Investigating the Conversion to LED Streetlighting on Nantucket

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Report Submitted to:

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Abstract

Light pollution adversely affects the environment, public safety and health, and energy consumption. Light pollution is the result of scattered artificial light, predominantly from sources such as streetlights as well as interior and exterior building lighting. To address the problem of light pollution and reduce costs, many municipalities throughout the United States have been implementing new policies, such as LED streetlighting. LEDs come with many benefits, such as reduced energy and maintenance costs, as well as the potential to reduce light pollution. In this paper, we discuss the best practices for a LED streetlight conversion for the Town of Nantucket, Massachusetts, as well as the benefits that this project will bring the community.

Acknowledgements

We would like to thank our project sponsors, Lauren Sinatra of the Nantucket Energy Office and Gail Walker of Nantucket Lights. We would like to thank our advisors, Dominic Golding and Fred Looft. We would like to thank Young's bicycle shop for providing us bicycles, as well as the Nantucket Yacht Club for housing us this B term. We would like to thank ReMain for providing a fun treasure hunt for us. Lastly, we'd like to thank everyone who spoke with us and provided insight for our research.

Executive Summary

Light pollution adversely affects the environment, public safety and health, and energy consumption. Light pollution is the result of scattered artificial light, predominantly from sources such as streetlights as well as interior and exterior building lighting. As of 2016, 80% of Americans cannot see the Milky Way from where they live, even on clear nights (Falchi et al., 2016). To address the problem of light pollution and reduce costs, many municipalities throughout the United States have been implementing new policies, such as replacing existing streetlights (typically high-pressure sodium or HPS lights) with light emitting diodes (LEDs). LEDs come with many benefits, such as reduced energy and maintenance costs, as well as the potential to lower light pollution levels.

As an island 30 miles from the coast of Cape Cod, Nantucket is one of the darkest places on the east coast and organizations such as Nantucket Lights, a citizen advocacy group, are dedicated to limiting light pollution to address a variety of concerns, including preserving Nantucket's dark sky. Currently, Nantucket depends on two undersea cables for its electricity and the Nantucket Energy Office (NEO) and town government are committed to promoting energy efficiency and conservation to minimize costs that would be incurred by the installation of a third cable. In a confluence of interests, NEO and Nantucket Lights are exploring the potential of converting the existing high pressure sodium (HPS) cobra streetlights to LED to reduce electricity consumption, maintenance costs, and light pollution.

The goal of this project was to evaluate the best practices of a LED streetlight conversion, and how these practices might be applied on Nantucket. We identified three project objectives:

1. Research best practices for converting current streetlighting to LED, including an evaluation of Massachusetts towns that have already converted to LED streetlighting.
2. Solicit input from stakeholders on Nantucket regarding possible conversion of the existing cobra-style HPS streetlights to LEDs.
3. Develop a recommended set of processes and policies for the implementation of a LED conversion based on the findings from objective 1 and 2.

To accomplish this goal and meet these objectives, we interviewed town administrators in several municipalities that had converted streetlights to LEDs as well as outdoor lighting consultants and experts. We also interviewed various stakeholders on Nantucket to learn how the

best practices for LED streetlight conversions might or might not translate into the island setting. Using this information, we developed a set of recommendations for the Town of Nantucket to utilize as a road map for their LED streetlight conversion.

Major Research Findings

Nationally, the United States is expected to invest approximately 8.2 billion dollars in LED streetlighting throughout the next decade ("Interest in smart streetlighting triples in US cities", 2020). Cities find energy reductions in their streetlighting of up to 80% with a 66% average ("Interest in smart streetlighting triples in US cities", 2020). To look specifically at Massachusetts, through interviews with the Cape Light Compact (CLC) and the Metropolitan Area Planning Council (MAPC), two regional planning authorities in Cape Cod and the Greater Boston respectively, we learned the primary motivations for towns to convert their streetlights to LED, as well as the general path that most municipalities take in their streetlight conversion process. Additionally, we spoke with several lighting consultant companies to see how their services assist towns in performing the most effective streetlight conversion possible.

We found that towns in the Cape Cod region typically reduced costs by ~75% following installation of LED streetlights and shifted to annual rather than monthly service schedules. Additionally, light pollution levels decreased, even in the most populated downtown areas. We learned that this was accomplished through effective lighting design, choosing lighting fixtures with an appropriate BUG[1] rating for the area, as well as a sufficient correlated color temperature (CCT). MAPC representatives, indicated that many communities have installed lighting control systems to dim the lights during some hours of the night. Such controls reduce light pollution and energy consumption and give towns the ability to better adjust lighting to residents' needs.

Recommendations

Based on our research findings, we identified a set of recommendations and best practices. Some of these actions can be conducted in parallel, and others will need to be implemented sequentially.

1. **We recommend the Town of Nantucket create an LED streetlight working group to facilitate major aspects of the conversion process.** This will allow Nantucket to easily

[1]The backlight, uplight, and glare (BUG) rating indicates if the fixture is dark sky compliant.

gain insight from key stakeholder groups in the community as well as serve as a primary decision-making body.

2. **Hire a streetlighting conversion consultant to assist throughout and after the conversion process.** By having an expert throughout the conversion process, Nantucket can be confident in their actions throughout the entire conversion process. The streetlighting consultant can help with the following tasks:
    a. **Performing an exhaustive GIS audit of all the streetlights on Nantucket.** Presently, there is no complete or comprehensive audit of the town streetlights, but this is a necessary first step in the conversion process.
    b. **Conduct an economic analysis of the LED streetlight conversion process.** An economic analysis will reveal the best options the town should pursue in terms of system design, including choice of hardware and software, and installation and maintenance options.
    c. **Purchasing the streetlights from National Grid.** Purchasing the existing streetlights gives Nantucket autonomy and independence in its conversion process, allowing the town to utilize a more granular approach rather than a blanket solution.
    d. **Creating a budget for the entire LED streetlight conversion process using the economic analysis.** Having a budget determined and approved by the Town of Nantucket is a necessary step in the conversion process.

In implementing the LED streetlight conversion, the Town of Nantucket must conduct the following logistical tasks:

3. **Conduct a pilot demonstration of LED streetlights to solicit public feedback on light fixture design and features.** This gives the general public insight into the conversion process, and lets them provide input on factors such as CCT, brightness, and fixture style
4. **Install the streetlights based upon the feedback from the pilot demonstration.** The lighting consultant can help the town negotiate to find a contractor to perform the installation process as well as interim maintenance.
5. **Obtain a maintenance contractor for the interim period of the conversion and afterwards.** Most towns see a maintenance contractor come once a year to replace the lights. Having an established relationship with a contractor starts this process.

When choosing lighting fixtures for the LED streetlight conversion, we recommend the following tasks:

6. **Obtain streetlight fixtures at 2200K that effectively direct light to only the area necessary.** A dark sky compliant sky mitigates light pollution and is effective for lighting
7. **Install lighting controls on the LED streetlighting fixtures to reduce energy consumption and light pollution.** This will allow for an effective way for the streetlights to be dimmed, reducing energy consumption. Additionally, remotely controlling the streetlights can be an effective way to implement resident feedback regarding streetlights.
8. **Dim the streetlights at night or when not in use to mitigate light pollution and energy consumption.** This will further reduce light pollution as well as energy consumption.

Lastly, the town should consider the following items:

9. **Implement a system for residential feedback.** This will allow the town to learn where extra lighting may be needed, where lights need to be removed, and were lighting shields should be installed through efficient resident engagement
10. **Develop a relationship with a larger regional planning organization.** This will provide Nantucket with closer access to a community able to provide their experiences in their streetlight conversion process.

By following these recommendations, we believe the Town of Nantucket can ensure that the streetlight conversion process is accomplished in a timely, effective, and cost-effective fashion.

Authorship Table

Section	Primary Author	Editors	Section	Primary Author	Editors
Abstract	FIM	ALL	*4.2.2*	LKM	ALL
Executive summary	FIM	ALL	*4.3.1 - 4.3.3*	FIM	ALL
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1.0 Introduction

Light pollution adversely affects the environment, public safety and health, and global energy consumption. Light pollution is the result of scattered artificial light, predominantly from sources such as streetlights as well as interior and exterior building lighting. One impact of light pollution is that as of 2016, 80% of Americans cannot see the Milky Way from where they live even on clear nights (Falchi et al., 2016). To address the problem of light pollution and to reduce costs, municipalities throughout the United States have begun replacing existing streetlights (typically high-pressure sodium or HPS lights) with light emitting diodes (LEDs). LEDs come with many benefits, such as reduced energy and maintenance costs, as well as the potential to lower light pollution levels.

As an island 30 miles from the coast of Cape Cod, Nantucket is one of the darkest places on the east coast. Organizations such as Nantucket Lights, a citizen advocacy group, are dedicated to limiting light pollution to address a variety of concerns, including the preservation of Nantucket's dark sky. Currently, Nantucket depends on two undersea cables for its electricity and the Nantucket Energy Office (NEO) and town government are committed to promoting energy efficiency and conservation to minimize costs that would be incurred by the installation of a third cable. In a confluence of interests, NEO and Nantucket Lights are exploring the potential of converting the existing HPS cobra streetlights to LED to reduce electricity consumption, maintenance costs, and light pollution.

The goal of this project was to evaluate the best practices of a LED streetlight conversion, and how these practices might be applied on Nantucket. To achieve this goal, we identified three project objectives:

1. Research best practices for converting current streetlighting to LED, including an evaluation of Massachusetts towns that have already converted to LED streetlighting.
2. Solicit input from stakeholders on Nantucket regarding possible conversion of the existing cobra-style HPS streetlights to LEDs.
3. Develop a recommended set of processes and policies for the implementation of a LED conversion based on the findings from Objective 1 and 2.

To accomplish our goal and meet these objectives, we interviewed town administrators in several municipalities that had converted streetlights to LEDs, as well as outdoor lighting consultants and other industry experts. We also interviewed stakeholders on Nantucket to learn

how the best practices for LED streetlight conversions might or might not translate into the island setting. Using this information, we developed a set of recommendations for the Town of Nantucket to utilize as a road map for their LED streetlight conversion.

2.0 Background

Throughout this section, we discuss light pollution and its adverse effects on the environment and people. Afterwards, we discuss how LED streetlighting can combat light pollution while maintaining visibility for pedestrians and motorists.

2.1 What is light pollution?

Light pollution is a result of scattered artificial light, predominantly from sources such as streetlights as well as interior and exterior building lighting. Light pollution adversely affects the environment, public safety and health, and global energy consumption. Figure 1 shows that in locations with significant light pollution, it is very difficult, if not impossible, to see the stars and other features in the night sky. By contrast, areas with little light pollution can provide a spectacular view of the heavens above. In 2016, it was estimated that 80% of Americans can no longer see the Milky Way Galaxy at night due to light pollution (Falchi et al, 2016).

Figure 1: Light pollution levels in high and low population densities (Chandrasekhar, 2017)

Light pollution was first referenced in the nineteenth century (Guillemain, 1864), but has become a growing concern only relatively recently (Klinkenborg, 2008). Unlike other forms of

pollution, light pollution has no physical manifestation like plastic in ocean water or soot in the air, making raising awareness and prevention more difficult.

Light pollution manifests itself in several forms but can be categorized into four major types: light trespass, glare, skyglow, and clutter, as shown in Figure 2 ("Singapore in 2016", 2019).

Figure 2: Four types of light pollution ("Singapore in 2016", 2019)

Light trespass is when light from one source reaches an unintended area, such as an outdoor light shining in a neighbor's bedroom. Glare is when excess light leads to visual impairment, making it difficult for pedestrians to see or motorists to drive. Skyglow is the result of undirected light reflected into the night sky, which limits the visibility of stars. Lastly, light clutter is when there is an excessive grouping of lights, which can be distracting and cause unnecessary light pollution. Light pollution is most concentrated in urban areas with extensive infrastructure such as highway, billboards, sports stadiums, airports, office buildings, and parking lots. Figure 3 shows that roadway lighting is the single largest contributor to light pollution in the United States at 48% with parking areas at 34% and exterior lighting for buildings at 10.5% (Ashdown, 2019).

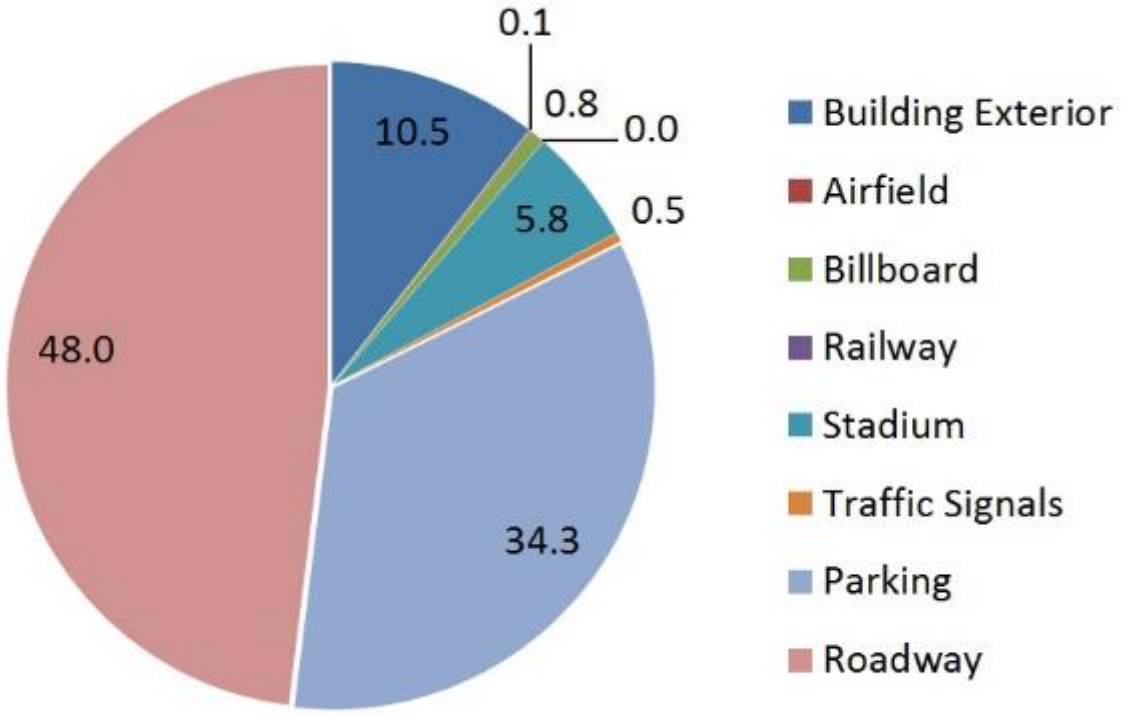

Figure 3: US light pollution contributors (Ashdown, 2019)

Much of the light intended for lighting our streets, parking lots, and homes is reflected or directed into the atmosphere (Ashdown, 2019) resulting in light pollution and wasted electricity. This light is then scattered by the atmosphere causing the night sky to dimly glow when viewed from the ground. This glow inhibits the visibility of stars. The map in Figure 4 shows the varying intensity of light pollution in the U.S. Areas in Figure 4 colored white or red (i.e., the left of the spectrum in the key) suffer more intense light pollution. In the map, we see that light pollution is most concentrated in urban areas. The light pollution produced by these urban areas also ‘leaks’ into the surrounding suburban and rural areas.

Figure 4: Light pollution in the United States (Stare, 2021)

To address rising light pollution levels, the International Dark-Sky Association (IDA) was founded in 1988 and now has chapters throughout the United States and world. The IDA advocates for dark sky policies and provides municipalities with guidance to reduce light pollution levels. Light pollution in cities like New York is so prevalent that it is difficult to see even the brightest stars on cloudless nights. By contrast, stargazing in Natural Bridges National Monument located in Lake Powell, Utah, a certified International Dark Sky location, has excellent views of not only the Milky Way Galaxy, but also its shadow (International Dark-Sky Association, 2007). Unfortunately, remote areas are beginning to be challenged by rising light pollution levels as well. Since these areas have an initial low level of light pollution, small increases in light pollution may be especially concerning to residents and visitors.

2.1.1 The Bortle Scale

To accurately measure and compare the severity of light pollution in different locations, astronomer John E. Bortle developed a nine-level numeric scale, now known as the Bortle Scale. In a location denoted as 'Class 1', or excellent dark-sky site, the full range of the night sky would be visible (Figure 5).

By contrast, in a ‘Class 9’ or inner-city location, most stars are totally invisible to the observer on the ground as the sky is brightly illuminated by artificial light due to skyglow. The only objects visible in an inner-city sky location would be the moon and only the brightest stars.

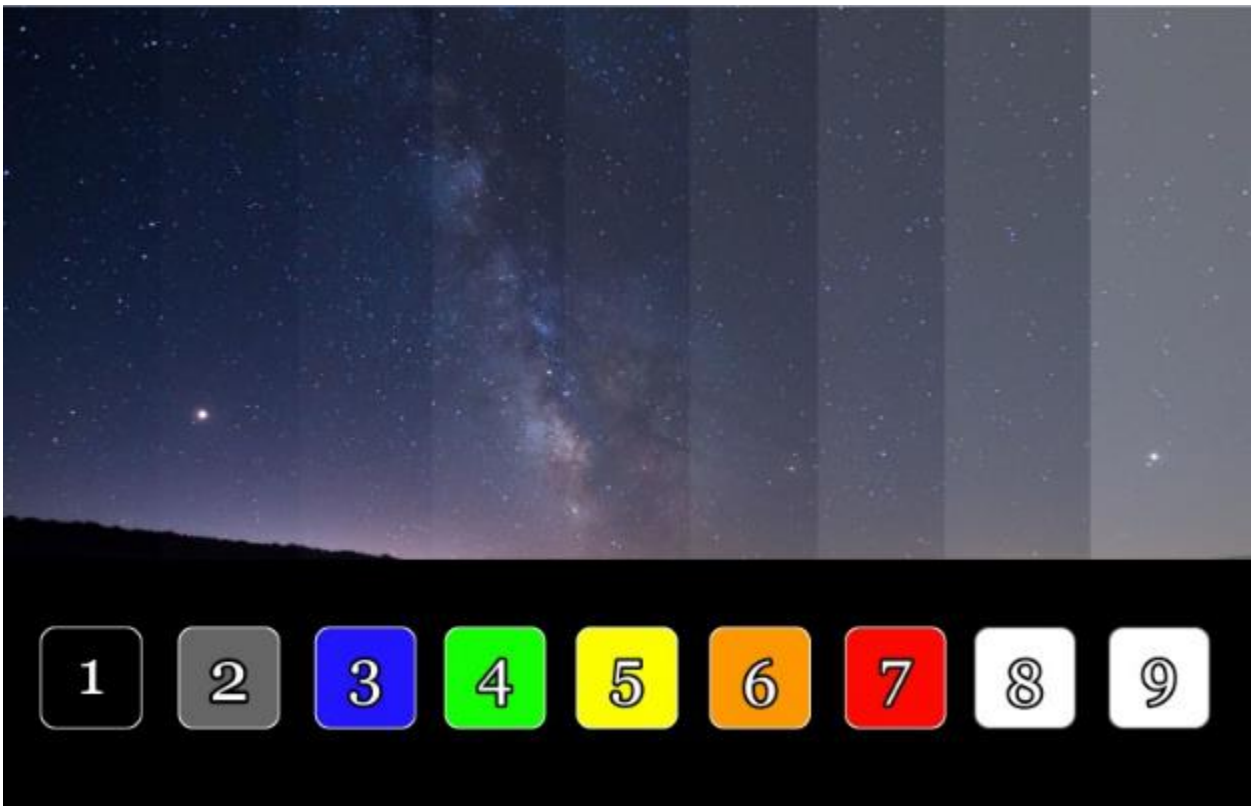

Figure 5: The Bortle Scale for measuring dark skies (Minoia, 2020)

2.2 Adverse effects of light pollution

Light pollution levels in the U.S. have been increasing since the 1950s (Plumer, 2014). It is estimated that light pollution now costs the United States about $3.5 billion each year in terms of wasted energy alone as a result of improper, overly dense and poorly planned outdoor lighting (Van Der Put, n.d.).

Light pollution’s adverse impact on wildlife is evident in a variety of cases, including bird migrations and turtle hatching. Research indicates that lights and light pollution encourage turtle hatchlings to move inland toward developed areas rather than towards the ocean resulting in excessive deaths (“Artificial Lighting and Sea Turtle Hatchling Behavior”, n.d.). Another study indicates that light pollution can cause migratory birds to fly off course into brightly lit buildings, often resulting in death. Similarly, the decline in insect populations have been linked

to rising light pollution (Owens et al. 2020). Light pollution levels impact "[d]iurnal animals that exploit artificial night lighting as a means to extend activity periods occupy the 'night light niche', thereby disrupting normal species interactions during the time locations are illuminated" (Longcore & Rich, 2016). Thus, animals that normally occupy this niche face extra competition that may limit procreativity and chances of survival.

Light pollution also has a direct impact on human behavior and wellbeing. A study conducted in 2020 found substantial evidence that light pollution can impact human sleep patterns and interrupt the body's circadian rhythm (Walker et al., 2020). This interruption can lead to sleep deprivation and sleep disorders (Falchi, 2011). The blue light that is common in most earlier LED lights and many home devices can interrupt the circadian rhythm negatively as well, lowering the quality of sleep ("Blue light has a dark side", 2020). Light pollution has been linked to hormonal cancers in humans, such as breast cancer and prostate cancer (Walker, Walton, DeVries, Nelson, 2020). Additionally, the light trespass in people's homes can be an annoyance and increase stress due to the inability to fall asleep. Light pollution can also be detrimental to amateur and professional astronomers alike, as increased light pollution makes it significantly more difficult to observe the night sky. The United Nations aggregated the findings of multiple studies into a report on the effects of light pollution and artificial light at night, not limited to: cancers, sleep disruption, diabetes, obesity, and depression. For more information, interested readers should see "Dark and Quiet skies for Science and Society: Report and Recommendations" (United Nations Office for Outer Space Affairs, 2020, pp. 92-102).

2.3 Mitigating Light Pollution

To reduce energy consumption and light pollution, many cities and towns within the last decade have pushed for lighting ordinances and regulations to limit unnecessary light emissions. In the town of Rockport, MA a bylaw was passed in 2017 that places restrictions on outdoor lighting as a means for mitigating light pollution. Some existing luminaire light sources are limited to 3000 Kelvin (K, the correlated color temperature) and other existing lights that aren't full cutoff, as well as new ones, are restricted to being 2750K. Full cutoff lights require that the light fixture directs no light upwards, and the correlated color temperature is how warm the light appears. Further discussion can be found in §1.3.1 and §1.3.2 respectively. Guidelines for

placement and orientation were put in place to further protect the community from light trespass ("Rockport MA Lighting Bylaw", 2017).

In November 2021, "An Act to improve outdoor lighting, conserve energy, and increase dark-sky visibility" was introduced in the MA State Senate (S.2147) and the state house (H.3306). This legislation, if enacted into law, would "promote energy-efficient lighting practices throughout the Commonwealth" by requiring municipal and state funded projects to use fully-shielded exterior lighting in new ore replacement installations; requiring these installations to use a lighting with a color temperature of 3000K or less; requiring the Massachusetts Department of Transportation (DOT) to update its criteria for roadway lighting to conform to commonly accepted best practices; and require the Massachusetts Department of Public Utilities to establish reduced-rate tariffs for low-wattage LED streetlights and for streetlights that are dimmed or turned off during the light to provide cost incentives for these conversions ("Fact sheet: 'An Act to improve outdoor lighting […]'", n.d.). At the time of writing, this legislation remained pending in the Joint Committee for Telecommunications, Utilities, and Energy.

Regardless of any local or state regulation of outdoor lighting, in 2020 the IDA and the Illuminating Engineering Society (IES) agreed on "Five Principles for Responsible Outdoor Lighting" that can be employed by everyone to help reduce light pollution. These are: (1) all light should have a clear purpose; (2) light should be directly only to where it is needed; (3) light should be no brighter than necessary; (4) light should be used only when it is useful; and (5) warmer color lights should be used where possible (Figure 6). These include making sure lights have a clear purpose, are directed to the target area, have low brightness levels, are controlled to produce light only when necessary, and have the warmest colors possible ("Five Principles for Responsible Outdoor Lighting", n.d.).

Figure 6: The Five Principles for Responsible Outdoor Lighting ("Light to Protect the Night"n.d.)

While removing all lighting from a highway or parking lot would certainly reduce light pollution, research indicates that poorly lit nighttime environments are often labeled as unsafe or dangerous. This perception of danger, even if none exists, is thought to originate from the association of a reduced vision range with encroaching or immediate danger (Haans et al., 2012). Research indicates, however, that streetlighting does not necessarily improve safety, but rather only the perception of it. Furthermore, research in the United Kingdom found that there is "little evidence for any associations between streetlighting adaptation strategies and day-adjusted night-time collision rates" and "There was no evidence from the overall estimates for an association between the aggregate count of crime and switch off or part-night lighting," but "[t]here was weak evidence for a reduction in the aggregate count of crime and dimming" (Perkins, Steinbach, Thompson, et al., 2015). Different research performed in Chicago indicated that crime was "sensitive to streetlight conditions" but counter-intuitively would move "downstream", away from the areas with streetlight outages and into adjacent, better lit areas (Chalfin, Kaplan and

LaForest, 2020). These studies suggest the idea that over illuminating an area will not have an appreciable, positive effect on public safety but instead would create large disparities between the lighting of areas that may put more people at risk.

Research on public streetlighting in Italy indicates that by restricting the types of lighting used in lit public spaces, municipalities were able to reduce light pollution without sacrificing the area of visibility (Beccali et al., 2018). Furthermore, the authors found that the refurbishment of old lighting fixtures is often more cost efficient than the installation of new ones in terms of perceived safety, visual comfort, and economic feasibility (Beccali et al., 2018).

2.3.1 Considerations in LED streetlight conversions

Many municipalities in the US have converted their streetlights from high pressure sodium (HPS) to LED fixtures. LED streetlights, when properly designed and installed, reduce glare, trespass, and skyglow as well as require less electrical energy. Figure 7 shows an example of an LED streetlight used to replace the standard HPS cobra models.

Figure 7: PHILIPS LED streetlight in Tallinn (G, 2016)

It should be noted that the streetlight in Figure 7 is consistent with dark-sky principles, meaning it is shielded and directed downwards to mitigate light pollution. Because of the effectiveness of this design, many municipalities throughout the United States use lighting fixtures such as the one shown above when converting their streetlights to LED.

One of the benefits of LED streetlights is that they require less maintenance than other streetlighting solutions. This is due to LED's long lifetime which in turn makes the replacement of non-functional lights far more infrequent. Jane Slade of Speclines stated that "LED fixtures require almost no maintenance as compared to their predecessors. Depending on the manufacturer, LED fixtures are expected to need little or no maintenance for 10, 20, and sometimes even 30 years after the date of installation." HomElectrical notes that LED's can last for up to 30,000 hours (Williams, 2017). With LEDs in a streetlighting system, the reliability of the system is improved as it is far more likely for failures to arise from electronics, connections, and other parts of the light system than from the light fixture themselves.

LED streetlight conversions have not been without their own controversies. For example, in 2016 New York City replaced newly installed LEDs with less bright LEDs due to complaints from citizens. Although the original LEDs produced less glare, and thus less light pollution, they were "too bright in many cases" (New York Post, 2016). This perception of increased "brightness" is likely due to several factors, including high color temperature, which is harsher on the eyes when used at night, and high brightness (measured in "lumens").

Besides being too bright, poorly positioned and/or designed, LEDs can still shine into other buildings causing light trespass. To mitigate this, shields can be installed on streetlights to help direct the light, improving visibility of pedestrians and motorists by reducing glare as well as mitigating light pollution. These improvements in reducing light pollution are not unique to LEDs. Many HPS lights have been using shields for years, but due to low demand, shields are either no longer being manufactured for HPS lights or are expensive (L. Sinatra, personal communication, September 2021).

Fortunately, many lighting fixtures can be modified to limit light pollution and provide acceptable forms of lighting with the installation of a shield or hood over the top of the fixture, as well as careful consideration as to the fixture's brightness and placement. More acceptable forms of fixtures include full cutoff fixtures, fully shielded parlor fixtures, & full cutoff streetlights.

In recent years, the terms ‘full-cutoff’ and ‘fully shielded’ are being phased out by the IDA in favor of using the ‘B.U.G. rating’ to categorize outdoor lighting. The BUG rating measures three attributes (backlight, uplight and glare), on a scale from zero to five where a zero rating representing the least light pollution and a rating of five representing the most light pollution. Figure 8 displays backlight, uplight, and glare as they relate to streetlights. The upper half of the figure highlights the low (UL) and high (UH) uplight (“BUG Rating System 101”, n.d.). BVH and BH refer to the backlight of the fixture, and FH and FHV refer to the forward light of the fixture (“BUG Rating System 101”, n.d.). Backlight is the light emitted from a fixture which illuminates behind the fixture or its intended area of illumination, often into private residences and businesses. Backlight is the most common form of light trespass. A fixture’s uplight is the light which spills above the fixture. Uplight is largely responsible for skyglow and any uplight categorizes a fixture as ‘not dark sky friendly.’ A light fixture with an uplight value of zero would previously be referred to as ‘full cutoff’. Lastly, glare refers to the light ‘within the wedge between horizontal light and useful light’. An excessively high glare intensity can cause difficulty seeing as well as visual discomfort and can impair the vision of pedestrians and motorists. Overall, the BUG rating system provides a more comprehensive description of the light and its effects than the previous term ‘full-cutoff’, and using it will be a key factor in balancing light pollution and converting HPS bulbs to LED.

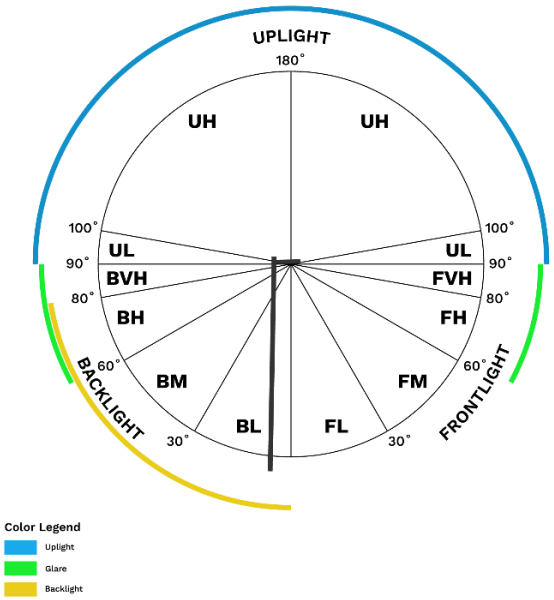

Figure 8: A diagram depicting backlight, uplight, and glare zones of a light fixture ("Lighting Fundamentals – BUG Ratings", n.d.).

Glare poses an issue to drivers at night, especially to older motorists. The Federal Highway Authority published a report outlining the importance of effective streetlighting, also highlighting the negative impacts that glare can have on motorist reaction time as they age, citing the FHWA Lighting Handbook. Figures 24, 25, and 26 in the handbook outline the degradation of the eye over time, which highlights the importance of effective lighting that does not produce glare for motorists. This degradation leads to an increased lead distance needed to spot changes in the road, which can be hazardous. Additionally, Section 6 of the handbook provides guidelines for lighting selection. The American Medical Association also "encourage[s] minimizing and controlling blue-rich environmental lighting by using the lowest emission of blue light possible to reduce glare." (Kraus, 2016).

2.3.2 Correlated color temperature

LEDs come in an array of 'color temperatures,' measured in units called 'Kelvin' (K). LEDs that are lower on the color spectrum (i.e., to the left in Figure 9) appear 'warmer,' while those on the right appear 'cooler.' An example of a warmer light is a candle, whereas 'cooler' light is the color of the sky during the day. Using cooler, bluer lights at night have been shown to cause more disruption of circadian rhythms and local ecosystems.

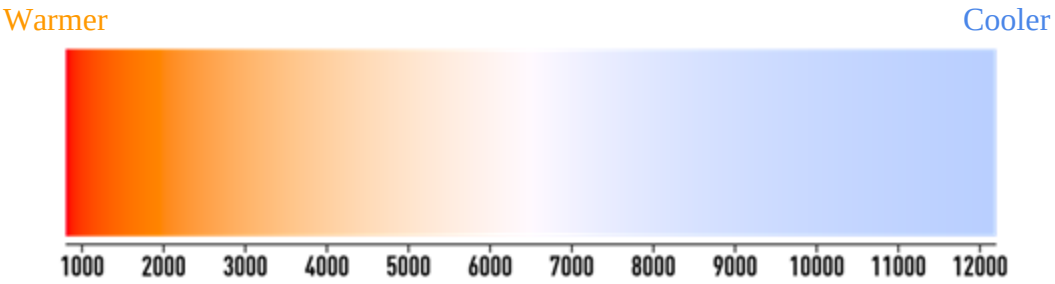

Figure 9: The LED color temperature spectrum in Kelvin (Bhutajata, 2015)

The "warmer" colors do not interrupt circadian rhythms or other natural cycles as much, and the International Dark-Sky Association currently recommends LED streetlights at 2200K for most outdoor lighting applications ("Values-Centered Outdoor Lighting", 2021).

2.3.3 Mitigating light pollution on Nantucket

Nantucket is an island located 30 miles off the coast of Cape Cod. Historically, Nantucket has had excellent views of the night sky, largely due to its limited development and location at sea far from other urban areas. Unfortunately, light pollution, especially from light sources in downtown and mid-island, as seen in Figure 10, is beginning to adversely affect the views of the night sky and may be adversely affecting wildlife.

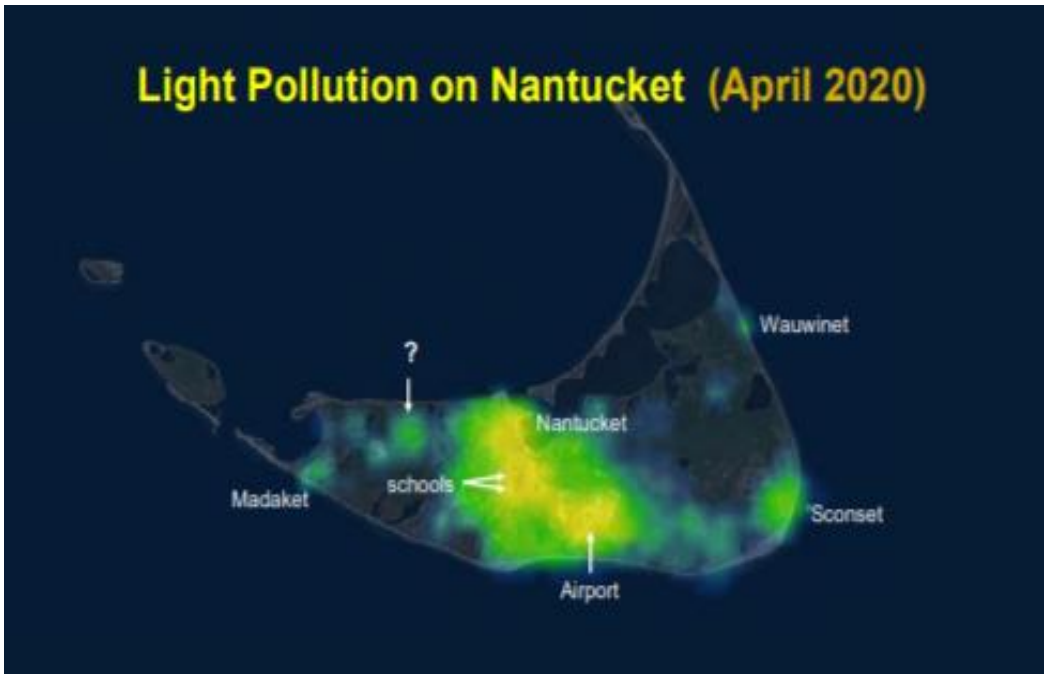

Figure 10: Nantucket Light Pollution
(Beatty, 2020)

Light pollution on Nantucket ranges from 2 on the Bortle scale in areas such as the Moors (the large dark region in the East) or Tuckernuck (the Western most island) to level 5 in mid-island or downtown. Thus, even in Nantucket's more densely populated areas, one can still see the brighter stars when the skies are clear. Recently, many residents are concerned that this may soon become difficult in the near future, given the rate of increase in light pollution on the island. Between 2012 and 2020, light pollution levels on the island have been climbing at a rate of 2.4% per year ("Light Pollution on Nantucket: How Bad Is It?", n.d.). In response, governmental and non-governmental organizations are beginning to take steps to reduce light pollution levels.

In 2005, Nantucket adopted a light ordinance "to reduce the problems created by improperly designed and installed outdoor lighting. It is intended to eliminate problems of glare, minimize light trespass, and help reduce the energy and financial costs of outdoor lighting. The

ordinance establishes regulations that limit the power consumption and brightness of outdoor lights, the direction of lighting and the area that certain kinds of outdoor lighting fixtures can illuminate" ("Town of Nantucket, MA: Outdoor lighting", n.d). The ordinance discusses steps to mitigate the four major types of light pollution as discussed in Section 2.1 and Figure 2. It also established the position of lighting enforcement officer to manage issues of lighting violations and outlines a process to resolve violations ("Town of Nantucket, MA: Outdoor lighting", n.d). Unfortunately, it remains unclear how effective the light ordinance has been, given the increasing levels of light pollution on the island. Enforcement of the bylaw is complaint based, and thus a lack of awareness can severely impact the effectiveness of the bylaw. If people do not know what is and is not permitted, or who to report violations too, this will lead to violations going unchecked.

Nantucket Lights was founded in 2021 to protect and preserve Nantucket's night sky. They employ several methods to raise awareness and advocate for community guidelines to help reduce light pollution. One of their main foci is the implementation of environmentally responsible outdoor lighting, following the five principles from the IDA summarized in Figure 6. These principles apply to both public light fixtures, such as streetlamps, and privately owned lights in parking areas and backyards.

Nantucket Lights is advocating for a streetlight conversion that is environmentally responsible and incorporates LEDs with appropriate color temperatures to suit particular locations. Nantucket Lights is working with the town to convert streetlights to LEDs while also ensuring that the LEDs are properly installed to achieve reduced light pollution. For example, members believe that the historic districts and low traffic residential streets could have 2200K LEDs (similar in color temperature to the existing HPS), while main roads could have 2400K – 3000K.

Currently, the Nantucket Energy Office (NEO) (Appendix C: Sponsor Description) is investigating replacing the 586 HPS cobra-head streetlights present throughout Nantucket Island with LEDs. As Nantucket is an island, the logistics of a streetlight conversion are more complex than on the mainland. In a confluence of interests, NEO and Nantucket Lights are exploring the potential of converting the existing HPS cobra streetlights to LED to reduce electricity consumption, maintenance costs, and light pollution.

The goal of this project was to evaluate the best practices of a LED streetlight conversion, and how these practices might be applied on Nantucket. To achieve this goal, we identified three project objectives:

1. Research best practices for converting current streetlighting to LED, including an evaluation of Massachusetts towns that have already converted to LED streetlighting.
2. Solicit input from stakeholders on Nantucket regarding possible conversion of the existing cobra-style HPS streetlights to LEDs.
3. Develop a recommended set of processes and policies for the implementation of a LED conversion based on the findings from objective 1 and 2.

Further details of the methodology can be viewed in Appendix B: Methodology.

3.0 Findings

In this section, we present our findings from interviewing several Massachusetts towns about their LED streetlight conversions, highlighting the major items from our interviews with members of their communities. Then, we outline how a LED streetlight conversion process might be implemented on Nantucket.

Nationally, The Northeast Group conducted a survey of 314 cities in the United States and estimated that the US is going to invest approximately 8.2 billion dollars into LED streetlighting over the next 10 years ("Interest in smart streetlighting triples in US cities", 2020). The Northeast Group "found that cities implementing smart streetlights achieve energy savings of up to 80 per cent with the average at 66 per cent." ("Interest in smart streetlighting triples in US cities," 2020). Shifting from a national scale to Nantucket, through discussion with many stakeholder groups, we learned about streetlight conversions in several towns in Massachusetts. We identified several key best practices and lessons learned that Nantucket should consider as they pursue the LED conversion process.

3.1 Comparison of LED streetlight conversion programs in selected Massachusetts towns

Through interviews with municipalities and planning board members, we have learned about several best practices in their LED streetlight conversions. Table 1 summarizes some of the key attributes from these towns. We found that many towns utilized a third-party consultant to assist in the conversion logistics, as well as conducting a pilot program to gauge resident feedback on the new LED streetlights. Additionally, we found that many towns opted to get warm color temperature streetlights, although only Pepperell opted for the 2200K color recommendation of the IDA. Many towns bought the streetlights from their utility provider as well to give them more autonomy in the conversion process, which required the towns to source their own maintenance solutions.

Table 1: Summary of Interview Information

Information	Pepperell	Rockport	Melrose	Cambridge	CLC Towns
Consultant?	RealTerm Energy	Tanko Lighting	No	Lam Partners/Dagle Electrical Construction	LightSmart Consulting
Pilot Program	Yes	Yes	Yes	Yes	Most
Temperature	2200K	2700K	3000K	4000K	3500K
Bought streetlights from utility	Yes	Yes	Yes (For at least 12 years before conversion)	Yes	Yes (except Eastham)
GIS Audit	Yes	Yes	Yes	Yes	Yes
Pilot Demonstration	Yes	Yes	Yes	Yes	Most
Maintenance	Through RealTerm energy	In house with another town	Siemens Energy	In house	Siemens Energy

3.1.1 The Cape Light Compact conversion program

On Cape Cod there is a regional energy service organization called the Cape Light Compact (CLC). Their mission is: "to serve its 200,000 customers through the delivery of proven energy efficiency programs, effective consumer advocacy and renewable competitive electricity supply." The participating towns are Hyannis, Dennis, Harwich, Chilmark, Chatham, Orleans, Brewster, Wellfleet, Truro, Provincetown, Mashpee, Cotuit, Edgartown, Oak Bluffs, Barnstable, Sandwich, West Barnstable, Yarmouth, Falmouth, Bourne, Centerville-Osterville-Marstons Mills, West Tisbury and Tisbury ("Energy Efficiency for Municipalities", n.d.).

In October 2012, the CLC started a demonstration program for converting streetlights from HPS to LEDs in several towns across Cape Cod and Martha's Vineyard (Galligan, 2013). Table 2 shows the projected cost savings for this conversion program for all the participating towns. On average, towns were projected to save $9,000 in annual maintenance costs and more than $28,000 annually in reduced electricity charges. Larger municipalities, such as Falmouth (highlighted in blue in Table 2), saw cost savings of hundreds of thousands of dollars. The LED

conversion reduced costs for all the towns involved in their utility bill charge as well as money saved through lower maintenance costs for LED streetlights.

Table 2: The Cape Light Compact Energy Savings Estimations (Galligan, 2014)

	Existing			Proposed LED				Estimated Yearly Savings		
Participating Municipality	**Light Count**	**Annual kWh**	**Utility Bill S-2 Charge ($)**	**Light Count**	**Annual kWh**	**Utility Bill S-2 Charge** ($)	**Estimated Project Cost** ($)	**Annual kWh Savings**	**Utility Bill S-2 Charge Savings ($)**	**Annual Maintenance Savings** ($)
Barnstable Fire District	8	6,200	1,125	8	1,378	290	3,121	4,822	835	108
Bourne	1,163	330,016	73,131	1,163	101,651	26,547	413,627	228,365	46,584	15,724
Brewster	106	33,296	7,175	106	9,578	2,469	39,094	23,718	4,706	1,433
C-O-MM Fire District (Ph II)	1,323	414,897	89,439	1,322	95,629	30,731	468,700	319,268	58,708	17,873
Chatham	559	164,548	36,089	559	47,689	12,575	206,166	116,859	23,514	7,558
Chilmark	21	9,252	1,689	21	1,688	456	7,745	7,564	1,233	284
Cotuit Fire District	303	85,968	19,051	303	27,592	7,092	106,429	58,376	11,959	4,097
Dennis	2,177	590,420	132,570	2,177	189,423	49,558	805,461	400,997	83,012	29,433
Edgartown	288	147,948	28,587	288	30,893	7,479	106,218	117,055	21,108	3,894
Falmouth	***2,573***	***634,040***	***144,930***	***2,573***	***221,140***	***58,139***	***903,766***	***412,900***	***86,791***	***34,787***
Harwich	1,137	292,424	66,716	1,137	98,427	25,803	421,896	193,997	40,913	15,372
Hyannis Fire District	1,311	585,224	115,888	1,311	174,364	40,709	509,015	410,860	75,179	17,725
Mashpee	368	114,260	24,697	368	33,806	8,660	129,260	80,454	16,037	4,975
Oak Bluffs	525	146,804	32,669	525	49,501	12,556	193,627	97,303	20,113	7,098
Orleans	287	89,248	19,283	287	25,996	6,695	105,849	63,252	12,588	3,880
Provincetown	***436***	***182,540***	***36,725***	***436***	***46,652***	***11,304***	***183,406***	***135,888***	***25,421***	***5,895***
Sandwich	257	89,812	18,832	257	25,206	6,300	90,271	64,606	12,532	3,475
Truro	40	14,368	2,993	40	4,109	1,010	14,753	10,259	1,983	541
Wellfleet	233	98,636	19,798	233	25,504	6,131	85,933	73,132	13,667	3,150
W Barnstable FD	91	22,152	5,142	91	8,276	2,128	31,964	13,876	3,014	1,230
West Tisbury (Ph II)	47	21,904	3,987	42	380	145	9,357	21,524	3,842	568
Yarmouth	2,163	610,572	132,636	2,163	203,625	52,121	779,552	406,947	80,515	29,244
Totals	**15,648**	**4,778,921**	**1,031,071**	**15,588**	**1,448,899**	**$ 373,411**	**5,662,975**	**3,330,022**	**657,660**	**210,750**

As highlighted in yellow in Table 2, Provincetown saw an estimated yearly savings of around $31,000 dollars ($25,000 in reduced electricity costs and $6,000 in reduced maintenance costs). With an anticipated cost of around $183,000 the project would pay for itself after only six years. Provincetown is similar to Nantucket in that it is a seasonal town, where the population increases greatly during the summer. A representative from the CLC indicated that among all the towns in the Compact, residents of Provincetown were the most engaged community in the demonstration phase. Figure 11 shows that light pollution in Provincetown declined substantially following the conversion. As of now, all the towns that participated in the pilot program have completed a full LED streetlight conversion.

Figure 11: Provincetown before and after the LED Conversion ("Provincetown before and after", 2014)

The Cape Light Compact hired a streetlighting consultant, George Woodbury of LightSmart Energy Consulting, to guide the regional planning association and work on behalf of all the participating communities. The CLC then performed an extensive GIS audit on the streetlights in their 23 municipalities. These audits identified 17,000 GPS points for streetlights and even included locations where lights had been removed and the towns were still getting billed. Based on these audits, all but one town (Eastham) decided to purchase their existing streetlights from Eversource, with facilitation by the CLC[2]. Due to the depreciated value of the streetlights and the necessity of taking over light maintenance, the poles were sold to the towns

[2] Eastham opted to not perform a conversion as the town thought it would be too complex.

for a dollar or less (per pole). At the time of LED streetlight conversion, the only two options available for CCT were 4000K and 3500K. The CLC allowed each municipality to decide on the fixtures they would use. The constituent members of the CLC performed their own community surveys, including civic associations, public works, police and fire departments and various other advocacy groups. Through their pilot programs they found that 3500K was the most popular option, although a very small minority of residents complained about their 'blueness'. The communities have not implemented any type of dimming controls, although the pins[3] are available for future implementation. During the initial public consultation process, residents in Provincetown asked for the lighting to be dimmer, but the police, fire, and public works departments pushed back on the grounds that this would reduce public safety. After installation, there have been no reported requests to dim the lights in Provincetown.

The CLC found that most LEDs they installed have required minimal maintenance in the approximately 7-year period since their installation. Margaret Song of the CLC indicated that damages due to weather, traffic accidents, and fallen trees have not been covered under warranty, so the Town would have to pay for a replacement (personal communication, November 4, 2021). The largest maintenance expenses for any CLC community have been associated with roadway widening or relocation schemes implemented after the LED conversion. Based on current maintenance data, the maintenance contractor Siemens Energy only has to service each community about once a year.

The move from monthly fees per light under Eversource to a pay-for-service model after conversion has resulted in significant savings in operations and maintenance (O&M) for all towns. The only exceptions involve roadway changes (e.g., in Tisbury) that required additional spending. These savings can be seen in Figure 12. The new maintenance contract with Siemens Energy yields a 70% reduction in maintenance savings, bringing the towns a strong return on investment for their streetlight conversions.

[3] Pins allow for lighting dimmers and other controls to be installed at a later date.

O&M Contract Comparison (Maintenance Pricing - $ Per Light Per Month)		
	non-LED fixture	LED fixture
Old O&M contract	$1.22	n/a
New O&M contract*	$1.27	$0.33
>70% lower fixture maintenance pricing with LED vs. non-LED		

* Siemens may adjust the $PLPM pricing each year of the contract; e.g., by a pre-stated amount or tied to the Boston CPI-U.

Figure 12: Cape Light Compact Operations and Maintenance Savings (CLC Governing Board, 2014)

3.1.2 Pepperell, Massachusetts

Light pollution in Pepperell, Massachusetts has been climbing at a rate of 6% per year ("Light, air and noise bylaw committee", n.d.). This is three times higher than the United States national rate of 2.2% per year since 2012 (Kyba, et al., 2017)[4]. Through these light intensity measurements, Pepperell became aware that light pollution was an increasing problem and in 2019, the Light, Air, and Noise Bylaw committee (LAN) of Pepperell drafted a bylaw which addressed the increase of light pollution ("Light, air and noise bylaw committee", n.d.). Section 2 of the bylaw highlights its purpose of minimizing light pollution and protecting residents from light trespass, glare, and skyglow ("Outdoor Lighting Bylaw for Pepperell, Massachusetts", n.d.). Additionally, the bylaw discusses how Pepperell will "Provide adequate light for the safe performance of outdoor tasks at night; Promote efficient and cost-effective lighting to conserve energy, thereby reducing carbon emissions and costs to the citizens of Pepperell" ("Outdoor Lighting Bylaw for Pepperell, Massachusetts", n.d.). The town of Pepperell is working to strike a balance between safety and savings and lowering light pollution. The bylaw plans to achieve this balance through outdoor lighting regulations, establishing what fixtures are permitted in the town as well as hours of operation. The bylaw also establishes guidelines for acceptable outdoor lighting fixtures. For example, 'Unacceptable' lights lack shields and fail to prevent glare and

[4] To obtain this value, the authors "measured the total area that was lit above a certain radiance threshold in 2012 and 2016" (Kyba, et al., 2017).

light trespass. ‘Acceptable’ lights mitigate glare and light trespass, as well as other forms of light pollution with ‘full cutoff’ shields.

To help further reduce light pollution, Pepperell also performed a LED streetlight conversion. To help with this conversion the town hired Real Term Energy, who started off by performing their own GIS audit to confirm if National Grid’s inventory had the correct numbers. The audit found that 5 lights had not been recorded by National Grid and it helped the company determine which areas needed brighter or dimmer lights. After purchasing the lights at a fixed rate from National Grid, Pepperell wanted to make sure the community was supportive of the conversion. A lighting demo and survey was implemented on Main Street where five LEDs with different CCTs were installed along with a control of two HPS bulbs. The survey indicated that most people preferred the 2200K LED lights and that the next most common choice was for the HPS bulbs.

Following the pilot, Pepperell replaced all its HPS streetlights with 2200K LEDs. The streetlights were equipped with dimming controls to allow the town to adjust brightness as needed. Including these controls led to a doubling of the return-on-investment (ROI) time for the conversion project, but Andrew MacLean (personal communication, November 11, 2021) indicated that town officials believed this was a worthwhile investment for their community.

3.1.3 Cambridge, Massachusetts

The city of Cambridge, Massachusetts is one of the few cities in Massachusetts to take full advantage of the emerging technologies in streetlight control. In 2013, Cambridge hired a contractor to develop a plan to convert the city’s 7,000 HPS streetlights to LED. The conversion included the addition of wireless control nodes on each streetlight, allowing for the individual control and dimming of each streetlight. This conversion plan predicted 80% energy savings and a payback period of 4.36 year. Over the next 20 years, Cambridge estimates an annual savings of approximately $500,000 a year, or a total of $10 million.

The conversion process took nine months to install 4,900 LED cobra streetlights, followed by another six months to install 2,100 decorative LED lights. The addition of the wireless control nodes allowed for the dimming of individual residential streetlights to 30% brightness after 10 pm. Meanwhile, streetlights on heavily trafficked thoroughfares do not dim to 30% until midnight. The conversion came with several benefits including “better illumination, reduced energy consumption, reduced glare, increased color rendition, and reduced light trespass

in residential neighborhoods" ("Cambridge MA: setting the example for adaptive streetlighting", 2016).

3.1.4 Melrose, Massachusetts

In 2005, Melrose purchased their inventory of HPS streetlights from National Grid. Melrose is a unique case where the town already owned their streetlights before considering an LED conversion. Melrose consulted the Metropolitan Area Planning Council (MAPC) at the beginning of the conversion process, because the involvement of a regional planning council can make negotiations with contractors easier. Melrose requested an inventory of their streetlights from National Grid, and then hired a contractor to survey and verify the inventory. They then hired a different contractor to design and install the lights under Procurement Law Chapter 25a, where one contractor does both the design and installation.

Before Melrose implemented the town-wide conversion, they conducted a pilot program by installing a small number of LED streetlights and soliciting public feedback. After receiving positive feedback, Melrose began the conversion. The lights were installed with 3000K of varying wattages – 70 W for arterial roads, 40 W for collector roads, and 20 W for residential roads (M. Grover, personal communication, November 5, 2021).

3.1.5 Rockport, Massachusetts

Rockport is in the process of developing a plan for and starting the process of converting their streetlights to LEDs (Fall, 2021). Before considering the conversion, the Town of Rockport completed an audit of their streetlight inventory with National Grid. However, Tanko Lighting, a streetlight conversion consulting company, is completing a more exhaustive streetlight audit. The purpose of this audit is to allow for a more complete understanding of the streetlights to allow for effective lighting design when installing the LED streetlights. The audit still needs to be funded, but following the streetlight audit, Rockport will purchase the lights from National Grid and take on their own maintenance, or have National Grid perform the conversion and keep maintenance costs and charges the same as they are for their HPS lights.

According to Tom Mikus, Chair of Rockport's Green Community Task Force, purchasing the streetlights from National Grid and performing the LED conversion and maintenance afterwards will save the town approximately $75,000 per year. By contrast, allowing National Grid to perform the conversion and retaining them for maintenance only saves the town approximately $26,000 per year. The only problem with purchasing the lights themselves is Rockport's Department of Public Works does not want to perform maintenance on

the new LED streetlights, so the town needs to contract this work out. Another goal for Rockport's LED streetlight conversion is to have Dark Sky compliant lighting fixtures to reduce light pollution. Performing the conversion with National Grid would mean keeping their 4000K lights with less effective shielding. By the end of the conversion Rockport hopes to be on track for substantial energy and cost savings and reduced light pollution with Dark Sky compliant lights.

3.2 Nantucket's LED streetlight conversion

At the time of writing, there are 586 HPS streetlights on Nantucket that include 50W, 70W and 100W bulbs, with one 20W light ("National Grid Bill issued 10/22/2021", 2021). The streetlights are owned by the Nantucket Electric Company, National Grid's electric utility company on the island (Reed, 2019). Under a NEO pilot program with National Grid, six 48W/4000K LED streetlights were installed on Milestone Road. The color temperature of these LEDs is far above the 2200K recommended by IDA. Currently, National Grid will install only 4000K LEDs in its streetlights. If Nantucket wishes to install LEDs with lower color temperatures, the town would need to purchase the streetlights from National Grid and assume all future maintenance responsibilities ("Streetlights", n.d.). National Grid has applied for a tariff to allow the company to install 3000K LED streetlights, but that tariff is not yet approved. However, this color temperature is still above the newest IDA guidelines.

Cobra-head HPS streetlights require more maintenance than LED streetlights, and the inventory available for maintaining HPS streetlights is becoming harder to source. Switching to an LED streetlight system instead of retaining on the old HPS lights is that LED lights have lower associated maintenance and last longer (G. Walker, personal communication, September 1, 2021). As such, the frequency of maintenance on Nantucket is not as crucial as it would be if the island continues maintaining HPS bulbs. That, combined with the fact that parts for HPS streetlights are becoming harder to source, means that converting to LED makes sense from a frequency-of-maintenance perspective. However, Nantucket would most likely need to contract with a company on the mainland to service the LEDs (as the towns on Martha's Vineyard have done), which must be considered.

If the Town of Nantucket owned their streetlights, this would allow them to install LED lighting fixtures of its choice. This would allow the town to install dark sky compliant fixtures, which would further mitigate light pollution on the island. Additionally, the right color

temperature can be chosen for the right location, instead of the whole island receiving the same LED color temperature. A more granular approach will allow Nantucket to have the most effective lighting design possible for the island, minimizing light pollution while maintaining visibility for motorists and pedestrians.

3.2.1 Economic considerations for LED streetlight conversion

According to the Nantucket Energy Coordinator Lauren Sinatra, Nantucket was last quoted a price of $260,000 dollars to buy all streetlights from National Grid in 2018 (L. Sinatra, personal communication, November 16, 2021). This price is reportedly much higher than other towns in Massachusetts have paid for their replacements (G. Walker, personal communication, September 1, 2021). For example, Weston (K. Wroten, personal communication, November 30, 2021) and Pepperell (A. MacLean, personal communication, November 11, 2021), Massachusetts only paid one dollar for their streetlights, and Rockport paid about $3,000 dollars ("Rockport Massachusetts LED Streetlights", n.d.). Melrose, Massachusetts paid about $100,000 dollars (M. Grover, personal communication, November 5, 2021) for their streetlights. Regardless of this high cost for Nantucket, Gail Walker believes that the transfer of ownership would eventually pay for itself, based on an analysis done by Tanko Lighting in 2020 at her request (G. Walker, personal communication, September 1, 2021).

Table 3 below outlines the costs that the Town of Nantucket incurs for electricity for the roadway streetlights, broken down into three categories: delivery service, supply service, and maintenance service. This does not include streetlight in downtown Nantucket. The delivery service charge is for National Grid to operate the electrical system, while the supply charge is for the amount of electricity that the town uses. The maintenance service charge is for maintaining the town's streetlighting.

Table 3: Nantucket existing lighting cost breakdown

Date	Delivery	Supply	Maintenance	Monthly Total
Oct 22, 2020 to Nov 20, 2020	$1,155	$1,626	$4,758	$7,538
Nov 20, 2020 to Dec 22, 2020	$1,344	$1,891	$5,250	$8,486
Dec 22, 2020 to Jan 25, 2021	$1,511	$1,977	$5,590	$9,079
Jan 25, 2021 to Feb 23, 2021	$1,226	$1,574	$4,771	$7,571
Feb 23, 2021 to Mar 25, 2021	$1,356	$1,457	$4,936	$7,749
Mar 25, 2021 to Apr 26, 2021	$1,321	$1,374	$5,273	$7,969
Apr 26, 2021 to May 24, 2021	$958	$1,049	$4,618	$6,625
May 24, 2021 to Jun 24, 2021	$1,020	$1,074	$5,113	$7,206
Jun 24, 2021 to Jul 26, 2021	$1,077	$1,115	$5,278	$7,470
Jul 26, 2021 to Aug 25, 2021	$1,124	$1,163	$4,948	$7,234
Aug 25, 2021 to Sep 23, 2021	$1,248	$1,291	$4,783	$7,322
Sep 23, 2021 to Oct 22, 2021	$1,158	$1,452	$4,997	$7,607
Monthly Average	$1,208	$1,420	$5,026	***$7,655***
Year Round (total)	$14,497	$17,042	$60,317	$91,856

On average, the town is spending $7,655 a month on the current roadway streetlight system. On average, $5026 per month or 66% of the average monthly cost comes from the maintenance of streetlights. In an LED streetlight conversion where the Town of Nantucket does not buy the streetlights, the Town will have lower net savings than if the Town buys the Streetlights from National Grid, as seen below in Table 4.

Table 4: Nantucket estimated lighting cost savings with both conversion options

Money	**Delivery Service**	**Supply Service**	**Maintenance Service**	**Total**
Monthly (Mean)	$1,208	$1,420	$5,026	$7,655
Year Round (total)	$14,497	$17,042	$60,317	$91,856
Staying with National Grid				
Monthly	$1,208	$1,420	$2,011	$4,639
Grand Total	$14,497	$17,042	$24,127	$55,666
% Maintenance Savings Estimate	60.00%		Total Savings per year	$36,190
			%	39.40%
Buying the Streetlights from National Grid				
Monthly	$411	$1,420	$1,759	$3,591
Grand total	$4,936	$17,042	$21,111	$43,089
Billable Wattage	25			
% Maintenance Savings Estimate	65.00%			
			Total Savings per year	$48,767
			%	53.09%

Table 4 shows the energy savings under the three major scenarios: maintaining the status quo (retaining the HPS streetlights), a National Grid conversion, and a conversion where Nantucket buys the streetlights. The information from the status quo is the same as the totals from Table 3. The second section shows the savings under a National Grid conversion. It is assumed that the maintenance and supply cost would remain the same under this. As such, the only possible savings come from maintenance service. At an estimate of 60% savings with LED streetlights, this results in 40% energy savings over the year in streetlights as compared to the HPS lights. The final scenario shows potential cost savings under a LED streetlight conversion where Nantucket buys the streetlights from National Grid. The savings here derive from lower maintenance as before, and additional savings in energy costs. This is because the town would be able to buy LED streetlights at a much lower wattage, and also determine when the lights should be on as well through controls. In total, we estimate that this scenario would bring Nantucket

between 45% and 60% energy cost savings per year with streetlights. What is shown above is a more conservative estimate. The reason that the cost savings under a National Grid conversion are lower is because the S-1 tariff rate for electricity for LED streetlighting increases to make up for the fact that the maintenance charge goes down significantly, which can be seen on page 3 of the S-1 tariff. As such, it is important to consider a scenario where the Town of Nantucket buys the streetlights.

One immediate change that would occur when buying the poles and streetlights is that the poles would transfer from the S-1 classification to the S-5 classification under National Grid policy. The S-5 tariff covers "Street and Area Lighting – Customer Owned Equipment", whereas the S-1 tariff is "Street and Area Lighting - Company Owned Equipment" The major shift is that "The Customer shall be responsible for providing maintenance, and, absent a separate contract between the Company and the Customer, the Company shall have no obligation to maintain facilities and equipment owned by the Customer." With National Grid relinquishing responsibility for the streetlights and poles, the rest of the document does not mention costs involved in maintaining streetlights, since all the costs would be on the shoulders of the Town of Nantucket.

A LED streetlight conversion under the S-5 tariff allows the town to save money, since the maintenance service charge disappears from the National Grid bill, and LED streetlight maintenance is minimal. According to LED streetlight conversion consultants, this will allow for additional savings and a faster return on investment for Nantucket. Most communities in Massachusetts see a return on investment of two to four years when buying the streetlights (J. Tanko, personal communication, November 15, 2021).

The most immediate consequence of moving to S-5 besides the initial price of buying the streetlights from National Grid is that the town would need to secure a contract for streetlight maintenance. This comes with one immediate question: should the maintenance facilities and staff be based off island on mainland Massachusetts, or should maintenance be based on island to handle streetlight issues as they occur? Currently, the Nantucket Energy Office does not have a complete understanding of all the items that are required to properly perform streetlight maintenance (L. Sinatra, personal communication, September 1, 2021). Because of this, more research needs to be done to see what Nantucket specifically would need to do to maintain streetlights on the island. However, LED streetlights would likely require far less maintenance

than HPS lights, making them a more attractive option for the island since repair crews would not have to take ferry rides over as frequently as for the current HPS lights.

4.0 Conclusions and Recommendations

From the case studies conducted as well as interviews with streetlight conversion consultants, below we offer the following recommendations for the Town of Nantucket to consider when undertaking an LED streetlight conversion. These recommended steps are not all in a sequential order, and many can be done in parallel with each other.

4.1 Create an LED streetlight working group to facilitate major aspects of the conversion process.

To begin the LED streetlight conversion project, the Town of Nantucket should create a working group to advise in and oversee the conversion process. The working group should include a range of participants with pertinent skills representing different stakeholder groups in town, such as elected officials, town employees, and interested citizens. The Town Administration and Selectboard should determine the membership of the group. Likely participants should include but not be limited to representatives from: the Nantucket Energy Office, Department of Public Works, Public Safety, Planning and Land Use Services (PLUS), and Nantucket Lights. The working group should be tasked with interviewing and evaluating lighting consultant options, reviewing installation and process management contracts, selecting the color temperature of the streetlights, as well as other items that arise during the conversion process.

None towns that we researched formed a discrete working group, but each used existing committees and town offices to oversee the process. Based on our interviews with local officials, however, a working group would offer Nantucket a more robust way to tackle the variety of issues that will arise before and during the conversion process. As currently staffed, the Town of Nantucket Energy Office alone does not have the bandwidth to handle the conversion process alone.

The LED conversion in Pepperell, Massachusetts was under the responsibility of the Light, Air, and Noise bylaw committee. The Town of Rockport, Massachusetts, did not utilize a working group either. Towns in the Cape Light Compact had the ability to leverage the larger organization to advise the towns throughout the conversion process. In Melrose, Massachusetts, the people involved in the conversion process would consult with existing town bodies, such as the Planning Board, City Solicitor, and the Department of Public Works. The Sustainability

Manager of Melrose said "if stakeholder meetings as you describe … are the culture of the municipality then yes, it makes sense." Nantucket, by comparison, has a number of working groups for many different functions within the town government. According to Erika Mooney who serves as the Operations Administrator the Traffic Safety Working Group, a LED streetlight conversion would not fit under their purview. As such, the creation of a LED streetlight conversion working group would be advisable, to involve all the relevant stakeholders in this important decision.

4.2 Hire a streetlighting conversion consultant to assist throughout and after the conversion process.

Every town and regional planning organization we interviewed utilized a third party lighting consultant to assist in the conversion process. After speaking with Tanko Lighting and LightSmart Consulting, we learned that they assist towns through the entire process, from buying streetlights, conducting a geographic information system (GIS) audit of the lights, doing the lighting design, managing the work and completing all coordination with the utility, as well as other action items outlined. Both companies come in with both a breadth and depth of experience, working with towns throughout the country in many different settings. Tanko Lighting, while based in San Francisco, has local energy consultants throughout the entire country to work closely with the towns that they assist. Additionally, they have experience with islands, having assisted Kauai, HI with an LED streetlight conversion.

Additionally, it is important the consultant has experience with harsh environments when conducting streetlight conversions. As Nantucket is an island, the winds come from all directions, contributing to corrosion of the wiring into the fixtures. A consultant with experience in providing solutions to this problem will be crucial to a successful streetlight conversion. From our meetings with both potential consultants, we feel that each can bring a wealth of experience to the project and that the best way for Nantucket to move forward is to try and get an updated quote from both companies to make this decision. Since both companies have demonstrated relevant experience with similar communities in the region and throughout the US, we'd recommend that the NEO set up follow up conversations directly with Jason Tanko and George Woodbury to follow up on items we've identified and ensure that they are choosing a group that they can work with effectively.

As Nantucket faces winds and corrosion from all sides, Tanko has experience to make sure that the right fixtures are installed to be resistant to the weather present on Nantucket. Tanko follows a two phased approach when performing a conversion to LED streetlighting. This two-phased approach has been effectively tested in 47 other municipalities in Massachusetts (totaling in 78,927 fixtures), as well as other towns throughout the country.

On the other hand, George Woodbury indicated that he and LightSmart Consulting had a great deal of relevant experience in the region, having worked with the Cape Light Compact on their conversion program.

Bringing in a subject matter expert ensures that the right decision will be made for the town, as well as help advise the town on what companies to buy lighting fixtures and LEDs from and evaluate maintenance contractors. Through use of a consultant, many towns have seen energy cost savings and returns on investments in under five years.

There are several tasks the consultant will need to preform, and we present these as a set of subsidiary recommendations below.

4.2.1 Perform an exhaustive GIS audit of all the streetlights on Nantucket.

To determine location of every streetlight and their lighting specifications (e.g. their lumen output, height, angle, backlighting, etc.), a GIS layer with the relevant information should be created. This GIS layer can then be utilized by the town, as well as the streetlighting consultant, to better understand the scope of the project.

The inventories maintained by National Grid have not always proven to be accurate. Moreover, George Woodbury of Light Smart Consulting, streetlights are often placed on existing poles and not necessarily based on lighting needs. James Lowenthal, President of the IDA-MA chapter, corroborated this, stating that “you need to see if you actually need the light you think you need”. He estimates that at least ¾ of light is unnecessary and wasteful. Both streetlighting consultants we spoke with emphasized the importance of such an audit to support future steps in the lighting design conversion process.

At the time of writing, Nantucket is already in talks with National Grid regarding an updated inventory. The updated inventory will provide the GIS auditor with baseline data on streetlight locations and other pertinent information. Melrose’s contractor for installation,

Siemens Energy, used ARCGIS for location data and displayed the location of newly installed LEDs in real time, notifying residents which street would be worked on next.

From our conversations with each community as well as the Cape Light Compact, we found that all of them undertook a GIS audit before installing the new LED streetlights. In fact, the Cape Light Compact performed an audit for all 23 of their participating municipalities, collecting 17,000 GPS-mapped points to be used in their LED conversions.

Rockport, a customer of Tanko Lighting, found from the National Grid inventory that there were 770 lights, although some that are not on distribution lines are too expensive to acquire as of 2021. Tanko is performing a field audit to synchronize a list of Rockport's existing lighting with the National Grid inventory.

Pepperell provided their inventory database to their streetlighting consultant, Real Term Energy, who verified it and found some minor discrepancies (e.g. some poles had no streetlights and others National Grid had overlooked entirely). Real Term created a GIS layer with each streetlight geotagged and was able to identify locations that may need brighter lights due to location, pole height, the presence of an intersection and other safety considerations.

4.2.2 Conduct an economic analysis of the LED streetlight conversion process.

Developing quantifiable measures for where there are cost savings can help the town make an informed decision regarding what lights to purchase and where there are break-even points. From our interview with Tanko, they indicated that two to four years is an attainable ROI period, but many towns will take four to eight years and still be content, due to other incurred costs such as higher price points for the light fixtures, controls or other factors. We conducted a much more limited version of this kind of economic analysis included in 3.2.1 based on available information, though a full inventory and expert opinions from the streetlighting consultant will yield a more comprehensive and likely more accurate cost analysis.

This economic analysis should include multiple possible scenarios, in the case of Nantucket this distinction is between a conversion with National Grid or using a consultant and purchasing the fixtures. Our conversations with towns as well as with streetlighting consultants has indicated that it is overwhelmingly more common to purchase the lights from the utility for additional savings in maintenance. Discussions with towns have indicated some variance in the cost of purchasing their lights, Nantucket and Melrose being quoted for an excess of $100k

whereas many other towns paid a few thousand to $1 to take on the maintenance responsibilities from their utility provider. Jason Tanko indicated that a streetlighting consultant could work to negotiate this to be more reasonable. A key takeaway from the Rockport interview was their usage of on-bill refinancing with National Grid to pay for their lights.

4.2.3 Buy the streetlights from National Grid to have full autonomy in lighting design for the LED streetlight conversion.

Purchasing the streetlights from National Grid will give Nantucket full ownership of the light fixtures. Even though Nantucket will have to set up its own maintenance responsibilities, they would be able to control any aspect of the lights and would ultimately save money. According to George Woodbury from LightSmart Consulting, the monthly fixture charges part of the electric streetlight bill gets eliminated from further bills if the consumer buys the streetlights from the utility. In most cases, the utility company will want to recoup for its losses now that they are no longer profiting from maintenance. Woodbury has seen the distribution energy rate go up by around $0.03/kWh on average when ownership changes from utility to customer. (G. Woodbury, personal communication, November 1, 2021). Despite this, towns still find considerable cost savings in their conversion projects.

A representative from Cape Light Compact indicated that 20/21 of the communities they work with on the Cape and Martha's Vineyard found that purchasing the lights from their utility was ultimately beneficial. All the communities we evaluated with purchased their own streetlights at varying initial costs based on the depreciation of their fixtures but indicated a great deal of their cost savings and autonomy could be attributed to the purchase of their streetlights. The one community that regretted purchasing its streetlights (Tisbury) felt that way because the maintenance responsibilities have proven to be burdensome; but that has been because of several roadway changes that involved the need to relocate many streetlights, an unusual situation.

4.2.4 Create a budget for the entire LED streetlight conversion process using the economic analysis.

There are many costs to consider: the price of the audit, acquiring the streetlights, installing the new LEDs, maintenance costs, paying contractors and/or a streetlighting consultant. Which of these expenses, or other ones are identified for Nantucket, depends on how

many of the services are covered by the streetlighting consultant, some providing more of a "full service" option that rolls costs into their services whereas others coordinate subcontracting of these necessities into separate costs.

The budget will need to be presented to and approved during a town meeting for Nantucket, something that Rockport also had to do for their own conversion process ("LED Streetlights", n.d.).

4.3 Implementation logistics

When performing a LED streetlight conversion, there are three key factors to consider: demonstration, installation, and maintenance. A demonstration of streetlight color temperatures to the residents of Nantucket will give them an opportunity to provide input before the formal installation process begins. Additionally, maintenance contractors must be considered for when the conversion is complete. We present three recommendations relating to implementation logistics (see 4.3.1, 4.3.2, and 4.3.3 below).

4.3.1 Conduct a pilot demonstration of LED streetlights to solicit public feedback on light fixture design and features.

Once Nantucket has full ownership of the streetlights it will be able to perform a pilot demonstration to solicit public feedback on an LED conversion. Pepperell performed a public demonstration, and the public responded quite positively to 2200K streetlights. For a pilot program on Nantucket, the town will obtain feedback from stakeholders as identified by the LED streetlight working group. One way Nantucket can conduct the demonstration is to have an electrician on site, and adjust brightness levels of a fixture, directly interviewing those who attend the demonstration. In this method, there can be multiple lighting fixtures of varying brands and color temperatures to gain feedback from attendees. Alternatively, the town can announce the pilot demonstration in advanced, and give residents a week to see the streetlights, and complete a survey after residents view the streetlights on their own time. After this period, the streetlights can be changed to another fixture of varying color temperature and brightness to receive another round of public feedback. In both cases, it is important that enough streetlights are installed for residents to get a full understanding of the pilot program. The location and time of any potential demonstration will also be important. Strong locations allow for a lot of traffic at night to maximize the amount of feedback that the town can receive. In Pepperell, this meant

installing streetlights along an entire street and letting residents drive through the street for people to see the lights and provide feedback to the town.

Either of these two methods will allow the town to determine what streetlight fixtures will best fit the community. It is more feasible for Nantucket to conduct a survey along the second approach, as this allows more people to see the lights and provide feedback. An example survey instrument used in the Seattle area for its LED conversion is shown in Figure 13.

	Rate Statements	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	No Opinion
1	*It would be safe to walk here, alone, **during daylight hours***	O	O	O	O	O	O
2	*It would be safe to walk here, alone, during darkness hours.*	O	O	O	O	O	O
3	*The lighting is comfortable.*	O	O	O	O	O	O
4	*There is too much light on the street.*	O	O	O	O	O	O
5	*There is not enough light on the street.*	O	O	O	O	O	O
6	*The light is uneven (patchy).*	O	O	O	O	O	O
7	*The light sources are glaring.*	O	O	O	O	O	O
8	*It would be safe to walk on the sidewalk here at night.*	O	O	O	O	O	O
9	*I **cannot** tell the colors of things due to the lighting.*	O	O	O	O	O	O
10	*The lighting enables safe vehicular navigation.*	O	O	O	O	O	O
11	*I like the color of the light.*	O	O	O	O	O	O
12	*I would like this style lighting on my city streets.*	O	O	O	O	O	O

13. How does the lighting in this area compare with the lighting of similar Seattle city streets at night?

Much worse Worse About the same Better Much Better

14. Write additional comments below.

Figure 13: Example subjective survey given out in Seattle (Clanton, n.d.)

In this example survey, question 11 allows the town to see if the color temperature is appropriate for the area, without the need to explain the Kelvin scale. This still allows the town to get meaningful input from residents without the need to explain all of the technical details. The other questions in the survey are also effective in the same manner, as they ask about technical aspects (such as glare in question seven) without the need to provide long, technical explanations. This makes the survey approachable and easy to fill out, which will increase the amount of responses.

After the survey and pilot period is complete, the town can analyze the results of the feedback to find what fixture and brightness levels will be best for different areas of the town.

One key benefit of this survey is that by allowing residents to provide feedback early in the conversion process, it makes complaints in the future less likely, since concerns can be addressed at this earlier stage.

4.3.2 Install the streetlights based upon the feedback from the pilot demonstration.

Once Nantucket is satisfied with a conversion plan, the Town can start installing the LEDs in their streetlights, taking input from the public demonstration. Most towns we interviewed spoke about having their consultant help them through this process. Towns can choose to contract out this process to another organization, such as Siemens Energy to perform the installation, which Melrose did. If Nantucket desires, during the conversion it can add dimming to its streetlights.

To ensure that the LED streetlight conversion effectively reduces light pollution and energy consumption, it is important to keep the lighting design in mind. The lighting design is the culmination of the GIS audit and public demonstration. Combining these two together allows Nantucket to install streetlights of appropriate color temperature, and in the right locations. This will minimize light pollution since streetlight fixtures will only be installed where necessary and at the right color temperature and brightness level. Additionally, shielding will be utilized to direct the light onto the right area, and minimally elsewhere.

4.3.3 Obtain a maintenance contractor for the interim period of the conversion and afterwards.

During the interim period throughout the pilot demonstration and LED conversion process, Nantucket will need to obtain a maintenance contractor to maintain the HPS streetlights during the conversion process. While the pilot demonstration is ongoing, the HPS streetlights currently in place will need to be maintained. This can be done by the Department of Public Works after the necessary training is complete, or a maintenance contractor on island, such as Kobo Utility[5].

Due to the nature of LED's long lifespan, maintenance need only be performed once a year or during extenuating circumstances such as storms. As such, it will not be necessary to pay a monthly maintenance charge to a contractor after the conversion is complete, as maintenance can be done on an as needed basis. Since Nantucket is an island, it will be best to have

[5] Kobo Utility is an on-island maintenance contractor that currently services some HPS streetlights.

maintenance occur on a yearly basis to repair all the lights at once, unless there is a more widespread failure in a part or all of the system.

4.4 Choosing fixtures and controls

When installing the streetlights, it is important to make sure that appropriate fixtures are installed for the locations in question. Not all LED streetlight fixtures are created equal in terms of color temperature, lumen level, shielding and other considerations when it comes to choosing dark sky compliant fixtures as well as an appropriate color temperature for the area. By buying the streetlights, this gives Nantucket the opportunity to buy the right light for each location, rather than the same fixture for everywhere on the island. We make three recommendations regarding the process for choosing fixtures and controls (4.4.1, 4.4.2, 4.4.3).

4.4.1 Obtain streetlight fixtures at 2200K that effectively direct light to only the area necessary.

When performing a LED streetlight conversion, choosing the proper fixture is vital. Proper fixtures and appropriate color temperatures will effectively balance visibility for pedestrians and motorists with the benefits that low light pollution brings. Currently, the IDA recommends 2200K streetlights for the color temperature. In Pepperell, they are following this recommendation and moving forward with this color temperature. Other towns have been using color temperatures ranging from 2700K - 3500K because more products are available in this range (J. Tanko, personal communication, November 15, 2021), although it can be expected that as the 2200K standard is adopted more widely, more products at 2200K will be developed. Additionally, it is important that the fixtures are properly set up in a way that only the roadway is being appropriately lit, and the other locations are left dark. Every interviewee has indicated the importance of 3000K color temperature or less, as color temperatures at or below this range are appropriate for wildlife, mitigating light pollution and visual clarity. Selecting the right brightness level (in Lumens) paired with the right color temperature allows for an effective streetlight. Additionally, it is also important to consider the BUG rating, and this provides important information about the direction of the light and helps to ensure it will only illuminate the intended region.

LightSmart Consulting believes that many municipalities are currently over lighting their communities. As such, it is important to consider removing unnecessary streetlighting. This can be done during the design stage of the conversion process. Lighting consultants and designers

will be able to assist in locating areas that are over illuminated, as well as some potentially under illuminated locations. If more lights are removed than added in this process, this will also bring more cost savings to the town, while directly lowering light pollution as there will be less total lighting in the area.

4.4.2 Install lighting controls on the LED streetlighting fixtures to reduce energy consumption and light pollution.

Lighting control systems can allow the streetlights to be disabled and dimmed. Some systems can be installed directly on the light fixture and contain a sensor to dim the light at night to save energy and reduce light pollution. Others are more advanced, such as mesh networks, point to point networks, and cellular networks. Additionally, WiFi can also be installed on streetlights using a 10-pin connector, but this increases the fixtures power consumption. All these systems require that the lights can have these controllers installed. As such, when buying streetlights, it is important to make sure that they have the ability to install desired controllers at a later date if they are not purchased immediately.

The installation of controllers at the same time of the rest of the streetlight conversion will increase the return-on-investment time, as it did for Pepperell. However, the benefits of these control systems are present, and should be considered when performing the streetlight conversion.

4.4.3 Dim the streetlights at night to mitigate light pollution and reduce energy consumption.

As mentioned in section 4.4.2, dimming can be added to streetlights during a conversion or later as long as the town owns the streetlights. Dimming is a useful way to reduce energy consumption without affecting functionality or public perceptions. According to George Woodbury, people typically do not notice up to 30% dimming and dimming reduces energy consumption by around 26% (G. Woodbury, personal communication, November 1, 2021). Dimming may also encourage the LEDs to last longer which will mean lower maintenance and replacement costs. Unfortunately, because of the shortage of chips due to the COVID-19 pandemic, dimmer controls are currently more expensive, on back-order, or unavailable. This is

likely a temporary problem, however, that should not affect Nantucket given the expected timeline for conversion.

4.5 Other Recommendations

Below are two more recommendations that Nantucket should consider for their LED streetlight conversion process.

4.5.1 Create a system for residents to report streetlight issues like the decorative streetlamp reporting form.

The current system for reporting a decorative streetlight outage is done through the nantucket-ma.gov website by submitting a "Decorative Streetlamp Reporting Form", as seen in Figure 14. The report can specify what is damaged on the streetlight with several options, as well as provide additional comments. An interactive map is located on the page which allows for the easy location of the decorative streetlights, as well as displaying the lights' current statuses. However, no form exists to report streetlights, so the reporter must call National Grid directly.

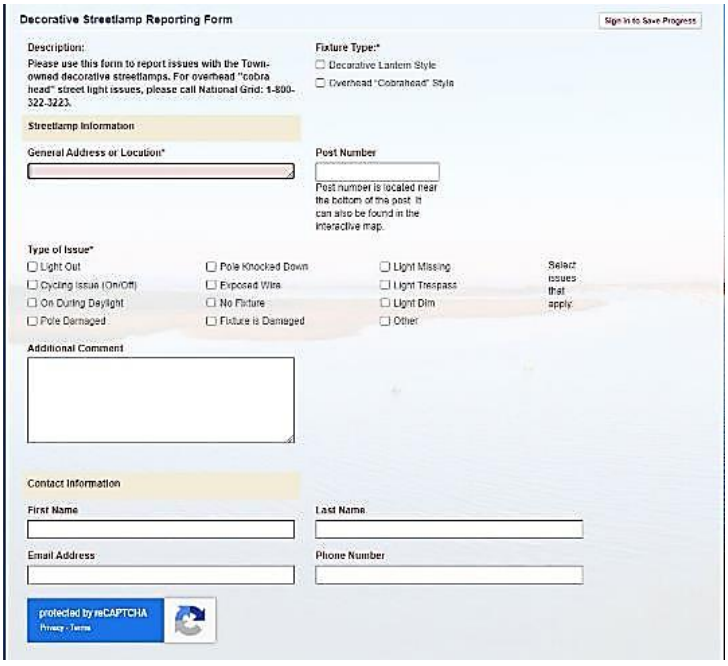

Figure 14: Current Streetlamp Reporting Form for the Town of Nantucket ("Reporting Streetlight Issues", n.d.)

To improve upon this system, Nantucket should incorporate their inventory of cobra head streetlights into an interactive map, like that of the decorative streetlight map. This will allow for an easier reporting process as well as displaying the status of each cobra head light. Additionally, if the town of Nantucket were to obtain ownership of the cobra head streetlights, the reporting of said streetlight outages and issues could be incorporated into the current reporting form.

4.5.2 Develop a relationship with a larger regional planning organization to gain the benefits of being a part of a larger collective.

Many small communities often opt to join regional planning councils when undertaking large public works or utility projects. In relation to Massachusetts, the greater Boston area hosts the MAPC while much of Cape Cod hosts the Cape Light Compact, which also includes Martha's Vineyard. The benefit of these groups includes better negotiations with contractors and utility companies at the expense of total autonomy. Nantucket is a unique case where its isolation often gives the impression that it is alone in its endeavors for maintenance and modernization. There are many communities on and off of Cape Cod with both similar experiences and goals. Therefore, Nantucket can learn from their experiences when undergoing a LED streetlight conversion as well as other projects that these organizations have assisted towns with.

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6.0 Appendices

Appendix A: Interview Scripts

Each interview was started with the preamble: "We are a group of student researchers from Worcester Polytechnic Institute (WPI) helping the Nantucket Energy Office conduct preliminary analysis of the consequences of an LED streetlight conversion on the island. You can stop answering questions whenever you like. Additionally, would you allow us to record this interview and take notes? Also, can we use quotations in our report? Before publication, we will send it to you to make sure that we have not misrepresented anything that you have said". After the preamble the interview started with each script below being used as a guide for our questioning. We would then end our interviews asking for any other helpful contacts we should seek out to achieve the snowball approach mentioned in Appendix B under Objective 1.

Appendix A.1: Cape Light Compact Script

- Our understanding is that your town/ group completed an LED conversion in 2014, could you walk us through a basic timeline of how you arrived there and work that's been done since?
- Followup questions about the items listed in the timeline to learn more about them (demos, surveys, etc.)
- One of the following questions, based on what we find in our research
    - For your LED conversion, what are the color temperature, power consumption,brightness etc. of the LEDs you've installed?
    - Is it at the discretion of the towns/fire districts in the CLC or universal
    - Is there any variance in the lights you use depending on location/application or are they fairly similar
    - Do the lights have a control scheme?
    - Is this something that all of the member communities have? Or on a case by case basis?
- During the planning/evaluating process for your LED conversion we understand you performed a demonstration project, did you perform a public survey?
    - How many community members were you able to reach with your survey? Could you estimate what percentage of your community you were able to engage?
- Did you run your own survey or contract out the work to an organization?
    - Were there any survey questions that worked particularly well or provided very insightful responses?
    - Were there any topics you think you would avoid if giving out a future survey?
- How are the lights managed/maintained by your town? How is light ownership and maintenance broken down amongst the town, the utility provider and any outside contractors?

    - We understand that the Towns or Fire Districts own their streetlights and have an O&M agreement with Siemens who are contacted on a case by case basis through a call center
    - Our understanding is that the original contract mentioned in the FAQs would have ended in 2017 unless it was extended. Did you evaluate other potential contractors in the area to provide this service?
- 7 years out, are there any services that aren't provided but you wish were?
- Were there any services you found may be provided by other contractors that weren't offered by Siemens?

Appendix A.2: International Dark Sky Association Script

- We have reviewed the LED practical guide from the IDA. Has anything changed since that document was last updated?
- We have read through the product selection considerations, and understand from Gail that the BUG rating system is increasingly important metric
    1. Can you explain its importance?
    2. Are there any resources to help us to better understand it?
- We know that color temperature in Kelvins (K) is an important factor to consider in our research. How would you introduce and explain the importance of color temperature to someone who isn't an expert?
- We know color temperature is an important factor to consider in our research, but what other important specs of the LEDs that we should be considering in our evaluation of LED streetlighting? (e.g. power, "luminous efficiency")
- In your opinion, should shields be used? Are they recommended for LEDs in the same way they are for High pressure sodium bulbs (HPS)? Does the IDA have more explicit guidelines about use cases then we have found on the website or does that defer to more specific, local guidelines?
- Best practices: Do you know of any local municipalities - in MA or elsewhere - who have converted their streetlighting to LED to your satisfaction/IDA's standards?
- We understand that many "dark sky" friendly lighting fixtures, such as decorative lantern-style street lamps, are "pane-less" to avoid upward light reflection. What would you advise if Nantucket's Historic District commission (HDC) will not allow the Town to install decorative fixtures without the historic aesthetic of glass panels?
- Would you be willing to talk to us again in the future when we've made more progress in our project?
- What would you suggest as some "best practices" when converting streetlights to LEDs?
    1. Some examples we've been discussing are forming a "working group" of stakeholders or hiring a streetlighting consultant.
- Could you give us some insight into how IDA came to recommend 2200K CCT lights?
- What types of controls, such as dimming, have you had experience with and recommend?
- Do the IDA MA have any consultants, maintenance companies that you recommend we look into for Nantucket's conversion?

Appendix A.4: Jason Tanko Script

- We understand that you are based out of San Francisco, how do you locally manage projects based in other states, or remote communities such as Nantucket? Nantucket is concerned about its remoteness and keeping contractors accountable and responsive to maintenance needs.
- We understand that Tanko has extensive experience helping municipalities convert to LEDs.
- Can you walk us through the general steps you recommend a municipality take in converting its utility-owned HPS lights to LED?
    1. How long is the typical timeline?
    2. We've heard that a best practice involves a lighting design consultant, is this a service you offer or would you work with specific people in our local area?
    3. We've spoken to other industry experts who have consistently recommended a GIS audit, is this something you provide?
    4. What have you found worked well (and things that have not) in your dealings with municipal staff and stakeholder engagement for managing a streetlight conversion project efficiently and successfully? (e.g. working groups or other stakeholder representation, municipal leaders or managers)
- Nantucket is interested in achieving energy savings, while also balancing environmental and historic aesthetic considerations.
    1. What's the most recent LED conversion you've performed in MA or small historic towns, such as Nantucket?
    2. What trends are you now seeing in terms of: color temperature, shielding, dimmers, automated timing, etc?
    3. Are there specific fixtures or "cutting edge technologies" you now recommend to municipalities with goals similar to Nantucket?
    4. What color temperature bulbs are now being requested? Have towns requested different fixtures for different areas?
- In the last year, Nantucket paid National Grid ~$60,000 for the maintenance of approximately 600 lights (or, $100/fixture).
    1. In your dealings with other towns, how does this compare?
    2. How would Tanko help Nantucket to select a maintenance provider?
    3. Would you recommend Nantucket contract with an island-based maintenance provider at any point during or after the conversion process to ensure better accountability and responsiveness, given the island's remoteness
- Have you worked with National Grid on behalf of your municipal clients in the past?
    1. If so, what was your experience/is there anything we should know?
    2. Nantucket recently received an estimate of ~260k to purchase National Grid's lighting inventory. In your experience, can this figure be negotiated (other communities we've spoken with have paid significantly less/next to nothing)?

Appendix A.5: LightSmart Consulting Script

- Have you done any HPS to LED streetlight conversions in the past?
    1. Where and when were these conversions performed?
    2. How long did the conversion process take?
    3. How many streetlights were part of the conversion?
    4. What difficulties, if any, did you encounter in the conversion process?

- Do you currently perform maintenance for any streetlights? If so, where?
    1. If maintenance is performed, are the bulbs HPS or LED?
    2. If it is LED bulbs, what color temperatures do you use?
- Are there any unique difficulties that you think Nantucket would present for either the streetlight conversion or continued maintenance due to its remote location?
- For the towns you work with, what kind of controls do you implement alongside their lighting solutions?
    1. Dimming?
    2. A computerized system for adjusting individual lights?
    3. Is there a fairly standard setup to allow for future modularity for lighting controls? (Gail and Kelly Beatty had mentioned 7 pin connectors during a previous meeting).

Appendix A.6: Melrose, MA Script

1. Our understanding is that your town/ group completed an LED conversion in 2016, could you walk us through a basic timeline of how you arrived there and work that's been done since?
    1. Follow questions about the items listed in the timeline to learn more about them (demos, surveys, etc.)
2. One of the following questions, based on what we find in our research
    1. We've read that your town uses 3000K color temperature lumens, is this correct?
    2. For your LED conversion, what are the power consumption, brightness etc. of the LEDs you've installed?
    3. Is there any variance in the lights you use depending on location/application or are they fairly similar?
3. Regarding the Survey
    1. How many community members were you able to reach with your survey? Could you estimate what percentage of your community you were able to engage?
    2. Our understanding is that you ran your survey in reference to your pilot lights, what was your mechanism for delivering this survey (a mailing list?)? Was it effective?
    3. Were there any survey questions that worked particularly well or provided very insightful responses?
    4. Were there any topics you think you would avoid if giving out a future survey?
4. How are the lights managed/maintained by your town? How is light ownership and maintenance broken down amongst the town, the utility provider and any outside contractors?

Appendix A.7: Pepperell, MA Script

1. Since you mentioned a growing interest regarding Dark Sky advocacy, has your community formed a "working group" or similar formal collection of stakeholders (community and business leaders, emergency services/law enforcement, environmentalists etc.) for the conversion?
2. For the survey you performed:
    1. Do you think only having one of each light provided an effective distinction between the different lights? Given the opportunity, would you have tried to install multiple of each to give a more consistent feel?

2. You mentioned installing the lights along your Main Street, were the other locations you considered for performing this survey? What led you to doing them on Main Street? What factors were important in this decision?
3. I know you mentioned that you could try and locate the survey, were there any survey questions you recall that worked particularly well or provided very insightful responses?

3. We understand from some other communities we talked to that they held off on implementing Smart Controls due to the high entry cost, was this something that was advocated for by interested groups? Emergency services and law enforcement? Dark Sky advocates?
    1. Motivations for buying them?
        1. Light pollution is the biggest one
        2. Noise and air quality sensors can be added, not a big city so they don't need them but for other communities that can be a useful element
        3. Always going to be another feature further down the line
        4. Hoping to take advantage of 5G as technology moves forward
        5. 11 of the 412 have some issue with them, in the final parts of he construction
        6. Over the next year or two they expect the smart controllers will have other uses then just light pollution mitigation.

You mention the "provider" giving Pepperell a "GPS layer", is this through an ARC-GIS audit of the town's streetlighting? Was this a step that Pepperell took?

Appendix A.8: Rockport, MA Script

1. Our understanding is that Rockport completed an LED conversion, could you walk us through a basic timeline of how you arrived there and work that's been done since?
    1. Follow questions about the items listed in the timeline to learn more about them (demos, surveys, etc.)
2. One of the following questions, based on what we find in our research
    1. We've read that Rockport uses around 3000K LEDs, is this correct?
    2. According to your website, you spent about $3000 to purchase the streetlights from National Grid. Why does this seem low compared to some other prices we have seen to purchase from them?
    3. Is there any variance in the lights you use depending on location/application or are they fairly similar?
3. During the planning/evaluating process for your LED conversion, did you perform a public survey?
    1. How many community members were you able to reach with your survey? Could you estimate what percentage of your community you were able to engage?
    2. Did you run your own survey or contract out the work to an organization?
    3. Were there any survey questions that worked particularly well or provided very insightful responses?
    4. Were there any topics you think you would avoid if giving out a future survey?
4. How are the lights managed/maintained by your town? How is light ownership and maintenance broken down amongst the town, the utility provider and any outside contractors?

Appendix A.9: Speclines Script

1. Our understanding is that LED technology is changing rapidly, and that 2200K LEDs are fairly new to be available for streetlights.
    1. Can you tell us what color-temperature trend you are currently seeing with municipal streetlighting?
    2. What is the most popular color?
    3. What municipalities have installed streetlights warmer than 3000K (the standard).
    4. What would you advise a town looking to balance dark sky concerns with public safety needs?
2. What other advances do you anticipate with streetlighting technology (K, BUG, controls) in the near future?
3. Does Specline perform LED streetlight conversion evaluations for municipalities?
    1. What types of products / deliverables do you create for towns?
4. With the groups that you work with, do you see them buying one type / color temperature / brightness light, or do they buy a customized inventory of lights?
    1. BUG ratings?
    2. Depends on the community, some want one fixture for the entire town which comes from the idea of maintenance being simpler but since LEDs last 30 years its an antiquated approach
    3. In support of the granular approach
5. How common would you say is usage of adjacent technology to reduce light pollution (dimming and motion activation?)
    1. Uncommon, based on what she said
6. Color temperature
7. When should shields be used? Do you provide any specific recommendations to towns based on their environment or are they used fairly universally?
8. How long would you estimate most LEDs last?
    1. 30 years?
9. What is the standard warranty?
10. Is there a lot of variance depending on certain factors? Related to our first question, do you anticipate that the changing in the technology will outpace most depreciation of the LEDs physically?
11. We understand that many “dark sky” friendly lighting fixtures, such as decorative lantern-style streetlamps, are “pane-less” to avoid upward light reflection. What would you advise if Nantucket’s Historic District Commission (HDC) will not allow the Town to install decorative fixtures without the historic aesthetic of glass panels?
12. We understand Speclines provided the LED parking lot lighting for the mid-island stop & shop. While many have complimented the warm-color temperature, we are surprised that the wattage levels are so high. While most HPS decorative lights of a similar style come in 50-watts, we understand the LEDs installed at Stop & Shop are 120-watts. Is this still an accurate wattage for a 2200K fixture? Why is the wattage of an LED equivalent to a less efficient HPS-technology so high?

Appendix A.10: Tim Brothers Script

1. What would you suggest as some “best practices” when converting streetlights to LEDs?

    1. Some examples we've been discussing are forming a "working group" of stakeholders or hiring a streetlighting consultant.
    2. Gail mentioned in the context of the 2200K vs 2700K lights you felt that the 2700K COULD work, does this track? Have you seen any implementations of 3000K lights that you felt were acceptable (seeing as this would be the best option in National Grid conversion)?
2. Could you give us some details on Pepperell's pilot program and how you implemented your survey?
    1. Do you think only having one of each light provided an effective distinction between the different lights? Given the opportunity, would you have tried to install multiple of each to give a more consistent feel?
    2. You mentioned installing the lights along your Main Street, were the other locations you considered for performing this survey? What led you to doing them on Main Street? What factors were important in this decision?
3. What types of controls, such as dimming, have you had experience with and recommend?
4. Any consultants, maintenance companies that you recommend we look into for Nantucket's conversion?
5. We understand from some other communities we talked to that they held off on implementing Smart Controls due to the high entry cost, was this something that was advocated for by interested groups? Emergency services and law enforcement? Dark Sky advocates?
    1. Motivations for buying them?

Appendix A.11: Weston, MA Script

1. Could you walk us through a basic timeline of your LED conversion and work that's been done since?
    1. Follow questions about the items listed in the timeline to learn more about them (demos, surveys, etc.)
2. For your LED conversion, what are the power consumption, brightness etc. of the LEDs you've installed?
    1. Is there any variance in the lights you use depending on location/application or are they fairly similar?
3. Regarding the Survey: did you do one?
    1. How many community members were you able to reach with your survey? Could you estimate what percentage of your community you were able to engage?
    2. Our understanding is that you ran your survey in reference to your pilot lights, what was your mechanism for delivering this survey (a mailing list?)? Was it effective?
    3. Were there any survey questions that worked particularly well or provided very insightful responses?
    4. Were there any topics you think you would avoid if giving out a future survey?
4. How are the lights managed/maintained by your town? How is light ownership and maintenance broken down amongst the town, the utility provider and any outside contractors?

Appendix B: Methodology

The goal of this project was to evaluate the best practices of a LED streetlight conversion, and how these practices could be applied on Nantucket. To achieve this goal, we identified three unique objectives. We: (1) researched best practices for converting current streetlighting to LED, including an evaluation of Massachusetts towns that have already converted to LED streetlighting; (2) solicited input from stakeholders on Nantucket regarding possible conversion of the existing cobra-style HPS streetlights to LEDs, and (3) developed a recommended set of processes and policies for the implementation of a LED conversion based on the findings from objective 1 and 2.

Appendix B.1: Objective 1: Evaluate Best Practices in LED Conversions

We added depth to our initial background research by conducting interviews with representatives from regional planning groups and government officials from XX towns in Massachusetts who were familiar with the details of LED streetlight conversion. We interviewed representatives of the Cape Light Compact which is a regional planning group for towns on Cape Cod and Martha's Vineyard that assisted several towns with their LED streetlight conversions. We also spoke with outdoor lighting experts at the Massachusetts Chapter of the IDA to learn how to balance effective lighting and keeping light pollution low. We also spoke with a representative of streetlight manufacturers to learn about technical details of streetlights and proactive ways to mitigate light pollution during the design process. We also spoke with 2 streetlighting consultants, George Woodbury of Light Smart Consulting and Jason Tanko of Tanko Lighting, to learn about what services they provide to towns and municipalities to assist in the conversion process. For a comprehensive list of all interviewees, see relevant entries in Table 5. We presented ourselves as researchers collaborating with the Nantucket Energy Office, emphasizing the fact that the town of Nantucket is considering performing a streetlight conversion. We implemented a snowball approach where we asked each interviewee to suggest other people that we could interview in their town or other towns. The interviews focused on topics such as costs and technical analyses, public involvement and opinions regarding their LED conversion and lessons learned from undergoing the process. The interviews primarily took place via Zoom or over the phone. While conducting our interviews, we modified the scripts as we identified more relevant and appropriate questions for each group. We began each interview by reading a preamble, outlining the goals of the interview and asked for consent to either record the interview to watch later or to take notes to refer to when conducting analysis.

Additionally, we obtained consent from those we interviewed to quote them and gave each interviewer the right to review the materials pertaining to them prior to publication.

Table 5: Interview Breakdown

Person	Affiliation	Role	Date
Kelly Beatty	IDA-MA	Dark Sky Advocate	10/26/2021
Jane Slade	Speclines	Dark Sky Advocate & Speclines lighting consultant	10/27/2021
Margaret Song	CLC	Commercial & Industrial Program Manager	11/4/2021
Cara Goodman	MAPC	Clean Energy Specialist II	11/18/2021
James Lowenthal	IDA-MA	Professor of Astronomy at Smith College, Northampton Resident	11/12/2021
Jason Tanko & Caroline McDonnell	Tanko Lighting	CEO & Energy Advisor	11/16/2021
George Woodbury	SmartLight Consulting	Owner/President	11/1/2021
Martha Grover	Melrose	Sustainability Manager	11/5/2021
Andrew Maclean	Pepperell	Town Administrator	11/11/2021
Tom Mikus	Rockport	Planning Board	11/8/2021
Tim Brothers	IDA-MA	Dark Sky Advocate	11/17/2021
Kortni Wroten	Weston	Sustainability Coordinator	11/30/2021

Appendix B.2: Objective 2: Translating Best Practices to Nantucket

Building on our assessment of current and best practices employed in other towns, we contacted selected Nantucket town officials and other stakeholders to see how these practices might best be applied to the Town of Nantucket. We emailed Erika Mooney and Andrew Vorce of the Nantucket government. Through these correspondences, we learned how key aspects of a LED streetlight conversion will be applied to a town setting, such how funding will be achieved and the formulation of a LED streetlight conversion working group. Through these interviews, we gained an understanding of the complexities that being an island brings, and how to

effectively work around them. Additionally, we spoke with Lauren Sinatra of NEO to see how each recommendation could be implemented.

Appendix B.3: Objective 3: Recommended Implementation Processes and Strategies

Based on the findings from the objectives above, we recommend if and how Nantucket might pursue the LED streetlight conversion. We focused our analysis and recommendations on some fundamental questions, such as:

1. What are the key steps in the process of converting from HPS cobra lights to LED?
2. Would it be beneficial to retain a streetlighting consultant to help with the conversion and provide an expert opinion?
3. Would Nantucket benefit from the formation of a working group/committee, to advise the Select Board and Town officials on outdoor lighting matters?
4. How important is a pilot/demo with multiple LED streetlight options to gauge community feedback before making a decision?
5. How important is community involvement and support?
6. How does a community best balance public safety with preserving the night sky and minimizing the negative impact of outdoor lighting?

Additionally, intend to provide strong recommendations evaluating the benefits and costs of continuing to work with National Grid or buying out the poles and hiring contractors or utilizing the DPW.

Appendix C: Sponsor Description

Nantucket is an island 30 miles off the coast of Cape Cod in Massachusetts, and due to this remote location, the island is completely dependent on off-island power generation. Two large undersea cables from National Grid provide a combined 74 megawatts (MW) of power to the island for commercial and residential purposes ("Brief history of energy on Nantucket", n.d.). The largest single consumer of electricity on the island is a biodigester used to create compost (Golding, 2021). With large, fixed energy consumers such as this biodigester, it would follow that finding ways to minimize other energy consumption is in the best interest of island accounting for future growth and expansion. The Nantucket Energy Office (NEO) notes that electricity demand has increased significantly in the 2010's, hitting all-time highs of 40 MW and 45 MW in 2012 and 2013 respectively. This would avoid the necessity of building more energy infrastructure, such as a third undersea cable that would be a significant financial burden on Nantucket residents ("Brief history of energy on Nantucket", n.d.). To further illustrate the significance of electricity consumption on the grid, Figure 15 demonstrates the consequences of a potential power failure. If one of the cables fails, this can lead to loss of power across residences and businesses.

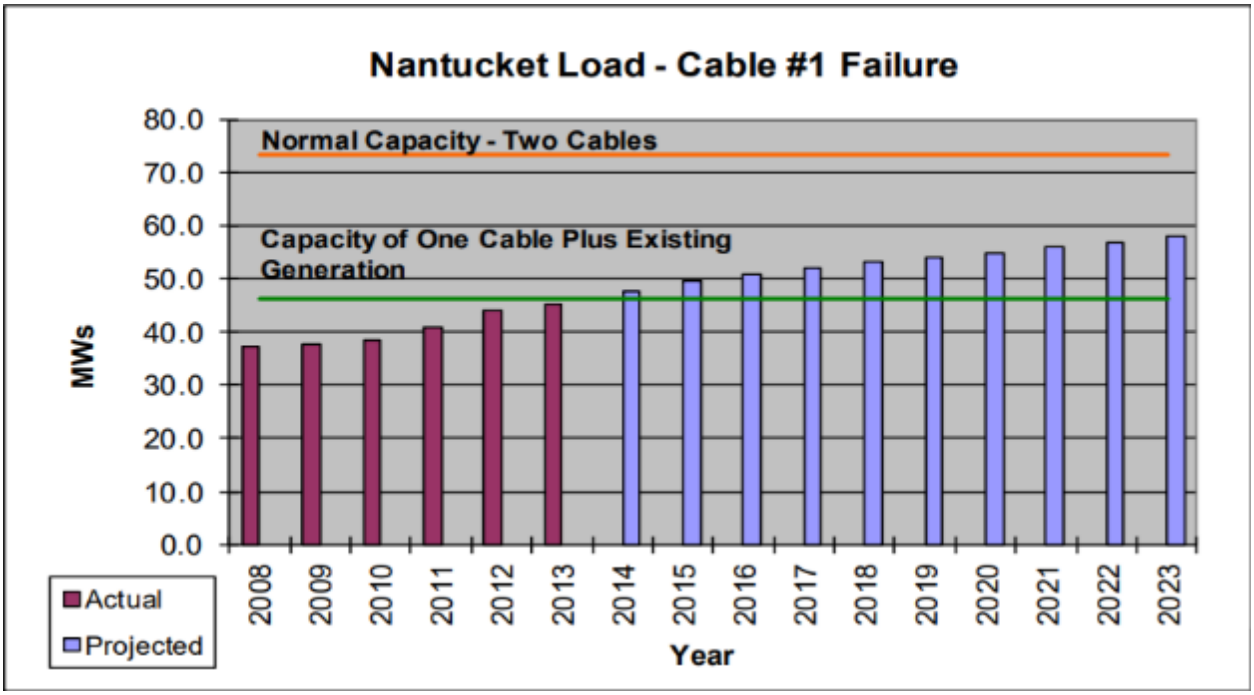

Figure 15: Projected load for cables one and two (Roughan et al., 2014)

National Grid is the sole public electricity utility to the island of Nantucket. On any given day, energy use peaks during the evenings, especially during the summer, per Figure 16. This is due to Nantucket's population soaring during these summer months, which can be seen in Figure 17. The peak demand is increasing almost every summer, except for 2014 which was noted to be "atypically mild." The main contributor to this growth in demand is due to the increase in the number of houses both being occupied by and built for summer residents every year (Golding, 2021).

The current peak power demand on Nantucket is greater than the capacity for either undersea cable individually. As such, a cable outage during a period of high demand could lead to widespread power outages for homes and businesses. One possible solution to this is to is to install a third undersea cable. However, this would be expensive and difficult to do. The alternative solution is to find new ways to lower island energy consumption or dependence on the cables during these peak periods. The incentive to find new ways to mitigate energy use or generate energy on island is active in the minds of the Nantucket government. According to a National Grid report in 2015, the island of Nantucket's energy growth on average 3.6% compared to Massachusetts's 0.6%, which is five times larger. Additionally, National Grid is forecasting 3.2% growth for the next five years for Nantucket and 1.1% growth for Massachusetts.

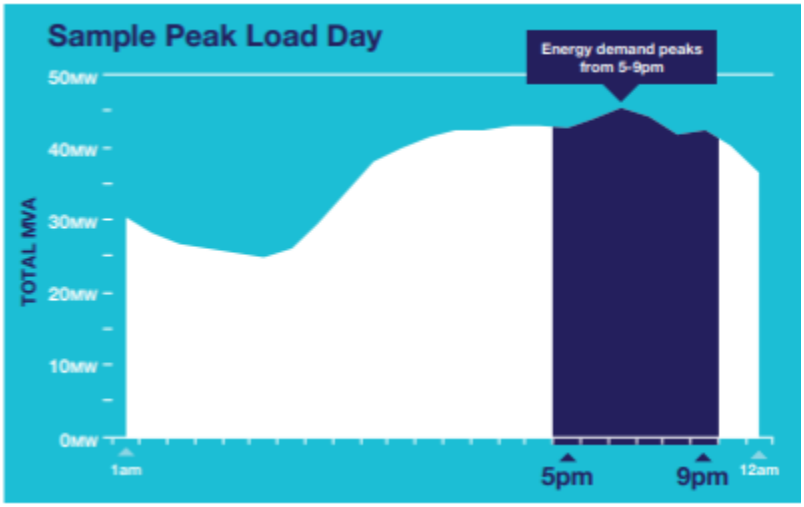

Figure 16: Peak Power Usage on a given day on Nantucket ("Nantucket peak load frequently asked questions", n.d.)

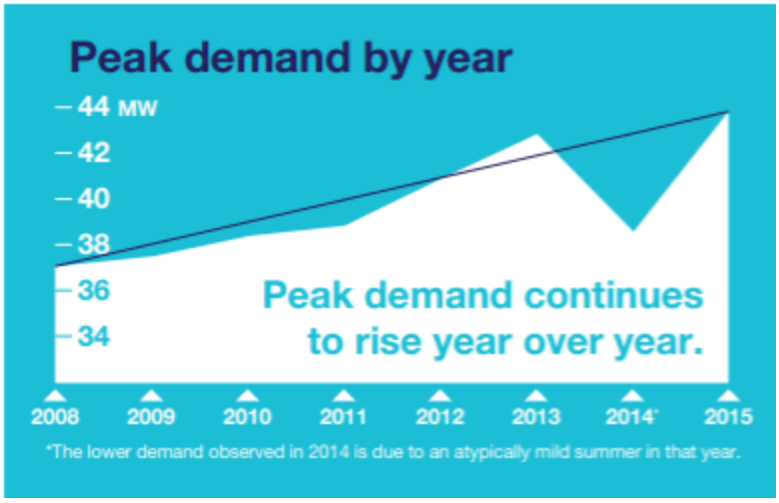

Figure 17: Year by Year Peak Demand
("Nantucket peak load frequently asked questions", n.d.)

Due to the rising energy demands, The Nantucket government created the Energy Office in 2011 to "assist the town in identifying and implementing energy efficiency, conservation, and renewable energy programs that are economically viable, environmentally responsible, and socially respectful for Nantucket." ("Brief history of energy on Nantucket", n.d.). Initially, the energy office was funded by ReMain Nantucket until 2014, when Nantucket secured a grant from the Massachusetts Department of Energy Resources to fund the office ("Brief history of energy on Nantucket", n.d.).

The NEO supports a variety of initiatives and projects on the island concerning energy policy. One such example is Mass Save, a program that is sponsored by National Grid and subsidized by a surcharge on residents' electricity bills, making nearly all residents eligible for their program's initiatives, some notable ones being free home energy audits and a 0% loan program for improving home energy ("What is Mass Save?", n.d.). In May 2013, a set of energy policy recommendations put forth by the NEO were adopted by the Board of Selectmen that include "energy efficiency, renewable energy and general planning and administration" ("Energy policy recommendations", n.d.). This NEO initiative includes some key goals along the way to reducing total energy consumption while supporting private development of on-island renewables (solar and geothermal) and ultimately including energy efficiency in the planning of future town planning, facilities and vehicles ("Energy policy recommendations", n.d.).

Nantucket underwent a series of five criterion in order to be designated as a Green Community in February 2020, a program that was created with the MA Green Communities Act

of 2008 and provides a grant of $139,340 to support energy reduction projects for the island ("Town of Nantucket Energy Office", n.d.).

The Energy Office is a part of the Planning & Land Use Services (PLUS) department, which was created in FY12 to reorganize the building, planning, and zoning departments into one ("Planning & Land Use Services (PLUS)", n.d.). The result of the reorganization can be seen in Figure 18.

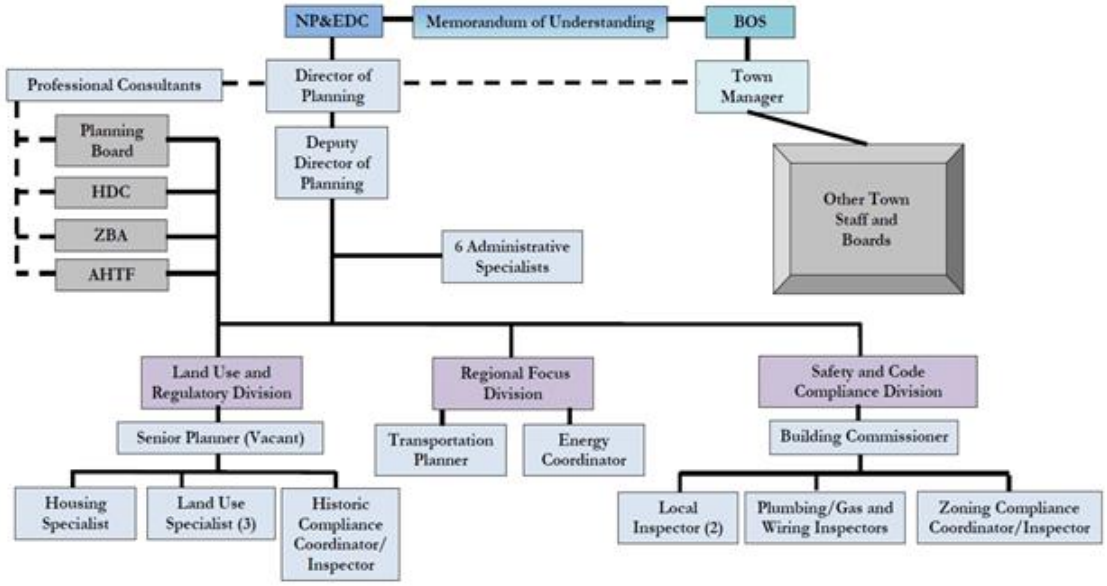

Figure 18: How PLUS was organized during FY20 (FY2020 budget PLUS department, n.d.)

In 2014 the Energy Office was having trouble with its decorative streetlights in the historic areas of Nantucket. There was no system in place for keeping track of their maintenance, condition, or location. Many of the streetlights were missing identification numbers and outages were a common issue. To top it all off the electric bill and maintenance costs for that year amounted to $50,250 ("WPI project center", n.d.). One IQP group that set out to Nantucket this year focused on this issue and helped provide the system the Energy Office was looking for. The system included an interactive map and database of all streetlights on Nantucket for easier maintenance of the streetlights. Many streetlights were also converted to LED as a pilot to get public opinion, which turned out very positive. The project helped to make the life of the Energy Office easier but started the attempts at reducing light pollution from streetlights which Nantucket Lights is concerned about.

Nantucket Lights is an organization dedicated to the restoration and preservation of Nantucket's dark skies. Their aim is to protect the island's nighttime environment against light pollution through education, awareness, and advocating for more responsible outdoor lighting. The organization is made up of both year-round and seasonal Nantucket residents, all of whom are passionate about minimizing light pollution on the island. Nantucket Lights is constantly looking for residents to join the cause, both by educating themselves and by supporting the passage of dark-sky friendly legislation. Aside from education and awareness, the current mission of Nantucket Lights is the conversion of the island's "cobra"-style streetlights from outdated high-pressure-sodium (HPS) lamps to LEDs.

The concern of the Energy Office and Nantucket Lights in 2021 is whether they can effectively and efficiently replace the HPS bulbs in the islands many cobra-head streetlights with LEDs. The decorative streetlights in the historic areas of Nantucket have already been replaced, but with these lights being town-owned it is easy for change to occur. However, with the cobra-heads owned by National Grid, many factors must be considered in whether this is feasible. The Energy Office goal with this project is to figure out if there is any way they can save money through a transition to LEDs with these lights. As for Nantucket Lights, they wish to see if light pollution can be kept to a minimal level while still lighting the way on Nantucket's streets.