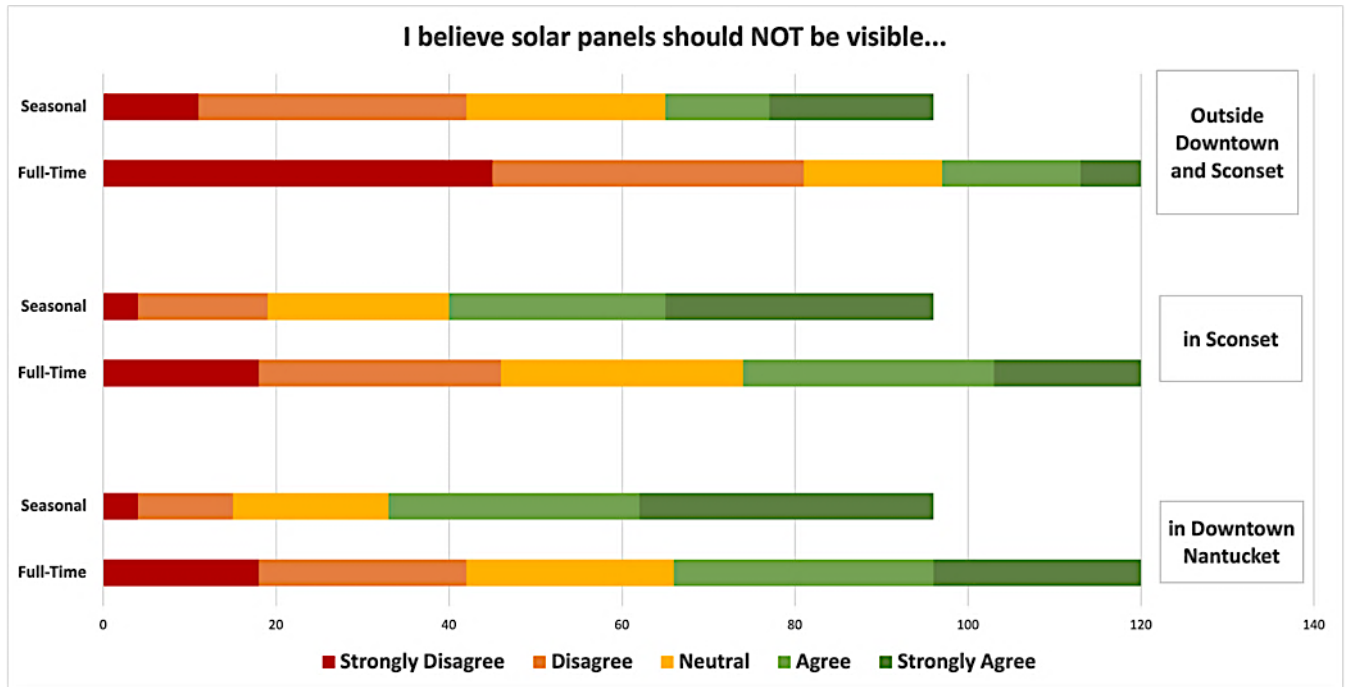


Figure 11. Panel visibility by location

“The preservation of Nantucket's "historic aesthetic" is important to me.”

In this question, the breakdown between full time residents and seasonal residents was similar, with both groups’ rating the preservation of aesthetic with high importance.

“The adoption of solar power should be encouraged more on Nantucket.”

The data distributions of encouraging more solar on the island and preserving the historic aesthetic were close to identical. From this data, we can report that Nantucketers wish to see more solar just as much as they wish to keep the current look of the island.

“I believe solar panels should NOT be easily visible in downtown Nantucket.”

This is where the first major split between full time and seasonal residents occurs. The full time responses are almost split perfectly even, compared to a visible left-tailed distribution for the seasonal data. This data tells us overall that Nantucket residents would prefer that solar panels not be easily visible inside the Downtown district, yet this sentiment is held more strongly by seasonal residents rather than people who live on the island year round.

“I believe solar panels should NOT be easily visible in Siasconset”

There was a difference in opinion between full time and seasonal respondents. Like the previous question, the full-time responses were more neutral than the clear left-tailed distribution of the seasonal residents. Seasonal residents felt strongly about not having easily visible panels in Siasconset. Full-time respondents did not come to a consensual agreement.

“I believe solar panels should NOT be easily visible outside of downtown and Siasconset on Nantucket.”

Residents were, on average, more accepting of easily visible solar panels outside of historic district zones, rather than inside them. The full-time respondents had a very negative response to the question, both negatives outweighing the other responses. The seasonal responses were more scattered, with Disagree being the highest response, and Neutral and Strongly Agree also having a sizable count. Full time residents are more supportive of easily visible panels outside of the historic zones of Downtown and Siasconset, whereas seasonal residents are split in their opinion.

The data shown in Figures 10 and 11 offer several important insights. The first is that seasonal respondents tend to be less in favor of visible panels and more supportive of the historic aesthetic of Nantucket than full-time residents. The second insight is that Nantucket residents value both the historical aesthetic of the island and encouragement of solar installations very highly. Finally, Nantucket residents would prefer that easily visible solar systems be outside the two major historic zones of Downtown and Siasconset.

Analyzing the survey data for various applications helped us to make key conclusions based on the opinions and views of respondents. These conclusions regarded the aesthetic impact, frequency of use and favorability of each application in order to gauge residents' interest in seeing these applications on island. Using surveyees' opinions, we determined the most to least favored applications were Bigbelly trash compactors, Charging Stations, Informational Kiosks and Charging Lockers respectively. Trash compactors are both a necessity, and a discreet application, and residents believed they would impact the aesthetic the least and had the most favorability of the applications. One respondent stated: “I believe trash compactors are valuable. If it is between trash compactors that are slightly different from the aesthetic and litter that enters our waterways, I am in support of more trash compactor installations.” Charging stations were also favored, and would likely be even more favored by visitors, who represented an insignificant demographic in our survey. A respondent stated, “I feel like having them in central locations would be great... Stop and Shop, the Airport”. Charging lockers were found to be the least favored, as surveyees responded that they would have the most negative impact on aesthetic and expressed concern that the application was not necessary, and that people needed to put their phones down and enjoy the scenery. Although more favorable, many people held the same opinion on charging stations. Informational kiosks, although not least favored, were still found to have a lack of interest and intent of usage by respondents, one stating “We already have too much information on cell phones. we don't need more” and another echoed “does not meet a need.”

Application Assessments

After a basic analysis of systems and locations, we examined in greater detail the factors that were more pertinent to consider for each application, but also recognized that there were implementation factors common to all small-scale PV applications. For example, an application was deemed useful only if its installation was feasible and its location provided a benefit to the citizens or area. A common factor was also the solar exposure of an application. If the location or application would not reliably collect the required amount of solar energy to power itself, it was removed from the list. Another factor we considered was cost, both monetary and opportunity cost, as an application that is expensive to buy, install and maintain is not ideal.

Our analysis of various application specific and general factors resulted in detailed assessments of possible small-scale solar projects for ReMain’s consideration. These assessments were then adapted to informational and promotional guides to fulfill our fourth and final objective (**Appendix D**).

Solar Pergola

A solar pergola is a wooden structure with roof mounted solar panels that is designed to offer shaded seating for the public while also generating solar power. The solar panels lie flat on the roof and are not easily visible from the ground. Figure 12 shows the pergola at the Corner Table Cafe in downtown Nantucket. This pergola does not currently have panels along its roof, but ReMain has partnered with ACK Smart to install panels to power outdoor lighting year round (T. Carruthers, personal communication, November 3, 2021). Excess power generated will be fed back into the building’s systems.

As a result, this particular application is not considered “small-scale” in terms of not being grid tied but is an example of a system that could be non-grid tied and used for lighting, solar charging or other “small-scale” applications.

Another business in the downtown area, Wheels of Delight, rents electric bicycles that are charged underneath their solar pergola, pictured in Figure 6. Several bus shelters also already have solar pergolas attached, such as the Pleasant Street bus stop (Figure 8), which powers lights inside.



Figure 12. Solar-viable pergola at Corner Table Cafe

Pergolas retrofitted with solar could be used to power a number of applications. For example, a string of outdoor lights could be run on a battery system that charges from the pergola during the day. An information kiosk could be run underneath a bus station pergola, providing information on bus routes and bus locations to passengers. As well, beaches are an option for installation sites, as pergolas could provide shade for beachgoers at concession stands or on the beach itself without being an eyesore.

Solar pergolas are a discreet and adaptable method of solar energy, allowing their installation process to be somewhat easier. Proof of this can be seen in that the HDC has already approved installations on island. Ray Pohl of the HDC described his interest in pergolas as they offer a great compromise between solar utility and aesthetic preservation of the island (R. Pohl, personal communication, November 4, 2021). While pergolas are an option for some businesses in the downtown, most businesses would not have the necessary property space to install such structures. As well, the costs associated with construction and installation (which vary greatly depending on location, size, and design) may be prohibitively expensive for some. Based on Zach Dusseau's comments mentioned earlier, panel power production averages around 1200W by 100 square feet, meaning pergolas could produce around 12W per square foot of area (Z. Dusseau, personal communication, November 17, 2021).

Trash Compactors

Bigbelly trash compactors operate year-round and are powered by a solar panel that is hidden in the top of each bin. Each unit collects and compacts trash until it fills up. It then locks and sends a signal to the owner, which would be the Nantucket Department of Public Works (DPW), to alert them to empty and reset it. The bins are relatively compact but can hold a significant amount of trash. For example, one model measures 50" x 25" x 27" and weighs 270 lbs. It can hold up to 150 gallons of compacted waste, compared to around a 50 gallon capacity on the current barrels. The panel on top of the bin charges a 12V battery that drives the compacting



Figure 13. Bigbelly trash compactors on Nantucket

mechanism (Bigbelly, personal communication, November 12, 2021).

These compactors have been previously installed and used on Nantucket in a limited manner. Figure 13 shows four different models located on the bike path near the Nantucket Cottage Hospital. Each unit varies in cost depending on the model and customization options, but estimated costs are around \$3,700 - \$4,000 per unit (Bykofsky, 2017). The DPW often faces labor shortages and often has to use limited labor hours to travel to bins around the island for maintenance and emptying. By having bins that not only fill less often due to the compaction, but also alert the workers precisely when they need to be emptied, the DPW would be able to better optimize their time use and collection routes, saving long-term costs in fuel, as they would be traveling to bins for cleanup much more efficiently. The initial deployment of Bigbellys around Nantucket was undertaken by the DPW years ago. Unfortunately, the bins did not perform as well as expected. These older models had relatively poor cell reception and were expensive. The Recycling and Solid Waste Coordinator Graeme Durovich recently applied for \$151,000.00 of funding to acquire eight new sets of Bigbellys to replace the older models around island, as the current units' lifespan of six to ten years has just about been reached, and local infrastructure and Bigbelly technology have greatly improved in the last decade (G. Durovich, personal communication, November 19, 2021). The DPW hopes that newer models and infrastructure will help offset this concern. While the replacement of older models will hopefully improve the current Bigbelly infrastructure's cell reception and be more useful to the DPW, the installation of Bigbellys in additional places around the island is still being discussed. Out of the 50 current waste receptacle sites that the DPW maintains, only five sites have Bigbellys installed. The hesitancy to employ Bigbellys in new locations stems from a few issues, including aesthetics, costs, and Nantucket's strict recycling mandates; the need to have multiple bins for each type of recycling can cause confusion. Bigbelly offers multiple models to address this very issue, as seen in Figure 13. However, the need for multiple units increases costs significantly.

Trash compactors can be adapted to blend into their surroundings. When asked to list any concerns about trash compactors on Nantucket, residents taking our public survey were largely in favor of their installation, however a vocal minority had serious concerns about their "ugly" appearance. While their basic design does not fit well with the historic character of Nantucket that the HDC aims to preserve, they can be easily concealed, possibly with a wooden or shingled structure built to house the bins. The compactors would most likely be deployed in places outside of HDC jurisdiction, such as beach parking lots and town sidewalks. According to HDC chair Ray Pohl, the HDC would not be directly involved in the permitting of Bigbelly installations, but should the DPW decide to deploy them more broadly, they would likely approach the HDC "as a courtesy" to get their input on the proposed locations and tactics used to blend them in (R. Pohl, personal communication, November 4, 2021).

The installation of Bigbellys would be most difficult in the downtown areas. The DPW placed Bigbelly's in the downtown area several years ago, but found them more of a liability than a convenience, as the downtown receptacles would often stop working for multiple reasons, including overfilling, leaving very little waste capacity in the area. (G. Durovich, personal communication, November 19, 2021). Downtown bins also fill significantly more quickly than the more remote receptacles, as they are in more frequented areas. Due to this, DPW workers found themselves constantly traveling back and forth to the downtown as individual bins filled, only cleaning a few bins at a time per trip. It was more efficient to follow a scheduled cleaning for all downtown bins. On top of this, the HDC and public may be less amenable to seeing trash compactors instead of their traditional wooden barrel bins in the downtown area.

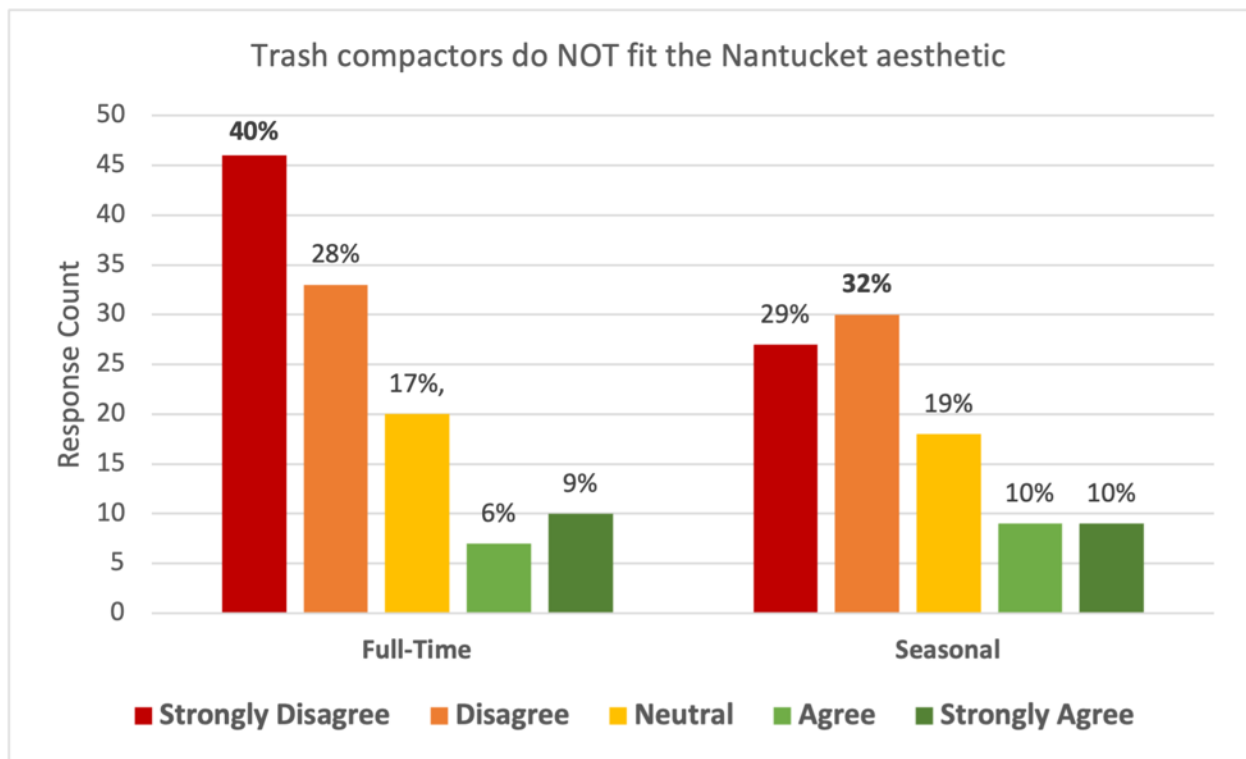


Figure 14. Agreement to trash compactor aesthetic concerns by residency

Based on our interview with Mr. Pohl, we suggest installing Bigbellys at beach parking lots. Specifically, the lot at Surfside Beach could work well, alongside “Moby,” the trash-collecting whale sculpture (R. Pohl, personal communication, November 4, 2021). Other locations include parking lots for hiking trails, tourist attractions, and bus shelters, although the DPW does not currently have receptacles at many of these areas. These locations are more remote than the downtown, so they would likely fill less often, and save fuel and labor as they will only be emptied when an alert is sent out to the DPW. Based on the results of our survey,

trash compactors were the most favored application. As shown in Figure 14, year round and seasonal residents thought that trash compactors were not severely detrimental to the Nantucket aesthetics. Both year-round and seasonal residents were either in favor or strongly in favor of trash compactor’s increased use on the island (Figure 15). The combination of a low level of public concern for aesthetic and a high favorability for their installation makes trash compactors the most feasible application.

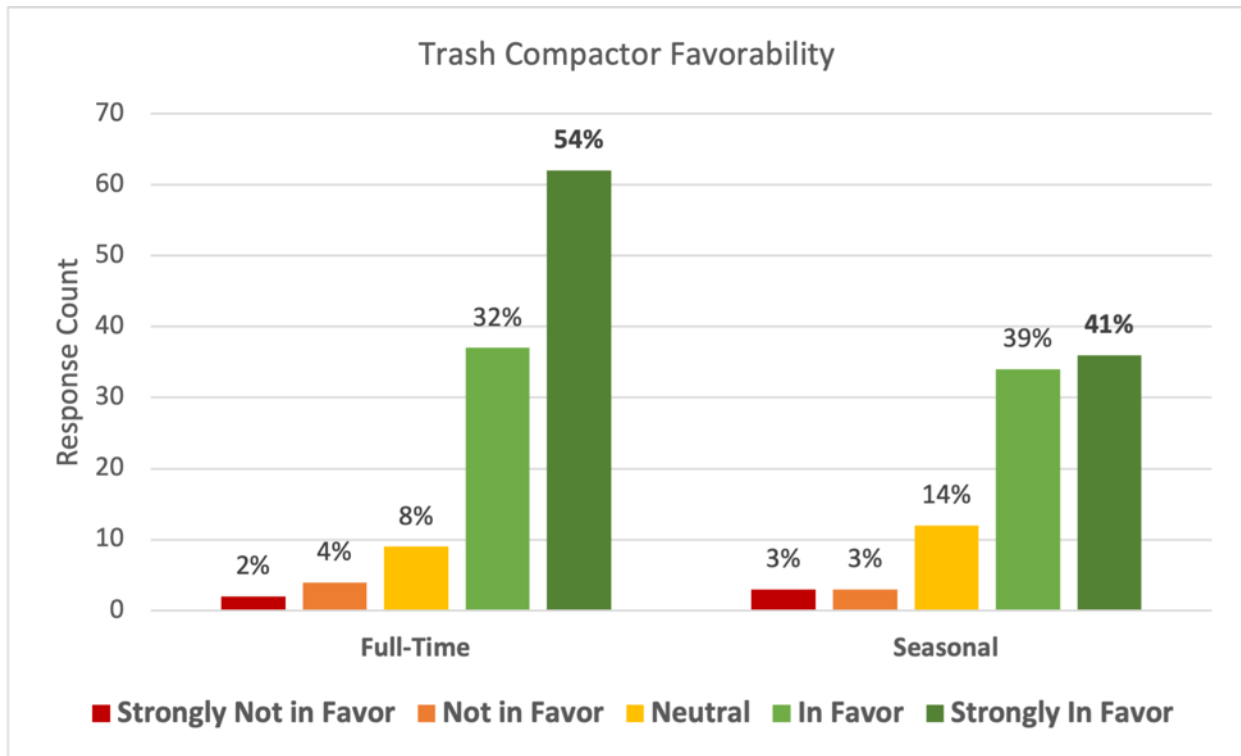


Figure 15. Trash compactor favorability by residency

Charging Stations/Tables

Solar-powered charging stations and tables can be used to charge small hand-held devices such as cell phones and tablets. The [Sunbolt Pavilion Carousel](#) (Figure 16) provides the user with not only a place to sit and enjoy a meal or get some shade in the summer months, but also a place to charge their phone. The table comes in 3, 4, and 5 seat options which are [Americans with Disabilities Act \(ADA\)](#) accessible. A 6 seat option is also available, but is not compliant with ADA accessibility standards (*Pavilion Carousel, n.d.*).

The table utilizes four 25W PV solar module panels, for a total 100W capacity, and two 10 amp-hour lithium ion phosphate batteries. The system can handle an average of 40 hand-held mobile device charges per day. These systems are considered “low-maintenance” and have an expected service life of 10-20 years. Even in the worst weather conditions, the charging element of the table still operates (Sunbolt. (n.d.)).

Some popular locations where we recommend placing these tables include:

- ❖ Surfside Beach, Children’s Beach, Jetties Beach
- ❖ Tom Nevers
- ❖ Handlebar Cafe
- ❖ The Corner Table
- ❖ The Chicken Box

The Sunbolt tables must be permanently mounted to a concrete slab when assembled (Sunbolt. (n.d.)). This makes the removal of the tables difficult, but it is possible. However, there are other charging table options that are designed to be portable. During the winter months when there is limited foot traffic, the portable tables could be disassembled and stored away to protect them from the elements. The DPW would require extra labor to remove these tables at the end of the peak season.



Figure 16. *Pavilion Carousel*. Sunbolt. (n.d.).

Permission to use this image was provided by GoSunbolt and was found on their website - www.gosunbolt.com @gosunbolt #gosunbolt

The cost of the Sunbolt Pavilion Carousel ranges from \$8,500 to \$9,400 depending on the number of seats desired. There is also currently a \$550 surcharge due to the increase in cost of materials. Other smaller, portable charging stations from Sunbolt can range from \$2,350 to \$4,950 depending on the model (V. Branco, personal communication, November 18, 2021).

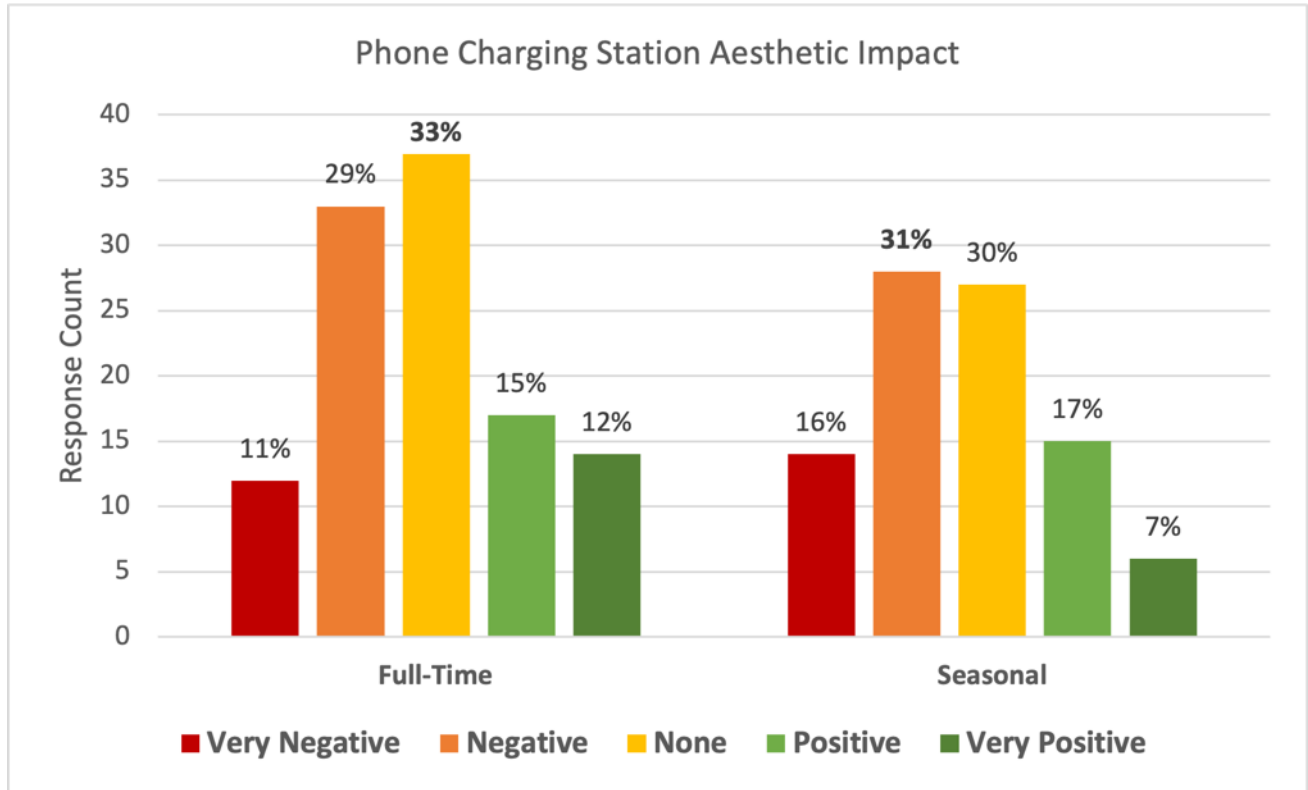


Figure 17. Aesthetic impact of phone charging stations

Figure 17 shows that most residents remain neutral or feel that the tables may have a small negative impact on the aesthetic. Based on this information, the charging stations may not be best suited for historic districts, but might be more widely accepted at beaches and parks outside of downtown and Siasconset. Figure 18 indicates that full-time residents favor charging stations more than seasonal residents. This difference may be due to the fact that seasonal residents come to the island to escape from the technology-driven mainland and want to enjoy the historic nature that Nantucket provides.

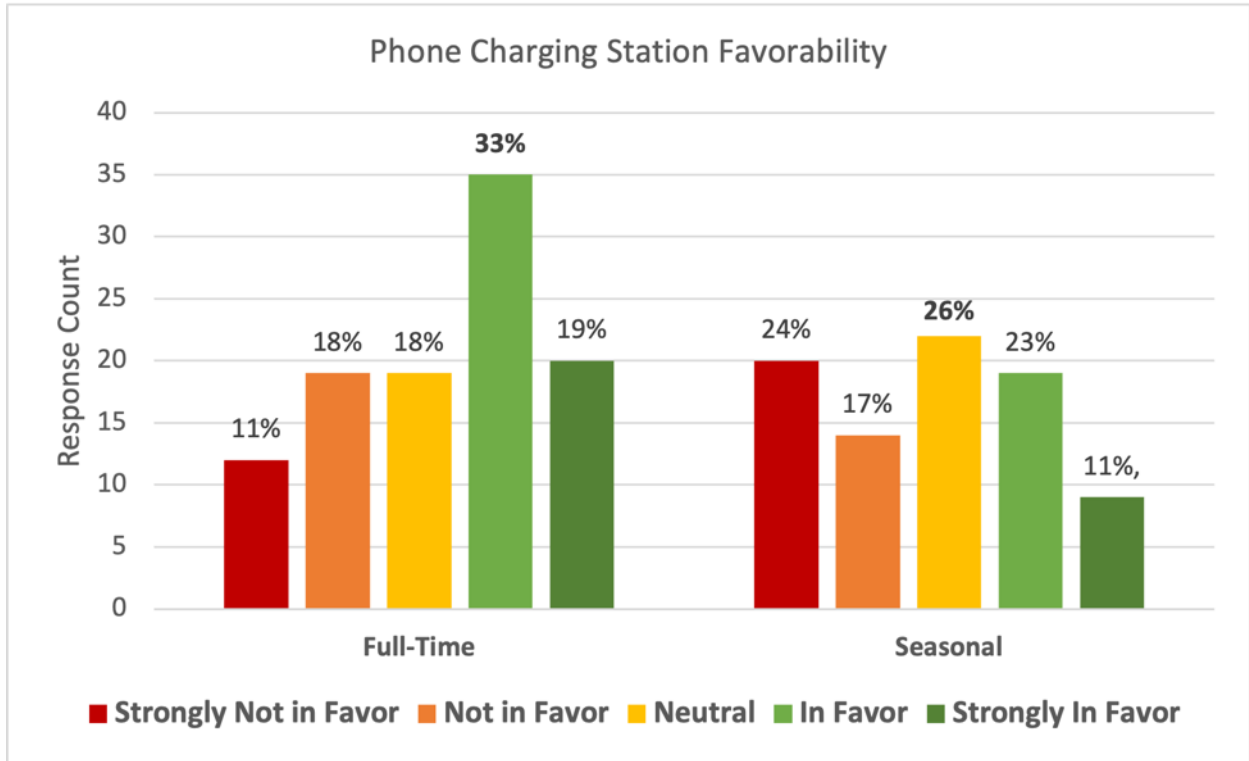


Figure 18. Charging station favorability

Several respondents expressed concerns that charging stations would encourage the use of cellphones on the island. For example, respondents said:

- ❖ “You should charge your phone at night and enjoy your time here. It’s a beautiful place!”
- ❖ “People should be looking at the scenery and not their phones.”
- ❖ “Constant use of cell phones in public areas should be discouraged, not facilitated.”
- ❖ “If we deployed these people would spend more time on their phones and less time being 'present' on Nantucket.”

Even though seasonal residents expressed concern, the overall favorability of the charging stations is the second highest of all applications discussed on the survey. Each application’s favorability was rated 1 through 5 (1 being lowest and 5 being highest). The average favorability for phone charging stations was 3.06.

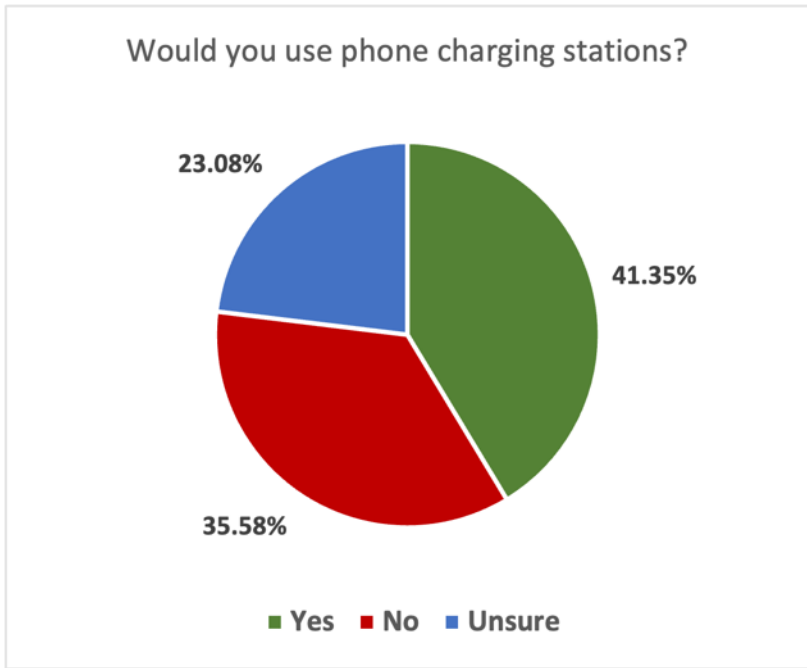


Figure 19. Projected usage of charging stations

Despite concern about the increase in cell phone usage, Figure 19 shows that 41% of respondents would use these tables if they were available and 35% would not. Compared to other applications, charging stations had the highest proportion of respondents indicating they would use the application regularly. The analysis of this question was not broken down into full-time vs. seasonal because there was no appreciable difference in opinion between the two demographics.

Kiosks and Screens

Paid parking on Nantucket is a controversial issue with residents, as paid parking has never been implemented before, and the residents are resistant to change. If Nantucket were to implement paid parking, parking kiosks might help to alleviate congestion and the lack of parking spaces. Kiosks only allow you to park in a space for an allotted time, meaning spaces would free up more frequently throughout the day. These kiosks accept all forms of payment and would allow vehicle owners to input their license plate information to “reserve” their parking spot for an allotted amount of time. The goal is to limit the time someone can park so that other cars have an opportunity to park without repeatedly circling in order to find a spot, which contributes to traffic.

Parking kiosks are designed to be stand-alone systems that function with little need for assistance, apart from someone to collect the money inside. However, collecting money from kiosks would be a foreseeable problem as it would require additional labor. This could be

avoided with custom models that include no physical payment options, but could leave some consumers at a disadvantage. Depending on the model, some kiosks house a 360 degree multidirectional solar panel that can “track” the sun to optimize energy collection. This system is both eco-friendly as it produces no waste, and is self-powered, with no need to connect to the grid. These kiosks are ADA accessible and can be altered to fit the Nantucket character by wrapping them in wood. However, this provides additional work for the Department of Public Works, which is already understaffed. As well, some interviewees and residents expressed concern that an application like this may be vandalized and damaged.

Similar to parking kiosks, informational kiosks are stand-alone systems powered by solar energy that could provide various types of information to the public. These kiosks are quite flexible in terms of design, as they could house different types and sizes of screens. One possibility is an interactive screen that allows users to navigate to their desired information, and may contain a larger set of information about Nantucket in general such as eateries, bike paths, museums, etc. Another use is setting them up inside or outside historical areas so that visitors can read facts and information about a site or area in order to learn more about them. As well, these screens can be set up by beaches, allowing beachgoers to see what the weather will look like for the day, as well as informing them about the tides. Bus stations could employ these screens in order to inform riders about the weather conditions as well as the whereabouts of their bus, keeping passengers updated on bus locations and expected arrival time. As well, businesses like the Nantucket Dreamland movie theater could use a kiosk with a payment system to facilitate contactless purchase of tickets. A large population owns smartphones, which are able to serve all of these purposes. However, these applications provide benefits to users by providing quick and easy access for those without their



Figure 20. Example solar parking kiosk

phones in hand. Ultimately, kiosks could serve a wide array of information needs based on their location and purpose, and therefore can be implemented on the island in many fashions.

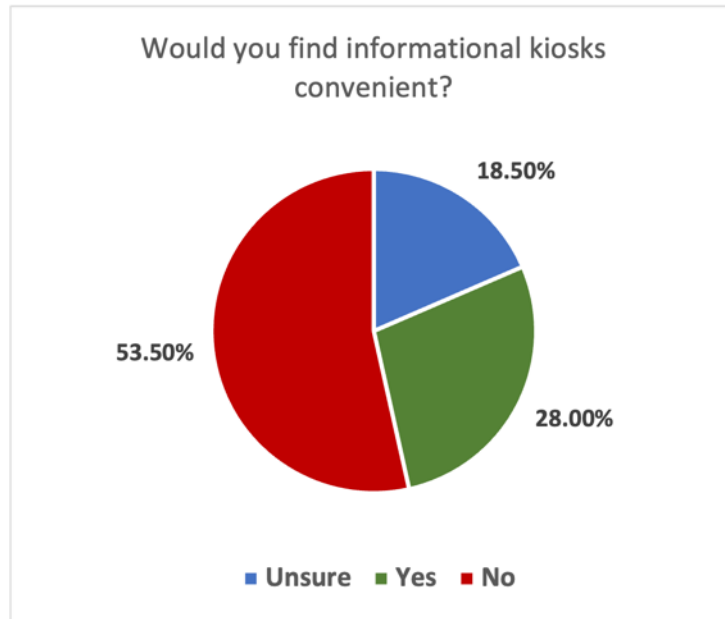


Figure 21. Would you find informational kiosks convenient?

Only 28% of respondents indicated they would find informational kiosks convenient (Figure 21), showing a lack of interest for kiosks among residents. If there is a lack of demand or need among residents, it is not worth implementing kiosks. Following this trend in Figure 22, 125 out of 185 respondents were neutral, or not in favor of informational kiosks, and only 32% of respondents were in favor. In sum, approximately 70% of respondents would not be in favor of or use informational kiosks, making them an unlikely application on Nantucket. However, information kiosks may be useful in specialty applications, such as outside some historic landmarks, or placed inside museums to provide factual information to visitors, as they would provide information not found through online searches. As well, indoor locations would prevent the opportunity for vandalism outside business hours and would complicate charge by solar panels.

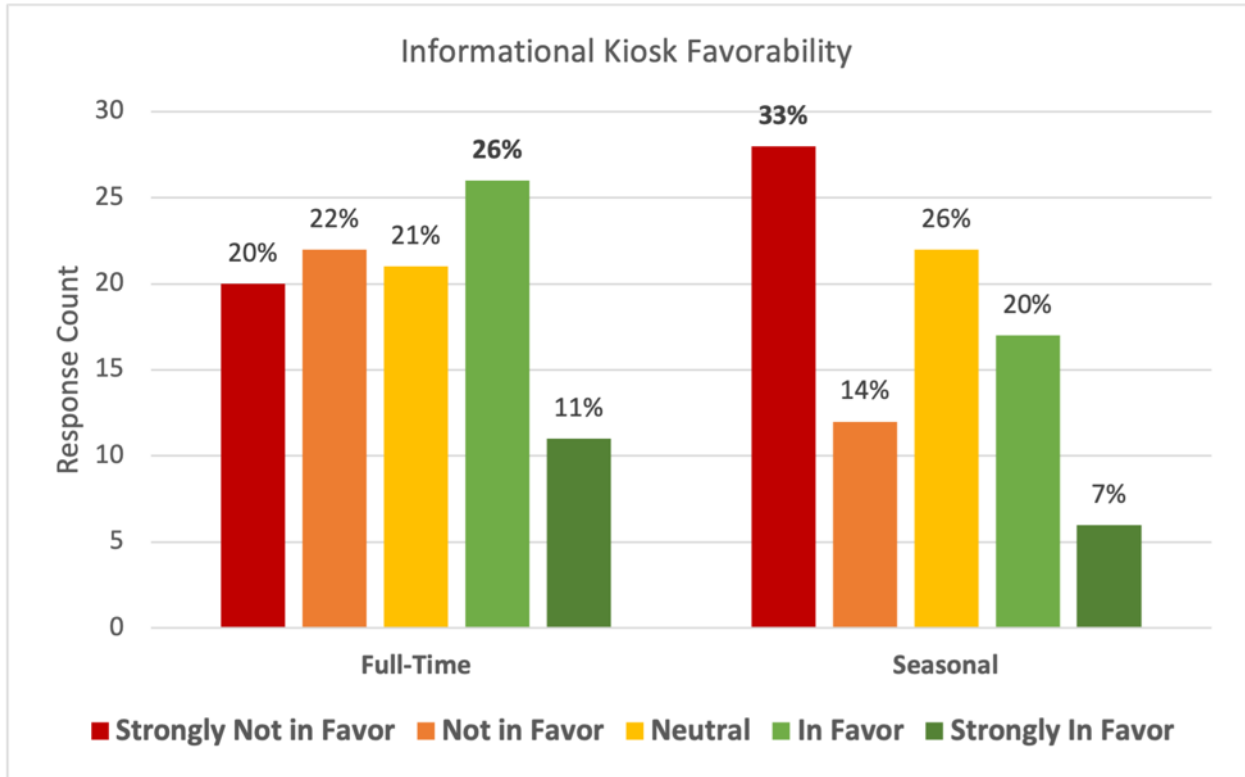


Figure 22. Informational kiosk favorability by residency

Charging Lockers

Charging lockers are more versatile than charging tables, but come with unique locational limitations and benefits. These lockers could be set up in public areas and would offer storage cubicles of different sizes. Members of the public could rent a cubicle (either free of charge or for a small fee depending on the installer’s intent) that would offer a cord to charge one’s mobile device. The cubby can be unlocked using a PIN (personal identification number) combination. Not only would these lockers allow beachgoers to charge their devices, but the cubicle could also hold other small valuables that one might prefer to not bring out on the beach such as keys, wallet, earbuds, or other electronics.



Figure 23. Solar powered MobileLocker beach model (Beach Lockers, 2019).

Permission to use this image was provided by **Mobile Locker** and was found on their website - www.mobilelocker.eu

These off-grid lockers are semi-mobile, meaning they can be loaded onto trucks for storage and transportation. This would allow the town to set up the lockers seasonally in the summer, and even regularly move them to beaches where they deem they would get the most use. While there are multiple companies that offer such devices, one such company we contacted was [MobileLocker](#), who's Beach Model is illustrated in Figure 23. These lockers are highly customizable, coming in multiple sizes and designs. Many additional features can be added to the lockers such as a battery-powered defibrillator and Wi-Fi hotspot (Beach Lockers, 2019). The lockers vary in price depending on company, model, and additions bought, but the particular model in Figure 23 has a price of around \$22,770 (MobileLocker, personal communication, November 15, 2021). While this locker is somewhat expensive for most businesses and individuals, the town of Nantucket could work to invest in one or more lockers to help encourage solar power's further adoption on the island.

The HDC would likely not have jurisdiction over the installation of such lockers given their location on beaches and temporary nature. This is because of the locker's status as a temporary structure, being non-grid tied and mobile. According to HDC chair Raymond Pohl, beaches are the "experimental test kitchen" of the island, meaning projects that might not be allowed in other parts of the island are more likely to be given a chance at beaches (R. Pohl, personal communication, November 4, 2021). If ReMain and the Town of Nantucket were to invest in these lockers, parking lots at local beaches such as Surfside, Jetties, Sconset and Children's Beach would be the best locations for installation, as beaches would experience the highest foot traffic during the summer usage season, and would be most likely to not cause conflict with the HDC. The Director of the Department of Natural Resources Jeff Carlson was interested by the idea of solar lockers in beach lots, but as mentioned previously, the need for permitting is determined on a case by case basis depending on location and exact positioning of the locker (J. Carlson, personal communication, November 18, 2021). The locker's semi-mobility could make this process much simpler as they could be positioned anywhere in the lot so as to comply with all NRD standards. Other possible locations of installation that were found viable in our research were bus shelters on more remote parts of the WAVE bus routes.

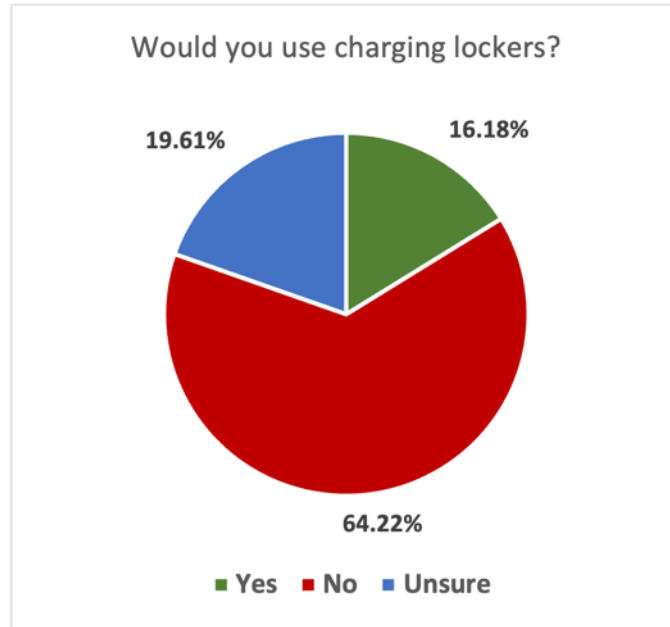


Figure 24. Projected usage of charging lockers

Charging lockers received the most pushback out of the four applications in our public survey. When asked if they would use such lockers if they were readily available, 64% of respondents answered no, and only 16% answered yes, as seen in Figure 24. Charging lockers were also the least favorable application on the survey, with a favorability score of 2.6 on the 1 to 5 scale, and both major residency groups having more people not in favor than in favor of their installation. The breakdown of locker favorability by residency is depicted in Figure 25. Based on these statistics, charging lockers would face significant public backlash should they be installed, and would not receive much use by locals, leaving only seasonal visitors as a pool of potential users.

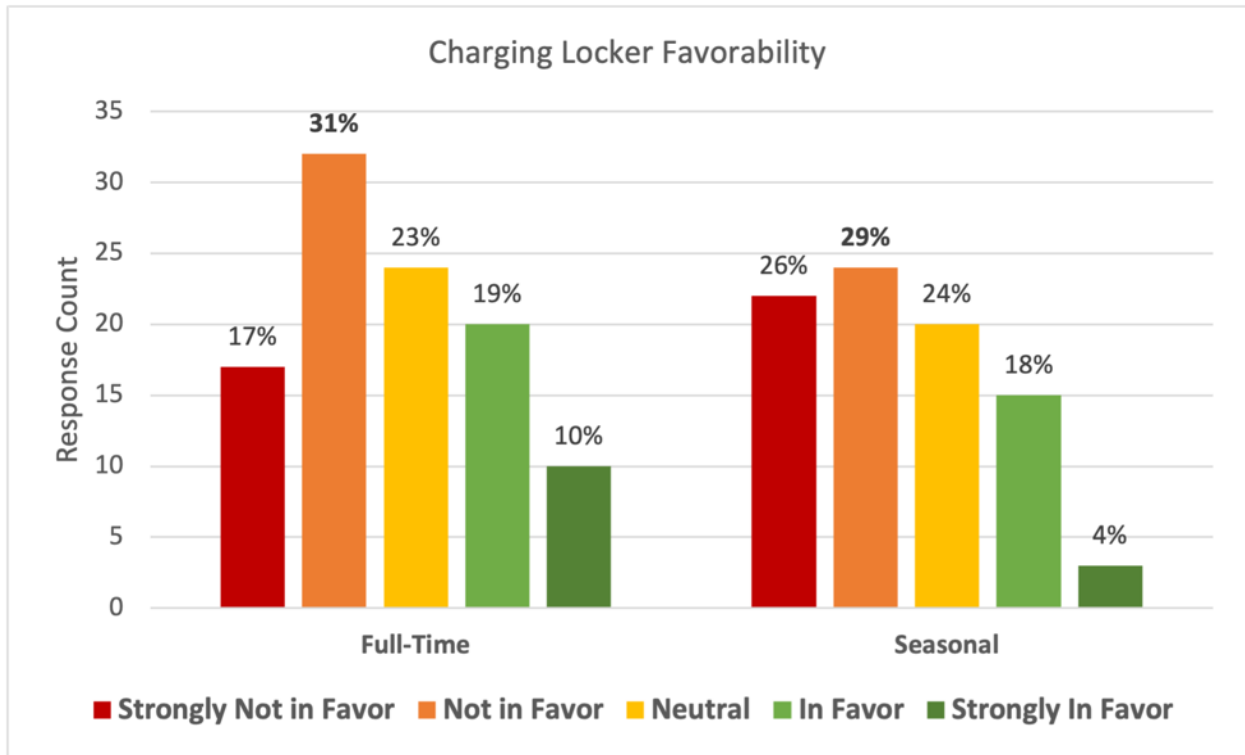


Figure 25. Charging locker favor by residency

Charging lockers had previously been met with enthusiasm and excitement in multiple interviews (contrary to the survey results), including those of Raymond Pohl and Mike Dobbert (R. Pohl, personal communication, November 4, 2021; M. Dobbert, personal communication, November 5, 2021). Part of this apparent discrepancy between surveyee and interviewee reception could be due to the inability to communicate the locker’s purpose and aesthetic customizability over the format of an online survey. Many respondents may not have considered or fully understood how aesthetically customizable the lockers are, nor how they could hold more than just small devices, and could even include additions like defibrillators, first aid kits, and a Wi-Fi hotspot. Regardless of this possible lack of communication, it was still agreed upon by the majority of both full time and seasonal residents that such lockers would have a negative impact on the island’s aesthetic. Specifically, 54% of full time residents and 62% of seasonal residents answered with either “Large Negative Impact” or “Small Negative Impact,” as can be seen in Figure 26.

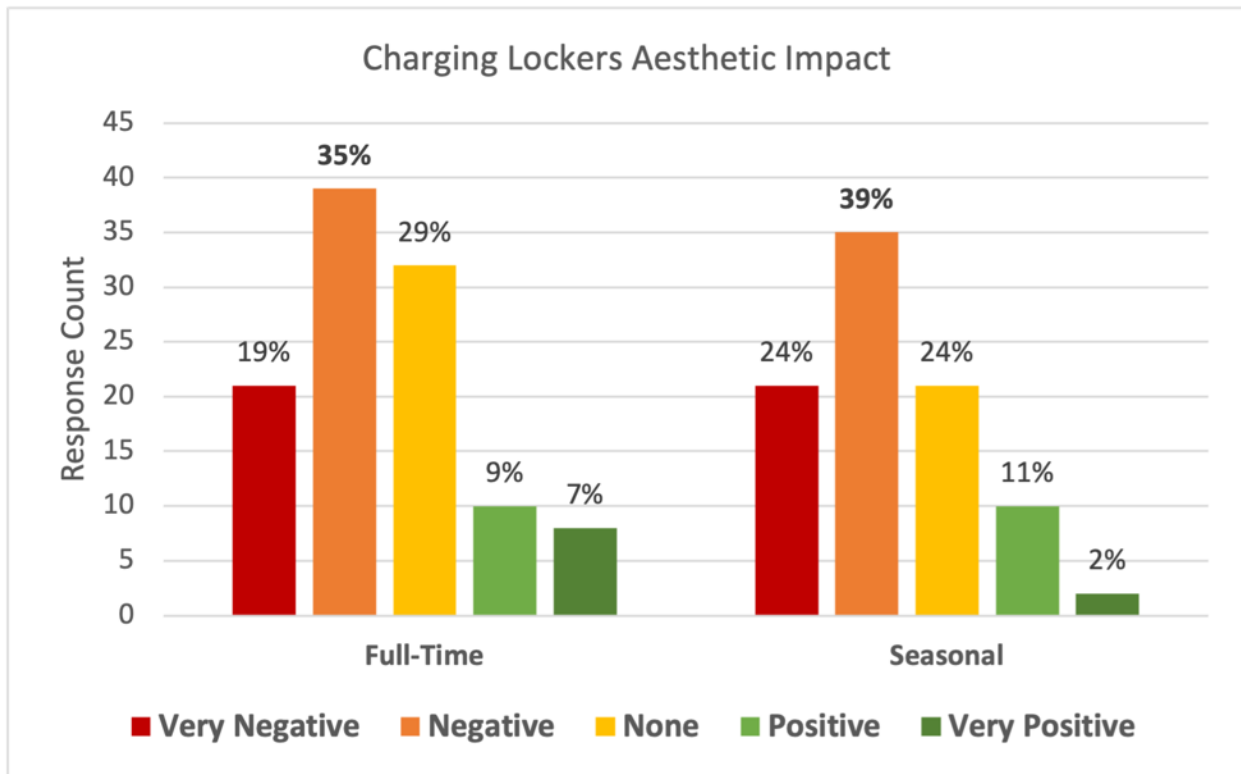


Figure 26. Charging locker aesthetic impact by residency

Towable Solar Generator

Towable solar generators are portable power generators that do not rely on grid connections. These devices are suitable for remote locations where electricity is not easily accessible and the use case doesn't warrant a permanent solar system installation. For example, a solar generator could be used as a quiet alternative to a gas-powered generator at venues such as outdoor weddings, beaches, and parks.

Figure 27 is an example of a solar generator called the "Solar Flower," which was previously owned by ACK Smart and brought to various outdoor events. ACK Smart spent approximately \$25,000 for the single unit. The design was intended to attract attention and raise awareness of the potential for solar systems. Unfortunately, the flower was damaged during a

storm and ACK Smart decided not to replace it (T. Carruthers, personal communication, 2021).

There are other towable generator options that are not as large as the solar flower such as the MS-150 Mobile Solar Generator by Mobile Solar. This generator has a more simplistic look. The generator is stored within a towable trailer, which keeps the equipment safe from the elements and provides a place to easily mount the solar panels. The trailer is light enough to be towed behind most 4 or 6 cylinder vehicles (Mobile Solar, (n.d.)), making this generator easily transportable to outdoor venues.

The Mobile Solar Generator costs between \$17,770 - \$22,210 per unit. The average battery life on this MS-150 trailer is 12-15 years, meaning the system would be providing energy savings for this amount of time. The generator has three, 350W panels which provide an average daily energy harvest of 7.5kWh and can power 3,500W loads (Mobile Solar, (n.d.)). This generator can easily power kitchen appliances like a refrigerator or freezer, an electric heater, an electric stove, LED lights, etc (Pike, J. (2020)).

Such a generator could be used both as a practical source of power at certain venues and also to promote the use of solar power on Nantucket. Tim Carruthers of ACK Smart mentioned how the public responded well to the Solar Flower, so a similar style of solar generator could easily be used to pique the public's interest in solar power (T. Carruthers, personal communication, 2021).



Figure 27. Image of “Solar Flower”
Provided by Tim Carruthers at ACK Smart
(T. Carruthers, personal communication,
2021)



Figure 28. Towable solar generator from Mobile Solar
Permission to use this image was given by Mobile Solar
<https://www.mobilesolarpower.net/>
(Mobile Solar. (n.d.))

Outdoor Lighting for Restaurants and Other Venues

Off-grid solar powered outdoor lighting is now commonplace in many homes and other venues, especially to light pathways, parking areas, and patios. Outdoor solar powered lighting can be achieved in two ways. The first would be ground-based lanterns, each with their own mini panel on top. These would charge an internal battery during the day and discharge over the night, rather than being fed from a single panel and battery. Such installations would vary greatly in price based on location and size. The other method is a string or series of lights hanging from the building attached to an awning, or, more preferably, through a pergola. AN example of the lights being mounted to an awning is shown in Figure 29. The charging would depend on how large each individual light is. If the light is big enough, a small panel could be attached to the back, facing the sky. If not, the series of lights could be connected to a larger panel that would power the entire series. Our focus is mainly on the second, string light method.

In regards to HDC approval, it is unclear on whether or not the lights will be removable, as it varies system to system. For example, the ground-mounted lights might be easier to take down during a storm rather than a string of lights attached to a solar pergola. However, even if the system is not mobile and therefore requires HDC compliance, it is unlikely that they will deny it. Based on previous pergola-based projects that have been approved, should the restaurant plan the construction in a collaborative effort with the HDC and installers, the panels could be well hidden and blend into the surroundings.

The choice of ground or air mounted lighting will depend on the space, size of the outdoor section, and the location of the roof of the building itself. Depending on the size and version of the lights selected, the installation process may need to be done by an electrician. For smaller systems, and especially the ground mounted version, self installation is possible, as it can be as simple as sticking the light in the ground.



Figure 29. String lights used in downtown Nantucket

Golf Course Systems

Nantucket currently has four golf clubs, three of which are private. These golf clubs span a lot of land, much of which is not visible to passersby from publicly traveled ways. This provides a highly feasible location for solar system installations due to their limited visibility to the public and would have minimal negative impact on the island's aesthetic. These systems would likely be larger in scale, but can still be off-grid tied and could be used to charge clubs' carts. Regarding golf courses, these systems could be used to charge clubs' carts. Golf clubs utilize carts for members to travel along the course, and these carts must be plugged in and charged if they are electric powered. This concept follows the same model as Wheels of Delight, which uses its solar powered pergola in order to charge a fleet of electric powered bicycles. Although it would mimic the design of Wheels of Delight, the pergola array for a golf course would be much larger and most likely not connected to the grid. The pergola would not only charge the carts, but provide semi-shading for the carts to keep them cool before use. This application type would require the installation of a large array mounted on a pergola and could not be considered small-scale, but can still be designed to be off-grid.

Another way to implement solar charging for golf carts is attaching solar panels to the carts themselves. Carts can be retrofitted with solar panels designed for golf carts in order to allow the carts to "self-charge." This allows carts to charge on the go, and eliminates the labor of plugging them all in unless necessary due to lack of sunlight. This method of charging the carts would be considered both small-scale and off-grid.

Golf courses have intricate irrigation systems in order to keep their courses bright and green. These systems span the entirety of courses, and have a large operating expense. A Florida golf course, Hobe Sound, spent \$1.2 million updating its irrigation system, not including the cost of the water (Gilliland, 2020). The club also states it saves around \$50,000-75,000 in water and labor costs due to the installation of solar. Installing a solar array can allow courses to run their irrigation system completely off-grid, only needing to pay for the panels, installation and maintenance. The Northport Creek Golf Club initially installed a system that produced 64,000 kWh, enough to power 7 homes of average size, and more importantly, the entire irrigation system for their property (Fortuna, 2020). They later added an array to produce an additional 21,000 kWh in order to generate electricity to power their clubhouse and charge golf carts.

If golf clubs use and support solar, they can get closer to their sustainability goals while also positively influencing public perception. This can also encourage club members to evaluate their sustainability goals and possibly invest in solar. Due to the fact that most clubs are private, this is most likely not an application ReMain should fund, but rather an application they should support and market to the clubs.

Additional Pergola and Household Applications

Although many of the applications previously discussed are intended for use by businesses and the public, homeowners can also install non-grid tied panels in order to provide electricity for small household needs. Homeowners may be able to install these small arrays on their garden sheds or pergolas and keep visibility to a minimum. To provide a sense for what can be achieved, consider placing a solar array with dimensions 10' x 10' on a side of the roof of your garden shed. This array will be able to produce about 1200 W of power. If you owned an electric lawn mower and bicycle, and wanted to charge both so you could mow the lawn before taking a scenic ride, you would be able to do so. For example, the [EGO Cordless Walk Behind Self Propelled Mower](#) has a 420 Wh capacity, and the [RadRunner 1 Electric Bike](#) holds 672 Wh of power on a full charge (Power+ 21" Self Propelled Mower, n.d.; Rad Runner 1, n.d.). Though small, these applications allow homeowners to save a bit of money while contributing to the goal of sustainability. Homeowners can also build pergolas with mounted arrays that allow some light to pass through to provide a warm, semi-shaded area, even poolside for applicable homes. A larger pergola mounted array, dependent upon size, could potentially gather enough energy to power pool heaters. An example heater, the [Raypak 6450ti](#), can produce 119,000 BTU's, enough to heat a large sized pool using 5.9 kW of energy, which would require about 500 square feet of panels to be powered (Heat Pumps, n.d.; Heat Pump Pool & Spa, n.d.). Both panel mounting methods can also be used to power outdoor lighting, irrigation systems and insect traps.

Conclusions and Recommendations

We conclude that:

- ❖ Solar PV is increasingly popular on Nantucket, although most attention is on residential PV systems.
- ❖ There are many potential small-scale off-grid applications that might be feasible on Nantucket, though each comes with unique limitations and none of them are likely to impact the grid nor peak demand in the summer season.
- ❖ The most immediately promising off-grid applications of solar PV on Nantucket are:
 - Pergolas for medium and light-duty lighting and charging;
 - Bigbelly trash compactors; and,
 - Off-grid golf cart charging (through multiple possible methods)
- ❖ Some other applications are promising but face much pushback from the community, specifically stand-alone parking stations, charging storage lockers, and charging station tables. Parking kiosks would be controversial because currently parking downtown is free of charge. Charging lockers and charging tables both raise issues with the Nantucket aesthetic and are expensive to purchase.
- ❖ When supporting efforts in the field of off-grid solar, a certain level of thoughtful carefulness must be maintained. This is due to the unregulated market nature of off-grid solar applications. Since the HDC and public at large have not interacted much with small-scale solar, the first few projects must be done thoughtfully and carefully to set a strong example for future projects and avoid controversies that could impede the progress of future groups' efforts in the field.

While small-scale, off-grid solar will most likely not have a substantial effect on the electric grid's peak demand, it can serve as an invaluable tool to promote adoption of solar across the island and educate the public on solar's many applications. We believe that installing additional solar powered trash compactors will have the strongest PR benefit without being controversial amongst the public and the HDC. Based on our research and findings, we provide ReMain with the following recommendations:

- 1. We recommend the DPW continue to apply for grants to replace Bigbellys on island, and work to install additional compactors at popular public parking lots and other venues outside of the historic cores.**

The DPW has asked for funding to replace the bins at the five locations that have Bigbelly trash bins on island. The lifespan of the barrels is about 6 to 10 years and the

technology of the bins themselves have improved drastically since their initial installation. According to Graeme Durovich, the town has requested \$151,000 to replace all of the existing bins. We feel that the wider deployment of compactors could save the DPW time and money, while simultaneously promoting solar power's diverse usage.

2. We recommend that ReMain Nantucket publicize the current solar pergola construction at The Corner Table Cafe as an example of the benefits of small-scale solar and identify potential new locations to encourage projects.

Considering ReMain is already familiar with installing pergolas and have had great success with them in the past, we feel that they should promote installing them wherever possible. We know that these pergolas are compliant with HDC regulations as long as they are constructed high enough so the panels are not visible from the street. These pergolas could alleviate electricity usage of the lighting used for outdoor dining. Since the COVID-19 pandemic began, outdoor dining has become greatly popular and will continue to exist.

3. We recommend that local golf courses pursue the gradual adoption of charging their golf carts, among other elements such as clubhouses and irrigation systems with solar PV systems.

The island has several golf courses: Miacomet Golf Course, Siasconset Golf Course, Nantucket Golf Club, and Sankaty Head Golf Course. The pergolas or garages would easily be hidden from the public way and would operate the same way as the pergola at Wheels of Delight that charges their bikes. The golf carts would stay the same; all that would change is where their power comes from. Since it is the off-season, we were unsuccessful contacting these locations ourselves. However, ReMain should have no problem getting in contact with the proper individuals.

4. We recommend that the Town of Nantucket conduct further research into the topic of paid parking in the Nantucket downtown area (either seasonal or yearly) and that solar powered parking kiosks be considered in lieu of individual parking meters.

We understand that paid parking currently does not exist on Nantucket and it is understandable that the people would love to keep it this way. However, research could be conducted to better understand if paid parking could help reduce the traffic issue in the downtown area. If so, parking kiosks could help solve the public parking issue while also promoting solar on the island. This can only be accomplished through discussion with town officials and citizens.

- 5. We recommend that ReMain consider providing a grant to a selected event planning group, which would be used to purchase a solar generator, similar to ACK Smart’s “Solar Flower” for use at public and private events around town.**

A solar generator would be an effective public relation tool for the education and encouragement of solar. The generator would highlight the potential for solar power on the island and could be decaled with the appropriate logo to help promote various organizations. ACK Smart could serve as a point of contact for maintenance, upkeep, and operation.

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Appendix A: Table of Interviewees

Name	Affiliation	Date Interviewed	Key Points
1. Jamie Holmes	General Manager of The Nantucket Hotel	Nov. 1, 2021	<ul style="list-style-type: none"> → Hotel uses geothermal solar to partially heat their water → Would be interested in solar to heat their outdoor pool
2. Tim Carruthers	Director of Operations at ACK Smart	Nov. 1, 2021	<ul style="list-style-type: none"> → Brought us to audit of solar pergola at The Corner Table → Brought us to solar panel install on new construction home → Would be willing to install future solar pergolas
3. Tobias Glidden	Wheels of Delight and ACK Smart	Nov. 3, 2021	<ul style="list-style-type: none"> → Showed us his solar pergola which charges electric bicycles → Panels each run through an inverter to change power generated from DC to AC
4. Anne Kuszpa	Housing Nantucket	Nov. 8, 2021	<ul style="list-style-type: none"> → Has solar on her own home → Puts solar on homes of her non-profit, Housing Nantucket → Benefits from SMART rebate credits
5. Zach Dusseau	Founder of ACK Smart	Nov. 3, 2021	<ul style="list-style-type: none"> → Solar panel pricing → HDC Involvement in installations
6. Raymond Pohl	Chair of Nantucket Historic District Commission	Nov. 4, 2021	<ul style="list-style-type: none"> → HDC guidelines, role, and jurisdiction → Applications ideas and HDC involvement → Nantucket's character → State of solar on Nantucket

7. Mike Dobbert	HVAC Specialist	Nov. 5, 2021	<ul style="list-style-type: none"> → Application ideas and his opinions → Battery technology and panels → Public awareness and education on solar
8. Marshall Thompson	Former Food Truck on Nantucket at Surfside Beach	Nov. 10, 2021	<ul style="list-style-type: none"> → Beach tourism season and beach goer habits → Food truck capabilities, opportunities, and concerns → Charging stations' viability
9. Lauren Sinatra	Energy Coordinator at Nantucket Energy Office	Nov. 10, 2021	<ul style="list-style-type: none"> → NEO's solar incentives → Application ideas → HDC involvement over time → Island's electric infrastructure → Guidelines and uniqueness of Nantucket
10. Jeff Carlson	Director at Department of Natural Resources	Nov. 18, 2021	<ul style="list-style-type: none"> → Application ideas → NRD and Conservation Commission's roles → HDC's involvement
11. Graeme Durovich	Recycling/Solid Waste Coordinator at Nantucket Department of Public Works	Nov. 19, 2021	<ul style="list-style-type: none"> → DPW is replacing existing Bigbellys with new ones → Bigbellys don't work well in downtown because they fill too quickly → Best for remote locations to less DPW trips needed
12. Janet Schulte	Director of Culture and Tourism at Nantucket Visitor Center	Nov. 22, 2021	<ul style="list-style-type: none"> → Kiosks could work well at ferry services → Already have kiosks at airport and inside visitor services, but are not solar powered

Appendix B: Sample Interview Scripts

Preamble:

Your participation in this interview is completely voluntary and you may stop at any time. We will be taking notes during our conversation and may wish to quote you in our final report. If so, may we quote you by name, or would you prefer we anonymize your responses? Prior to publication, we will, of course, give you an opportunity to review any quotations. We will also be happy to provide you with a copy of our report when it is completed. We appreciate your participation in this research.

Would you mind if we record this conversation so we can verify our notes later? If you would prefer that we not record the conversation, we'll just keep notes.

Do you have any questions before we begin? If there are any questions or concerns following the interview, you can contact us at gr-ACK21-ReMain@wpi.edu or our faculty advisors, Dominic Golding, at golding@wpi.edu and Fred Looft, at fjlooft@wpi.edu.

Interview Script - Historic District Commission:

- 1. Preamble**
- 2. Interview Questions**
 - a.** We would like to record this interview for our records and to ensure proper quotation and reference when writing our report, do you consent to this conversation being recorded?
 - b.** Give a bit of context - We want to research the feasibility of small-scale solar applications, so we wanted to run some by the HDC to get an initial sense of their opinion on each, as well as help make a guide to HDC processes and guidelines for the public, in order to help both parties involved in future proceedings.
 - c.** In your own view, how would you describe your mission as the HDC?
 - d.** What is your overall view of solar power on the island?
 - e.** Has the HDC dealt with mobile (can be set up as needed and removed when not in use) applications? How do they differ from permanent installations? E.g. Heaters outside restaurants clash with aesthetic but are mobile so aren't a committed change to aesthetic
 - f.** We wanted to step through some of the small-scale solar ideas that we have gathered so far and get your first impressions of them. For each idea, what would the HDC process for approval look like? Are there any ideas you do not think could happen on Nantucket? After we've gone through them all, if you have any input in the direction we should take our thinking, or any new ideas that we didn't mention please let us know! We want as much input from experts like you and Nantucket residents as possible.

- g.** Are there certain projects we have mentioned that you think the HDC would be more inclined to approve?
- h.** Would you be able to provide any contact information for other members of the HDC? We may want to discuss our ideas with them later in the fall.

Interview Script - ACK Smart:

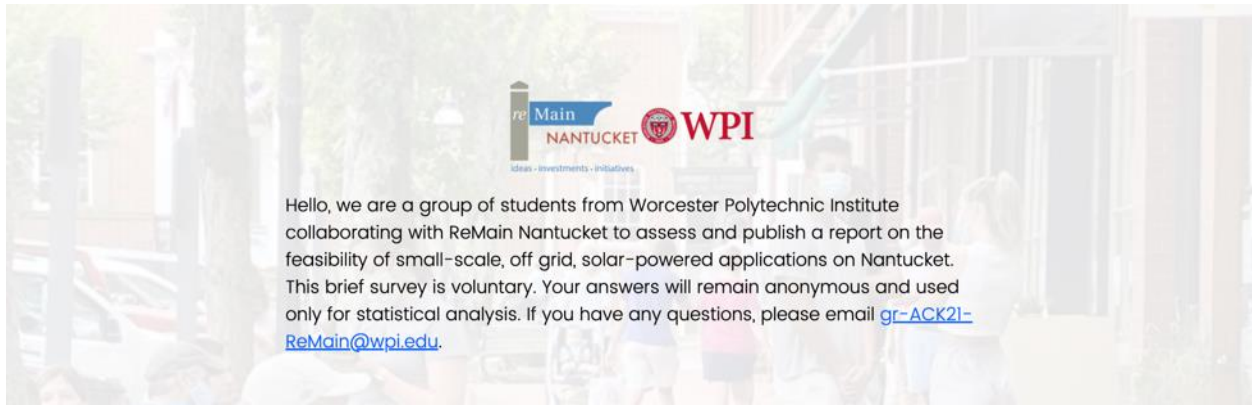
1. Preamble


2. Interview Questions

- a.** We would like to record this interview for our records and to ensure proper quotation and reference when writing our report, do you consent to this conversation being recorded?
- b.** To give context to the rest of the interview, we wanted to step through some of the small-scale solar ideas that we have gathered so far and get your first impressions of them. For each idea, what benefits do you see? What possible stumbling blocks do you see happening? Based on your experience in the field, do any ideas not seem technically feasible in terms of power generation, size, and usage? After we've gone through them all, if you have any input in the direction we should take our thinking, or any new ideas that we didn't mention please let us know! We want as much input from experts like you and Nantucket residents as possible.
- c.** What types of battery storage options are there for non grid connected solar applications? Are there many sizes or just a few? How does a battery pack work for a solar panel, is it standard on most systems, and what costs come with them? What is the state of battery storage technology? How does it relate to solar applications, both large scale and small-scale?
- d.** For the applications you deem feasible, what size solar panels would be required? How much power generation is needed?
- e.** Based on your experience on island and interactions with solar customers, do you think privately owned small-scale solar is a viable market on island (e.g. collapsible charging station in one yard for electric bikes, commercial use of towable solar generators for events)?
- f.** Should some of these applications be implemented, do you think it would be easier/preferable to use pre-integrated solar systems or attach an external solar power system to pre-existing systems (e.g. restaurant outdoor lighting, outdoor heaters, etc)?

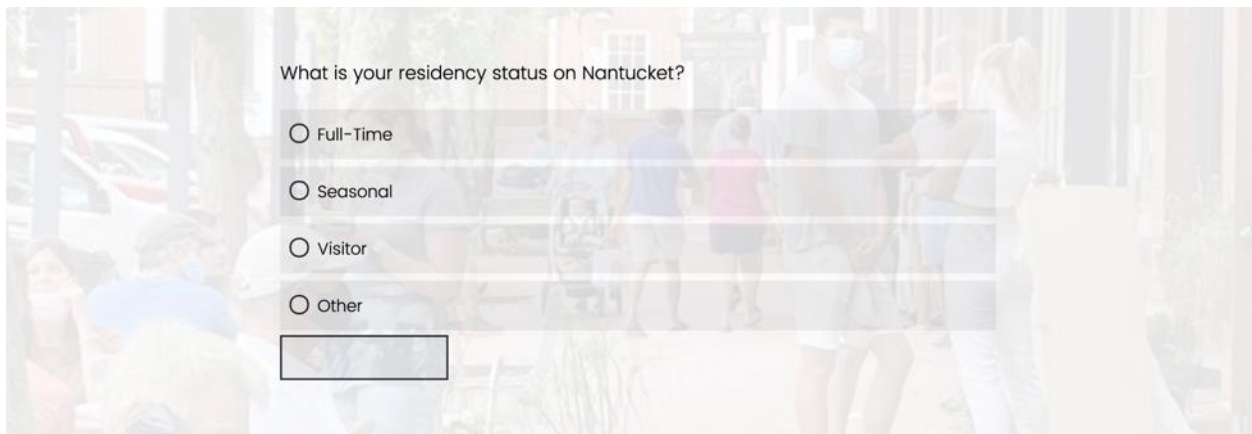
- g.** For each application idea, should ReMain or other local organizations pursue the implementation of these kinds of small-scale solar applications, would ACK Smart be interested in either consulting or installing said system?
- h.** What experiences/conflicts have you had with the HDC in the solar business? What issues usually arise? How do you go about resolving them? Do you think the market of small-scale solar would be more agreeable to the HDC (e.g. smaller systems, mobile/disassemblable systems)?

Appendix C: Public Survey



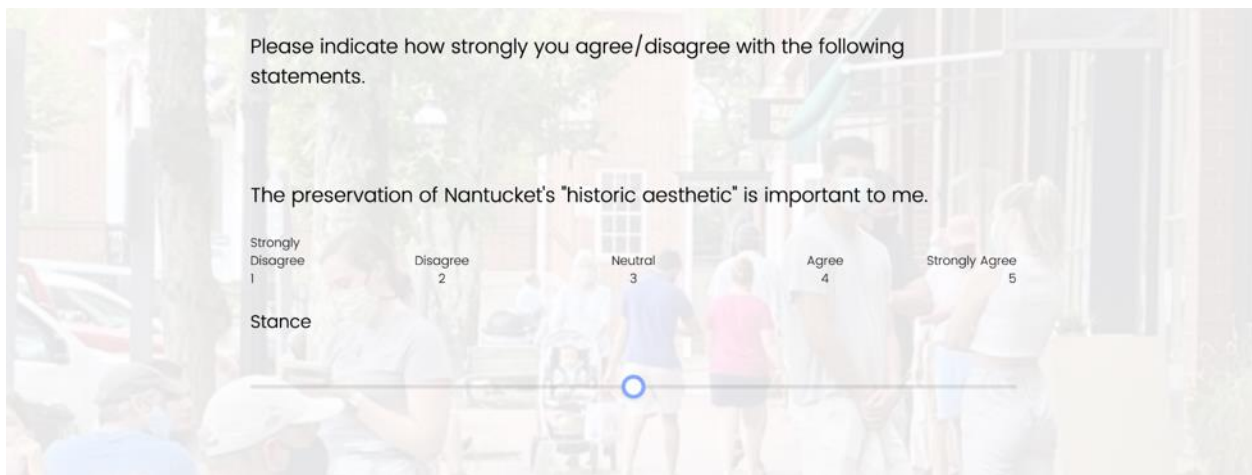
reMain
NANTUCKET  **WPI**
Ideas - Investments - Initiatives

Hello, we are a group of students from Worcester Polytechnic Institute collaborating with ReMain Nantucket to assess and publish a report on the feasibility of small-scale, off grid, solar-powered applications on Nantucket. This brief survey is voluntary. Your answers will remain anonymous and used only for statistical analysis. If you have any questions, please email gr-ACK21-ReMain@wpi.edu.



What is your residency status on Nantucket?

- Full-Time
- Seasonal
- Visitor
- Other

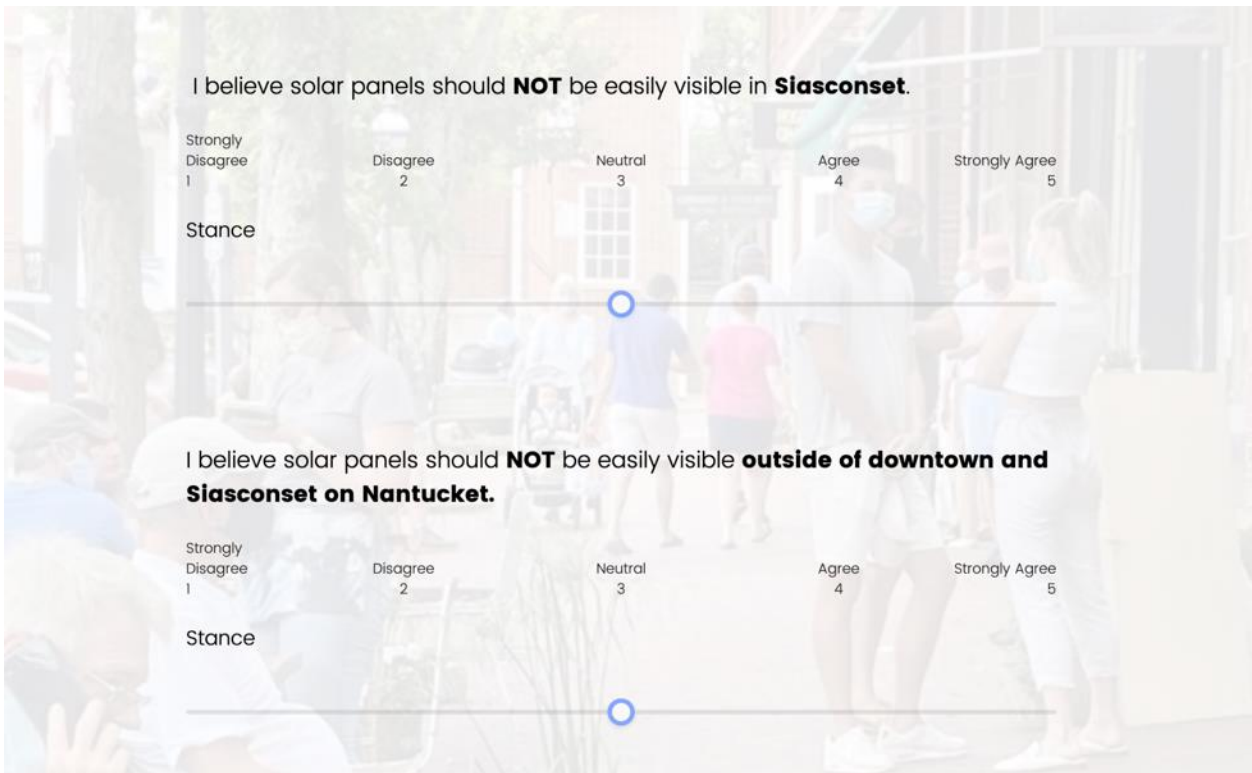
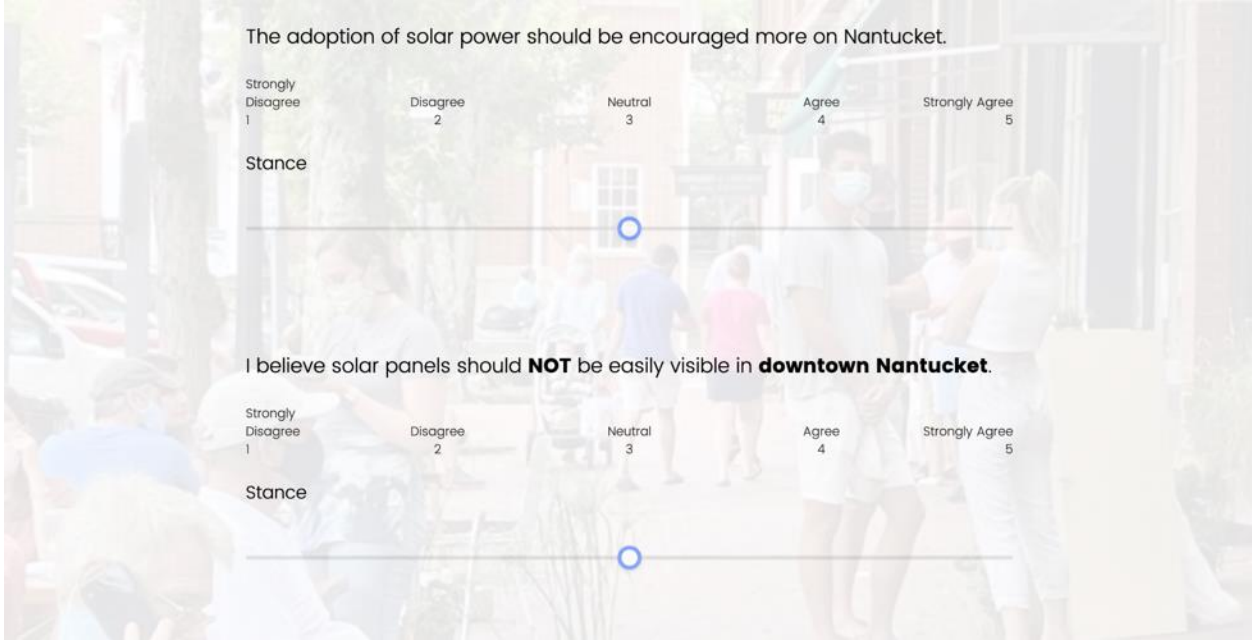


Please indicate how strongly you agree/disagree with the following statements.

The preservation of Nantucket's "historic aesthetic" is important to me.

Strongly Disagree 1 Disagree 2 Neutral 3 Agree 4 Strongly Agree 5

Stance





The questions in this section pertain to four small-scale applications that utilize solar panels but would **NOT** be connected to the grid. Each application will be described and pictured at the top of the page.



1/4: **Solar Powered Trash Compactors**

These stand alone devices could be set up in high traffic locations such as parking lots, beaches, and bike paths to collect and compact trash. The device would operate using solar panels that are built into the bin itself and are not visible to the user. Some of these trash compactors do exist on the island, but we would like to install more. This image shows trash compactors already on the island.



Please indicate how much you agree/disagree with the following statement:
Trash compactors do not fit the Nantucket aesthetic.

Strongly Disagree 1 Disagree 2 Neutral 3 Agree 4 Strongly Agree 5

Agree/Disagree



Would you be in favor of more solar trash compactors being installed at key locations around Nantucket?

Strongly Not in Favor 1 Not in Favor 2 Neutral 3 In Favor 4 Strongly in Favor 5

Favor



Please list any concerns you have with trash compactors being installed on Nantucket.



2/4: **Phone Charging Stations**

These stand alone stations could be set up at restaurants, cafes, and other venues. These stations would use a single solar panel that is held up by a standing table with outlets available so the public could charge their phones and other small devices. The station could be disassembled and taken inside during the evening.




Permission to use this image was provided by **GoSunbolt** and was found on their website - www.gosunbolt.com @gosunbolt #gosunbolt (Pavilion Carousel, n.d.)

Please indicate your opinion on the following statements using the sliders below:

The public will use phone charging stations...

Almost Never 1 Not Often 2 Somewhat Often 3 Often 4 Very Often 5

Frequency of Use



Would you use phone charging stations if they were available at your favorite restaurant or café?

Yes


No

Unsure

Phone charging stations will have the following impact on the island's aesthetic:

Very Negative Impact 1 Small Negative Impact 2 Neutral 3 Small Positive Impact 4 Very Positive Impact 5

Impact



Would you be in favor of phone charging stations being implemented around Nantucket?



Please list any concerns you have with phone charging stations being installed on Nantucket.



3/4: Solar Powered Charging Locker

These lockers would be installed in public places such as beach parking lots, and would have small doors with chargers for different kinds of phones. People could place their phone and other items in a cubby to charge and lock the door for retrieval later. The entire locker would be powered by a set of panels on its roof. **The image below is just an example locker, and would not reflect the actual look of the locker. Should they be installed, they would be designed to fit the Nantucket aesthetic.**



Permission to use this image was provided by **Mobile Locker** and was found on their website - www.mobilelocker.eu (Beach Lockers, 2019)

Please indicate your opinion on the following statements using the sliders below:

Charging lockers will have the following impact on the island's aesthetic:

Very Negative Impact 1 Small Negative Impact 2 No Impact 3 Small Positive Impact 4 Very Positive Impact 5

Impact



The public will use charging lockers...

Almost Never 1 Not Often 2 Somewhat Often 3 Often 4 Very Often 5

Frequency of Use



Would you use charging lockers if they were easily accessible?

Yes

No

Unsure

Would you be in favor of charging lockers being implemented around Nantucket?

Strongly Not in Favor
1

Not in Favor
2

Neutral
3

In Favor
4

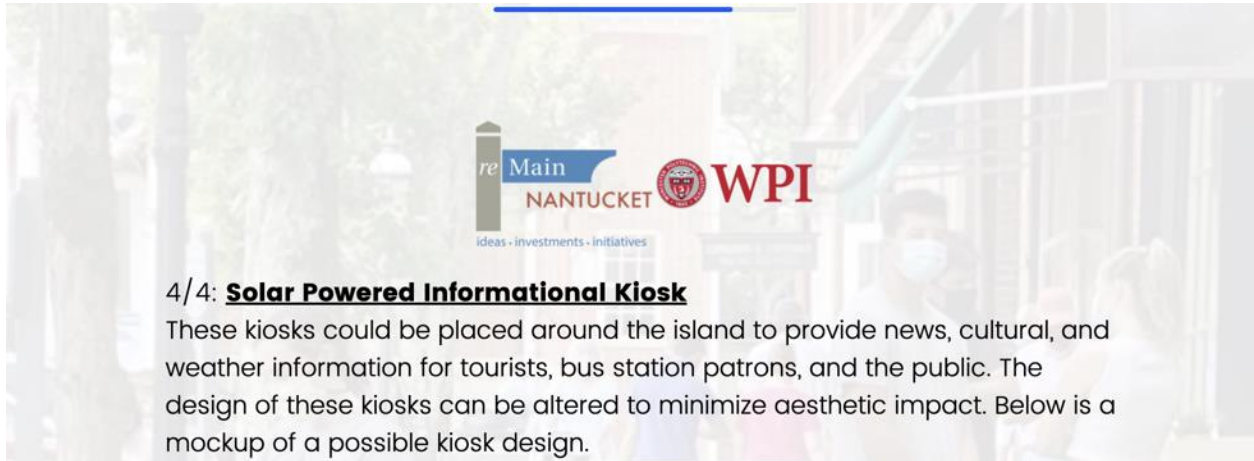
Strongly In Favor
5

Favor



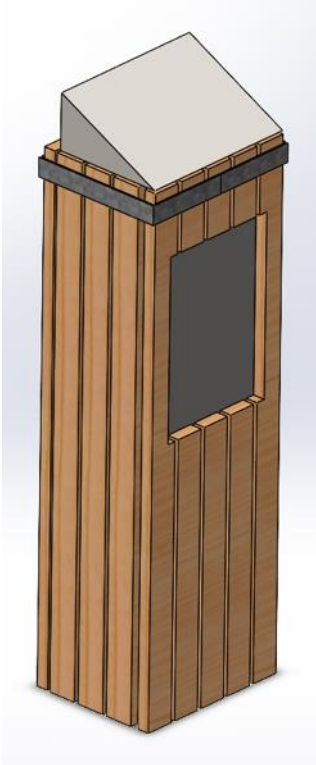
Please list any concerns you have with charging lockers being installed on Nantucket.





4/4: **Solar Powered Informational Kiosk**

These kiosks could be placed around the island to provide news, cultural, and weather information for tourists, bus station patrons, and the public. The design of these kiosks can be altered to minimize aesthetic impact. Below is a mockup of a possible kiosk design.



Please indicate your opinion on the following statements using the sliders below:

Informational kiosks will have the following impact on the island's aesthetic:

Very Negative Impact 1 Small Negative Impact 2 No Impact 3 Small Positive Impact 4 Very Positive Impact 5

Impact



Would you find informational kiosks convenient?

Yes

No

Unsure

Would you be in favor of informational kiosks being implemented around Nantucket?

Strongly Not in Favor 1

Not in Favor 2

Neutral 3

In Favor 4

Strongly in Favor 5

Favor



Please list any concerns you have with informational kiosks being installed on Nantucket.



If you would like to suggest ideas for small-scale solar powered applications that could be implemented on Nantucket, please list them here. If not, you may leave this question blank.



Appendix D: Project Assessment Guides

This appendix contains the one-page informational and promotional guides we developed for the seven most beneficial applications on Nantucket. These were developed as a deliverable to ReMain Nantucket for use at their discretion. They are intended to act as a quick reference guide to some of the key facts about each application. For example, should ReMain or another organization make an effort to convince the DPW to reinvest in Bigbelly trash compactors on a larger scale than before, they could use the informational guide as a reference point to present the DPW with quick information, then answer any questions they'd have by consulting our in depth report and other resources.

Trash Compactors



Stand-alone units that collect and compact trash using a hidden solar panel, sending a signal to the installers to alert when they are full.

Locations

- Parking Lots
 - Siasconset Lighthouse
 - Surfside Beach
 - Stop & Shop
- Trails & Reservation Land

~ **\$3,700** price per unit

Seasonality

Year-Round

Pros

- DPW is understaffed
- Concealable
- Mobile
- HDC friendly
- Already in use
- Seasonally ideal

Cons

- Aesthetic impact
- DPW habitual change
- Recycling confusion



85%

**of surveyees
were in favor**

Phone Charging Table



Permission to use image provided by GoSunBolt and was found on their website - www.gosunbolt.com @gosunbolt #gosunbolt

A table that includes outlets in the center to charge the user's cellphone. The table is equipped with an umbrella and 3-5 person seating options.

Locations

- Restaurants
- Cafes
- Parks
- Beaches

~ **\$8,500 - \$9,400**
depending on seating option

Seasonality

Year-Round

Pros

- Everyone has a cellphone!
- Would easily promote solar
- Lots of usage in the summertime
- Average of 40 mobile device charges per day

Cons

- Not appealing in the downtown area
- Could trickle drain battery if cables left plugged in



44%

of surveyees
were in favor

Beach Charging Locker



Permission to use image provided by MobileLocker and was found on their website - www.mobilelocker.eu

Public lockers with small doors and chargers for different kinds of phones. People could place their phone and other items in a cubby to charge and lock the door for retrieval later.

Locations

- End of WAVE routes
- Parking Lots
 - Siasconset Lighthouse
 - Surfside Beach
 - Chlidren's Beach
 - Jetties Beach

~ **\$22,770** price per unit

Seasonality

Summer

Pros

- Public interest
- Mobile for seasonality
- Custom designing available
- Add ons - wifi, defribilator, etc
- More than just phones
- HDC Grey Area

Cons

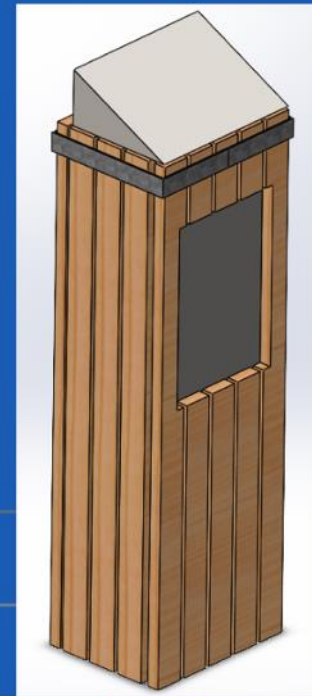
- Trickle drain of chargers
- Costs
- Public education and adoption



26%

of surveyees
were in favor

Informational Kiosks



Kiosks providing news, cultural, and weather information for tourists, bus station patrons, and the public.

Locations

- Main Street of Downtown
- Bus Station Shelters
- Trails & Reservation Land
- Parking Lots
- Ferry Wharfs

~ **\$7,000** price per unit

Seasonality

Year-Round

Pros

- Designed to be well hidden
- Mobile
- Seasonal and hourly operation
- Great for solar PR
- Encourages tourism

Cons

- Aesthetic impact
- Hard to maximize utility
- Maintenance and upkeep



32%

of surveyees
were in favor

Towable Solar Generator



Image provided by ACKSmart <https://www.acksmart.com/>

A solar-powered generator that can be set up and disassembled and towed from event to event.

Locations

- Parking Lots
 - Siasconset Lighthouse
 - Surfside Beach
 - Stop & Shop
- Trails & Reservation Land

~ **\$25,000** price per unit

Seasonality

Spring to Fall

Pros

- Lots of varying uses
- **Great** for solar PR
- Mobile
- Done on island before
- HDC does not have jurisdiction on this application

Cons

- Strict market
- Very expensive
- Difficult to store
- Previous owner did not think it was valuable enough to replace

Solar Pergola



Pergola with solar panels installed on top used to power other applications. Many already exist on Nantucket, and a panel flat on the roof is invisible to the general public's view from the ground.

Locations

- Restaurants
- Bus shelters
- Shading at the beach
- Golf Courses

Varies price per install

Seasonality

Year-Round

Pros

- Willing installers
- Concealable
- Can power many applications
- HDC friendly
- Already in use
- ReMain is familiar with pergolas

Cons

- Takes up large amount of space
- Might need to build new pergola - expensive

Outdoor Restaurant Lighting



Outdoor lighting can be easily powered by a small set of solar panels which charge a single battery during the day and discharge at night. The lights would provide vision for outdoor diners and patrons.

Locations

- Restaurants
 - Outdoor patio
 - Awning
 - Pergola

Varies price of install

Seasonality

Year-Round

Pros

- Lights are easy to implement
- Widely used already
- HDC friendly
- Easy way to get solar in Downtown
- Great source of solar PR

Cons

- Downtown would require a pergola and battery system
- Replacing old systems with solar lights will be expensive