

Analyzing and Operationalizing the Nantucket Energy Plan

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Abstract

While the Nantucket Energy Plan was designed to promote conservation and efficient energy usage, the strategies described in the plan are currently too generic to fit the Island's specific energy demands. Our goal for this project was to perform a thorough analysis of the Nantucket Energy Plan and suggest an appropriate course of action for the town. We conducted extensive research on the cost, energy savings, and acceptability for a select group of energy options. Using the information we collected, we identified the most feasible options and made recommendations for how the town should proceed with implementation.

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Executive Summary

Nantucket's high energy costs and closely bound community mean Nantucket is uniquely positioned to implement a climate action plan. In 2010, using protocols developed by an organization known as ICLEI, Nantucket drafted its climate action plan, now known as the Nantucket Energy Plan (NEP). However, the NEP has recently run into headwinds and has not yet received the full approval of the Board of Selectmen. Some members of the Board, as well as other concerned citizens, felt that while the ICLEI process provided local governments with an overall model for lowering energy consumption, its guidelines and embedded assumptions and algorithms were too generic to meet Nantucket's specific needs. Many of these individuals believed a more 'transparent' method, catered to fit Nantucket's unique situation, was needed for evaluating and setting priorities among the various energy reduction strategies described in the NEP (W. Willauer, personal communication, 2011).

To fulfill these needs, our project assisted the Nantucket Energy Study Committee (NESC) in developing a process for setting energy priorities that could be used to implement many of the energy strategies that are outlined in the NEP. Our team clarified the methods used by Sustainable Nantucket to select and evaluate energy options included Nantucket's Climate Action Plan, determined the nature of the concerns regarding the NEP and its priority setting methods by interviewing key stakeholders and opinion leaders in the community, identified and developed alternative ways to determine energy policy priorities based on the unique characteristics of Nantucket's situation, gathered information on the selected energy reduction strategies listed in the NEP, and recommended how the NESC should determine energy priorities in the future.

Method of Analysis

To try to address the concerns of the NESC and the Board of Selectmen, we needed to establish a transparent set of criteria to analyze individual energy saving measures and show how each solution would fit Nantucket specifically. In our analysis, we calculated the overall cost of several selected energy reduction strategies to help the town evaluate the economic feasibility of each option. We also evaluated the amount of energy that would be saved by implementing each option, which enabled us to determine the impact that the strategy would

have on Nantucket's energy use. Additionally, via interviews with key informants, we collected anecdotal information on the social and political acceptability of the energy strategy in order to gauge its likely effectiveness on the Island.

We used this method of analysis to evaluate several of the options listed in the Transportation and Buildings sections of the NEP. Our team did not address the alternative energy options in the NEP due to time and resource constraints, and because many of these solutions are currently being extensively explored by others on the Island. The results of our research and analysis of the energy options that are described in these sections of the NEP are summarized in the table below.

Conclusions and Recommendations

Based on our selective analysis of proposed energy conservation solutions described in the NEP, we have identified the strategies that would be most beneficial to Nantucket. Additionally, we can recommend a method that the NESC can use to evaluate energy reduction options in the future.

Conclusions

From our research, we were able to make many conclusions regarding the NEP and the effect it might have on Nantucket's energy use. An investigation of Nantucket's unique energy situation revealed that the consumption and cost of energy on Nantucket is a significant concern that is likely to become more critical in future years as the summer population increases and energy costs climb.

Additionally, we found that the Climate Action Plan provided a good basis for future reference with the identification of a broad array of theoretical strategies to reduce energy consumption on the island. The Plan ran into substantial headwinds, however, for two major reasons: (1) some people objected to framing the issue in terms of climate change and greenhouse gas emissions; and (2) the assessments were based on generic models and data that fail to account for the particularities of the Nantucket situation. While the Nantucket Energy Plan addressed the first issue by shifting the emphasis away from climate, it still failed to

provide a sufficiently detailed analysis of the costs and benefits of the different strategies to allow for the identification of priorities for implementation.

Accordingly, this report includes a more detailed analysis of the advantages and disadvantages of selected energy strategies using data and assumptions that are more closely tuned to Nantucket sensibilities. Recognizing that many Nantucket officials and residents are more concerned about cost than they are about climate change, our research has tried to examine in more detail some of the likely costs and savings associated with the different energy saving options. Any effort to implement energy policies, however, must also be aware of the likely social and political obstacles. Consequently, our project has also tried to assess the political and social acceptability of the different options.

The table below presents a summary of the results of our analysis. Each of the selected energy saving options taken from the Nantucket Energy Plan is rated according to cost, energy savings, and political and social acceptability. The categories have been color coded to highlight the differences among and between options.

However, even with these ratings, selecting priorities for implementation is not necessarily a straightforward process of selecting those options that have low costs, high energy savings potential, and high social and political acceptability, since these categories are not fungible or easily compared, and other factors may need to be considered. For example, putting more bicycle racks downtown may not save much energy, but it is socially and politically acceptable, relatively cheap to pursue, and may result in other social benefits, such as less traffic congestion downtown, less clutter from disorganized parking of bicycles, and better health from exercise.

Recommendations

The quantitative and anecdotal information we collected through our research and personal encounters enabled us to determine which energy reductions strategies, of those listed in the NEP, would be most successful on Nantucket. Our recommendations are divided into three parts: (1) Energy saving options the town should pursue; (2) Options the town should not pursue at this time; and (3) Future Assessment and Implementation efforts.

Cost, Energy, and Acceptability Ratings for the Explored Energy Reduction Strategies

Energy Strategy	Cost	Energy Savings	Social Acceptability	Political Acceptability
Park and Ride (T.1)	High	Medium	Low	Low
Ethanol (T.3)	High	Low	Medium	Medium
Biodiesel (T.3)¹	High	Medium	High	High
Straight Vegetable Oil (T.3)	High	Medium	High	High
Green Fleet Policy (T.2)	Medium	Low	Medium	Medium
Bike Racks (T.13)	Low	Low	High	High
In-Town Bike Path (T.13)	High	Low	High	Medium
Tire Inflation Pumps (T.6)	Low	Low	High	High
Rotary (T.1)	High	Medium	Medium	Low
Mass Save Home Energy Assessment	Low	High	High	High
Efficient Lighting (B.1)*	Low	Medium	Medium	High
Programmable Thermostats (B.8)*	Low	Medium	Medium	Medium
Phantom Loads - Smart Strips (B.4)*	Low	Medium	High	High
Low Flow Toilets (B.15)	Medium	Low	High	High
Rain Water Collection (B.16)	Medium	Low	Low	Low
Grey Water Collection (B.16)	Medium	Low	Low	Low
Energy from Waste (R.11)	High	High	Medium	Medium
Composting (B.20)	Medium	Medium	Medium	Medium
Green Building/LEED Certification (B.13)	Low	Low	Low	Medium
Luxury Building Mitigation Fund (B.14)	Low	Medium	Low	Medium
Weatherization (B.6)	Medium	High	Medium	High
LED Streetlights (B.2)	Medium	Medium	Medium	Medium

¹ **Bold** text indicates our recommended energy reduction strategies, while an * signifies recommended strategies that are included in the recommendation of the Mass Save program

Energy Saving Options the Town Should Pursue

One program that we strongly recommend the town promote to reduce residential energy use is the Mass Save Home Energy Assessment Program. Through Mass Save, residents can receive free CFLs and programmable thermostats, as well as discounts on smart power strips, refrigerators, and weatherization improvements. Since the Mass Save program is a free service that can save homeowners money on their energy bills, many residents would likely be in favor of having a Home Energy Assessment performed on their house. The town should therefore raise awareness about the Mass Save program to encourage residents to register for a Home Energy Assessment². Additionally, this program would reduce residential electricity consumption by making it easier for homeowners to obtain smart power strips and energy efficient light bulbs. This would delay the need for National Grid to install a third submarine cable from the Mainland to Nantucket.

According to our research, weatherization is a valuable energy saving strategy, and therefore we recommend that the town educate citizens on how it could significantly reduce their energy bills. Residential housing is one of the largest users of energy on the Island. More specifically, heating and cooling is the largest source of energy usage in residential houses, so it is a high priority target for energy reduction. Nantucket is home to many historic and aged houses, many of which are poorly insulated. Our research showed that proper weatherization of a poorly insulated house can reduce heating and cooling energy use by over 20%. We suggest that the town raise awareness by holding a weatherization lecture, where citizens can come to learn how weatherization could help them save money and talk to experts about what they can specifically do to weatherize their house. The town can raise awareness of programs, like Massachusetts' Weatherization Assistance Program, which can provide residents with financial assistance for these renovations. This is an inexpensive solution for the Town that could reduce the island's energy usage noticeably.

We also recommend that the town install additional public bike racks in the downtown area and other popular locations. The cost and installation per bike rack is relatively low, and

² Lauren Sinatra, Nantucket's Energy Project and Outreach Coordinator, is actively working with National Grid to enhance awareness of this program and to improve the scheduling of audits with Island residents

although the energy reduction is difficult to measure, this would be a helpful step towards making Nantucket more bike-friendly. The main goal of making Nantucket more bike-friendly is to reduce the public's usage of cars, which therefore reduces total vehicle emissions and fuel consumption, especially by reducing automobile congestion in downtown. Public opinion is high, and the HDC would have little objection to the racks as long as they fit in with Nantucket's style, and are preferably made of wood. From our research, installing more bike racks would be a quick and valuable use of the town's resources.

Another conservation technique we recommend the town should explore further, due to its ease of implementation, is installing tire inflation pumps at beach access points. Installing air pumps at these locations would encourage drivers to re-inflate their tires immediately after exiting the beach, therefore reducing the amount of excess fuel consumed by vehicles traveling on under-inflated tires. Although tire inflation pumps will not have a large impact on reducing the Island's overall energy consumption, this is a strategy that would be welcomed by the public, while costing the town little to no money to implement. As a result, it would set the stage for the implementation of future energy solutions that have a greater impact on energy consumption.

The last two recommendations that we made were not entirely based on the ratings that we gave them. We looked more at their potential if further research was to be carried out. We decided to recommend them in this way due to their abstract nature and the fact that they are larger projects than most of the others outlined in our report. They may have a lot of different factors for or against their implementation, which we may not be able to foresee at the present time.

We recommend the use of biodiesel and SVO on the Island in municipal fleets and/or personal vehicles. Utilizing the waste oil from local restaurants will eliminate the need to dispose of the oil off-island, substantially reduce emissions, eliminate some of the shipping costs associated with bringing diesel fuel to the island, and potentially create a small number of new jobs on the Island. In addition to these ancillary benefits, using biodiesel or SVO will directly reduce energy use and costs. It is worth the town's time to research this option further to determine whether biodiesel or SVO is viable at the municipal or private level.

Along the same lines, using waste to create energy, EfW is an energy option that we recommend to eliminate the composting of waste and to generate a large amount of energy on the Island. An EfW processing plant would supply all of the electrical needs of the landfill, allow waste mined from the landfill to be disposed of, and supply more electricity than any renewable energy source currently on or planned for the island. Although there are many unknowns at this point, EfW could have substantial benefits for the Island and should be researched further. Educating the public about the benefits of an EfW plant and clarifying some of the misconceptions surrounding it would be worth the town's time.

Energy Saving Options the Town Should Not Pursue

From our research, we determined that the proposed extension of the Park and Ride system is not economically feasible. The costs are high, the predicted utilization rates are low, and the energy savings are modest.

Green Fleet Policy was not considered for the six recommended options because the cost savings (medium) and energy savings (low), make it a low priority for quick implementation, and social and political support would likely be limited. .

While many members of the community are strong proponents of installing an In-Town Bike Path, we do not recommend this initiative as an *energy saving strategy* for the Island.

While a bike path in Nantucket's downtown area is socially appealing and would encourage some individuals to ride a bicycle into town instead of driving their car, the amount of energy that would be saved is not large enough energy to account for its high installation costs.

We chose not to recommend the rotary due to its high implementation cost and low political acceptability. In theory, it would save a lot of time and fuel if it was constructed, but with the lack of political support that it has now, it would not be easy to pursue.

Low flush toilets were not considered in our top recommended options because it is already required under Massachusetts building codes, and the ultimate energy savings would not be very high. Given the existing building codes, it is expected that the proportion of low flush toilets will increase steadily over time as new buildings are constructed and older homes renovated. A more aggressive policy requiring replacement of old toilets would not be socially or politically acceptable, and would yield limited energy savings.

LED street lighting was not a highly recommended option at this time since there is no rate change and therefore no financial benefit for the town to switch over. However, this can become an appealing energy and money saving strategy if future negotiations regarding rate changes occur.

Future Assessment and Implementation

Due to limited time and resources, it was not possible for us to fully research all the energy saving options listed in the NEP. Instead, we recommend that when the town explores the remaining options, they use a similar method of analysis. It is imperative that any assessment use data on costs, energy savings, and social and political acceptability that are tailored to the Nantucket situation. A tailored assessment will allow the town to have a better understanding of its options and the various tradeoffs. From our research, we found that there are differences in opinion based on whether cost or emissions should be the main focus in the energy plan. Our method does not provide a specific priority ranking of the solutions based on one variable, but rather it attempts to make more transparent the various assumptions, costs, benefits, and tradeoffs that are being made. Informed debate among citizens and officials will be necessary to determine priorities before moving to implementation.

Authorship

This writing of this report was a collaborative effort by its authors: Christopher Bannon, Timothy Ellsworth, and Nicholas Musselman. While individual members of the group were responsible for writing parts of the Introduction, Literature Review, Methodology, and Conclusions and Recommendations chapters, all written material was edited and reviewed by all group members.

The Findings and Analysis chapter was also a collaborative effort, but each group member was involved with the initial research and writing of certain sections of the chapter. Chris wrote the initial draft of the Park and Ride, In-Town Bike Path, Tire Inflation Pumps, Mass Save Home Energy Assessment, Energy Efficient Lighting, Programmable Thermostats, and Phantom Loads - Smart Strips sections. Tim was primarily responsible for the research and writing of the Ethanol, Biodiesel, Straight Vegetable Oil, Green Fleet Policy, Low Flush Toilets, Rain Water Collection, Gray Water Collection, Energy From Waste, and Composting sections. Nick drafted the Bike Racks, Rotary, Green Building Practices/LEED Certification, Luxury Building Mitigation Fund, Weatherization, and LED Streetlights sections of the report. Although one group member was predominantly responsible for the previously described parts of the chapter, all group members edited and made significant contributions to each section.

Disclaimer

This report was written and compiled by students from Worcester Polytechnic Institute as part of their Interactive Qualifying Project. The opinions or views expressed here are not those of Worcester Polytechnic Institute, nor those of any person or group of persons involved with the report. The authors are not experts in the fields concerned within the report, nor do they claim to support or not support any of the views expressed here. They worked closely with the Nantucket Energy Study Committee and were sponsored by Dr. Peter Morrison, Dr. Whiting Willauer, and Lauren Sinatra, but views and results presented were not influenced from their participation. Information was obtained through online and print sources, as well as from emails and personal interviews. The authors do not claim or refute that any of the

aforementioned contacts are experts in the specific fields that their interviews pertained to. This report includes broad estimates in some fields that should not be viewed to be exact calculations, nor should the authors be held responsible for any possible miscalculations or misrepresented information. This project was completed within a sixteen week period, seven of which were spent on Nantucket, and the authors were not financially reimbursed for their work, as specified by the nature of the project. All conclusions and recommendations presented in the report are derived from information obtained from research and were written with the objective of containing no prior bias.

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Introduction

Global energy consumption and increased carbon dioxide emissions are a growing problem in modern society. The burning of fossil fuels and the release of greenhouse gases (GHGs) have given rise to concerns about global warming. While many national and international agreements have been made in an attempt to reduce GHG emissions, much of the implementation occurs at the local level. ICLEI is one organization that has been established to service the needs of the cities and towns trying to develop and implement policies to reduce GHG emissions by controlling energy consumption.

Nantucket joined the ICLEI community in 2008. In 2010, using the ICLEI protocols, the Island drafted its climate action plan, known as the Nantucket Energy Plan (NEP). The NEP described the measures that are necessary for reaching Nantucket's overall emissions goal, which is to reduce GHG emissions by 10% below 2000 levels by 2020 (Town of Nantucket, 2011, p. 8). As an Island, Nantucket is uniquely positioned to implement a climate action plan. Nantucket's high energy costs and closely bound community make Nantucket an ideal situation for employing emissions reducing measures. However, the NEP has recently run into headwinds and has not yet received the full approval of the Board of Selectmen. Some members of the Board, as well as other concerned citizens, felt that while the ICLEI process provided local governments with an overall model for lowering energy consumption, its guidelines and embedded assumptions and algorithms were too generic to meet Nantucket's specific needs. Many of these individuals believed a more 'transparent' method, catered to fit Nantucket's unique situation, was needed for evaluating and setting priorities among the various energy reduction strategies described in the NEP (W. Willauer, personal communication, 2011).

To fulfill these needs, our project assisted the Nantucket Energy Study Committee (NESC) in developing a process for setting energy priorities that could be used to implement many of the energy strategies that are outlined in the NEP. Our team clarified the methods used by Sustainable Nantucket to select and evaluate energy options included Nantucket's Climate Action Plan, determined the nature of the concerns regarding the NEP and its priority setting methods by interviewing key stakeholders and opinion leaders in the community,

identified and developed alternative ways to determine energy policy priorities based on the unique characteristics of Nantucket's situation, gathered information on the selected energy reduction strategies listed in the NEP, and recommended how the NESC should determine energy priorities in the future.

The beginning of this report provides background research on the methods used to develop the draft climate action plan for Nantucket. The subsequent section outlines the process we used to gather and analyze the information needed to set energy priorities. The list of resources used in our research and the appendix conclude the report.

Literature Review

The relentless rise in energy consumption worldwide has led to increasing concerns among scientists and policy makers regarding the impact we are having on the climate. In particular, people are concerned about carbon emissions, since CO₂ is the dominant anthropogenic greenhouse gas (GHG) that contributes to climate change. In 2010, the International Energy Agency (IEA) estimated that 30,000 Mt of CO₂ were produced worldwide, which is double the amount of CO₂ emissions produced in 1973 (International Energy Agency, 2011, p. 44). This massive increase in CO₂ emissions is primarily due to the burning of fossil fuels, in particular oil, coal, and natural gas. Fossil fuels are the main source of energy in today's world, as they are readily used for transportation and in the production of electricity.

Several international policies and protocols have been developed in an attempt to combat climate change. Perhaps the most prominent of these is the Kyoto Protocol, which is aimed at reducing the combined GHG emissions of participating nations by 5% below 1990 levels by 2008-2012 (BBC, 2005). Numerous national and international are underway to try to achieve these goals, but much of the activity is actually taking place at the local levels.

As in many communities in the United States, many people in Nantucket are concerned about the growing consumption of energy and the potential impacts on climate. Consequently, the Town commissioned Sustainable Nantucket to explore options to reduce energy consumption and GHG emissions. Sustainable Nantucket chose to adopt the assessment methods developed by ICLEI (International Council for Local Environmental Initiatives) and in 2008 Nantucket became an ICLEI 'community'. Following the ICLEI methods, Sustainable Nantucket first created a Greenhouse Gas Emissions Inventory for the Island and then drafted a Climate Action Plan that outlined many different strategies to reduce energy consumption. The plan was reviewed by the Board of Selectmen, who determined that the plan needed further revision before they would adopt it and move forward with implementation. Some of the difficulties regarding the plan included: whether the focus should be more related to saving energy or reducing emissions; controversy over the name of the plan with its emphasis on climate rather than energy; concerns about the feasibility of and priorities among the proposed strategies; and, whether or not the town should continue to follow the ICLEI guidelines. As a

result the Climate Action Plan was substantially re-drafted and renamed the Nantucket Energy Plan. The plan (dated May 2011) remains in draft form and has not been officially adopted by the Board of Selectmen.

The Nantucket Energy Plan lays out a long list of policy options that might be pursued to reduce energy consumption on the island. While it highlights certain approaches, it does not explain why or how these particular items were selected and how they were tailored to ‘fit’ Nantucket’s unique situation, nor does it establish a clear set of priorities for which policies to tackle first. George Aronson, the energy consultant for the Town of Nantucket points out how ICLEI was designed based on California energy and emission standards that do not apply to Nantucket (G. Aronson, personal communication, November 10, 2011). This comment was mainly directed at the software created by ICLEI to calculate emissions as opposed to the entire organization. Establishing a methodology that clearly determines priorities among the various policy options is imperative, whether or not the town decides to continue following the ICLEI process. Any priority-setting process also needs to carefully account for the particularities of life on Nantucket, including the feasibility and social and political acceptability of specific policy options. The goal of this project is to help the NESC develop a method for setting such priorities. By way of background, we begin an overview of the ICLEI methods used by Sustainable Nantucket and then explore briefly the major findings from the Greenhouse Gas Emissions Inventory and the major policy recommendations contained in the Nantucket Energy Plan. We conclude the section by reviewing some of the general guidance on priority setting as well as case studies of the priority-setting process in several communities.

ICLEI

ICLEI, which previously stood for “International Council for Local Environmental Initiatives” and is now known as ICLEI-Governments for Sustainability, is an organization devoted to helping local governments address the environmental issues of climate change, biodiversity, sustainability, and EcoMobility (ICLEI Global, 2008). ICLEI focuses on sharing protocols and information about energy strategies; they have “over 1220 local government Members who are committed to sustainable development. [Their] Members come from 70 different countries and represent more than 569,885,000 people” (ICLEI Global, 2008). The

Global ICLEI website outlines their main ideas and objectives in their Vision, Mission, and Mandate section (ICLEI Global, 2008). The ICLEI Vision incorporates three key parts: Association, Movement, and Agency (ICLEI Global, 2008). ICLEI describes Association as the interaction between the local governments around the world in the field of sustainable development; through ICLEI, local government agencies can exchange ideas or solutions they have found on their path to a cleaner environment (ICLEI Global, 2008). This leads into Movement, the second part of the Vision. ICLEI describes Movement as, “a high energy, flexible Movement of local governments working together in networks for performance, supported by campaigns and programs, and strategic alliances” (ICLEI Global, 2008). The third part of ICLEI’s Vision claims that ICLEI acts as an Agency promoting different environmental programs and implementing the ideas derived from those programs (ICLEI Global, 2008). In addition to their Vision, ICLEI mentions how their Mission and Mandate is to work with local governments to supply them with their services and recruit people who will have a lively role in sustainability and environmental issues (ICLEI Global, 2008).

ICLEI is entirely dependent on the action of people at both the local level and the global level of organization. Many different types of communities, from big cities to small towns, can participate in ICLEI (ICLEI Global, 2008). ICLEI is not a professional organization or consulting group that brings people in to manage the environmental issues of local governments. Instead, the people in the local governments simply follow ICLEI’s guidelines to develop strategies and solutions suited to the local community. A council and executive committee of local government members oversee and direct ICLEI’s operations and programs (ICLEI Global, 2008).

ICLEI’s Cities for Climate Protection (CCP) Program

ICLEI’s primary campaign for climate change is the Cities for Climate Protection (CCP) program (ICLEI Global, 2008). The CCP program is designed to help local governments save money, reduce GHGs and, in some cases, get closer to energy independence (ICLEI, 2011). The CCP revolves entirely around its Five Milestone organization system. The Five Milestones are to “1) [Create an] Inventory [of] GHG emissions...2) Establish [a] reduction target...3) Develop [a] climate action plan...4) Implement policies and measures...[and] 5) Monitor and verify [the] results” (ICLEI US Action 2011). The purpose of Milestone 1 is to collect data on all of the GHG

emissions in a community and determine where the community stands on the amount of emissions produced. This first step is crucial because the rest of the Milestones depend on the accuracy of this baseline information. Milestone 2 focuses on setting a timeline by which different parts of the climate control or sustainability programs will be completed, allowing government officials to plan projects accordingly. Milestone 3 entails developing and writing the Climate Action Plan (CAP) is. It requires planning and setting priorities for the different conservation methods selected to lower emissions and work towards sustainability. Milestone 3 focuses on the actions necessary to achieve the deadlines set in Milestone 2. Milestone 4 involves the implementation of the priorities and plans identified in Milestone 3. It is the most hands-on part of the CCP. Milestone 5 is the monitoring stage of the CCP and tells participants if their solutions are working (ICLEI, 2011).

CCP Protocols

The CCP program requires that certain protocols be followed in the process of reducing emissions. The US ICLEI website describes three different protocols³. The first protocol outlined on the US website is called Local Government Operations Protocol. The website describes it by saying, “The Local Government Operations Protocol [LGO] is the U.S. national standard guidebook on how to quantify and report local government greenhouse gas emissions” (ICLEI, 2011). The website goes on to state that, “The methodologies contained within the LGO Protocol are incorporated into ICLEI's GHG software and tools” (ICLEI, 2011). It is important to realize that the protocol is incorporated into the software that will be described in more detail below.

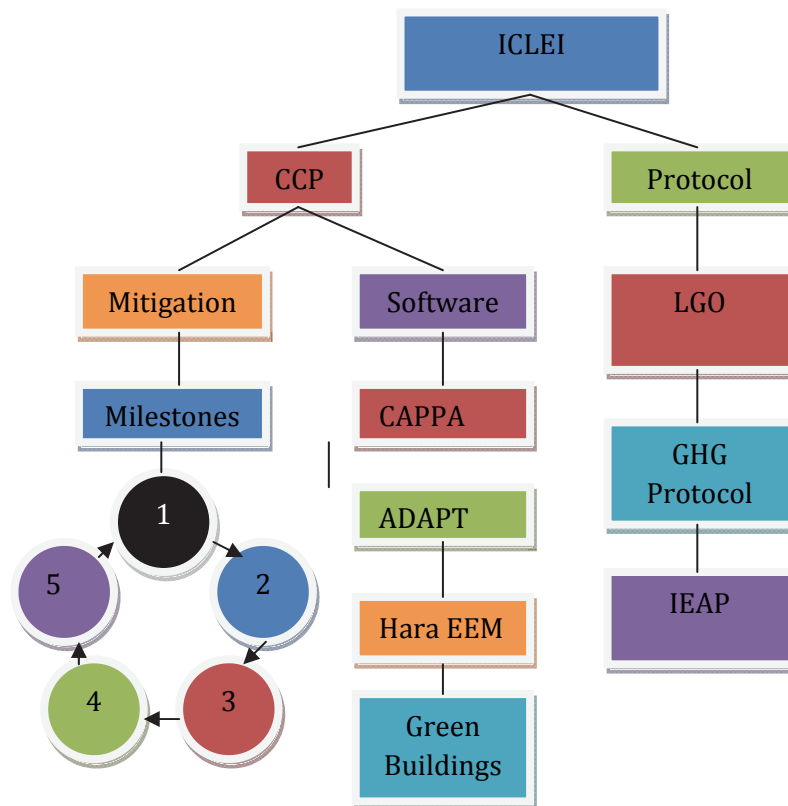
The second protocol, called the GHG reporting protocol, sets up a standard on how to report GHG emissions (ICLEI, 2011). Local governments do not need to be members of ICLEI to use this protocol. The last and most important protocol is the International Emissions Analysis Protocol⁴(IEAP). According to ICLEI, the IEAP “provides a general framework for inventories around the world and draws on existing best practices from the IPCC [United Nations Intergovernmental Panel on Climate Change] and WRI [World Resources Institute] [both of

³ The Global ICLEI website only stresses one of the protocols from the US website.

⁴ This is the only protocol discussed on the Global ICLEI website.

which deal with climate change] (ICLEI, 2011). ICLEI Global explains that the IEAP protocol is based on experiences of the ICLEI members over the past 17 years (ICLEI Global, 2008). It says that, “The IEAP consists of the general principles and philosophy that any local government, regardless of location, should adhere to when inventorying GHGs from its government operations and community as a whole” (ICLEI Global, 2008). All of these protocols and programs are designed to help local governments make their decisions and set priorities in the energy planning stages of CCP’s milestone program.

Figure 1: ICLEI Structure



CCP Programs

ICLEI has developed four software programs to assist local governments in creating climate action plans. These programs are CAPPA, ADAPT, Hara Environmental and Energy Management Software, and the Green Building Decision Tool.

CAPPA

One of the tools ICLEI provides local governments to assist them in creating a climate action plan is called the Climate and Air Pollution Planning Assistant (CAPPA). CAPPA breaks

down the climate action plan into four sections: Energy Efficiency/Conservation; Energy Generation; Transportation; and, Waste. Each of these categories contains numerous energy conservation strategies. Every strategy included in CAPPa has its own page describing the strategy, with links to websites created by cities in the United States that have already implemented that particular solution. This helps the user to easily identify the successes and problems encountered by other cities when attempting to execute certain energy conservation methods into society. The strategy pages also include formulas that calculate various components such as the cost of implementation, the total annual energy savings, and the total reduction in greenhouse gas emissions. For example, under the page promoting the switch to LED Street-lights, the user can enter in the price of electricity, the daily hours of operation, and the wattage for the specific LED light being used. CAPPa will then calculate the total annual energy savings, the annual cost savings, the simple payback period, and the greenhouse gas emission reductions. CAPPa also includes a final emissions report page, which lists all of the possible solutions and their estimated emissions reductions, and shows how each solution would contribute to the city's overall emissions reductions goal. The information provided by CAPPa can be extremely valuable to cities looking to compare costs and environmental impacts of several different solutions.

ADAPT

ADAPT is an important software tool that ICLEI offers to its members. This software program deals with the Five Milestone system and the energy planning process. It is therefore a potential tool that can be used in the formation of climate action plans (ICLEI, 2011). The US website states, "ADAPT walks you through the process of assessing your vulnerabilities, setting resiliency goals, and developing plans that integrate into existing hazard and comprehensive planning efforts" (ICLEI, 2011).

Hara Environmental and Energy Management Software

Hara is another software program offered by ICLEI that helps with both GHG emission management and energy planning (ICLEI, 2011). According to the website, "[Hara EEM] supports them at each stage of ICLEI's Five Milestone process through advanced GHG emission inventorying, forecasting, target setting, and climate action planning capabilities" (ICLEI, 2011).

Green Building Decision Tool

The Green Building Decision Tool is ICLEI's Excel program that deals specifically with green building planning by highlighting the best options to explore (ICLEI, 2011). The program is broken into 5 steps: "1) Understand the value of green building, 2) Explore your green building options, 3) Decide how to implement your green building option, 4) Review existing green building policy options, 5) Review green building tips" (ICLEI, 2011). This is a great tool for developing energy plans; it directly helps in making decisions specific to the building section of energy consumption.

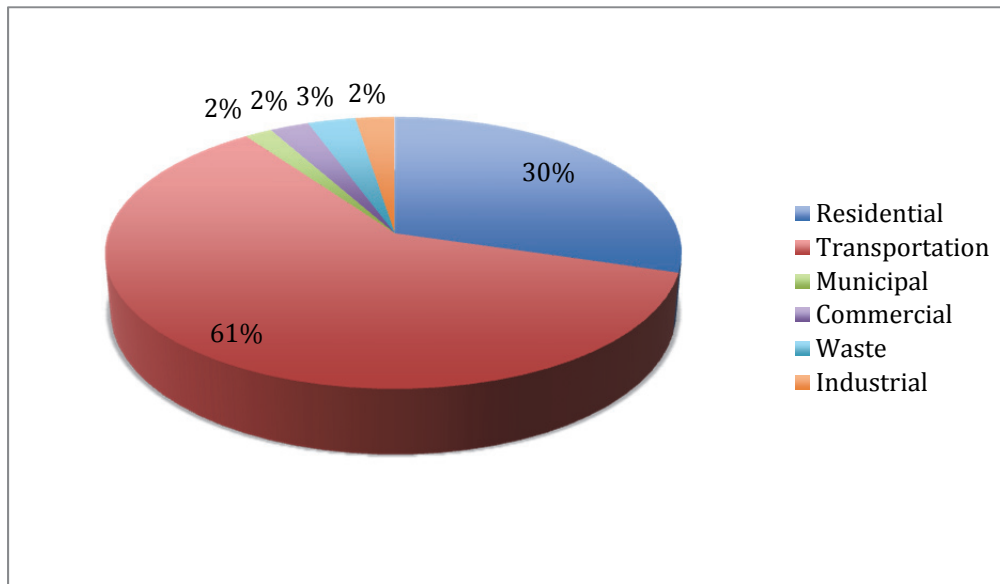
Nantucket's Participation in ICLEI

In March 2008, Nantucket joined ICLEI and elected to participate in the CCP campaign (Town of Nantucket, 2011, p. 4). Sustainable Nantucket helped the Town of Nantucket reach its first milestone by creating the Greenhouse Gas Emissions Inventory in 2009 (Town of Nantucket, 2011, p. 4). This report identified the main sources of energy and greenhouse gas emissions on the island. It was determined that the Town of Nantucket generated 6,275 tons of CO₂ in 2007, while spending a total of \$2,913,639 on energy (Sustainable Nantucket, 2009, p. 9). Transportation accounts for 64.4% of the total energy used and 61% of CO₂ emissions on the island. Additionally, 31.4% of Nantucket's energy use went toward residential energy needs (Sustainable Nantucket, 2009, p. 9). Additional energy and emissions data were collected for the municipal, industrial, commercial, and waste management sectors of Nantucket, as summarized in Figure 1 (Town of Nantucket, 2011, p. 7). These data enabled Sustainable Nantucket to forecast that Nantucket's energy use would increase 6.42% by 2020 (Sustainable Nantucket, 2009, p. 10).

Completing this energy and emissions evaluation of the island made it possible for Nantucket to proceed into Milestone 2 of the ICLEI process and set goals for future reduction of greenhouse gases. On March 25, 2009, the town's Board of Selectmen approved the goal of reducing emissions by 10% below 2000 levels by 2020 (Town of Nantucket, 2011, p.8). By reaching this goal, Nantucket would lower its carbon dioxide emissions by an estimated 86,000 tons from its 2007 levels (Town of Nantucket, 2011, p.8). Having approved this goal, the need

for a plan of action grew more pressing. This led the town to begin work on Milestone 3, which involved creating a climate action plan for the island.

Figure 2: 2007 Nantucket CO2 Emissions by Energy Sector



(Data from: Town of Nantucket, 2011, p. 7)

Climate Action Plan for Nantucket Island

The Nantucket Energy Studies Committee was formed because of increasing concern about Nantucket's growing energy consumption. This concern has been sparked not only by the environmental impact of Nantucket's current energy usage, but also by the high cost of energy on the Island. The current energy prices can be largely attributed to Nantucket's geography. As an island, electricity must be supplied to Nantucket through two submarine cables that stretch approximately 26 miles from mainland Massachusetts to the Town of Nantucket (National Grid, 2011). While these submarine cables give Nantucket easy access to power, the costs associated with installing and maintaining them greatly increases the price of electricity on the Island. The average cost of electricity in Massachusetts, in 2010, was 16.03 cents per kWh, compared to 18.4 cents per kWh in Nantucket (Beliveau, Hesler, Jaskolka, & Sigety, 2010, p. 19). The average cost of gasoline on Nantucket also exceeds the state average. In April 2011, gasoline prices on Nantucket surpassed \$4.00 per gallon, while the average cost in Massachusetts was \$3.63 per gallon (Graziadei, 2011).

The NESC and others have been attempting to combat both costs and emissions by implementing various forms of energy conservation and exploring the role of renewable energy generation. For example, in October 2010, a Northwind 100 kW wind turbine was installed on the Nantucket High School campus (Nantucket Alternative Energy Products, 2011a). This wind turbine is expected to generate approximately 308,000 kWh of electricity each year, which is approximately 20 – 30% of Nantucket High School’s annual electricity needs (Remain Nantucket, n.d). Due to the success of the Nantucket High School wind turbine, the Town of Nantucket is attempting to install a 900 kW turbine at the DPW Compound, the land that serves as the town’s landfill (Nantucket Alternative Energy Products, 2011b). The NESC has also expressed interest in reducing electricity usage by developing a Smart Grid on the Island (Beliveau, Hesler, Jaskolka, & Sigety, 2010).

While the NESC has been making strides in introducing energy reduction strategies to the Island, an action plan was needed to explore many additional energy saving solutions and formalize a plan for their implementation. Nantucket’s Climate Action Plan, now known as the Nantucket Energy Plan, was drafted by Sustainable Nantucket with the assistance of ICLEI’s CAPP program (Town of Nantucket, 2011, p. 15). The Nantucket Energy Plan contains conservation strategies relating to transportation, heating, green buildings, electricity use, renewable energy, and waste management (Town of Nantucket, 2011, p. 35-38). Many of these potential energy conservation solutions were originally described in detail in the CAPP program.

As shown below in Table 1, Sustainable Nantucket focused on transportation solutions relating to cars, public transportation, bicycles, water and air travel (Town of Nantucket, 2011, p. 10 - 20). These strategies include promoting plug-in hybrid and electric car technology, increasing NRTA (Nantucket Regional Transit Authority) ridership, enhancing bicycle use on the island, and creating an airport/ferry sustainability fund (Town of Nantucket, 2011, p. 13 – 19).

Table 1: Actions, Costs and Priorities for Reducing Emissions from Transportation

Ground Transportation --> 20% reduction target	Cost	Impact	Spotlight	Agency
<i>Municipal - short term</i>				
Town anti-idling policy	Low	Med	T.7.	BOS
Optimize school transportation flows and alternatives	Low	Med	T.14.	School Committee
Encourage fuel conservation in recreational boating	Low	Med	T.11.	BOS
School bus anti-idling policy	Low	Low	T.8.	School Committee
Restrict idling at public facilities	Low	Low	T.7.	BOS
Encourage car-pooling, van-pooling, and NRTA use by municipal employees	Low	Low	T.1.	BOS / Chamber
Utilize fuel-efficient vehicles (e.g. bicycles) for parking enforcement	Low	Low	T.12.	BOS
Increase NRTA ridership	Med	High	T.1.	NRTA / BOS
<i>Municipal - long term</i>				
Green fleet policy	Med	Med	T.9.	BOS
Utilize alternative fuel vehicles for city fleet	Med	Med	T.4.	BOS
Parking management	Med	Med	T.3.	BOS
<i>Community - short term</i>				
Bike friendly Nantucket	Low	Med	T.2.	Various
Open local government alternative fueling stations to the public	Low	Med	T.4.	Private
Education on proper tire inflation at Wauwinet and other tire inflation spots	Low	Low	T.14.	Various
Food miles program	Low	Low	T.15.	Various
Local biodiesel	Med	Med	T.4.	Private
Trip consolidation technologies	Med	Med	T.5.	Private

(Town of Nantucket, 2011, p. 35)

The conservation strategies that deal with heating and green buildings include weatherization of community and municipal buildings and installing programmable thermostats in municipal buildings (Town of Nantucket, 2011, p. 36). Many other solutions regarding community and municipal heating and buildings are listed below in Table 2.

Table 2: Actions, Costs and Priorities for Reducing Emissions from Heating and Green Building

Heating (Target --> 20%)	Cost	Impact	Spotlight	Agency
<i>Municipal - short term</i>				
Pass the Stretch Code to the MA state building code	Low	High	H.5.	BOS
Install programmable thermostats	Low	High	H.2.	BOS / Town Admir
Promote and identify weatherization programs for municipal buildings	Low	High	H.1.	BOS
Encourage / Sponsor city staff to become LEED Accredited professionals	Low	Med	H.8.	BOS
Historic and Sustainable Preservation Guidelines	Low	Med		BOS / HDC
Install low flush toilets in municipal buildings	Med	Med	H.3.	BOS
Rain barrels and greywater collection	Med	Med	H.4.	BOS
<i>Municipal - long term</i>				
Luxury building mitigation fund	Med	High	H.6.	BOS
Perform energy-efficient building lighting retrofits	Med	Med	H.1.	Various
Incentives or mandates for LEED or ENERGY STAR new construction or retrofits	Med	Med	H.8.	BOS
<i>Community - short term</i>				
Promote weatherization programs	Low	High	H.1.	Various
Encourage the use of programmable thermostats	Low	Med	H.2.	Various
Provide green building information to the public	Low	Low	H.8.	Various
Energy Efficiency kits	Med	Med		Various
Loans for weatherization programs	Med	High	H.7.	Various
<i>Community - long term</i>				
Incentives or mandates for LEED or ENERGY STAR homes	Low	Med	H.1.	Various

(Town of Nantucket, 2011, p. 36)

The Climate Action plan also outlined many ways to conserve electricity and promote renewable energy solutions. As potential solutions to the island’s electric concerns the report

emphasized switching to energy efficient lighting, exploring the possibilities of wind, solar, and geothermal power on the Island, and promoting the use of energy measurement and management tools through a Smart Grid system (Town of Nantucket, 2011, p. 24-25, 28-32).

Additional electric and renewable energy solutions are shown in Table 3.

Table 3: Actions, Costs and Priorities for Reducing Emissions from Electricity Use and Renewables

Residential, Commercial and Industrial Electricity (Target --> 20%)	Cost	Impact	Spotlight	Agency
<i>Municipal - short term</i>				
Efficient lighting	Low	High	E.1.	BOS
As of right siting for wind generation and expedited permitting	Low	High	E.16.	BOS
Install building/office occupancy sensors	Low	Med	E.1.	BOS / Town Admin
Institute a "lights out when not in use" policy	Low	Med	E.4.	Town Admin
Decrease average daily time for street light operation	Low	Med	E.1.	Town Admin
Install energy-efficient exit sign lighting	Low	Med	E.1.	Town Admin
Green purchasing policy	Low	Med	E.2.	Town Admin
Participate in demand response programs	Low	Med	E.6.	Town Admin
Employee energy education programs	Low	Med	E.9.	Town Admin
Shade tree program	Low	Med	E.11.	BOS / Planning
Climate change curriculum in schools	Low	Low	E.10.	School Committee
Purchase green tags/renewable energy certificates	Low	Low	E.12.	BOS
Wind turbine education in schools	Low	Low	E.18.	BOS / School
LED street lights	Med	Med	E.2.	BOS
Implement time of use or peak demand energy pricing	Med	Med	E.7	BOS / National Grid
<i>Municipal - long term</i>				
Renewable energy research	Low	High	E.19.	Planning Board
Perform energy-efficient building lighting retrofits	Med	Med	E.1.	Planning Board
Improve water pumping energy efficiency	Med	Med	E.8.	Planning Board
Require energy-efficient vending machines	Med	Med	E.1.	BOS
Plug-in / electric vehicle demonstration project	High	High	E.17.	Planning Board
<i>Community - short term</i>				
Switch to energy efficient lighting	Low	High	E.1.	Various

(Town of Nantucket, 2011, p. 37)

Among the possibilities for reducing energy usage in the waste management sector of Nantucket is installing a waste to energy plant. It is anticipated that this plant would be capable of producing 590 kWh of electricity through the burning of one ton of waste (Town of Nantucket, 2011, p. 32). Further conservation strategies for waste management are listed in Table 4.

Table 4: Actions, Costs and Priorities for Reducing Emissions from Waste Management

Wastewater treatment, recycling and waste (Target 20%)	Cost	Impact	Spotlight	Agency
<i>Municipal - short term</i>				
Reduce / re-use materials from building demolitions	Low	Med	W.4.	Various
Efficiency of landfill use and access	Low	Med	W.5.	BOS / Waste Options
<i>Municipal - long term</i>				
Transfer station on east side of island	Med	Med	W.3.	BOS
Gasification	High	High	W.1.	Waste Options
Waste to energy	High	High	W.2.	BOS / Waste Options
<i>Community - short term</i>				
Use clear and biodegradable plastic bags for trash	Low	Med	W.5.	Private
Continue extensive recycling efforts	Low	Low		Private

(Town of Nantucket, 2011, p. 38)

As shown in the preceding tables, each conservation solution was evaluated according to cost, impact, and the agency responsible for implementation and oversight. The strategies were given a rating of high, medium, or low for the cost and impact categories (Town of Nantucket, 2011, p. 35-38). The conservation measures that Sustainable Nantucket felt would be most influential on Nantucket were then highlighted, indicating that they were a high priority. These typically included conservation ideas that had a low cost but a high or medium impact.

The Climate Action Plan also described the requirements Nantucket must fulfill if it is to qualify for state funding from the Green Communities Division of the Massachusetts Department of Energy Resources. To qualify for this grant, Nantucket must reduce its energy consumption in municipal buildings, vehicles, and street lighting by 20% within 5 years of approving the Climate Action Plan. The Island must also purchase only fuel-efficient vehicles, establish requirements for minimizing life-cycle energy costs in new construction, adopt an accelerated permit process for as-of-right energy facilities, and introduce as-of-right citing for facilities involved with renewable energy generation, research, or manufacturing (Town of Nantucket, 2011, p. 33).

Pending Approval of the Climate Action Plan

The Climate Action Plan was first presented to the Board of Selectmen and the NESC in 2010, but it did not gain the approval of these committees. While the Climate Action Plan lists many different approaches Nantucket can take to lower energy consumption, it fails to go into detail on any of these potential solutions. Although the plan assigns a cost rating to each

strategy, the parameters of these ratings are undefined in the report, although they may be 'buried' within the underlying data, assumptions, and algorithms used in generating the report. In order to begin implementing the Climate Action Plan, the town must consider numerous aspects of cost, including the total cost of implementation, operating costs, and the payback period for each of the energy saving methods as well as who pays the cost and who benefits directly and indirectly. Many estimates of these expenses are found in the CAPPA program provided by ICLEI, but were not reported out in detail. Many more studies on the expenses of these operations would also need to be completed before determining which solutions would be best for Nantucket.

Similarly, Nantucket must further investigate the various energy and environmental impacts each solution could have on the island. Before putting the Climate Action Plan into effect, the town will need to determine the total amount of energy each particular conservation method would save over a certain period of time. In addition, the environmental benefits these methods could provide would need to be established in order to find the solution that is most advantageous for the island.

If the Climate Action Plan, or the Nantucket Energy Plan, as it is now known, is to be effective, Nantucket must identify the most effective energy saving solutions and create an overall implementation strategy for the plan. Finding the most effective solutions involves balancing the energy savings and environmental benefits with the ability for each solution to be acceptable to the public.

Case Studies

Nantucket is not alone in their endeavor; other cities from around the US and the rest of the world have developed their own Climate Action Plans, and can offer much wisdom that would aid Nantucket in their efforts.

Case Study: Worcester

Driven by the desire to do their part in making the world a better place, numerous other local governments have followed the ICLEI method for reducing emissions and at the same time saving money on their energy needs. With a population of almost two hundred thousand, the

city of Worcester is one of the larger cities in Massachusetts, and therefore can greatly benefit from reducing energy consumption and emissions. According to the City of Worcester's Energy Task Force, there are several benefits that could be gained from successfully enacting an effective Climate Action Plan. The two obvious reasons behind it are to reduce air pollution and to save money on energy costs. Aside from that, they believed that it would also lead to improved energy market security, more energy related jobs, and general public health and fitness (Williams, 2006, p.34)

Worcester joined ICLEI in 2006 and has since completed Milestone 3 and the city is currently working on implementing the strategies laid out in its Climate Action Plan (ICLEI , 2011). The success of a plan greatly depends on how it is introduced to the people who will make the final decision. Worcester's plan was presented in a report containing nearly two hundred and fifty pages of detailed research, reasoning, and recommendations. As such, the backbone of this Climate Action Plan was the in-depth research and emissions inventory conducted in Milestone 1.

One of the ideas behind the formation of Worcester's Climate Action Plan that makes it an effective tool is if enough data are provided about the problem, finding the solution becomes easier. The vast amount of background information and projections on each idea presented in the plan allowed for a clear idea of what strategies would be most effective. This information was gathered through multiple sources, one of which includes specially designed software to calculate total emissions and results of certain measures (Williams, 2006 p.178). The data was organized into charts showing the estimated implementation cost, tons of CO₂ saved, annual monetary savings, payback period, fuel saved, and the page number that contains more information for each measure suggested (Williams, 2006 p.14).

The Worcester report is extremely thorough and comprehensive. In addition to the proposed measures, the plan explains in detail almost every aspect of energy use and emissions. This provides policy makers with a more complete understanding of the issues at hand and allows them to make better informed decisions.

The plan recommends hiring a full-time Energy Manager as the most important measure to reduce energy consumption and emissions. This position will be the guiding force for the

whole plan. The energy manager would be responsible for "...overseeing the implementation of the Plan, ensuring that proper plans are developed before implementing reduction measures, updating the emissions inventory, and writing progress reports"(Carissa Williams, 2006 p.16). This would not only give Worcester a single unified source of energy information, but it would create a position that is responsible for hearing everyone's opinions for energy strategies.

Case Study: Berkeley, CA

Berkeley, California is also a member of ICLEI and followed the 5 Milestone process to develop a Climate Action Plan. Since Berkeley's final draft of the Climate Action Plan was not adopted until 2009, however, it is a little behind Worcester in terms of implementation. Like most ICLEI communities that are in the same situation, Berkeley believes it can always improve the plan and adapt it to the results achieved along the way (City of Berkeley, 2009 p.6).

In revising the various drafts of the Climate Action Plan drafts, Berkeley took the novel approach of allowing citizens to contribute their ideas through various events, workshops, email networks, and community meetings (City of Berkeley, 2009 p.4). The goal of this approach was to both gather input on the current status of the plan, and more importantly, educate the public on what the City is planning and what citizens can do on their own to help lower emissions. The plan includes a section at the beginning that provides tips on what citizens can do in everyday life to reduce their carbon footprint (City of Berkeley, 2009 p.ES6), as well as a later section that provides additional strategies that can be implemented by the public, along with statistics indicating the range of associated impacts on energy and emissions reductions.

Case Study: Falmouth

The Town of Falmouth, Massachusetts has developed a strategy to assist in the implementation of the Falmouth Climate Action Plan. This strategy, titled, "Energy Element 4.4" outlines five action items that need to be accomplished (Falmouth Energy Committee, 2004 p. 8). These items have been prioritized by the town to allow for the successful implementation of energy conservation strategies included in the Falmouth Climate Action Plan. The first action item that is listed under their priorities is the need to hire a town energy coordinator and the importance of having one person who can focus on energy issues

(Falmouth Energy Committee 2004 p. 8). This action item directly describes the work the energy coordinator will be doing by saying, “The Energy Coordinator will facilitate the implementation of Falmouth's Climate Action Plan” (Falmouth Energy Committee, 2004 p. 8). The second action item on their list of priorities is to have the energy coordinator assist in the implementation the Falmouth Climate Action Plan, as mentioned above. The next action item is for the Town Administrator and the Town Accountant to establish an energy fund to pay for the Energy Coordinator and for energy conservation purposes. The fourth action item deals with the importance of educating the public on energy conservation and furthering the knowledge of existing renewable energies. The final action item stresses the importance of making municipal buildings energy efficient (Falmouth Energy Committee 2004 p. 8-9). Together, these items form a distinct method, which can be followed to successfully implement the Falmouth Climate Action Plan.

Priority Setting Approaches

EPA

The Environmental Protection Agency (EPA) developed a set of criteria for local governments to consider when prioritizing energy conservation solutions. The EPA’s criteria contain many issues relating to cost, including economic efficiency, and private and public sector costs and savings (U.S Environmental Protection Agency, 2011). The EPA also advises local governments to consider the potential for GHG emission reductions that each solution might lead to. The EPA states that governments should also consider how the GHG emission savings may be measured, as it is important for the results to be monitored and progress to be shown so that the action will gain public support (U.S Environmental Protection Agency, 2011). EPA guidelines also state that local governments should acknowledge the particular constraints that surround the conservation strategies they wish to implement. These constraints include the city’s ability to enforce each action, as well as the technological, economic, and legal capabilities the city possesses for the implementation of each action (Environmental Protection Agency, 2011). Another important factor to consider when setting energy priorities is the social and political feasibility of each solution. The EPA states that each strategy must be approved by a variety of social and political groups for the strategy to be successful (Environmental

Protection Agency, 2011). Using this set of criteria as a basis for comparison will enable local governments to successfully prioritize different energy conservation solutions. Methodologies that used these criteria have been created by local governments in many areas of the United States, and could provide Nantucket with a model for how to successfully carry out the Nantucket Energy Plan.

International City/County Management Association (ICMA)

The International City/County Management Association released a report titled “Breaking New Ground: Promoting Environmental and Energy Programs in Local Government” detailing case studies of different sites working towards energy conservation and sustainability (Svara, Read, & Moulder, 2011 p. 2). One of the cities that was looked at was Anacortes, Washington, which wrote a GHG inventory and a proposed Climate Action Plan back in 2006 (Svara, Read, & Moulder, 2011 p. 15). This plan gave suggestions as to what energy conservation methods would be easily implementable (Town of Anacortes, 2006, p. 29). These conservation strategies were then organized in a chart near the end of the Climate Action Plan where the different ratings of CO2 emissions, cost and implementation time were clearly presented. Some of the suggested strategies included creating a full time manager position, using B20 biodiesel in garbage trucks, and installing LED exit signs (Town of Anacortes, 2006, p. 36). These three solutions were given a time frame rating of top priority, long term, and short term respectively (Town of Anacortes, 2006, p. 36). This allows the reader to distinguish easily between unrealistic goals and the “low hanging fruit”.

Conclusion

The purpose of the Nantucket Energy Plan is to establish a program for lowering Nantucket’s energy consumption over time. However, the NESC is having difficulty determining what solution would be the best fit for Nantucket. There are many factors that go into a decision of this magnitude including; cost of implementation, operating costs, total energy savings, social and political acceptability, and environmental considerations. A balance must eventually be reached among these variables for the NEP to effectively outline a solution for the Island’s energy crisis. An analysis of all energy saving prospects, along with a clear and easy

to follow methodology for the comparison of each strategy is necessary for the successful completion and implementation of the Nantucket Energy Plan.

Methodology

Goal and Objectives

The goal of this project was to evaluate the NEP and work towards finalizing an operational and acceptable method for setting priorities for the implementation of energy reduction strategies on Nantucket.

The five main objectives that assisted our team in accomplishing our goal were to: 1) Clarify the methods used for selecting and evaluating energy options included Nantucket's Climate Action Plan, 2) Determine the nature of the concerns regarding the NEP and its priority setting methods, 3) Identify and develop alternative methods to determine energy policy priorities, 4) Gather information on the individual energy strategies listed in the NEP, 5) Recommend how the NESC should determine energy priorities in the future.

A set of tasks was associated with each objective, such as setting up interviews, attending pertinent meetings, conducting in-depth research, and analyzing all gathered information.

Interviews

Many of the individuals we interviewed were recommended to us by our project sponsors, based on the individual's knowledge of the pertinent issues. Additional interviewees were chosen based on the recommendations of other interviewees, as a result of the snowball sampling technique we employed in each interview. Prior to each interview, we formed questions that focused on the interviewee's area of expertise, as it applied to our project.

Each interview we performed followed the same basic protocols. All of the interviews were conducted face-to-face. Prior to the interview, we notified the interviewee how many group members would be present. We began all of the interviews by first introducing each member of our group, and briefly discussed our overall project goal. We then asked the interviewee if they would give us permission to quote them in our final report, and to what level of anonymity they wish to uphold. They were also told of their right to review our report before finalization. For many interviews, we proceeded to ask if they would be comfortable if a recording device were to be used to assist in documenting what was discussed. The interview then proceeded by asking the interviewee the questions we had prepared prior to the

interview, which are included in Appendix A. One member of the group acted as the primary conductor of the interview, while the other group members present took notes on the topics discussed. At the end of the interview, the interviewee was asked if they could recommend to us any other individual who might have information that pertained to our project.

Meetings

In addition to conducting interviews, we also attended meetings of the NESC on November 3, 2011 and December 1, 2011, and the town's Wind Energy Forum on November 10, 2011. These meetings informed us of current efforts by the NESC and the town to address various energy issues, including in particular the development of additional wind and solar resources on the Island. They also raised our awareness of many economic, regulatory, political and societal concerns associated with energy policy on Nantucket.

Objective 1: Clarify the Methods Used for Selecting and Evaluating Energy Options in Nantucket's Climate Action Plan

Research for Objective 1

As indicated in the literature review, we conducted a thorough review of ICLEI and the programs it provides to local governments to assist them in creating climate action plans. In our research, we explored the Five Milestones for Sustainability program, as well as many of the software tools ICLEI supplies to help cities complete these milestones. Performing this review of the ICLEI methods enabled us to better understand in theory how Sustainable Nantucket developed Nantucket's Climate Action Plan, now known as the Nantucket Energy Plan. As the project progressed, we found that it was necessary to perform additional research on the methods used by other local governments to implement their climate action and energy plans and set priorities among various conservation strategies. We also explored the guidelines that were created by the EPA to assist local governments in setting energy priorities.

Interviews for Objective 1

To better understand the process used in forming the NEP, we conducted an interview with Michelle Whelan, the director of Sustainable Nantucket, who was responsible for assembling Nantucket's original Climate Action Plan. This interview revealed more clearly how

the NEP was developed and why the ICLEI process was chosen as the basis for the plan. We also learned about the difficulties Sustainable Nantucket encountered when they presented their plan to the Board of Selectmen. The set of questions that were asked during the course of this interview is provided in Appendix A.

Objective 2: Determine the Nature of the Concerns Regarding the NEP and its Priority Setting Methods

Sustainable Nantucket first introduced the Climate Action Plan to the Board of Selectmen and the NESC in 2010. However, the plan sparked a great deal of discussion and received criticism from some members of the NESC and the Board of Selectmen. As a result, the plan was placed under the guidance of the Town of Nantucket's Planning Department, where it has been substantially re-drafted and renamed the Nantucket Energy Plan, but has not yet been approved by the Board of Selectmen.

Fully understanding the reasons behind Board of Selectmen's decision not to approve the NEP involved discussions with key opinion leaders to identify the nature of their concerns regarding the NEP. We began by speaking with two of our project sponsors, Dr. Whiting Willauer and Dr. Peter Morrison. Morrison is a member of the NESC, and Willauer is the current Vice Chairman of the Board of Selectmen and serves on the NESC as well. Speaking with these two individuals gave us a perspective on how the NEP was received by the Board and the NESC, and helped us to identify the main concerns these organizations had with the Plan. We also spoke with H. Flint Ranney, a member of the NESC, and George Aronson, Nantucket's energy consultant, about their views toward the NEP and its shortcomings, as well as how they believe energy priorities should be determined. Additionally, our interview with Michelle Whelan gave us insight into Sustainable Nantucket's opinion of why the Board of Selectmen did not approve the NEP. Speaking with these individuals enabled us to gather many different opinions regarding the information that is necessary for setting energy priorities.

Objective 3: Identify and Develop Alternative Methods to Determine Energy Policy Priorities

Extended Literature Review

After identifying the concerns regarding how energy priorities were set in the NEP, we looked at alternative ways to determine energy policy priorities. In doing so, we researched the protocols designed by ICLEI and the EPA that describe many of the factors that should be taken into consideration when setting energy priorities. We also performed additional research on the methods used by Worcester, Massachusetts, Berkeley, California, and Anacortes, Washington to set energy priorities in their communities.

Interviews for Objective 3

Identifying alternative methods for setting energy policy priorities also involved speaking with individuals who have had prior experience with similar situations. The first individuals that we talked to were experts in the field on the WPI campus. The two main individuals that we interviewed were Professors Robert Krueger and Scott Jiusto. Robert Krueger and Scott Jiusto provided us with valuable information that identified numerous factors that should be taken into consideration when setting priorities.

These interviews provided insights into how the priority setting methods in the NEP could be made more acceptable to the NESC and Board of Selectmen. Additionally, from these interviews and the research we performed on the methods used by other communities, we determined that the Island needed a more transparent, Nantucket-specific account of the advantages and disadvantages of each energy options than was provided by the ICLEI programs.

Objective 4: Gather Information on the Individual Energy Strategies Listed in the NEP

The next step in evaluating the NEP was to examine the individual conservation strategies included in the plan. Due to time and resource constraints, Willauer and Morrison suggested that our team focus on the Transportation and Buildings sections of the plan and not address the part of the plan that deals with renewable energy. Due to time constraints, we could not evaluate every strategy included in the Transportation and Buildings sections. Therefore, we decided to focus on the solutions that our project sponsors and interviewees

deemed most important. We also chose to research strategies that we believed might have a significant impact on Nantucket's energy use. The strategies we chose are listed below in Table 5.

Table 5. Evaluated Energy Reduction Strategies and Their Locations in the NEP

Energy Reduction Strategy	NEP Section
Park and Ride	T.1
Ethanol	T.3
Biodiesel	T.3
Straight Vegetable Oil	T.3
Green Fleet Policy	T.2
Bike Racks	T.13
In-Town Bike Path	T.13
Tire Inflation Pumps	T.6
Rotary	T.1
Mass Save Home Energy Assessment	-
Efficient Lighting	B.1
Programmable Thermostats	B.8
Phantom Loads - Smart Power Strips	B.4
Low Flow Toilets	B.15
Rain Water Collection	B.16
Grey Water Collection	B.16
Energy from Waste	R.11
Composting	B.20
Green Building/LEED Certification	B.13
Luxury Building Mitigation Fund	B.14
Weatherization	B.6
LED Streetlights	B.2

When collecting information on the strategies in these sections of the plan, we found it important to make more specific assessments about the cost and energy savings that each solution would possess if it were implemented on Nantucket. Additionally, we recognized that the priority setting process must require an assessment of the political and social conformity and acceptability of the strategy options in Nantucket. By performing these evaluations and gathering more local information than was presented in the ICLEI models, we were able to

better determine how each strategy might play out in Nantucket. In addition, we hoped to make the tradeoffs of each conservation solution as transparent as possible to decision makers.

To gather this information, we performed in-depth research on each strategy and interviewed members of the community who are knowledgeable about the subject we were investigating. Our project sponsors identified numerous individuals to speak to about various conservation strategies, including Michael Burns, Nantucket's Transportation Planner; Harvey Young, owner of Young's Bicycle Shop; Paula Leary, Administrator of the NRTA; H. Flint Ranney, Nantucket's Representative to the Steamship Authority; Clark Whitcomb, a Nantucket resident; Kara Buzanoski, Director of the Department of Public Works; Brooke Meerbergen, director of Meerbergen Designs; and Mark Voigt, the Administrator for the HDC. From our discussions with these individuals, we were able to gather both quantitative data and anecdotal information regarding specific energy conservation strategies.

Having conducted a more specific analysis of the energy solutions as they might play out in Nantucket, we were better able to see the tradeoffs inherent in setting priorities among different energy options. This enabled us to determine the most viable solutions, and make recommendations to the NESC as to which conservation strategy from the options we researched should be implemented depending on how the NESC and others choose to weigh the various tradeoffs.

Objective 5: Recommend how the NESC should Determine Energy Priorities in the Future

Using the information we gathered throughout the course of this project, we were able to recommend to the NESC particular energy saving strategies that they may want to pursue based on the solution's potential to successfully lower energy consumption on the Island. In addition, we were able to recommend a set of criteria that should be used to effectively evaluate future energy strategies on Nantucket.

Findings and Analysis

By applying our methodology to our research on the Island, we were able to form an analysis of many of the energy conservation strategies that were discussed in the NEP. The first step that we took was to outline the history of the NEP and identify the issues concerning the NEP. Using this information, we were able to create a set of criteria for analyzing the different strategies presented in the NEP. From here, we selected a subset of energy initiatives and thoroughly analyzed their individual costs, energy savings, and their potential for social and political acceptance.

Origins of the Climate Action Plan

The nascence of the Climate Action Plan is important in understanding the content and purpose of the plan and the current issues surrounding it. Michelle Whelan, executive director of Sustainable Nantucket and one of the original people involved in the creation of the plan, gave some insight into the plan's original purpose and why the Board of Selectman rejected it (M. Whelan, personal communication, October 26, 2011). Whelan explained that the idea for the plan came from a volunteer group, comprised of a few people on the island, to help meet the community's need for sustainable energy-related policy and action. Without a previous plan to reference as a starting point, ICLEI was chosen based on the lack of alternatives, and the fact that it coincided with established Massachusetts guidelines which would make Nantucket eligible for state grants. Due to the absence, at the time, of a "comprehensive municipal driven vision" surrounding climate and energy issues, the original group was absorbed by the Sustainable Nantucket organization (M. Whelan, personal communication, October 26, 2011). The Board of Selectman agreed with the idea of the creation of the plan and the decision to choose ICLEI, and cast a unanimous vote of approval (M. Whelan, personal communication, October 26, 2011).

According to Whelan, the original purpose of the plan was to provide a comprehensive menu of ideas to choose from, and to lay the groundwork for the creation of an implementation plan, with the only criterion for inclusion in the "menu" being "is it proven to reduce carbon emissions?" (M. Whelan, personal communication, October 26, 2011). Whitey

Willauer, the Vice Chairman of the Board of Selectman, expected the plan to list the options as Sustainable Nantucket had done, but wanted it geared more towards the unique situation of Nantucket (W. Willauer, personal communication, 2011). The Board of Selectmen was looking more at cost and feasibility of the options in the plan as opposed to emissions (W. Willauer, personal communication, 2011). Whelan said that if the town wrote the plan, the menu of choices could have been narrowed and an implementation plan drafted at that point, but it would have been difficult for an outside consultant to identify the criteria, implementation priorities, and action items of the Town. One of the specific issues that the Board of Selectmen had with the plan was the title of “Climate Action Plan” because there are people who are not convinced about climate change.

Concerns Regarding the NEP and its Priority Setting Methods

In order to successfully set energy priorities among the solutions listed in the NEP, it was important to identify the main concerns that the Board of Selectmen and the members of the NESAC have with the plan. Whiting Willauer and Peter Morrison stated that the Board and the NESAC were skeptical of the ICLEI programs that were used to create the plan. Many individuals believed that the ICLEI programs were too generic and failed to capture Nantucket’s unique energy situation (P. Morrison & W. Willauer, personal communication, 2011). In addition, George Aronson, the energy coordinator for Nantucket, stated that the ICLEI programs used to create Nantucket’s CAP were designed with energy and emissions data from California. Aronson affirmed that since Nantucket and California have vastly different climates and cultures, and receive fuels and electricity from different sources, the exact impact that each conservation solution would have on Nantucket’s energy consumption could not be measured accurately using the ICLEI programs (G. Aronson, personal communication, 2011).

Willauer and Morrison also stated that the NEP was primarily focused on reducing GHG emissions, whereas the Board and the NESAC believed the main goal of the plan was to lower energy consumption and energy related costs (P. Morrison & W. Willauer, personal communication, 2011). Willauer and Morrison also noted that, while all of the solutions in the NEP are viable ways to save energy, not all of them would be effective on Nantucket. They believed that in order for the NEP to be successful in lowering the Island’s energy consumption,

additional research would need to be done on the individual energy solutions in the plan to see how each solution would fit into Nantucket's unique culture (P. Morrison & W. Willauer, personal communication, 2011). More specifically, estimates on various aspects of costs and energy savings should be made to determine whether or not each solution would have a significant impact on the Island. Additionally, Willauer and Morrison stated that qualitative information would need to be gathered from citizens and other knowledgeable individuals to determine if each conservation measure listed in the NEP would be politically and socially feasible (P. Morrison & W. Willauer, personal communication, 2011). By investigating these factors, it will be possible to set priorities among the energy conservation solutions described in the NEP.

Method of Analysis

To quell the concerns of the NESC and the Board of Selectmen, we needed to establish a transparent set of criteria to analyze individual energy saving measures and show how each solution would fit Nantucket specifically. To do so, we evaluated the proposed energy conservation initiatives on their relative cost, energy savings, and social and political acceptability.

In our analysis, we calculated the overall cost of each energy conservation solution to help the town evaluate the economic feasibility of each option. We focused primarily on the implementation and operation costs when researching the expenses associated with each strategy. However, maintenance costs were also taken into consideration for those strategies that would require a lot of upkeep.

We also evaluated the amount of energy that would be saved by implementing each solution. Estimating the amount of energy that would be conserved enabled us to determine the impact that the strategy would have on Nantucket's energy use.

Via interviews with key informants, we collected anecdotal information on the social and political acceptability of the energy conservation solutions in order to gauge its likely effectiveness on the Island. Without the public approval, the energy reduction solution would not be effective in lowering energy use on the Island. In addition, many solutions cannot be

implemented without the approval of the Board of Selectmen, HDC and other departments on the Island. As a result, it was crucial for us to gauge the public and political attitudes toward each solution before we concluded whether or not the strategy could be effective in reducing Nantucket's energy consumption.

We used this method of analysis to evaluate many of the strategies listed in the Transportation and Buildings sections of the NEP. Our team did not address the alternative energy options in the NEP due to time and resource constraints, and because many of these solutions are currently being extensively explored by others on the Island. At the beginning of our analysis of each strategy below, we included the section of the NEP the solution originates from (e.g., T.1), as well as a summary our assessment of the solution's cost, energy savings, and social and political acceptability.

Transportation

Park and Ride (T.1)

Cost: High

Energy Savings: Medium

Social Acceptability: Low

Political Acceptability: Low

The NEP proposed installing a park and ride system to increase NRTA ridership and provide passengers easier access to the Steamship Authority and HyLine Cruise ferries. In January 2010, Tetra Tech Rizzo, an engineering and consulting company, filed a report that explored the possibility of creating this Park and Ride system. Surveys of 2009 ferry passengers, performed by ReMain Nantucket, indicated that between 12 and 39 percent of existing passengers would be interested in a Park and Ride system (Tetra Tech Rizzo, 2010, p. 3). Using the results from this survey and 2008 Steamship Authority and HyLine Cruise passenger data, Tetra Tech Rizzo determined that approximately 53,325 passengers would ride the shuttle from the Park and Ride parking lot to the ferries during the peak season between June 20th and September 6th, while 35,885 passengers would board the shuttle the shoulder seasons between April 20th and June 19th, and September 7th and October 26th (Tetra Tech Rizzo, 2010, p. 16). Tetra Tech Rizzo determined that the parking lot used for the Park and Ride would need at least 208 parking spots to accommodate these passengers. Based on these

calculations, the parking lot at Two Fairgrounds Road was determined to be the best location for the Park and Ride parking lot (Tetra Tech Rizzo, 2010, p. 8).

The report compiled by Tetra Tech Rizzo also highlighted the number of buses that would be necessary to successfully manage the Park and Ride. They determined that the system would need three buses operating between the hours of 5:30 a.m. and 11:00 p.m. and one bus operating from 9:00 a.m. to 8:00 p.m. during the peak summer season. During the shoulder seasons, only three buses operating between 5:30 a.m. and 11:00 p.m. would be required. The shuttles would arrive at the bus stops every 15 minutes (Tetra Tech Rizzo, 2010, p. 15,16).

Energy

From the data in Tetra Tech Rizzo's 2010 report, it is possible to estimate the fuel savings and GHG emissions reductions that would result from the expected participation in the Park and Ride system. Data obtained from the Research and Innovative Technology Administration (RITA), a division of the Bureau of Transportation Statistics, showed that the average 2011 model year passenger car driven in the U.S. had a fuel efficiency 33.7 mpg (Research and Innovative Technology Administration, 2011.). To make our calculations, we assumed that all of the vehicles driven by Park and Ride passengers have this fuel efficiency. The proposed shuttle route for the Park and Ride system is 3.0 miles round trip (Tetra Tech Rizzo, 2010, p. 9). Therefore, we estimated that each passenger would reduce their fuel consumption by approximately 0.089 gallons each time they take they use the Park and Ride. Knowing that a total of 89,210 passengers will ride the Park and Ride shuttle annually, we calculated that a total of 7,942 gallons of gasoline would be saved by using the Park and Ride system instead of driving to and from the ferry. Since the average fuel efficiency of the vehicles driven by the Park and Ride passengers is most likely less than 33.7 mpg, the actual amount of fuel savings should surpass 7,942 gallons. However, these calculations do not account for any excess fuel required for passengers to drive to the parking lot at Two Fairgrounds Road.

Assuming that gasoline costs an average of \$4.00 per gallon, and that 7,942 gallons of gasoline would be saved each year, a combined total of \$31,768 would be saved annually in passenger fuel expenses. Additionally, since each passenger would save 0.089 gallons of

gasoline every time they took the bus to the ferry instead of driving their car, it is calculated that passengers would save \$0.36 in fuel expenses each time they used the Park and Ride system.

Cost

The installation of the Park and Ride system, as described in the 2010 report, would require a significant capital investment. Tetra Tech Rizzo estimates that temporary upgrades to the parking lot at Two Fairgrounds Road to accommodate shuttle passengers would cost approximately \$450,000, while permanent upgrades would cost \$700,000 (Tetra Tech Rizzo, 2010, p. 8). With the addition of the Park and Ride shuttle, the town would also need to purchase new buses. The cost of four diesel-powered buses would be approximately \$908,000 if they were purchased from the International Corporation bus company. The cost of buying four hybrid vehicles from the same company was estimated at \$1,168,000. The price of these vehicles, combined with cost of the temporary upgrades to the Two Fairgrounds Road and improvements to the in-town infrastructure required for the shuttle system, results in an estimated initial capital cost between \$1,404,500 and \$1,664,500 (Tetra Tech Rizzo, 2010, p. 15).

In order to accommodate the number of people that are expected to use the Park and Ride, Tetra Tech Rizzo determined that expenses for operating this system during the peak season would approach \$427,000, and \$493,000 during the shoulder seasons (Tetra Tech Rizzo, 2010, p. 15). Taking into account the fuel, maintenance, insurance, and employment of bus drivers, Tetra Tech Rizzo calculated that the annual operating costs of the Park and Ride would be approximately \$919,500. Consequently, they determined that it would cost passengers \$8.00 per ride during the peak season, and \$13.73 per ride during the shoulder seasons for the shuttle service to function successfully (Tetra Tech Rizzo, 2010, p. 15).

Knowing that passengers would save \$0.36 in fuel expenses by using the Park and Ride, we calculated that the net cost for passengers to ride the bus to the ferries would be approximately \$7.64 per trip during the peak season, and \$13.37 per trip during the shoulder seasons.

Emissions

It is also possible to estimate the CO₂ emission reductions that will result from the implementation of the Park and Ride. The combustion of one gallon of gasoline releases 8.8 kg of CO₂ into the atmosphere (U.S Environmental Protection Agency, n.d.a). Therefore, if 7,942 gallons of gasoline were saved each year with the installation of the Park and Ride, 69,890 kg of CO₂ emissions would be reduced annually. However, this measurement does not account for the CO₂ produced by the four buses, so the actual amount of CO₂ reduced will be less than 69,890 kg.

Acceptability

For the proposed Park and Ride system to be successful, it would have to gain both political and social acceptance. Paula Leary, the administrator of the NRTA, believes the high cost of the Park and Ride will make the current design of the Park and Ride politically and economically impracticable.

Funding and public participation are two main points of controversy surrounding the creation of the new Park and Ride. When the public was originally surveyed about the Park and Ride, they were asked about their participation based on the idea of the Park and Ride alone, were not aware of the costs associated with using the Park and Ride system (Tetra Tech Rizzo, 2010, Appendix B). While the Park and Ride would eliminate much of the hassle passengers go through to find a ride to and from the ferries, the \$8.00 and \$13.73 ticket prices would likely deter ridership. Therefore, the exact number of people riding the bus each year would be fewer than Tetra Tech Rizzo's prediction of 89,210.

Additionally, the behavioral intent of those surveyed likely differs greatly from their actual future actions. It is likely that the actual number of people using the buses would be far lower than the surveys indicate.

Furthermore, many members of the Nantucket community doubt that the Park and Ride would receive much public support. Paula Leary does not believe the Park and Ride system would be utilized to its full potential. When asked about the public's use of the proposed system, she stated, "Here, it's so small that regardless of the traffic downtown, it's so easy to go drop someone off [at the ferry] regardless of what you may have to go through to get there."

She added, “People tend to comment that if I’m in my car, I’m going to keep going” (P. Leary, personal communication, November 3, 2011). Harvey Young, the owner of Young’s Bicycle Shop and a longtime citizen of Nantucket, shares the same opinion. He believes the public would be very reluctant to change their ways unless they were forced to do so (H. Young, personal communication, 2011). Based on these opinions and the high costs associated with the system, we concluded that the Park and Ride system would not gain significant public support, regardless of the modest fuel savings it may produce.

Ethanol (7.3)

Cost: High
Energy Savings: Low

Social Acceptability: Medium
Political Acceptability: Medium

The NEP mentions ethanol as having potential for energy conservation method. Ethanol (an alternative to gasoline) has gained increasing public and political interest. Ethanol is produced from corn or cellulose sources, and is therefore considered a ‘biofuel’.

Cost

Ethanol costs on average \$2.95 a gallon (versus an average of \$3.20 per gallon for gasoline) (e85prices 2011). There are likely few ‘Flex fuel’ cars on Nantucket, however, and it would not be worth shipping ethanol to the Island, unless there was a large fleet of such cars that could use E85 ethanol. Furthermore, fuel retailers would likely oppose to the idea since they would have to purchase an ethanol blending fuel pump (\$70,000 per retail outlet) (Willette, 2011). An ethanol blending pump would be required to distribute fuel and mix at different ratios with gasoline.

Energy

Data from the Clean Air Trust shows that ethanol would not be a good choice as an alternative fuel on Nantucket. The town’s main goal is reducing energy consumption and costs, and ethanol is in fact less efficient than gasoline (Clean Air Trust, 2008). The Clean Air Trust states that, “E100, which is the pure ethanol fuel, only has 70.22 mBtu/gal energy content. This is far less than the 103.94 mBtu/gal energy content that pure gasoline gives, hence using pure gasoline yields more gas mileage” (Clean Air Trust, 2008). E85, which is a blend of 85% ethanol

and 15% gasoline, is also less efficient and produces 20% less energy than pure gasoline (Clean Air Trust 2008).

Emissions

In terms of GHG emissions, an article published by researchers at Iowa State University shows that ethanol would reduce GHG emissions by 11.2 kg per gallon, if one excludes the emissions released as a result of the production of the fuels (Babcock, Rubin, and Feng, 2007). However, if the emissions resulting from the production of the fuel itself are included, the environmental benefit is not as clear cut, although the actual amount of GHG emissions released during fuel production depends on the production methods of the different producers (Babcock, Rubin, and Feng, 2007).

Acceptability

Nantucket residents might hesitate to accept ethanol without further education about its use. According to an article titled *Nantucket gas stations might be selling some bad ethanol*, written by Sebastian Blanco for The Inquirer and Mirror, there was an incident in 2006 that involved damage to engines reportedly due to ethanol (Blanco 2006). As a result, there might still be some resentment towards ethanol.

Biodiesel (T.3)

Cost: High
Energy Savings: Medium

Social Acceptability: High
Political Acceptability: High

Biodiesel was briefly mentioned in the NEP although there were no details about its source on the island. Biodiesel is a plant-based fuel that is made from a form of vegetable oil. Methanol and the base sodium hydroxide (lye or NaOH) are used in a chemical reaction to change the stock oil into biodiesel. The process involves a processor as well as some power to run it. There are two different ways to make biodiesel; the first uses new oil and the second utilizes waste vegetable oil (WVO). Biodiesel does not have to be used at 100% (B100); it can be mixed with regular diesel to create a variety of mixture ratios such as B20, B5, and B2 et cetera. In the case of Nantucket the WVO from the local restaurants could be collected and processed in a small plant. If this is considered economically infeasible or politically and socially

unacceptable, WVO could be purchased off island, although this would likely increase its cost and would do nothing to reduce the amount of waste oil to be disposed of on island..

Energy

The energy content of biodiesel, 121mBtu/gal, exceeds both ethanol and gasoline but is slightly less than diesel (Supple 2007). According to the Clean Air Trust website, "Gas mileage has...to do with how much energy is stored in a particular fuel. The more energy the fuel has, the more gas mileage the fuel offers" (Clean Air Trust 2008). This is the reason why biodiesel will yield a better fuel economy than gasoline. It is very close to the energy content of diesel, which means that there is little difference in the fuel economy.

Emissions

Biodiesel greatly reduces emissions from diesel vehicles whether it is B100 or a lower mixture of biodiesel and diesel. As shown in Table 6, biodiesel has lower emissions than diesel, except for NO_x, and its relative impact is based on the amount of biodiesel mixed with the diesel. The amount of CO₂ produced is 20.84 lb/gal (Local Government Operations Protocol, 2010, p. 204). The CO₂ emissions of biodiesel cannot be thought of in the same way as emissions from diesel, however. The CO₂ that is released in the form of emissions from biodiesel is captured by a living plant source in approximately the same year. Therefore, biodiesel does not increase the overall amount of CO₂ in the atmosphere. However, diesel CO₂ emissions come from fossil fuels that have not been present in the atmosphere for a very long time, so it increases the amount of CO₂ in the atmosphere.

Cost

The costs of biodiesel and its supporting infrastructure depend on the supply method chosen. Obtaining WVO from local restaurants and processing it on the island would be easier than importing biodiesel from an off-island supplier. The first option eliminates the need to ship new unused virgin oil or finished biodiesel over to the island although if it were produced here it would need to be certified or tested to make sure that it meets all the necessary standards. It would also use a waste that would otherwise need to be disposed of in an environmentally safe fashion. Both might cut down on cost. If biodiesel were produced on island, the cost of shipping methanol and lye to the island would need to be considered.

Table 6. Biodiesel Emissions Data

Emission Type	Emission	B100	B20
Regulated	Total Unburned Hydrocarbons	-67%	-20%
	Carbon Monoxide	-48%	-12%
	Particulate	-47%	-12%
	NOx	+10%	+2% to -2%
Non-regulated	Sulfates	-100%	-20%
	PAH (Polycyclic Aromatic Hydrocarbons)	-80%	-13%
	nPAH (nitrated PAH's)	-90%	-50%
	Ozone potential of speciated HC	-50%	-10%

(Biodiesel.org, 2011)

In terms of putting a total cost to each option it is hard to say without doing significant research on each one. A small 4,000 gallon a year biodiesel plant using WVO on island might cost \$10,000 total capital investment according to Ontario Ministry of Agriculture, Food, and Rural Affairs website (Ontario Ministry of Agriculture, Food, and Rural Affairs, 2011). Assuming that 40 restaurants on the island produce a minimum of 10 gallons of WVO a week each during the summer (May through October⁵) would produce enough WVO (9600 gallons) to allow the plant to run at its designed capacity although these are very provisional numbers that require

⁵ Biodiesel is generally only used between these times due to gelling in cold weather.

further refinement. The biofuel from WVO would cost approximately the same as regular diesel fuel per gallon on the island.

If biodiesel were shipped in from an off-island supplier, the cost might be close to the price of diesel⁶. Biodiesel might end up being lower on Nantucket with the lack of competition in WVO collection due to its island nature, the lack of transportation (except for the small percentage of methanol and lye) compared to diesel, and the elimination of current WVO disposal costs.

Dylan Wallace, a local resident who uses WVO directly in his work truck, notes that currently the WVO is considered hazardous waste and is shipped off island for disposal (D. Wallace, personal communication, November 11, 2011). Another plant example is Northeast Biodiesel LLC in Greenfield, Massachusetts, which plans on producing, “1.75 million gallons of recycled vegetable oil biodiesel with an expansion to 5 million within a few years” (Northeast Biodiesel, n.d). The Northeast Biodiesel website explains how they are “investing \$2.5 million in the facility and we will hire 13 staff to operate the plant” (Northeast Biodiesel, n.d).

Acceptability

Biodiesel appears to be acceptable to Nantucketers, judging from those with whom we have spoken. Wallace said that, “biodiesel would be best for getting on the pump for the public/diesel community as a whole” (D. Wallace, personal communication, November 11, 2011). Paula Leary from the NRTA would utilize biodiesel in the NRTA buses if the biodiesel came from a reliable source (P. Leary, personal communication 2011). She liked the benefits of better lubricity with biodiesel and the possibility of mixing the biodiesel in different proportions. She said that the mixing was a big factor because if for some reason the biodiesel supply stopped the buses could simply return to using diesel; she said that she would most likely use the B20 ratio if she were to use biodiesel (P. Leary, personal communication 2011). Kara Buzanoski, the director of the Department of Public Works (DPW) said that she would not be opposed to using biodiesel in DPW fleet vehicles (K. Buzanoski, personal communication,

⁶ This is exemplified by the Burke Oil-Irving gas station in Chelsea Massachusetts, which currently sells biodiesel at \$3.86 per gallon while the cost of diesel is \$3.85 per gallon (Burke Oil).

November 29, 2011). She said that approximately half of the DPW fleet vehicles currently run on diesel, so they would be able to use biodiesel fuel.

Straight Vegetable Oil (T.3)

Cost: High

Energy Savings: Medium

Social Acceptability: High

Political Acceptability: High

An alternative to biodiesel but still dependent on WVO is straight vegetable oil (SVO). This involves filtering WVO to be used directly in a vehicle with a preheating system installed in each vehicle. The oil needs to be heated to lower the viscosity, which then allows it to easily pass through the fuel system as normal diesel would. Although this would eliminate most of the processing the preheating system would need to be installed on each vehicle as opposed to biodiesel which can be used in any diesel vehicle without modification. SVO vehicles need to start on diesel to get warmed up. With short distance trips this is not efficient because the WVO would only be used for a small percentage of the travel time. Because fleet vehicles tend to run for long periods of time SVO is a better option. Due to this difference SVO might have an advantage in fleet vehicles over biodiesel.

Cost

The cost of an SVO conversion system varies from vehicle to vehicle and ranges from \$1,130 for car kits to \$2,900 for truck kits (Greasecar Vegetable Fuel Systems 2010). Justin Carven from Greasecar said that a kit for a bigger vehicle, such as a garbage truck, might cost upwards of \$6000 per vehicle (J. Carven, personal communication, November 21, 2011). In addition to the cost of the kit there is an additional cost of approximately \$1000 for the filtration system (Greasecar Vegetable Fuel Systems, 2010). Mr. Wallace uses WVO in his work truck and paid \$900 for the conversion kit and \$800 for the filtration system (D. Wallace, personal communication, November 11, 2011). In terms of maintenance and operation costs, Wallace says that it costs \$30 in filters every year, \$40 in fuel lines every 5 years not including labor, and the WVO is free (D. Wallace, personal communication, November 11, 2011). To him this means a savings of \$480-\$576 a year when the fuel price is at \$4.80 per gallon and a usage of 100-120 gallons per year (D. Wallace, personal communication, November 11, 2011).

Energy

The energy content of vegetable oil is slightly different than biodiesel or diesel at 0.12 MMBTU/gal (Local Government Operations Protocol, 2010, p. 204). Although slightly lower than biodiesel it should not significantly affect the fuel economy. Wallace estimates his 81 Toyota Pick-up SR5 averages about 28-35 mpg and the restaurant owners who use WVO in their 1980 Mercedes 123 Wagon average about 25-30 mpg (D. Wallace, personal communication, November 11, 2011).

Emissions

The amount of CO₂ per gallon of vegetable created would be 21.59 lb/gal. Burning vegetable oil would fall into the same exception that biodiesel falls under in terms of CO₂ emissions. There would not be an overall increase in CO₂ emissions in the atmosphere.

Acceptability

There seems to be a little interest in using WVO on Nantucket. Wallace expressed interest in having more people using SVO on the island. He said, "SVO would be best used in the vehicles that are idling all day (shuttle buses & trash trucks) because the oil runs best when the engine is warmed up" (D. Wallace, personal communication, November 11, 2011). As far as we can tell, Wallace and the restaurant owners are the only people currently using WVO as fuel on the island.

Green Fleet Policy (T.2)

Cost: Medium

Energy Savings: Low

Social Acceptability: Medium

Political Acceptability: Medium

A section of the NEP dealt with Green Fleet Policy. It is located in a part of the Green Communities Act that specifically deals with the implementation of a green fleet for municipal purposes, excluding large trucks or buses (Mass.gov, 2011). This guide outlines the criteria for a Green Fleet with as-of-right siting, expedited permitting, energy baseline/20% reduction plan, purchase only fuel efficient vehicles, and minimize life-cycle cost (Mass.gov, 2011). Nantucket would not currently fulfill the requirements of the Green Communities Act by the 20% reduction plan alone, but it would be a good idea to try to meet the requirements at some

point in the future. Currently the Nantucket Energy Plan has a goal of a 10% reduction of GHG emissions by 2020 (Town of Nantucket, 2011, p. 8).

Cost

Although there would be an initial cost of buying new fuel efficient vehicles, Nantucket would gain access to Green Communities Grants if the other areas of the Green Communities Policy were fulfilled. The grant requirements specify that the grants would need to be applied to further energy efficiency efforts. This funding could help Nantucket lower energy consumption in future years.

Emissions

One of the criteria of the Green Communities Act lists the acceptable mpg ratings for different sizes of vehicles that would need to be purchased in order to be considered a Green Fleet (Mass.gov, 2011). According to the Bureau of Transportation Statistics, the average mpg rating of a passenger car is 33.7 mpg (Research and Innovative Technology Administration, 2011). This is much higher than the 29 mpg rating required by Green Fleet Policy (Mass.gov, 2011). The difference in mpg ratings is similar for trucks as well. Although this is a minimum, it shows that the Green Fleet Policy is not a good method of reducing emissions. It might be better for Nantucket to create a policy for fleets based on its own unique situation.

Acceptability

While implementing the green fleet policy will not save the town a lot of money on fuel or significantly reduce the GHG emissions produced by municipal vehicles, the potential funding from the Green Communities Act might make this a politically feasible option. However, the high cost of purchasing these vehicles would lower both the political and social acceptability of this action.

Bike Racks (7.13)

Cost: Low
Energy Savings: Low

Social Acceptability: High
Political Acceptability: High

The NEP suggested setting up a fund to purchase and maintain public bike racks for riders to park their bikes. During the peak tourism season, bike parking is disorganized,

clustered, aesthetic unappealing, and in short supply in many areas, which discourages people from taking their bikes into town. Lack of bike parking discourages people from riding their bikes to stores, schools, town buildings, beaches, and ferry terminals. As a result, people might drive their cars into town instead, which causes increased energy use and GHG emissions production.

The NEP and other advocates, expect that bike racks would be placed in a variety of destinations including the downtown area, schools, town buildings, beaches, ferry terminals and at key locations on popular bike paths. It would be relatively easy for the town to identify key locations for bike racks based on the observations and experiences of residents, town employees, and local businesses.

Cost

The cost of purchasing, installing and maintaining bike racks can differ depending on the type of bike rack purchased. Harvey Young, the owner of Young's bicycle shop, stated that he might be able to supply bike racks to the town at a reasonably low price. A popular bike rack choice is the inverted U type bike rack, which holds 2 bikes. Its purchasing and installation price ranges from \$150-\$300 per rack, but the price might vary slightly depending on the location chosen (University of North Carolina Highway Safety Research Center, 2011). Additional expenses would come from shipping the racks over to the Island. The cost of maintenance for each bike rack is very low, and some bike racks require little to no maintenance. However, due to Nantucket being a coastal island, sea air can cause racks to need to be replaced somewhat more frequently than normal.

Energy and Emissions

Although the total emission and energy reductions from bike racks are difficult to calculate, it is expected that any efforts to enhance the ease of using bikes will have numerous positive impacts including reduced vehicle use and congestion and therefore reduced energy consumption and emissions, as well as other benefits, such as better health.

Acceptability

The general acceptability of this idea would likely be high. The HDC would prefer the bike racks to be wooden in order to fit in with the Nantucket's style, but other than that they seem very supportive of the idea. Along with encouraging people to choose a bike over a car, sufficient public bike racks and proper bike locks could lower bicycle theft. The actual placement of the racks in the downtown area is a source of concern, since that some of the sidewalks are already quite narrow and the addition of bikes and bike racks would make passage more difficult. This problem could most likely be addressed by careful selection of the optimal installation sites.

In-Town Bike Path (T.13)

Cost: High

Energy Savings: Low

Social Acceptability: High

Political Acceptability: Medium

An additional strategy described in the NEP for lowering energy consumption is to encourage people to ride their bicycle rather than drive their car. The designs for a number of bike paths have been proposed in order to make Nantucket more bike-friendly. (Nantucket Planning and Economic Development Commission, 2011, p. 6-77 – 6-88). The installation of an in-town bike path is likely the most effective proposal in this regard. The design for this path, as described in the 2012 Nantucket Regional Transportation Plan, involves creating a bike path to connect the Downtown Core District to the Milestone Rotary. This path would involve “a shared use path along the railroad right of way, and a system of 5 foot wide sidewalks and 4-foot wide bike lanes along Washington Street and Orange Street,” as shown in Figure 3 (Nantucket Planning and Economic Development Commission, 2011, p. 6-78).

Cost

The Nantucket Planning and Economic Development Commission (NP&EDC) has estimated that the installation of the proposed in-town bike path would cost a total of \$1,627,000. The NP&EDC estimated that it would cost \$161,000 to design the path, and \$1,466,000 to construct it.

Energy and Emissions

While concrete numbers are difficult to determine, the construction of an in-town bike path would certainly conserve energy and advance GHG reduction efforts. An in-town bike path would persuade many people to ride their bikes into the downtown area instead of drive their cars. This would result in a small decrease both fuel consumption and the emissions that are produced as a result of driving into town. Additionally, the bike path would lower the amount of energy consumed as a result of the congestion and idling that occurs in the town during the peak tourist seasons.



(Nantucket Planning and Economic Development Commission, 2011, p. 6-78)

Acceptability

The exact reduction of depends largely on the number of people who use the bike path. Harvey Young reports that the most frequent complain he hears in his bike shop is that the town needs better biking infrastructure downtown (H. Young, personal communication, 2011). The town's crowded streets, especially during peak tourism seasons, can make biking a hazardous activity, which deters people from riding their bikes. Paula Leary, noted that many visitors to the Island comment on how difficult it is to access many of the bike paths from the ferries and the downtown area (P. Leary, personal communication, November 3, 2011). For these reasons, it can be inferred an in-town bike path that would increase safety and accessibility in the downtown area would be highly acceptable to the public.

While the in-town bike path is a socially acceptable measure for reducing energy consumption, the plan for its construction is apolitically contested issue. Some organizations, including ReMain Nantucket, are pushing for its construction. The idea of a downtown bike path is discussed in ReMain Nantucket's 2008 report titled *Nantucket Massachusetts, Planning Downtown's Future*. ReMain Nantucket states that, "Downtown and Mid-island need stronger connections. Presently, bicycles, cars, trucks, and pedestrians face numerous real and perceived barriers when moving between the two areas. These barriers must be understood and removed to enable the two areas to become distinct but mutually supportive. The proposed bike path connecting downtown and Mid- Island needs to be constructed." (Urban Land Institute, 2008, p. 16) However, the process involved with constructing the bike path makes it difficult to gain political approval. According to Joe Magni, the principal of VHB, the consulting company working on this project, the town would need to acquire a number of permits, perform tidal flushing, and carry out invasive plant removal studies before construction on the bike path could begin (Graziadei, 2011). Therefore, although many individuals and organizations are lobbying for the creation of an in-town bike path, the complex process the town must go through to obtain permits and receive funding this project makes it challenging to acquire political support.

Mark Voigt, the HDC administrator, believed the HDC would support the creation of a bike path in the downtown area, as long as the signage along the path was kept to a minimum

and would not detract from the historic look of the town (M. Voigt, personal communication, November 17, 2011).

Tire Inflation Pumps (T.6)

Cost: Low
Energy Savings: Low

Social Acceptability: High
Political Acceptability: High

A further energy conservation feature described in the NEP deals with proper tire inflation. According to the U.S Department of Energy, drivers can improve the gas mileage of their cars by as much as 3.3% by properly inflating their tires (U.S Department of Energy, 2011, November 22). For example, a car that drove 25 miles on one gallon of gas with under-inflated tires would be able to drive 25.82 miles, or 3% farther, with properly inflated tires. This increased mileage would help drivers save money on fuel and prolong tire life for additional savings.

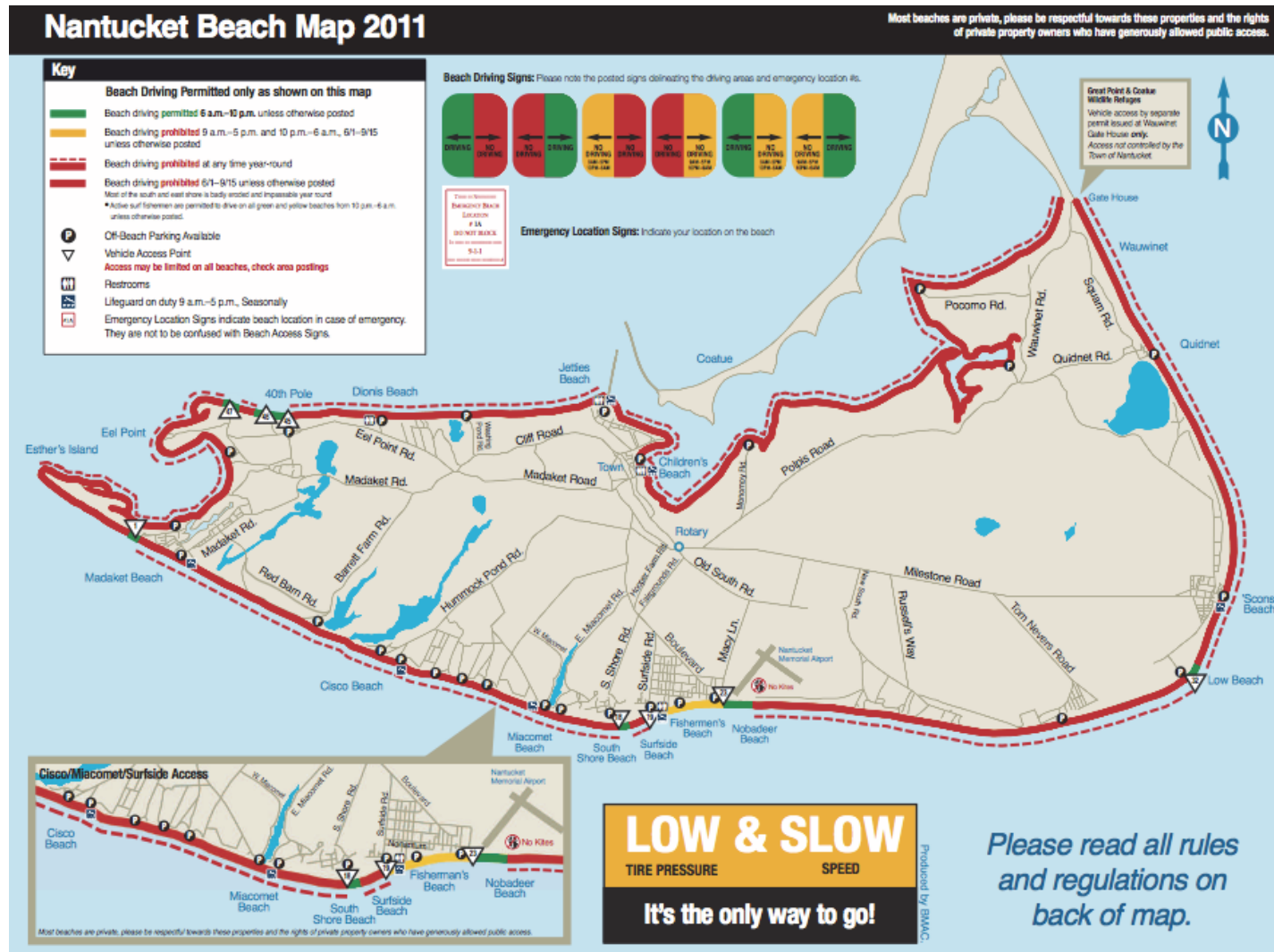
The issue of tire inflation is especially pertinent on Nantucket, as people are allowed to drive their cars on designated areas of the beach if they obtain a permit from the town. The town requires that drivers decrease their tire pressure to between 12 and 15 p.s.i before driving on the beach (Town of Nantucket, 2011b). However, drivers often fail to re-inflate their tires to the proper pressure after driving on the beach, which decreases the fuel efficiency of the vehicle.

Currently, the town permits vehicles to drive year-round on portions of 6 beaches, as shown below in Figure 4. Installing air pumps at these locations would encourage drivers to re-inflate their tires immediately after exiting the beach.

Cost

The installation and operation of these air machines would cost the town little to no money. By charging a small fee to drivers to use the air pump, the company Air Serv, one of the leading air machine manufacturers, would install, operate, and maintain the air pumps at no cost to the town. (Air-serv Group LLC, 2010). The town would also be able to generate revenue through the contract that allows the air pump company to install their pumps on the town property.

Figure 4: 2011 Nantucket Beaches with Vehicle Access



(Town of Nantucket, 2011b)

Energy and Emissions

By increasing their gas mileage, drivers would be reducing their vehicle's GHG emissions. However, the exact GHG emission reduction numbers are difficult to determine, as emission values vary depending on the vehicle and the number of miles the car would have driven with under-inflated tires if the air pumps had not been provided at the beach.

Acceptability

Installing air pumps at these locations would most likely be a politically feasible solution, since the installation and operation of the pumps would not cost the town money. Additionally, Mark Voigt does not believe the HDC would be opposed to installing air pumps at beach access points (Mark Voigt, personal communication, November 18, 2011). This would also be a socially acceptable action, as it would make it easier for car owners to refill their tires and reduce their fuel consumption. It is expected that many drivers will re-inflate their tires at these air pump stations, seeing as they will have to re-inflate their tires at some point anyway. While some people may be discouraged from using the pumps if they had to pay a small fee for the air, many others would most likely continue to use the pumps due to their convenient locations. However, to increase usage, the town could set up advertising posters at the air pumps that describe the benefits of properly inflated tires.

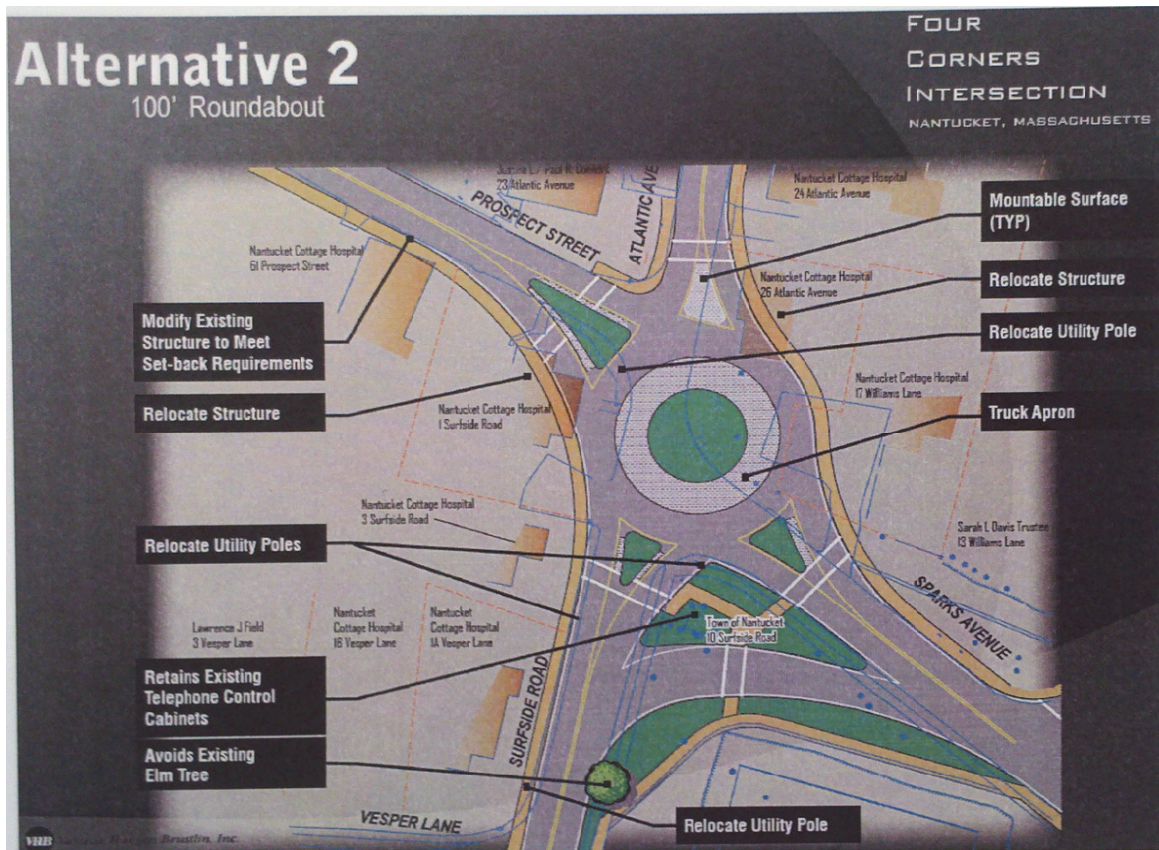
Rotary (T.1)

Cost: High
Energy Savings: Medium

Social Acceptability: Medium
Political Acceptability: Low

The NEP suggests reconstructing high-traffic intersections to reduce congestion and improve safety for pedestrians and bicyclists. One of the intersections suggested for possible action is the intersection at Sparks Avenue, Atlantic Avenue, Prospect Street, and Surfside Road, also known as the Four Corners intersection, as shown below in Figure 5. This intersection is extremely congested in the peak tourism season, causing large backups and contributing to a significant amount of vehicle idling time and fuel consumption.

Figure 5. Plans for Reconfiguring the Four Corners Intersection



(Nantucket Planning and Economic Development Commission, 2011, p. 4-50)

Currently this four-way intersection has stop signs at all four involved roads. A major concern is that Prospect Street and Sparks Avenue are not aligned with each other. Vanasse Hangen Brustlin, Inc. (VHB) was retained by the Board of Selectman to evaluate the intersection, and develop and analyze design alternatives (Magni, Hayes, Thompson, 2008). A draft report prepared by VHB in 2008 shows the expected benefits that could be achieved from constructing a roundabout at this intersection. According to T. Michael Burns, Nantucket's Transportation Planner, a design for the installation of a roundabout has been initiated and demonstrates a possible reduction the traffic congestion (T. M. Burns, personal communication, 2011).

Cost

The Nantucket Regional Transportation Plan estimates the initial cost of construction for implementing this design would range from \$690,000-\$990,000 (Nantucket Planning and

Economic Development Commission, 2011, p. 4-50). However, additional potential costs will have to be taken into account.⁷ Annual maintenance costs for the rotary shouldn't be much different than normal road maintenance costs, so annual costs wouldn't be a major factor.

Energy and Emissions

The emissions savings from this project would come from the reduction of vehicle idling when the intersection is congested. Based on data collected from the intersection, and models provided by MassDOT, the total emission reductions are estimated to be around 60,000kg of CO₂. The emissions reduction was converted to BTU savings using a fuel emissions conversion table, which shows a total energy savings of over 854 million BTU. The total fuel saving would be around 6,800 gallons, and if the cost of gas is \$4.50 then the total fuel savings would be over \$30,000 a year.

Acceptability

Many of our interviewees felt it would be a good idea to improve the intersection. However, with regards to the rotary design proposed there is a multitude of opposing views within the town. According to Paula Leary, the NRTA director, the idea of reducing traffic at that intersection is very appealing, but unfortunately it has been a very controversial issue with several groups concerned about pedestrian safety (Paula Leary, personal communication, November 3, 2011).

Nantucket's 2005 Mid-Island Area Traffic Study flags the Four Corners intersection as a critical intersection, though due to factors including heavy pedestrian activity, proximity to the high school, the need for crossing guards, and the amount of land takings required, a rotary at this intersection is considered as "not a viable option"(Greenman-Pedersen, Inc., 2005, p. 106). Some groups might still hold this opinion, but a further investigation might ascertain whether this still holds ground in light of subsequent findings.

⁷ The plan states that two buildings would need to be relocated, one porch needs to be removed, and four utility poles will also need to be relocated, therefore some of those costs will need to be investigated further.

Buildings

The second section of the NEP we explored dealt with conservation strategies that could be employed to decrease energy consumption in municipal and residential buildings on the Island.

Mass Save Home Energy Assessment

Cost: Low
Energy Savings: High

Social Acceptability: High
Political Acceptability: High

The residential sector accounts for much of Nantucket's energy consumption. According to the Greenhouse Gas Emissions Inventory, approximately 30% of the Island's energy is used to meet residential heating and electric needs (Sustainable Nantucket, 2009, p. 9).

One way residents can lower their energy consumption is to request for a Home Energy Assessment provided by Mass Save. Mass Save is an organization sponsored by numerous Massachusetts energy companies, including National Grid, which focuses on reducing the energy use of businesses and residences statewide (Mass Save, 2011a). To assist residents in lowering their energy consumption, Mass Save will send a certified energy specialist to a home upon request to perform a free Home Energy Assessment. As part of the assessment, the energy specialist will inspect a home and identify the areas that could be made more energy efficient. The specialist will inspect the home's thermal layer, mechanical systems, lighting, and electronics, and identify the areas where energy could be saved (Mass Save, 2011b). Following the inspection, the resident will be given Home Energy Assessment Report listing the long term and short term actions that could be taken to increase the home's energy efficiency (Mass Save, 2011b). This service is available to both homeowners and renters.

Clark Whitcomb, a Nantucket resident, had a Home Energy Assessment performed on his house in September 2011. Whitcomb said the Mass Save energy specialist walked through his home and carefully inspected his windows, insulation, appliances, and lighting (C. Whitcomb, personal communication, November 9, 2011). At the end of the inspection, Whitcomb was given a report describing numerous actions that could lower his energy consumption. Whitcomb said the report highlighted the approximate costs of each energy

saving measure. Additionally, the energy specialist replaced 38 incandescent light bulbs with compact fluorescent light bulbs (CFLs). The specialist also gave him three programmable thermostats and three energy efficient showerheads. Whitcomb said these supplies, worth approximately \$500 combined, were given to him for free. He also received a rebate form for \$150 off the purchase of an Energy Star refrigerator, as well as a form for \$50 off the cost of removing of his old refrigerator. Whitcomb said he would strongly recommend Mass Save Home Energy Assessments to all Nantucket residents, as the appointments for the assessments are easy to schedule, and the assessment is a simple way to save money and energy.

Cost

The Home Energy Assessment provided by Mass Save is a free service. By having this service performed, homeowners are also eligible for rebates on energy efficient heating equipment, Energy Star refrigerators, advanced power strips, and the installation of insulation and other weatherization practices. (Mass Save, 2011b). Following a Home Energy Assessment, the resident may also qualify for 0% financing on loans that go toward the installation of qualifying energy efficient measures such as Energy Star window replacements and solar hot water systems (Mass Save, 2011d).

Acceptability

According to a 2005 Survey performed for Mass Save by Nexus Market Research, Inc., 88% of the people who had a Home Energy Assessment were satisfied with the results, with 76% being either very satisfied or extremely satisfied (Nexus Market Research Inc, 2005, p.22). Additionally, 61% of the people surveyed said that the Mass Save Home Energy Assessment influenced future decisions they made to make their home more energy efficient (Nexus Market Research Inc., 2005, p. 29). As this survey shows, the process taken by the energy inspector and the results given by the Home Energy Assessment are generally viewed as beneficial. In addition, the high cost of energy on Nantucket may persuade many residents to seek a Home Energy Assessment for their home. For these reasons, we can conclude that Home Energy Assessments would be well received by many Nantucket residents. The promotion of Home Energy Assessments would also be accepted politically, since lowering

residential electricity consumption would diminish the need for a third submarine electrical cable to be run from the mainland to the Island.

Awareness

To help lower residential energy use on the Island, the town will have to raise awareness about the Home Energy Assessment. An organization called Next Step Living has attempted to promote the Mass Save Home Energy Assessments in various towns across Massachusetts. To promote the Mass Save programs, Next Step Living encourages local governments to email outreach messages to their communities, informing them of the free energy assessments (Hirsh, 2011). Next Step Living also stresses the need to emphasize in the email that incentives and rebates that are given after the assessment, as well as the fact that the assessments are free of cost (Hirsh, 2011). Nantucket may want to adopt an outreach program such as this to raise interest in Home Energy Assessments. In addition, educating high school students about the energy assessments could help to raise awareness among families that reside on the Island. Lauren Sinatra, Nantucket's Energy Project and Outreach Coordinator, is currently working with National Grid to enhance awareness of this program and to improve the scheduling of audits with Island residents. Clark Whitcomb also suggested that the town should promote Home Energy Assessments by airing commercials on local television stations and printing articles in various newspapers. Whitcomb also stressed that it was important for the Town Manager and the Board of Selectmen to promote Mass Save, as it would raise awareness and give credibility to the Home Energy Assessments. He also anticipated that National Grid would help the town promote Mass Save, because conserving residential energy use would prevent National Grid from having to build a new power plant to fulfill energy demands (C. Whitcomb, personal communication, November 9, 2011).

Using the Mass Save program would allow residents to receive free or discounted energy efficient light bulbs, programmable thermostats, and smart power strips, as described in more detail below.

Energy Efficient Lighting (B.1)

Cost: Low

Energy Savings: Medium

Social Acceptability: Medium

Political Acceptability: High

Another strategy included in the NEP for lowering residential energy consumption is to switch to energy efficient lighting. The most widely available form of energy efficient residential lighting is the compact fluorescent light bulb (CFL). CFLs are cost and energy saving alternatives to incandescent light bulbs that are recommended for use in open air light fixtures, which include table lamps, floor lamps, wall sconces, pendants, and open ceiling fixtures (U.S Department of Energy, 2006, p. 4).

Energy

Replacing incandescent light bulbs with CFLs is an easy way for homeowners to save energy. According to a Consumer Reports a 60-watt incandescent bulb will have an average lifespan of 1,000 hours, while an Energy Star approved 13-watt CFL will last an average of 10,000 hours while emitting the same amount of light as an incandescent bulb (Janeway, 2010). Therefore, it can be calculated that a CFL will use a total of 130 kWh of electricity during the bulb's lifespan. Comparatively, one incandescent bulb will use 60 kWh during its lifespan. However, since an incandescent bulb lasts only 1,000 hours, 10 incandescent light bulbs would be needed to emit light for the same amount of time as one CFL. Combined, these 10 bulbs would use a total of 600 kWh of electricity, which is 470 kWh more than the CFL. According to the EPA, the average American house contains approximately 30 light fixtures (U.S Environmental Protection Agency, n.d.b.). As a result, residents would save approximately 14,100 kWh of electricity if every incandescent bulb in a house were replaced with a CFL.

Cost and Savings

Nantucket residents could realize substantial savings by decreasing the amount of electricity needed to light their homes. In 2010, the average cost of electricity on the Island was 18.4 cents per kWh (Beliveau, Hesler, Jaskolka, & Sigety, 2010, p. 19). As a result, it costs Nantucket residents approximately \$11.04 to power one incandescent light bulb over its 1,000 hour lifespan, and \$110.40 to power 10 bulbs. On the contrary, it would only cost \$23.92 for

residents to produce the same amount of light using a CFL that lasts 10,000 hours. At Nantucket's Marine Home Center, a Westinghouse Bright White Mini Twist 13-watt CFL costs \$4.89 (Marine Home Center, 2011a). Comparatively, one 60-watt Westinghouse Inside Frosted incandescent bulb costs approximately \$0.50, and 10 bulbs cost \$5.00 (Marine Home Center, 2011b). Taking into consideration the cost of the light bulbs, Nantucket residents would pay \$115.40 to get 10,000 hours of light from incandescent light bulbs, and \$28.81 to get the same amount of light from one CFL bulb. Over the lifespan of the bulb, this results in a total savings of as much as \$86.59 for each incandescent bulb that is replaced with a CFL. If the 30 light fixtures in each home were replaced with CFL bulbs, residents would save approximately \$2,597.70 in lighting expenses during the bulb's expected 10,000-hour lifespan.

According to the EPA, a light bulb is used 3 hours per day on average in a typical American home (U.S Environmental Protection Agency, n.d.c). Therefore, a CFL that lasts 10,000 hours would have a lifespan of about 9.13 years. As a result, if the savings produced by replacing one incandescent bulb with a CFL amount to \$86.59 during the duration of the bulb, a resident would save \$9.48 per year, or \$0.79 per month. However, if 30 incandescent bulbs were replaced, the resident would save \$284.40 per year, or \$23.70 each month.

Acceptability

In order for energy efficient lighting to noticeably reduce Nantucket's energy use, the town must persuade the public to replace their incandescent light bulbs with CFLs. This could be a difficult task, considering there are many current issues with CFLs. Many people dislike the quality of light CFLs produce. While Energy Star rated bulbs are designed to produce the same amount of light, many people find that, despite recent efforts to improve light quality, the light emitted by CFLs is "cooler" and more off-putting than incandescent bulbs (Audubon, 2009). Additionally, many consumers are finding that CFLs do not last for 10,000 hours, contrary to advertising. As previously mentioned, CFLs are only designed for use in certain light fixtures. In a New York Times article titled "Do New Bulbs Save Energy if They Don't Work?" author Leora Broydo Vestel stated that, "Using the bulbs incorrectly, such as by screwing low-end bulbs into fixtures where heat is prone to build up, can greatly shorten their lives" (Vestel, 2009). When speaking with Clark Whitcomb, he mentioned that some people may be opposed to changing

their lighting because of the fact that CFLs take longer to reach full brightness than incandescent bulbs (C. Whitcomb, personal communication, November 9, 2011). The disposal of CFLs is another issue that dissuades people from purchasing energy efficient light bulbs. Since CFLs contain mercury, they have to be recycled and cannot be disposed of in traditional means. Additionally, Nantucket is a rather affluent community and many people who reside on the Island during the summer months may not be concerned with saving money or electricity. On the other hand, there is often a higher level of awareness and concern about environmental issues among more educated, affluent homeowners. Therefore, it remains unclear how many Nantucket residents might be willing to change their light bulbs.

However, the idea of switching to CFLs may appeal to many of the Island's less-wealthy, permanent residents who are disproportionately affected by Nantucket's high electricity prices since they pay for electricity all year round and often have less disposal income than summer residents. The energy savings that result from replacing incandescent bulbs with CFLs are very high if the bulbs last for their expected 10,000 hours. Even if the CFLs only last 5,000 hours, residents would still save approximately \$142.20 on annual lighting expenses. This financial benefit is high enough to persuade some residents to change their lighting sources. Additionally, residents would be more easily persuaded if they receive the bulbs for free through the Mass Save Program or similar programs offered by the town.

Awareness

To encourage residents to replace their incandescent bulbs, the town would need to raise awareness of the financial benefits and energy savings that result from switching to CFLs. The town could promote CFLs by advertising in newspapers and on local television stations. The town may also want to use public funds to purchase CFLs and hold CFL giveaway days to encourage residents to replace their incandescent bulbs. CFL recycling stations should also be formed at various points around the Island, to make it easier for residents to properly dispose of their old light bulbs.

Programmable Thermostats (B.8)

Cost: Low

Energy Savings: Medium

Social Acceptability: Medium

Political Acceptability: Medium

The NEP suggests that the town install programmable thermostats in residential and municipal buildings around the Island. Programmable thermostats, unlike manual thermostats, can be set to automatically begin heating or cooling the building at designated times throughout the day (U.S Department of Energy, 2011). These thermostats are designed to give people greater control over their heating and cooling systems, enabling people to save money by eliminating unnecessary energy use.

Energy

According to the U.S Department of Energy, homes and businesses can reduce their energy consumption by 10% by turning the thermostat back 10° – 15°F for eight hours each day (U.S Department of Energy, 2011). Programmable thermostats would be particularly effective in municipal buildings, as many office buildings are only in use during the workday. Installing these thermostats in town buildings would make it possible to automatically control the temperature of the building during working hours, and turn down the heating or cooling systems in the buildings when the workday concludes. As described in the NEP, the Town of Nantucket spends, on average, a total of \$429,016 on light fuel oil per year (Town of Nantucket, 2011a, p. 24). Reducing energy consumption by 10% by switching from a manual thermostat to a programmable thermostat could save the town as much as \$42,000 annually (Town of Nantucket, 2011a, p. 24).

Programmable thermostats, when used properly, could also help Nantucket residents save money. The EPA estimates that residents could save as much as \$180 per year by replacing their manual thermostats with programmable thermostats (U.S Environmental Protection Agency, n.d.d.). The exact energy savings that could result from using programmable thermostats depends on the particular heating and cooling systems of the

home, the temperature the thermostat is set to, and how the resident programs the thermostat.

However, many recent studies have been performed that questioned the energy savings created by programmable thermostats. A 2009 study by Florida Power and Light showed that people with programmable thermostats tended to set their thermostats to a lower temperature during warm weather than residents with a manual thermostat, and as a result, actually increased their energy consumption by 12% due to excessive air conditioning (Roth, 2011). Another study, performed by RLW Analytics for GasNetworks in 2007, showed that programmable thermostats lowered a home's annual natural gas consumption by an average of only 6.2% (Roth, 2011). In fact, in 2008, the EPA removed its Energy Star label from programmable thermostats because it could not conclusively prove that the thermostats saved a significant amount of energy (DiClerico, 2011). As this data shows, the exact energy savings that will result from the installation of programmable thermostats on Nantucket greatly depends on how people use them.

Cost

The cost of purchasing a programmable thermostat ranges from \$30 to \$200, depending on the specific model. However, a resident who participates in a Home Energy Assessment can receive programmable thermostats from Mass Save for free.

Acceptability

Given the uncertain potential energy savings from installing programmable thermostats, the town might hesitate to invest in services to promote these thermostats to Nantucket residents. Instead, many town officials would probably view it as more beneficial to use town funds promote proven energy saving techniques such as switching to CFLs. On the contrary, installing these thermostats in municipal buildings would be a politically acceptable solution, as the town would be able to set regulations for the heating and cooling systems to ensure that energy is being conserved.

In addition, it is likely that programmable thermostats would receive a mixed reception from the public. It is expected that many homeowners would be drawn to these thermostats

because they would have increased control over their heating and cooling systems. Not only does this give residents the opportunity to save money, but it allows them to program their systems to power down and conserve energy for a set amount of time while they're not in the house, but turn on again to heat or cool the house to the desired temperature before they return home. However, many residents may be opposed to installing programmable thermostats due to the level of difficulty in operating these systems. According to Consumer Reports, many people have difficulty programming their thermostats and 50% of the surveyed homes had thermostats that were set to "long-term hold", which "basically overrides any pre-programmed temperature adjustments" (DiClerico, 2011). Due to these factors, it can be concluded that programmable thermostats would be welcomed by some residents to help them save money and energy, while many others would not want to transition away from their manual thermostat. Thermostats that are more easily programmed, or are preprogrammed for the consumer by a technician, might be a future solution to this conundrum.⁸

Phantom Loads – Smart Strips (B.4)

Cost: Low

Energy Savings: Medium

Social Acceptability: High

Political Acceptability: High

As discussed in the NEP, standby power, otherwise known as phantom loads, is responsible for a substantial and growing portion of residential and municipal electricity consumption. Phantom loads are defined as the electricity used by a device when it is turned off or in standby mode (Town of Nantucket, 2011, p. 22). According to SmartPower, an energy efficiency marketing organization, televisions, DVD players, printers, MP3 players, computers, cable boxes, cell phone chargers, and game monitors are the biggest users of standby power (SmartPower, 2009). One way to combat these phantom loads is to use a smart power strip, known simply as smart strips. Smart strips are power strips that automatically turn off electronic devices when they are not in use, and eliminate the power supply to those appliances that go into standby mode. Smart strips can be programmed to turn off and on certain devices at specific times throughout the day (Reliant Energy Retail Holdings LLC, 2011).

⁸ Progress has recently been made to make programmable thermostats more user-friendly, as noted in the New York Times article "Home Thermostats, Wallflowers No More" (Manjoo, 2011).

They also allow devices to be connected to one another, so that when one device is turned off, additional devices also power down (Town of Nantucket, 2011, p. 22).

Energy

In 2009, McKinsey Global Energy and Materials performed a study titled “Unlocking Energy Efficiency in the U.S Economy,” which determined that phantom loads are responsible for 6 to 8 percent of residential electricity use (McKinsey Global Energy and Materials, 2009, p. 49). SmartPower calculated that a television uses approximately 31.39 kWh of standby power, while a computer uses an average of 13.87 kWh in standby power throughout the course of a year (SmartPower, 2009). If residents purchased a smart strip to eliminate these two phantom loads, assuming the 2010 price of electricity of 18.4 cents per kWh, they would save approximately \$8.33 in one year. However, if more appliances were connected to smart strips, the savings would be even greater. As with programmable thermostats, the amount of energy saved by converting to smart strips depends on how they are used by residents.

Smart strips can also be used in office buildings. Frequently, many appliances, such as computers, printers and copiers, are not turned off overnight because they take too much time to power on the following morning. Smart strips would allow these devices to be put on a timer, so that they would be shut down overnight, but could power on before the workers arrive in the morning (Reliant Energy Retail Holdings LLC, 2011). Using smart strips in this manner would help the town reduce its electricity consumption in municipal buildings.

Cost

The cost to purchase a smart strip ranges from \$18 to \$60, depending on the model and manufacturer (Bits Limited, n.d.). However, residents are eligible for rebates on smart strips if they participate in a Home Energy Assessment (Mass Save, 2011c).

Acceptability

Since smart strips are relatively inexpensive items that can help save electricity and money, purchasing smart strips with town funds for use in municipal buildings would not receive much opposition from the public. In addition, many Nantucket residents would most likely use smart strips in their homes if they were made aware of the electrical and monetary

savings that result from their use. The promotion of smart strips would also be accepted politically, as it would defer the need to install a third submarine electrical cable to the Island.

Awareness

As with energy efficient lighting and Home Energy Assessments, the town would need to promote the use of smart strips to raise awareness about their energy saving capabilities.

Along with advertising in local newspapers and television stations, the town may want to consider purchasing a few smart strips and testing their energy saving capabilities in a town building. By doing this, the town could provide the public with first-hand information on the usability and the efficiency of the smart strips. Additionally, the town could make bulk purchases of smart strips with town funds and hold giveaway days to encourage residents to use smart strips in their homes.

Low Flow Toilets (B.15)

Cost: Medium
Energy Savings: Low

Social Acceptability: High
Political Acceptability: High

The buildings subdivision of the NEP mentions installation of low flow toilets as a way to decrease energy use by requiring less pumping of water. Replacing the old toilets with low flow toilets when remodeling or renovating is not a problem. According to the “Low Flow Toilets” page on the Massachusetts Water Resources Authority website, “The Massachusetts State Plumbing Code requires that all new or replacement installations of two-piece tank-type and floor-mounted flushometer toilets use no more than 1.6 gallons per flush. These toilets are called low-flow, low-consumption or low-flush” (Massachusetts Water Resources Authority, 2011). Some form of education might be effective in getting people to replace their old toilets with low flow ones whether they are remodeling or not.

Cost

A replacement toilet is more of an investment than simply replacing light bulbs or changing power strips. The Home Depot is currently selling their cheapest low flow toilet for \$88 (The Home Depot, 2011). The company “National Builder Supply” is currently selling their cheapest low flow toilet for \$150 (National Builder Supply, 2009). The U.S. Department of

Energy website has an Energy Cost Calculator for Urinals which estimates an approximate \$50 and 10,920 gallons savings per year if a toilet is switched to a low flow toilet (U.S. Department of Energy, 2010). This would mean that it would take about two years to pay off the cost of the new toilet.

Energy

The water supply is a major user of energy. “The U.S. Water Supply and Distribution” study by the University of Michigan states that, “Groundwater supply from public sources requires 1,824 kilowatt-hours per million gallons [0.001824 kilowatt-hours per gallon]” (Center for Sustainable Systems, 2010). This means that the 10,920 gallon per year saving from the example in the toilet calculator would mean a 19.92 kilowatt-hour saving in electricity per year per toilet.

Emissions

From the “eGRID2010 Version 1.1 Year 2007 Summary Tables” on the EPA website it is shown that the New England eGRID sub region creates 1,236.14 lb/MWh of CO₂ (U.S. Environmental Protection Agency, 2011). By converting this to lb/kWh and multiplying by the amount of electricity saved, the amount of CO₂ saved is found to be 24.62 lbs of CO₂ per year.

Acceptability

Acceptability would be pretty high based on the Massachusetts code by itself. In terms of people taking the initiative to replace their toilets without having to do remodeling, acceptability would depend on the education about the cost savings of installing a low flow toilet.

Rain Water Collection (B.16)

Cost: Medium
Energy Savings: Low

Social Acceptability: Low
Political Acceptability: Low

Rain Water Collection is closely related to Low Flow Toilets in the NEP. Collected rain water in barrels from the down spouts on buildings is an effective way to reduce the use of water outside in applications such as lawn care, gardens, and car washing. The reason why the

use of the rain water is focused on outdoor use is to avoid any concern about the aquifer.

Some are concerned that if rain water is collected and put into the sewer system as opposed to getting absorbed into the ground the aquifer might be affected. The roof of a building is an effective surface for collecting rain water. As the “Nantucket Energy Plan” specifies, “If the Building Department building (a roughly 58’x52’ building) were to harvest its rainwater, an annual average of 78,917 gallons of water per year could be harvested” (Town of Nantucket, 2011, p. 26-27). This water will then be transported by pipes to other surrounding locations or stored in barrels at the facility. If the pressure caused by the height of the barrels transports the water, there would be no need for electricity to run pumps.

Energy

With the elimination of pumping there will ultimately be a reduction in energy use. According the “Water Sense” page on the EPA website, “An American family of four can use 400 gallons of water per day, and about 30 percent of that is devoted to outdoor uses” (Water Sense). This means that 120 gallons of water is used outside per day and therefore 43,800 gallons used per year. If this is multiplied by the amount of electricity used per gallon of water from the low flow toilet section, the amount of electricity used per year on outdoor water use is approximately 79.89 kWh per year. From the example it can be calculated using the 0.001824 kilowatt-hours per gallon number that 78,917 gallons of water equates to saving 143.94 kWh per year.

Cost

From the energy section above it can be determined that, using residential rates from the Smart Grid IQP for one house hold, the savings in electricity per year would be approximately \$26.50. Because the savings would be at the water facility as opposed to the residential site, the savings can be multiplied by the number of houses using the system. If say, 1,000 houses were to use this system, the water facility might see a savings of about \$26,500 per year.

Emissions

Based on the amount of electricity used per year on outdoor water use, the amount of CO2 emissions produced can be calculated from the eGRID Summary on the EPA website. The amount of CO2 would then be 98.76 lb of CO2 per year.

Acceptability

The acceptability of rain water collection systems is entirely based on the regulations of the HDC, the cost of the system, and any changes in the way they use their water. This kind of system would most likely get implemented through the initiative of a home or business owner.

Gray Water Collection (B.16)

Cost: Medium
Energy Savings: Low

Social Acceptability: Low
Political Acceptability: Low

In the NEP, Gray Water Collection is grouped with Rain Water Collection; now it is broken into two different categories. Gray water collection is the collection of water that was used once in showers, tubs, or washing machines. The gray water can be used to flush toilets to reduce the overall water consumption of a house.

Energy

The energy savings in this case would be the amount of electricity used to pump water to your toilets. For the toilet chosen in the Energy Cost Calculator for Urinals, this amount would be 22.76 kilowatt-hours per year. Although some electricity might be used in pumping the gray water after it is created (although gravity should be utilized where possible) the system should still save money on water bills and it will take some of the load off of the water supply company.

Cost

The Green Building Supply website has information on a gray water system called BRAC (Green Building Supply 2010). According to the website a gray water system would not cost more than \$3000 (Green Building Supply 2010). In terms of installation the website says, "The system integrates seamlessly into your existing plumbing system" (Green Building Supply 2010).

In terms of savings in energy, the 22.76 kilowatt-hours per year, at the rate of 18.4 cents per kWh, would mean a dollar amount savings of \$4.19 per year for one toilet.

Emissions

Using the emission data from the EPA in the low flow toilet section, the amount of CO₂ that is saved by using the gray water system is 28.13 lbs per year of CO₂ (U.S Environmental Protection Agency, 2011).

Acceptability

Although this solution will most likely save both energy and money, the acceptability might not be very high. This is due to two main reasons: the regulations of the HDC regarding the visibility of any outdoor apparatus, and the cost of installing the system.

Energy from Waste (R.11)

Cost: High

Energy Savings: High

Social Acceptability: Low

Political Acceptability: Medium

Although Energy-from-waste is mentioned in the renewable energy part of the NEP and not the Efficient Waste Management category of Buildings, it is closely related to it and therefore included. Gasification is the only option for EfW on Nantucket because there are restrictions against having smokestacks on the Island (G. Tivnan, personal communication, December 7, 2011). The website Gasification Technologies Council explains that “[gasification] is a manufacturing process that converts any material containing carbon—such as coal, petroleum coke (petcoke), or biomass—into synthesis gas (syngas). The syngas can be burned to produce electricity” (What is Gasification, 2011). This method of gasification can be applied to waste disposal by using the waste as the feedstock and converting the syngas to electricity (Waste Gasification, 2011). This website also differentiates gasification and incineration; gasification converts the waste to a gas which can then be used to power generators while incineration burns the waste to directly generate electricity (Waste Gasification, 2011).

Cost

Nantucket would have to do a more detailed assessment of the size and nature of the plant to derive meaningful cost data. Waste Options Inc. on Nantucket might not have to compost the waste stream, but there would still be a need to handle the recycling on the Island. Further research would need to be done to see what can be gasified based on the system that would work on Nantucket. This means that the entire waste stream might not be able to be gasified.

Energy

Because MSW is made of many different materials, the energy content of MSW can only be calculated as an average of the individual energy contents of the materials it contains. The company Ze-gen, which operated a gasification incineration plant in New Bedford, Massachusetts, states that 1 ton of solid waste is equal to 600 kWh (Home, 2011). Although the plant “suffered from operational failures requiring it to be shut down,” the Island can learn from their experiences to ensure that the same mistakes are not made on Nantucket (Ciplet, 2009, p. 13). In addition, although this plant is technically an incineration plant, the energy that can be obtained from the waste is relatively the same as gasification. The Massachusetts government website published an “Active Landfills” document that reports Nantucket’s annual tons of waste to be 2,138 tons per year (Active Landfills, 2011 p. 3). Using these two numbers, we calculated that approximately 1.3 million kWh could be produced per year on Nantucket.

Emissions

The emissions production of the gasification plant would be entirely based on the system used to convert the syngas to electricity. Further research would need to be done to determine that conversion. One point that does need to be considered in an emissions estimate is that amount of electricity that the landfill will save by not running the composter.

Acceptability

The draft of the NEP states that, “While popular in Europe, trash-to-energy plants have met resistance in the U.S.” (Town of Nantucket 2011 p. 32). Given the size of and controversy surrounding trash to energy plants, this would most likely not be an acceptable short term

solution to the trash and energy issues on Nantucket. It would require further research into the technology in order to be implemented in the future. The time frame would be much longer than any current project such as the potential wind turbine at the landfill. Gasification on Nantucket might get a better reception with further education about the benefits and emissions reduced through its use. Given Nantucket's unique situation of higher energy cost and of waste removal being difficult due an inability to cheaply move waste off the island, a trash to energy facility might be a long term solution that needs further exploration. There appears to be some interest in EfW on the island right now. Kara Buzanoski, the manager of the DPW, said that the landfill is currently storing waste from mining the landfill that could be used in an EfW plant in the future (K. Buzanoski, personal communication, November 29, 2011).

Composting (B.20)

Cost: Medium

Energy Savings: Medium

Social Acceptability: Medium

Political Acceptability: Medium

Currently

Presently, the Nantucket landfill is run by Waste Options Inc., which utilizes a composting digester to help counter the harmful gases created by putting compostable materials in a landfill (The Nantucket Story, 2002). This approach solves some of the major problems with waste management on the island such as bringing Nantucket's recycling rate to 90% and restoring contaminated wetland surrounding the landfill (The Nantucket Story, 2002). Although this solution is working and very beneficial to Nantucket, it still requires a great deal of electricity to compost the waste material.

Solutions

The only way to have less waste is to create less waste. The "Composting" page on the EPA website states that, "Yard trimmings and food residuals together constitute 26 percent of the US municipal solid waste stream" (U.S Environmental Protection Agency, 2011). The 26% of waste is the waste that can be composted locally but instead gets sent to the dump (U.S Environmental Protection Agency, 2011). One way to do this is to start small localized or on-site compost bins that do not require any electricity. The EPA gives instructions on their "Create Your Own Compost Pile" page on how to start simple compost set-ups with a bin either indoors

or outdoors (U.S Environmental Protection Agency, 2011). These localized compost systems would not require electricity and would decrease the amount of waste at the dump. The bins would be about the same cost and size as a trash bin. They could be placed at municipal buildings and education about them could be used to get private businesses and homes to adopt them.

Cost

In terms of the cost of the bins themselves The Home Depot is currently selling a simple compost bin for \$109 (The Home Depot, 2011). The cost of electricity on Nantucket is 18.4 cents/kWh from the “Feasibility of a Smart Grid on Nantucket” IQP (Beliveau, Hesler, Jaskolka, Sigety, 2010 p. 3). At this rate the amount of money that could be saved by composting the 26% of compostable waste at home as opposed to at the dump would be \$69,837 per year⁹.

Energy

According to the National Grid Summary Statistics the landfill used 1,459,804 kWh in 2011 (National Grid, 2011). If 26% of this energy use were to be eliminated, assuming that the reduction in waste is proportional to the potential reduction in energy, 379,549 kWh would be saved by composting locally at on-site locations.

Emissions

By using the estimated amount of electricity saved per year, assuming the 26% of composting is done at home, 469,175.70 lbs of CO₂ will be saved per year.

Acceptability

Through education and incentives private composting might have a medium acceptability by both public and government sectors. Nantucket is already the leading community in recycling in Massachusetts, which might make for an easier transition into decentralized composting. Although this would most likely not work to 100% of its potential, any amount would be beneficial to the waste disposal system as a whole.

⁹ This would assume that every one composts the entire 26% of compostable trash, including renters and homeowners with limited yard space.

Green Building Practices/LEED Certification (B.13)

Cost: High
Energy Savings: Medium

Social Acceptability: Low
Political Acceptability: Low

The U.S. Green Building Council is a non-profit organization focused on trying to make a more sustainable future through cost-efficient and energy-saving methods for builders when constructing or renovating structures. According to the U.S. Green Building Council's website, buildings are responsible for about two fifths of CO2 emissions and electrical usage in the United States (U.S. Green Building Council, 2011). The organization's main tool is their LEED, or Leadership in Energy and Environmental Design, program. The LEED program is a certification system in which buildings can get LEED certified if they are considered to be sustainable in several areas including water efficiency, energy usage, and building materials used (U.S. Green Building Council, 2011). Having a LEED certification is not only a symbol showing environmental awareness, but might also qualify people for tax rebates. Mostly LEED applies to new building but there are some case studies of LEED being used for renovations of existing buildings

The NEP suggests that Nantucket support education of this program and maybe offer some incentive for becoming LEED certified, for instance offering expedited permit processing, or lower building fees.

Costs/Energy Savings

The cost to the town to implement this strategy would be very low but would vary on what actions were taken and what buildings were involved in the program. The profit from this program comes mainly from the total energy usage reduction, which means a lower energy bill. Some case studies on buildings that were involved with the LEED program show around a 20-30% energy cost savings while some buildings were as high as 40%and higher, energy reduction.

One of the buildings that were renovated was the California EPA Headquarters Building in Sacramento, California. The initial investment for renovations was \$500,000, and after all improvements had been made the annual savings total slightly over \$600,000 total. With almost 35% more energy efficiency, equaling close to \$400,000 saved annually on energy for

the building. These numbers will definitely not be reproduced in every building that follows the program on Nantucket, but it shows that major changes can be seen from a building that is already somewhat environmentally friendly (U.S. Green Building Council, 2011). This building is much larger than anything that would ever be built on Nantucket but the percent energy saved can give an idea as to what it can do.

Acceptability

Public acceptability of this passing this idea would most likely be low. The appealing aspects behind this idea are that it is a voluntary option for the public, it could reduce emissions, and it could save them money. Unfortunately, getting people to actually participate in the program would be difficult considering that it would require a lot of paperwork to get certified and they would have to make a large personal initial monetary investment, which will discourage many from taking part. Also, during an interview with Mark Voigt of the HDC, he mentioned that he feels that the LEED program does not give enough credits toward the aspect of conserving building materials, since he considers the use of new materials in construction to be a large use of energy (M. Voigt, personal communication, November 17, 2011).

Political acceptability for using LEED on municipal buildings would be most likely be low acceptability until a bit more research has been done focusing on case studies that are more related to Nantucket. With regards to political acceptability for the mere education of the program for the public, there should be no major objections but it might not be very effective.

It is worth noting though that current energy codes have many of LEED's building goals as a requirement for new homes and renovations. This might either encourage people since it makes meeting LEED requirements a bit easier, or it would discourage people since their house is already decently efficient making it seem not worth the extra effort.

Luxury Building Mitigation Fund (B.14)

Cost: Low
Energy Savings: Medium

Social Acceptability: Low
Political Acceptability: Medium

To raise money for the town and to encourage sustainable energy practices, the NEP suggests setting up a luxury building mitigation fund program. This program would focus on

setting up a fee that is targeted towards high end houses with the goal of reducing their energy usage.

The city of Aspen, Colorado has a program similar to the Luxury Building Mitigation Fund, called the Renewable Energy Mitigation Program. This program is designed to ensure that individuals who are in the process of getting a building permit, obtain 50% of their exterior energy use from renewable energy sources. Exterior energy usage applies to exterior snowmelt units, spas, and swimming pools. If renewable energy does not account for 50% of this energy, the individual would have to pay a fine to the city (Aspen REMP, 2001). On top of that, there is another fee that would be applied to houses if they did not contain a small on site renewable energy source.

The NEP looked at what Aspen did in their Renewable Energy Mitigation Program and tweaked it a bit to come up with an example of what the Luxury Building Mitigation Fund could be. This program would require certain buildings over a set size to generate 20% of the total amount of its energy use through renewable energy sources (Town of Nantucket, 2011, p. 26). If buildings do not meet the requirement, then they would pay a fee that would go directly into the fund and be used for other energy conservation options.

Cost

The cost for the town would be very low considering that the only expenses would be the normal legal expenses of setting up a new policy, creating the paperwork for the permits, and educating municipal workers and building contractors about the new policy. Actual income for the town would depend on how many houses are built each year on Nantucket that would choose to pay the fee over the installation of a renewable energy source.

The cost of this plan would fall mainly on the future home owners or anyone planning on renovating their house significantly on Nantucket. The fees suggested in the NEP from Aspen's program were \$5,000 for a non-complying house that is over 5,000 square feet and \$10,000 for a house over 10,000 square feet. In the first year that Aspen had this program in action, the town accumulated about \$500,000 for the fund (Aspen REMP, 2001). If Aspen, with a population of around 6,000, were to be compared to the island of Nantucket, that has a

population of double that during the off season, then potential funds that could be generated might be around \$1,000,000.

Energy and Emissions

The actual amount of energy and emissions saved from this program is hard to say since it all depends on how many new houses would be influenced to choose renewable energy sources over a fine and how much 20% of the total energy use for each new house actually is.

Acceptability

This plan would probably have a low public acceptability and a medium political acceptability. Public acceptability would most likely be low due to both the price of homes being high enough already and the part about being forced to have a device on their property that they might not want to have. Since Nantucket has a strong sense of historical presence, the renewable energy sources would have to be strategically designed and placed to minimize visual impact. Also, if the house is located in the downtown Historic District, they would have even more restrictions on what type of renewable energy can be used and where it can be put. There is no primary benefit to the individuals who are subject to the fee. Political acceptability is rated as a medium because there are benefits to the town from this plan but there would also be significant opposition from those who do not support renewable energy.

Weatherization (B.6)

Cost: Low
Energy Savings: High

Social Acceptability: Medium
Political Acceptability: High

Heating and cooling is the largest source of energy usage in residential homes, accounting for over half of the energy used in a household (Town of Nantucket, 2011, p. 23). Weatherization as proposed in the NEP holds considerable promise for reducing residential energy usage. Weatherization programs are designed to look at a house's ability to insulate against the outside and find ways of improving areas that are found to be poorly insulated. This includes looking at the insulation built into the house to see if more should be added, looking around doors and windows to find gaps that can be filled, and sometimes looking for inefficient appliances that can be replaced (Town of Nantucket 2011, pg 23). This would be mainly focused

on “homes built between 1940 and 1990 due to ‘relaxed’ energy standards” (B. Meerbergen, personal communication, November 15, 2011). Houses built or renovated recently are required to meet current energy standards. This requires the structure to be hyper insulated; therefore it should already be properly weatherized.

The NEP suggests that educating the public about energy saving programs that can help them save money might convince some homeowners to take advantage of these programs. The plan mentioned possibly having a lecture where the public is invited to learn about how weatherization can save them money, as well as talk to experts in the field (Town of Nantucket 2011, pg 23).

Added Insulation

Regarding insulation that is physically added to the structure, common techniques, according to Brook Meerbergen, of Meerbergen Designs include: close cell urethane foam, icynene open cell foam, and new batt insulation, which all require a gut renovation and are either blown in or applied from the interior (B. Meerbergen, personal communication, November 15, 2011). Without a gut renovation cellulose insulation can be blown in through the exterior (B. Meerbergen, personal communication, November 15, 2011). According to Meerbergen, close cell polyurethane is beneficial due not only to its high insulation rating but also its ability to act as a structural reinforcement (B. Meerbergen, personal communication, November 15, 2011). When working with older homes cellulose is the preferred choice since it can suppress termites, pests, and fire while at the same time is not too tight which can cause problems, such as mold, in older houses (B. Meerbergen, personal communication, November 15, 2011).

Windows and Doors

When focusing on weatherizing windows and doors, a few techniques are available but they can be limited based on the location of the house on Nantucket. Houses that are located inside of the historic downtown district are restricted by the HDC on what type of windows can be used. These houses will therefore have low emissivity storm windows installed, to retain a historical feeling. Houses located outside of the historic downtown district have the option of

choosing insulated glass over storm windows, but when considering the insulation performance of the two different methods, they differ very little (B. Meerbergen, personal communication, November 15, 2011). A technique for which Nantucket's location is not a hindrance, is insulating around jambs and interior trims. Caulking is commonly used to fill cracks in most houses to prevent drafts and heat loss. Unfortunately, Nantucket's coastal environment causes caulking to deteriorate rapidly, so it is not an effective option.

Cost

The overall cost to the town for this strategy would be very small. The actual price varies depending on how the town would choose to proceed with educating the public and if a weatherization lecture is established, as well as the chosen experts that would attend. Although some money could be saved by the town from using a weatherization program on municipal buildings, most of the money would be saved by the citizens when they weatherize their homes. According to the NEP these savings could be as high as 10-20% of their energy costs (Town of Nantucket, 2011, p. 23). When looking at a report done for the Department of Energy in 1997, estimates for the amount of energy saved nationally from weatherization was averaging over 20% (Linda Berry, 1997, pg xii). This could be much higher taking into account improved insulating techniques that have become available within the past 14 years since the study was published. This percent could also be lower if previous weatherization steps had already been taken in certain households. If a house spends an average of \$250/month on electricity, and an average of \$400/month on heating fuel costs, then they might see as much as \$1,500 a year in energy cost savings.

There are programs that could help some families that might not be able to afford to pay for renovations. One of the programs that should be looked into is the Mass Weatherization Assistance Program which helps low-income owners to lower their energy bills, which services over 6.4 million households, and saves over \$430 per year on energy bills (U.S. Department of Energy, Energy Efficiency & Renewable Energy, 2011). This program won't be able to cover the cost of major weatherization renovations but what it does cover will still reduce the energy bill.

Energy and Emissions

Since heating mainly uses fossil fuels and cooling mainly uses electricity, there should be a reduction in emissions as well as a reduction in the electrical energy used by each household. Since determining the actual amount of energy saved from weatherization is extremely difficult, using rough estimates it is possible to get only a basic idea of the potential energy saved. The estimate would be using the estimated residential heating emissions from the NEP of 71,946 Tons of CO₂e and the estimate of 20% energy saved from weatherization (Town of Nantucket 2011, pg 7), as well as factoring in a rough estimate, by Brook Meerbergen, of 30%-40% of the homes on the Island might be eligible (B. Meerbergen, personal communication, November 15, 2011). Based on these assumptions the total emissions savings could range from 4,300 to 5,800 tons of CO₂e saved a year, and an expected energy savings of 6% to 8% off of total energy used for all of Nantucket's residential housing. The real savings could be much higher depending on the current level of insulation for the targeted houses.

Example House for Windows

In a study for the Center of ReSource Conservation, the comparison between replacing old historic windows and retrofitting them in different ways was studied. For testing purposes, an old house with four windows was selected and a laboratory model house was built to be used in testing. Using Boston's weather conditions, a gas cost of \$1.51/therm, and a electricity cost of \$0.17/kWh to heat and cool a house with old double hung windows had an annual cost of \$915. When old double hung windows were combined with a new efficient wooden framed storm window the annual cost dropped to \$109 (Larry Kinney & Amy Ellsworth, 2011). According to this study, the cost of retrofitting the windows with new efficient storm windows could cost around \$10,000. Comparing that with a total savings of about \$800 a year, the payback period could be around 12 years (Kinney & Ellsworth, 2011).

Acceptability

The political and public acceptability of this strategy should be high. Politically there is very little cost associated with the implementation and it is completely voluntary on the citizen's part. Acceptability for the public might be more complicated considering a major

renovation can be expensive for those who don't qualify for the Mass Weatherization Assistance Program. Taking into account the large savings, however, this is rated medium to high for public acceptability. The HDC should be consulted before decisions are made about weatherizing a house on Nantucket, however, since some methods are discouraged the HDC can suggest ways of saving energy without taking away from the historic look of the house.

LED Streetlights (B.2)

Cost: Medium

Energy Savings: Medium

Social Acceptability: Medium

Political Acceptability: Medium

Using LEDs for the town's street lights instead of other less efficient lights is another strategy that was suggested in the NEP. Although Nantucket has no traffic lights, which has been the most common use of LEDs regarding roads, Nantucket does have streetlights, which can be replaced with more efficient LEDs. One of the benefits of LEDs over the current streetlight is that the current streetlights contain harmful chemicals and can be more difficult to dispose of.

On Nantucket, streetlights are maintained and powered through National Grid. The town has a contract in which they are charged a fixed rate for each streetlight depending on the type of light installed.

Cost

Since streetlights are based on National Grid's Street Lighting Service, Nantucket is charged a rate for the type of high pressure sodium bulb, plus an additional pole charge, for each active streetlight. The two common types of HPS bulbs are 70 and 100 watts, for which the annual rate would be \$28.85 and \$31.26 respectively plus a \$49.94 charge for the pole (King, 2010). Presently, no rate change has been established for the use of LED streetlights. If the rate charge were to stay the same for LEDs, there would be no financial gain from switching to LEDs (King, 2010). If rate changes become available through negotiations then any savings would be determined by the new rates charged.

Energy and Emissions

When comparing HPS streetlights with LED lights that are commonly used to replace them, there are a significant energy savings, but studies show it is not as simple as comparing one LED to one HPS. A report in the National Lighting Product Information Program, at Rensselaer Polytechnic Institute, showed that in order to pass lighting recommendations there would need to be twice as many LED lights per mile than HPS lights (Radetsky, 2010, p.5). Even with this adjustment the study shows, LED's tend to used anywhere from 1%-10% less power than HPS lights. Estimates for streetlight energy usage are around 80,000kWh per year on Nantucket, so providing sufficient lighting using LEDs can save up to 8,000kWh per year, which is equivalent to saving a month's worth of energy for streetlights.

Acceptability

The public acceptability of LED streetlights is rated as a medium. It was ranked this way because many people like the idea of LED streetlights but only if it can provide a decent amount of light and does not impede on the historic feel of the town. There are also those opposed to LED's and like the current lights. The political acceptability is rated as medium due to no financial incentive associated with the change being available at this time, but with successful future negotiations, there could be a reasonable incentive of converting. If rates change and agreements are made in the future, political acceptability would rise.

LED and HPS bulbs produce about the same lumens per watt, though LEDs are usually able to provide better lighting with fewer lumens than HPSs. This is because HPS bulbs produce a yellow light that provides lower contrast than the light that LEDs produce. Therefore LED bulbs that produce fewer lumens can provide the same quality of light, while using less energy in the process (My LED Lighting Guide 2011). On Nantucket, there is an urge for a historic feel throughout the town and from an interview with Mark Voigt, the warm yellow glow of current street lights is a preferred light than normal LEDs (M. Voigt, personal communication, November 17, 2011). It is unclear whether LEDs would be able to be altered so that they emit a hue of light similar to HPS bulbs, and what effect it would have on energy savings.

Conclusions and Recommendations

Based on our selective analysis of proposed energy conservation solutions described in the NEP, we have identified the strategies that would be most beneficial to Nantucket. Additionally, we can recommend a method that the NESC can use to evaluate energy reduction options in the future.

Conclusions

From our research, we were able to make many conclusions regarding the NEP and the effect it might have on Nantucket's energy use. An investigation of Nantucket's unique energy situation revealed that the consumption and cost of energy on Nantucket is a significant concern that is likely to become more critical in future years as the summer population increases and energy costs climb.

Additionally, we found that the Climate Action Plan provided a good basis for future reference with the identification of a broad array of theoretical strategies to reduce energy consumption on the island. The Plan ran into substantial headwinds, however, for two major reasons: (1) some people objected to framing the issue in terms of climate change and greenhouse gas emissions; and (2) the assessments were based on generic models and data that fail to account for the particularities of the Nantucket situation. While the Nantucket Energy Plan addressed the first issue by shifting the emphasis away from climate, it still failed to provide a sufficiently detailed analysis of the costs and benefits of the different strategies to allow for the identification of priorities for implementation.

Accordingly, this report includes a more detailed analysis of the advantages and disadvantages of selected energy strategies using data and assumptions that are more closely tuned to Nantucket sensibilities. Recognizing that many Nantucket officials and residents are more concerned about cost than they are about climate change, our research has tried to examine in more detail some of the likely costs and savings associated with the different energy saving options. Any effort to implement energy policies, however, must also be aware of the likely social and political obstacles. Consequently, our project has also tried to assess the political and social acceptability of the different options.

Table 7 below presents a summary of the results of our analysis. Each of the selected energy saving options taken from the Nantucket Energy Plan is rated according to cost, energy savings, and political and social acceptability. The categories have been color coded to highlight the differences among and between options.

However, even with these ratings, selecting priorities for implementation is not necessarily a straightforward process of selecting those options that have low costs, high energy savings potential, and high social and political acceptability since these categories are not fungible or easily compared, and other factors may need to be considered. For example, putting more bicycle racks downtown may not save much energy, but it is socially and politically acceptable, relatively cheap to pursue, and may result in other social benefits, such as less traffic congestion downtown, less clutter from disorganized parking of bicycles, and better health from exercise.

Recommendations

The quantitative and anecdotal information we collected through our research and personal encounters enabled us to determine which energy reductions strategies, of those listed in the NEP, would be most successful on Nantucket. Our recommendations are divided into three parts: (1) Energy saving options the town should pursue; (2) Options the town should not pursue at this time; and (3) Future Assessment and Implementation efforts.

Energy Saving Options the Town Should Pursue

One program that we strongly recommend the town promote to reduce residential energy use is the Mass Save Home Energy Assessment Program. Through Mass Save, residents can receive free CFLs and programmable thermostats, as well as discounts on smart power strips, refrigerators, and weatherization improvements. Since the Mass Save program is a free service that can save homeowners money on their energy bills, many residents would likely be in favor of having a Home Energy Assessment performed on their house. The town should therefore raise awareness about the Mass Save program to encourage residents to register for

Table 7. Cost, Energy Savings, and Acceptability Ratings for the Explored Energy Options

Energy Strategy	Cost	Energy Savings	Social Acceptability	Political Acceptability
Park and Ride (T.1)	High	Medium	Low	Low
Ethanol (T.3)	High	Low	Medium	Medium
Biodiesel (T.3)¹⁰	High	Medium	High	High
Straight Vegetable Oil (T.3)	High	Medium	High	High
Green Fleet Policy (T.2)	Medium	Low	Medium	Medium
Bike Racks (T.13)	Low	Low	High	High
In-Town Bike Path (T.13)	High	Low	High	Medium
Tire Inflation Pumps (T.6)	Low	Low	High	High
Rotary (T.1)	High	Medium	Medium	Low
Mass Save Home Energy Assessment	Low	High	High	High
Efficient Lighting (B.1)*	Low	Medium	Medium	High
Programmable Thermostats (B.8)*	Low	Medium	Medium	Medium
Phantom Loads - Smart Strips (B.4)*	Low	Medium	High	High
Low Flow Toilets (B.15)	Medium	Low	High	High
Rain Water Collection (B.16)	Medium	Low	Low	Low
Grey Water Collection (B.16)	Medium	Low	Low	Low
Energy from Waste (R.11)	High	High	Medium	Medium
Composting (B.20)	Medium	Medium	Medium	Medium
Green Building/LEED Certification (B.13)	Low	Low	Low	Medium
Luxury Building Mitigation Fund (B.14)	Low	Medium	Low	Medium
Weatherization (B.6)	Medium	High	Medium	High
LED Streetlights (B.2)	Medium	Medium	Medium	Medium

¹⁰ **Bold** text indicates our recommended energy reduction strategies, while an * signifies recommended strategies that are included in the recommendation of the Mass Save program

a Home Energy Assessment¹¹. Additionally, this program would reduce residential electricity consumption by making it easier for homeowners to obtain smart power strips and energy efficient light bulbs. This would delay the need for National Grid to install a third submarine cable from the Mainland to Nantucket.

According to our research, weatherization is a valuable energy saving strategy, and therefore we recommend that the town educate citizens on how it could significantly reduce their energy bills. Residential housing is one of the largest users of energy on the Island. More specifically, heating and cooling is the largest source of energy usage in residential houses, so it is a high priority target for energy reduction. Nantucket is home to many historic and aged houses, many of which are poorly insulated. Our research showed that proper weatherization of a poorly insulated house can reduce heating and cooling energy use by over 20%. We suggest that the town raise awareness by holding a weatherization lecture, where citizens can come to learn how weatherization could help them save money and talk to experts about what they can specifically do to weatherize their house. The town can raise awareness of programs, like Massachusetts' Weatherization Assistance Program, which can provide residents with financial assistance for these renovations. This is an inexpensive solution for the Town that could reduce the island's energy usage noticeably.

We also recommend that the town install additional public bike racks in the downtown area and other popular locations. The cost and installation per bike rack is relatively low, and although the energy reduction is difficult to measure, this would be a helpful step towards making Nantucket more bike-friendly. The main goal of making Nantucket more bike-friendly is to reduce the public's usage of cars, which therefore reduces total vehicle emissions and fuel consumption, especially by reducing automobile congestion in downtown. Public opinion is high, and the HDC would have little objection to the racks as long as they fit in with Nantucket's style, and are preferably made of wood. From our research, installing more bike racks would be a quick and valuable use of the town's resources.

¹¹ Lauren Sinatra, Nantucket's Energy Project and Outreach Coordinator, is actively working with National Grid to enhance awareness of this program and to improve the scheduling of audits with Island residents

Another conservation technique we recommend the town should explore further, due to its ease of implementation, is installing tire inflation pumps at beach access points. Installing air pumps at these locations would encourage drivers to re-inflate their tires immediately after exiting the beach, therefore reducing the amount of excess fuel consumed by vehicles traveling on under-inflated tires. Although tire inflation pumps will not have a large impact on reducing the Island's overall energy consumption, this is a strategy that would be welcomed by the public, while costing the town little to no money to implement. As a result, it would set the stage for the implementation of future energy conservation solutions that have a greater impact on energy consumption.

The last two recommendations that we made were not entirely based on the ratings that we gave them. We looked more at their potential if further research was to be carried out. We decided to recommend them in this way due to their abstract nature. They are larger projects than most of the others outlined in our report. They may have a lot of different factors for or against their implementation, which we may not be able to foresee at present.

We recommend the use of biodiesel and SVO on the Island in municipal fleets and/or personal vehicles. Utilizing the waste oil from local restaurants will eliminate the need to dispose of the oil off-island, substantially reduce emissions, eliminate some of the shipping costs associated with bringing diesel fuel to the island, and potentially create a small number of new jobs on the island. In addition to these ancillary benefits, using biodiesel or SVO will directly reduce energy use and costs. It is worth the town's time to research this option further to determine whether biodiesel or SVO is viable at the municipal or private level.

Along the same lines, using waste to create energy, EfW is an energy option that we recommend to eliminate the composting of waste and generate a large amount of energy on the island. An EfW plant would supply all of the electrical needs of the landfill, allow waste mined from the landfill to be disposed of, and supply more electricity than any renewable energy source currently on or planned for the island. Although there are many unknowns at this point, EfW could have substantial benefits for the island and should be researched further. Educating the public about the benefits of an EfW plant and clarifying some of the misconceptions surrounding it would be worth the town's time.

Energy Saving Options the Town Should Not Pursue

From our research, we determined that the proposed extension of the Park and Ride system is not economically feasible. The costs are high, the predicted utilization rates are low, and the energy savings are modest.

Green Fleet Policy was not considered for the six recommended options because the cost savings (medium) and energy savings (low), make it a low priority for quick implementation, and social and political support would likely be limited. .

While many members of the community are strong proponents of installing an In-Town Bike Path, we do not recommend this initiative as an *energy saving strategy* for the Island.

While a bike path in Nantucket's downtown area is socially appealing and would encourage some individuals to ride a bicycle into town instead of driving their car, the amount of energy that would be saved is not large enough energy to account for its high installation costs.

We chose not to recommend the rotary due to its high implementation cost and low political acceptability. In theory it would save a lot of time and fuel if it was constructed but with the lack of political support that it has now, it would not be easy to pursue.

Low flush toilets were not considered in our top recommended options because it is already required under Massachusetts building codes and the ultimate energy savings would not be very high. Given the existing building codes, it is expected that the proportion of low flush toilets will increase steadily over time as new buildings are constructed and older homes renovated. A more aggressive policy requiring replacement of old toilets would not be socially or politically acceptable, and would yield limited energy savings.

LED street lighting was not a highly recommended option at this time since there is no rate change and therefore no financial benefit for the town to switch over. If future negotiations regarding rate changes occur, then this can become an appealing energy and money saving strategy.

Future Assessment and Implementation

Due to limited time and resources, it was not possible for us to fully research all the energy saving options listed in the NEP. Instead, we recommend that when the town explores

the remaining options, they use a similar method of analysis. It is imperative that any assessment use data on costs, energy savings, and social and political acceptability that are tailored to the Nantucket situation. A tailored assessment will allow the town to have a better understanding of its options and the various tradeoffs. From our research, we found that there are differences in opinion based on whether cost or emissions should be the main focus in the energy plan. Our method does not provide a specific priority ranking of the solutions based on one variable, but rather it attempts to make more transparent the various assumptions, costs, benefits, and tradeoffs that are being made. Informed debate among citizens and officials will be necessary to determine priorities before moving to implementation.

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Appendix A

Statement Read to the Interviewee Prior to the Interview

Thank you for agreeing to be interviewed to aid us in our research. We are WPI students working on a project aimed at analyzing Nantucket's Energy Plan, and developing a strategy to determine energy option priorities. The information you provide us will help us better understand how to improve the Nantucket Energy Plan.

Since there are very few experts in this field, your responses during this interview will be valuable to our project. The interview process will be accommodated to meet your comfort. There are three members to our project and during the interview one of us will converse with you while the other two take notes. If you feel comfortable, then a recording device will be used to ease our efforts in documenting the interview. With your permission, we may quote your responses in our final report. You will be given the opportunity to review any quoted material we include in the. Pseudonyms may be used to preserve your confidentiality if you so wish.

Interview Scripts

T. Michael Burns – October 26, 2011

1. Did you have a role in writing or editing the car section of the NEP and if not who did?
 - a. Is there any background information that you used to develop these solutions?
2. Do you think that improving parking would have a big energy impact?
 - a. If YES: What are the best ideas to focus on?
3. Do you think that improving traffic flow would have a big energy impact?
 - a. If YES: How can it be done in the most effective way?
4. Is implementation of a green fleet for municipal vehicles feasible?
 - a. What would be the energy impact?
 - b. What is the political atmosphere or public opinion?
5. What would the necessary infrastructure for accommodating electric cars comprise of?
 - a. What would be the cost of electric car infrastructure?
 - b. What is the public opinion regarding this infrastructure?

6. What is the course of action that the plan would want to take regarding anti-idling policy?
 - a. Would it be enforced?
7. What are your thoughts on implementing proper tire inflation program?
 - a. How effective do you think it would be?
8. Are you involved with the traffic flow at the landfill?
9. Is there anyone else that we can talk to?
10. Out of the options discussed which ones would be that easiest to implement first?

Michelle Whelan – October, 26, 2011

1. What made Sustainable Nantucket first decide to adopt an emission lowering program?
2. Why did Sustainable Nantucket choose the ICLEI program?
3. Were there any other programs that Sustainable Nantucket considered?
4. Did Sustainable Nantucket use any of the ICLEI software tools to help write the plan?
5. CAPP provided a long list of potential energy saving solutions, so how did you narrow down that list to the one found in the Climate Action Plan?
6. Did you base the design of the Climate Action Plan on a plan created by another city in the United States?
7. There are tables in the Appendices section of the NEP that organize the list of potential solutions by the energy sector they apply to. Here, each solution is given a high, medium, or low rating for cost and impact. How were these parameters determined?
8. It seems that the solutions of the highest priority are highlighted in these tables. What were the criteria for determining priority?
9. How was the Climate Action Plan received by the Board of Selectmen?
10. What is the status of the plan now?
11. How do you see this process moving forward?
12. Is there anyone who was closely involved with developing the NEP that you would suggest we interview?

13. If the agricultural sustainability of Nantucket reaches its full potential what would the impact on energy consumption be with regard to Food Miles?
 - a. What is Nantucket's maximum level of sustainability?
 - b. What level of sustainability will Nantucket realistically reach in the near future?

H. Flint Ranney – October 28, 2011

1. What is your involvement with the Steamship Authority?
2. How effective do you think a sustainability fund on ferries would be in collecting money, considering the suggested amount of donation is \$5 or less?
 - a. Do you think the public would be in favor of such a fund?
3. What do you think the impact on energy consumption will be if a Ferry Sustainability fund were to be established?
4. How much fuel do the ferries consume on average throughout the seasons?
5. Are the ferry companies working on anything right now to reduce emissions or energy consumption?
6. Is there any ferry engine idling time that can be eliminated?
7. We noticed a lot of cars are idling while waiting to board the ferry or pick up a passenger from the ferry; what potential solutions might you suggest to solve this issue?
 - a. Could there be a more efficient parking arrangement for cars that are not boarding the ferry to reduce their idling time?

Harvey Young – October 28, 2011

1. How do you think the town could make Nantucket more bike friendly?
 - a. How would you implement these solutions?
 - b. Do you think these solutions will be expensive to implement?
 - c. How do you think the public will react to these solutions?
2. Do you think there are enough public bike racks for available for bikers?
 - a. Should the town dedicate more funding towards purchasing and maintaining bike racks?

- b. Would this encourage more people to ride their bikes around the Island instead of drive their cars?
3. Do you think local businesses (maybe your business too) would be willing to offer incentives to people who ride their bike instead of driving their car?
4. The plan mentioned a tire inflation program for cars, would it be possible to raise awareness for tire inflation by identifying locations of air pumps on your map?
5. As a citizen of Nantucket:
 - a. What are your thoughts on the town installing a rotary at the 4-way intersection near the high school?
 - b. What are your thoughts on the town creating a park and ride system for the NRTA? Do you think this will encourage people to ride the bus more often?

Paula Leary – November 3, 2011

1. Approximately how many people ride the bus each year?
2. Approximately how many gallons of gas does a bus use in a typical day?
3. What are your thoughts on creating a Park and Ride system for the Island?
 - a. Do you think a Park and Ride system will increase ridership significantly?
 - b. Is this option economically feasible?
4. What do you think would be the best way to increase NRTA ridership?
 - a. How expensive would this solution be?
 - b. How effective do you think this solution will be in increasing ridership?
5. Do you think ridership could be increased if businesses provided workers with incentives if they ride the bus to work instead of driving their car?
6. Have you looked into using hybrid shuttles? Shuttles that run on fuel other than gasoline, such as propane or biodiesel?

Clark Whitcomb – November 9, 2011

1. Why did you decide to have a Home Energy Assessment done on your home?
2. How did you find out about the Home Energy Assessment?
3. When did you have the Home Energy Assessment done?

4. How was the Home Energy Assessment done?
 - a. What did the energy specialist look for in your home?
 - b. What recommendations did they give you for saving energy?
 - c. Did they give you any free supplies such as light bulbs, thermostats, or power strips?
 - d. If these supplies weren't free, would you buy them?
 - e. Did you follow any of their recommendations? What changes did you make?
5. Would you recommend this service to others?
6. What do you think would have to be done to encourage others to get a Home Energy Assessment done on their homes?

Mark Voigt – November 17, 2011

1. How are people appointed to the HDC?
2. Does the HDC have a set of general rules and regulations that it follows when making decisions?
 - a. How are decisions made? What is the process to get items passed?
 - b. How are the HDC decisions enforced?
2. If _____ was proposed, what regulations would you look into?
 - a. Is it likely it will gain HDC approval?
 - b. Ask about:
 - Biodiesel Plant
 - Air Pumps at beach access points
 - Bike Racks
 - In-Town Bike Path – connects downtown to orange and union streets
 - Solar and Wind Energy
 - Residential and Municipal?
 - Rain Water and Gray Water collection
 - Weatherization
 - Windows and doors, indoor and outdoor insulation

- LED Streetlights

Kara Buzanoski – November 29, 2011

1. Do you have fleet vehicles that could use biodiesel fuel?
2. Do you think installing a biodiesel plant would be feasible at the dump?
 - a. Are there any other locations for this plant?
3. How is waste vegetable oil disposed of on the Island?
 - a. What is the cost of disposing of the oil?
4. Do you think an EFW plant would be a good idea on Nantucket?
5. Do you think it would be possible to establish a transfer station on the eastern side of the Island?
6. Is there a current system in place for recycling CFLs?
 - a. If not, how, could a new system be implemented?
7. Are you involved with the town's streetlights?
 - a. If yes, do you know how many streetlights there are on the Island?
 - b. How does the town pay for them?
 - c. Have you looked into using LED streetlights?

Gregg Tivnan – December 7, 2011

1. How familiar are you with the Nantucket Energy Plan?
2. We have a group of strategies that we looked into and we were wondering if you could give us your input on their public and political acceptability.
 - a. -Alternative fuels
 - b. -Green Fleet Policy
 - c. -EfW
 - d. -Mass Save (lighting/thermostats/power strips)
 - e. -LEED
 - f. -Luxury Building Fund
 - g. -LED Streetlights

Appendix B

Dylan Wallace Questionnaire

How much did the start up of your straight vegetable oil system cost you?

5 years ago Grease car (<http://www.greasecar.com/>) light truck conversion kit was about \$900 & filter unit was \$800, filter unit could supply WVO for many many cars. We did the conversion ourselves, the straight wharf people had the Mercedes converted with another type of kit specific to that car by mechanics.

How much does it cost to maintain?

About \$15 a year in filter for filter unit & \$15 on board WVO system. After 5 years of use I will have cleaned fuel tank every year and replaced fuel/coolant lines once. Cost of lines about \$40. Not including labor.

How much money do you save on fuel per year?

For toyota: \$480/\$576 with fuel @ \$4.80 per gallon

What is the cost per year to maintain this system?

\$30 in filters. Not counting time/labor and gas to pick up oil. Oil is free / recycled and we reuse 35 lb. containers oil comes in.

How many gallons do you use per year?

Toyota is in operation for 5/6 months using 20 gallons per month = 100-120 gallons per year = 2,800-3,360 island miles driven

What do your vehicles get for mpg?

81 Toyota Pick-up SR5 = 28-35 MPG / 1980 Mercedes 123 Wagon = 25-30

From the restaurant that you are receiving oil from now, how much oil do you collect per week?

We need to fill out 15 gallon WVO fuel tank every two/three weeks. We collect oil when its available and clean, filter it and save it. WVO is stable and keeps well, as long as you keep it away from rodents!

Do you know what they do with the oil from restaurants now (is that what they compost at the dump or is it dealt with somewhere else)?

WVO is considered a Hazardous Waste and has to be picked up in a designated truck, and shipped off island for "processing" at an approved facility. So it is shipped her and then back off again, not being composted.

What would you think of someone collecting the oil for production of biodiesel or use in WVO vehicles?

That would be fine. Biodiesel is sold on Maratha's Vineyard, you could look into that for how they have done it.

Would that impose on your use?

No, the more the better!

Are there any other people besides you and the people at the restaurant using WVO on Nantucket?

Someone at Toscana Corp. has been experimenting with brewing biodiesel. No one other than that I think at the moment.

Brooke Meerbergen Questionnaire with Responses– November 15, 2011

Thank you for agreeing to answer some questions to aid us in our research. We are WPI students working on a project aimed at analyzing Nantucket's Energy Plan (NEP), and developing a strategy to determine energy option priorities. Our goal right now is to gather information on energy saving ideas suggested by the plan and then come up with a way of setting priorities for the ideas so that the town can easily decide on what they want to pursue further. The information you provide us will help us better understand how to improve the Nantucket Energy Plan.

There are three members to our project, Nick, Chris, and Tim, we are all juniors at WPI and this project is our Interactive Qualifying Project (IQP). All junior level students at our collage do one of these types of projects and there are project centers around the world. With your permission, we may quote your responses in our final report. You will be given the opportunity to review any quoted material we include in the final draft. Pseudonyms may be used to preserve your confidentiality if you so wish.

The Nantucket Energy Plan draft has a section on Weatherization and one on Green Building/LEED. I'll copy these sections and put them at the bottom of this document. If there are any questions that you feel uneasy answering or unable to answer don't worry.

Weatherization:

-We are trying to get an idea of how much weatherization would affect a house on Nantucket with regards to energy,

-What kind of weatherization techniques are used on Nantucket mostly?

OPTIONS FOR OLDER HOMES (pre 1940)

- Cellulose insulation blown in from the exterior (commonality: 7 (scale 1-10))
- Close cell urethane foam blown in from interior during “gut reno” (commonality: 6)
- Icynene open cell foam blown from interior during “gut reno” (commonality: 8)
- New batt insulation applied from interior during “gut reno” (commonality: 8)
- Layer of ½” rigid poly isocyanurate on inside stud faces prior to applying finish substrates (commonality: 3)
- Low Emissivity storm windows (exterior side) (commonality: 6)
- Adding pile weather stripping to sides of sash (commonality: 2)
- Replace windows/doors with insulated glass (outside historic downtown) – (commonality: 8)
- Pull interior trim and insulate around jambs (commonality: 9)

OPTIONS FOR NEW HOMES (post 1940)

-All recently permitted homes are required to meet the 2009 IEC which is basically LEEDS level U-values, thus, recent vintage homes are not relevant to this inquiry in terms of what is common practice. Most improvement issues are related to homes built between 1940 and 1990 due to “relaxed” energy standards and can include the above options, though will focus more on the windows and doors than on the insulation techniques as the age of the structure moves towards the present. Newer homes will typically employ foam technology to get the R-values and the air infiltration values.

-What technique do you believe is most important for saving energy?

In general, I’m a fan of close cell polyurethane foam because of its insulation AND structural qualities. It not only provides more R per inch than icynene, but acts as extra structural reinforcement due to the strength of its molecular bonding capacity. It also has evolved to include “earth friendly” blowing agents. However, when it comes to older homes, I prefer the cellulose insulation because it is treated with a naturally occurring borate salt compound that acts to suppress termites, critters, and fire and is less “tight”. As counter intuitive as this might seem, for homes that were built prior to 1880, a super tight house is not the best thing for the structure of the house itself. Prior to 1880, many homes used solid timber construction with large corner posts that have thru-thermal conductivity due to the fact that the timber has a warm side and a cold side and have no thermal break. Hyper insulating forces the heat to seek the path of least resistance at the corners of the house creating a dew point in the middle of the timber and rotting it out over time. This can be somewhat mitigated with the ½” rigid poly isocyanurate panels installed on the inside face of the structure, but a lot of the historic detail gets covered. A modern stick frame house can have insulated corners and avoid this scenario.

Poly iso panels also make great rafter bay insulation in attics where exposed timbers are encountered.

With older homes, it is very important to keep the proper humidity level and if you decide to super insulate an old home, you will also need to provide mechanical ventilation and humidity control in order avoid splitting historic trim and millwork. These homes were built by housewrights who understood how to put together wood in such a way as to take into account natural variations in humidity with no consideration to insulation or heat sources other than a fireplace.

With newer homes, proper insulation, taking advantage of passive solar opportunities and using high efficiency appliances and infrastructure are really the best ways to reduce all manner of energy consumption. Some examples of high efficiency appliances that I think are useful are energy star refrigeration, tankless hot water (potable & hydronic heating), LED lighting or compact fluorescent lights.

In the big picture, the best way to conserve energy is to buy an old home and tighten it up. Conventional wisdom will tell you that there are a lot more invisible costs both monetary and environmental, with any new construction.

-What useful techniques, if any, are limited by the Historic District Committee?

The only energy saving technique that is limited by the HDC is whether a window can be insulated glass or not. In the down town area, insulated glass is not allowed. Only true divided light units are acceptable. The assumption of energy conservationists however, is that the U-values are drastically better with insulated glass. The truth is that a low air infiltration, high quality true divided light unit with a wood storm window that has low E glass, will give you virtually the same U value as an Andersen insulated glass unit (Green Mountain tests at .33 vs .32 for Andersen).**

-Do you have an idea of how much energy could be saved from proper weatherization on Nantucket?

In terms of BTUs or monetary terms, that is difficult to quantify, but if you subtract the number of homes built after 1990 from the total number of homes and then add the number of renovations after 1990, you will get a good idea of the number of structures that could be “improved” with proper weatherization techniques. In terms of percentages, I would guess that

between 30% - 40% of homes are eligible. If this is applied to current fuel costs, etc, I'm sure the number would be significant.

-Do you know how much it would cost to weatherize an average existing house?

This would depend on the scope and the type of the structure. The problem with this line of questioning is that it seems to be pushing for a "one size fits all" approach and this is not necessarily the best approach for all the homes out here. For the sake of argument, let's assume a 1940's era home with windows in need of replacement and no wall cavity insulation. Let's also assume that the homeowner does not want to gut the house and that the HDC wants to see true divided light windows and doors. The following solutions would be employable – Replace all the windows with a true divided light window or door assembly that meets the .33 U value; Insulate all wall & roof cavities with blown in cellulose from the exterior; insulate all floor cavities above unconditioned space with high density batt insulation or close cell polyurethane foam; foam all the rough openings around the window and door jambs; properly spline all structural corners and areas behind window and door trim; install a tankless domestic hot water system; new heating and conditioning system....total cost would be approximately \$70 – 100K depending on variables and the vagaries of the upgrade. This makes no other assumptions about electrical system upgrades, plumbing upgrades or similar infrastructure upgrades.

-How effective do you think public education (is in communicating energy conservation?)

Public education is effective where there is a demographic that can understand and appreciate the value of home energy solutions. This demographic is typically more educated/indoctrinated in the environmental and conservation discussion. In order to broaden the effect, it is necessary to raise the consciousness of the broader diaspora about this discussion before trying to sell them on the energy conservation practicalities. The reality is that these techniques cost money; therefore, the only ones who can afford these techniques are the only ones who can take advantage of them.

Green Building/LEED program:

-We want to find out more about Green Building and the LEED program to see how it would save energy for Nantucket, are you familiar with the LEED program?

I'm familiar with the general USGBC bureaucratic structure and the checklist approach to "greening" our homes and living spaces

-If yes, do you think it is a good idea?

I think that broadly it is a good idea as it is well intentioned, but it seems very cumbersome for the average homeowner who can't afford to pay an architect or consultant to shepherd them through the process. I also feel that the 2009 IEC takes care of a lot of the basic issues that LEED has as their benchmark (insulation, fenestration, etc)

-Also do you think it could save Nantucket money?

Again, this presupposes that LEED is an effective tool in the first place. Please remember that most of the energy (and money) in a building is the energy (and money) used in creating the products used in construction in the first place. Saving money on the back end is a nice thought, but keeping buildings small, or utilizing existing infrastructure (re-purposing) is the best way to "save" money, because it is not being spent.

-Are Green Building practices popular on Nantucket?

Current energy code requires that buildings be hyper insulated and super tight so it is not a question of popularity, it is more a question of compliance. In terms of external gizmos (solar panels, etc), Nantucket is a very foggy place and I think that most people understand that you will not get a good "bang for the buck" with PV, and thus it tends to be something employed by those who can afford it as an accessory rather than a necessity. Solar tubes (hot water) are more useful though, as they are more affordable, can be easily (and inexpensively) linked to existing technology, and seem to work well no matter the conditions (fog, temperature, etc). These are not as popular because they are very bulky and unattractive. I personally believe that wind is the real unsurpassed and under utilized resource out here, but placement of wind mills is subject to HDC and zoning concerns and sometimes these concerns can affect the usefulness of the appliance.

As for energy star appliances, etc, most of what people purchase is required by law to be energy star compliant.

-Is your company influenced by Green Building Practices?

Of course! 😊

-If yes what are they?

-FSC lumber wherever possible

- Close cell, high R foam
- Tankless or similar high efficiency heating appliances
- Hydronic (radiant heat) vs. forced hot air
- Indigenous plantings whenever possible
- Non CA pressure treated lumber whenever possible
- Smaller structure design whenever possible
- Reclaimed lumber
- Windows with good U-values
- Siting for Passive Solar
- Energy Star appliances (water; electricity)

Closing remarks:

As you can see, going after cracks with a caulking gun was not mentioned in my “techniques”. This is because caulk is something that fails very quickly in a marine environment and is a very ineffective way to pursue proper weatherization in the long term. While some types of “caulk”, such as silicone are very helpful, they are not a replacement for good building practice. These practices were outlined at the beginning of this questionnaire.